AUDIO ENGINEERING

AUGUST
1951
35c

California West Coast Issue

ANNUAL PACIFIC ELECTRONICS EXHIBIT
San Francisco—August 22-23-24

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CONTENTS — AUGUST, 1951 — Vol. 35, No. 8

COVER

The majestic Bay Bridge extending from San Francisco eastwards toward Oakland and Berkeley, with Yerba Buena Island approximately midway between the two ends of the bridge. With the exception of the renowned cable cars, the Bay Bridge and the shorter Golden Gate Bridge are the most famous attractions of the metropolis which plays host to the Pacific Electronic Exhibit this month.

(Both Editor and Publisher are aware that this photo is reversed. Artistic license has been invoked to make a more photogenic cover.)

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Publisher's Letter . . .

JUAN RODRIGUEZ CABRILLO first saw the Pacific Coast in 1542. In the 409 years that followed you would expect some changes to have come about in this region—though hardly enough to justify a special issue of a technical magazine. Yet the events of the past decade, unprecedented in any other area or in all history, are so fantastic, so widespread in their industrial and commercial effects on all fields including electronics and its voice, audio, that recognition becomes mandatory.

When over five million people pulled up stakes and marched across the nation it became the greatest mass migration in history. Of course, a war was its motivating factor, so when the war was over you would expect the people to have drifted back to their former homes. They didn't. Instead, they not only stayed but others came out to join them. And they are still coming. In California, during the last decade, the population increased 53.3 per cent.

Such an increase would indicate commerce and industry must be moving too. It has. We find great national organizations moving their headquarters westward. We find branches of eastern factories as large as their parents burgeoning almost everyplace. Civilian employment in the Golden State went from two and a half million in 1940 to four and a half million in 1950. Retail sales went from three to eleven billions in the same period.

Steel, ships, and styles now move from the Coast all over the world. And, from Boeing at Seattle to an empire of wings in Southern California, the aviation industry has made this area a favored spot.

Where there is a concentration of aviation you expect to find strong electronics representation. Where there is a mass growth of population you expect to find communications in full growth. And naturally the voice of both, audio, must also be in crescendo.

Let's look at the facts. Quoting from the Economic Survey of California—"Manufacture of electrical machinery and equipment in California showed the largest expansion between 1939 and 1947 of any large industry group. Some 216 new establishments were added, the number of workers increased by 264 per cent or more than three and a half times, and the value added by manufacture increased by 515 per cent." During 1950 employment increased another 25 per cent over 1947 levels.

Now comes a report that over a billion dollars worth of contracts for electronic equipment is in the process of being let by the aircraft industry alone. The West Coast Electronic Manufacturers' Association says that between ten and twelve per cent of all defense dollars will be spent in the field of electronics.

In our sister field, video engineering, the Coast is also making spectacular strides. The entertainment news is dominated these days by reports of the marriage of TV and the movies. The reports of new production units run into hundreds. The Coast has its own TV hook-up, and the relay network to connect East and West is now promised to be ready for use within a few months.

A dynamic manifestation of all this activity is the annual Pacific Electronic Exhibit to be held this year in the Civic Auditorium, August 22-24, at San Francisco. The affair will attract something over 7500 people actively engaged in the manufacture and sale of professional and commercial electronic products. This year 70 Eastern and 50 Western factories are exhibiting, plus 19 manufacturers' representatives and seven university and government agencies.

The displays are not open to the general public. But those interested besides WCEMA and IRE members may secure tickets without charge by proper identification in the lobby during the opening hours.

San Francisco, where the exhibit is being held, can proudly boast that it has been called "the youngest of the world's truly cosmopolitan cities." Since 1940 the "Metropolitan District" of 3,314 square miles has had the greatest population growth of any corresponding area in the United States—approximately 40 per cent or 583,000 souls.

Visitors to the exhibit will be amused at the cable cars, thrill to the Golden Gate and the mighty bridges (see Cover), enjoy the bracing air, dine on some of the best food of the widest variety to be found in the nation.

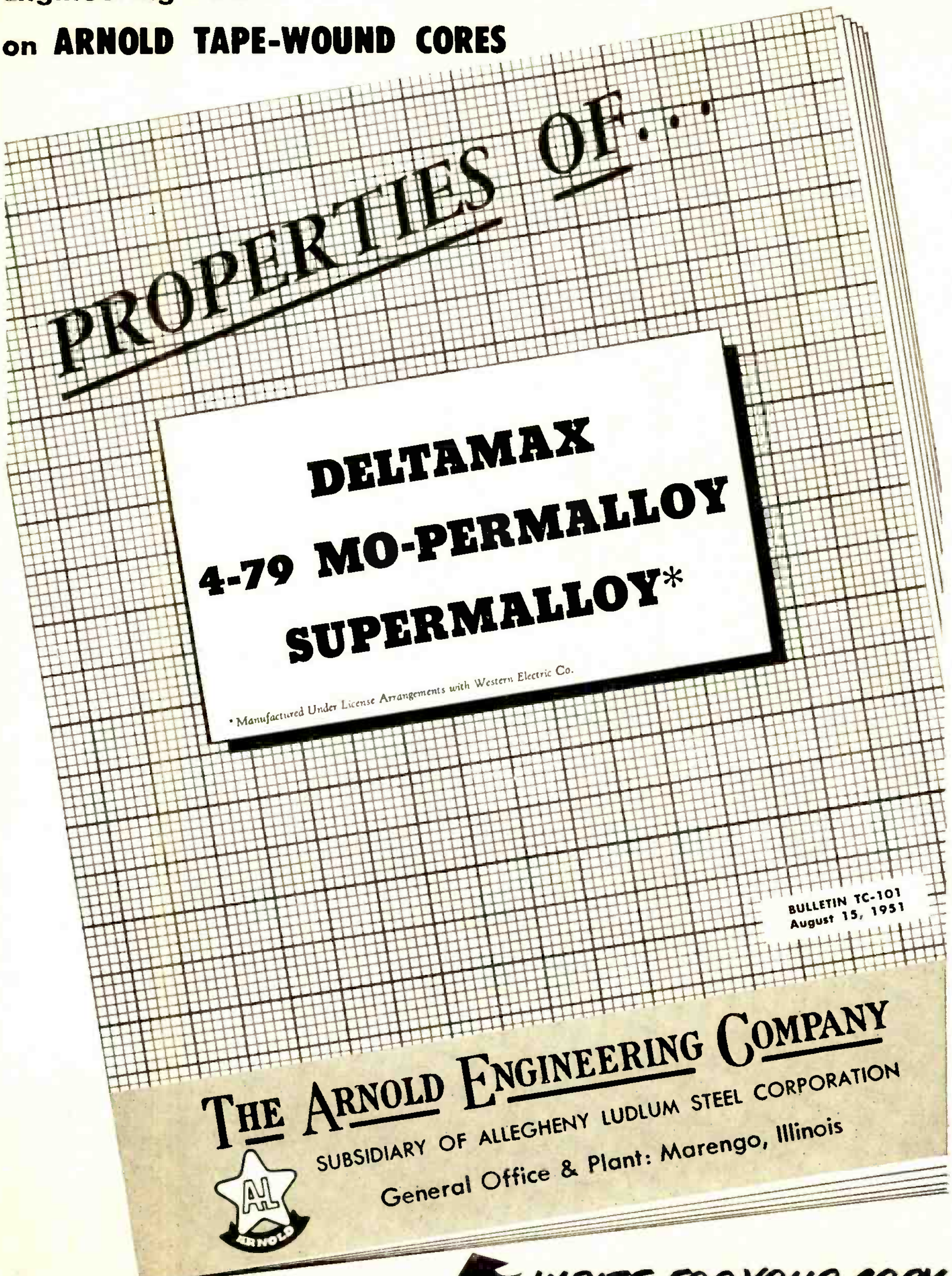
So to the Host City, the several thousand Æ subscribers in the West, the West Coast Electronic Manufacturers' Association, and audio folks everywhere, a salute in the form of this special issue. Although it is off the beaten track (and for the regulars who protest any change of format in their favorite technical magazine we promise to return to orthodoxy next month) we hope it will be received as a job that was deserved by this new, spirited, little giant segment of electronics.

In the language of the California dons "Bien Venido."

Ladd Haystead

Engineering Data

on ARNOLD TAPE-WOUND CORES



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AUDIO PATENTS

RICHARD H. DORF*

Electronic musical instruments must have provisions for vibrato or tremolo, preferably the former. When vacuum tubes are used for tone generation vibrato is always possible, simply by injecting a vibrato-frequency (4 to 7-cps) signal somewhere into the generator to vary its frequency. It stands to reason, however, that —ordinarily, at least—an oscillator whose frequency can be varied that easily cannot be very stable. The same problem arises in FM transmitters which employ a reactance tube to produce the modulation.

James A. Oswald of Chicago has patented a vibrato system which does not greatly affect the stability of the tone generator, in Patent No. 2,506,679, assigned to Central Commercial Company, maker of the Lowrey Organo.

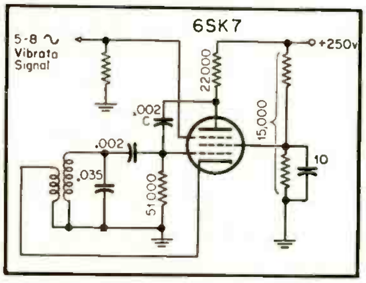


Fig. 1

The circuit appears in *Fig.* 1, with a set of sample component values. This is one of the master oscillators used in a generator system which includes twelve of them, each followed by a string of frequency dividers to produce the lower octaves. The 6SK7 is connected as an electron-coupled oscillator with its cathode, grid, and screen forming the oscillator triode. An electron-coupled oscillator is effectively a combined oscillator and isolating amplifier, and here the amplifier is made up of the screen (acting as cathode), the suppressor, and the plate. The suppressor, which is the control grid of the amplifier triode, is connected to a source of vibrato-frequency oscillations.

As a result, the gain of the amplifier triode varies at the rate of around 6 cps. This means that the transfer of oscillator-frequency energy through capacitor *C* back to the tank circuit also varies at the vibrato rate. The result is a periodic change in output frequency, accompanied by a small amount of amplitude variation as well. The two combine to produce a pleasing vibrato effect.

There are definite advantages to this arrangement. Many instruments employ a modulator tube (usually a reactance modulator or one kind or another) with each oscillator tube; this circuit does the whole job in a single pentode. More important is the frequency stability. An electron-coupled

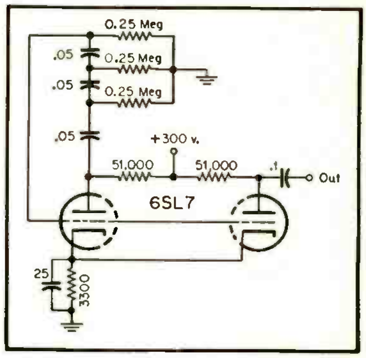


Fig. 2

oscillator is normally stabilized by the fact that with correct selection of component values, changes in electrode voltages cancel each other. This process still goes on in the circuit of *Fig.* 1, the only additional provision being a periodic change of plate current, which does not affect stabilization.

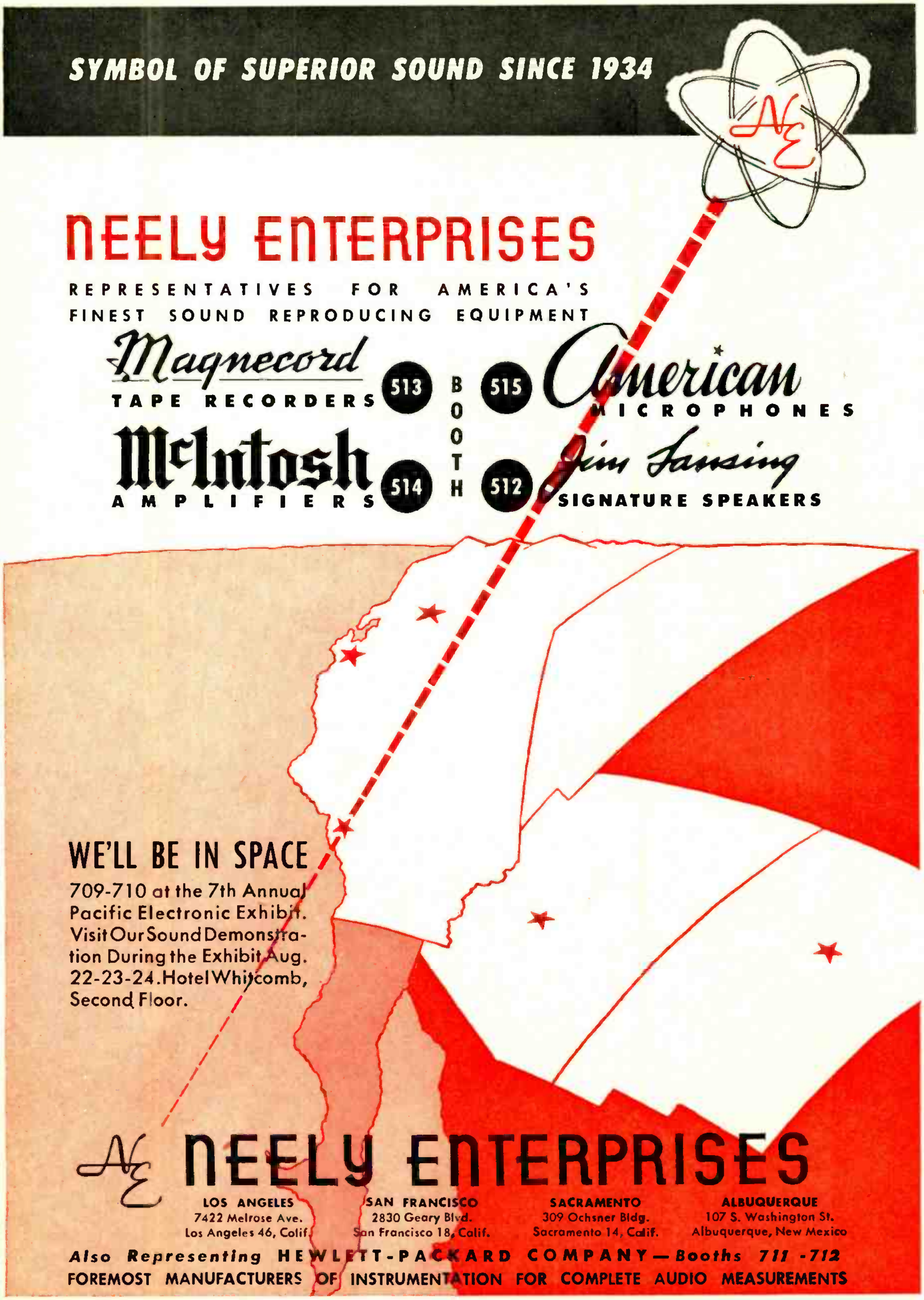
Figure 2 shows the vibrato-frequency oscillator illustrated by the inventor. It is not particularly new, being a more or less standard phase-shift oscillator with a following amplifier. The exact values, however, should be of interest to many electronic music enthusiasts to save them the trouble of designing the oscillator.

On this same subject, a different kind of vibrato-frequency oscillator is the subject of Patent No. 2,546,645, which the inventor, Thomas H. Long, has assigned to C. G. Conn, Ltd., maker of the Connsonata. Mr. Long's oscillator is diagrammed in *Fig.* 3, and those familiar with the Connsonata will notice a marked similarity to the oscillators used as tone generators in that instrument. Mr. Long has apparently been experimenting for a long time with this kind of oscillator, for he has a number of patents on variations of it.

The circuit is essentially a modified Hartley. The plate is connected to one side of a tank circuit, the inductor of which is the primary of a transformer. Output is taken from the secondary, across a potentiometer. The other side of the tank is not connected directly to the grid but goes instead through potentiometer R_1. The

[*Continued on page 48*]

* *Audio Consultant, 255 West 84th Street, New York 24, N. Y.*



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LETTERS

Editor vs. Canby vs. B.B.C.

Sir:

Will some audio engineer shed a tear for the perplexed non-technical reader?

The EDITOR'S REPORT (Æ, June, 1951) on *Loudness vs. Frequency Content* concludes that, "If the monitoring were done principally by listening to the monitor speaker rather than by adjusting the level to satisfy the VU meter, it seems this trouble would not exist at all if the speaker were sufficiently good. . . ."

The following month Canby, wiping the blood from his unbowed head with that Damp Cloth, staggers from the control room firm in the conviction that be it ever so humble, there's no place like the old familiar home listening spot.

But perhaps we should be thankful for small mercies; our transatlantic cousins have an added problem. Somerville and Brownless (Listeners' Sound Level Preferences—*B.B.C. Quarterly*, January, 1949) report a "striking divergence" between the men and women program engineers of the B.B.C. when listening to speech. The level preferred by the men being seven db greater than that preferred by the women.

One is reluctant to inject the romantic note in a technical magazine, but surely there is something to be said in favor of less wear and tear on the listener's gain control.

B. Mitchell,
225 Foster Ave.,
Brooklyn 30, N. Y.

Audio Colleges

Sir:

I have just received the July issue of Æ and noticed your editorial about College Audio Training. While Michigan State does not at present offer a course in Audio Engineering, I have had such a course added to our catalog for next year. As planned, it will be a three-hour-per-week elective course for seniors majoring in electronics or communications. It will be taught for only one term.

I realize that the time allotted is too short to do the field justice but feel that it is a beginning upon which we may build in the future.

I. O. Ebert,
Assistant Professor
Michigan State College,
East Lansing, Michigan.

Diamond vs. Sapphire

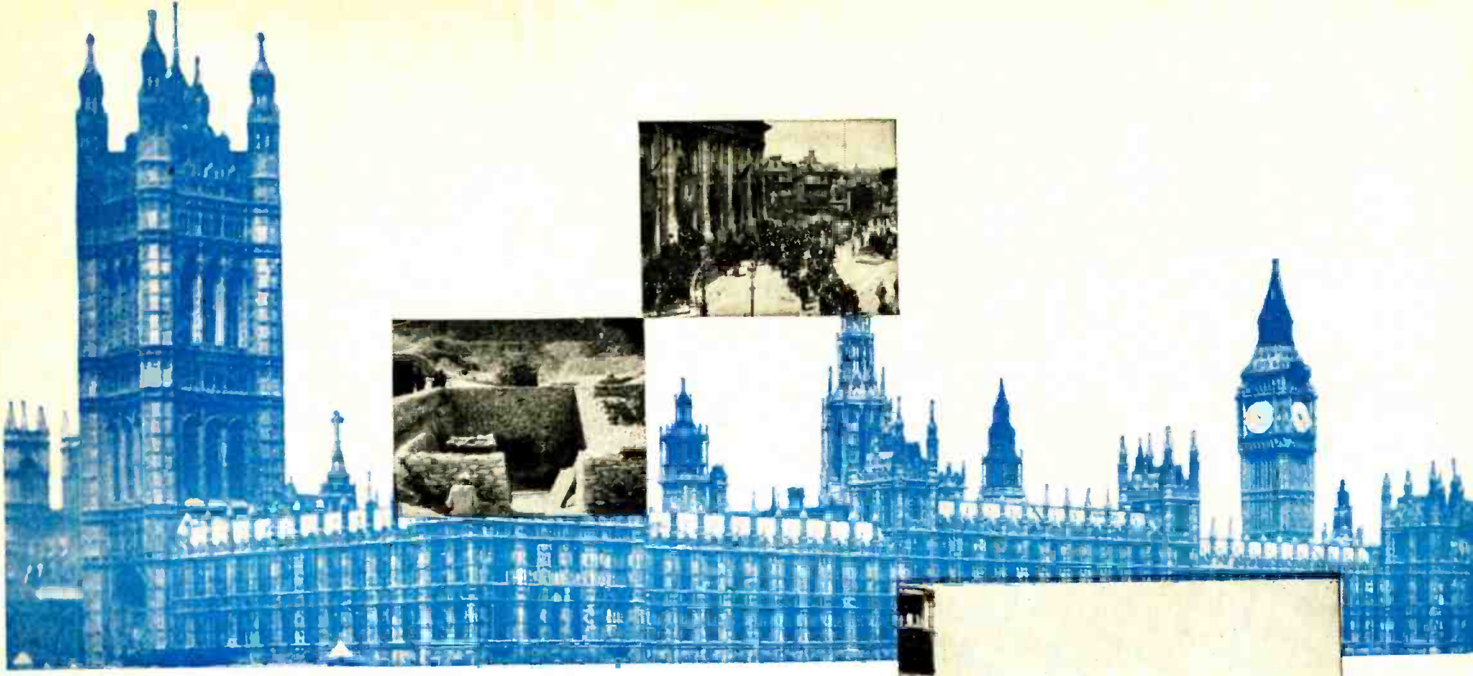
Sir:

Any further controversy over the relative merits of sapphire vs. diamond styli may seem old hat to most readers and about as necessary as an argument over whether push-pull operation is better than single-ended operation.

Engineers know that in every respect—except in the matter of initial cost—the diamond stylus has the advantage over its less precious counterpart. Diamond is a harder, denser material than sapphire and can be given just as high a polish, if not higher. Whatever the polishing susceptibilities of *natural* sapphire may be, it should be recognized that practically all sapphire needles today are made of synthetic sapphire. However high the polish may be originally, a relatively few hours of playing time will suffice to grind two flats on the tip surfaces which are in contact with the grooves, and these flats have ever-increasing magnitude as playing continues. The groove walls are in turn abraded by the sharp edges of these self-same flats.

"Phono Facts" in Æ (June 1951) lists,

[*Continued on page 50*]



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"I shall be interested to discover", says Kenneth Melvin, "whether any tape-recording equipment has ever been subjected to so grueling a test as my PT-900 . . . not on a single occasion—over four months of constant operation, averaging six hours a day, under murderous variations of temperature, current, voltage and with constant man-handling from car to scene, upstairs and down cellars—*not once has it failed me.*"

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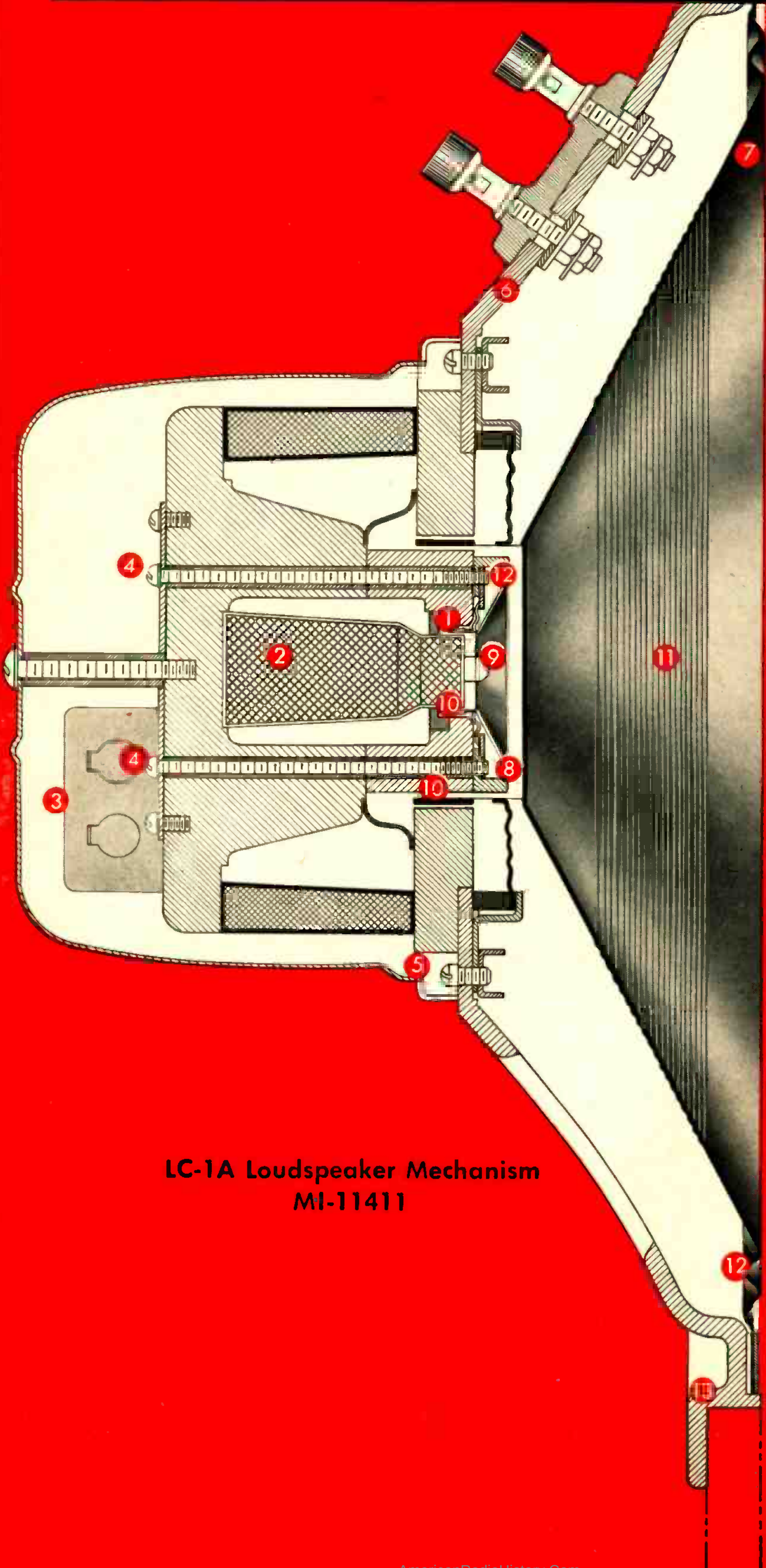

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7 Shallow cone for smooth response and greater angle of distribution

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9 H-f cone. Diaphragm diameter only 2⅜". Wide-angle distribution to 15,000 cycles

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Today, more than 3000 of these speakers are serving in station control rooms, listening rooms, auditioning booths, lobbies, clients' offices, and private homes.

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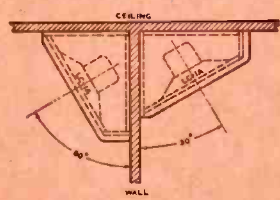

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EDITOR'S REPORT

WESTWARD HO!

West Coast folks usually dislike, or just downright hate, anything written about them by an Easterner or by an Eastern publication. They take their pen in hand and write nasty letters-to-the-editor, the general tone of which is "If you'd just get out of your Ivory Tower and come out here to see for yourself, you'd know how wrong you are." Often their criticism is justified. But for this issue and this one magazine, we'd like the westerners to know that at least two of the staff are West Coasters—the editor (Calif. Inst. of Tech.), and whilom publisher Ladd Haystead (U. C. L. A.). Also, we boast on the staff a Texican, a Sooner, and several—you should forgive it—New Yorkers.

The mention of the publisher reminds us that a few curious readers have wondered why the somewhat odd name of Ladd Haystead floats in and out of our masthead. What place does he have in the audio industry? Answer: He has an interest in the magazine, candidly admits he knows little or nothing about electronics, and has thirty years of publishing work behind him. For reasons one and three we endure him.

His advent in the office at spasmodic intervals usually results in complete confusion—and sometimes in such things as this California-West Coast issue—Æ's first special. The staff's only hope is that he will not demand a nude on the cover.

The foregoing sentence elicited the following intra-office correspondence:

LH to McP: Great idea. When do we do it?

McP to LH: We don't!

See what we mean?

Seriously, however, we will be at the Exhibit in San Francisco—Booth 623—and hope we may have an opportunity to renew some of our West Coast acquaintances.

AES STANDARD PLAYBACK CURVE

The standard curve for record playback systems as promulgated by the Society is beginning to be recognized by equipment manufacturers, as evidenced by the announcement of the new Altec Lansing A433A Preamplifier which incorporates this curve on one position of the equalizer switch. This is the second commercially built unit made to fit the new curve—Pickering's Model 132E Record Compensator being the first.

HUM VAGARIES

One manufacturer of our acquaintance reports having serviced an amplifier four separate times to reduce hum—although even in the first place the hum from the amplifier was within specified limits. It developed that the customer was using a speaker and cabinet combination which was strongly resonant at 60 cps, with the result that he heard hum which was all out of proportion to that coming from the amplifier.

Such a condition is not unusual. In the search for more bass, it is common practice to employ vented cabinets which *can* be resonated at 60 cps just as easily as at some lower frequency—in fact, if the cabinet is not quite large enough, it is likely to be easier to resonate it at the hum frequency.

Standing waves at the hum frequency are occasionally encountered, and it is not unusual to find spots in the listening room where the hum will be unbearable, while over most of the room it is not noticeable. Before throwing out an amplifier as having too much hum, it is a good idea to make sure that neither the cabinet nor the room resonates at 60 cps—if that is the supply frequency used in your city.

STEREOPHONIC BROADCASTING

One reader, Milton Sackin, writes to suggest the use of two channels of transmission to provide stereophonic sound in the home. These two channels could readily be transmitted over the stations which have both AM and FM facilities, and listeners with two receivers and two speakers could then receive sound which should be more realistic than that from a single channel.

While the idea is not new—having been tried in Holland some years ago—we admit to having attempted to "sell" the idea to one of New York stations with both outlets. Station agreed, program producer demurred.

On the same subject—what is wrong with *this* idea? Two separate channels, fed by suitably spaced microphones, are used to modulate the positive and negative halves, respectively, of an AM carrier. Ordinary receivers using half-wave diode detectors would reproduce the output of one channel or the other, but since the microphones are reasonably close together there should not be much difference in the resulting sound. Stereo receivers would have two half-wave detectors, of opposite polarity, followed by separate audio and speaker systems. Thus no changes would be required in existing sets unless a listener wanted the additional advantage of stereo reproduction.

One of the precepts of good engineering is that no equipment should be obsoleted by a change of standards. In view of recent color TV decisions, it appears that all standard-making agencies are not in agreement with this precept. We would, however, like to hear some experimental work on a dual-channel transmission.

Efficiency of Direct-Radiator Loudspeakers

VINCENT SALMON*

An analysis of the factors affecting the efficiency of the type of speaker most commonly employed in sound reproduction installations.

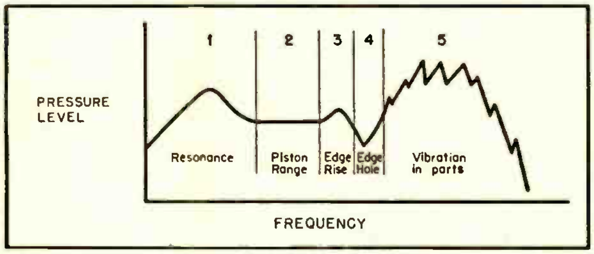


Fig. 1. Characteristic frequency regions in the free-space axial sound pressure response of mass-controlled direct-radiator speaker in infinite baffle.

The most widely used loudspeaker is the direct-radiator, moving-coil, mass-controlled type. In this note are discussed some of the factors influencing its available-power efficiency, and especially that in the piston-range.

In any speaker the response is commonly understood to be the acoustic output as a function of frequency for some constant electrical input. On the other hand, the efficiency is usually a single value, a sort of figure of merit, so that the speaker may be compared with others. As may be expected, there are many types of efficiencies, depending on which combination of electrical input, acoustical output, or test signal is used.

