Communication and Broadcast Engineering

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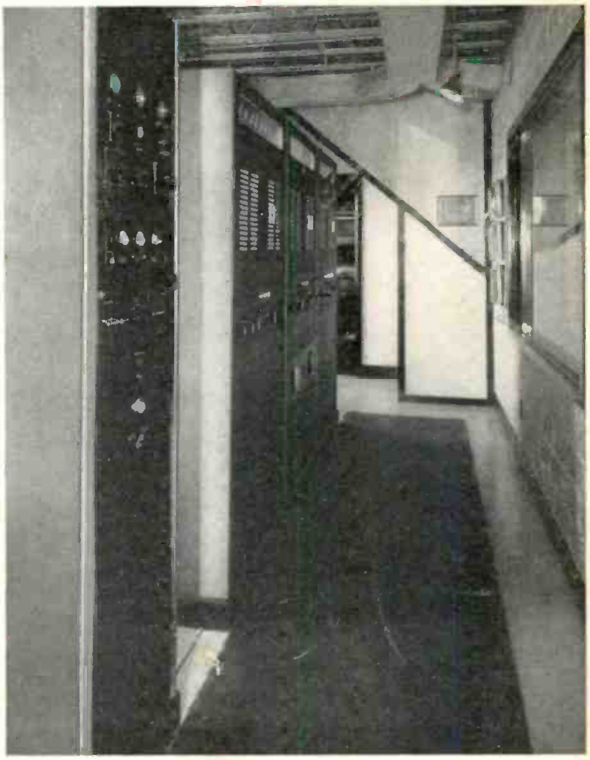

The Journal of World Communication

Pick-up Facts

This will answer a great many letters on the question of tone-arm mounting:

Any radial play-back mechanism, to be effective, must recognize simple geometry. From the very nature of the circular object called a record and the path inward which is taken by the needle, it is obvious that "tangency" (the angle at which the actual "functioning axis" meets the record) varies as the needle progresses.

Contrary to some erroneous opinions,—the arm should be so mounted as to definitely favor the inner grooves as much as possible. To one versed in the art, the reasons for this are obvious. The fact is that the outside grooves can much better stand a tracking error than the inner ones. For that reason the leading phonograph companies long ago adopted an arm-mounting generously favoring the inner grooves.

It is possible to average up the errors over all the grooves, either by varying the distance of arm-pivot from center of record, or, as has been done back in the Victrola days, in the case of short arms, the reproducer head itself, may be put at an angle to the arm. However, unless properly executed, this only "robs Peter to pay Paul,"—taking it away from the inner grooves and giving it to the outside ones. In no case should this be done unless the error on the outside grooves becomes too great,—as happens when the arm is short.

Away back in 1918, while the boys were still in France, I was called away from my laboratory one bright morning for an emergency consultation at the plant of one of the leading phonograph companies. These folks had just made a change in their talking machine mechanism . . . and something was WRONG.

It wasn't long before the trouble was located. In mounting the tone-arm they had been favoring the outer grooves at the expense of the more needy inside ones . . . and the resulting angular pressure on the last part of the record was giving trouble. (Today there still are a good many electric pick-ups having destructively high needle-point impedance but, serious as this is, they are mild as compared with what the reproducers were in those days).

The obvious answer:—A pickup whose needle-point impedance is so low that the average tracking error can have no effect on wear.

Tremendous trifles have their say in the construction of electrical reproducing sound-apparatus. Men and machinery and methods are important . . . but the one intangible MILLION-DOLLAR "if" is EXPERIENCE.

COMMUNICATION & BROADCAST ENGINEERING

Registered U. S. Patent Office

Member of Audit Bureau of Circulations

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Editor

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Associate Editor

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Published Monthly by the

BRYAN DAVIS PUBLISHING CO., INC.

19 East 47th Street
New York City
New York Telephone: PLaza 3-0483

BRYAN S. DAVIS
President

JAMES A. WALKER
Secretary

PAUL S. WEIL
Advertising Manager

A. B. CARLSEN
Circulation Manager

Chicago Office—608 S. Dearborn St.—C. O. Stimpson, Mgr.
Telephone: Wabash 1903.

Wellington, New Zealand—Te Aro Book Depot.

Cleveland Office—10515 Wilbur Ave.—J. C. Munn, Mgr.
Telephone: Republic 0905-J.

Melbourne, Australia—McGill's Agency.

Entered as second class matter October 17, 1934, at the Post Office at New York, N. Y., under the act of March 3, 1879. Yearly subscription rate: $2.00 in the United States and Canada, $3.00 in foreign countries. Single copies: twenty-five cents in United States and Canada, thirty-five cents in foreign countries.

EDITORIAL

VERTICAL RADIO MARKER BEAM

A BEAM OF RADIO ENERGY directed skyward and supplementing the familiar "cone of silence" has recently been developed by the Bureau of Air Commerce under the direction of William E. Jackson, chief of their development section. Development work on this vertical beam, known as the "Z marker," has been in progress in the field and in the laboratories of the Bureau for several years. Trial installations of the latest equipment have been made in Chicago, Kansas City, Newark and Washington, these installations operating on a frequency of 75 megacycles with 3000-cycle modulation.

A special receiver, developed to utilize these marker signals, provides both aural and visual indication for the pilot. The aural signal is obtained by connecting the audio output of the marker receiver in parallel with the output of the range receiver, thus superimposing the marker signal on the range signal.

The visual signal is indicated by a standard 12-volt white switchboard lamp mounted on the instrument panel adjacent to the flight instruments. It remains lighted over most of the period that the marker signal is audible.

In our opinion, this vertical radio beam has a number of advantages over the familiar "cone of silence." One advantage in particular is that the beam will provide a positive means of identifying the marker beacon.

CONFERENCE

A PRELIMINARY regional radio conference, for the purpose of consulting with the governments of Cuba, Canada and Mexico regarding radio matters in this hemisphere, particularly broadcasting, began in Havana, Cuba, on March 15. According to the State Department, the object of this meeting was to consider problems of interest to all of the participating governments and the formulation of an agenda for a formal regional radio conference to be held in early November of this year and to be participated in by the governments of the Western Hemisphere.

Commander T. A. M. Craven, chief engineer of the FCC, was selected as chairman of the U. S. delegation to this preliminary conference. Other delegates of this Government were E. K. Jett, assistant chief engineer of the FCC, Gerald C. Gross, chief of the International Section of the FCC, and Harvey B. Otterman, Treaty Division, Department of State.

While no reports have as yet been received, it is anticipated that much was accomplished at this gathering.

PRESENTING . . .

TUNED-COUPLED CIRCUITS are widely used in communications systems and hence have been the subject of many studies, the results not always being entirely satisfactory from the standpoint of design. Recently, however, an intensive investigation of two-mesh tuned-coupled circuit filters has been made, and some of the more interesting results of this investigation are set forth in Dr. C. B. Aiken's article which appears on page 5 of this issue. In attacking this subject, Dr. Aiken has avoided the special terminology and procedures of general filter theory with effective results, the theory being applicable to the calculation of the effects of unequal circuit resistances, detuning, resistance of coupling impedance, and the like. We feel sure that design engineers will find this article of considerable interest.

THE RAPID GROWTH of air traffic together with the tendency towards increased size in transport planes are making it necessary for aircraft to operate on schedule regardless of weather conditions. As a result, there is considerable interest in blind-landing systems and as we have already pointed out (see editorial for November, 1936) a number of blind-landing arrangements have been suggested and tested. In this country, considerable development work has been done by the Bureau of Air Commerce, the army, and commercial airlines, while in Europe the Lorenz system has been installed and tested at a number of airports. A description of the Lorenz system of blind-landing will be found on following pages. Data on other systems will appear in following issues.

SOME OF THE PROBLEMS encountered in making large indoor public-address installations are discussed in John P. Taylor's article on "Inside Public-Address Installations." In this article, Mr. Taylor also describes in considerable detail a typical inside installation.

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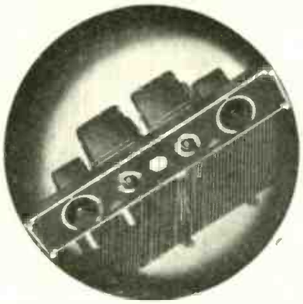
MODEL 2A—The ideal remote amplifier. This UTC unit incorporates a three position mixer with a 100DB gain amplifier having uniform response from 30 to 14000 cycles. The power output is plus 7DB with noise level, weighted, 60DB below output. A single meter is used for checking individual plate currents and volume indication. Complete unit with AC power supply measures only 12 x 16 x 9 and weighs 27 pounds. Model 2A amplifier with AC power supply, laboratory wired and calibrated, net price to broadcasting stations $160

"JEWEL BOX" REMOTE AMPLIFIER

UTC COMMUNICATION EQUALIZER



MODEL 3A—The UTC universal equalizer will correct frequency discrimination of telephone lines, recording systems, microphones, pickups, cutters, and all other broadcasting equipment. It is accurately calibrated and quickly adjustable for independent high and low frequency equalization. Low frequency controls permit maximum equalization at 25, 50 or 100 cycles with zero to 25DB control. The high frequency controls permit maximum equalization at 4000, 6000, 8,000 or 10,000 cycles with zero to 25DB control. Net price to broadcast stations and recording studios $85

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These audio units are guaranteed to be ± 1DB from 30 to 20,000 cycles. The use of a true hum balancing coil structure and *tri-alloy magnetic shielding* in low level units makes possible the lowest hum pickup units ever developed. Though a complete line of stock units are manufactured for every requirement up to 1000 watts, a large proportion of UTC Linear Standard units are designed and constructed to customers specifications.

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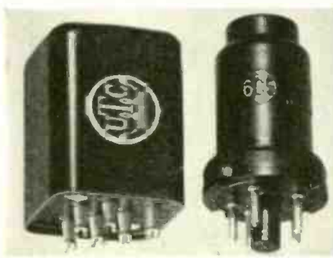

are the smallest wide range audio units in their class. The frequency response is ± 2DB from 30 cycles to 20,000 cycles; weight approximately 5½ oz. These units employ a full hum balancing coil structure to effect minimum hum pickup. List prices vary from $10 down.

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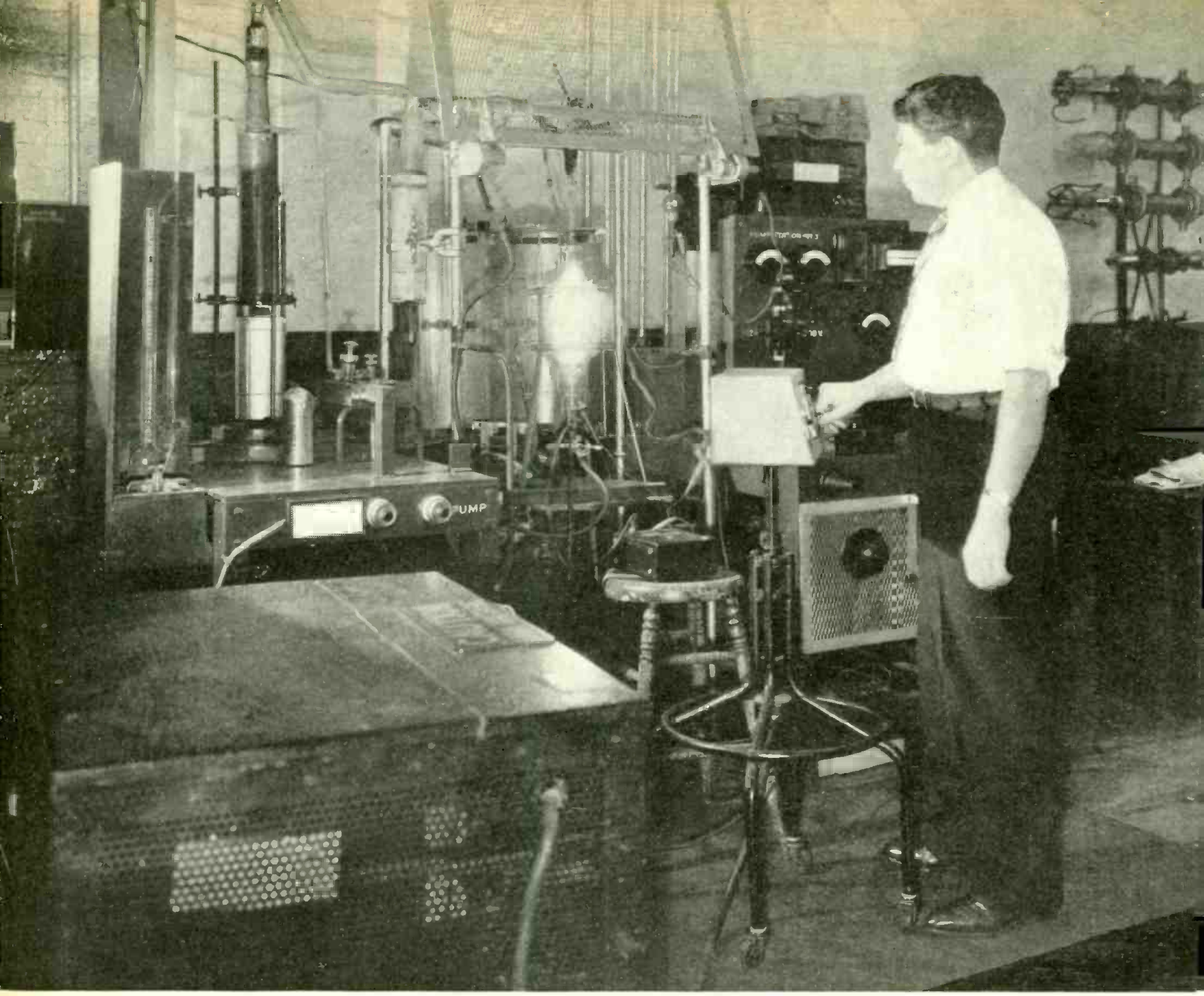


HEATING THE METALLIC STRUCTURE OF A 1,000-WATT VACUUM TUBE DURING PUMPING. THE ENGINEER IN THE FOREGROUND, IS CONTROLLING THE INPUT TO AN INDUCTION HEATING COIL. THIS SCENE WAS PHOTOGRAPHED IN THE EXPERIMENTAL VACUUM TUBE LABORATORY OF THE BELL TELEPHONE LABORATORIES.