For the purposes of this discussion, we shall consider the efficiency that is related to the program energy output of a speaker used indoors. Thus the measure of acoustic output is the total radiated power, and especially that near 400 cps, where the program energy peaks. Consider next where this frequency region lies with respect to those observed on a pressure-response curve.

If the free-space axial sound pressure response of a direct-radiator speaker in an infinite baffle (chosen because it is a reproducible mounting) is taken as a function of frequency, it is found that there are at least five regions of interest, starting at the low-frequency end. As shown considerably smoothed in *Fig.* 1, the first is centered about the fundamental resonance of the speaker. At very low frequencies the response rises 12 db/octave, shows a peak at resonance (for the usual speaker), and then falls off. In region 2 the response is practically constant; this is the piston range where we shall calculate the efficiency. The program energy spectrum usually maximizes in this range. In region 3 the response peaks at the edge rise, where the cone is about a quarter wave long. Waves in the cone material are reflected from the outer termination and arrive back at the voice coil so as to lower the mechanical driving-point impedance, thus increasing the velocity and hence the energy radiated. With increasing frequency, the half-wave condition is next approached, and in region 4 the resulting edge hole is seen, arising from the high impedance reflected into the voice coil from the cone edge. Beyond this region the wave pattern in the cone becomes more complicated, the driving-point impedance fluctuates considerably, and the speaker becomes more directional. All of these add up to the ragged, bulged response of region 5, that of cone vibration in parts. Only in region 2 is there anything approaching a level response; in addition, the program energy the speaker must handle is greatest in this range, about 50 per cent lying between 200 and 600 cps.

In this region a number of phenomena cooperate nicely to simplify the analytical treatment. First, the cone is moving practically as a rigid piston in an infinite baffle; hence the Rayleigh radiation impedance may be used. Also in the piston range the mechanical driving-point impedance is principally that of a mass, since the speaker is working well above the fundamental resonance and well below vibration in parts. Third, the speaker is not yet too directional, so that the sound pressure varies little with angle, permitting the total radiation to be calculated quite simply from the sound pressure. Fourth, for most speakers the frequency is still moderate so that the (series) radiation resistance varies as the square of the frequency. And finally, in this frequency range the inductance of the voice coil may be neglected. All this makes possible a simple expression for the piston-range efficiency.

Efficiency is expressed as a ratio of acoustic output to electrical input. To be useful, the measure of acoustic output should correspond to what the ear hears. Since for indoor use the total acoustic power radiated plus room effects determines the sound pressure at the ear, we choose power radiated rather than the axial sound pressure (which serves for outdoor listening). As a measure of electrical input the most suitable for the present purpose is that power which the representative test amplifier used will deliver to its rated load. Note that this is not the power to a matched load (one equal to source impedance), since amplifiers are not operated that way. This rated load is simply that given by the number on the output terminals: if they are marked 16 ohms and the amplifier is adjusted for one watt into a 16-ohm load, the power available *to the speaker* (*not* power available *from the source*) is said to be one watt. It is necessary to use this criterion, since the maximum power from the amplifier is of no use to us: it is the maximum "undistorted" power delivered to the optimum load that is useful. The speaker efficiency on this basis is then the number which when multiplied by the power available to the speaker gives (as closely as possible) the acoustic power from the speaker, under the infinite-baffle condition. In the frequency range considered, a cabinet will give a somewhat rougher response, fluctuating about that of the baffle.

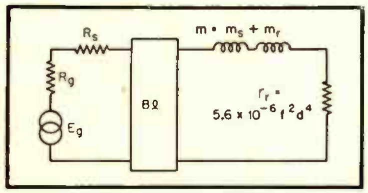


Fig. 2. Equivalent piston-range circuit of speaker with amplifier connected. See text for symbols.

Electromechanical Circuit

In the frequency range considered, usually 200 to 600 cps for 8- to 15-in. speakers, the output (source) impedance of most satisfactory amplifiers may be considered to be a constant resistance. With this assumption, plus the others obtaining in the piston range, the equivalent electromechanical circuit will be as in *Fig.* 2, where the force-voltage analogy is used. Here E_g and R_g are the source open-circuit voltage and impedance, respectively; R_s is the d.c.

**Stanford Research Institute, Stanford, California.*

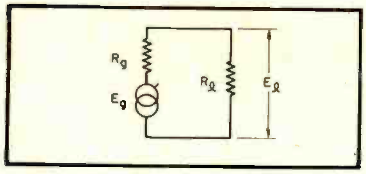


Fig. 3. Measurement of power available to amplifier load.

resistance of the speaker in ohms; Bl is the product of flux density in gauss and conductor length in cm; m is the total moving mass, including the speaker mass m_s and the radiation mass $m_r = 6.6 \times 10^{-3} d^3$ (m_r is in grams, d is effective cone diameter in inches); and the series radiation resistance is given by $r_r = 5.6 \times 10^{-6} f^2 d^4$ in mechanical ohms, where f is the frequency in cps. If the r.m.s. cone velocity is v (in cm./sec.), then the radiated acoustic power in watts is $P_a = 10^{-7} v^2 r_r$.

The power available to the load is obtained by replacing the speaker by R_l, the rated load impedance of the amplifier, as in *Fig.* 3. It is easily shown that the power in the load is

$$P_l = \frac{E_g^2}{R_l} \cdot \frac{1}{\left(1 + \frac{R_g}{R_l}\right)^2}. \qquad (1)$$

To digress a moment, note that E_g^2/R_l is the load power if the source impedance R_g were zero; hence the second factor on the right expresses the deviation from this condition caused by finite source impedance, and hence is also a measure of the damping effect of the amplifier on a speaker load. The term *regulation* has been given to the quantity

$$D = 20 \log_{10} \left(1 + \frac{R_g}{R_l}\right). \qquad (2)$$

For properly loaded push-pull 6L6's, the regulation is about 15.5 db, while a pair of 6B4's will have a regulation near 3.5 db. If sufficient feedback is used, D can be reduced to as little as 1.0 db, although 3 to 5 db is nearer average commercial practice in high-quality sound system amplifiers. To measure D, simply load the amplifier properly and read the output voltage. Then remove the load; D is the db rise in output voltage. In the so-called constant-voltage audio distribution system, D is 3 db or less.

To return to the main topic, it is seen that the efficiency is given by

$$\eta = \frac{P_a}{P_l} = \frac{10^{-7} v^2 r_r \, R_l \left(1 + \frac{R_g}{R_l}\right)^2}{E_g^2}. \qquad (3)$$

By calculating the cone velocity to be expected when the connections of *Fig.* 2 are used, the following expression finally results:

$$\eta = \left[\frac{R_s}{R_l}\left(\frac{R_g + R_l}{R_g + R_s + \frac{10^{-9}(Bl)^2}{(r_r^2 + 4\pi^2 f^2 m^2)^{\frac{1}{2}}}}\right)^2\right] \times \left[\frac{(Bl)^2}{R_s}\right]\left[\frac{r_r}{(r_r^2 + 4\pi^2 f^2 m^2)}\right] \times 10^{-9}. \qquad (4)$$

Now we can begin to introduce the piston-range approximations. In practically all direct-radiator speakers, the last denominator term in the first brackets can be neglected, because of the low efficiency. Since the speaker is mass controlled, the first denominator term in the last brackets can be neglected, and since the frequency is not too high, $r_r = 5.6 \times 10^{-6} f^2 d^4$. For most properly used direct-radiator speakers R_s/R_l is near 0.85. Finally, let us examine the

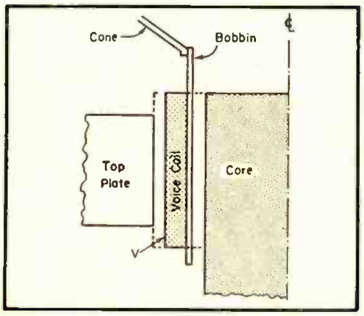


Fig. 4. Geometry of voice coil and gap volume.

term in the second brackets at length.

Since this term contains much of the information which determines the efficiency, its algebraic manipulation will be described in some detail. Resistance may be expressed in terms of conductor length l and cross section area A by $R = \rho l/A$, where ρ is the resistivity. Thus $l^2/R = l^2 A/\rho l = lA/\rho$. But lA is the volume of the conductor. Set this volume equal to a fraction α of the total gap volume V, which is defined in *Fig.* 4 to include that in the voice coil overhang. The fracton α is the space factor, and is a measure of how efficiently the voice coil makes use of the magnetic flux density available. Now suppose that the magnetic energy W in the gap is determined by the measured flux density, using the relation $W = B^2V/8\pi$. Then $B^2 = 8\pi W/V$. Thus after all substitutions B^2l^2/R_s becomes $8\pi\alpha W/\rho$, where W is the gap magnetic energy in ergs and ρ is the voice coil resistivity in ohm-cm.

If all the piston-range substitutions and approximations are made in the efficiency formula, there results

$$\eta \doteq \left[\frac{2.44 \times 10^{-9}}{\left(1 - \frac{0.3}{1 + \frac{R_g}{R_l}}\right)}\right] \frac{C\alpha W}{(m/d^2)^2}.$$

(ergs, grams, inches)
(5)

Here C is the ratio of the conductivity of the voice coil to that of copper. The coefficient in brackets has the following values for these output stages: PP6L6, no feedback, about 2.6×10^{-9}; PP6L6, considerable feedback, (6 db regulation) 2.9×10^{-9}; and PP6B4, 3.1×10^{-9}. To repeat, α is the space factor, the fraction of the gap volume used by the voice coil; W is the magnetic gap energy in ergs; m is the total effective moving mass in grams; and d is the effective cone diameter in inches. A good approximation to d is the distance from the top of the innermost bead on the annulus to the opposite outer clamp diameter of the cone. See *Fig.* 5.

Analysis of Formula

Let us now examine this expression more closely. The effect of frequency has canceled out because of the two main assumptions that the principal mechanical-impedance component is that of the moving mass, and that the radiation resistance varies as the square of the frequency. Two important factors in the efficiency are seen to be the space factor and gap energy. In the form given, the influence of magnet size is easily seen, for magnets are characterized by a guaranteed maximum externally available energy. In a well designed PM speaker, about 40 per cent of this energy apears in the useful gap, the remainder being lost in leakage and fringing. Thus efficiency may be increased by using larger magnets only as long as iron saturation is not a

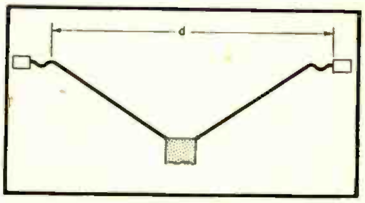


Fig. 5. Measurement of effective cone diameter d.

limiting factor. Hence the gap-energy term in the efficiency reflects the economics of speaker manufacture, and aids in comparing speakers; neither the flux density nor the total flux will permit direct comparison. The use of Alnico V in place of Alnico III is an example of this: while the cost per pound of V is greater, it has over three times the energy per pound, so that the cost per million ergs is less, offsetting even some of the mechanical problems of fastening Alnico V magnets in place. It is magnetic energy the customer pays for, not gauss or maxwells.

The space factor α can be improved by using a rectangular or ribbon shape instead of circular for the voice-coil conductor. However, if a reasonably high impedance is needed, the ribbon must be made quite thin, and then the inter-turn insulation may be a very appreciable fraction of the total thickness. For ordinary direct-radiator speakers, the space factor—which includes allowances for clearances as well as insulation and precision of wire lay (see *Fig.* 4)—may be about 20 per cent. Voice coils of edgewound ribbon sometimes reach 30 per cent by also omitting the bobbin, but one sturdy enough for use in a "woofer" should offer only a slight advantage. The theoretical advantage should be that of the square over the circle, or 27 per cent gain. The actual gain cannot be very great, for the coil-to-pole-piece clearances required in low-frequency

[*Continued on page 42*]

A Two-Tap Bass and Treble Compensated Volume Control

WILLIAM O. BROOKS*

A simplified analysis of the method of determining the constants for a loudness control which will simulate the Fletcher-Munson curves to a reasonable degree of accuracy.

Anyone who has adjusted the uncompensated volume control of an amplifier when music was being played has noted that as the control was rotated from its full volume position to its minimum, less and less bass and treble were heard as compared to the amount heard in the maximum or full-volume position. This is borne out by the Fletcher-Munson sound pressure curves appearing in engineering texts. As the curves show, it is necessary to boost the bass—and to a lesser degree, the treble—more and more as the control is lowered to make up for the hearing curve of the ear.

By adding a tap on the volume control and running the sliding arm down to this tap we have an "L" type tone compensating network as shown in *Fig.* 1. The network can be figured so as to give correct compensation for hearing losses at this one point. Now it becomes apparent that in order to have a 100 per cent perfect control, we would have to have an infinite number of taps on the control with an equal number of networks. This is impractical from a mechanical and economical standpoint.

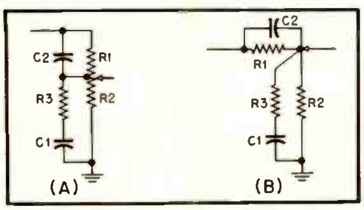


Fig. 1. Basic arrangement of components for L-pad compensation of frequency response.

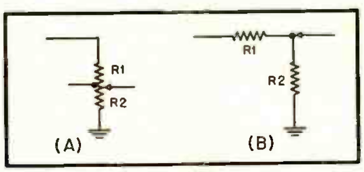


Fig. 2. Simplified equivalent of uncompensated volume control.

The next choice would be three controls back to back on the same shaft—one acting as a volume control, one as a continuously variable bass-compensation network, and the other a continuously variable treble-compensation network as described by E. E. Johnson.[1] For those in the radio manufacturing industry where cost is a great factor, a good but cheaper method might be desired.

It is possible to make two well located taps on a single control approach the desired boost requirement to a very acceptable degree. This has been done in commercial radio equipment for many years in the form of one or two tap volume controls; however, only bass compensation was obtained. On recent designs treble compensation has shown up on a single-tapped control. The development of a two-tap control with both bass and treble compensation, as proposed by the author, is to be discussed in this paper. Let us start with a single tapped volume control as shown at (A) in *Fig.* 2. If the slider is set at the tap, we have an L pad divider made up of R_1 and R_2 as shown at (B). The voltage ratio will be $R_2/(R_1+R_2)$. If $R_1 = 0.25$ meg and $R_2 = 0.25$ meg, then $\frac{0.25}{0.25+0.25} = 0.5$, or 6db attenuation of voltage. If C_1 is now connected from tap to ground as at (A) in *Fig.* 3, we would have a definite attenuation of voltage at some desired center frequency. Above this frequency, the reactance of C_1 decreases at a constant rate, attenuating the highs. Below this frequency, the reactance of C_1 increases at a constant rate, thus effectively boosting the bass (by attenuating the high frequencies). Since this bass-boost circuit should not function at the expense of losing treble, it is necessary to insert R_3 in series with C_1. At the frequency when the reactance of $C_1 = R_3$ the curve will begin to flatten out. This frequency is known as the bass turnover frequency. It is subject to change with each design engineer from a minimum of 250 to a maximum of 1000 cps. Since 800 cps has been chosen as the center frequency of the audio spectrum, a bass turnover frequency of 1000 cps will tend to raise the midrange too much, while a 250-cps turnover will not allow the bass to rise to a sufficiently high amplitude. It is thus desirable to stay within 250 and 1000 cps. It

[*Continued on page 47*]

[1] "A continuously variable loudness control," Audio Engineering, Dec. 1950.

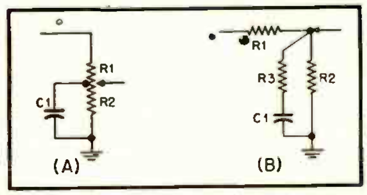


Fig. 3. Volume control with single tap, allowing for one bass turnover frequency.

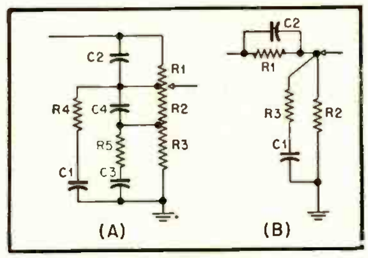


Fig. 5. Development of dual-tap control.

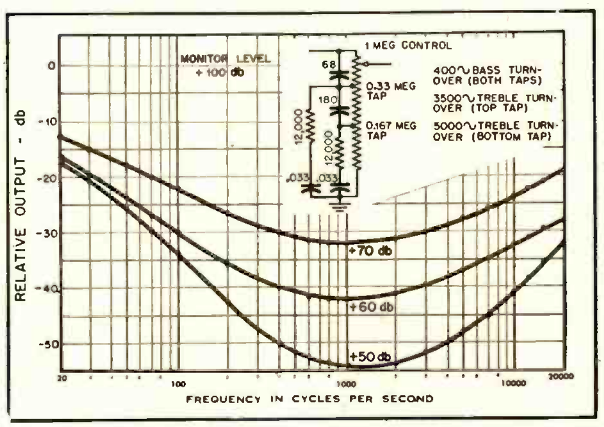


Fig. 4. Response curves for dual-tap control shown in the boxed-in schematic.

**Senior Engineer, Hoffman Radio Corp., 3761 So. Hill St., Los Angeles 7, Calif.*

Audio and the Armed Forces

Lt. GEORGE MARAKAS, USN*

The Armed Forces Radio Services combine the production and technical facilities required in a network headquarters with the processing facilities of a major record manufacturer. All illustrations are Official A.F.R.S. photographs.

IF YOU WERE TO ASK a GI overseas his favorite stateside address, next to home of course, its a better-than-even chance that he would mention 1016 North McCadden Place in Hollywood. It is from this address that a cargo of more than 6000 transcriptions originates each week, consigned to radio stations of the Armed Forces Radio Service, and destined to bring a little bit of home to American Doughboys, Sailors, Marines, and Coast Guardsmen in China, Alaska, Korea, Germany—in fact, wherever they're doing their job. To these fighters for democracy, transcriptions mean information, education, and entertainment from back home.

The Armed Forces Radio Service is unique in the fact that it is a unified command dating from the early days of 1942—long before the major services teamed up. Known colloquially as "The Voice of Information and Education," AFRS is a completely merged Army-Navy-Air Force operation, functioning under the Armed Forces Information and Education Division, Office of the Secretary of Defense. Its Commanding Officer is Col. William M. Wright, Jr., AGC, U.S. Army, while Major Clifford Frink, USA, is Executive Officer-Chief of Operations.

In its overseas transcription activities, AFRS writes and produces approximately 16 hours of programs weekly, including the famous "Command Performance." In addition, more than 50 hours of programs are taken from the major networks and de-commercialized, and approximately 60 musical numbers are recorded for the AFRS basic music library. At present the Service is shipping early 40,000 16-in. 33 1/3 r.p.m. Vinylite recordings monthly. All shipments are made by high-priority air and originate in Los Angeles, where most of the recording is done and where all transcriptions are processed.

Just as AFRS steps beyond the boundaries of service and rank in the selection of its personnel, so does it operate without restriction in the choice of equipment to perform the various functions of recording and broadcasting. A visit to the Remote Recording Section will disclose a veritable hodgepodge of the best known trade marks in the audio industry. A recent remote recording job, for example, made use of two Stancil-Hoffman type R4 tape recorders, two Western Electric 22-D portable mixer-amplifiers, three RCA 44BX microphones, and one Altec Lansing 21B condenser microphone. Each of these items was chosen by Vernon McKenny, Chief of the Section, because of its unique ability to perform some specific function. It can be seen from this that AFRS is operating virtually without equipment limitation in its efforts to maintain highest audio quality in all of its programs.

A visit to the AFRS headquarters in Hollywood discloses one of the country's best-equipped sound studios. Under a single roof are five studios, twelve soundproof rooms for auditioning, a recording equipment room, facilities for editing tape, a thoroughly equipped shop for repair and maintenace, and a master control room for shortwave broadcasting.

Following the practice established by commercial broadcasters, AFRS records a number of its programs on magnetic tape rather than on acetate discs to facilitate program editing and assembly. This is of special importance where network programs are to be de-commercialized. The studios are equipped with two Ampex type 200 recorders, ten Stancil-Hoffman type R4 recorders, and three Gates control consoles. To maintain quality in keeping with highest commercial standards, the bulk of tape recording is handled at 15 in. per second. After being recorded on tape, programs are dubbed on acetate, processed, then pressed on Vinylite for shipment to AFRS stations throughout the world.

Technician checks grooves on transcription being cut on Scully lathe in Recording Section.

Programming

Supervision and programming of AFRS is a task comparable to that of operating a large commercial network. The AFRS "network" consists of sixty stations ranging in power from 25 watts to 200 kw. It can be seen from this that procurement and installation alone are prodigious chores. In addition, maintenance must be considered. Add to this the job of providing each of these stations with 63 hours of programming weekly and producing 13 hours of programming daily for shortwave distribution, and the full magnitude of the AFRS radio operation becomes apparent.

Shortwave operations are maintained from both Los Angeles and New York over eleven transmitters beamed to all parts of the world. West Coast transmission totals 1777 hours monthly over seven of the stations, and East Coast transmission totals 450 hours over the remaining four. Program schedules from Los Angeles begin at 5:15 p.m. (PST) and end at 6:30 a.m. Newscasts are aired on the hour, compiled from the three major news services, State Department and Office of the Secretary of Defense releases, and other recognized news sources. AFRS also shortwaves prominent baseball and football games, as well as outstanding boxing matches.

Navy Radioman 2c David Cleveland shown discussing disc on turntable in recording section of AFRS with Ralph Zerbe.

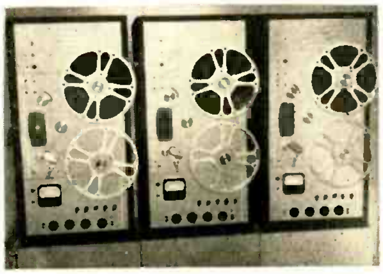
** Liaison Officer, Armed Forces Radio Service, Hollywood, Calif.*

AFRS, while primarily concerned with informing and entertaining American forces overseas, is acutely conscious of its important role as the voice reaching behind the Iron Curtain and into those areas dominated or influenced by the word from Moscow. Ninety million listeners in all parts of the world turn to AFRS, as well as to the State Department's "Voice of America" programs, for news of the USA. And although it is not true that AFRS is the official voice of the U.S. Government, these millions accept what they hear from AFRS as an accurate, undoctored reporting of events at home and abroad. Through AFRS's informational and educational programs, they learn the reasons underlying our passions for the American way of life.

Top right. Private James Ross, AFRS technician, checks operation of Stancil-Hoffman Minitape recorder before sending it out on a remote.

Bottom right. One of three Gates speech input consoles used in recording the hundreds of weekly programs.

Bottom. Group of three Stancil-Hoffman tape recording machines used in the Shortwave department. Mounted on dollies, these machines may be moved readily from studio to studio.



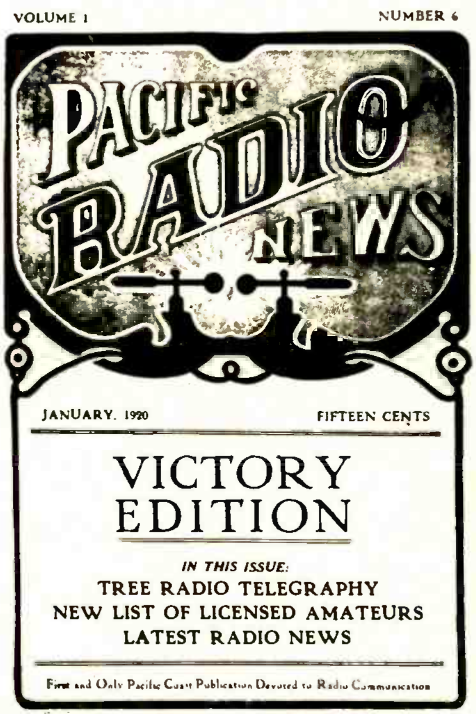
WHODATHUNKIT—

ÂE Was Born in California

WHEN THE IDEA for bringing out a special Pacific Coast issue first took hold in the Æ office, the mental giants therein immediately applied the full weight of their monumental intellect to the task. The creative ability inherent in this notable group is sharply evidenced by the originality and design-for-action in their first move—an editorial conference was called. One member of the staff, a displaced Californian naturally—came up with the reasoning that all good things originate west of Arizona—so that by following the obvious we could easily conclude that Æ was California born. Hot feature item for a special West Coast issue.

The comptroller—opportunist, he—seeing a chance to throw his weight around, and forgetting momentarily the fate that usually overtakes bookkeepers who venture opinions on editorial matters, said, in simple words, no soap. Then—realist, he— sensing that his neck was out a mile, and doing a slow burn with the dawning realization that he was a downtrodden minority of one, he modified the monolithic quality of his impetuous outburst to say he'd go along with the idea, providing that the California birth of Æ could be proved. The editorial group, not entirely unmindful of expense accounts and salary checks, acceded with becoming grace.

At this stage of the discussion the advertising staff entered the act. Between ill-stifled yawns they considerately offered to place their entire research facilities—three dog-eared copies of *Western Stories*—at the editorial staff's disposal for proving or disproving the legend that Æ was a child of California. Kipling notwithstanding, the twain met—and the editorial group took the advertising boys up on their offer.


VOLUME I NUMBER 6

PACIFIC RADIO NEWS

JANUARY, 1920 FIFTEEN CENTS

VICTORY EDITION

IN THIS ISSUE:

TREE RADIO TELEGRAPHY

NEW LIST OF LICENSED AMATEURS

LATEST RADIO NEWS

First and Only Pacific Coast Publication Devoted to Radio Communication

Earliest existing copy of Pacific Radio News, antecedent of Audio Engineering, from the archives of the New York Public Library.

Backward, Turn Backward

Research, to an advertising man, means digging out reams of facts and figures designed to prove this or that point about markets, circulation penetration, etc. To an editor seeking to verify early events, however, research has a different meaning.

It offers a chance to lose one's self in the delicious nostalgia of the past—to partake once more of youth and its fancies—and, in the case at hand, to re-live those days when DX was anything further away than next door, and the average "old-timer" shared concern over the efficiency of his rig with anxiety about the date on which his voice would change.

Retrospect

Let's turn back the pages of radio history to the romantic and thrilling year 1917. DeForest, Cunningham, Moorhead and other notables in the art of placing a grid, a plate, and a filament into a piece of glass tubing known as the Audion, Audiotron, and other analogous trade names, were vieing with each other to capture supremacy in the great new field which was ripe for the harvest of their earlier endeavors.

The magic lamp of the "wireless" days was destined to revolutionize the infant, industry of communication. Manufacturers of such gadgets as variometers, tickler coils, grid

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Constant-Resistance Dividing Networks

BOB HUGH SMITH*

A presentation of the design parameters for dividing networks which use two coils of equal inductance with two identical capacitors.

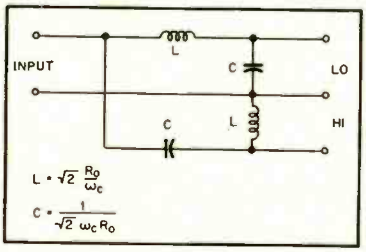

Fig. 1. Schematic of parallel configuration of constant-resistance dividing network.

There are two principal types of dividing networks in extensive use—the constant-resistance network and the "*m*" derived half section network, and the first type has several minor practical advantages over the second. These are: (1) It requires about 15 per cent less inductance in the low-pass section, and hence, for a given wire size the insertion loss is about 7½ per cent less. (2) It requires about 15 per cent less capacitance than the second. (3) When feeding from a zero impedance source each section of the first type is down 3 db, while for the second type each section is down 4 db, thus the second type results in a one decibel dip at crossover. (4) The input impedance of the first type is exactly equal to the characteristic impedance of the filter and contains no reactive component, providing the network is terminated in pure resistances. The last two points are of more academic than practical significance.

* *University of California, Berkeley, Calif.*

The design procedure for the constant-resistance network is really quite simple.

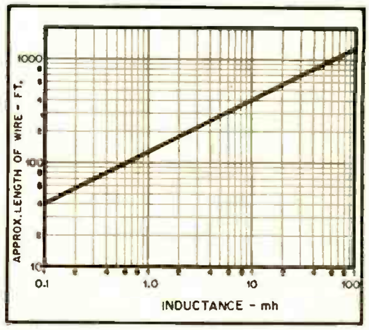

Fig. 3. Chart showing length of wire for given inductance. Example: If the required inductance is 5 mh, approximately 290 feet of wire will be needed for the coil.

The values of inductance and capacitance are read from the chart, *Fig.* 2, once the characteristic impedance of the filter and cross-over frequency have been selected. Next, the wire size is chosen from the following considerations: (1) If the wire size is too small, the insertion loss of the low-pass section will be excessive, and (2) if too large a wire size is chosen, the inductances become inconveniently bulky. A satisfactory compromise may be made by choosing a wire size which will result in a coil resistance equal to 10 per cent of the characteristic impedance of the filter.This produces about one decibel loss through the low-pass section and is undetectable on complex signals. The approximate length of wire needed may be obtained from *Fig.* 3, and the wire size may be selected from *Fig.* 4.

Next the coil is wound to approximate size using the length of wire already determined, and then turns are either removed or added as required to provide the exact inductance. If an impedance bridge is not available, the scheme shown in *Fig.* 5 may be used. When the inductance is of the correct value, the voltmeter indicates the null to occur at the crossover frequency. If the null is below the crossover frequency, the inductance is too high and turns must be removed; if above, the inductance is too low and turns must be added. This method has the advantage, over the impedance bridge method, that it automatically compensates for error in the capacitance. Thus, it is not necessary to have precision capacitors, but they should be of either

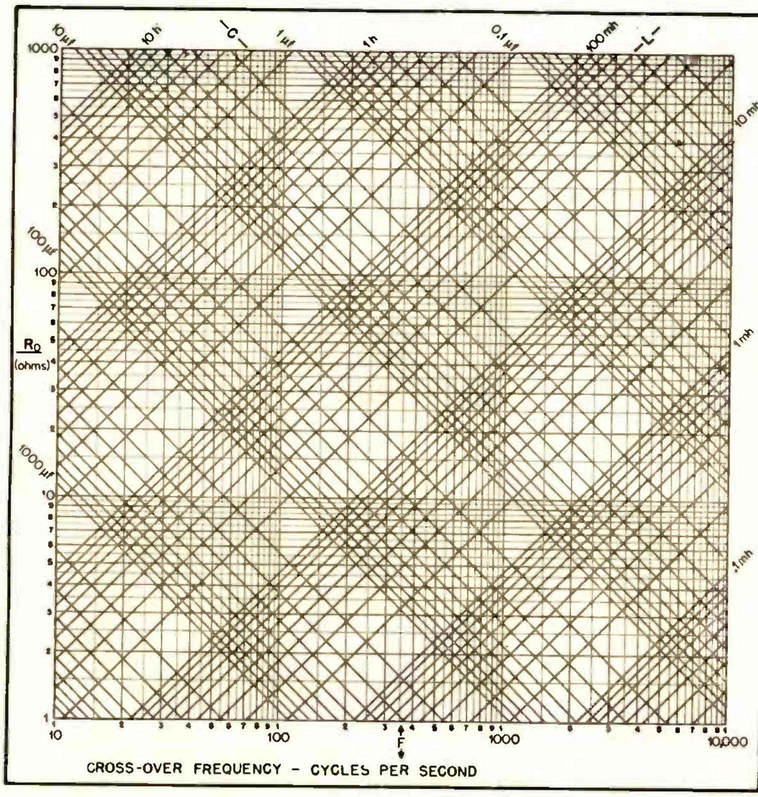

Fig. 2. Chart for determining constants for network. Example: Suppose the characteristic impedance is 11.5 ohms and the desired crossover frequency is 500 cps, then the inductance should be 5.0 mf and the capacitance should be 20 μf.

the oil or paper type and should be non-inductive.

Design of Network

The following example may clarify the procedure of producing a dividing network. Suppose it is desired to design a crossover network for a 16-ohm two-way speaker system. One might select 1,000 cps as the crossover frequency and 16 ohms as the characteristic impedance. *Figure* 2 indicates that the inductance should be 3.5 mh and the capacitance should be 7.0 µf. Referring to *Fig.* 3, it is seen that a coil having an inductance of 3.5 mh will require about 240 feet of wire. *Figure* 4 indicates that the resistance of the coil will be about 1.6 ohms if #18 wire is used. Since it is easier to remove turns from the coil than to add more to it, about 275 feet of wire is measured out and wound into a coil. The process is then repeated, since two such coils are required. Two 7.0 µf capacitors are connected in the circuit of *Fig.* 5, using a 15-ohm resistor for R_0. Suppose it is found that the null occurs at 800 cps; then turns are removed until the null occurs at 1,000 cps. The coil is taped and checked again in the circuit of *Fig.* 5 to be sure that the tape has not pressed the wires closer together and thus increased the inductance. Next the coils and capacitors are mounted and wired, completing the network.

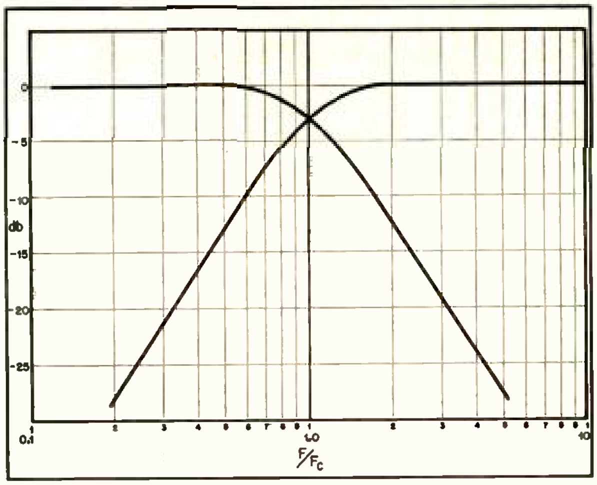

Fig. 6. Frequency response of constant resistance network.

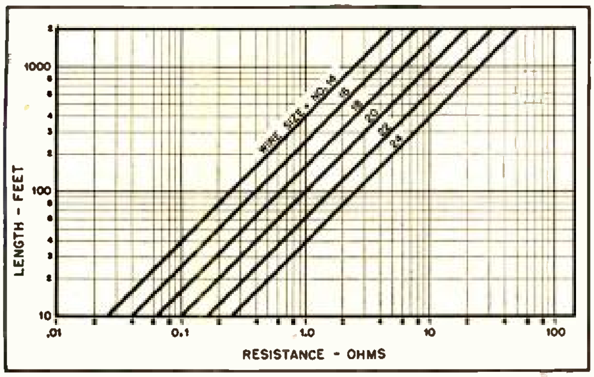

Fig. 4. Chart showing length of wire vs. resistance for various gauges. Example: A coil resistance which is 10 per cent of the characteristic impedance results in coils of practical size. Since the impedance is 11.5 ohms and the approximate length of wire is 290 ft., #16 wire should be used.

The expression for the transmission of the low-pass section is:

$$K = 20 \log \frac{\frac{f_c}{f}}{\sqrt{\left(\frac{f}{f_c} - \frac{f_c}{f}\right)^2 + 2}}$$

and the expression for the gain of the high-pass section is:

$$K = 20 \log \frac{\frac{f}{f_c}}{\sqrt{\left(\frac{f}{f_c} - \frac{f_c}{f}\right)^2 + 2}}.$$

These expressions are plotted in *Fig.* 6.

It is evident that the slope of the curve in each stop band is 12 db per octave.

The effect of the coil resistance in the low-pass section is to provide almost uniform attenuation throughout the pass band but to have little effect in the stop band. The effect of the coil resistance in the high-pass filter is negligible in the pass band and also in the stop band down to the frequency for which the coil reactance becomes equal to the coil resistance. Below this frequency the slope becomes asymptotic to 6 db per octave. Thus, for the case in which the coil resistance is 10 per cent of the characteristic impedance of the filter, the high-pass section drops 12 db per octave from crossover down to 7 per cent of the crossover frequency, and from then on is asymptotic to 6 db per octave. Actually, this is hardly significant for a practical network since at 7 per cent of crossover the attenuation is already 46 db.

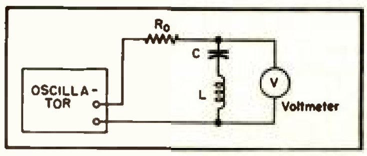

Fig. 5. Equipment set-up used to adjust inductance. Turns are added or removed to obtain a null indication on the voltmeter at the crossover frequency.

Is Your Ear Tin or Golden? Step Right Up and Get Your Answer

Announcement of the 1951 Audio Fair, scheduled for November 1, 2, and 3, in Manhattan's famous Hotel New Yorker, has already started the ingenuity of many exhibitors working at top speed.

Lafayette Radio, for example, has cooking a plan to give every visitor to its display a "Golden Ear" test to determine the frequency range of his hearing. According to Irving Frisch, Lafayette advertising manager, the idea is being developed in the form of a "Golden Ear" contest with prizes posted for the winners who prove their "ear superiority." To ensure absolute fairness in the contest, all measurements will be made with an Audiometer.

The feature is expected to create a high degree of interest among those sharp-eared high-fidelity enthusiasts who are constantly boasting about their superior sense of hearing. Each contestant will be given a token "Golden Ear" as evidence of his having participated in the contest.

This test should provide some enlightening comparisons between the hearing characteristics of persons with training in the field of audio, and those of the population as a whole.

Note: There is some question as to whether the Lafayette exhibit should be illuminated with red lights to minimize the visibility of red faces. Suggestions are in order.

Headache Saver

Many of the headaches usually associated with the solution of complex mathematical problems are eliminated by the latest "thinking machine" developed by Friden Calculating Machine Co., San Francisco, Calif.

Capable of extracting the square root of 10-digit numbers in nine seconds, without use of tables of any kind, the machine is entirely automatic—extracts square roots and automatically points off the correct decimal in the root through entry of the number and touch of but one key.

The machine is expected to ease greatly many of the mathematical aspects of engineering and electronic design in many industries.

A New Approach to Loudspeaker Damping

WARNER CLEMENTS*

Modestly styled by the author as "the hottest thing in audio," positive feedback added to a negative-feedback amplifier is shown to reduce output impedance to zero or below, achieving a damping factor of infinity.

IS APPRECIABLY BETTER LOUDSPEAKER damping really attained by increasing the damping ratio of amplifiers higher and higher? The answer, sadly enough, is "No!" Some lowering of the otherwise very high impedance of a pentode amplifier is desirable, and there are other concurrent benefits obtained from the use of the same negative feedback which reduces apparent output impedance. However, it appears that there is a widespread misunderstanding of the principles involved.

In this article, the author will endeavor to show that we have been deluding ourselves to a great extent about the merits of a high damping ratio, and that there is a way to achieve high damping other than by the application of more and more negative feedback. By the method to be described herein, it is possible to take the damping ratio right up to infinity and beyond. In fact, it is in the region well beyond infinite damping ratio that an amplifier must operate in order to provide theoretically perfect speaker diaphragm control. By the addition of only one inexpensive part, your own amplifier may be transformed to operate either at infinite damping ratio, or at a condition of near-perfect electrical damping.

Let us examine the principles involved in amplifier-damping of loudspeakers. Take an ohmmeter or bridge to the nearest speaker and measure the d.c. resistance of the voice coil. Ten ohms is a representative value for a 16-ohm speaker. Now measure the resistance of 16-ohm secondary of an output transformer. Another ohm or so. Now add the 11 ohms thus obtained to the tiny apparent output impedance—0.6 ohms, maybe?—you have obtained in your amplifier, perhaps with considerable expense and circuit complexity. Doesn't look so good, does it? For instance, if you have been successful in doubling your damping ratio from 4 to 8—thus cutting output impedance from 4 ohms to 2 ohms—you have, for your pains, cut *total* effective generator resistance only from 15 ohms to 13 ohms. Actually you haven't even done that well because in either case additional damping has been contributed by the mechanical resistance of the cone suspension.

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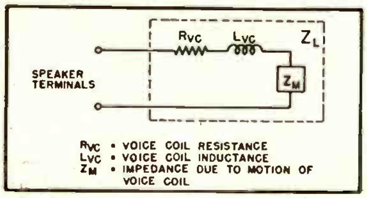


Fig. 1. Electrical equivalent of loudspeaker load.

It is justifiable to take voice-coil resistance, normally considered as part of the load, and add it to the source, for two reasons. First, as in the case of motor rotor windings, resistance and self-inductance of the voice-coil are necessary evils and contribute nothing to performance. Second, the voice-coil parameters are effectively in series with, not shunted across, the "business" part of the load. If one measures the electrical impedance of a speaker at a given frequency and then impedes the motion of the voice-coil, the impedance is seen to go *down*, being lowest with the voice-coil completely blocked. At this point the voice-coil shows the same impedance that it would if completely removed from the speaker except that its inductance is affected somewhat by the metal surrounding the gap. Conversely, if a weightless voice-coil could be suspended in the gap so that it could move freely without encountering stiffness or friction, the electrical impedance of the speaker would be infinity. The total electrical impedance of the circuit will always be greater than that of the voice-coil alone unless the speaker is inoperative. Clearly, then, the equivalent circuit is the series one of *Fig*. 1.

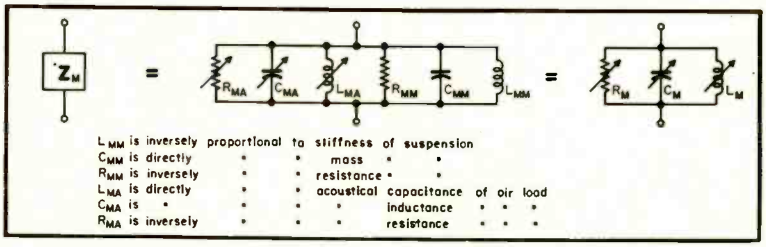


Fig. 2. Equivalent circuit for motional impedance of loudspeaker.

Transient Response

Good transient performance is often equated to the reduction of overshoot or "ringing." There is more to it than that, but the yardstick thus suggested is a useful one for underdamped systems. Certainly ringing contributes largely to the characteristic "loudspeakerish" sound from which all direct-radiator speakers seem to suffer. To induce ringing in any underdamped system it is only necessary that an impulse be introduced which contains components higher in frequency than the resonant frequency of the system. The familiar "mouth-harp" is an example of such a system. The pitch of the vibrating part of the mouth-harp does not vary. Yet when placed in the performer's mouth, tunes are produced by tuning the cavity (formed by the mouth) which the initial transient starts ringing. Circuit switching can produce widely differing sounds in different speakers. This writer once arranged a half-dozen speakers of various sizes and makes so that he could play a simple tune with the thumps created by closing toggle switches connected between the respective voice-coils and a dry-cell. Fine tuning was accomplished by changing baffling. In no case was the speaker installation any different from one which might have been intended for sound reproduction. This experiment suggests one reason why two-way systems are likely to *sound* good to the layman. If the pitch of the click of the high-frequency speaker bears an inharmonic relation to the pitch of the thump of the low-frequency speaker, a disagreeable noise is produced on every transient—which is to say on at least every note of music and syllable of voice reproduced.

It is clear that damping is a desirable objective, but it is also clear that beyond a certain point inverse feedback does virtually nothing toward attaining this objective. Actual tests with pulses

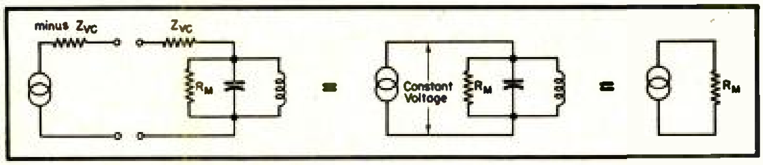


Fig. 4. Method of using negative impedance to achieve perfect damping.

and interrupted wave-trains show that a triode output *without* feedback represents about the point of vanishing return. A lower output impedance than that thus represented is of very little importance in restraining the ringing of a typical diaphragm assembly. Direct-radiator speakers will ring at their resonant frequency even if fed by a generator of zero internal impedance. Just how badly they will ring under that circumstance will depend on the amount of flux in the gap and upon the amount of damping inherent in the diaphragm suspension. The role of mechanical damping, which takes place mostly in the outer roll, is illustrated in *Fig.* 2. The power that goes into R_{ma}, shown in the middle circuit of that figure, is the power that counts—the power that represents acoustic output. The shunting reactances are necessary evils. Any power lost in

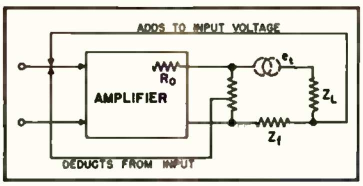


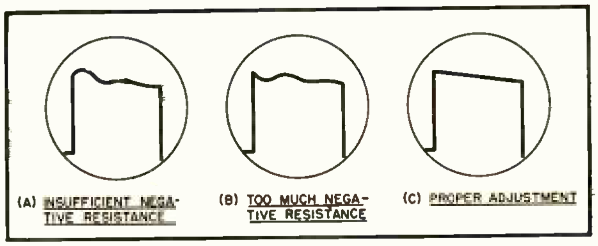
Fig. 3. Arrangement for applying voltage-proportional negative feedback simultaneously with current-proportional positive feedback.

R_{mm}, the edge damping, is power wasted from the standpoint of efficiency. Nevertheless it can be seen that a low value of R_{mm} will do much to minimize the effects of the shunting reactances.

It is impossible to get all of the way to zero apparent output impedance by means of negative feedback. Even assuming that it were possible, the speaker would still not be cured of ringing, because of the intervening impedance of the voice-coil. High flux-density in the gap can reduce the effect of the voice coil, but cannot eliminate it. But suppose that it were possible to make the amplifier exhibit *negative* impedance as viewed from the output terminals. The negative impedance would subtract from the voice-coil impedance. If the two just matched, the effect of the latter would have been eliminated entirely. This is no idle dream, but is, in fact, quite easy of attainment. The means is *positive* feedback. Readers will recall that constant-*voltage* inverse feedback from an output causes apparent output impedance to decline, while constant-*current* feedback causes it to rise. With *positive* feedback the opposite holds—voltage-proportional feedback causes the output impedance to rise and current-proportional feedback lowers it. Furthermore, current-proportional positive feedback will take the output impedance right down past zero and into the negative region if desired. The ideal setup, then, is to use voltage proportional negative feedback *plus* current-proportional positive feedback.

Direct and inverse feedback can thus be used simultaneously without cancelling each other out, although cancellation occurs insofar as the distortion-reducing and frequency-response-smoothing effects of inverse feedback are concerned. But with regard to reducing apparent output impedance, the effects of the inverse and direct feedback are additive. Referring to the block diagram of *Fig.* 3, it will be seen that any voltage developed only in the load causes the input voltage to be modified in the *same phase* by the resultant out-of-phase voltages in the two respective feedback circuits. The operation of the circuit is as follows: starting with negative feedback alone, the apparent output impedance goes down as positive feedback is applied. It requires only a slight amount of positive feedback to bring it to zero. Damping-ratio at this point is, of course, infinity. As more positive feedback is added, the apparent output impedance becomes negative and starts to "erase" the series part of the speaker load impedance. At some point the voice-coil impedance is exactly matched by the negative impedance of the amplifier and theoretically perfect damping is achieved, as illustrated in *Fig.* 4. If positive feedback is increased considerably beyond this point, oscillation will eventually occur. In actual installations it may take place before the midband gain gets up to what it would be with no feedback at all. This is due to the difficulty of securing an exact phase match between the load impedance and the negative impedance. This last consideration is of only academic interest, however. There will always be an ample safety margin before oscillation, even if the inductance of the voice-coil is ignored and the amplifier is made to exhibit a pure negative resistance.

Fig. 5. Waveforms across output of negative-impedance amplifier with 30-cps square-wave input. Speaker resonant frequency = 120 cps.



"Perfect" Damping

Thus perfect damping is arrived at long before the benefits of the negative feedback have been cancelled out. The exact amount of positive feedback necessary varies with the installation. With a typical high-efficiency speaker and a fairly high amount of negative feedback, the ideal amount of positive feedback to be added will be found to be that amount which just about doubles the gain. Circuit algebra shows that this means the effective negative feedback will have been cut in half. In other words, the principle is applicable to any circuit from which you can get roughly 6 db more of feedback than you really need from a standpoint of distortion. This will include most high-quality amplifiers and practically *all* triode amplifiers. *Figure* 5, drawn from actual 'scope traces, shows that the combined feedback principle works out as neatly in practice as it does in theory. It also illustrates the quickest and easiest way to adjust the amount of positive feedback applied when one of the circuits to be described is added to an amplifier. Note that if too much positive feedback is used, ringing resumes, but is now reversed in phase.

Figure 6 shows a circuit that has been recommended for applying positive feedback to the popular Williamson amplifier. It would seem that this circuit has several drawbacks. Since it applies feedback before even-order harmonics have been bucked out, it increases the magnitude of those harmonics and lessens the likelihood that they will be perfectly cancelled. Since it introduces constant-current negative feedback, it defeats its own purpose up to a point and requires high output from the driver tubes. Finally, since ordinary ganged potentiometers run well above 10 per cent "tracking error," the signal balance of the output stage is likely to be rather bad.

The circuit of *Fig.* 7 was devised by the writer in 1949 and is believed to be far superior to that of *Fig.* 6. It is easy to apply to existing amplifiers using any of the popular circuits and the single adjustment has no effect on push-pull balance. It may be seen that a split-load type of phase inversion is applied to the positive feedback, permitting it to be returned to the same point at which the negative feedback is applied. This keeps phase shift identical in the amplifier part of both positive and negative feedback loops. If desired, the phase-inversion feature can be left out and the positive feedback applied to grid of same stage, as shown in *Fig.* 8. This circuit is satisfactory where the damping is desired only at the lower frequencies. The stray and interelectrode capacitance to ground from the top of the grid resistor prevents the higher frequencies from

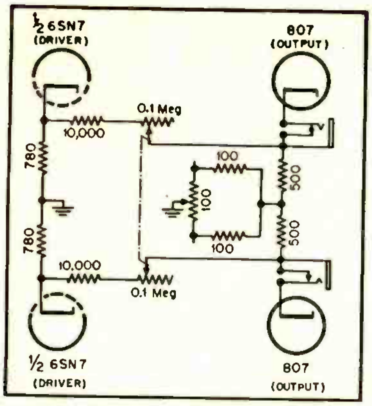


Fig. 6. One method of obtaining current-proportional positive feedback.

being fed back, even without the inclusion of R and C. R_g may be a volume control if desired.

Negative Inductance

An interesting refinement on the negative-output-resistance amplifier is to make it display negative *inductance* as well, thereby cancelling out the inductance of the voice-coil and improving high-frequency response and stability. This can be done by including an inductance in series with the positive-feedback rheostat, as shown dotted in *Fig. 7*. The optimum value for this inductance is given by the formula:

$$L_f = \frac{L_{vc}}{A' - 1}$$

Where A' is gain of part of amplifier enclosed by feedback loop, with *negative feedback only* and *unloaded*. To apply this formula, you need to know L_{vc}, the blocked voice-coil inductance of your speaker (or speakers). Unfortunately, I know of no way to block the voice-coil of a speaker securely without injuring it, so even if a means of measuring inductance is available it will do no good unless the speaker has an electromagnetic field. In that case the effect of blocking can be achieved by simply leaving off the field current.

If you are prepared to tackle it on a cut-and-try basis, you can assume that the blocked voice-coil inductance of a 16-ohm speaker is about 1 millihenry and start from there. Such a coil should be toroidally wound of #16 wire on an air core. Connect the coil into the circuit and add or remove turns until a value is found that permits R_f to be advanced the furthest (greatest resistance) without oscillation taking place. Actually there is nothing critical about this inductance. If it permits R_f to be turned at all further than it could be without the coil in the circuit, it will improve the operation of the circuit. After turns on coil are adjusted, R_f can then be adjusted to its final setting by means of square waves applied to amplifier and 'scope across speaker terminals, as in *Fig. 5*. It is also possible to do a fairly good job by ear with program material consisting of male speaking voice by adjusting for the least boominess. When you are through, you will have an outfit that provides the cleanest reproduction you have ever heard from direct-radiator speakers. This is, of course, provided that other things are right. Bear in mind that no amount of damping in one circuit will dampen another resonant circuit that is but loosely coupled to it. For instance, if a room resonance is present—it is almost impossible to get away from it in small rooms—no amount of speaker damping will obviate it. Look out also for acoustic feedback to turntable or microphonic tubes.

Limitations

Now for the bad news. A generator of low or negative internal resistance is in some regards not an ideal device with which to drive a loudspeaker. Some writers, describing the performance of amplifiers of high damping ratio, have spoken of the "apparent" lack of lows and have gone on to imply that the ear of the listener needs retraining; that the lows are there all right, just less conspicuous because of lack of resonance. Actually the lows *are* attenuated more and more as damping is applied. With the circuits of *Figs.* 6 and 7 the loss of lows will be very pronounced with some speaker arrangements, though negligible with others, as will be explained.

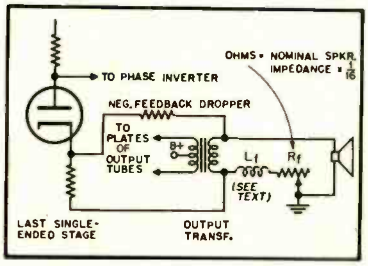


Fig. 7. Preferred method of applying positive feedback.

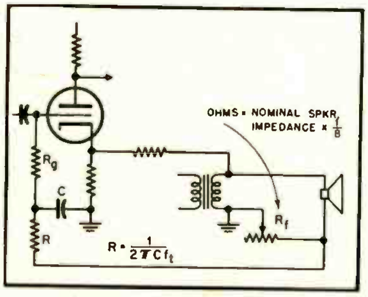


Fig. 8. Variation of Fig. 7 that produces low-frequency boost but damps speaker only at one low frequency, which may be set to be resonant frequency of the speaker.

It has to do with variation, with frequency, of the air loading on the speaker cone. In (B) of *Fig. 2*, the resistance and reactance contributed to the equivalent electrical circuit of the motional impedance by the mass and mounting of the voice-coil and cone have been depicted as fixed. On the other hand, resistance and reactances arising from air loading have been depicted as variable. In general, the circuit values due to definable *mechanical* parameters are relatively fixed. Those due to *acoustic* values may vary with frequency, even the equivalent inductance and capacitance. Over a wide range of frequencies where the speaker (if considered as a perfect piston) gets a big enough "bite" of air, the loading due to air is almost purely resistive and is constant with frequency. For the equivalent circuit within this range C_{ma} and L_{ma} could be left completely out, and R_{ma} could be shown as fixed. However, if the applied frequency is lowered far enough, the "bite" will cease to be big enough at some frequency that depends on the size of the cone and the resistive loading will start to change. Whether it may be said to go "up" or "down" depends upon the acoustical-electrical analogy one uses (e.g. force-current or force-voltage). At any rate, the net effect is that the resistance "seen" by the electric circuit, R_m in *Figs.* 2 and 4, goes *up* with decreasing frequency.

Figure 9 shows the variation of R_m with frequency on the assumption that R_m is entirely due to the air loading on the cone. (In different speakers, the contribution of R_{mm} will flatten the actual rise of the curve to various degrees.) The "turnover" frequency, f_t, will vary from about 520 cps for a 15-in. speaker to about 1,660 cps for a 5-in. speaker. It can be seen that loudspeaker response will drop off about 6 db per octave below this frequency if an effective constant voltage is applied across Z_m (since the power output will then be inversely proportional to R_m). But the ordinary amplifier, with considerable output resistance adding its effect to that of the voice-coil, will drive a speaker in such a manner that there will not, in general, be such a low-frequency attenuation. The reason is that the reactive part of the motional impedance, as at (C) of *Fig. 2* "looks", above resonance, like a capacitance shunting the load. Together with output resistance and voice-coil resistance it forms a power-eating tone control circuit that flattens out the response be-

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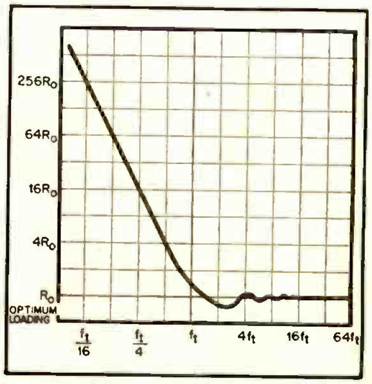

Fig. 9. Variation with frequency of resistive component of air loading on diaphragm, using the force-current analogy.

Acoustical Balance in Recording

EDDISON von OTTENFELD, Mus. D.*

A musician expresses his viewpoint on the old and continuing controversy between engineers and musical directors—but with an understanding of the problems of both.

Ever since the turn of the century—when the introduction of mechanical devices for the recording of sound captured in evolutionary degrees the tremendous musical contribution of the world's greatest composers—there has been a division of opinion as to what constitutes acoustical balance in recording. On the one hand we have the questionable opinion of music directors and on the other the adamant viewpoint of the recording engineer. Actually, it is a battle between the music director trying to obtain the inspiration he hears in the music and the recording engineer working with his equipment to keep what he records in balance. Neither of these viewpoints is necessarily correct. There has been much progress in engineering, but a lot more can be added to the art of recording.

The interest in acoustical balance has been gradual because the knowledge of the science of acoustics has been incomplete. All evolution, as we know of it, is a gradual process of unfoldment and better understanding. Engineers in the recording industry have spent countless hours in improving their techniques; those who are best informed spend just as many hours in understanding music. A progressive engineer knows his music as well as his profession. This is evident in all recording studios of repute.

Invaluable research has contributed to the development of the telephone, radio, radar, recording, and motion picture sound, as well as in all forms of acoustical reproduction. Many times progress has been made through chance discoveries and through a genuine cooperation among engineering contributors to perfect their scientific medium. Unfortunately, there is no scientific evaluation of inspiration or the creative process of the individuals who have given their lives to compose the world's music. If there were such a thing as a yard stick with a scientific approach, creative music could be analyzed. Because of this, the engineer must take a different approach to the subject and put as much study and application to individual musical selections as he does in maintaining and perfecting his equipment.

Conflicts

I am always amused when a serious conflict ensues between the music director and the engineer. Each assumes that he knows his subject better than the other fellow, and the atmosphere becomes charged with slightly veiled insults. The conflict begins, of course, with a lack of knowledge by the parties concerned. However, the practice of riding gain and knocking the top off of climactic passages in music is not the answer to proper acoustical balance. It might, in some instances, smooth over a rough situation, but the problem as a whole lies in the scoring and use of instruments. There is no such thing as a perfect music score that can be recorded with the same results when used for radio, commercial recordings, motion-pictures, or choral work. These separate techniques are well established in themselves, and the engineer is obligated to know how each medium is handled. Without this knowledge, nothing but a questionable recording result is attained.

The phenomena of sound is particularly satisfying as a branch of physics, but sound in a tonal sense is not necessarily measured accurately. Tonality is often unpredictable. What is true with reed instruments is not necessarily true with brass instruments, especially where the many types of mutes are concerned. The same is true with the various stringed instruments—even individual instruments of the same type—although they may be playing the same musical passage. With human voices we have the greatest challenge.

The engineer must do more research of his own. Much has been accomplished with reflection and absorption of sound in the recording studio, but it is not enough. The real problem is in interpretation of the music, and this demands a full working accord between engineer and music director. The engineer should be able to analyze the musical score to determine if it is acoustically correct for recording. If perfection is the goal, the engineer and music director can discuss their problem intelligently and iron out their difficulties before the recording is attempted.

In all of our work, we check the repertoire thoroughly before we attempt a recording. We know the problems involved and we are prepared to meet them. Ironically, there is no problem that cannot be met when musical knowledge and scientific engineering get together. The inspiring end result is a contribution to our culture, for through recording, countless thousands of listeners are able to audit music which they normally have no opportunity to hear.

Arrangements

In general, concert arrangements in music do not necessarily adapt themselves to radio, phonograph recording, or motion pictures. The problem lies in the score and the use of instruments—mainly on how they are used. Much of our work is in *a cappella* recording. As a result, our first approach to this medium is the analysis of the physical mechanism which produces speech as a sound-producing vibrator in resonance chambers for acoustic waves. We know, for example, that during speech these waves are changing constantly. This is basically true with instruments. The only manner in which proper diction in singing has been attained is to get the chorus to think and act as a unit. The simplest way to overcome diction problems is to agree on the emphasis of the vowel itself. When this is accomplished, the end results in soft and loud passages are the same.

When the engineer understands that the bass, tenor, baritone, alto, or soprano sections are subject to tonal variations, he is usually able to correct problems of tonel and diction by having each section sing as a group, alone, and with the director monitoring the results. A director invariably is impressed with these peculiarities in tonal variations between individuals as well as groups. On-the-spot corrections can then be made or a different scoring applied to the problem.

The engineer should understand the relative intensity of vowels when sung by different sections of the chorus. The intensity of bass will frequently overshadow the soprano, for example. If the soprano section is singing in consecutive thirds, it frequently causes "shattering," both in tone and diction. Inversion of tones then should be applied to overcome the problem if the singers themselves are unable to control their tones. No juggling of equipment will iron out this problem.

The engineer is in an excellent position to determine what is wrong with a score if he knows why a music interval overlaps, as in the case of consecutive thirds. The same is true where overlapping of intensity occurs in each section of the chorus. If he can explain the physics of sound to music directors they are not only impressed but grateful for his knowledge and suggestions.

Choir Recordings

Some of the choirs which we have recorded have produced what we consider perfectly balanced recordings. St. Olaf Choir of Northfield, Minnesota, is one of these. It is under the direction of Olaf Christiansen. Little need be said about the St. Olaf Choir, so well known because of its concert tours and its radio broadcasts. Many observers feel that the

[*Continued on page 58*]

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* *President, Vonna Records Inc., Hollywood, California.*

An AES Paper
Presented
October 26, 1950

Toward a More Realistic Audio

ROSS H. SNYDER*

A complete, frank discussion of the trend in equipment development which is necessary to provide the discriminating listener with optimum reproduction in the home, if the consumers' demand is to guide the engineers.

THIS IS, FIRST, a report on the attitudes Consumers' Research has found commonest among those interested in high-fidelity in the home. CR receives more inquiries on this subject than on any other except automobiles, so we believe we are dealing by no means with an insignificant minority. Common factors in these inquiries have importance to those in the profession.