COMMUNICATION & BROADCAST ENGINEERING

FOR MARCH, 1937

SOME NOTES ON TUNED-COUPLED CIRCUITS

By C. B. AIKEN

Purdue University

A LARGE NUMBER of mathematical studies of coupled resonant systems have been made, some of them long ago, but very few of these have produced results which are of direct interest to the radio receiver engineer. This is due to the fact that the particular requirements of narrow-band, high-frequency filters have not usually been considered by the investigators, and only limited use has been made of appropriate simplifying approximations. Some work has been done which does not suffer from these limitations, but it has failed to take account of certain factors, such as detuning, which are of great practical importance.

If attention is restricted to filters of reasonably high Q whose passed band is a small percentage of the mid-frequency, and if a few simple and well-justified approximations are used, interesting mathematical results can be obtained without undue labor. These are capable of describing the performance not only of identical circuits. but also of those which have unequal resistances, those which are tuned to slightly different frequencies, or are coupled by an impedance which is not a pure reactance. The details of such an analysis have been fully described elsewhere[1], and we shall outline here only some of the more interesting results which have been obtained.

First of all, let us consider the case of circuits that are tuned alike and are coupled by a pure reactance. In order to avoid unmanageable complexity it has been found necessary to use a few simple approximations. Let u_0 represent the coupling reactance, considered as constant over the small frequency range in which we are interested; and X, the total reactance around either one of the circuits by itself. Three of the abbreviations that we shall need are

$$s = \frac{u_0}{\sqrt{R_1 R_2}} \quad \ldots\ldots (1)$$

$$b = \frac{R_1}{R_2} + \frac{R_2}{R_1} \quad \ldots\ldots (2)$$

$$v = \frac{4\pi L}{\sqrt{R_1 R_2}} \Delta f \quad \ldots\ldots (3)$$

Δf is the frequency measured from the center of the passed band, while R_1 and R_2 are the total resistances around the primary and secondary circuits, respectively, and include any resistance which may be coupled into these circuits from nearby circuits.

In terms of these quantities, the absolute value of the secondary current is given by

$$|i_2| = \frac{se}{\sqrt{R_1 R_2}\sqrt{(1+s^2)^2 - 2v^2(s^2 - b/2) + v^4}} \quad \ldots\ldots (4)$$

e is the voltage which is effectively in series with the primary circuit. Its relation to the actual driving voltage, which may, for instance, be that induced in an antenna, is readily calculated in any given case. e is assumed to be constant over the narrow frequency range considered.

Since v is directly proportional to frequency and the other quantities are independent of frequency, it is evident that a resonance curve of the coupled pair could be readily plotted from (4). If this were done, the actual height of the curve would be dependent upon the magnitude of e and upon that of $\sqrt{R_1 R_2}$. In making design calculations on a pair of coupled circuits, we are interested primarily in the width and general shape of the resonance curve which will be obtained, and it is therefore convenient to remove unessential factors of proportionality by introducing another abbreviation

$$y_2 = 2\frac{\sqrt{R_1 R_2}\,|i_2|}{e} \quad \ldots\ldots (5)$$

(4) then becomes

$$y_2 = \frac{2s}{\sqrt{(1+s^2)^2 - 2v^2(s^2 - b/2) + v^4}} \quad \ldots\ldots (6)$$

This new abbreviation has been so chosen that $y_2 = 1$ when $v = 0$ and $s = 1$. The quantity s has been called the coupling index, and when it has a value of unity, the circuits are said to be critically coupled.

If we plot y_2 versus v for any given value of s and b, we obtain a resonance curve. A family of such curves differing from each other by small steps in s may all be plotted on a sheet of logarithmic paper, and used to precalculate any filter having a specified value of b. A number of such sheets, each corresponding to a different value of b, will furnish performance data on filters with a wide range of parameters with very little labor. The

[1] "Two-Mesh Tuned Coupled Circuits," by C. B. Aiken. Proc. I.R.E., February 1937.

method of using such resonance curves is discussed in the more detailed article already mentioned.

From (6), it is easy to show that the peaks of the resonance curve occur when

$$v = \pm\sqrt{s^2 - b/2}$$

and, hence, the frequency separation of the peaks is

$$W = \frac{\sqrt{R_1 R_2}}{2\pi L}\sqrt{s^2 - b/2}$$

$$= \frac{1}{2\pi L}\sqrt{u_n^2 - \left(\frac{R_1^2 + R_2^2}{2}\right)}$$

CRITICAL AND TRANSITIONAL COUPLING

It has often been assumed that two peaks will occur in a resonance curve whenever the coupling is greater than the critical value. This, however, is not the case unless the circuit resistances are equal. If they are unequal, two peaks will occur only when

$$s > b/2 \qquad \text{(7)}$$

The value of coupling represented by $s = b/2$ has therefore been given a new name, transitional coupling.

Inspection of (6) shows that, when $v = 0$ (that is, at the resonant frequency), the magnitude of the secondary current is independent of b, and hence of the ratio of the circuit resistances. Simple calculations will show, also, that the value of the secondary current at the resonant frequency will be a maximum when $s = 1$; that is, at critical coupling. It is evident, then, that the concepts of both critical and transitional coupling are useful in determining the performance of a coupled circuit pair.

When the circuits are critically coupled, the maximum current, which occurs at the center of the passed band, is

$$i_{2m} = \frac{e}{2\sqrt{R_1 R_2}} \qquad \text{(8)}$$

When the coupling is greater than critical and the circuit resistances are equal, two peaks occur which have the same current value as that indicated in (8). However, if the circuit resistances are not equal, the peaks that occur when the coupling exceeds the transitional

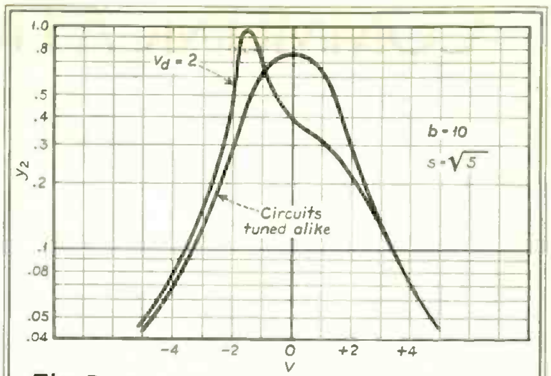


Fig. 2. Effect of detuning on the resonance curve of a pair of coupled circuits when the resistance ratio is approximately 10 to 1

value will be smaller than $\frac{e}{2\sqrt{R_1 R_2}}$, and the tighter the coupling the lower the peaks will be. These facts, which are obtained from a detailed study of (6), have not been generally appreciated.

CURRENT IN PRIMARY CIRCUIT

If we represent the primary current by i_1 and introduce the abbreviation

$$y_1 = \frac{2\sqrt{R_1 R_2}\,|\,i_1\,|}{e}$$

then

$$y_1 = \frac{2\sqrt{R_2/R_1 + v^2}}{\sqrt{(1 + s^2)^2 - 2v^2(s^2 - b/2) + v^4}} \qquad \text{(9)}$$

It will be observed that the denominator is exactly the same as in the expression (6) for y_2. Because of the presence of v^2 in the numerator, a curve of primary current versus frequency will usually have a very different shape from that of the secondary current versus frequency. Fig. 1 shows curves of both currents for the case of equal circuit resistances and critical coupling. While a single peak appears in the secondary current, a deep valley occurs between the peaks in the primary current. In order to get rid of the double peak in the primary current, the coupling index must be reduced to a value of 0.487, less than half critical coupling.

The impedance across the primary, which is presented to the plate of the amplifier tube that supplies energy to the filter, is sometimes a matter of interest. If plots are made of the primary current, this impedance can be very readily derived from them. Expressed in absolute value, it is

$$Z_1 = \frac{y_1 X_c^2}{2\sqrt{R_1 R_2}} \qquad \text{(10)}$$

If we consider that the reactance X_c of the tuning condenser does not change appreciably over the narrow frequency range in which we are interested, it follows from (10) that the magnitude of the impedance across the primary circuit is directly proportional to the amplitude of the primary current and is inversely proportional to the geometric mean of the resistances of the two circuits.

The impedance across the primary at the resonant frequency can be expressed in the form

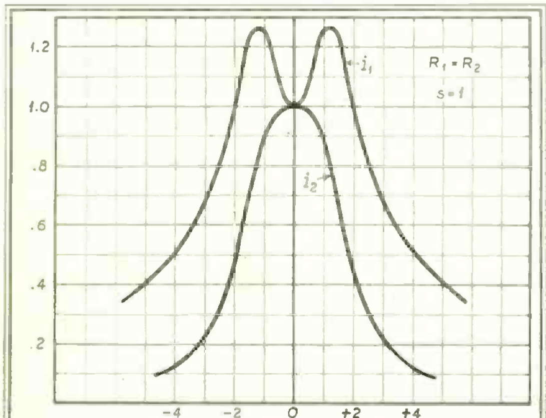


Fig. 1. Comparison of primary and secondary currents

	Low-Frequency Peak Depressed	High-Frequency Peak Depressed
$f_2 > f_1$ $R_2 > R_1$		√
$f_2 > f_1$ $R_2 < R_1$	√	
$f_2 < f_1$ $R_2 > R_1$	√	
$f_2 < f_1$ $R_2 < R_1$		√
Coupling by common capacity and resistance		√
Coupling by common inductance and resistance	√	

$$Z_{s0} = \frac{X_c^2}{R_1 (1 + s^2)} \qquad \text{.......(11)}$$

If the secondary circuit is removed, s becomes zero, and (11) reduces to the familiar expression for the anti-resonant impedance of a tuned circuit. But, as s is increased, the effective impedance becomes steadily smaller, and is reduced to half that of a single circuit when critical coupling is employed.

GAIN AND SIGNAL-TO-NOISE RATIO AS COMPARED WITH A SINGLE CIRCUIT

It is sometimes stated that the gain of a stage of high-frequency amplification is reduced by 6 db if a coupled circuit pair is used in place of a single tuned circuit. This is true if both circuits of the pair have a resistance equal to that of the single circuit. However, because of the resistance reflected into the primary, or into the single circuit, by the plate of the screen-grid tube, it often happens that the secondary has a lower resistance than the primary. Under such circumstances, the loss is not as much as 6 db as will be readily shown.

If R_1 is the resistance of the single circuit and is also the resistance of the primary of the coupled pair, and R_2 is the resistance of the secondary, then the current in the single circuit will be $\frac{e}{R_1}$, while that in the secondary will be $\frac{e}{2\sqrt{R_1 R_2}}$. Since the same condensers are used in both cases, it follows that the ratio of the output voltages will be

$$\frac{\text{output of coupled pair}}{\text{output of single circuit}} = \frac{1}{2}\sqrt{\frac{R_1}{R_2}}$$

If the circuit resistances are equal, the loss is 6 db; if the primary resistance is twice that of the secondary, the loss is only 3 db; while if the primary has 4 times the loss of the secondary, the loss is zero db. This, of course, indicates a transformer action in the coupled circuit pair.

In the case of a preselector, the effective resistance of the primary is generally higher than that of the secondary, because of the resistance reflected into the primary from the antenna circuit. Corresponding to the misconception that the use of two circuits will reduce the gain 6 db, is the statement which is sometimes made that the use of a two-circuit preselector will reduce the signal-to-noise ratio of the receiver by a factor of 2 to 1. This is never true, even when the circuit resistances are equal.

In order to compare the signal-to-noise ratios in the two cases, it will suffice to consider the case of critical coupling. The anti-resonant resistance across the grid of the tube will be

$$Z_{s1} = X_c^2/R_1$$

for the single-circuit case.

Equation (11) was derived for the impedance across the primary. The impedance across the secondary will, of course, be the same, except that R_1 must be replaced by R_2. At critical coupling, the impedance across the tube in the two-circuit case will then be

$$Z_{s2} = X_c^2/2R_2$$

Now, it is well established that the thermal noise applied to the grid of the tube is proportional to the square root of the resistance between the grid and cathode. Consequently, the ratio of noise in the two-circuit case to that in the one-circuit case will be

$$\frac{N_2}{N_1} = \sqrt{\frac{R_1}{2R_2}}$$

Comparing this with the ratio of the output voltages, which has already been derived, it is evident that the signal-to-noise ratio will be reduced by a factor $\frac{1}{\sqrt{2}}$ when two circuits, critically coupled, are used instead of one. This corresponds to a loss of 3 db, and is independent of the ratio of the circuit resistances.