Assemblies of high-fidelity components have been well received by consumers. We are much impressed with the willingness they show to make substantial investment in their equipment. It is surprising that so many are asking, not for the "best low-cost equipment," but for the "best available." Encouraging as this may be, there are widespread danger signals of consequence to everyone in audio.

The amount of misinformation reflected in our inquiries is appalling. Some of what passes for quantitative data in advertising is, we believe, downright misleading. Some of it may be written by people who are, themselves. misled, but much of it appears to be deliberately misinforming, composed with full understanding that however ambiguous the impressive figures may be, even professionals are enormously influenced by graphs and charts that appear to be derived from measurements on equipment too complex and expensive to be familiar.

Aside from the advertisements, the dealer himself too often sponsors confusion in the buyer. There seem to be two common types: the one who first feels out the customers' prejudices, and then feeds on them; and the type which assumes an Olympian attitude toward *all* mere customers—an attitude whose loftiness is the best measure of its ignorance. There are, of course, the honored few who offer respect and seek to inform: we owe them a profound debt of gratitude.

Nature of Unfilled Demand for Audio Systems

Non-professional high-fidelity enthusiasts, we find, are more interested in good record-playing equipment than in anything else. Radio is most often regarded as an accessory, to be used for incidental listening, but not as a primary source of serious musical entertainment.

There is an important minority of non-technician consumers which is interested in home recording. These are almost exclusively concerned today with magnetic apparatus, with tape commanding most inquiries.

Another matter of wide concern is the consumers' inability to hear and see the equipment before purchase. Many still are unaware that well-equipped sound salons are maintained by dealers in the larger metropolitan areas.

Many purchasers of assemblies inform us that they experience difficulty in making the necessary interconnections in their assemblies. Much hum, and most reports of unreliable performance are traceable to this difficulty. Often when the supplier has not volunteered full information on the necessary wiring, the non-technician is at a complete loss.

A fourth too-common complaint is made over the difficulty of laying out an assembly so that the controls come out symmetrically and at one central point, so that duplication among them is avoided, and so that convenience of operation is optimum. The physical configuration of the equipment is blamed.

Related to this objection is the series of inquiries on how to arrange the equipment in either built-in or cabinet set-up so that the final assembly looks neat and professional. It is said that expensive arrays of fine equipment should look well enough to justify their cost. Nobody, it is suggested, short of a combination architect and electronic engineer could assemble, re-arrange, and alter some of the components on the market,

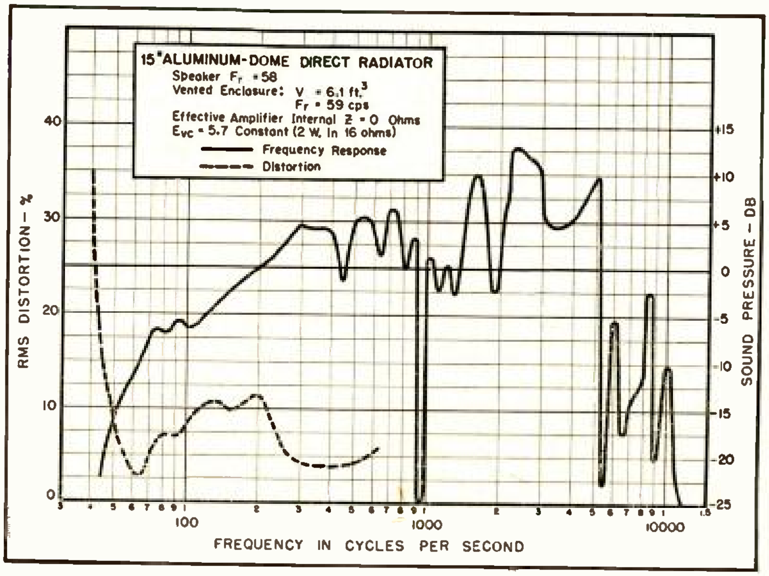


Fig. 1. By no means a "horrible example," this is one of the most highly-regarded of contemporary loudspeaker systems. The measurement was made outdoors from the top of a high building in a silent location. It should be noted that the amplifier source impedance was artificially reduced to absolute zero (constant-voltage) conditions. The bass characteristic assumes somewhat more normal proportions when the source has some, if little, effective internal impedance. The 1000-cps dip may be due to rim resonance or to a cancellation arising out of cabinet conditions.

* *Audio Engineer, KJBS, San Francisco, Calif., and Audio Consultant, Consumers' Research, Inc., Washington, N. J.*
(Consumers' Research is a non-profit organization which examines a large variety of consumer goods and makes reports evaluating them, in a published Bulletin.)

Responsibility for the contents of this paper rests upon the author, and statements contained herein are not binding upon the Audio Engineering Society.

so as to avoid ugly cabinet proportions, eccentric lumpy shapes, and trailing wires.

To most of us here the most important objection raised by non-technical people is this: many expensive assemblies *don't sound good enough.* The specific complaints most often received are with respect to *noise, shrillness,* and *weak or dirty bass response.* This is not with reference to users of faulty equipment, either.

Now, presumably, the reason we make measurements in designing and building equipment is in order to *predict,* in the scientfic sense, the *end result* to be obtained, namely listener satisfaction. If we refuse to recognize a listener's objections on the ground that *he* is incompetent, we are ignoring a serious discrepancy in the accuracy of our predictions. A refusal to admit that the experimental results disagree with the predictions is an inexcusable violation of scientific method, and can't be tolerated. Before we conclude that the listeners are mainly tin-ears, and retire to the laboratories to please no one but ourselves, we had better re-examine our measuring methods and their interpretations. It is suggested that the trouble lies with simple and attractive, but unrealistic, interpretations of our evidence. We're not relating the physics *and* the psychology of the problems before us in an adequate way. Our engineering. it is suspected, is excellent, but our psychology needs an overhaul. We are preoccupied with the glamorous means we are using to the point that we're forgetting the ends toward which we should be working.

Fig. 2. A high-quality home system in which control complexity has been reduced to a minimum.

Listener Preference

Our findings indicate that listener satisfaction increases with increasing frequency-range *only* when *noise, distortion,* and *raggedness of frequency response* are *all* greatly reduced simultaneously. To be sure, there is nothing new about such a theory. Many investigators feel these are the culprits in the public's notorious distaste for wide-range systems. Yet, many of us continue to display attitudes—*and equipment*—which overemphasize wide range to such a degree that, *by comparison,* noise, distortion, and raggedness are ignored. Equipment is commonly designed to pass 30 to 15,000, or even 20 to 20,000 cps—the very limits of human hearing—yet how miserably short are we still of getting *noise* down to the threshold of hearing, of reducing distortion to the point where it's undetectable, or of reducing *acoustic* output that is free of dips and peaks. Extending *range* is easy, and therefore tempting. But extending range without correspondingly improving noise, distortion, and smoothness characteristics, is costing us listeners. We think it cannot be overemphasized that in a system of *any* range—wide or narrow—noise, distortion, and raggedness are *not* sufficiently reduced if the listeners don't like the sound. Sometimes a *reduction* of frequency-range will improve the listeners' reactions. Still better listener-reaction is observed if, instead, further reductions are made in noise, distortion, and raggedness. We think that in *this* direction, laboratory predictions and listener reactions may be brought to coincide.

Suggestions for Improvements of Acoustic Quality

These, then, are our impressions of the most significant needs of the home user, and a theory from which we think better satisfaction of those needs can grow. On the basis of these needs we suggest expanded criteria for judging components and assemblies, to include not only (1) highest possible acoustic quality, defined in terms of listener satisfaction, but also (2) convenience of installation, maintenance and operation, (3) appearance matching or excelling that of comparable-cost production consoles, and (4) reliability and safety above any reproach.

Noise Level Limits

To evaluate audio quality realistically by means of physical measurements, we have to *integrate* them together at every point. Quantitative standards are necessarily arbitrary, so it is best to make them marginally more exacting than the majority of cases requires. To illustrate how much electrical noise is tolerable, we find that listeners are displeased if such noise, in the absence of signal, is audible a few feet from the speaker. In our tests the electrical output, in tube-noise and hum, that was just audible varied between 0.1 and 5.0 microwatts, depending upon the level and character of ambient noise and upon the efficiency of the speaker system. This amounts to between –23 and –40 dbm, representing performance which, with a nominal 10-watt amplifier, would be described as "Noise 63 to 80 db below full output." The first figure is not hard to attain, but the latter, when high-gain magnetic pickup preamps are in the circuit, is rarely achieved, representing noise corresponding to a noise-input level of –118 dbm. The listener who wants quietness enough to pay two or three hundred dollars for his amplifier expects to have this demand *met.* Lower-cost installations will, presumably, involve speakers of lower efficiency, especially at the hum frequencies, and will meet the requirement with the higher noise figure.

Record Scratch Limits

Take another example: how much record-scratch is tolerable? When we integrate *several* factors together at once, we find that the *character* of the scratch is at least as important as its relative level. If the sound-pressure response of a *whole system* is full of dips and peaks, scratch causes objections out of all proportion to its level. But if the system is *smooth* throughout its range, and that range does not include much more than the cleanly-recorded frequencies, the silky character of the hiss is tolerable when its measured level is as little as 25 db below peak recorded signal; with modern recording means it can be reduced much more than this—and it should be.

The Pickup Cartridge

A common source of gross distortion and intolerable raggedness is the alignment of the cartridge relative to the record, especially in changers as they are installed by dealers, some of whom

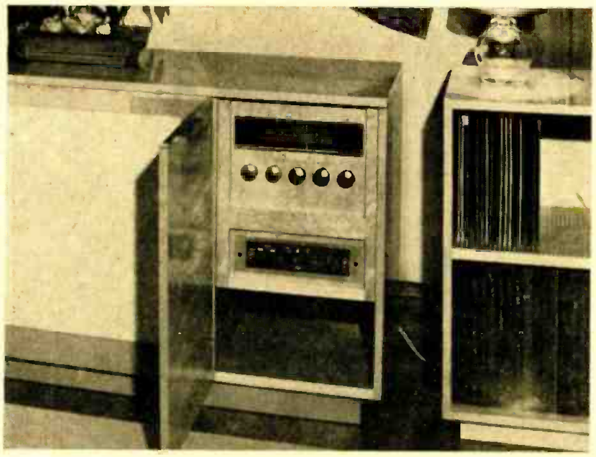


Fig. 3. A high-quality home system in which the necessities of component construction have led to duplication and complexity in control functions.

seem to have the impression that the cartridge is properly installed if its stylus manages to contact the record surface once each revolution. If gross disorders of this kind are relieved, the loudspeaker becomes the limiting factor. As response-smoothness improves, the upper tolerable range, we find, can be extended.

Distortion Limits

When we consider *distortion* limits we have to integrate them with *power* requirements. At the risk of extended argument, we report that oscilloscopic observations at the final grids of a number of amplifiers in actual home service, using musical transmissions with low-efficiency speakers, showed *no* peaks driving the amplifiers beyond 5 watts, even when uncomfortably high sound-levels were developed. With high-efficiency speakers the signals were considerably lower. Furthermore, when peaks of this power, transient or otherwise, drive virtually all our tested speakers into violent distortion, we feel that a 10-watt amplifier which is uncritical of its load at any usable frequency, is generous, and that expense incurred for greater power is extravagance. We find that such an amplifier contributes no audible unpleasantness if the following conditions are met: distortion must decline with power, and at the 10-watt level must not exceed 2 per cent r.m.s. at any frequency from 40 to 7000 cps. IM distortion of 8 per cent is alternately acceptable if the frequencies are 40 and 7000 cps separated by 12 db.[1] Pre-amplifier and tone-control stages must be included, and must not, except in treble-boost or bass-cut positions, increase these figures.

Distortion in AM receivers is, we think, inadequately measured at the low percentage-modulation used in standard test procedures. With the high modulations routinely maintained nowadays, there is need for drastic improvement in detectors. FM distortion may be expected to be below 1 per cent with ±75 kc swing and 50-microvolt signal, at which 40 db of quieting should be observed. Such a standard is attainable and is, we find, required in many locations to satisfy critical listeners.

We come last to the question of frequency-range because we are so firmly convinced that this is the *last* place where improvement should be sought. It will appear sheer heresy to speak of a high-fidelity system whose range is good only from perhaps 70 to 6000, or 60 to 8000 cps. BUT IF WE MEASURE IN TERMS OF ACOUSTIC OUTPUT, ACCORDING TO THE SAME STANDARDS WE APPLY TO FILTERS AND OTHER ELECTRICAL ELEMENTS, THE LOUDSPEAKER IMPOSES SUCH LIMITATIONS. That this is due to no form of carelessness or lack of research by loudspeaker makers does not obviate the necessity that we recognize the problem is enormously complex and difficult. *For this reason* we feel required to consider the limitations of *the best speaker which the economics of any given installation will permit* when we select every other component. We believe the profession owes the speaker-makers the compliment of recognizing the magnitude of their problem, and that we ought to discredit the misconception that such a range as 30 to 15,000, or 20 to 20,000 cps is now expectable with *anything resembling* the smoothness and low distortion we realize routinely from the electrical components. We can find *no* evidence that *any* speaker or system accomplishes such a standard. See *Fig.* 1. Only the costliest systems we have examined produce a *recognizable* 40- or 50-cps tone, much less one of low distortion. The hash which most speakers make of the range above 4000 or 5000 cps may best be judged by the jaggedness of their response-curves in that region. Even the vital mid-range is full of points of violent disturbance. Where frequency-response range is concerned, no engineer would rate the "upper cutoff" of a filter or an amplifier at the point where response is just measurable, on the tail-end of an 18-db-per-octave declination, but the practice is apparently common in rating loudspeakers. We think the industry is sufficiently grown-up today that it can afford to apply the same rigorous standards to speakers that it does to other components.

If the speakers merely cut off the top and bottom, it wouldn't be so bad. But the distortion that results in the middle-range when a cone is driven out of the linear portion of its magnetic gap by boosted 40-cps fundamentals makes a strong argument for electrically restricting the bass range. The same holds for the top, when the ragged residue of response goes to work on the harmonic structure. Horns help a great deal in the top range, of course, but if they are to begin handling power at 800 or 1200 cps their diaphragm-mass forces a fast roll-off from 6000 or 7000 cps. The value of adding a miniature third unit for the extreme top is questionable, since in our experience its function is largely to make a fine display of the hash to be found there from *almost* all program sources. *Provision* for cutting off the top electrically should be provided in every quality installation. If our listeners set the cutoff lower than we do, we might inquire what distortion products and jagged responses up there drove them away. Control of the high frequencies presents more complexities than the usual controls allow for. If horn speakers, or others of good distribution and smoothness, are used, sharp cutoff points are needed to minimize program-source irritations. If ragged speakers are dictated by economics, gentle roll-off of the whole upper range is demanded, we find, by listeners. Very sharp cut-offs, or, worse, peaks followed by sharp declination, produce the same sort of listener-irritation as does excessive raggedness.

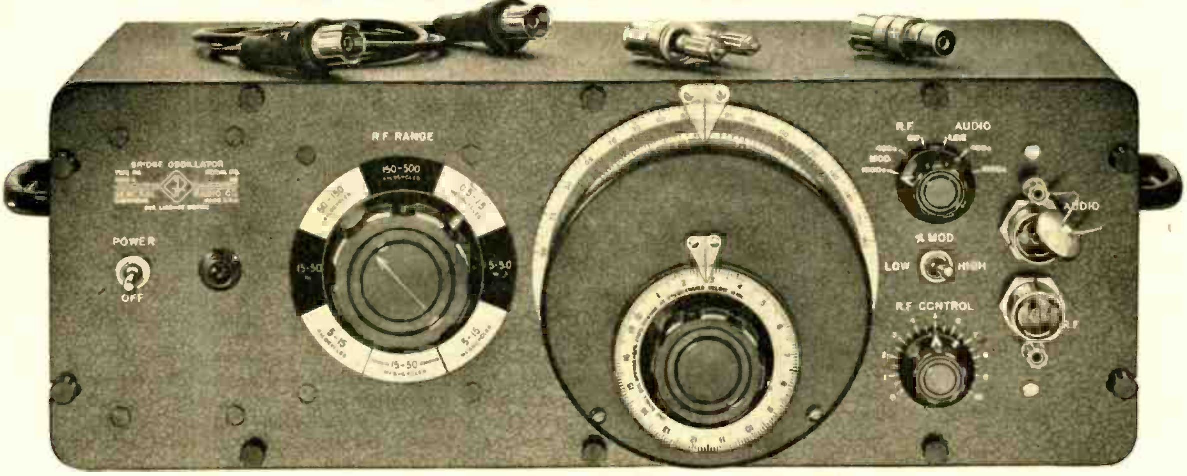
Where bass response is concerned, we find once more a widespread engineering reluctance to take the listener seriously. If he prefers a loud one-note-thump to electrically-measured flatness, there is entirely too much tendency to charge off the trouble to the listener's tin ear. Reconsideration indicates that many electrically flat systems are acoustically decidedly weak at the bass end. We customarily drive speakers from extremely low source-impedance amplifiers, so that the power expressed into the speakers at their high-impedance bass frequencies, is low. Furthermore, loudspeakers work into living-rooms whose dimensions do not encourage excitation at long wavelengths. Because higher source impedances involve us in serious damping problems, some provision is needed to lift the voltage output approximately with speaker impedance. Further boosting will be needed to overcome the living-room's unfriendliness to low frequencies. The boost should not be extended too far down, of course, or the amplitudes involved will drive the

[*Continued on page 52*]

[1] It has been shown elsewhere, by C. J. LeBel and others, that the relation between total r.m.s. and IM distortion is by no means a simple or a constant proportion. To the conditions defined here needs to be added only the condition that distortion-content shall decline regularly with its harmonic number in order to make the meaning of the 2 per cent r.m.s. figure coincide with that of the 8 per cent IM distortion figure.

NEW WIDE RANGE BRIDGE OSCILLATOR

5Kc to 50 Mc — 12 Volts output



Type 1330-A Bridge Oscillator . . . $525.00

WIDE FREQUENCY RANGE: *5 kc to 50 Mc, carrier*

THREE MODULATION FREQUENCIES: *internal a-m at line and at 400 c and 1,000 c, at two levels of approximately 30% and 60%*

GOOD OUTPUT: *12 volts, open circuit; ¾ watt into 50-ohm load*

FREQUENCY ACCURACY: *Carrier: ±2% above 150 kc, ±3% below, no load. Audio: ±5% for 400- and 1,000-cycles*

LOW LEAKAGE: *about 50 µv per meter at 1 Mc, two feet from oscillator*

COAXIAL OUTPUT *jacks, cable and adaptors permit complete shielding from oscillator to measuring instrument*

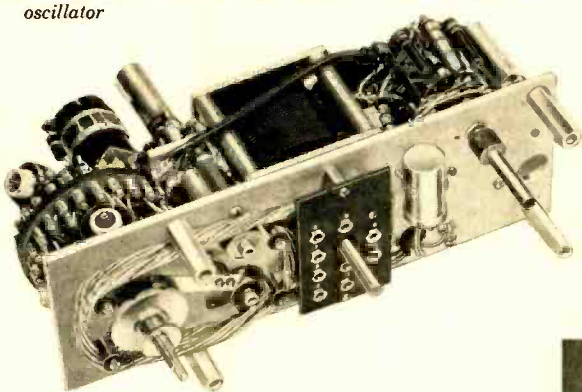
LOGARITHMIC DIAL: *from 5 kc to 15 Mc*

INCREMENTAL-FREQUENCY DIAL: *indicates increments of 0.1% per division from 5 kc to 15 Mc*

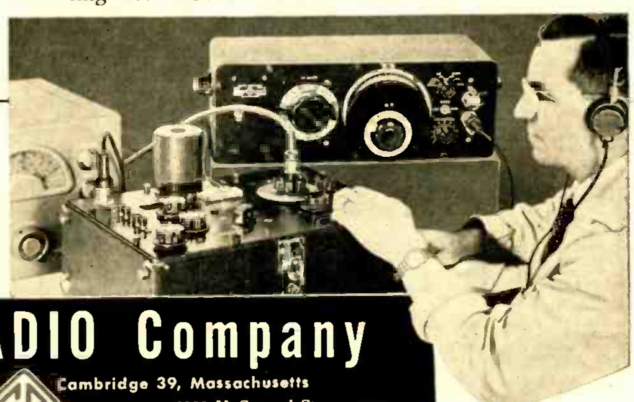
LOW DISTORTION: *between 1% and 6% at 60% modulation level; r-f distortion 3% over most of range*

VERY COMPACT CONSTRUCTION: *panel relay-rack width, only 7 inches high; cabinet 9 inches deep*

EASY SERVICING: *oscillator plugs out of shielding box and has servicing cable to test instrument*



The new Type 1330-A Bridge Oscillator is designed especially as a power source for bridge and general laboratory measurements. It is relatively inexpensive, has high output and excellent mechanical construction throughout. Oscillator assembly plugs into deep brass box; double cover completes shielding. Note servicing cable permitting instrument to be tested on bench.



Typical Set-up

Measuring characteristics of r-f coil. Types 1330-A Bridge Oscillator, 821-A Twin T Impedance Measuring Circuit and a communications-type receiver. The oscillator is equally suited to use with other bridges such as the Type 716-C Capacitance Bridge and the Types 916-A and 916-AL R-F Bridges.

GENERAL RADIO Company

275 Massachusetts Avenue Cambridge 39, Massachusetts

920 S. Michigan Ave., CHICAGO 5 *90 West St.* NEW YORK 6 *1000 N. Seward St.,* LOS ANGELES 38

Since 1915, Designers and Manufacturers of Precision Electronic Laboratory Equipment

Seventh Annual Pacific Electronic Exhibit

Pacific area comes into its own with mammoth display of electronic equipment—Held in conjunction with Western Convention of I.R.E.

No more emphatic means of dramatizing the swing of industry to the West could be devised that the seventh Annual Pacific Electronic Exhibit, scheduled for a three-day run beginning August 22 in the San Francisco civic auditorium. Held in conjunction with the annual western convention of the I.R.E., the APEE this year will be considerably larger than the 1950 show when 66 eastern and 30 western manufacturers exhibited. In addition to commercial displays, a number of prominent colleges, universities, and government agencies will participate. Attendance is expected to exceed the ten-thousand mark.

The theme of the 1951 exhibit is "Behind the Scenes in Electronics" and, despite the fact that many of the electronic items being produced today are on the classified list, exhibits are being designed to animate the various processes involved in all branches of electronics manufacturing, beginning with raw materials and carrying through to finished products.

The I.R.E. portion of the activities will include presentation of many important technical papers, field trips of general interest, sight-seeing excursions, and a special program for entertainment of the ladies.

Established originally in 1945 as a non-profit venture by the West Coast Electronic Manufacturers' Association, of which Paul F. Byrne, *Sierra Electronic Corp.*, is president, the APEE rotates annually between northern and southern California. Alex W. Fry, *Electro-Engineering Works*, is chairman of the WCEMA exhibit committee. The Exhibit has displayed a consistent annual growth of 20 per cent, both in exhibitors and in attendance, and today ranks with the two New York shows—the Audio Fair and the I.R.E. Convention—and the Chicago Parts Show as the "big four" of the industry.

This year, for the first time, the APEE program will include special sessions for manufacturers and jobbers, with attendance limited to qualified representatives. In addition, two forums have been arranged for executives, production, and operating personnel of manufacturers and wholesalers, both of which will be open to all visitors to both the Exhibit and the Convention. Thus the Exhibit will combine the best points of an engineering forum, a manufacturers' display, and a business conference under a single roof.

Principal speakers at these meetings will be Donald F. Marshall, chief, Industries Planning Board, Western Air Procurement District, USAF, and Glen McDaniel, president, RTMA. Mr. Marshall will discuss regulations and explain procedure covering government procurement of electronic equipment, while Mr. McDaniel's subject will be *Where the electronic industry stands now and its part in the Nation's preparedness program.*

Credit for success of the APEE may be found in the teamwork of its officials—helped along, of course, by the famous "native-son" complex with which all West Coasters are imbued. In addition to Mr. Byrne and Mr. Fry, other WCEMA officers are: Fred W. Falck, *Advance Electric & Relay Co.*, vice-president; A. C. Davis, *Cinema Engineering Co.*, secretary; and Norman H. Moore, *Litton Industries*, treasurer. Manager of the annual Exhibit is Heckert Parker.

Board members of the WCEMA are Herbert Balderson, *Thermador Electrical Mfg. Co.*, Los Angeles; Robert Bell, *Packard-Bell Co.*, Los Angeles; Orrin H. Brown, *Eitel-McCullough, Inc.*, San Bruno; William Gates, *Dalmo Victor Co.*, San Carlos; E. P. Gertsch, *Gertsch Products, Inc.*, Los Angeles; L. W. Howard, *Triad Transformer Mfg. Co.*, Los Angeles; John Kaar, *Kaar Engineering Co.*, Palo Alto; Noel Porter, *Hewlett Packard Co.*, Palo Alto; Leon Ungar, *Ungar Electric Tool Co., Inc.*, Los Angeles; Russell Varian, *Varian Associates*, San Carlos, and Messrs. Byrne, Falck, Davis and Moore.

Cooperating with the WCEMA in conducting the exhibit are members and officials of The Representatives of Radio Parts Manufacturers, Inc. The San Francisco chapter will staff the message center under the directorship of Dave Ross. When the exhibit occurs in southern California, this function is performed by the Los Angeles chapter with Norman B. Neely as chairman.

List of Exhibitors and Booth Numbers

A

ADVANCE ELECTRIC & RELAY CO. 208
Burbank, Calif.
Electrical relays.
(See adv. on Page 57)

AEROVOX CORPORATION 606
New Bedford, Mass.
Capacitors, resistors.
Wm. Hitt, Charles Meyers, Al Bissi.

AIRCRAFT-MARINE PRODUCTS, INC. 112
Harrisburg, Pa.
Solderless wiring devices, radar pulse networks.
Wm. H. Knowles, Jr., Thomas H. Welsby, O. W. Holmes.

AIRTRON, INC. 611
Linden, N. J.
Waveguides, switches, directional couplers, mixer duplexer assemblies, dummy loads.

ALTEC LANSING CORPORATION 225
Beverly Hills, Calif.
Loudspeakers, amplifiers, tuners, transformers, microphones, consoles, intermodulation test equipment.
A. A. Ward, Ed Grigsby, John K. Hilliard, E. B. Harrison, W. W. Simmons.
(See adv. on Page 43)

AMERICAN MICROPHONE CO. 515
Pasadena 1, Calif.
Microphones, phono pickups.
Gramer Yarbrough, G. N. Christensen, William W. Vogel.
(See adv. on Page 61)

AMERICAN PHENOLIC CORPORATION 116
Chicago 50, Ill.
Coaxial cables and connectors, AN connectors and fittings, antennas, radio components, plastics for electronics.

W. R. AMES COMPANY 109
San Francisco 7, Calif.
Aluminum and steel chassis, boxes, cabinets, frames and containers for electronic assemblies and end equipment.
Earl Hallas.

AMPEX ELECTRIC CORPORATION 805
Redwood City, Calif.
High-fidelity magnetic tape recorders.
E. G. Swanson, Myron Stolaroff, Walter Selsted, Frank Lennert.
(See adv. on Page 55)

ANDREW CORPORATION 122
Chicago 19, Ill.
Coaxial transmission lines, communications antennas and accessories, tower lighting equipment, dry air equipment, and related items.

ARNOLD ENGINEERING COMPANY 316
Marengo, Ill.
Permanent magnetic materials, cast Alnico magnets, sintered magnets. Vicalloy, Remalloy, Cunico, Cunife, cast cobalt magnet steel. Also high permeability materials, Deltamax toroidal cores, Supermalloy toroidal cores, Permendur.
(See adv. on Page 3)

AUDIO SERVICES, INC. 605
New York 22, N. Y.
Recording discs and tape.
Alan H. Bodge, Herman Kornbrodt.
(See adv. on inside front cover)

AUTOMATIC ELECTRIC SALES CORP. 120
Chicago 7, Ill.
Telephone-type relays and switches.
K. A. Regel, V. E. James, J. E. Bunt, A. D. Boehm, Jr.

AVERY ADHESIVE LABEL CORP. 108
Monrovia, Calif.
Pressure-sensitive labels.
Howard Black, W. G. Proper, John S. Torrey.

B

HERB BECKER
Los Angeles 15, Calif.
Electronic components and equipment of various manufacturers.

BERKELEY SCIENTIFIC CORP. 713
Richmond, Calif.
Frequency meters, electronic tachometers, high-speed counters, nuclear equipment.
G. H. Bruns, Jr., Ernest C. Helme, M. C. Burns.

BERMAN, E. L., COMPANY 223-24
San Francisco 3, Calif.
Sound equipment, electronic and TV components.
E. L. Berman, Ed Brandt, Jack Berman, Howard Harwood, Sidney Harman, P. N. Cook.

BIRD ELECTRONIC CORP. 311
Cleveland 14, Ohio.
Termaline RF wattmeters, coaxial switches, LF filters.
L. E. Bird

BROWN ELECTRO-MEASUREMENT CORP. 212
Portland 15, Ore.
Impedance bridges, bridge amplifiers and related equipment.

BRUSH DEVELOPMENT CO. 509
Cleveland 14, Ohio.
Test instruments, amplifiers, direct-writing oscillographs.

BURGESS BATTERY CO. 106
Freeport, Ill.
Complete line of dry batteries for standard and special applications.
Dave Miller, Phil Crocker, Vern Rupp, L. H. Harriss.

BURLINGTON INSTRUMENT CO. 507
Burlington, Iowa.
A.C. and D.C. electrical indicating instruments.
Walter Corman, David H. Ross.

BUSSMAN MANUFACTURING CO. 113
St. Louis 7, Mo.
Fuses and fuse holders.
O. A. Alderman, N. S. Beyer.

C

CANNON ELECTRIC CO. 613
Los Angeles 31, Calif.
Electronic and electric connectors.
Don A. Davis, Floyd Cate.
(See adv. on Page 6)

CENTRALAB DIVISION, GLOBE-UNION CORP. 501
Milwaukee 1, Wis.
Controls, switches, ceramic capacitors, printed electronic circuits, Steatite.
W. S. Parsons, Wickham Harter, Robert A. Mueller.

CHICAGO TRANSFORMER DIVISION, ESSEX WIRE CORP. 222
Chicago 18, Ill.
Transformers and reactors.
P. N. Cook, E. L. Berman, John Hill.
(See adv. on Page 37)

CINEMA ENGINEERING CO. 422
Burbank, Calif.
Precision wire-wound resistors, attenuators, magnetic recording components and related items.
James L. Fouch, Arthur C. Davis, David Ross.
(See adv. on Page 36)

CLEAR BEAM TELEVISION ANTENNAS 102
Los Angeles 36, Calif.
Antennas and lead-in.

CLEVELAND ELECTRONICS, INC. 619
Cleveland 3, Ohio.
Loudspeakers.

COASTWISE ELECTRONICS CO., INC. 313
Beverly Hills, Calif.
Television accessories and test equipment.

CORNING GLASS WORKS 408
Corning, N. Y.
Glass bulbs, tubing and parts for TV, radar, radio transmitting and receiving and other electronic applications.

D

DISTILLATION PRODUCTS INDUSTRIES (Division of Eastman Kodak Co.) 411
Rochester 3, N. Y.
High-vacuum equipment.
Carl W. Herrmann.

DRAKE ELECTRIC WORKS, INC. 502A
Chicago, Ill.
Soldering irons and guns.

ALLEN B. DU MONT LABORATORIES, INC. 813-14
Clifton, N. J.
Cathode-ray tubes.
I. G. Rosenberg, W. C. Scales, R. G. Scott.

E

THOMAS A. EDISON, INC., Instrument Division 607
West Orange, N. J.
Time-delay relays, thermostats, temperature controls.
H. E. Van Cleef, Jr., Dale Thompson, Harold E. Smith.

EITEL-McCULLOUGH, INC. 301
San Bruno, Calif.
Late tube developments.
Orrin H. (Hank) Brown, W. G. (Win) Wagener, J. L. (John) Reinartz.

ELECTRO ENGINEERING WORKS 214
Oakland 18, Calif.
Transformers, voltage regulators, power supplies, voltage normalizers etc.

ELECTRO-VOICE, INC. 604
Buchanan, Mich.
Microphones, pickup cartridges, loudspeakers.

ELECTRONIC ASSOCIATES, INC. 110
Long Branch, N. J.
Plotting equipment, analog computers, computer components, radar modifications, guided missile instruments.

ELECTRONIC INSTRUMENT CO. 807
Brooklyn, N. Y.
Electronic test instruments and kits.
Claude Erlanger.

ERIE RESISTOR CORP. 508
Erie, Pa.
Ceramic capacitors, button silver mica capacitors, printed circuits, ceramic trimmers and suppressors.
A. K. Shenk, D. H. Ross, W. H. Davis.

F

FAIRCHILD CAMERA & INSTRUMENT CORP. 519
Jamaica 1, N. Y.
Precision potentiometers, oscilloscope recording cameras.
H. E. Dale, E. Larralde, E. Heronen.

G

GENERAL ELECTRIC CO. 520
Syracuse, N. Y.
Transmitting, receiving, industrial, and cathode-ray tubes, test equipment, phono cartridges, tone arms.

GENERAL RADIO CO. 418-19
Cambridge 39, Mass.
Precision electronic test equipment.
(See adv. on Page 31)

GERTSCH PRODUCTS, INC. 706
Los Angeles 25, Calif.
VHF frequency meters, radar power supplies.
E. P. Gertsch, Leonard S. Cutler, Robert S. Hood, D. Fuller.

GIRARD-HOPKINS 403
Oakland 1, Calif.
Fixed paper capacitors.

GOODYEAR AIRCRAFT CORP. 808-9
Akron 15, Ohio.
GEDA (An electronic differential analyzer)

GUARDIAN ELECTRIC MFG. CO. 505A
Chicago, Ill.
Relays.

H

HEINTZ & KAUFMAN DIVISION, The Robert Dollar Co. 107
Redwood City, Calif.
Transmitting tubes, specialty communications equipment.
R. W. Bunce, M. C. Harp, P. L. Coggeshall, C. C. Conner.

HERMAN E. HELD 123
San Francisco 5, Calif.
Electrical measuring instruments, relays, timers.
Herman E. Held, Ross K. Patterson, E. F. Schimbor.

HELIPOT CORP. 219
South Pasadena, Calif.
Precision potentiometers.
D. H. Jones, W. Tanchek, D. C. Duncan, G. S. Marshall.

HERMETIC SEAL PRODUCTS CO. 518
Newark 7, N. J.
Hermetic seals, glass-metal hermetically-sealed terminals, bushings, headers, plugs, and bases.

HEWLETT-PACKARD CO. 711-12
Palo Alto, Calif.
W. Noel Eldred, C. Van Rensselaer.

JAMES P. HERMANS CO. 117
San Francisco 3, Calif.
Electronic components and equipment of various well-known manufacturers.

J. T. HILL SALES COMPANY 220-21
Los Angeles 15, Calif.
Electronic stop watches, oscillographs, cathode-ray tubes, oscillograph-record cameras, oscilloscope time calibrators, spectrum analyzers, oscillo-tracers.
J. T. (Jerry) Hill, John T. Hill, James J. Hill, James L. Wells.

RUSS HINES CO. 101
San Francisco 3, Calif.
Electronic equipment and components.
R. W. Moulthrop, A. A. Hines, G. M. Moulthrop.

HOFFMAN RADIO CORP. 322-23
Los Angeles 7, Calif.
Television receivers and other electronic equipment.

HYCOR CO., INC. 625
North Hollywood, Calif.
Precision resistors, toroid coils, decade inductors.
(See adv. on Page 52)

I

INDIANA STEEL PRODUCTS CO. 409
Valparaiso, Ind.
Permanent magnets.

INSTITUTE OF RADIO ENGINEERS 802
New York 18, N. Y.
Proceedings of the I.R.E., membership applications, and general I.R.E. information.

INTERNATIONAL RECTIFIER CORP. 614
Los Angeles 43, Calif.
Selenium rectifiers and photo cells.
Philip Diamond.

J

JENNINGS RADIO MANUFACTURING CO. 806
San Jose 8, Calif.
Vacuum capacitors, vacuum micro-wave transformers, vacuum switches and components.

K

KAAR ENGINEERING CO. 417
Palo Alto, Calif.
Radiotelephones, transmitters, receivers, depth sounders, radio direction finders.
John M. Kaar, Norman C. Helwig, Sherwood French.

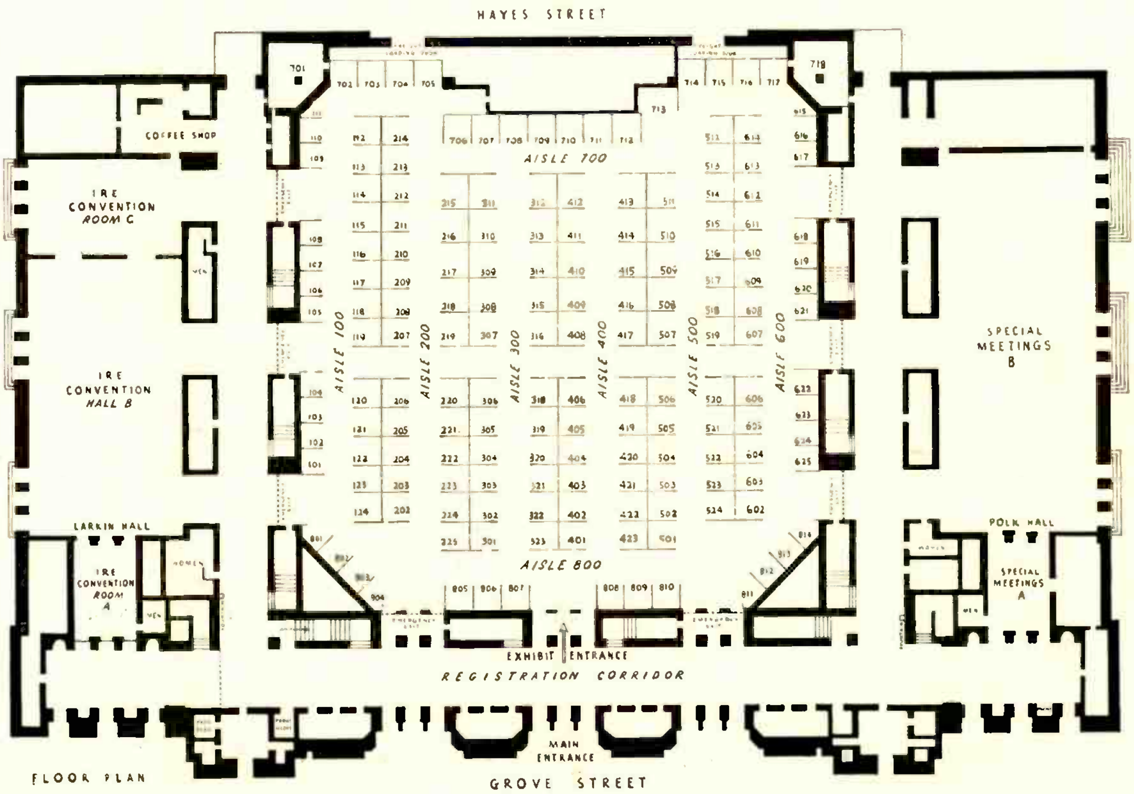
KALBFELL LABORATORIES, INC. 314
San Diego, Calif.
Bridged-T filters, plug-in amplifiers, Micro-Miker, decade amplifier, logatens.
D. C. Kalbfell, William G. Royce.

KARP METAL PRODUCTS CO., INC. 420
Brooklyn 20, N. Y.
Cabinets and enclosures for electronic equipment.

HAROLD A. KITTLESON 609-10
Los Angeles 46, Calif.
Components and equipment of various well-known manufacturers.

JAMES KNIGHTS COMPANY 207
Sandwich, Ill.
Quartz crystals and holders, ovens, frequency standard.

Floor Plan and Booth Numbers, San Francisco Civic Auditorium



L

JAMES B. LANSING SOUND, INC. 512
Los Angeles 39, Calif.
Loudspeakers.
William H. Thomas, Leonard Larson.
(See adv. on Page 56)

HARRY A. LASURE CO. 416
Los Angeles 6, Calif.
Record changers, three-core solder, dial lights, capacitors.
Harry A Lasure, F. B. Lasure, Robert G. Moye.

LENKURT ELECTRIC CO. 121
San Carlos, Calif.
Carrier telephone and telegraph equipment, electrical wave filters.
W. H. Heflin, E. G. Hall, J. Semelman.

LENZ ELECTRIC MFG. CO. 505
Chicago, Ill.
Wire.

DEAN LEWIS ASSOCIATES 321
San Francisco, Calif.
Radio-TV-electronic parts and equipment.
Dean A. Lewis, Frank H. Barstow.

LITTLEFUSE, INC. 517
Chicago 40, Ill.
Fuses and fuse mountings.

M

McINTOSH ENGINEERING LABORATORY, INC. 514
Binghamton, N. Y.
High-quality audio amplifiers.
(See adv. on Page 46)

MAGNA ELECTRONICS CO. 624
Los Angeles, Calif.
Amplifiers, radios, electronic components.
Miss Jan Risa, Britten Kimball, Otto Heeger.

MAGNECORD, INC. 513
Chicago 1, Ill.
Professional magnetic tape recorders.
C. G. Barker, J. S. Boyers, R. S. McQueen.
(See adv. on Page 39)

MARCONI INSTRUMENTS, LTD. 518
New York 4, N. Y.
Precision electronic measuring instruments.
Howard Schoendure, Chet Lincoln, D. A. Pittman.

MARION ELECTRICAL INSTRUMENT CO. 213
Manchester, N. H.
Measuring instruments, meters, induction heating equipment, and meter testers.

G. S. MARSHALL CO. 218
Pasadena 1, Calif.
Electronic components and equipment of various well-known manufacturers.
Gordon S. Marshall, Jack Hachten.

MASTER MOBILE MOUNTS, INC. 801
Los Angeles 36, Calif.
Mobile communications antennas.

MERIT TRANSFORMER CORP. 306
Chicago 40, Ill.
Radio-TV transformers and components.

MIDWESTERN GEOPHYSICAL LABORATORY, INC. 616
Tulsa, Okla.
See official program for product listing.

GERALD B. MILLER CO. 510-11
Hollywood 28, Calif.
Electronic components and equipment of various well-known manufacturers.

J. W. MILLER CO. 503
Los Angeles, Calif.
Radio coils.

MOTOROLA, INC. (Communications and Electronics Division) 119
Chicago 51, Ill.
Two-way radio for mobile, portable, and point-to-point applications.

N

NATIONAL BUREAU OF STANDARDS 717
Washington, D. C.
Atomic clock, testing standards.

NATIONAL COMPANY, INC. 302
Malden 48, Mass.
Radio receivers and component parts.

NAVAL RADIOLOGICAL LABORATORY
Hunters Point, Calif.

NEELY ENTERPRISES 709-10
Los Angeles 46, Calif.
Electronic and sound equipment.
Norman B. Neely, R. L. Morgan, F. B. Koessler, J. F. O'Halloran, R. V. Getsen, W. R. Saxon, J. C. Ingersoll, D. Kesteil, R. Poucher, L. E. French, D. Kelsey.
(See adv. on Page 5)

NEWCOMB AUDIO PRODUCTS CO. 406
Hollywood 38, Calif.
P.A. systems, transcription players, amplifiers, radios, phonographs.
Robert Newcomb, Donald Warner.
(See adv. on Page 51)

HAROLD L. NEWMAN 209
San Francisco 11, Calif.
Electronic components and equipment of various well-known manufacturers.

J. M. NEY CO. 103
Hartford, Conn.
Precious metal alloys for electronic instruments.

NICKERSON & RUDAT 318-19
San Francisco, Calif.
Electronic parts and equipment.
Dan J. Rudat, E. C. Nickerson.

L. A. NOTT & CO. 320
San Francisco 3, Calif.
Electronic components and equipment of various well-known manufacturers.
L. A. Nott, W. M. Nott, R. M. Melvin.

O

OAK MANUFACTURING CO. 105
Chicago 10, Ill.
Rotary, push-button, and slide switches, vibrators, capacitors, tuners, and power packs.
I. M. Cochrane, J. T. Driscoll, L. H. Flocken, E. J. Schomburg, R. E. Wood.

OHMITE MANUFACTURING CO. 305
Chicago 44, Ill.
Resistors, rheostats, tap switches, RF chokes.
Roy S. Laird.

P

PERIMUTH-COLMAN & ASSOCIATES, INC. 307-8
Los Angeles 15, Calif.
Components and equipment of various well-known manufacturers.

PERMOFLUX CORP. 522
Glendale, Calif.
Loudspeakers and transformers.
John R. Mutschler, L. M. Heineman, H. E. Lasater.
(See adv. on Page 41)

POLYTECHNIC RESEARCH AND DEVELOPMENT CO. 521
Brooklyn 1, N. Y.
Microwave test equipment.
W. H. Fenn.

POTTER & BRUMFIELD 118
Princeton, Ind.
Relays.
Dick Brumfield, Ralph Brengle, Jim Hermans, Bud Hunter.

POTTER INSTRUMENT CO. 812
Great Neck, N. Y.
Electronic counters, chronographs, frequency measurement counters, computer components.
John J. Wild, Dudley Wright.

WILLIAM J. PURDY CO. 204-5
San Francisco 3, Calif.
Pickups, microphones, TV boosters, relays, oscilloscopes, TV-FM-AM tuners, recording equipment.
William J. Purdy, William J. Purdy, Jr., James S. Heaton.

R

RADCRAFT PUBLICATIONS, INC. 503A
New York 7, N. Y.
Radio-Electronics magazine, Gernsback library books.
Les Logan.

RADIO CORPORATION OF AMERICA (RCA Victor Division) 523-24
Camden, N. J.
Electronic components, tubes, test and measuring equipment.
(See adv. on Pages 1, 8-9)

RADIO MAGAZINES, INC. 623
New York 17, N. Y.
AUDIO ENGINEERING magazine, AUDIO ANTHOLOGY, Edward Tatnall Canby broadcast transcriptions.
James Galloway, Ladd Haystead, C. G. McProud.

RADIO RECEPTOR COMPANY, INC. 502
New York 11, N. Y.
Selenium rectifiers.
Martin Mann.

RAYTHEON MANUFACTURING CO. 210
Newton 58, Mass.
Radio and TV receiving tubes, cathode-ray tubes, subminiature tubes, microwave tubes.
H. L. Newman.

E. V. ROBERTS & ASSOCIATES 309-10
Los Angeles 16, Calif.
Shallcross precision instruments and components.
Ernest V. Roberts, Don Hagen, Frank LeBell.

RAYMOND ROSEN ENGINEERING PRODUCTS, INC. 312
Philadelphia 4, Pa.
Telemetering equipment.
Jack Moses, Jr.

S

SANGAMO ELECTRIC CO. 304
Springfield, Ill.
Mica, paper, electrolytic capacitors, time switches.

WALTER L. SCHOTT CO. 606
Los Angeles 8, Calif.
Antennas, alignment tools, electronic hardware, chemicals, accessories.
Robert Mueller, Jack Carter, Charles H. Meyer.

SCINTILLA MAGNETO DIVISION, Bendix Aviation Corp. 206
Sidney, N. Y.
Aircraft ignition systems, magnetos, connectors, Diesel fuel injection equipment.

SERVO CORPORATION OF AMERICA 217
New Hyde Park, N. Y.
Servo mechanisms, analyzers, sub-audio generators, direction finding equipment, thermal radiation measuring and detection systems.
S. N. Howell.

SIERRA ELECTRONIC CORP. 115
San Carlos, Calif.
Test equipment and instruments.
W. Feldscher, Paul F. Byrne, Ormand Show.

SIMPSON ELECTRIC CO. 203
Chicago, Ill.
Meters and test equipment.

SOLA ELECTRIC CO. 315
Chicago 50, Ill.
Constant voltage transformers and related products.
L. G. Warren, J. M. Smith.

SORENSEN & CO., INC. 414-15
Stamford, Conn.
AC line voltage regulators, regulated DC power supplies, 400-cycle power equipment, 400-cycle variable autotransformers.

SPERRY GYROSCOPE CO. 211
Great Neck, N. Y.
Klystrons and Microline test equipment.
W. Horn, A. Mayer, C. Kodera.

SPRAGUE ELECTRIC CO. 202
North Adams, Mass.
Capacitors, resistors, magnet wire.

STANDARD COIL PRODUCTS CO., INC. 506
Los Angeles 32, Calif.
Standard TV tuner, electronic equipment and components.

STANFORD UNIVERSITY 702
Palo Alto, Calif.
Research projects from the electronics research laboratory and the microwave laboratory.

CONRAD R. STRASSNER CO. 404-5
Los Angeles 38, Calif.
Electronic parts and equipment and radiation detection systems.
Conrad R. Strassner, Bernard Epstein, Ellard Strassner.

SURPRENANT MANUFACTURING CO. 412
Boston, Mass.
Wire, tubing, tape, multi-conductor cables.

SYLVANIA ELECTRIC PRODUCTS, INC. 401-2
New York 19, N. Y.
Germanium diodes, tubes for communications and radio-TV receivers, ruggedized tubes for industrial use.
W. G. Patterson, F. E. Gilbert, Jr., Raymond P. Guion, Garland Morse, E. T. Carter, T. A. Fuller, Thomas Holland.

T

TEKTRONIX, INC. 707-8
Portland 7, Ore.
Cathode-ray oscilloscopes, wide-band amplifiers, square wave generators.

TELEBEAM INDUSTRIES 617
Napa, Calif.
TV antennas, TV masts TV boosters.

TETRAD COMPANY, INC. 421
Los Angeles 16, Calif.
Transformers and coil components.

TRANSFORMER ENGINEERS 124
Pasadena 1, Calif.
Transformers, chokes, filters.

TRIAD TRANSFORMER MANUFACTURING CO. 423
Los Angeles 64, Calif.
Transformers and reactors, toroidal coils, TV components, hermetic terminals.
L. W. Howard, O. D. Perry, George Clark, Dick Hastings, Ernest Clover, Thomas P. Walker.
(See adv. on Page 38)

TUNG-SOL SALES CORPORATION 608
Los Angeles, Calif.
Tung-Sol electron tubes.

THE TURNER COMPANY 504
Cedar Rapids, Iowa.
Microphones.

U

U. S. NAVY ELECTRONICS LABORATORY 703
San Diego, Calif.
Exhibit described in official program.

U. S. ENGINEERING CO. 622
Glendale 3, Calif.
Custom-built terminal boards.

UNIVERSITY OF CALIFORNIA 716
Berkeley 4, Calif.
Electron research projects.

V

V-M CORPORATION 618
Benton Harbor, Mich.
Automatic record players.

J. C. VAN GROSS 620-21
Hollywood 27, Calif.
Components and equipment of various well-known manufacturers.

VARIAN ASSOCIATES 413
San Carlos, Calif.
Klystrons, traveling wave tubes, microwave measuring equipment, nuclear induction apparatus.

W

WALDES KOHINOOR, INC. 215-16
Long Island City, N. Y.
Truarc retaining rings, pliers, grooving tools.
H. F. Bower, John H. DeBree, L. S. Bluth.

DON C. WALLACE & WILLIAM H. WALLACE 104
Los Angeles 15, Calif.
Radio parts and electronic equipment.
Don Wallace, Bill Wallace.

WEST COAST ELECTRONIC MANUFACTURERS ASSOCIATION 804
Various officials of WCEMA will be present at this booth during the entire course of the Exhibit.

WESTERN GOLD AND PLATINUM WORKS 114
San Francisco, Calif.
Brazing alloys, ceramic parts.

WESTERN LITHOGRAPH CO. 612
Los Angeles, Calif.
Wire markers, contact labels.

WESTINGHOUSE ELECTRIC CORP. 410
San Francisco 8, Calif.
Electronic components.

ASH M. WOOD CO. 810
El Monte, Calif.
Electronic components.

WORKSHOP ASSOCIATES 504A
Needham Heights, Mass.
Antennas.

Z

ZIFF-DAVIS PUBLISHING CO. 803
New York 17, N. Y.
Radio and Television News
Leonard L. Osten, Lynn Phillips, Jr., John Payne, Oliver Read.

Famous Products by Jensen

Hypex
Projectors

VIKING
economy speakers

Concert
Series

Speechmaster
Reproducers

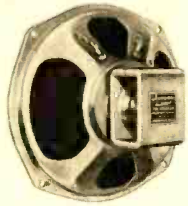
G-610
Triaxial

H-510 Coaxial
with Acoustic Lens

K-210
Coaxial

Extended Range

Type M
Reproducer
Cabinet



Standard Series

Jensen MANUFACTURING COMPANY
Division of the Muter Company
6601 S. LARAMIE AVENUE • CHICAGO 38, ILLINOIS

BURTON BROWNE ADVERTISING

Survey of European Sound Apparatus

JOHN K. HILLIARD*

A prominent audio authority reports on ten-country tour of the Continent.

In keeping with his responsibilities to be well informed on sound apparatus developments, the writer has just completed a ten-country tour of Europe, including England, on behalf of Altec Lansing.

In these countries engineers showed a remarkable willingness to discuss our mutual problems and hobbies of audio equipment and apparatus. This friendly attitude was universal, extending from the one-man development physicist to the large laboratories, such as Philips' at Eindhoven. We were invited to their factories and homes, met their wives and families and joined in their discussions about the Russian frontier, the Marshall Plan, Americans, the U. N., and sound equipment interests. This method of surveying the resources of many laboratories proved to be much more satisfactory than the correspondence and engineering report channels, which necessarily are incomplete and delayed and can not completely transmit thoughts regarding avenues for new developments.

In addition to visiting the various laboratories, and design and manufacturing groups, considerable time was spent with the professional users in the radio and recording fields. In general the European professional audio engineer is still forced to work with pre-war designs of apparatus, which are now considered obsolete in the U. S. market. As economic recovery has progressed, replacement with more modern apparatus has been planned, but in a large number of cases these plans have not yet been executed.

Since markets for audio apparatus are generally limited to the originating country, Europe has a large number of small but highly capable plants. Typical was the operation of Jakob Bohli, in Solothurn, Switzerland. Mr. Bohli operates a microphone and magnet factory. He, with his three sons and daughter and a very few skilled mechanics, produce their entire output of equipment, with the daughter acting as office manager, interpreter, and translator. The high capabilities of the individuals in a number of these small enterprises are seen in the ingenuity of some of their designs in order to get a satisfactory amount of production without the large tooling costs which are involved in quantity manufacturing. Every effort is expended to avoid the non-uniformities of finished products which often result from inadequate tooling facilities.

Even when a manufacturer finds it possible to cross national boundaries with his product, he often finds that different standards prevent uniform product design. For example, manufacturers in many instances are required to build two models of equipment—one using the European type of vacuum tube, with the other designed for American tubes. These differences are not limited merely to a change in sockets, but in many cases are still further complicated because of filament voltages and other tube characteristics which vary greatly between the two types of tubes. In a Danish factory, Bruel & Kjaer, of Naerum, Denmark, many units are assembled and wired less vacuum tubes and sockets and then are completed when the country of final destination becomes known. Add to these complexities the problems arising from power line voltages and frequencies encountered in many European markets and you will have an indication of some of the reasons why most European sound equipment is literally "hand made."

Rugged economic conditions still prevail in both Germany and Austria, and there is a six- to eight-month delay in securing scientific text books, publications, and reprints. Nevertheless, in Vienna, the Henry Radio and the Akustische und Kino Gerate, build dynamic microphones with definite improvement in diaphragm and magnetic structure.

In the professional sound fields of Europe, the advantages of the condenser microphone have been appreciated for a number of years and the manufacture of them is particularly concentrated in Berlin at the Georg Neumann Company, under the direction of Dr. Hans Heyda. These microphones are used extensively, being exceeded only in numbers by the 639 and 44B types of United States manufacture. In contrast, however, loudspeakers used for monitoring in most of the radio and recording studios are still limited to 8-, 10-, or 12-inch cones, often mounted in reverberant cabinets with reflectors, diffusers, or other devices to improve distribution and quality. To overcome the high frequency beaminess of such cones, several models had the cones mounted in the top or sides of the cabinets so that the listener heard only the indirect sound. Motion picture studios and theatres were practically the only places in which modern two-way loudspeaker systems were to be found.

With the post-war problems of rebuilding their bombed areas, as well as their national economies, it is not surprising that the average European citizen has not yet been introduced to home music systems comparable in quality to those available in the United States.

Phonograph reproduction is principally with 78 r.p.m. records rather than the slower speed equipment, since it is not economical to replace existing equipment. This is perhaps the basic reason why in England LP records are not manufactured in quantities for the domestic market. Most of these records are made for export. Crystal and earlier type magnetic pickups are in common use, while variable reluctance and other more modern pickups are available only in limited numbers.

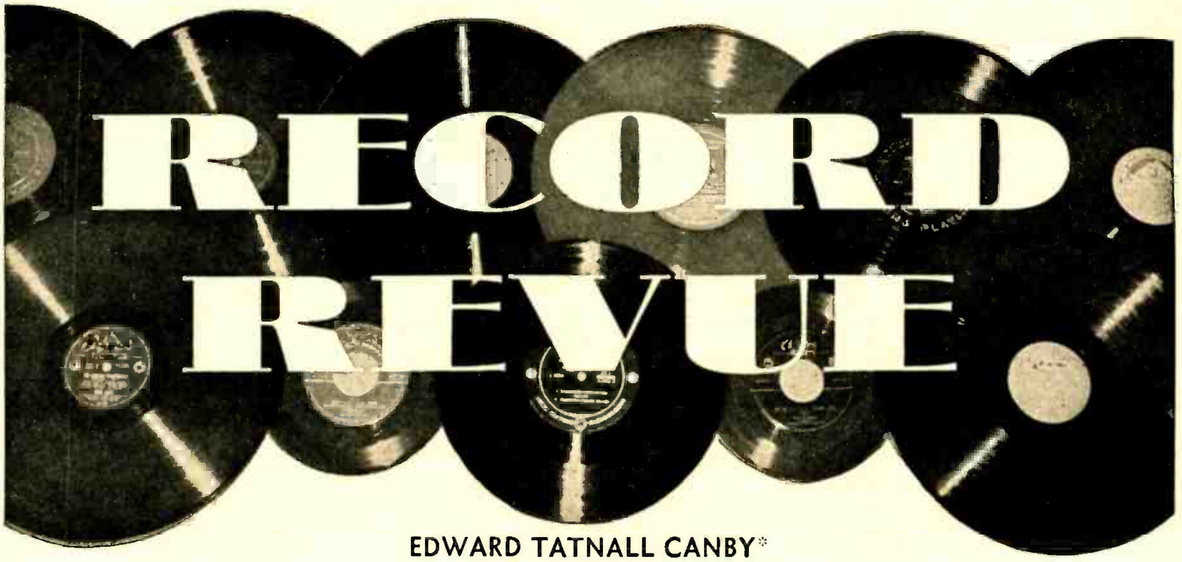
At the present time England has two transmitters radiating a single television program on a restricted hourly basis, but plans call for additional transmitters in areas not now covered, such as Northern England and Scotland. New and more modern television and broadcasting equipment is being planned but it will be some time before British broadcasting studio facilities can be modernized to the degree that British engineers have visualized. One of the interesting observations in their television reception is that the English use vertically polarized radiation as compared to our horizontal polarization.

A lasting impression of the trip was the display of hospitality, friendship and eagerness of the engineers visited to discuss freely our technical problems. If all diplomatic relations between countries in the world could be maintained on the same basis as those extended by the technical engineering groups, our problems in human relations would be simplified, and our ability to establish world peace would be much nearer to realization.

** Chief Engineer, Altec Lansing Corp.*

New Ampex Chairman

Recent election of T. Kevin Mallen, general manager since 1949, as Chairman of the Board is announced by Ampex Electric Corporation. Typical of many executives in the audio field, Mallen also has a deep interest in the field of music, expressed forcibly in his position as president of the Peninsula Symphony Association in Redwood City, Calif.



EDWARD TATNALL CANBY*

Tape Libraries

When tape first appeared, the possibility of pre-recorded tape appeared with it. Due to tape's special advantages—notably the erase, re-record-patch feature plus the portability and quality offered for "original" or instantaneous recording—the pre-recorded concept was allowed, so to speak, to lie fallow. Other crops were cashed in on. Everything from home-taped baby prattle to the Private Eye's invisible talkie-walkie (or whatever you call one of those self-powered tape midgets). from supersonic engineering measurements (see the Ampex 60") to the plain and simple recording on tape of a couple of billion hours of music for LP, not to mention a dozen or so quadrillion light-years' worth of recorded broadcasts. Tape for permanent record and tape for transitory record; tape for exact transcript of events and tape for highpowered editing—but not an inch of it was commercially pre-recorded, to sell on the open market.

How come? Well, that's the point now coming to an interesting preliminary issue and trial, for the first time on any reasonably large scale, thanks to a new offshoot of the Audio-Video people, the AV Tape Libraries, to be launched around September and expected to be nationally distributed within another six months or so, and another prospective venture by the enterprising Concertone people—"Concertape." These are, to my knowledge, the first tape libraries making available material not available in disc form, in original-quality, direct re-recordings (not magnetic "prints"), though for a long while we've been hearing rumors and tentative beginnings in this direction, and that, as I say, inevitably; for pre-recorded tape in some form has been bound to turn up sooner or later. The problem was, and still is, to determine the proper place that such tape can occupy in the record scene; which involves as well the determining of the form it shall take—there are all sorts of possibilities, an infinitude of conceivable business and distribution set-ups, a world of recorded or recordable material to draw upon. Where to begin? How?

It seems to me obvious that the main thing which has held pre-recorded tape in abeyance has been the shifting development of the new speeds and their attendant tape-to-disc techniques. That has taken a solid three years—no time at all, when you come down to it—and for these three years pre-recorded tape was bound to flounder in the mind, unable to find a solid resting place.

But now the time has come. The situation with regard to speeds has jelled very rapidly these last months. As rather fully predicted in this space a year ago this last January (I think it was) the 45 r.p.m. record has now been categorized, as ideal for pops, for light classics, operas, for the conventional best-seller classicals and for "name" performances. Columbia now makes 45's up to and including such a release as the complete "Carmen"—but no further.