EFFECTS OF DETUNING

If the two circuits are not tuned exactly alike (a condition which often occurs in practice), the analysis is somewhat more complicated, but can still be carried through without great difficulty. For simplicity, let us assume that the inductances of the two circuits are equal. Let f_1 and f_2 be the respective resonant frequencies of the two circuits, and let f_c be the frequency

(*Continued on page* 30)

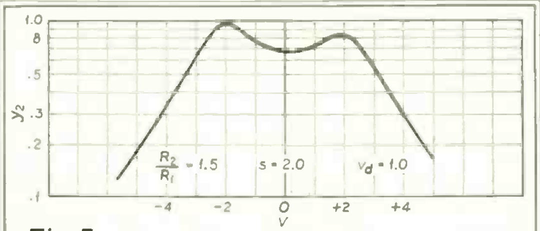


Fig. 3. Dissymmetry caused by detuning when the resistance ratio is only 1.5 to 1

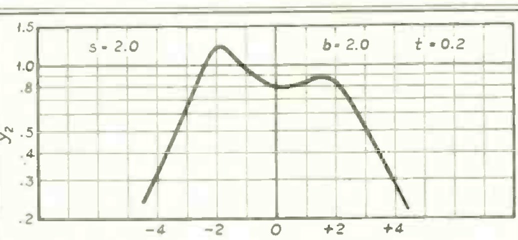


Fig. 4. Effect of resistance in the coupling condenser

AN INSTANTANEOUS RECORDING HEAD

By GEORGE J. SALIBA

Chief Engineer

PRESTO RECORDING CORPORATION

INSTANTANEOUS RECORDING has progressed so rapidly in the last two years and its field of application has been so widened that now the hue and cry is for recordings that are equal in every respect to commercially pressed electrical transcriptions. The amplifiers, record materials, and recording machines have been so highly developed that instantaneous records are now equal to commercial transcriptions in every respect except one—and that one exception is high-frequency response. The fault has been in the type of cutting head used, and it is the purpose of this article to discuss a late development in recording heads.

In designing the cutting head herein described the following specifications were laid down:

(1) It must be driven with comparatively little power

(2) It must have a good frequency response from 50 to 7,000 cycles

(3) It must work from a low-impedance source not exceeding 500 or 600 ohms

(4) It must not be susceptible to weather conditions and high temperatures

(5) It must maintain its calibration with very little service.

A good recording head operates in a linear fashion over the range of amplitudes involved in speech and music. It is essentially a constant-velocity device. This means that for a given input voltage to the speech coils of the cutter, the amplitude of the wave on the disc at a frequency of 500 cycles will be twice as much as the amplitude for 1,000 cycles and four times as much as the amplitude for 2,000 cycles. Since the energy of speech and the timbre and depth of good music lie principally in the lower frequencies, it is obvious therefore that the greatest tendency for two adjacent grooves to cut into each other will occur at the lower frequencies. Therefore, below 400 cycles the cutter should have constant amplitude. This means that for a given input the amplitude at any frequency below 400 cycles will be the same. The frequency characteristic of the cutting head in Fig. 1 is shown in Fig. 3.

The upper limit of high-frequency response is seen to be 7,000 cycles. This is about the practical limit in lateral disc recording. The sharpness of the angle of cut becomes of great importance in the reproduction of frequencies higher than this. At any given distance from the center of the disc the wavelength of the groove will be inversely proportional to the frequency. Therefore, with increase of frequency the distance between successive points at which the groove crosses the mean will become less and less. If a record is cut with maximum lateral amplitude for a number of single frequencies proceeding from low to high, a frequency will presently be reached for which the wavelength is so small as compared with the amplitude that the groove crosses the mean very nearly at right angles. It is impossible for a needle to follow so steep a wave front, and therefore it will be necessary to reduce the amplitude in order that the needle may track at such frequencies. As soon as the amplitude is reduced, the surface noise will become quite noticeable, with the result that little is gained. (A study of amplitudes and wavelengths appeared in the January, 1936, issue of COMMUNICATION AND BROADCAST ENGINEERING.) Since the linear velocity of the needle in the groove is at all times proportional to the distance from the center of the disc to the groove where the needle rests, it follows that the angle of cut is of less importance as a limiting factor toward the outside of the disc than it is toward the inside. For example, a frequency of 7,000 cycles might be easily reproduced at the outside of the disc and not reproduced at the inside.

ARMATURE MOUNTING

The electrical principle involved in the operation of recording heads is the same as that involved in the operation of electric motors. The recording head performs the same function as an electric motor; both take electrical energy and convert it to mechanical energy. The principle involved in either case is the same; namely, that of a wire carrying current in a magnetic field. In recording, alternating current is fed to the coils of the head and the armature

FIG. 1. THE WIDE-RANGE INSTANTANEOUS RECORDING HEAD.

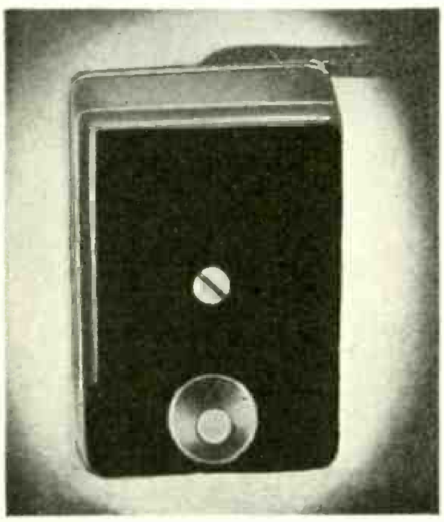


FIG. 2. ANOTHER VIEW OF THE RECORDING HEAD OF FIG. 1.

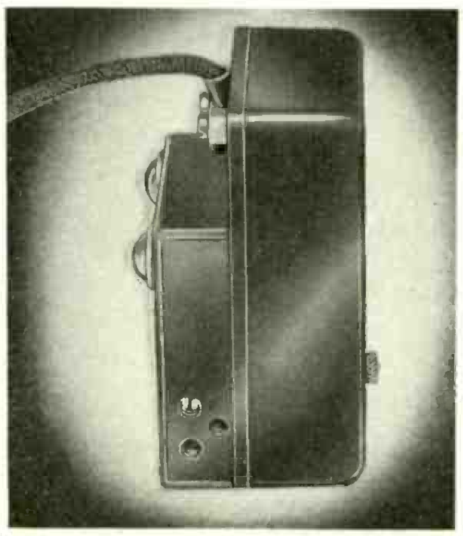
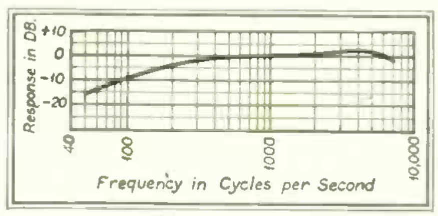


FIG. 3. FREQUENCY CHARACTERISTIC OF THE CUTTER.



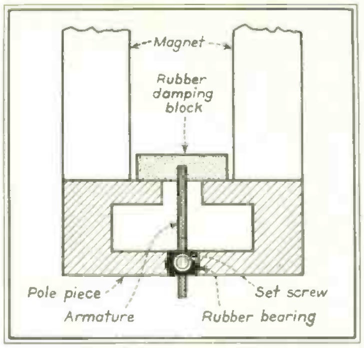


FIG. 4. AN OLDER TYPE CUTTING HEAD.

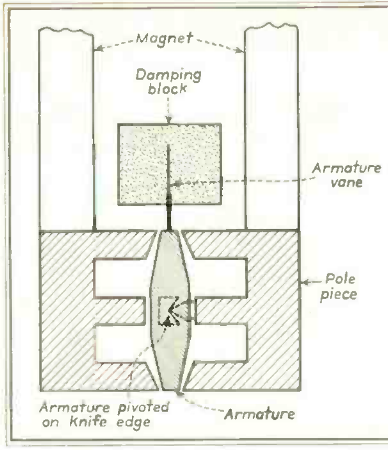


FIG. 5. A CUTTER HAVING THE ARMATURE PIVOTED AT THE CENTER.

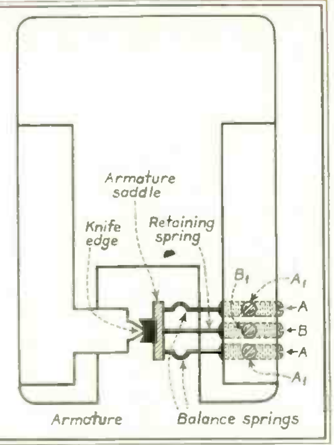


FIG. 6. REAR VIEW OF THE NEW CUTTER SHOWING ARMATURE MOUNTING.

vibrates from side to side in direct proportion to the current being fed. In the converted pickup type of cutter the armature is held in place by a rubber block which also acts as a damping block (Fig. 4). The armature is free to vibrate between the polepieces, but all the magnetic action takes place at the top of the polepieces. In the cutter shown in Fig. 5, the armature is pivoted in the center and action takes place between both the top and the bottom of the polepieces. In the cutter of Fig. 4, again, the armature is held in place by the pressure of the polepieces which are milled out in semi-circular form to fit the armature. Between the polepieces and the armature is the rubber washer, and, as mentioned previously, it is this rubber washer with its lost motion that plays the biggest part in limiting the high-frequency response.

In designing the cutter of Fig. 1, a great deal of thought was devoted to finding a method of mounting the armature which would eliminate all possibility of lost motion. The method finally found to be the most satisfactory is shown in Fig. 6. This shows a detailed rear view of the armature looking at the back of the cutter. The armature has a V bearing milled out along its longitudinal length. In manufacturing, this operation is very carefully carried out so that a perfect V is made, the apex of which is a fine line. The armature is mounted with this V resting against a knife edge which is also carefully ground and hardened.

The method of keeping the armature tight against the knife edge is unique and at the same time practical. On the right side of the armature is mounted the armature saddle on which are mounted three springs. The center spring is known as the retaining spring and is fastened to screw B. Turning screw B pushes the armature up against the knife edge. Inspection of the contact area between the knife edge and the V of the armature is then made under a powerful microscope. When the proper contact is made B is locked with set-screw B-1 and sealed. Once this adjustment is made, it need never be tampered with.

The two balance springs are used to center the armature between the polepieces. Each spring is controlled by its own screw A and when the position of the armature is definitely set, the screws are locked by set-screw A-1. These three screws comprise the entire adjustments on the cutter and, since they are set and adjusted at the factory, the cutter should require very little service and very little adjustment in the field.

DAMPING

In any transmission system a correct terminating impedance is desired and since the cutting head is a transmission system in itself, converting electrical energy to mechanical energy, it also requires a proper terminating impedance.

In commercial wax recording the load imposed by the wax is very small and therefore it is necessary to create a mechanical impedance in the cutter that is relatively large. The mechanical load used as a terminating impedance is a rod of rubber about 10 inches long. Loss of energy along this rubber rod is such that a vibration is substantially dissipated by the time it has travelled down the line and back. Thus the rod constitutes a substantially pure mechanical resistance. In acetate recording the material which is being cut offers a much higher resistance to the cutter than wax does, and, therefore, a built-in large mechanical terminating impedance, such as a long rubber rod, is not required. Hence, the problem of damping is quite different, and the damping block consists of a small piece of absorbent material which successfully dissipates the vibrations without causing them to react again on the armature.

OPERATING LEVEL

This cutter operates at a level of + 16 db which is the equivalent of 0.242 watt referred to .006 watt as zero level on a 500-ohm line. At this level the groove in the disc is fully utilized at a pitch of 112 lines per inch and the surface noise is 40 db below the level of the recorded sound. This is 10 db better than the surface noise on a shellac pressing, and about equal to the surface noise on the best acetate transcription disc. A level of + 16 db is comparatively low, and any well-designed recording amplifier having clean power output of at least 2 watts will handle the head very easily.

MEASUREMENT OF FREQUENCY RESPONSE

In obtaining a frequency characteristic of a cutting head three methods are commonly used. In the deflection method the cutting head with a recording stylus set in it is clamped tightly in a vise and frequencies are fed to it. Then a polarized beam of light is focused on the needle and by means of calibrated microscope the amount of deflection of the needle point is measured for each frequency. The frequency characteristic of the head is then plotted. This is the true frequency response of the head and the readings give the air velocity of the needle point. This method is satisfactory for measuring wax cutters where the terminating impedance is built in as part of the head as discussed previously. With acetate, the major portion of the terminating impedance is the disc material itself, and any true frequency response of the head should include the recording material. One method of utilizing the disc ma-

(*Continued on page* 16)

TWO-TERMINAL EQUALIZERS

By CARL E. SMITH*

Assistant Chief Engineer

WHK - WJAY

MOST TRANSMISSION NETWORKS inherently produce frequency and phase distortion. This is because the inductive and capacitive elements are not in the correct proportion to give distortionless transmission.

Frequency and phase distortion can be improved by artificial loading to bring the inductive and capacitive elements into the correct proportion, or an equalizing network can be added to make the desired correction. Loading decreases transmission loss to give distortionless transmission, while the equalizing network merely adds more attenuation and phase shift until the transmission is distortionless. Since artificial loading must be applied along the transmission network, its installation is justified only as a permanent installation. The equalizing network can be added as a permanent installation or only temporarily to improve the transmission characteristics of a network.