The LP record, with all the interminable 33 vs. 45 arguments dead and forgotten, now has taken over 99 per cent of the classical field and, moreover, has developed a tremendous classical repertory and a vast new audience for out-of-the-way classical music, not to mention a hundred-odd new classical companies, a major export music business in every country of Europe (poor souls, they never hear a note of it) and a monthly output of classical music perhaps twenty times the pre-war quantity.

(Footnote: It's really funny to see the way in which RCA, making LP's right and left and selling them, advertises 45's for everything, as at the height of the Record War—whereas Columbia, making 45's right and left in the proper divisions, keeps incredibly silent about anything but 33, and indeed never even mentions the dreadful term "45" in its listings to dealers, except when utterly necessary!)

The 78? Dead, except for a classical trickle (Columbia scarcely makes any, now issues LP's without 78 equivalents) and the inevitable pops. Even the pops are shifting over fast to 45. They said it would take ten years.

And so, with the situation stabilized and on a reasonably permanent peace-time footing, we can consider the uses of pre-recorded tape. Let me do so, before looking at Concertone's and the AV Tape Libraries' opening guns in the field.

The primary division of thought must be immediately into the basic categories, (a) rental library or (b) outright sale; and (c) "industrial"—radio, dinner music, the ET market, or (d) "home" records, which, if LP is any indication, also involves education and a large amount of radio. And involving all of these, one must consider the crucial matter—what shall we offer on pre-recorded tape? Popular, best-seller classical, out-of-the-way classical, collectors' items, or what have you? Naturally in all these cases the tape library builder must look at available competition and weigh the pros and cons of comparison—which vary with every situation, every potential use, even with various types of music and, above all, types of listeners. (Compare those people who will do and pay anything for hi-fi, no matter how clumsy, with those who will do and pay anything for a gadget that will flip fifty records without the touch of a human hand!)

Tape vs. Disc

Perhaps we should consider first, before the choice of music, the mechanical aspects and the electrical. Granted that tape gives top quality at its various levels of use (AV Libraries will give the best that can be had at the slower speeds—which, if you read my description of the Ampex 400 last summer, is very good.) Tape is economical of space, though no more so than 33 and 45 disc. Perhaps most important, tape wears, both physically and as to sound quality, very much better than any ordinarily cared for disc. (Yes, with ideal treatment a disc does pretty well. But disc treatment is seldom ideal, and tape is bound to win here, anyway, since lack of noise is inherent in the magnetic principle.)

The editing and erase features are of course out in pre-recorded tape, those being among the most vital features for other types of tape work.

Long-play is no special advantage, since LP has more or less taken care of that—and in pre-recorded tape the really long playing time (on home machines, with small reels) comes only with a sacrifice in quality. With high fidelity now possible, almost equal to the better LP's, at 7½ inches double track, tape at least can compare in length of hi-fi play with disc, though it would be hard to show any marked superi-

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

only you can decide

that's what the man says...

"... Some months ago, I bought an AUDAX L-6 and hooked it in place of my pickup cartridge. The next day I sold it for half price to a neighbor. On all sides, since then, I have been hearing sky-high praises about AUDAX, so I again bought an L-6 POLYPHASE. But this time I hooked it up right and what a difference. It sure is mighty pleasing to my ears. I thought it only fair to drop you a line. . . ."

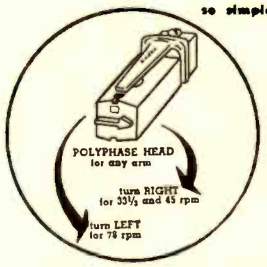
(from a letter)

Audax POLYPHASE reproducers

"The Standard by which Others are Judged and Valued"

have won the acclaim of thousands of users everywhere—Never before such EAR-QUALITY, such FAITHFUL REPRODUCTION but . . . after all the reams are written about kilocycles and other laboratory data—when the chips are down—you and only you can decide what sounds best and most pleasing to your ears. Therefore . . . SEE and HEAR POLYPHASE —and you be the judge.

so simple



One single magnetic unit plays all records— Replaceable Sapphire or Diamond styli.

Special models for radio stations, including Vertical-Lateral units.

Available with the new Compass-pivoted Audax Arms and for Record Changers.

Write for editorial reprints on POLYPHASE principles and PHONO FACTS

AUDAK COMPANY

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ority in most applications. True, with large reels—such as Concertone's N.A.B. reels—a very long play is simple enough. But who wants it? The half hour length is pretty conclusively the most useful for a majority of purposes, only a few special problems, such as complete opera, really needing a longer unbroken stretch. For most uses, the longer the play, the more difficult the problem of musical choice—for what is to be arbitrarily combined with what? We have enough headaches with the two-sided LP already.

Which leads to the disadvantages, from the consumer's-eye point of view. Tape is clumsy to use, even in the much improved transports now in production. If the manual record player is an annoyance to plenty of lazy people, what about the threading of tape—and the annoyance of rewinding? I can hear violent arguments on both sides. Suffice it to indicate that right here is a crucial question and one very hard to prejudge. Some people won't mind a bit; others will steer entirely clear of anything but a tape magazine, which might still be a possibility if some large company were to introduce tape plus its own special player system. That was suggested by me a couple of years ago and still stands. However, we are not concerned with such a development now. Both "Concertape" and AV tape will be straight, conventional thread-it-yourself material, to the best of my knowledge.

If tape is clumsy to service, it has a far more serious disadvantage—for some people, not others. You have to begin at the beginning. You can't find a selection or passage in the middle without running tape through via the hit-or-miss system or with the "help" of some ingenious marking method which, however you look at it, cannot possibly match the utter ease of finding an LP band of music of a disc. This I know from abundant personal experience. I thoroughly dislike fussing with the stuff I have on tape, find records far easier to use. I've even had LP discs made of tapes in order to render comparisons and quick spotting of individual numbers possible. For those who always play their discs from beginning straight through without a break, tape records will be good; but for a lot of people (the people for whom LP separation bands are provided—that's most record buyers) the begin-at-the-beginning aspect will be a pain in the neck. Especially when numerous items are on one tape, as is inevitable.

Players

So much for the factors of doubt, pro and con. You can think of as many more, no doubt. To determine a formula for tape library operation out of all this is anything but simple. However, both Concertone and AV have approached the tape record from still another angle, that of the player.

1. People who own tape machines will be quick buyers for pre-recorded tape, if only out of curiosity and gadget-mindedness. Increases the usefulness and scope of one's machine. A sizeable audience already exists now, thanks to home tape machines already sold.

2. Tape records will stimulate the tape machine industry. Concertone makes its own. AV has already been working with machine makers and Pentron, for one, has announced a tape player for playback only, minus the recording feature. (See New Products.) Ampex may well revive the 450 super-player announced last year if there is good reason.

It is clearly realistic business to base a tape library development on close tie-ins with the machines themselves and, moreover, the rest of the forming picture may be more easily sketched in starting from this concrete base.

Duplication

Right along with the above is still another factor, a tie-in. Concertone can easily set up inexpensive batteries of its own machines to do the basic tape copying from masters. Common power supplies, simplified or modified innards would be no trouble, given the basic mechanism. Similarly, Audio & Video are both agents for machines and owners of similar batteries of them, used alternatively for other business. Thus both these libraries will start with most of the "plant" already available. Double-speed recording or even 4 or 8 times as fast can save time in dubbing without involving too-great engineering problems.

AV, I gather, will lay in sizeable stocks of material. Concertone, I infer, plans to do more of a quick-service on-order job. Purely a matter of practical policy. Disc records are made, after all, on a combination of stock and special-order runs. No real problem here.

AV is further along in plans, with detailed information on the AV library. The set-up: all reels ½ hour, offered in 4 versions, at 3¾ and 7½ in., single and dual, lengths to fit, on 5- and 7-in. reels. List price runs from $4.50 for the slower dual to $8.75 for the faster speed single—which means that tape is going to be a lot more expensive than LP disc, per playing time unit.

Thanks to Ampex 400 (Concertone may well duplicate the widened tonal range) this tape at 7½ will give wide-range response, easily up to best LP standards I'd say, with less distortion and noise. At 3¾, quality at best is quite good, range up to 5 or 6 thousand. However, only the proper machine will give all of this; many present players, including expensive ones, have too wide a gap to play the full tonal range. Home players will sound as well as they can—the machine, not the tape being the limiting factor. AV's 3¾-in. tape, played on a Revere, was remarkably steady, with good quality through a fancy speaker. Standards are high. Concertape is not officially launched yet but we may expect roughly similar standards, possible if the Concertone machines are used with factory supervision and control. It would seem likely that Concertone may indulge in larger reels to suit their larger machine. There will be close tie-ins with present Concertone ownership, in the Concertape distribution.

Music

Aha! If you are exploding at this point to know *what's* available, you are a true music lover. For the present, alas, AV's library holds no interest at all for the classical lover. 14 preliminary rolls, two more a month (in the fall); of the 14, all but one are dinner and cocktail music, safe and sound; classical daring is represented by the Nutcracker Suite and the Faust ballet music. AV is not committed necessarily to this—they have here a planned experiment, hope to be able to try other musical areas. Frankly, I don't go along with this idea, but then I'm no market researcher. I feel, however, that hi-fi and LP between them have enormously changed the old rigid ideas about classical music, and even about classical best sellers. Anything may go, these days. I feel that cocktail music may have a solid and dependable initial sale but that its limits are severe, it will not interest the large number of hi-fi people, of home record and tape machine owners, who would be enterprising enough to want to try tape. I may be utterly wrong.

Concertape, still in the planning stage and not yet actually in existence, is to the best of my knowledge to be slanted in just the opposite way, appealing fairly directly to the classical listener, with policies somewhat like many LP companies now existing. We can assume that there will also be popular or light Concertape material, but there certainly will be music for the foreground listener.

Neither company plans to reissue music available on discs. A basic and wise decision. AV's music is anonymously performed. OK in the present area, not so good for classical demands. Concertape would have artists contracted for and announced in the usual way.

Both of these endeavors are in a sense explosive. Both may expand suddenly or wither; both are apt to shift ground as experiment indicates. Concertone (partly I think at my suggestion) may consider simultaneous dual-channel records or modification of the same, with special head attachments for the Concertone machine, thereby achieving a wholly new type of reproduction so far impossible with disc records. We may be sure that, behind many a scene in many a company, these ventures will be watched with hawk-like interest. We can also be certain that under-cover experiments have been going on in this direction since the beginning of tape. Rumors of big-company plans of this sort reached me, and were reported, almost two years ago. Anything might happen—but probably won't unless the present record business gets into a really bad hole. We shall see.

RECORDS

R. Strauss, Der Rosenkavalier. Complete Recording. Soloists of Dresden State Opera, Saxonian State Orchestra, Kempe.
Urania LP
URLP 201 (4)

Haydn, Orfeo ed Euridice. Complete Recording. Soloists, Orchestra & Chorus of Vienna State Opera, Swarowsky.
Haydn Society LP
HSLP 2029 (3)

Mozart, Don Giovanni. Complete Recording. Soloists, Vienna State Opera Chorus, Vienna Symphony, Swarowsky.
Haydn Society LP
HSLP 2030 (4)

Here we are again with a glimpse at what has become one of the most significant phases of the LP revolution in many respects—complete opera. Note a number of interesting points herewith. First, these are small-company releases again. The large companies have just begun putting out complete operas, still favor the old pattern of opera "high-lights" or excerpts. The reason should be obvious—most large companies are entangled with other speeds than LP, an enormous disadvantage in these long works. The small all-LP companies still have this one great and vital lead over their huge rivals and they continue to exploit it— but nowhere more effectively than in the musical colossus. In operas of this sort the issuance of any speed other than LP is virtually unthinkable now. (Unless, mayhap, at 16 r.p.m.!)

The "Rosenkavalier" recording, of which I have played so far a mere half hour or so, is a really stunning job, done on the latest German Magnetophon equipment at 30 in./sec. (Old-style German tape, new recording equipment.) Urania not only exploits the usual favorability of European recording and its cheapness—accountable for a huge segment of existing LP repertory—but, note well, this recording comes from the East Zone of Germany. Most interesting; for it seems that, curtain or no, the operation of an American company there in all its tremendous technical, musical and organizational detail is quite feasible; moreover, the Magnetophon recording would seem to be in no way different in quality from the best in the West Zone—suggesting that Magnetophon equipment circulates freely, somehow or other, in both zones. This is a lively, well sung performance, the sound excellent with very low distortion in the voice parts and unusual microphoning, a close-to, sharp-voice sound to the solos, yet with a volume balance that keeps the solos reasonably low in level, the orchestra loud enough, though at a greater "distance."

The Vienna Haydn Society recordings, from another section of divided Europe, are presumably done on American tape at 15 in./sec. Acoustics and mike balance count far more than any technical difference—here is a quite different mike technique, the voices at more nearly stage distance, a biggish liveness in "Don Giovanni," a somewhat more intimate, deader sound (appropriate to the musical style) in the Haydn Opera. One must judge these differently on the musical side: "Don Giovanni," a world famous opera, often done, with the very finest available singers (cf. the RCA Glyndebourne recording on 78, soon to be reissued on LP) is given a relatively stiff and stodgy performance here—though far from unlistenable. The Haydn, a rare masterpiece virtually never heard, has no competitors whatsoever and so must be taken with thanks as good music otherwise completely unavailable, and this in spite of a certain stiffness and a few ineptitudes in the performing. These Haydn Society large-scale releases struggle manfully to avoid an ever-threatening sense of academic overweight; a tremendous expenditure of brains and work on the scholarly background, on outward authenticity, sometimes at the expense of really top-flight artistic recreation. This is inherent, no doubt, in a combined scholarly and performance organization such as this one, and we can easily forgive it in view of the contributions of Haydn Society to our greater æsthetic pleasure. All of the above operas come boxed, with elaborate notes and complete libretti in both languages; a leisurely study of any one would take weeks to complete, so great is the content of these offerings.

Remington again

The "answer" to the launching of the low priced Remington LP was a possibly coincidental price rise in all other records, instead of a cut. (That was, perhaps, to take care of the widespread 30 per cent discounts that still obtain in the large cities and via mail order on virtually all LP material.) The first Remingtons, as reported, were strictly a mixed bag, with some pretty squashy lemons in the lot. But since then the company has expanded phenomenally and—however it is managed—I must objectively report that the new issues of the company, speaking generally, have (a) quite excellent recording, pressed on an adequate material with soft hiss, trademarked Websterlite; (b) a surprisingly interesting musical catalogue, both of standard works and of many unusual items easily as enterprising as those from small companies charging standard prices, and finally (c), though the percentage of sour notes and the like is fairly high, musical performances of decidedly high value, and a general musical average not significantly below that of other LP companies. All of this though the records sell at something less than half the price of others.

Is this a matter of unusually good business acumen, or, as some presumably jealous competitors might be ready to suggest, is there something rotten in Denmark? That, again, my friends, is a matter into which it is not my business nor interest to investigate. The facts as to the records themselves are clear enough. For the price, they are unexpectedly good and their position in the market is decidedly not one to ignore. Here are a few samples:

Beethoven, Symphony #3 ("Erioca").
Austrian Symphony, Fritz Busch.
RLP 199-21

Haydn Symphony #101 ("Clock").
Austrian Symphony, Fritz Busch.
RLP 149-32

Busch is one of the finest Mozart-Haydn-Beethoven conductors and these two, while exhibiting some sour notes, are masterful interpretations, notably the Eroica scherzo and the finale of the Clock.

Mozart, Symphony #40
Salzburg Festival Orch., Paul Walter
RLP 149-23

Schubert, Symphony #6
Austrian Symphony, Woss.
RLP 149-30

Two lesser performances, both at least as good as average in other LP offerings, both with the quite good recording now apparently standardized for the line.

Bizet, Symphony in C
Paris Conservatory, Allain
RLP 199-31

A clinker—and with supposedly one of the best orchestras in Europe! It's not only as fault-ridden as any of these with lesser orchestras, but the performance is astonishingly wooden.

RECORD LIST

Try these on your hi-fi outfit

(Note: These are LP's recommended as combining top technical quality with good microphoning for the type of music, plus at least reasonably good musical performance. Detailed reviews omitted for quantity coverage. Readers' opinions on the value of this type treatment—to cope with unprecedented floods of LP—as compared with selectively detailed discussion, as in past issues, will be appreciated. Future policy is wide-open!)

* Outstanding over-all sound. ** Very unusual.

Modern—pretty tough, but plenty hi-fi.

***Bartok, Miraculous Mandarin** (ballet).
Bartok BRS 301.

Milhaud, Quartet 1912; Turina, La Oracion del Torero.
Polymusic PRLP 1004

Berg, Quartet op. 3; Casella, 5 Pieces.
Bartok BRS 006

Hindemith, Quartet #4 (Guilet)
Concert Hall CHS 1086

Bartok, The Six Quartets (Juillard).
Columbia ML 4278/79/80

***Bartok, Violin Sonata #1.**
Columbia ML 4376

Prokofieff, Wind Quintet op. 39; Ov. on Hebrew Themes; Swanson, Night Music.
Decca DL 8511

Schoenberg, Quartet #3.
Dial #4.

Modern—easier listening

Prokofieff, Piano Concerto #5; Piano Sonata #5.
Period SPLP 527

Britten, Fantasy for Oboe & Strings; Quartet #1.
Esoteric ES-504

*__Bernstein, The Age of Anxiety__ (ballet).
Columbia ML 4325

Barber, Symphony #2
Barber, Medea Ballet Suite
Barber, Cello Concerto
London LPS. 334, 333, 332

Barber, "Knoxville, Summer 1915" (sop. & orch.)
Columbia ML 2174

*__Villas-Lobos, Bachianas Brazilieras #1; Chorus #4, #7.__
Capitol P-8147

Hindemith, Symphony in E Flat (1940).
Columbia ML 4387

Bartok, Rhapsody, piano & Orch; 1904; 15 Hungarian Songs; Sonatina. (Foldes).
Polydor-Vox PL 6410

Modern—lush

*__Ibert, Suite Elizabethaine; Divertissement; Capriccio__ (all orch.)
Westminster WL 5061

*__Dohnanyi, Suite in F Sharp for Orch.__
Columbia ML 2172

Martinu, Sinfonietta La Jolla. Britten, Les Illuminations.
Alco ALP 1211

Nystroem, Sinfonia del Mare.
Dial #11

Music of Mexico (Symphonic)
Decca DL 9527

Good solo piano

*__Liszt, Annees de Pelerinage: Italie__ (Balogh)
Lyrichord LL 14

Liszt, Two Legends; Annees de Pelerinage (Kempff)
London LLP 315

Beethoven, Sonata op. 110; Schumann, Etudes Symphoniques. (Casadesus).
Columbia ML 4388

Beethoven, Sonatas op. 31, #2; op. 81a (Novaes)
Vox PL 6270

[s]**Beethoven, Sonatas op. 109, 110** (Demus)
Remington RLP 199-29

Beethoven, Sonata op. 106 (Horszowski)
Vox PL 6750

Schubert, Sonata in B flat (posth.) (Kempff)
London LLP. 307

**__Schumann-Brahms Recital__ (Sandor)
Columbia ML 4375

[f]**Chopin, Four Scherzi** (Rubinstein)
RCA Victor LM 1132

[o]*__Schumann, Kinderscenen; Piano Sonata #2.__ (Blancard)
Vanguard VRS 415

[f]**Schumann, Carnival; Chopin, Sonata #3.**
Vox PL 6710

[s]**George Copland plays Debussy**
M-G-M E-526

Music of Fauré (Kathleen Long)
London LPS 260

[p]**Brahms, Three Intermezzi** (Kempff)
London LPS 205

[m]**Rachmaninoff, The 24 Preludes** (Lympany)
London LLP 328/9

Key: [s] some surface noise. [f] some flutter [o] overcut in spots [p] tends towards the percussive. [m] mechanical background noise.

SPEAKER EFFICIENCY

[*from page 14*]

speakers are fairly large (10 to 15 mils) and are primarily responsible for the space factor being so low. These facts, combined with the greater manufacturing difficulties and costs of edgewound coils, account for the more widespread use of round-wire voice coils.

The product αlV is the magnetic energy embraced by the actual conductor in the voice coil. It can be determined for a completely assembled speaker by measuring the blocked force produced by d.c. power in the voice coil. The use of d.c. is permissible because of the piston range characteristics enumerated earlier. The force F is BlI_s, and the power P is $I_s^2R_s$. Thus the quotient $F^2/P=(Bl)^2/R_s$, which by the relation developed for gap energy is also $8\pi\alpha lV/\rho$. Thus

$$\alpha lV=\frac{\rho}{8\pi}\frac{F^2}{P} \qquad (6)$$

If the force is measured in pounds and the power in watts, then $\alpha lV=1.35\times 10^6F^2/PC$ *ergs*. If a spring scale is used for measuring the force, the reading must be taken with the voice coil restored to and in its undeflected rest position so as to avoid the undesired extra contribution from the restoring force of its annulus and centering member. Special test devices are easily made for measuring or comparing the product αlV.

Voice-Coil Winding

If the voice coil is wound with other than copper, but with the same dimensions and space factor, then the relative conductivity will affect the efficiency by the factor C. If aluminum is the alternate material to copper, its C is 0.64, thus lowering the efficiency. However, its density is only 0.33 that of copper, so a smaller total mass should result, increasing the efficiency by the $1/m^2$ factor. It turns out that a change from copper to aluminum will not improve the efficiency unless the copper voice-coil mass is over 30 per cent of the total moving mass. In most cases this condition will obtain only when the speaker is specifically designed as the low-frequency end of a two-way system.

The factor (m/d^2) in the denominator is a measure of the surface density of the moving system. It varies (in units of grams and inches) from about 0.15 to 0.30 for standard speakers in the 8- to 18-in. range. In the popular 10- and 12-in. sizes it is about 0.25. Thus there is not too much variation in this factor, which leaves the gap energy as the principal variable in the efficiency. The value of m may be estimated by first measuring f_0, the frequency of resonance. Then add to the voice coil region of the cone of the speaker a known non-metallic mass m_1, such as modeling clay, which will cling to and vibrate with the cone. Measure the new resonant frequency f_1. The mass m is then given by $m=m_1/[(f_0/f_1)^2-1]$. It is best to make m_1 fairly close to m.

In the piston range the frequency is usually low enough so that the sound pressure will not vary much with angle. On this basis a speaker which would absorb and convert into the acoustical form all power available to it would produce at a distance r feet in front of it a sound pressure level given by

$$L_p=L_w-20\log_{10}r+92.5 \qquad (7)$$

Here all the radiation is assumed to be confined to a hemisphere in front of the speaker and infinite baffle. L_p is the sound pressure level in decibels above 0.0002 dyne/cm²; the unit is the dbp, from analogy with *dbm*. L_w is the input available power level in decibels above one milliwatt, and thus is in *dbm*. A non-directional speaker of 100 per cent efficiency should thus produce, with one watt available input, an axial sound pressure level at ten feet of 102.5 dbp. A standard 12-in. speaker will have a piston-range efficiency of about 2 per cent, so it will produce a level of 85.5 dbp under the above conditions. This will be increased by directional effects starting near the end of the piston range. This use of free-space measurements of sound pressure for calculating the total radiation in a room is justified in the piston range, where the effect of the room is small.

It is to be noted that this simple use of efficiency in pressure level calculations is not possible if the efficiency is based on the ratio of motional to total impedance. The efficiency should reflect two characteristics of the speaker: the ability to absorb power from the load without causing undue distortion; and the ability to convert the power absorbed into the acoustical form. The "energy efficiency" calculated by motional resistance measurements neglects the first factor.

When speakers are audited properly, they may be rank ordered in terms of loudness. It will be found that this order is not necessarily that of the piston-range efficiencies. This arises from the determining influence of the frequency range from 1000 to 4000 cps on the loudness. Since these frequencies are outside the piston range, no correlation is, of course, to be expected. However, for speakers of similar total radiation response shape the piston-range efficiency should be a very good indication of the loudness rating.

In closing, it is believed that the efficiency relations discussed provide a useful means of comparing the basic performance of direct-radiator speakers. The factors entering into the expression may be measured independently, or the efficiency may be calculated from observed sound pressure levels. The principal factors are shown to be the gap energy and space factor, and their relation to some design considerations has been noted.

NEW LITERATURE

• **Sola Electric Co.,** 4633 W. 16th St., Chicago 50, Ill. has recently published an interesting 24-page two-color booklet devoted to an overall description of the company—its history, its production facilities, and the products it manufactures. Long known for its eminence in the constant-voltage-transformer field, Sola is to be commended for an excellent job in the field of public relations.

• **Engineering Products Department, Radio Corporation of America,** Camden, N. J. has available for broadcast engineers a 4-page illustrated brochure describing in detail the new RCA Type BTL-1A STL equipment. Well illustrated and text is strictly to the point. Must be requested on station letterhead.

• **Hickok Electrical Instrument Company,** 10617 Dupont Ave., Cleveland 8, Ohio, is offering free of charge a 16-page booklet illustrating and describing the four basic methods of tube testing. Circuit diagrams and useful formulas are included. Also a catalog listing of various Hickock test instruments.

• **Sigma Instruments, Inc.,** 170 Pearl St., South Braintree (Boston 85), Mass. has available its new Catalog 51-3, an exceptionally well-handled illustrated listing of the complete line of Sigma sensitive relays. In addition to pictures, dimensional drawings, and rating tables, the booklet contains a wealth of technical data to help the designer in the selection of the proper relay for any given application. The Sigma catalog is the type of industrial publication that should receive the recognition and approbation of the entire industry.

• **Roberts Numbering Machine Company,** 700 Jamaica Ave., Brooklyn 8, N. Y. has recently published a two-color leaflet titled "Metal Identification Marking". Of interest chiefly to companies with problems in metal stamping or embossing, the leaflet covers such diverse subjects as parts identification, embossing, engraving, and serializing.

• **Audio-Video Recording Co., Inc.,** 1650 Broadway, New York 19, N. Y. has prepared a unique pocket-size rate card listing charges for every conceivable type of recording service. Both tape and disc recording, dubbing, duplicating, editing, and processing are included. Will be mailed free upon request to anyone making use of recording media.

• **The Astatic Corporation,** Conneaut, Ohio, has recently completed preparation of a new phonograph cartridge directory and replacement guide. Cartridges manufactured by competing companies are listed, together with recommended Astatic replacements. Printed on heavy stock to withstand frequent usage, a copy may be obtained by writing for Form No. S-168.

• **Berlant Associates,** 4917 W. Jefferson Blvd., Los Angeles 16, Calif. will mail on request a new bulletin which illustrates and describes the Concertone basic magnetic-tape recorder, together with standard accessories. Included in the data are schematic diagram, frequency response curves, and list prices.

• **Linde Air Products Company,** 30 E. 42nd St., New York 17, N. Y. has assembled a wealth of interesting data on the company's synthetic single-crystal products in a new 4-page booklet titled "Linde Synthetic Crystals for Industry". Synthetic sapphire, spinel, titania, calcium tungstste, and other materials are arranged in tabular form. Properties, available forms, and uses are listed. Copy of the booklet will be mailed without charge.

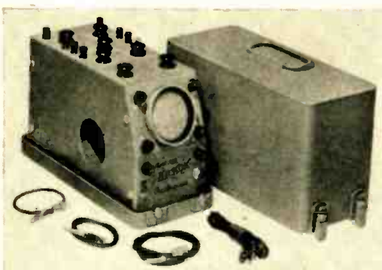
• **General Electric Tube Divisions,** Syracuse, N. Y. has recently published a 107-page pocket-size handbook listing essential characteristics of every type of vacuum tube likely to be found in a home receiver—AM, FM, or TV. Basic diagrams of 856 different tube types are shown, together with performance data. The book is priced at 35 cents and may be obtained only through General Electric and Ken-Rad tube distributors.

NEW PRODUCTS

• **High-Quality Amplifier.** Altec Lansing's new amplifier for home music systems is of the remote-control type, consisting of a Type A-433A pre-amplifier-control unit

and a Type A-333A power amplifier mounted on separate chassis. Among front-panel controls is a three-position selector switch permitting choice of recording turnover frequencies. The user has available the correct crossover for European 78's, LP's, and records made in accordance with AES standards. Other controls provide rise and droop for both treble and bass, input channel selection, and volume control. Three inputs permit use of magnetic pickup, tuner, and tape reproducer. Frequency response is virtually flat from 20 to 20,000 cps. Harmonic distortion is less than 5.0 per cent at full 27-watt output, and is less than 0.5 per cent at 15 watts. The A-433A and A-333A are available either in combination or as separate units, the A-433A being equipped with a six-foot flexible cable for interconnection with any conventional power amplifier. Technical bulletin available from jobbers or by writing Altec Lansing Corporation, 9356 Santa Monica Blvd., Beverly Hills, Calif.

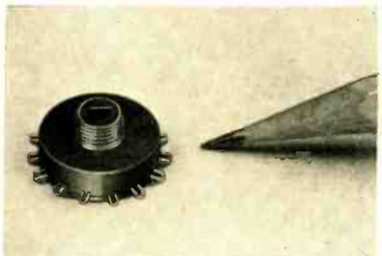
• **Portable Oscilloscope.** Further expanding its line of test equipment, Hickok Electrical Instrument Co., 10617 Dupont Ave., Cleveland, Ohio, has recently introduced the Model 380 "Miniscope", a three-inch oscilloscope with frequency coverage to 2.5 mc, and sensitivity to 0.1 r.m.s.



volt/in. Shock mounted and housed in a moisture-proof aluminum case, the Miniscope is an excellent instrument for military and laboratory use where portability is a factor. Size is 6 × 9 × 13¼ in. Complete technical information will be supplied by the manufacturer.

• **FM Tuner.** Precise tuning is accomplished by means of a microammeter in the new Model HP-14 FM tuner manufactured by Collins Audio Products Co., Inc., P.O. Box 368, Westfield, N. J. Engineered to meet exacting requirements, the HP-14 uses 14 tubes and permeability tuning to achieve sensitivity and selectivity. Automatic squelch circuit may be switched in or out as desired. With squelch out maximum sensitivity is between 5 and 10 microvolts. The tuner output may be fed into any load from 500 ohms to 0.5 megohm. Output level is approximately 3 volts, dependent upon the load resistance. Image ratio is 1500 to 1, and audio response is flat to beyond 15,000 cps.

• **Tiny Rotary Switch.** Developed to meet the need for miniaturization in airborne electronic equipment, a new rotary switch recently announced by Electro Development Corp., 6014 Washington Blvd., Culver City, Calif. is less than one-tenth the size of conventional units for performing



similar functions. Diameter of the new Edco switch is 5/8 in. and the switch body is 3/16 in. thick. Insulation between shaft and contact arm will withstand 2500 v.a.c. Contacts are of pure silver. Technical literature available from the manufacturer.