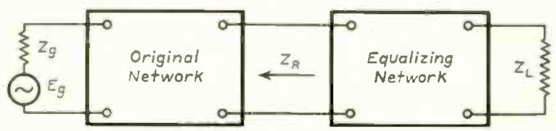
Due to the added loss in equalizing, a distortionless amplifier sometimes has to be added to obtain the desired output level. The equalizer itself is usually inserted at the receiving termination, hence, none of the signal is attenuated before entering the transmission network, thus improving the signal-to-noise ratio. If the transmission network signal-to-noise ratio is satisfactory, the amplifier can be added at the receiving termination and, hence, will not have to handle as high a level as if it were inserted at the transmitting end. If the signal-to-noise ratio is objectionable, it may also be necessary to insert an amplifier at the transmitting end of the transmission network. In the case of imperfect amplifiers, the equalizer can be designed to at least improve the overall frequency-response characteristic.

Since it is not ordinarily necessary to correct for phase distortion in the transmission of audio frequencies, the equalizer can be materially simplified in its design to give only attenuation equalization. It should be noted. however, that phase shift is very important in certain applications.[1]

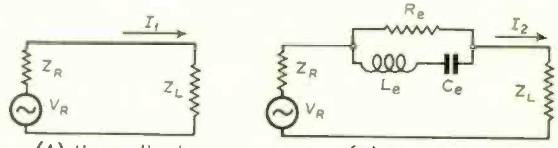
One of the simplest forms of the attenuation equalizer is the two-terminal equalizer of either the series or shunt variety. The series-admittance equalizer can be used in a series circuit and is more adapted to the unbalanced transmission line while the shunt-impedance equalizer is equally applicable in balanced or unbalanced circuits.

The two-terminal equalizer in simplest form contains resistance, inductance and capacity elements. With these three variables it is possible to obtain perfect equalization at only three points. By the proper selection of these frequencies, the frequency distortion over the desired frequency range can be made very low.

*Author of "A Practical Radio and Communication Engineering Course for Home Study."
[1]C. E. Smith. "Phase-Shifting Networks." COMMUNICATION AND BROADCAST ENGINEERING, Vol. 3, p. 21, May 1936.



An equalized network
Fig. 1



(A) Unequalized (B) Equalized
A simplified network for determining the insertion loss of a series admittance equalizer
Fig. 2

Before designing an equalizer, it is necessary to decide upon the band of frequencies to be equalized. In telephone practice this may be from 200 to 2,500 cycles per second, to give reasonably clear articulation of the received speech. In broadcast networks it is desirable to equalize from at least 100 to 5,000 cycles per second, and in the very best installations the frequency range may extend from 20 to 17,000 cycles per second for high fidelity.

In the design of a two-terminal equalizer it is essential to know the load impedance Z_L and the receiving-end impedance Z_R looking back into the original network as shown in Fig. 1. These values can be obtained by impedance measurements or by theoretical calculation if the network constants are known. The equalizer will then modify the termination, hence the modification must be taken into account in determining the equalizer characteristics.

The original network including any generators can by Thevenin's theorem be replaced by a generator V_R in series with an impedance Z_R as shown in Figs. 2 and 3. From these equivalent networks the insertion loss can be determined and the design equations developed.

SERIES-ADMITTANCE EQUALIZER

Briefly, the design equations of a series-admittance equalizer can be determined as follows. The equation of the insertion loss of the equalizer is developed from the simplified network of Fig. 2. At a very low frequency f_1 the resistance R_e is the determining factor of the equalizer insertion loss because the reactance of the condenser C_e is very high, making the parallel arm ineffective. Hence, R_e is selected to give perfect equalization at the low frequency f_1. At the intermediate frequency f_2 the capacity C_e is selected such that the equalizer will offer the correct admittance. In order to make this determination, it is necessary to know f_3, the highest frequency at which perfect equalization is to be obtained, because the inductance L_e at this frequency is finally selected to give series resonance with C_e. At the frequency f_3 the equalizer offers no insertion loss.

The insertion loss of the series-admittance equalizer illustrated in Fig. 2 can be obtained from the current ratio, thus

$$\varepsilon^{\gamma} = \frac{I_1}{I_2} = 1 + \frac{Y_s}{Y_e} \qquad \text{(1)}$$

where

ε = 2.718... base of natural logarithms
γ = $\alpha + j\beta$ the propagation constant
α = attenuation constant
β = wavelength constant
I_1 = unequalized load current
I_2 = equalized load current
Y_s = mho admittance of Z_R and Z_L in series
Y_e = mho admittance of the equalizer.

Since phase distortion is neglected, we will define the attenuation factor **F** as

$$F = \varepsilon^{2\alpha} = \left|\varepsilon^{2\gamma}\right| \qquad \text{(2)}$$

The attenuation due to the insertion of the equalizer can be obtained by substituting (1) in (2) to obtain

$$F = \frac{(G_s + G_e)^2 + (B_s + \omega' C_e)^2}{G_e^2 + (\omega' C_e)^2} \qquad \text{(3)}$$

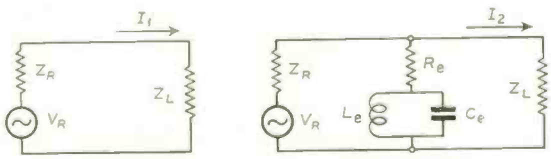
where

$Y_s = G_s + j B_s$ mho series admittance
G_s = mho series conductance
B_s = mho series susceptance
$Y_e = G_e + j\omega' C_e$ mho equalizer admittance
G_e = mho equalizer conductance
$\omega' = \dfrac{2\pi f}{1-(f/f_s)^2}$ where f_s is the highest frequency chosen for perfect equalization
C_e = farads equalizer capacity.

At a very low frequency f_1, ω' becomes small, hence $\omega' C_e$ can be neglected to give approximately

$$F_1 = \frac{(G_{s1} + G_e)^2 + B_{s1}^2}{G_e^2} \qquad \text{(4)}$$

The subscript refers to the frequency at which perfect equalization is to be obtained.



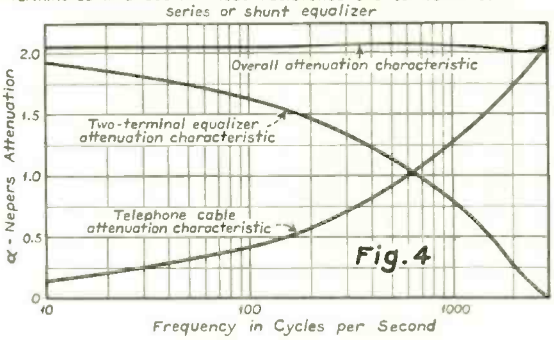
(A) Unequalized (B) Equalized
A simplified network for determining the insertion loss of a shunt impedance equalizer
Fig. 3

This equation can be solved to determine the equalizer resistance

$$R_e = \frac{1}{G_e} = \frac{F_1 - 1}{G_{e1} + \sqrt{F_1 G_{s1}^2 + (F_1 - 1) B_{s1}^2}} \text{ ohms} \qquad \text{(5)}$$

This value of resistance R_e, if substituted in (3) along with the intermediate frequency f_2, yields the capacity of the equalizer

Attenuation characteristic of a 10-mile, 19 gage, telephone cable terminated in a 500 ohm load resistance and corrected by a series or shunt equalizer



$$C_e = \frac{B_{s2} + \sqrt{F_2 B_{s2}^2 + (F_2 - 1)\left[(G_e + G_{s2})^2 - F_2 G_e^2\right]}}{(F_2 - 1)\,\omega_2'} \qquad \text{(6)}$$

in farads.

The final step is to determine the equalizer inductance, L_e to give series resonance with the above determined capacity C_e, thus

$$L_e = \frac{1}{(2\pi f_s)^2 C_e} \text{ henries} \qquad \text{(7)}$$

SHUNT-IMPEDANCE EQUALIZER

The design equations of the shunt-impedance equalizer are obtained in a manner similar to those of the series-admittance equalizer. Referring to Fig. 3, the insertion loss can be obtained from the current ratio, thus

$$\varepsilon^{\gamma} = \frac{I_1}{I_2} = 1 + \frac{Z_p}{Z_e} \qquad \text{(8)}$$

where

Z_p = ohms impedance of Z_R and Z_L in parallel
Z_e = ohms impedance of the equalizer.

The attenuation factor can be written in a form similar to that obtained in (3), thus

$$F = \frac{(R_e + R_p)^2 + (X_p + \omega' L_e)^2}{R_e^2 + (\omega' L_e)^2} \qquad \text{(9)}$$

where

$Z_p = R_p + j X_p$ and $Z_e = R_e + j\omega' L_e$

The attenuation factor F_1 is approximately

$$F_1 = \frac{(R_{p1} + R_e)^2 + X_{p1}^2}{R_e^2} \qquad \text{(10)}$$

which solved for the equalizer resistance R_e yields

$$R_e = \frac{R_{p1} + \sqrt{F_1 R_{p1}^2 + (F_1 - 1) X_{p1}^2}}{F_1 - 1} \text{ ohms} \qquad \text{(11)}$$

If this value of R_e is substituted in (9) the equalizer inductance L_e can be obtained

$$L_e = \frac{X_{p2} + \sqrt{F_2 X_{p2}^2 + (F_2 - 1)\left[(R_e + R_{p2})^2 - F_2 R_e^2\right]}}{(F_2 - 1)\,\omega_2'} \text{ henries} \qquad \text{(12)}$$

(*Continued on page* 31)

ULTRA-SHORT-WAVE RADIO LANDING BEAM

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C. LORENZ—A.G., BERLIN—TEMPELHOF, GERMANY

WITH MODERN METHODS of aerial navigation and growing air traffic density, electrical landing facilities are constantly increasing in importance. Under unfavorable weather conditions they are indispensable to successful aircraft operation.

Preliminary to a description of the essential advantages of the C. Lorenz-A. G. ultra-short-wave system, it may be stated that basically it provides radio-telegraph reception, indicating the approach path to the airport, and, similarly, two distance markers governing the landing process. When developing the system, the guiding principle was to employ radio only for such purposes as could not be accomplished by other means, and at the same time provide a receiver which would be electrically independent of that used for communication purposes, thus reducing the manipulation on board the plane to a minimum. In view of these considerations and with due regard to such factors as interference from landing beacons of neighboring airports, the operating frequency had to be chosen. Because of their definitely determined operating ranges, only frequencies above 30 megacycles could be considered, both for the radio beacon and for the marker beacons.

The direction of approach in the C. Lorenz-A. G. system is based on the beacon principle, giving side or boundary indication of the landing path; and, also, at two points along this path, signals serving as distance markers, and indicating to the pilot the distance of the machine from the landing field (Fig. 1).

Ultra-short-waves, with their lines of constant field strength, may be utilized under specific circumstances in vertical navigation as electrical landing curves; but they have not been thus applied in Germany during the last part of the landing process, despite the fact that experiments have indicated their practicability under certain conditions. Difficulties in their application lie mainly in the fact that the course of their curve does not correspond to the natural glide path. These difficulties have been overcome with the help of clockwork regulating instruments which reshape the normal indication obtained

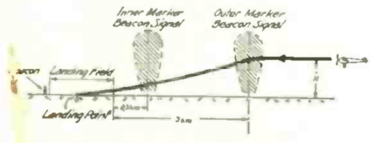


FIG. 2. SCHEMATIC ARRANGEMENTS OF LANDING METHOD.

by means of the beam into a straight glide path. The experimentally tested glide path (Gleitweg) process, with due regard to certain attendant circumstances, can be utilized as, for example, in Switzerland, where the glide path is followed down within a few meters from the ground.

The equipment of the ground station is the same, irrespective of whether the method of electrical vertical navigation is employed or that at present utilized in Germany, viz., of landing at a constant rate of descent (Fig. 2).

APPROACH AND LANDING PROCESS

If, in consequence of poor visibility due to fog or other conditions, landing by means of a radio beacon beam is necessary, the pilot guides his machine to the vicinity of the airport (a zone of approximately 30 km radius) by existing means of direction finding or homing. By means of the tone-modulated signals radiated by the main beacon, he reaches the approach path marked by this beacon. For the reception of the beacon signals an automatically operating receiver is used, furnishing the pilot with both aural and visual indication of the position in the horizontal plane of the machine with respect to the guiding beam of the radio beacon. The approach path sector, as is well known, is defined by the intersection of two radiation diagrams produced by the alternate operation of two reflector dipoles (Fig. 3). Should the airplane be outside of this approach path, short dots are heard on the port side or dashes on the starboard side. Divergencies off the course are again indicated both aurally and visually (Fig. 4). By intermittent deflections to left or right of the received signal, the indicating instrument shows the direction in which the pilot should steer his machine in order to reach the approach path in which the (complementary) signals, by merging into one another, becomes a continuous note. At the moment when the continuous note is reached, the direction indicator comes to rest and indicates to the pilot that he should maintain his course for a safe landing at his destination.

During the approach, the pilot gradually decreases the height to about 200 meters. At about 3 km from the boundary of the landing field when reaching the outer marker beacon signal, lamp ("V") on the left-hand side of the visual indicator apparatus lights up and, at the same time, a deep note (700 p : s) is heard in the headphones. The pilot then throttles back and gliding down at an approximately constant rate of descent reaches the admissible minimum height at the inner marker beacon. The inner marker beacon signal is given at a distance of 0.3 km from the boundary of the landing field—a few seconds before the machine reaches this boundary—and is conveyed to the pilot by a rhythmic short-keyed high note as well as by the lighting of the right-hand lamp H in the visual indicator equipment. The pilot now knows that there are no obstacles to his flight in the final section of the landing path and can, consequently, further reduce the height of flight in order that he may bring his machine down safely even when ground visibility is at its worst.

This briefly described landing method is used to a very great extent in Central European traffic. It consists in the determination of the approach course to the airport as well as in the transmission of signals which mark two important distances from the boundary of the landing field and which are involved in the process of landing. This landing method, employing landing beacon beams of the type used in the C. Lorenz-A. G. ultra-short-wave system, is being increasingly applied in European air traffic.

DESIGN OF THE SYSTEM

The Lorenz system of navigation necessitates a "ground station" at the airport, and the installation of complementary receiving equipment ("plane station") in the airplane. For the ground station, central and fully automatic remote control, both of the main transmitter and of the marker transmitters, is provided. On the control panel, indication of the correct working of all three beacons is provided by means of similar revertive signals. The airplane receiving set is fully automatic in operation; it employs a minimum number of tubes, is simple in design, and is light in weight. The necessary range is insured by an adequate design of the ground station.

The ground equipment comprises a 500-watt guide-beam beacon transmitter together with two or four small (5-watt) transmitters for the transmission of the "signals," according to whether provision is made for one or two directions of approach flight (Fig. 5). The remote control of all transmitters takes place from a central control set ("control station") where, also, the revertive signal impulses for the supervision of traffic are made perceptible. All the transmitters are crystal controlled, operating on ultra-short waves and are designed for all-mains operation. They are supervised in every phase of operation by means of visual and audible indications at the "control station." These measures doubly insure the operation of every component part and guarantee a high degree of reliability for the system as a whole. They represent an absolute necessity for purposes of landing when visibility is bad.

(*a*) *The Radio Main Beacon Transmitter*. The requirements for this transmitter emerge from the physical bases of the landing method employed in the C. Lorenz-A. G. system. In addition to necessary constancy of radiation to provide constant field strength, the navigational significance of "beacon" radiation requires a high-frequency stability as well as an adequately constant degree of modulation. Fundamentally, the circuit employs a crystal-controlled oscillator stage from which the operating frequency ($f_B = 33.3$ megacycles) is amplified in four stages and, by means of the grid potential, the fourth stage is tone modulated. The transmitter is shown in Fig. 6-A, where the disposition of the constituent equipment may be seen. In the lower part are housed the component aggregates for the power supply which, in addition to the ventilation devices for the transmitter container, also include the high- and low-tension rectifiers (selenium rectifiers and smoothing devices). Above this equipment are the component sections intended for the circuit distribution of the feed potentials including all the associated testing instruments and also the auxiliary devices used for modulation of the operating frequency and for the keying of the associated radiation system. Near the cast-iron transmitter container, a quick-acting voltage regulator operates from the local 3-phase mains regulated to ±0.5%. The beacon transmitter is installed in a specially provided, small brick building from which feeder and keying lines connect to the radiator system. The latter consists of an energizing dipole, which is fed from the transmitter terminal stage, and on both sides of which a reflector dipole is placed at an interval $\lambda/4$. These, with the energizing dipole, are in a plane vertical to the guide beam plane and are fed by radiation coupling. The complete vertical radiation system is mounted on stiffened wooden masts erected directly in front of the beacon building (Fig. 6-B).

(*b*) *The marker beacon* (*signal*) *transmitters* function on an operating

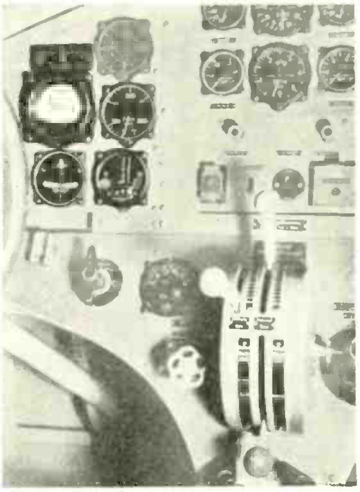


FIG. 4. VISUAL INDICATOR EQUIPMENT MOUNTED ON THE DASHBOARD OF A COMMERCIAL AIRPLANE.

frequency of $f_E = 38.0$ megacycles and differ, from a high-frequency aspect, from the beacon transmitter only in the number of amplifier stages (Fig. 7). According to the purpose for which they are to be used, the modulation frequency is either 700 p : s, for the outer marker beacon signal) or 1,700 p : s (for the inner marker beacon signal); the allocated keying series are shown in Fig. 8. The current supply of the signal transmitters is arranged for mains connection, the anode and initial grid potential being obtained by means of dry rectifiers. The transmitter itself is of a rigid and concentrated design and includes completely mounted keying and revertive signal equipment as well as all the accessories.

With regard to all the transmitters, the following may be said: in principle, importance is attached to easy manipulation and control of the correct operation of all the component apparatus. In addition to being remotely controlled all transmitters can be put into operation locally by means of switching devices which are conveniently accessible on the transmitter front panel. In practical operation they are normally connected and disconnected from the "control station" which is generally installed in the control tower of the airport.

(*c*) *Transmitter Radiation Fields*. The arrangement of the radiation fields, in relation one to another, is illustrated in Fig. 1. It shows how the approach path sector—produced as a result of the keying rhythm of the main transmitter by the alternating operation of the reflector dipole—is intersected at two characteristic points by the two radiation fields of the signal transmitter.

The transmission of the marker signals necessary to the landing process is effected by the upwardly directed, horizontal dipoles of the signal transmitters. The correct time period of reception (so-called wall strength) of the marker signals during flight is obtained by influencing in a simple way the radiation field of the horizontal dipoles. By a suitable arrangement of a wire netting, which may be regarded as a reflecting surface, it is possible with the dipole placed at about $\lambda/2$ above the surface to attain the required vertical radiation, the separation of the dipole from the reflection surface being considerably less at its center, because of the curvature of the netting (Fig. 9). Fig. 10 shows the characteristic curve of this vertical radiation. The marker transmitter is housed in a wooden hut below the netting.

Operation of Ground Station. As already mentioned, the easy supervision at any time of the operation of all component parts is of exceptional importance in view of the purpose of the system. This is accomplished by means of visual and audible signals on the same apparatus from which the switching is done. The "control station" is accordingly the nucleus of the navigational system and, at the same time, the agency that regulates and supervises the manifold switching processes pertaining to traffic operations. The operating control of all transmitters is based on the revertive signal process; the mains voltage and demodulated antenna currents from all transmitters are carried back to, and suitably indicated at, the control station. The same operating supervision directly at the individual transmitters themselves is also provided.

In practice all transmitters are put in operation by means of one main switch on the remote-control panel.

When planning the ground station the direction of approach to the airport for (perfect) landing is determined

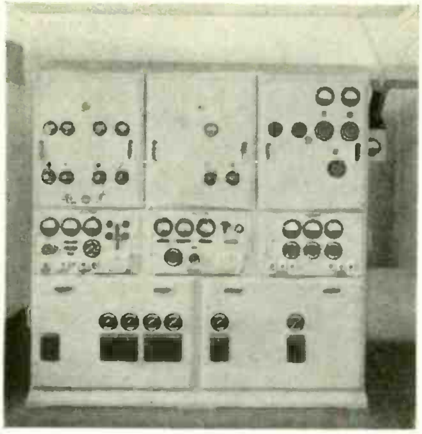


FIG. 6-A. THE RADIO BEACON GUIDE BEAM TRANSMITTER INSTALLED IN PROTECTING HUT SHOWN IN FIG. 6-B.

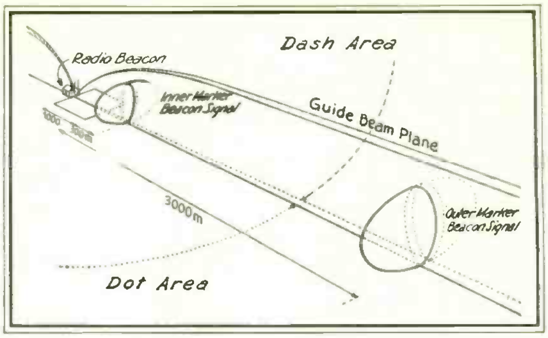


FIG. 1. GUIDE BEAM LANDING RADIO BEACON IN THE LORENZ SYSTEM.

FIG. 9. THE COMPLETE SIGNAL TRANSMITTER SYSTEM. THE TRANSMITTER IS IN THE WOOD HUT UNDER THE REFLECTOR ARCH.

with due regard to the wind direction.

The main switch on the remote-control panel with its corresponding control contacts indicated in color on the panel is so arranged that by switching either to one or the other side the appropriate marker beacons for that particular direction of approach are brought into operation. Simultaneously, by the same means, the keying of the beacon transmitter is adjusted in a manner such that dots are always transmitted to the port side of the course. These measures obviously add to the degree of safety in the carrying out of this navigation process.

On the front panel of the "control station" (Fig. 11) colored signal lamps show the presence of mains voltages and meters show that the transmitters are actually working the needles of these meters, swinging in the keying rhythm of each particular transmitter. Along with these purely visual signals, arrangements may be made for listening to the different keying signals and modulation frequencies by means of telephone control. Furthermore, any trouble is indicated acoustically by the operation of an alarm whistle and visually by the warning signal of a drop indicator. In addition, simple means are provided for the quick testing of all control and revertive signal lines to all transmitters.

Revertive signal equipment which, in particular, is intended for checking the dipole relays and which is mounted near the transmission line, is an additional means of supervising locally the beacon transmitter.

The plan in Fig. 5 shows the fundamental design of the ground station in its electrical association with the central control and supervisory stations provided for two directions of flight and, correspondingly, four signal transmitters. The spacing of the complete ground system is dependent on the position of the airport and, above all, upon the immediately surrounding conditions. It is, therefore, determined as occasion arises.

The Airplane Receiving System (Airplane Set) for Landing Purposes. The airplane receiving system serves to receive the high-frequency signals which follow one another successively on the principle of the landing method. It consists of the receiver and two associated receiving antennae. The apparatus for the pickup of the beacon frequency is a simple amplifier which has

FIG. 3. ILLUSTRATION OF THE GUIDE BEAM ZONE.

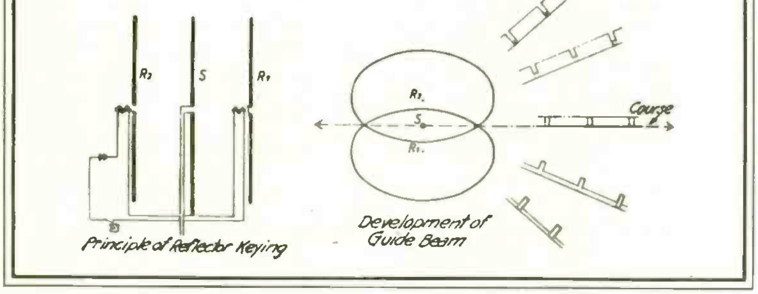
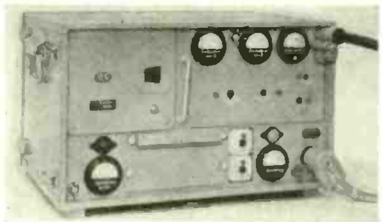


FIG. 8. THE SIGNAL TRANSMITTER WITH MAINS AND ANTENNA CABLE CONNECTED.



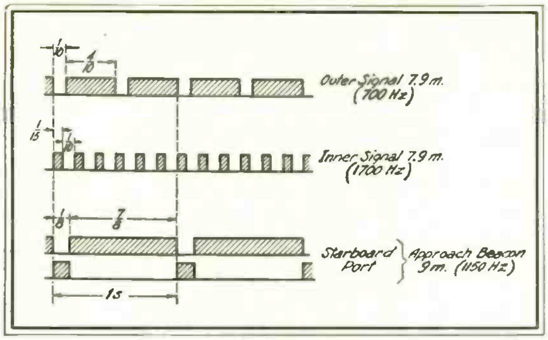


FIG. 7. ILLUSTRATING THE KEYING SEQUENCE.

FIG. 6-B. THE RADIO BEACON GUIDE BEAM TRANSMITTER HUT WITH COMPLETE RADIATION SYSTEM. SEE FIG. 6-A.

a high-frequency amplifier stage, a detector, and a low-frequency amplifier. Automatic amplifier regulation maintains the sound volume fluctuations in the headphones (Fig. 12) within admissible limits even with very considerable field strength alterations during flight. A special detector, mounted in its own metal container, is provided for the reception of the marker beacon signals. It retransmits the demodulated tone frequencies of the outer marker beacon signals to the low-frequency amplifier of the beacon receiver. Here, therefore, all three modulation notes of the ground transmitter are amplified. A filter network (frequency filter), adjusted to the existing tone frequency, filters the modulation frequencies of the marker signal transmitter (700 p : s or 1,700 p : s, respectively) and passes these low-frequency voltages on to the visual indicator apparatus. During the approach to the radio beacon, an approximate idea of its distance is obtained by means of a vertical indicator instrument which is in the visual indicator set and which is connected through a rectifier to the low-frequency amplifier. The modulation frequency of the main beacon (1,150 p : s) governs the amplifier regulation as well as the indication of distance and divergence to the side. Special equipment, which is connected to the low-frequency amplifier through a rectifying arrangement, and which is mounted horizontally in the instrument container of the visual indicator set, indicates divergences to the side and serves to clearly determine the course of the airplane. During flight, a switch mounted in the operating set on the dashboard of the airplane is placed in the "approach" position, and amplifier regulation is effected. (For the purpose of glide path landing—vertical navigation—this switch is thrown to "glide path" at the outer marker beacon signal, whereupon automatic amplitude regulation is disconnected.) The airplane battery provides the power supply for the receiving set and operates the converter: the latter supplies power for the filament lamps as well as the necessary voltage for the anode circuit of the amplifier. An example of a typical installation of an airplane set in an airplane of the "Deutschen Luft-Hansa" is shown in Fig. 13.