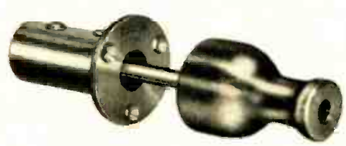
• **Carrier Dialing System.** Users of Type H-1 Western Electric carrier systems may convert the equipment for dial signalling through use of an inexpensive auxiliary unit now being manufactured by Lenkurt Electric Co., San Carlos, Calif. In oper-

ation the new Lenkurt auxiliary permits full-duplex carrier-frequency dial-signaling pulses at 10 to 14 pps on frequencies not essential to the H-1 voice channels. The equipment is exceptionally compact, occupying less than nine inches of panel space on a standard 19-in. rack.

• **Electronic Counter.** Operating considerably beyond the range of standard mechanical counters, the new Berkeley Model 10 electronic counter is capable of counting any electrical, optical, or mechanical occurrence that can be converted into electrical impulses, at rates up to 6000 per minute. Capacity is 9,999,999. The

Model 10 is unique in the fact that all circuits have been developed around a single tube type, the 12AU7, to facilitate replacement. Selenium rectifiers provide d.c. power supply. Manufactured by Berkeley Scientific Corporation, 2200 Wright Ave., Richmond, Calif.

• **Tandem-Type Connector.** Although it was designed primarily for use in electric analog computers, the new Cannon Type CS connector is adaptable to many other applications where tandem-type contacts are required. Because of its low capacitance and contact resistance, the CS connector is espe-

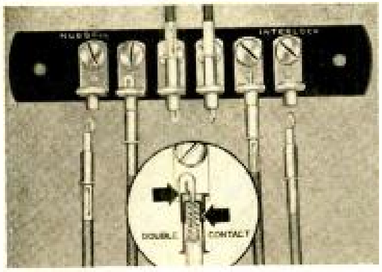


cially well-suited for setting up analyzer circuits. The CS plug has a single silver-plated brass contact ¼ in. in diameter, and the receptacle contains two socket contacts in tandem, insulated from each other. Bulletin RCS-1 will be mailed free by Cannon Electric Company, 3209 Humboldt St., Los Angeles 31, Calif.

• **Fifty-Watt Utility Amplifier.** Two separately controlled 25-watt channels are a unique feature of the newest addition to the Newcomb E Series of low-cost utility amplifiers. With inputs for three microphones and a record player, the E-50D amplifier is ideally suited for application where individual control is

needed simultaneously for two auditoriums with different power requirements. A jack is provided on the chassis to permit interconnection with another E-50D, thus affording 100 watts of audio power from four separately controlled channels. Manufactured by Newcomb Audio Products Co., 6824 Lexington Ave., Hollywood 38, Calif.

• **Interlocking Connectors.** Major improvement in design is inherent in the new, patented line of connectors recently placed in production by Harvey Hubbell, Inc., Bridgeport 2, Conn. Introduced as



the Hubbell Interlock, the new connector has an automatic locking action which takes place when the plug is inserted in the outlet. Contacts themselves form the lock, and are held under constant coil spring pressure. Release is simple, requiring only slight thumb pressure on an exposed flange. Data sheets are available from the manufacturer upon request to Department X.

• **Dynamic Headphones.** Frequency response flat from 100 to 7000 cps is featured in the new high-fidelity dynamic series of headphones recently announced by Permoflux Corporation, 4900 W. Grand Ave., Chicago 39, Ill. Also stressed in design of the new phones is freedom from irritating blasts and rattles. They are exceptionally well-suited for TV studio monitoring, and already have been chosen for this purpose by a number of prominent orchestra conductors. Full information may be obtained by writing the manufacturer for Catalog J203.

• **Handy Card Reference.** A wealth of technical information, with meaning in all phases of mechanical and electrical engineering, is contained in "Card-All", a compact reference tool available from General Design Company, 1200 Commercial Trust Building, Philadelphia 2, Penna. Made of heavy varnished cardboard to withstand constant usage. Card-All is a compact assembly of much of the technical data required in general engineering practice.

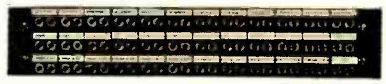
• **Miniature Insulated Terminals.** Manufacturers engaged in the miniaturization of electronic equipment will find interest in three new insulated terminals now be-

ing marketed by Cambridge Thermionic Corporation, 464 Concord Ave., Cambridge 38, Mass. The smallest of the new series, Type X1980XA, has an overall height of only three-eights of an inch including terminal. Terminals are available in various lengths with voltage breakdown ratings up to 5800 volts. Additional data will be supplied by the manufacturer.

• **Variable Reluctance Pickup.** High-quality and low price are both featured in the new Clarkstan Model 204 pickup cartridge, a velocity-responsive unit with frequency curve virtually flat to above 10,000 cps. Stylus is removable and interchangeable, permitting use of a single unit for standard, microgroove,

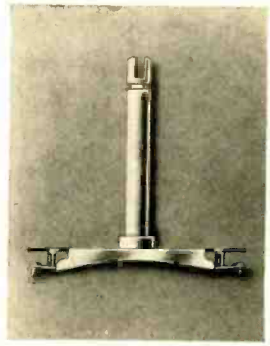
and transcription recordings. Unique in design, the 204 is housed in clear polystyrene plastic. Weight is 14 grams and overall length is 1½ in. Full technical information will be supplied by Clarkstan Corporation, 11921 W. Pico Blvd., Los Angeles 64, Calif.

• **Jack Panels.** Advanced constructional features provide an improved standard of mounting convenience in the new line of jack mounting panels recently introduced by Audio Equipment Sales, 153 W. 33rd St., New York 1, N. Y. Marketed under the trade name AUDIO-LINE, the new jack panels are available in 11 types—for single- and twin-plug cords, in single, double and triple rows, and with panel sizes for minimum rack space as



well as panels of standard rack multiples. Appearance is improved by use of a one-piece front panel without conventional mounting slots. Installation is simplified by means of a concealed clamp mounting. Half-oval Plexiglas designation strips plug into panel without the use of screws. Panels are available with brass or chrome jacks, or minus jacks.

• **Diamond-Tipped Styli.** Increased public demand for permanent styli is answered by the new Walco line of diamond-tipped needles for Astatic, GE, Shure, RCA, Philco, and Webster-Elec-



tric cartridges. According to the manufacturer, Electrovox Co., Inc., East Orange, N. J., the new Walco styli comprise the first complete line of diamond-tipped needles available for use in standard cartridges.

• **Magnetic Tape Player.** This new Pentron development is ideally suited for those instances where tape reproduction is required without the need for recording facilities. Available with or without self-contained amplifier, the Pentron player is capable of playing back tape recorded on any standard recorder at either 3¾ or 7½ in./sec. Model PB-1 contains a built-in pre-amplifier and may be fed into any standard amplifier, radio

or TV receiver. Model PB-A1 contains in addition a five-watt amplifier and 5¼-in. PM speaker. Frequency range of both models is 50 to 8000 cps at 7½ in./sec. and playing time is one hour. Flutter is less than 0.5 per cent. Weights of the two models are 4½ and 7 lbs. respectively. Full details will be supplied upon request by The Pentron Corporation, 221 E. Cullerton St., Chicago 16, Ill.

COMPENSATED CONTROL

[*from page 15*]

has been suggested that all manufacturers use 400 cps as the bass turnover frequency. The curves in *Fig*. 4 are plotted around this point. The next step is to add treble compensation (*Fig*. 1).

There are two reasons for adding this compensation:

1. To make up for the loss in highs due to adding the bass compensation. (The turnover of C_1 and R_3 causes a flattening out of the curve, but not 100 per cent. There is always some attenuation of highs above the turnover point.)
2. To make up for the hearing loss in highs as the volume is lowered, in accordance with the Fletcher-Munson curve.

Selection of Boost Frequencies

From the hearing curves we can pick out the necessary treble boost for this tap point. Since the tap is already set, the value of R_1 is fixed. If capacitor C_2 is added across R_1, the highs above the turnover point are boosted. This upper turnover frequency is the point at which $X_{C_2} = R_1$. (Refer to *Fig*. 1.) A suggested treble turnover frequency would be 2500 cps to make the turnover frequencies of bass and treble symmetrical on each side of 1000 cps. The curve can now be calculated or an oscillator and vacuum-tube voltmeter can be used to obtain the curve experimentally. This control can be designed as a separate unit from the amplifier, or together with it as desired. If it is designed together with the amplifier, the tone controls on the amplifier should be set to the "flat" position. Then with the volume control in maximum volume position, a flat reference curve is obtained. Let this flat curve be equal to the 100-db Fletcher-Munson curve which is flat and add the boosts accordingly as the midrange level is reduced at the different taps. If more bass compensation is needed, lower R_3 and increase C_1, thus keeping the same turnover frequency. If more treble boost is desired and R_1 is fixed by the tap, it is attained by increasing C_2, which turns over at a lower frequency and allows the curve to start rising sooner. If less treble boost is desired, decrease C_2, making the turnover frequency higher and the treble rise will start later.

In adding the networks for the second tap, the same procedure should be followed. Keep the same bass turnover frequency as before for the network C_3 and R_5 as in *Fig*. 5. The treble boost network is C_4 and R_2. Referring to the sound pressure curves again, it can be seen that the treble increases as the bass increases with each successively lower tap but to a lesser degree. To do this, the treble turnover frequency at this second tap must be increased, thus allowing the treble to start rising later in the curve. C_4 does not return to the top of the control, but only to the tap above it. It only continues the treble rise started by the first tap.

One thing might be pointed out. Do not run the treble boost capacitor from the top of the control to the arm for continuously variable treble boost, because even though this works well as the arm is lowered from the top down to the tap, treble boosting continues below the tap while the bass boost stops at the tap. This over-boosts treble response.

The taps can be located as desired, but it is found that a nice result is obtained by setting the top tap at one-third the total resistance and the bottom tap at one-sixth total resistance. On a 1-meg control, these would be 0.33 and 0.167 meg, respectively. The curves of *Fig*. 4 show how closely the respective bass and treble boosts follow the Fletcher-Munson curves at each tap point.

A check of the hearing curves will indicate that the 100-db curve is approximately flat. For a reference level, it must be assumed that the maximum volume position as at this flat position. The nearer to this 100-db level the maximum volume of the amplifier is, the closer to reality the music will sound.

It is hoped that this article will indicate a simple but complete way of designing this type of control. The component values will change with different turnover frequencies, and are not to be taken as fixed values that must be used. It is realized that when used with certain amplifier curves, it may be desirable to under-compensate or over-compensate the volume control.

AUDIO PATENTS

[*from page 4*]

other end of R_1 is connected to the grid (through a blocking capacitor) and also to a capacitor leading back to the plate.

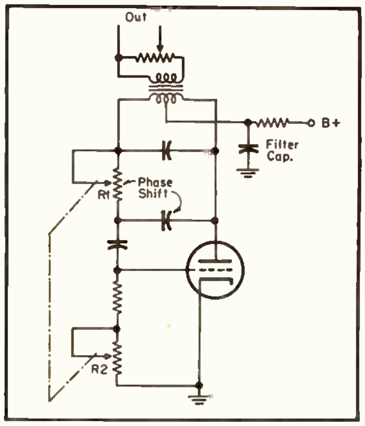


Fig. 3

R_1 and this capacitor in series form a phase-shift network. By adjusting R_1 the operator can adjust the phase shift and thus the phase angle at which voltage reaches the grid. A change in this phase shift will, of course, cause a shift in oscillator frequency, and in this way the vibrato rate of the instrument is variable with a single control.

Frequency changes made in this manner tend to cause changes in the amplitude of the vibrato-frequency output. For a change from 4.7 to about 6.1 cps the output amplitude change is less than 6 per cent which is tolerable. Greater frequency changes, however, cause larger amplitude variations. To compensate, a part of the grid leak is made variable. R_2 can be ganged with R_1 on the same shaft so that the player can vary both at once, obtaining a large variation in vibrato rate without causing the amplitude change which would result in decreasing vibrato depth (amount of frequency swing in the tone generator).

Variable Phase Shifter

W. C. Morrison of Princeton, N. J., is the inventor of an interesting device which will shift the phase of an audio voltage between zero and almost 180 deg. continuously, either statically by adjusting a control or dynamically in response to a modulating voltage. The patent number is 2,547,767 and it is assigned to RCA.

The circuit appears in *Fig.* 4. The inventor states in the patent that he is not sure how it works but he gives an explanation he believes to be correct. Input voltage applied to the transformer primary is applied between grid and ground in series with a small bias voltage. The shield grids are connected to the B-supply though resistor R_1 across which degeneration voltage appears because the shield grids are in the electron stream. (Ignore capacitor *C* for the moment.) The voltage developed in this way across R_1 is in phase with that across R_2, which is the plate load. This relatively large signal across R_1 is applied to that part of the shield grid which lies between the screen and suppressor.

The screen is connected to a potentiometer across the bias battery, so that its potential can be varied between zero and about 7.5 volts negative. As the screen voltage is made more negative more electrons travel to the part of the shield grid

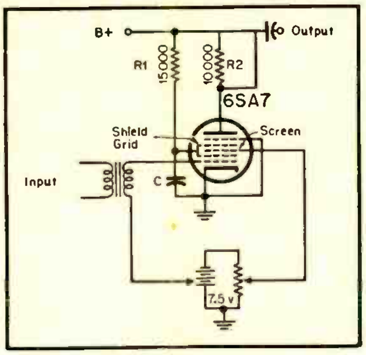


Fig. 4

between the control grid and screen, lowering the shield-grid voltage, and less go to the plate, raising the plate voltage. At some value of screen voltage, the modulation of the electron stream by (a) the input (control-grid) voltage and (b) the voltage on the upper portion of the shield grid is equal. Since the two are 180 deg. out of phase, the net tube output (a.c.) is zero.

As the screen voltage is made more negative now the effect of the upper shield grid voltage is *greater* than that of the control grid voltage and the plate output voltage is in phase with that of the input. In practice, if control grid excitation is about .05 volt r.m.s. and the screen voltage is varied from zero to −6 volts, the output plate voltage is shifted 180 deg. At zero screen volts the plate output is about 3 volts and is the conventional 180 deg. out of phase with the input. As screen voltage goes negative, plate output goes down to zero, then rises again to 3 volts in phase with the input.

Now let us insert capacitor *C*. This is not a bypass but is chosen as a phase shifter so that the degeneration voltage on the shield grid is no longer 180 deg. out of phase with the input but has some odd phase relationship. Now when we vary the screen voltage and gradually transfer control of the electron stream from the control grid to the upper part of the shield grid, the phase of the plate output changes gradually over a range which approaches (but does not reach) 180 degrees.

The amount of phase shift affects the variation in output amplitude. The inventor has found that a range of about 120 deg. can be covered with an amplitude variation of about 6 db. The control function, instead of being performed by a potentiometer across the bias battery, can be delegated to a transformer as in *Fig.* 5. That gives us

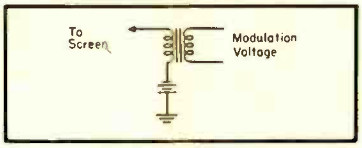


Fig. 5

a phase modulator when we feed modulation voltage to the transformer primary. In a transmitter the input frequency to the tube's control grid would be r.f. and with this simple circuit an extremely large phase deviation would be possible compared to conventional methods. Effective frequency deviation is equal to the phase shift in radians times the modulating frequency. A shift of 2 radians is possible with this circuit, compared to about 0.5 radian with most others; this means that following frequency multiplication to obtain the full frequency swing in an FM transmitter could be reduced by a factor of 4 or so.

Another use which suggests itself is for vibrato in either electronic musical instruments or such devices as guitar amplifiers. When the frequency of a musical signal cannot be varied at its source—as, for instance in an electro-mechanical instrument like the Hammond or in a guitar whose player is not skilled in the necessary finger motion—ordinarily the only effect possible in following amplifiers is tremolo, a variation in amplitude. Vibrato might be obtained, however, by incorporating this phase shifter in the amplifier and modulating the screen with a 5- to 8-cps signal from a vibrato-frequency oscillator such as those described earlier. Since resultant frequency deviation is equal to the maximum phase shift times the modulating frequency, a 6-cps vibrato modulator signal would produce a 12-cps deviation with the shifter adjusted for a 2-radian (about 115-deg.) maximum shift. Deviation would, of course, vary with music-signal frequency since any one value for capacitor *C* would produce a different phase shift at different frequencies. A little more calculation and some experimentation in this line might yield some interesting answers.

LETTERS

[*from page 6*]

in item 38, diamond as being 4½ times as hard as sapphire. The term "hardness" is, by itself, meaningless, since it can refer to any one of a number of different properties of a substance such as resistance to breakage, resistance to indentation, resistance to scratching, stretching, bending, and so on. With respect to phonograph stylus usage the important property to measure is resistance to abrasive wear, and it was determined many years ago that in this department the diamond's ratio of superiority to sapphire is 90 to 1, not 4½ to 1. Confirmation of this has come from many tests on relative stylus life.

Mr. Weil's "Fact" No. 40 states, "There is no difference in the musical results, all other things being equal." This is undoubtedly true if one is speaking only of brand-new styli, but after ten hours usage under average conditions, the diamond tip will be absolutely unaltered whereas the sapphire will have flats. It can then no longer follow the groove modulations faithfully and distortion and high-frequency losses are inevitable. It is useless to argue that by this time the sapphire needle would have been changed, because (1) no longer then would everything "everything else be equal" and (2) hardly anyone changes needles as often as they should be changed. Human inertia is one factor, and the other is that stylus wear is a very gradual process, and so the accompanying musical depreciation tends to escape detection.

While the writer would agree that a good sapphire stylus is preferable to a poor diamond stylus, the only factor of importance—if one considers only professional-quality styli—whether the record collector can afford the extra fifteen or twenty dollars which the diamond costs. Since in the long run the diamond is at least ten times as cheap as the sapphire, and since the life of a record collection hangs in the balance—particularly LP's—it is hardly surprising that more and more phonophiles are turning to the diamond.

Gerald Shirley,
Televex,
474 W. 238th St.,
New York 63, N. Y.

Beef, Boost, Question

Sir:

I wish to put in my vote to keep television and radio strictly *out* of the publication. Also another pet annoyance of mine at most publications is the "continued on page —." Keep your articles and advertising completely separate so that articles may be bound for future reference.

Mr. Canby is still worth the price of the magazine.

Has anyone, other than myself, ever put a counterbalance spring on a pickup arm to equalize the force due to a tangential (offset) head which tends to pull the arm towards the center of the record? I found that it improved the tracking greatly.

G. W. Ginn,
411 Oneawa St.,
Lanikai, Oahu, T. H.

Book Reviews

Piezoelectric Crystals and Their Application to Ultrasonics, by Warren P. Mason. 508 pp. New York: D. Van Nostrand Company, Inc., $7.50.

This volume of the Bell Telephone Laboratory Series is an excellent reference work for all engineers in the audio-acoustics field, and should be required reading for all transducer men.

The first five chapters describe crystal systems, classes and symmetries, the electrical and mechanical properties of crystals, and the determination of the properties of crystals. The methods for handling both large and small samples are discussed. Included is a list of over two hundred crystals and their degrees of coupling, which will be a guide for further development. In the second group of chapters the properties of six of the most frequently used piezoelectric crystals are discussed. Two chapters are devoted to a discussion of the ferroelectric crystals such as barium titanate and of the electrostrictive effect in barium titanate which is used in making the modern ceramic phonograph pickups.

In the last three chapters is packed a wealth of practical information on the use of crystals in ultrasonic measurements of the physical properties of gases, liquids, and solids.

The powerful mathematical tools of tensor analysis are fully exploited in this work, and a thorough appendix treats this subject in detail. Thus anyone with the usual engineering background in mathematics should not hesitate to avail himself of the useful material in this book.

Sound Absorbing Materials, by C. Zwikker and C. W. Kosten. 171 pp. New York: Elsevier Publishing Company, Inc., $3.00.

This contribution to the literature on acoustical materials, from the Netherlands, is a simple straightforward presentation of the phenomena of sound absorption.

The first three chapters are devoted to the development of the theory of sound absorption by various media. Following this is a discussion of the experimental determination of porosity, air resistance, and compression modulus.

The chapter on measurement of normal impedance and absorption shows considerable thought and discretion in the selection of methods of measurement, from the large volume of material on the subject. Also a large amount of applied instrumentation is described. A final chapter on absorbing materials presents a thorough, if brief, comparison of theoretical with practical results.

The last quarter of the text consists of a chapter on resonators as sound absorbers and a chapter on the oblique incidence of sound waves on sound absorbing surfaces and resonators.

Frequent use of plots in the complex Z plane, the authors' lucid style, and the treatment of normal incidence waves only in all but the last chapter have added to make a valuable reference work in the field of acoustical materials.

REALISTIC AUDIO

[*from page 26*]

voice-coils out of their magnetic gaps, with attendant uproar.

We're getting better speakers all the time, but until the problem is much better solved we'll make more friends by allowing realistically for necessary speaker shortcomings. Our present speaker systems, if kept within their power and frequency capabilities, and properly baffled, will produce great satisfaction—even 'though it's within a range of 60 to 8000 cps.

Suggestions for Improvements in System Design

So much for the audible characteristics of systems. The weight and spatial requirements of some of the best quality components impose difficulties. The problem of interconnections among components is vexing, and indicates that it is surely time for an industry conference on standard plugs, at least for inputs and outputs. Fortunately many audio houses are willing to make up the necessary intercables, and to code them clearly. That doesn't help much when the healthy curiosity of the owner leads to his changing amplifiers or tuners or what not.

The difficulty of arranging controls into a compact and attractive center are formidable. *Figure* 2 illustrates an electrically and acoustically fine instrument, marred by duplication and excessive complexity of controls. Consumers want the knobs to come out symmetrically, with none duplicated or useless as they are in *Fig.* 3. It seems to them a reasonable request. This may involve alterations in wiring and chassis arrangement which non-technicians cannot be expected to make. Some of the best amplifiers cannot, for this reason, be used attractively. Long steps in the direction of solving this problem are being made in the various remote-control amplifiers. Such a technique as the use of removable lock-in shafts could be applied both to tuners and to amplifiers, so that duplicated controls could simply be pre-set, and removed when their function can be served by an adjacent knob on another chassis. Some tuners are so designed that removal of one, two, or more shafts, whose function may be duplicated at the amplifier, leaves a symmetrical panel. This is admirable, and could and should be adopted with amplifier-control panels. Most of these will be mounted in cabinets, and that fact should be considered in their design. Great flexibility in provisions for the connection of antennas to tuners can and should be provided. Tuners which are designed to serve also as control-centers need flexible arrangements for the connection of external inputs, like tape-recorders and TV sound. These are only *some* of the means available to meet listeners' needs. The important thing is that these needs *exist,* and for the sake of survival of the profession deserve attention.

It seems to us that some of the problems of high-fidelity are in an admirable state of solution, and that time can be spared from them to pursue the acoustical rodents that still plague us. Among the best-solved problems in all electronics is that of the amplifier output stage. What we emphatically do *not* need is more good engineering talent devoted to yet another variation of the push-pull feedback power amplifier. At their best, tape and disc recording means have reached a degree of excellence that far outstrips our ability to display it acoustically. The finest of existing pickup cartridges, arms, and turntables leave little to be desired except cost-reduction. May we not hope for concentration, then, on those elements that are still giving trouble? The biggest problem, of course, is the loudspeaker system. But there are others: record-changers, for all the low esteem in which they are held by the professional, are seriously wanted by most consumers, and their wishes deserve more than our disapproval. The techniques that have made separate turntable-and-arm combinations so satisfactory, are applicable to changers. Tone-control systems designed to meet real needs, instead of to fill graph-paper prettily, are not beyond reach, technically or economically. AM radio receivers are not hopeless: we have recently seen demonstrated an AM detector circuit whose distortion did not exceed ¾ of 1 per cent at 99 per cent modulation. A tuner with performance approaching this should be available.

Realism toward high-fidelity in the home requires our taking the non-professional listener seriously. It may be that he cannot *define* exactly what he wants, in our terms, but his approval ultimately determines the success of our efforts. We hold that it is the audio professionals' deepest responsibility, not only to understand and to meet, but *to anticipate* the needs of those whose interest lies in the *program,* not in the equipment. More realistic and respectful attitudes toward the *listener,* we are sure, will result, in the end, in more realistic sound reproduction.

LOUDSPEAKER DAMPING

[*from page 22*]

tween speaker resonance frequency and f_t. Then above f_t, where the tone-control effect is no longer bucked by a changing radiation resistance, one would expect a falling-off of response. There is less than might be anticipated, however, because speaker cones are designed to quit functioning as rigid pistons at about this point.

At any rate it can be seen that some apparent internal resistance in the amplifier is essential for flat frequency response from the usual direct-radiator speaker. This should make it clear why it is that some speaker manufacturers have specified limits on the amount of feedback to be employed in amplifiers suitable for use with their respective speakers. It also explains why exponents of a high damping-ratio sometimes contradict themselves by placing a pad between amplifier and speaker.

But suppose that the benefits of perfect damping are desired without reduction of low-frequency response. The speaker system must be given a big enough bite

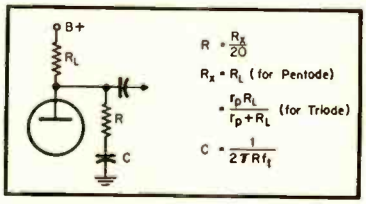


Fig. 10. Bass-compensation circuit for use at low level in preamplifier.

of air so that loading will remain constant down to the lowest frequency to be reproduced. Horn loading presents one possibility. But with a horn (or horns) pains must be taken to see that the mouth area is adequate at frequencies well below taper cutoff. To fulfill this condition down to 100 cps or below requires a huge installation. Horn systems designed for home use are mostly short on mouth area and as a result the diaphragm loading fluctuates violently with frequency. This may do no harm where there is series resistance to smooth out the output, but, as has been shown, with the negative-impedance amplifier the output will fluctuate exactly as the cone loading does. Another possibility is to use a large number of direct-radiator speakers. Theoretically, to be down not more than 4 db at 60 cps would require a cone area of 5,900 sq. in. in an infinite wall. This would correspond with the staggering total of fifty-four 15-in. speakers. But it is not as bad as that. By mounting in a corner near the ceiling or floor, one-fourth as much radiating area will suffice. By making use of the effective radiating area of a bass-reflex port, the number of speakers can be cut in half again. As it figures out, six 15-in. speakers in a bass-reflex cabinet in a corner will do very well. Since the power each speaker will be required to handle will be small, bargain-basement speakers will do; the total investment can be quite small.

If space or purse does not permit a cone area large enough for constant air loading, the only recourse left is to add some bass-boost, to decrease the amount of damping, or to compromise and do both. The proper turnover frequency, f_t, for the boost and the amount of boost required will vary with the speaker and with the installation. The circuit of *Fig.* 8 will give a mild amount of bass-boost, depending on the setting of R_f. The circuit of *Fig.* 10 will give the maximum amount that could possibly be needed and has the advantage that it may be adjusted separately from output damping. However, it may be preferable to adjust the present bass-boost control and the damping control, R_f, together until the settings that *sound* the best are determined.

If the reader is impressed by the lure of improved damping, he may still want to adapt for negative impedance just for its novelty value. When the indicated simple changes have been made, it will result in an amplifier whose output voltage actually goes *down* when the load is removed. This phenomenon is so fascinating that the writer has had to demonstrate it for friends over and over again.

Loudspeaker damping is an extensive subject and this article is probably not really the "last word." But it should finally lay the ghost of some old fallacies, and it does point the way to securing perfect damping by electrical means. It would be hard to ask for anything more in this direction. In the writer's opinion, it's hard to improve on perfection.

CANNON ELECTRIC OPENS LARGE EASTERN PLANT

Accenting its expansion to the Atlantic seaboard, Cannon Electric Company, Los Angeles, recently began operations in a new 10,000-sq. ft. plant located in the East Haven district of New Haven, Conn.

At present the new plant will provide engineering and design consultation services for Cannon's eastern customers; however, the company intends to add warehousing, assembly, sub-contracting, and eventually manufacture, in order to give overnight service to the east coast, according to Robert J. Cannon, president.

Condensed Schedule For Western Electronic Event

Marked increase in co-ordination of sponsoring organizations is evidenced in the complete integration of engineering and commercial interests in the 1951 program of the Western I.R.E. Convention and the Annual Pacific Electronic Exhibit.

The ever-increasing size and importance of these annual Western Electronic Events are due to close co-operation between the West Coast Electronic Manufacturers' Association—sponsors of each Exhibit and Business Conference—and the local I.R.E. Sections in San Francisco and Los Angeles which alternate annually as hosts for the I.R.E. 7th Region Convention.

As will be seen below, all events—engineering, business, and social—have been merged into a program which is both informative and entertaining.

WEDNESDAY, AUG. 22

Morning

Registration
Convention Papers
  Broadcast and Television

Afternoon

Exhibit Open to Visitors
Convention Papers
  Propagation and Optics
  Noise and Communication Theory
Business Conference
  Government Procurement Regulations
TV Inspection Trip
U. C. Radiation Laboratory and Cory Hall—Inspection Trip

Evening

Cocktail Party
Exhibit Open to Visitors
TV Inspection Trip

THURSDAY, AUG. 23

Morning

Registration
Convention Papers
  Vacuum Tube Applications

Afternoon

Ladies Fashion Luncheon
Exhibit Open to Visitors
Convention Papers
  Linear Array Antennas
  Circuits
Business Conference
  Electronic Manufacturing and the National Preparedness Program
TV Inspection Trip
Inspection Trip to Eitel-McCullough tube plant

Evening

Exhibit Open to Visitors
Convention Papers
  The Utilization and Handling of Information
TV Inspection Trip

FRIDAY, AUG. 24

Morning

Peninsula Trip
Convention Papers
  Vacuum Tubes
  Special Equipment

Afternoon

Convention Luncheon
Exhibit Open to Visitors
Convention Papers
  Antenna Applications
  Computers
TV Inspection Trip

Evening

Exhibit Open to Visitors

WHODATHUNKIT

[*from page 17*]

leaks, and other devices, were eager and anxious to promote the sale of their wares in any medium that found its way into the homes, shops, and factories of those who might become prospective buyers. Even Wm. B. Duck was still a duckling.

By this time there were already certain wireless magazines in circulation, but all of them were published in the eastern sectors of the nation. Believing that the radio sun rose in New England and set in Hoboken, no publisher of wireless literature had ventured the risk of establishing a publication on the Pacific Coast. Until 1917, that is.

The year became memorable in radio history when a wild and wooly westerner, H. W. Dickow, then 19 years of age and for seven years prior thereto an amateur and commercial wireless operator, risked his personal fortune of a twenty-dollar gold piece in launching *Pacific Radio News*. Four issues of the magazine were published in San Francisco during 1917. Then came the entry of the U.S. into World War I. The staff of the magazine went to war in the wireless service of the Navy, returning some three years later to resume publication. The first issue of the magazine published in 1920 is shown on page 17.

Although its home office was in San Francisco, only five per cent of *Pacific Radio News*' circulation was absorbed by westerners, and the title of the magazine was changed to *Radio* in keeping with its growth into a publication of national stature. The change was made in 1921 when Dickow was joined by Arthur H. Halloran as a business partner. The two partners built *Radio* into one of the most influential technical journals in the nation. It became the largest magazine publishing venture west of Chicago, and its circulation soared to a peak of 110,000 copies monthly. Branch offices were opened in New York, Chicago, Boston, and Los Angeles.