A vertical dipole about 90 cm in length, connected through a suitable transformer to the receiver input,

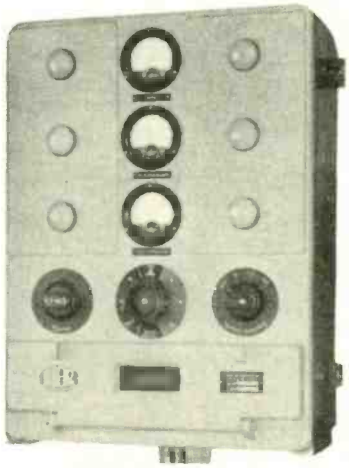


FIG. 11. THE CONTROL STATION. NOTICE THE COLORED SIGNAL LAMPS AND THE METERS DESCRIBED IN THE ACCOMPANYING TEXT.

FIG. 13. INSTALLATION OF A RECEIVING SET IN AIRPLANE OF DEUTSCHEN LUFT-HANSA.

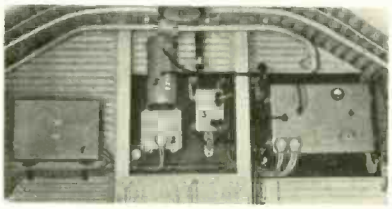
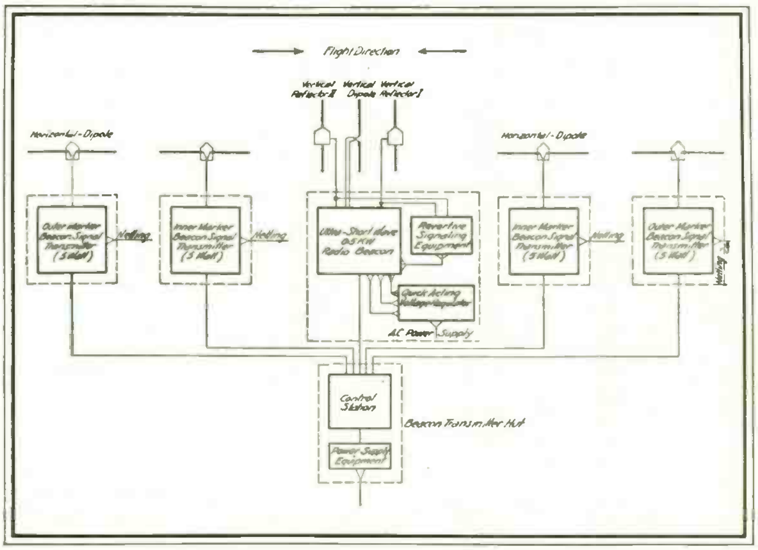


FIG. 5. PLAN OF A COMPLETE LANDING SYSTEM.



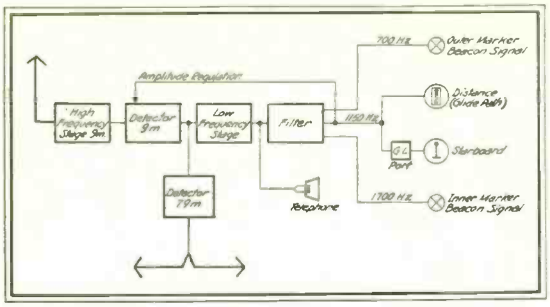


FIG. 12. FUNDAMENTAL BLOCK DIAGRAM OF THE AIRPLANE SET.

serves as an antenna for the 9-meter wave of the beacon transmitter (Fig. 14). A horizontal dipole consisting of two copper tubes about 1 meter in length is used for the reception of the marker signals. These copper tubes are fastened at an interval of about 5 cm along the airplane and under the fuselage by means of streamlined supports, and are connected through a transformer to the detector. The complete airplane receiving equipment, accordingly, consists of the beacon receiver, which contains the common low-frequency amplifier, the detector, and the frequency filter, as well as the battery box or a rotary converter. On the dashboard of the airplane is mounted the visual indicator set which includes the two instruments indicating the distance and the deviation from the course as well as the two signal lamps.

ULTRA-SHORT-WAVE LANDING RADIO BEACONS IN THE EUROPEAN AIR COMMUNICATIONS SYSTEM

If it be recognized that adaptation of the requisite ultra-short waves to this landing procedure makes normal aircraft radio communication on medium waves for additional direction finding indication unnecessary and, also, that the normal airplane radio equipment is available for communication purposes during the last minutes prior to landing, a very essential advantage will have been achieved from the viewpoint of the service organization; this, quite apart from the fact that navigation on ultra-short waves is, in practice, not interfered with by simultaneous transmission and reception on medium waves. Furthermore, the ground equipment necessary for this landing method is designed so that it can, without difficulty, be introduced into existing ground station radio organizations. As early as the year 1932, under the direction of German Air Authorities, an experimental system was erected by C. Lorenz-A. G. for bad weather landing at the Berlin-Tempelhof airport and was demonstrated to those attending the International Air Service Conference in January, 1933. The next conference (Geneva, 1934), also the Meeting of Experts (Paris, November, 1933, and Warsaw, September, 1934), dealt with the improved design of this system and determined the operating frequency for the guide-beam beacon as well as for the marker beacons, together with the associated modulation frequencies. These decisions and further practical experience led, during the last two years, to a rapid extension of the landing radio network in Germany and, from time to time, other European countries have adopted it. Today, the following German state airports are equipped with radio landing systems: Berlin, Breslau, Danzig, Leipzig, Frankfurt a/M., Hamburg, Hannover, Köln, Königsberg, München, Nürnberg, Stettin, and Stuttgart. Among foreign airports, the following already have complete sets: London (three radio landing systems), Milan, Paris, Stockholm, Warsaw, Vienna, and Zürich; similarly, Japan and Russia.

These radio landing systems are in preparation for Budapest, Prague, Rome, Venice, as also for Poland, Australia, South Africa, and South America.

In view of the great significance of the air service in modern communications, the landing radio beacon offers security facilities which can no longer be disregarded. It is, in fact, fundamental to developments in the important branch of aeronautics pertaining to safety.

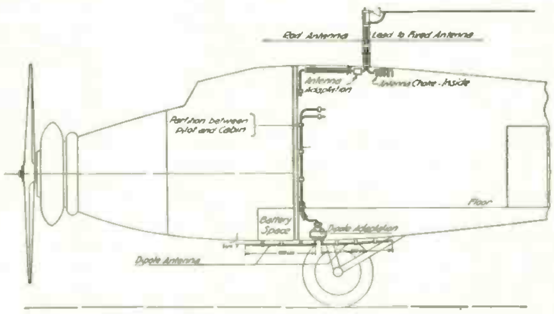


FIG. 14. THE ANTENNA ARRANGEMENTS OF THE AIRPLANE SET.

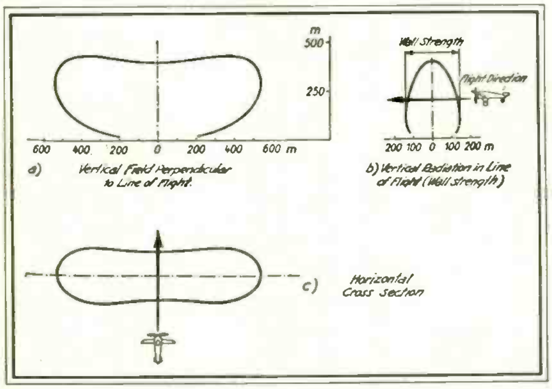


FIG. 10. RADIATION CHARACTERISTIC CURVE OF THE SIGNAL TRANSMITTER.

•

RECORDING HEAD

(*Continued from page* 9)

terial is to record the different frequencies and then measure their amplitudes on the record by means of a calibrated microscope. This method is an excellent one but tedious and long drawn out. An easier way is to record the different frequencies and then reproduce them using a calibrated pickup, amplifier and vacuum-tube voltmeter. Then by taking into consideration the discrepancies in the pickup and amplifier the true response of the cutter is found. This is the method used in obtaining the characteristic shown in Fig. 3.

The development of this high-fidelity cutting head makes possible much wider

(*Continued on page* 25)

INSIDE PUBLIC-ADDRESS INSTALLATIONS

by JOHN P. TAYLOR

IN A PRECEDING ARTICLE[1] the equipment and methods suitable for public-address installations intended to serve very large areas—fairs, exhibitions, raceways, and the like—were discussed. In that discussion, considerable emphasis was placed on the correspondence with broadcast methods and equipment—and, in fact, it was found that installations of this size were, with the exception of the distributing systems, practically identical to broadcast installations of similar size. In the somewhat smaller equipments considered in the present article, this correspondence is not as good—and, as still smaller equipments are considered, the divergence will be found to increase. Largely this follows from the fact that, whereas small broadcast installations use the same equipment *units* as large ones, there is in public-address installations a considerable difference in equipment with size. The lesser importance of standardization, and the difference in relative quantities involved, has something to do with this. However, the chief reason is that whereas broadcast installations are almost invariably planned for future expansion, public-address installations are usually designed for maximum possible requirements. Moreover, in the latter there does not exist that requirement of flexibility, which, in the former, makes the use of standard units—even in the smallest installations—so desirable. As a result, public-address installations are ordinarily made as compact and simplified as the requirements of the particular installation and the limitations of available equipment will allow.

[1] "Super-Power Public-Address Installations," by John P. Taylor, COMMUNICATION AND BROADCAST ENGINEERING, December, 1936.

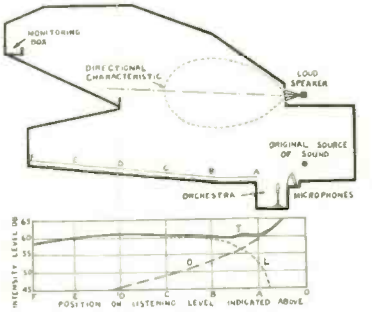


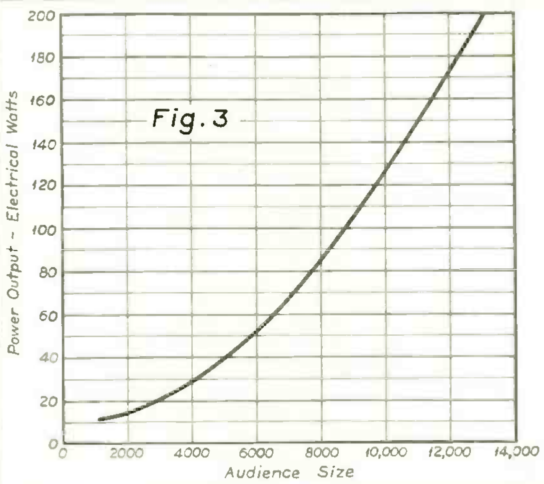
FIG. 1. ARRANGEMENT DESIGNED TO PROVIDE EQUAL SOUND INTENSITY THROUGHOUT AN AUDIENCE. (FROM "SOUND REENFORCING SYSTEMS," BY H. F. OLSON, RCA REVIEW, JULY, 1936.)

FUNDAMENTALS OF SOUND REENFORCEMENT

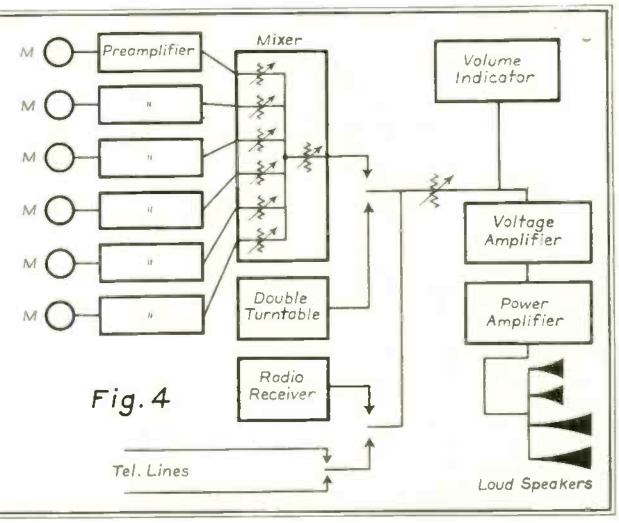
In taking up equipment for inside installations—auditoriums, theatres, exhibition halls, arenas, and the like—after considering large outside installations, it is necessary to first make clear one particularly marked distinction. In outside installations the sound is, for practical purposes, picked up, amplified and delivered to the audience by means of loudspeakers of relatively high power. In such a system the intensity of the original sound is, comparatively, so small as to be negligible—and hence can be omitted from the consideration. On the other hand, for most inside installations—and certainly for all of those of the general type of auditoriums, theatres, etc.—the original sound is of some importance, and plays a part in covering the listening audience which must be given consideration. Thus, inside systems may be said to function to reenforce and add to the original rather than to completely replace it.