Radio rode the crest of the sensational boom of the twenties, but its life hung in the balance during the great depression, when its large and noteworthy staff was reduced to the two original partners. It was sold twice—first in 1935 and again in 1942. Once more it gained a position of prominence and prestige which continued throughout World War II.

Today it is AUDIO ENGINEERING as you know it—a title not far removed from the name of the old Audion tube to which the magazine owes its birth. Its founders are now engaged in other technical activities and its present publishers are confirmed in the belief that old magazines never die; they just find new owners who doggedly labor away under the impression that radio—audio, that is—is here to stay.

—*H.K.R.*

ACOUSTICAL BALANCE

[from page 23]

choir, through Dr. F. Melius Christiansen, is primarily responsible for the impetus given serious choral music in America. When this dean of directors began by insisting on standards in performance and repertoire that made no compromise with supposed popular taste, he accomplished two objectives: first, the shattering of an old idea that the public must be played down to if the box office is to prosper: and, second, that students must be fed music of a difficult nature only in sugar coated doses.

Another choir is that of Dr. Charles C. Hirt, long a close associate of the late John Smallman. In addition to his church program of some 300 singers, Dr. Hirt is Professor of Sacred Music at the University of Southern California. He is a recognized authority on Russian Liturgical Music. His Cathedral Choir of sixty-five voices is dedicated to Christian Service through music. Many of his renditions include contemporary composers of today. Our most recent choral series is that of the famous Notre Dame Cathedral of Paris, France. This was recorded in the cathedral itself with sixty boys and fifteen men, with the great organ.[1]

Musical Education

For a well rounded education in music and its acoustic values, the engineer should study the following subjects to attain a better concept of music:

1. The development of musical instruments.
2. Production of sound in general.
3. The production of sound with strings, reeds and brass.
4. The production of sound by air.
5. The study of harmonics and overtones.
6. The human voice.

If the engineer studies these subjects as well as he does those of physics and engineering, he will be able to bridge the gap between engineering analysis and creative inspiration. The engineer must get rid of the idea that he is separate and apart from the production of music. Music is the universal language, and if the engineer fails to recognize this fact, he is unwittingly contributing a disservice to the recording industry.

Directors, on the other hand, must get rid of the idea that they have a corner on inspiration and interpretation. If what they produce doesn't get results, then they must find out why, and the only way they can do this is through a partnership with the recording engineer. A good slogan for both would be "Is it so? Does it work? Where do I fit into the picture?"

[1] These are but a few of the outstanding choral groups we have recorded. Many of our colleges and universities have inspiring musical organizations, and the trend toward serious *a cappella* singing is spreading throughout America.

"THE REPRESENTATIVES"
of Radio Parts Manufacturers, Inc.

One of the unsung heroes in the radio and electronic industry is the manufacturers' representative. Seldom seen by the ultimate user of the equipment he sells, the "rep" does the spade work when a new product passes the design and development stage and is ready for commercial introduction. He is the man who places new amplifiers, speakers, tuners, and the like on jobbers' shelves, then creates a demand for them, expedites orders and delivery schedules, and generally serves as trouble-shooter throughout the long linkage between the manufacturer and consumer.

Because the representative relieves the manufacturer of sales overhead he is one of the industry's great economy factors. Without his presence the manufacturer would be forced to carry a large sales payroll which, in the long run, would be reflected in higher prices to the consumer. This, in turn would result in reduced sales volume and a corresponding loss in manufacturing efficiency. It can be seen from this that "the rep" is truly an essential entity if sound, efficient merchandising is to be achieved.

Resembling a professional society in character and intent, "The Representatives" of Radio Parts Manufacturers, Inc. is the organization of these important figures. It is divided into seventeen regional chapters, each of which is composed of members who cover a particular geographical area. Listed below are members of the western groups.

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Logan, Jim, 530 Gough St., San Francisco 2
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Rupp, V. T., 1150 W. Olympic Blvd., Los Angeles 15
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Minthorne, Roger M., Weatherly Bldg., Portland
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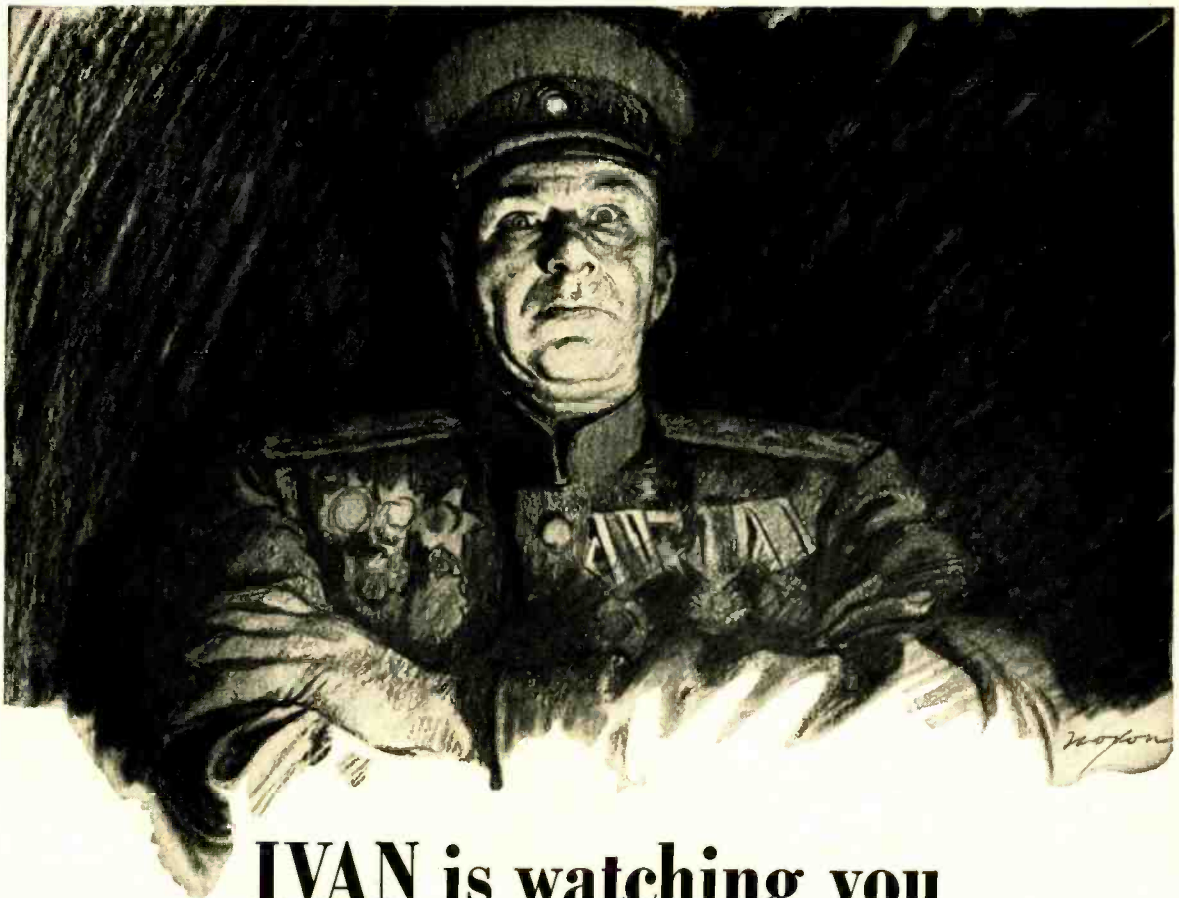

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- ***Improved HF Performance***

Completely new throat design makes this driver outstanding in its field. **Price, $80.00 List.** Write for bulletin.

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ADDRESS CHANGES

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

RADIO MAGAZINES, INC.
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W. D. Brill & Co., 198 10th St., Oakland
C. C. Brown Co., 61 Ninth St., S.F.
California Electronic Supply, 11801 W. Pico, L.A.
Channel Radio Supply Co., 434 State St., Santa Barbara
Coast Electric Co., 744 G St., San Diego
Coast Electronic Supply Co., 527 W. Main St., Alhambra
Fred S. Dean Co., 969 American Ave., Long Beach
DeJarnett Radio Supply, 1260 Van Ness St., Fresno
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Dunlap Wholesale Radio Co., 2001 "O" St., Sacramento
Electric Supply Co., 149 12th St., Oakland
Electronic Equip. Distributors, 1228 2nd Ave., San Diego
Electronic Supply Co., 150 W. Green St., Pasadena
Empire Electronic Supply, Inc., 37 E. Union St., Pasadena
Federated Purchaser, Inc., 911 S. Grand Ave., L.A.
Figart's Radio Supply Co., 6320 Commodore Sloat Dr., L.A.
Gough Industries, Inc., 827 E. 1st St., L.A.
Haggerty Radio Supply, 6826 San Fernando Rd., Glendale
Henry Radio Shop, 11240 Olympic Blvd., L.A.
Hollywood Radio Supply, Inc., 5606 Hollywood Blvd., Hollywood
Inland Electronic Supply, 863 Colton Ave., San Bernardino
Kemper Barrett Dealers Supply Co., 1850 Mission, S.F.
Kaemper-Barrett Dealers Supply Co., 1940 Ashby Ave., Berkeley
E. M. Kemp Co., 1115 R St., Sacramento
Kieruiff & Co., 820-830 W. Olympic Blvd., L.A. (See Ads on Pages 38, 42, 50, 56, 59, 63)
Larry Lynde Radio Supply, 853 Pine Ave., Long Beach
Mac's Radio Supply, 8320 Long Beach Blvd., Southgate
Martin Distributing Co., 2303 S. Union Ave., L.A.
Leo J. Meyberg Co., Inc., 2027 S. Figueroa St., L.A.
Miller's Radio & Television, 336 E. 8th St., Oakland
Nelson Brothers Co., 630 N. Alvarado, L.A.
Pacific Radio Exchange, 1407 Cahuenga Blvd., L.A.
Pacific Wholesale Co., 116 N. 9th St., S.F.
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Radio Parts Co., Inc., 1045 11th Ave., San Diego
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Appliance Wholesalers, 600 NW 14th St., Portland
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Central Distributors, 1131-35 SW Washington St., Portland
Cressey & Allen, 35 Commercial St., Portland
Harper-Meggee, Inc., 1506 NW Irving St., Portland
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Portland Radio Supply Co., 1300 W. Burnside, Portland
Radio Electronics Co., 9th and Commercial, Astoria
Stubbs Electric Co., 33 NW Park Ave., Portland
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United Radio Supply, Inc., 179 W. 8th St., Eugene
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Columbia Electric & Mfg. Co., South 123 Wall St., Spokane
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Standard Sales Co., 1219 W. First Ave., Spokane
A. T. Stewart Co., 743 Broadway, Tacoma
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Washington Distributors, 115 Madison Ave., Seattle
Western Electronic Supply Co., 2609 First Ave., Seattle
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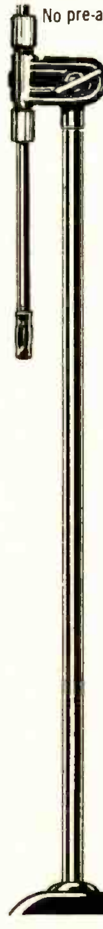

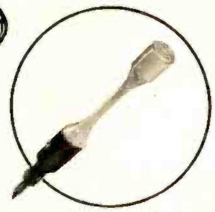

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Employment Register

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

★ Positions Open   ● Positions Wanted

★ **Sales Engineer, E. E.** To cover Long Island on protected basis for manufacturers' representative having outstanding line of nationally advertised electronic instruments covering range from d.c. to microwaves. Salary, commission, expenses. State education, experience, past earnings. P. O. Box 569. Ridgewood, N. J.

★ **Engineer** to design loudspeakers and acoustic devices. Should have minimum of two years' experience in such work. This is a permanent position with a good future. in a city known as an educational and musical center, located in western New York. Box 801. **Audio Engineering.**

★ **Sales Engineer** wanted by leading distributor of professional tape and disc recorders, playbacks, and all accessories. Man selected will be paid for knowing his stuff. Box 802, **Audio Engineering.**

★ **Wanted**—TV Production man who can sell production equipment such as "rear process projection" to the right people in TV, film, and the agencies: high caliber personality. Box 803, **Audio Engineering.**

Catalog For Music Lovers

The music lover and the layman are given first consideration in a new Sound Equipment Catalog now being circulated by Leonard Radio, Inc., 69 Cortlandt St., New York 7, N. Y. Representing considerable departure from the established practice of directing descriptive copy to technically-minded persons, the new Leonard Catalog seldom wanders from the vocabulary of the average non-technically-inclined music lover. Prepared by Arthur Priest, the Company's advertising manager, the new catalog is being watched with interest by the entire industry in the belief that it may point the way to new, untapped markets for audio equipment.

Industry Notes—

Concord Radio Corp., Chicago, Ill. has appointed Bill Cameron (W9SWO) general manager, and Gerald Levenfeld advertising and merchandising manager—promotions are from store manager and ad manager respectively . . . **Audio & Video Products Corp.** has taken over quarters vacated by station WQXR at 730 Fifth Avenue, New York 19, N. Y.—space will be shared by Audio & Video's subsidiaries **Audio-Video Recording Co., Inc.** and **A-V Tape Libraries, Inc.** . . . Building formerly occupied by **Howard Radio Company** plant in Attica, Ind., has been taken over by **Edwin I. Guthman & Company** for manufacture of coils and other electronic com-

CLASSIFIED

Rates: 10¢ per word per insertion for noncommercial advertisements; 25¢ per word for commercial advertisements. Rates are net, and no discounts will be allowed. Copy must be accompanied by remittance in full, and must reach the New York office by the first of the month preceding the date of issue.

BROWNING RJ12 TUNER. little used. Modernized by Browning to RJ12A identical performance. $95 f.o.b. or best offer. Fred Barsam. 40 Kimball Road, Watertown, Mass.

FOR SALE: Hi-Fi speaker system. 800-cps crossover. 15-in. woofer and H-F horn with driver unit, Hammertone cabinet $160. Hi-Fi Meissner 9-1091-B FM-AM tuner, rack-mounted, $110. Hyatt Lemoine. 323 West 75th St., New York 23. N. Y. TR 4-8831.

TRANSCRIPTION TT OWNERS: Collection of original acetate recordings, including symphonies. Horowitz and Rubinstein Piano works. Colman's "Tale of Two Cities," and others—over 200 total. Write for list. Box CK-4. AUDIO ENGINEERING.

LET ME improve your present amplifier to sound like a Williamson. $49. Arthur Levine. 3405 Kossuth Ave., Bronx 67, N. Y. OL 2-6815. evenings.

PRESTO OWNERS—ATTENTION

6N and 8N overhead mechanism rebuilt for microgroove. 80 to 290 lines in 66 steps. Design proven 2 years in our studios. Write for particulars.

Trans-Radio Recordings, Inc.,
683 Boyston Street,
Boston 16. Mass.

FOR SALE: Rek-O-Kut Challenger disc recorder; wire recorder: accessories. Ed Cherney. 40 Ocean Parkway, Brooklyn, N. Y.

WILL TRADE: Presto 6-N. like new, for a magnecorder in good condition. Box CB-1, Audio Engineering.

PROFESSIONAL DIRECTORY

ponents—55,000-sq. ft. building was chosen in keeping with government's decentralization program—beyond areas of critical labor shortage and the probability of air attack.

Approaching shortage of critical materials heralded by **Eitel-McCullough's** appeal to users for return of certain types of Eimac tubes when broken or worn out, for salvage of parts—they even pay for 'em . . . **Berlant Associates,** Los Angeles, expanding with appointment of Vern Maynard and John Maynard as factory representatives for western and south central states respectively . . . **Jensen Manufacturing Company's** Charles A. Hansen reelected by the **Association of Electronic Parts and Equipment Manufacturers** for a second term as the Association's representative on the board of directors for the **Radio Parts and Electronic Equipment Shows.** Other Chicago board member is **Radio Craftsmen's** John H. Cashman.

Cinema Engineering Company, Burbank, Calif. has appointed A. J. Warner as factory rep for north central states . . . **The Turner Company,** Cedar Rapids, Ia. adds Hobert M. Murdock to its executive staff—will function as sales manager . . . **Hycor Company, Inc.** announces appointment of John F. Lorber as chief engineer—was formerly with **Raytheon Manufacturing Co.** and **RCA Institutes** . . . **Du Mont Television Network** has named Chris J. Witting as director—succeeds Mortimer W. Loewi who retires to become assistant to the president of **Allen B. Du Mont Laboratories, Inc.** . . . **Lear, Inc.,** Los Angeles, honored by award of Doctor of Engineering degree to William P. Lear, board chairman . . . **Federal Telecommunication Laboratories, Inc.** has promoted William T. Rapp to an assistant vice-presidency—formerly assistant comptroller . . . **Kay Electric Company,** Pine Brook, N. J. has promoted **Louis A. Garten** to sales manager and **Cyril H. Brown** as his assistant . . . **Neely Enterprises,** Hollywood, has erected 1400-sq. ft. single-story addition to provide greater floor space for its expanded activities and increased personnel.

Industry People—

Dick Dorrance, audio veteran formerly with CBS, is new director of public relations for Mutual Network. . . . **Ernie Jones,** head of New York office of McManus, John and Adams advertising agency, trying to explain away the published report that his hobby is "high-frequency" recording. . . . **T. O. Brown** advanced to supervisor in sales service department of Erie Resistor Corporation, Erie, Penn.—will be assisted by **Earl R. Farver** and **John A. Mayer.** . . . **William T. Buschman** announced as new merchandising coordinator for the Radio and TV Picture Tube Divisions, Sylvania Electric Products, Inc. . . .

C. J. LeBel, vice-president, Audio Devices, Inc., heartened over notable response to his article on record critics in **The Audio Record.** . . . **Louis Kahn,** director of research for Aerovox Corporation, has been appointed expert consultant on components by Research & Development Board for the Armed Forces . . . . **John K. Hilliard,** Altec Lansing chief engineer, a guest of Board of Governors of New York chapter of AES at pre-meeting dinner—accompanied by **Mel Sprinkle** of Altec Lansing's Manhattan office. . . . **Louis J. Kleinklaus** appointed chief engineer of WQXR, New York, to succeed the late **Russell D. Valentine**—**Athan Cosmas** named engineer-in-charge of FM and AM transmitters. . . .

Roger B. Yepson upped to manager of marketing research for the Tube Divisions of General Electric. . . . **Ken Hamilton,** formerly with Capehart, named to direct promotional sales activities for Marshank Sales Co., Los Angeles. . . . **Jack Coles,** many years with the Bell System, has joined J. T. Hill Sales Co., Los Angeles, as office manager. . . . **Read Hamilton Wight,** who master-minded World Broadcasting System's Chicago office into world-wide prominence, and who is now radio-TV head of J. M. Mathes Advertising Agency, adding new Garard changer and high-quality pickups to custom-built amplifier and speaker system. . . .

Jack Simon, director of Terminal Radio Corporation's Sound department, reports rising curve of audio equipment sales in TV homes—says music lovers want music, TV or no TV. . . . **Crump Smith,** ad chief for Federal Tel and Tel, is industry's only "reverse commuter"—lives in Manhattan and travels daily to Federal plant in Clifton, N. J. . . . **Luci Turner,** Æ production manager, on vacation—Help!

HIGH-FIDELITY H. T. GREETINGS TO THE WEST COAST

To all our customers and friends in Washington, Oregon and California, greetings. The intervening 6,000 miles will prevent our being at the Annual Pacific Electronic Exhibit to greet you personally, but we shall be there in the minds of those who get our news letters and buy our products.

We have a lot of very satisfied users of the 215 Speaker on the West Coast, as well as in all other parts of the U. S. Each and every one of those customers exhibited three characteristics: curiosity as to what we were up to; intelligent appreciation of the sanity of our technical arguments; and faith that in sending their money out into the blue waters of the Atlantic and beyond, they would get something good in return.

Eighteen months ago we gave the opinions of seven dissatisfied users of the 215. Since then we have had no others. On the contrary, the pile of wonderful testimonials we get steadily grows taller and, although we thought the 215 a good Speaker before we dared to offer it to you, we prefer you to ask the man who trusted us and found we did not let him down.

A day or two ago, we had a letter: "How easy it is to become lost in the barrage of high-pressure advertising that audio enthusiasts here are subjected to. I have been bombarded with full color literature about co-axial Speakers as well as all sorts of single Speakers with fancy cones. Although the "axials" appear to be on the increase I have not as yet heard rumors of a quatra-axial, but that should be the logical outcome of the trend. Reading all this is disquieting and buying a Speaker is a real financial trauma."

Our literature is not polychromatic, nor are our technical arguments highly-coloured. We need not shout the odds, for the 215 speaks in a cool, clear voice free from distortion. What we say, with cool, clear confidence is that, if you really know what music sounds like, the 215 at $48.00 will give you greater pleasure than any other speaker at any price. Ask the man who owns one.

Send a dollar bill today for "New Notes in Radio" and a regular mailing of worthwhile technical data. Present subscribers please note a new packet of info will soon be on the way.

Illustrated literature is free on request.

H. A. HARTLEY CO. LTD.
152, Hammersmith Road
London W.6, England

ADVERTISING INDEX

PARTRIDGE

THE AUDIO TRANSFORMERS that pass ALL tests

Time, no less than test, has proved Partridge Audio Transformers to be the most efficient and reliable in the world.

★ **WILLIAMSON** Output TRANSFORMERS, of which there is no U. S, equivalent (vide "Audio Engineering" Nov, 1949) built to the original specification, comes to you for $21.00, mail and insurance paid.

★ **PARTRIDGE CFB** 20 Watt output type, accepted as without rival. Series leakage induct. 10 m.H; primary shunt induct. 130 H, with 'C' core construction and hermetically sealed—to you for $30.00, mail and insurance paid.

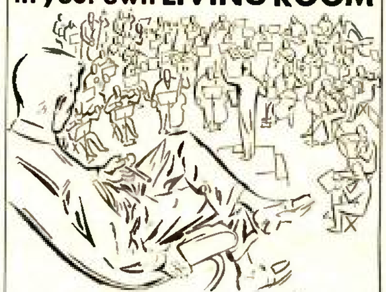
Fullest data, including square wave tests, distortion curves etc., together with list of U. S. stockists rushed Air Mail to you.

NOTE: We despatch by insured mail per return upon receipt of your ordinary dollar check.

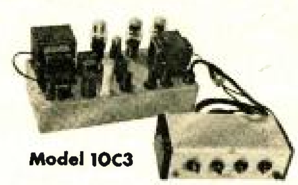
Jobbers are invited to handle the transformer that the States is eager to buy—remember, immediate delivery from large stocks in New York!

PARTRIDGE TRANSFORMERS LTD.
ROEBUCK ROAD, TOLWORTH, SURREY, ENGLAND

Stage a "*Music Festival*" in your own **LIVING ROOM**



For "Live" Symphony **reproduction ....**



Model 10C3

the BROOK High Quality All-Triode AUDIO AMPLIFIER

Write for free Technical Bulletin, detailed Distortion Analysis & booklet "Better Listening"

Brook Electronics, Inc., Dept. AH-1
34 DeHart Place, Elizabeth, New Jersey

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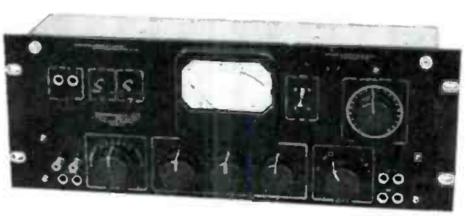


GAIN SET TYPE 11A

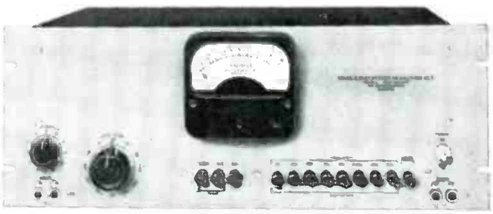
FIRST CALL ON DAVEN

Prime Supplier of Electronic Instruments of Unparalleled Quality, Accuracy and Dependability

In the manufacturing of sensitive, accurate instruments, the reputation of the Daven organization is world wide. For substantially more than a generation, specialization in electronics, coupled with unexcelled development and engineering personnel, has thrust the Daven Company far in the forefront of producers of instruments of notable quality.

Shown on this page is only a small part of the Daven line. When writing for more complete information on the units illustrated, please identify by name and model number.

OUTPUT POWER METER
TYPE OP-962



DISTORTION & NOISE METER TYPE 35-A

ATTENUATION BOX
SERIES 690

Precision equipment demands the finest components. Always specify Daven Attenuators.

THE DAVEN CO.

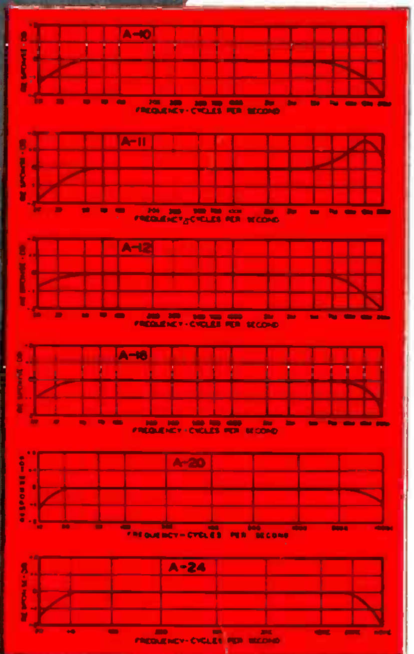
185 CENTRAL AVENUE • NEWARK 4, NEW JERSEY

ULTRA COMPACT UNITS...OUNCER UNITS

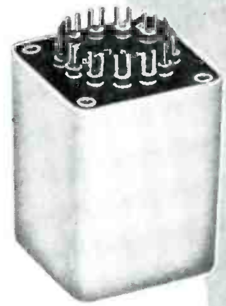
HIGH FIDELITY . . . . SMALL SIZE . . . . FROM STOCK

UTC Ultra compact audio units are small and light in weight, ideally suited to remote amplifier and similar compact equipment. High fidelity is obtainable in all individual units, the frequency response being ± 2 DB from 30 to 20,000 cycles.

True hum balancing coil structure combined with a high conductivity die cast outer case, effects good inductive shielding.



Type No.	Application	Primary Impedance	Secondary Impedance	List Price
A-10	Low impedance mike, pickup, or multiple line to grid	50, 125/150, 200/250, 333, 500/600 ohms	50 ohms	$16.00
A-11	Low impedance mike, pickup, or line to 1 or 2 grids (multiple alloy shields for low hum pickup)	50, 200, 500	50,000 ohms	18.00
A-12	Low impedance mike, pickup, or multiple line to grids	50, 125/150, 200/250, 333, 500/600 ohms	80,000 ohms overall, in two sections	16.00
A-14	Dynamic microphone to one or two grids	30 ohms	50,000 ohms overall, in two sections	17.00
A-20	Mixing, mike, pickup, or multiple line to line	50, 125/150, 200/250, 333, 500/600 ohms	50, 125/150, 200/250, 333, 500/600 ohms	16.00
A-21	mixing, low impedance mike, pickup, or line to line (multiple alloy shields for low hum pickup)	50, 200/250, 500/600	50, 200/250, 500/600	18.00
A-16	Single plate to single grid	15,000 ohms	60,000 ohms, 2:1 ratio	15.00
A-17	Single plate to single grid 8 MA unbalanced D.C.	As above	As above	17.00
A-18	Single plate to two grids. Split primary	15,000 ohms	80,000 ohms overall, 2.3:1 turn ratio	16.00
A-19	Single plate to two grids 8 MA unbalanced D.C.	15,000 ohms	80,000 ohms overall, 2.3:1 turn ratio	19.00
A-24	Single plate to multiple line	15,000 ohms	50, 125/150, 200/250, 333, 500/600 ohms	16.00
A-25	Single plate to multiple line 8 MA unbalanced D.C.	15,000 ohms	50, 125/150, 200/250, 333, 500/600 ohms	17.00
A-26	Push pull low level plates to multiple line	30,000 ohms plate to plate	50, 125/150, 200/250, 333, 500/600 ohms	16.00
A-27	Crystal microphone to multiple line	100,000 ohms	50, 125/150, 200/250, 333, 500/600 ohms	16.00
A-30	Audio choke, 250 henrys @ 5 MA 6000 ohms D.C., 65 henrys @ 10 MA 1500 ohms D.C.			12.00
A-32	Filter choke 60 henrys @ 15 MA 2000 ohms D.C., 15 henrys @ 30 MA 500 ohms D.C.			10.00

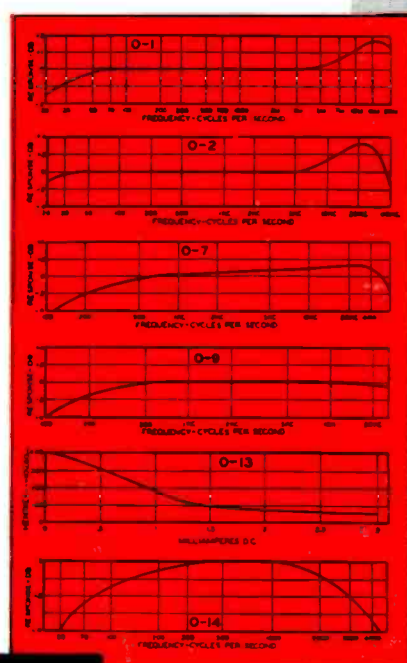


TYPE A CASE
1½" x 1½" x 2" high

UTC OUNCER components represent the acme in compact quality transformers. These units, which weigh one ounce, are fully impregnated and sealed in a drawn aluminum housing ⅞" diameter... mounting opposite terminal board. High fidelity characteristics are provided, uniform from 40 to 15,000 cycles, except for 0-14, 0-15, and units carrying DC which are intended for voice frequencies from 150 to 4,000 cycles. Maximum level 0 DB.

OUNCER CASE
⅞" Dia. x 1⅛" high

Type No.	Application	Pri. Imp.	Sec. Imp.	List Price
0-1	Mike, pickup or line to 1 grid	50, 200/250 500/600	50,000	$14.00
0-2	Mike, pickup or line to 2 grids	50, 200/250 500/600	50,000	14.00
0-3	Dynamic mike to 1 grid	7.5/30	50,000	13.00
0-4	Single plate to 1 grid	15,000	60,000	11.00
0-5	Plate to grid, D.C. in Pri.	15,000	60,000	11.00
0-6	Single plate to 2 grids	15,000	95,000	13.00
0-7	Plate to 2 grids, D.C. in Pri.	15,000	95,000	13.00
0-8	Single plate to line	15,000	50, 200/250, 500/600	14.00
0-9	Plate to line, D.C. in Pri.	15,000	50, 200/250, 500/600	14.00
0-10	Push pull plates to line	30,000 ohms plate to plate	50, 200/250, 500/600	14.00
0-11	Crystal mike to line	50,000	50, 200/250, 500/600	14.00
0-12	Mixing and matching	50, 200/250	50, 200/250, 500/600	13.00
0-13	Reactor, 300 Hys.—no D.C.; 50 Hys.—3 MA. D.C.		6000 ohms	10.00
0-14	50:1 mike or line to grid	200	½ megohm	14.00
0-15	10:1 single plate to grid	15,000	1 megohm	14.00



United Transformer Co.
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