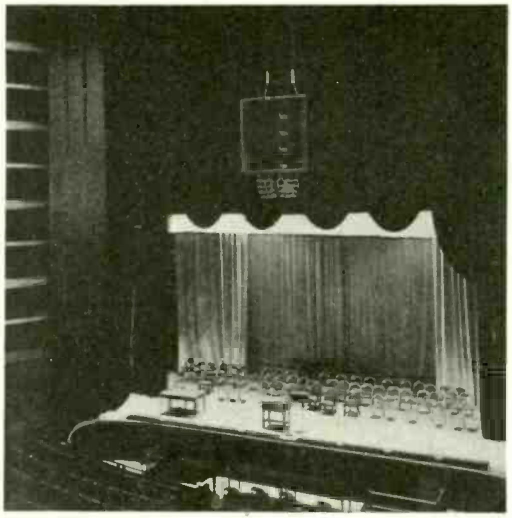
The operation of such a system—and the correct relation of the several components—is particularly well explained by the diagram of Fig. 1 which is due to

APPROXIMATE ELECTRICAL POWER REQUIRED AS A FUNCTION OF AUDIENCE SIZE. DRAWN FROM THE AVERAGE OF RECENT INSTALLATIONS AND MANUFACTURER'S RECOMMENDATIONS.



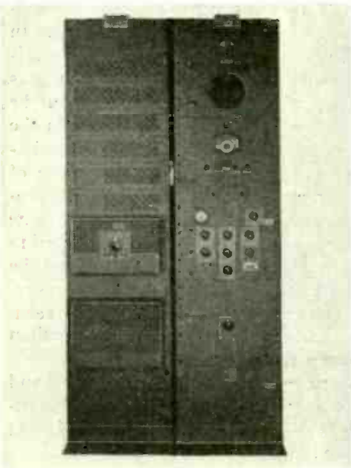
SIMPLIFIED SCHEMATIC DIAGRAM OF THE 40-WATT SINGLE-CHANNEL EQUIPMENT ILLUSTRATED IN FIG. 5 AND DESCRIBED IN THE ACCOMPANYING TEXT.





Western Electric Photo

FIG. 2. TYPICAL LOUDSPEAKER INSTALLATION FOR SMALL AUDITORIUM OR MUSIC HALL. LOW-FREQUENCY AND HIGH-FREQUENCY UNITS ARE LOCATED IN THE PROSCENIUM AND DIRECTED SO AS TO PROVIDE UNIFORM FREQUENCY RESPONSE AND INTENSITY LEVEL.



RCA Photo

FIG. 5. SINGLE - CHANNEL PUBLIC - ADDRESS EQUIPMENT FOR USE IN AUDITORIUMS, THEATRES, ETC.

Dr. H. F. Olson.[2] Referring to this diagram, there will be seen (above) a cross-section of a typical theatre indicating the usual placement of microphones and loudspeakers—and (below) a graph showing the proper combining of relative intensity levels to provide satisfactory coverage of all parts of the audience. In this graph, curve *O* represents the intensity level due to the original sound alone. It will be seen that this falls off quite rapidly with distance away from the source. In a detailed analysis of reproduction problems, Olson and Massa[3] have determined that, for ordinary conversation, the mean power fluctuates about an average of 65 db above the threshold of audibility. For maximum intelligibility it is necessary that this level be approached throughout the audience. At the same time it is undesirable to increase the intensity very much above this at any point. The solution is to place the loudspeakers and to direct them so that when the sound coming from them is added to that of the original sound, an even distribution results. Fig. 1 shows how this is accomplished. Curve *L* is the intensity level due to the loudspeakers alone. When the points on this curve are added to those on curve *O* (remembering that the intensity values are logarithmic) the result is curve *T*, showing that practically all parts of the house receive identical sound irrespective of their distance from the source.

THE POWER REQUIRED

Accomplishment of an even distribution as shown in Fig. 1 requires selection of speakers with proper directional characteristics, proper placing of these—orientation as well as location—and, finally, correct amount of power output. Ordinarily the latter allows of the widest variation. It may be calculated from the various constants involved, or arbitrarily estimated on the basis of experience with similar previous installations. Neither method yields very accurate results, because of the many complicated factors which enter. However, approximation is sufficient, since the power can always be adjusted somewhat after the installation is made. In any event, the total power requirement will be markedly less than the outside installations considered in the previous article. Not only are the audiences smaller, but they are usually more concentrated. Moreover, the noise levels are usually lower, and there is a certain amount of sound reflection which adds somewhat to the intensity. The graph shown in Fig. 3 gives a rough indication of the power ordinarily required in terms of total audience. This is drawn from a compendium of manufacturers' recommendations and specifications of recent typical installations. It should be remembered, however, that total audience is only one factor—and, probably, not the most important at that. The total volume of the theatre or hall is usually considered a more accurate indication of the power required. The curve in Fig. 3 was plotted in terms of audience in this instance because this has more meaning to the engineer not experienced in this work, than would the total volume—which is a quantity difficult to visualize rapidly. Depending on this and other factors, the actual power required in any particular installation may be expected to vary 50 percent from the values of Fig. 3.

Once the power required for adequate reenforcement of the original sound has

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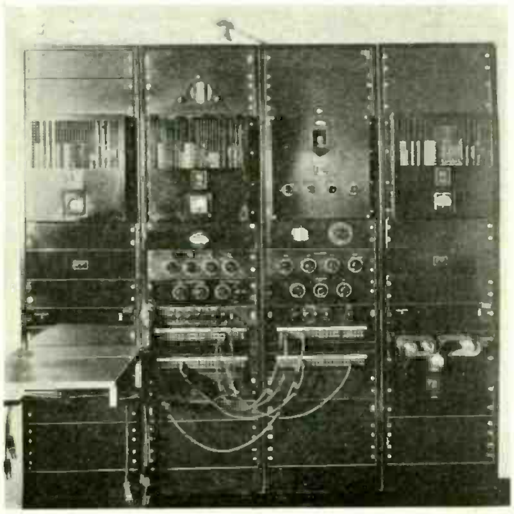


FIG. 8. INPUT, SWITCHING AND LOW-LEVEL EQUIPMENT OF THE KANSAS CITY AUDITORIUM INSTALLATION.

[2]"Sound Reenforcing Systems," by Harry F. Olson, *RCA Review*, July, 1936.
[3]"Applied Acoustics," by H. F. Olson and F. Massa, P. Blakiston's Son & Co., Inc.

been determined, as above, the equipment necessary to produce and handle this output can be considered. Involved are the functions of pickup, mixing and switching, amplification, monitoring, and distribution. The first of these are similar to those encountered in a broadcast system and will require corresponding units; that is, microphones, preamplifiers, mixing and switching panels, voltage amplifiers and volume indicators—and generally these will be individual units, although not necessarily of the same construction as the corresponding broadcast units. In addition to these units, which are familiar to broadcast engineers, there will be one or more power amplifiers, loudspeaker control panel and, of course, the loudspeakers.

While the basic units of all systems must necessarily be very much alike, the details of the arrangement may vary considerably. For instance, high-level mixing (that is, with individual preamplifiers ahead of the mixing panel) and low-level mixing (that is, with a single preamplifier following the mixer) are used about equally. The number, and, of course, also the type, of microphones used may vary widely—as may the other input provisions (that is, for outside lines, turntables, radio receivers, etc.). Ordinarily the voltage amplifier and volume indicator are standardized units. The power amplifiers may range from a single small unit, of 10 watts or so output, to as many as four or six parallel units, each capable of 40 or 50 watts output. The loudspeaker control panel will depend upon the flexibility required of the system. The loudspeakers themselves may be of any of a dozen different types—ranging from small metal directional speakers to multi-unit exponential horns—or almost any combination of the several different types (see Fig. 2).

In the larger installations various adaptations of the standard rack-and-panel construction are used. The placement of the equipment also offers some choice. In installations where the control room commands a view of the pickup point, the mixer and switching panel may be located on the main rack with the other units. Where the control room is located some distance away, it is necessary to use a small control box—either portable or fixed—located within view of the microphones in order that proper mixing can be accomplished. The standard placement of speakers for auditoriums has been indicated above. However, for large arenas and similar places, quite different arrangements for speaker location may have to be made, and even some provision for choice of speakers to be used. These alternatives, as well as other details of suitable arrangements, will best be illustrated by consideration of two typical examples chosen from actual installations.

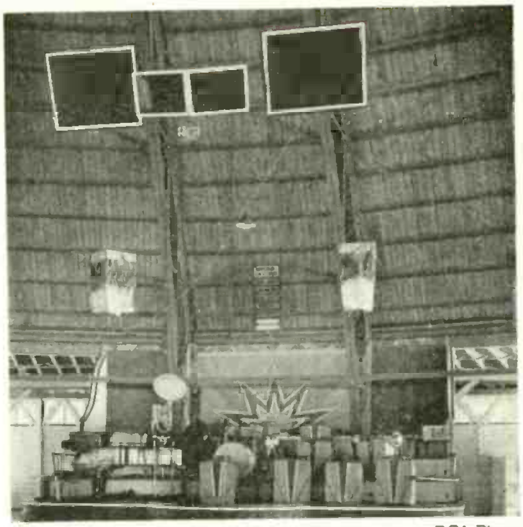


FIG. 6. LOUDSPEAKER INSTALLATION SUITABLE FOR USE WITH EQUIPMENT SHOWN IN FIG. 5. THE LARGE HORNS ARE WIDE-RANGE HIGH-FIDELITY UNITS. THE SMALLER HORNS HAVE THE LOW FREQUENCIES ATTENUATED TO PREVENT "BOOMINESS."

RCA Photo

A 40-WATT SINGLE-CHANNEL SYSTEM

In Fig. 4 is shown the schematic diagram of a typical public-address installation for use in auditoriums or theatres of moderately large size and other similar places where a single-channel sound-reenforcing system is required. In addition to providing for reenforcement of a local program, it also provides facilities—radio receiver, turntables and line inputs—so that entertainment can be supplied from other sources as well. Fig. 5 shows the front view of this equipment—while Fig. 6 shows loudspeaker installations suitable for use with it.

Six microphones of the high-quality type (low-level output) are intended to be used with this equipment—and six

FIG. 9. THE 60-WATT POWER AMPLIFIERS FOR THE KANSAS CITY AUDITORIUM INSTALLATION.

Western Electric Photos

FIG. 10. THE ARENA OF THE KANSAS CITY AUDITORIUM. NOTE THE SPEAKER INSTALLATION SUSPENDED FROM THE CEILING.

separate preamplifiers and a six-position mixer are provided. This arrangement is more expensive than a low-level system, but has the advantage that a better ratio of program-to-noise level is obtained. The mixer panel, which also includes a master gain control, can be seen at the center of the right-hand rack. Just above this is located the volume-indicator panel and, above the latter, a simplified switching panel. This last allows the following amplifiers and loudspeakers to be fed either from the microphone input, the radio receiver, the turntables or a 250-ohm or 500-ohm line.

The voltage amplifier is mounted on the left-hand rack just opposite the mixer panel. This amplifier has an available total gain of 103 db, so if desired a microphone can be operated directly into it without need of an intervening preamplifier. It is a four-stage unit using a 6C6 input stage, a 76 second stage, a 76 third stage and an output stage employing 45s push-pull. It contains its own power supply and calibrated gain control. A remote volume control—push-button operated—is placed in operation by the "manual-remote" switch located on the panel just beneath.

The power amplifier is located at the bottom of the left-hand rack. This unit utilizes a pair of 845s push-pull and furnishes an output of 40 watts. It contains its own power supply, using a pair of 866s, and is provided with a tapped output transformer. The system is so designed that as many as four power amplifiers of this type may be operated from the single voltage amplifier if greater output power is required.

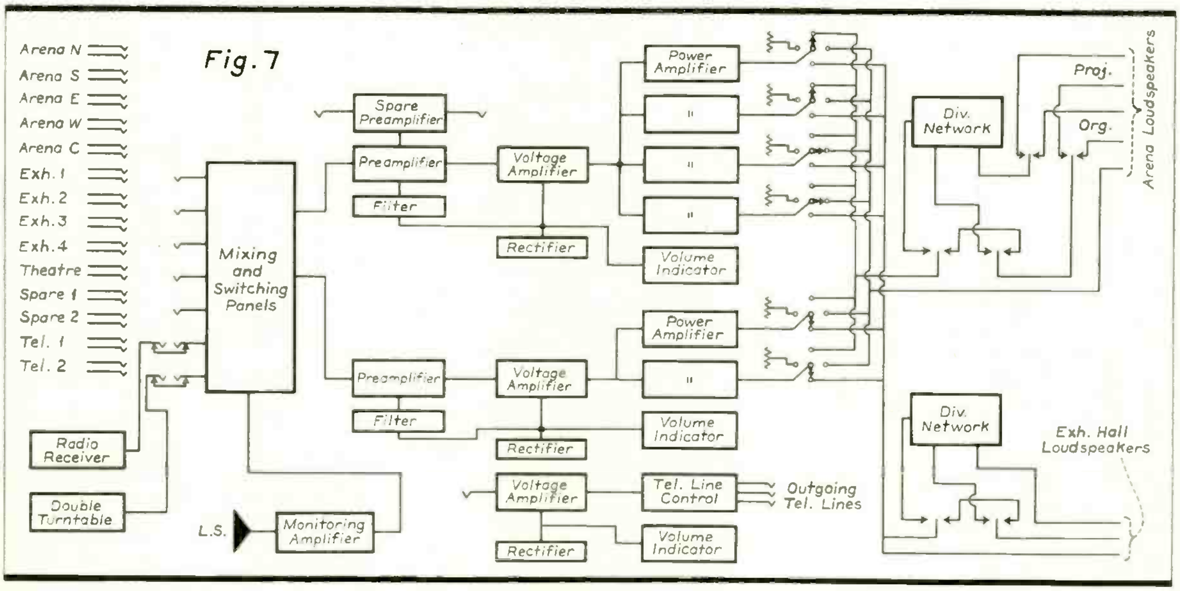
The type of loudspeakers used with this system will depend upon the acoustical properties of the installation point. The particular speaker installation shown in Fig. 6 was chosen for illustration because it shows two typical types of units. The two large exponential speakers have a wide distribution angle—55 degrees in each direction—and a very wide frequency range. These units are used where high-fidelity reproduction of both speech and music is desired, and where the acoustics are such as to permit of such operation. The two smaller speakers have been especially designed for installation where high reverberation and other acoustical difficulties are met with. The low-frequency response has been cut off at around 300 cycles, thereby eliminating any tendency towards boominess.

The construction of this equipment deserves at least brief notice. A double-faced type of construction is utilized—the units being enclosed in back as well as in front. In the amplifier units all of the components are mounted on the rear panel—usually with transformers and the like projecting to the rear. The front panels act merely as covers. They may be removed very easily, thus providing front access to the tubes and all terminals. For this particular kind of work, this type of construction has a number of advantages which will be obvious. The units and racks are of standard dimensions and are mounted and arranged much as in broadcast systems. Referring to Fig. 5, all of the amplifier units are located on the left-hand rack, while all of the control facilities, including the radio receiver and monitoring loudspeaker, are mounted on the right-hand rack.

The system described above is suitable for audiences of four or five thousand, and, with additional amplifiers, for even the largest of auditoriums—providing no additional facilities are required. However, very large indoor areas, such as arenas (and other places where noise level is high) will require considerably higher power and possibly other methods of distribution. Moreover, in such cases it is usually necessary to make provision for feeding outlets at other points. Fig. 7 is the schematic diagram of an actual installation of this type. This is a simplified diagram of the equipment recently installed in the Kansas City Auditorium. In addition to providing much greater power than the one previously considered, this system also illustrates the provision of facilities for extra outlets.

As will be seen from the diagram, this installation includes two complete channels with the exception of the mixing and switching controls, which are common. One channel provides sound reenforcing in the arena, while the other provides for reproducing the same program in the exhibition hall. This not only provides for overflow audiences, but also is of convenience in handling conventions and the like. In addition to these two main channels there is a simplified channel for feeding outgoing broadcast lines and a completely separate monitoring system.

The central equipment of this installation is shown in Fig. 8 and Fig. 9. The four-rack layout contains all of the controls, input circuits and everything up to and including the voltage amplifiers. The two-rack assembly contains the six-power amplifiers, the two-volume indicators associated with the main channels and necessary jack panels.



(Continued on page 23)

OVER THE TAPE . . .

NEWS OF THE RADIO, RECORDING AND SOUND INDUSTRIES

PHASE INVERSION

The phase inversion technique as practiced in both Europe and America is dealt with in detail in the June, 1936, issue of the *Aerovox Research Worker*. Because of the widespread interest in phase inversion, additional copies of this publication have been printed and made available to anyone writing to Aerovox Corporation, 70 Washington Street, Brooklyn, N. Y.

"BULLETS" IN COLOR

The Transducer Corporation, 30 Rockefeller Plaza, New York City, have announced that the Model TR-3 "Bullet" microphone is now available in Chinese red or antique ivory as well as the standard bright black color. Combinations of the three colors can also be supplied by using one color for the rear section of the microphone housing with contrasting color for the front section.

TRIUMPH BULLETIN

"How to Operate an Oscillograph and Wobbulator" is the title of a new 6-page technical bulletin offered free by the Triumph Mfg. Co., 4017 West Lake Street, Chicago, Ill. The bulletin describes a number of tests which may be made with the oscillograph, with and without the wobbulator. It also lists the uses of the new Triumph Models 77 and 820 oscillographs.

INDUSTRIAL COMMUNICATION SYSTEMS

Kelvin Engineering Company, Inc., sales engineers of technical products for export, are interested in receiving data on communication systems for installation in large industrial plants and offices. The address of the above organization is 106 Front Street, New York City, N. Y.

MICARTA BOOKLETS

A booklet entitled "Micarta In The Radio Industry" illustrates uses of this plastic material in the industry including switch parts, coil supports, tube sockets, etc. Also, a publication entitled, "Where Can You Use Micarta," includes a description of Micarta, its mechanical and electrical properties and the standard forms available. Copies may be obtained from the nearest district office or direct from the Advertising Department, Westinghouse Electric and Manufacturing Company, East Pittsburgh, Penna.

RCA BULLETIN

A new cathode-ray oscillograph, using the 913 tube, and an electronic sweep test oscillator are described in a 4-page bulletin that has just been made available. Write to the Parts Division, RCA Manufacturing Co., Inc., Camden, N. J.

WBZ APPLIES FOR 500 KW

Application for an increase in power from 50,000 to 500,000 watts for WBZ, Boston, has been filed by its owner, Westinghouse Electric and Manufacturing Company, with the Federal Communications Commission at Washington, D. C. WBZ is the Boston outlet of the National Broadcasting Company's blue network.

In addition to the application for increased power, the announcement said WBZ's plans include the removal of the transmitting station at Millis, Mass., to Provincetown, Mass., on the eastern tip of Cape Cod, and the erection of a new directive antenna.

CREI BOOKLET

The Capitol Radio Engineering Institute, Riggs Bank Building, Washington, D. C., have just issued a very interesting 46-page booklet entitled "A Tested Plan for a Future in Practical Radio Engineering." This booklet gives the history of the organization, and a complete description of the facilities, method of study, and courses.

UNIVERSAL MICROPHONE CO. INCREASES PRICES

The Universal Microphone Co., Inglewood, Calif., on Feb. 15 announced price increases for most of its recording equipment. The price increase, according to James R. Fouch, president, has been made necessary because of higher costs all along the line including raw materials, wages, overhead expenses, laboratory fees and the cost of marketing and distribution.

LEEDS & NORTHRUP CIRCULARS

Circulars describing several instruments of interest to laboratories and production test departments have been received from the Leeds & Northrup Company, 4901 Stenton Avenue, Philadelphia, Pa.

The apparatus includes high-frequency resistance boxes, limit bridges, capacitance and conductance bridge, shielded ratio box, and a quick-acting dp-dt switch that may be used for reversing the connections to a circuit.

Copies of these bulletins may be obtained from the manufacturer.

LOW-LOSS PARTS BULLETIN

A line of Hi-Q parts for critical radio circuits and assemblies is illustrated and described in a new bulletin just issued by Boonton Radio Corporation, Boonton, N. J. The line includes threaded and grooved Isolantite forms for coils and high-frequency transformers, complete inductors and aluminum shields, flat sockets, mica-insulated binding posts, jacks and terminals, and other handy parts. A copy of the bulletin may be had by addressing the company.

THE ELECTRONICS INSTITUTE

During the 1937 University of Michigan Summer Session, an Electronics Institute consisting of a special lecture and conference program in electronics, will be held at Ann Arbor, under the joint auspices of the General Electric Company, the Westinghouse Electric and Manufacturing Company, and the Bell Telephone Laboratories.

The lecture program will consist of two independent four-weeks' lecture sequences, dealing respectively with high-vacuum (June 28 to July 24) and gaseous-conduction (July 26 to Aug. 20) electronic principles. In parallel problem laboratory and conference courses the lecture material will be worked into illustrative engineering problems, and teaching methods will be demonstrated and discussed. Opportunities for informal conferences will be provided.

The primary objective of the Electronics Institute will be to provide an opportunity for teachers and prospective teachers of electronics, engineers and physicists, engaged in electronic development work in industry, and graduate students interested in electronics, to broaden and unify their grasp of fundamental electronic principles.

A special bulletin describing the details of the Institute program is being prepared, and on request will be mailed to anyone interested. Address Professor W. G. Dow, Electrical Engineering Department, University of Michigan, Ann Arbor, Michigan.

NEW C-D BROCHURE

Specifications on the new type TL capacitors are now available in Cornell-Dubilier's Catalog 135A. The type TL's are high-voltage paper condensers, impregnated and filled with Dykanol. These capacitors are quite compact, yet retain the excellent characteristics of the more bulkier types. Especially suited for power supplies and high-fidelity amplifiers. Address requests for Catalog 135A to the Cornell-Dubilier Corporation, South Plainfield, N. J.

TEMCO BULLETIN

An interesting bulletin has just been released by The Transmitter Equipment Manufacturing Co., Inc., 130 Cedar Street, New York City, N. Y. This bulletin gives a complete description of the Temco 1000-watt transmitter.

PRESTO BOOKLET

The Presto Recording Corporation, 139 West 19th Street, New York City, have recently issued a booklet describing how radio stations use instantaneous recordings to increase sales and promote operating efficiency. This booklet is the result of a recent survey made among owners of Presto equipment.

TELECOMMUNICATION

PANORAMA OF PROGRESS IN THE FIELDS OF COMMUNICATION AND BROADCASTING

AUTOMATIC TAPE RECORDER

THE AUTOMATIC SIPHON TAPE RECORDER shown in an accompanying illustration has been developed for the recording of code signals directly from the output of a radio receiver. Essentially, the recording system (see Fig. 3) is comprised of three units, namely, the high-speed recorder (A), an amplifier-rectifier-limiter (C), and a variable-speed motor (B) for pulling the tape. In the particular setup shown in Fig. 3 two auxiliary units are also used: the variable-speed motor (D) allows the tape to be pulled through the typewriter tape guide at any easy reading speed.

The amplifier-rectifier-limiter unit has been designed to amplify the signal from the output of a radio receiver, rectify it, and use the rectified current to control the direction of current flow through the pen-actuating mechanism of the recorder. Referring to Fig. 1 it will be seen that during the no-signal period there is a negligible amount of plate current flowing through the 46 tube, and since the bridge is unbalanced current will flow through coil *D*, from *X* to *Y* and hold the pen down. When a signal is impressed on the grids of the 46, the bridge is unbalanced in the opposite direction. This causes current to flow through *D* in the opposite direction holding the pen at its up position.

The copper-oxide rectifier is poled so as to pass current only from *Y* to *X*. Since the rectifier tends to keep its terminal voltage constant, it acts as a current-limiting device for *D*.

A resistance lamp *L* is placed in the plate return path of the tube. After a certain stage of incandescence is reached, the terminal voltage of the lamp will vary approximately with the square or higher power of the plate current (Fig. 2). The lamp, therefore, acts as a nonlinear self-biasing resistor to decrease the effective grid bias caused by the incoming signal at any moment. Due to the ability of the lamp to lose its incandescence slowly with respect to the termination of a signal the grid will be biased negatively for a short time after the end of the signal; this tends to prevent the pen from being actuated by noise. The lamp also limits the amount of current drawn by the tube and as a result prevents overloading...an important consideration from the cost standpoint.

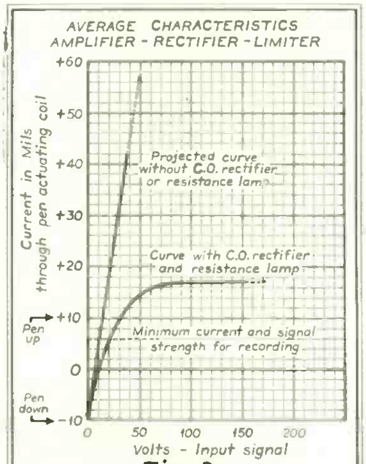


Fig. 2

The recorder makes use of a "Nipermag" permanent magnet, which permits the use of a small, light coil form. The coil is wound from No. 40 copper wire and has a resistance of about 150 ohms.

The ink feed is of the constant level type and no adjustment is necessary after the initial setting. The ink may be drained from the inkwell and inkline back into the reservoir by means of a thumbscrew.

The recorder will copy transmissions in excess of 200 words per minute and requires no adjustment for pen swing, etc., up to 80 words per minute. The tape guide is fashioned to facilitate threading the tape and adjusting the tape pressure against the pen.

Boris A. Sidoroff
Universal Signal Appliances

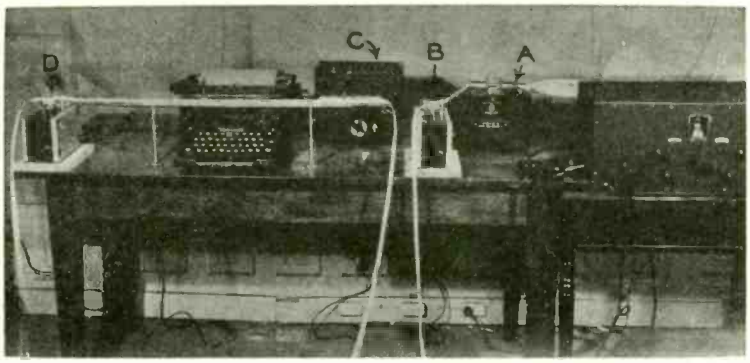
TELEVISION DEMONSTRATION

More than one hundred editors and publishers of daily newspapers and magazines recently attended the first large-scale demonstration of 441-line television by the Philco Radio and Television Corporation. The program, lasting nearly one hour, was broadcast from the studios of the Philco Company at its plant at Tioga and "C" Streets, in Philadelphia, and was received at the Germantown Cricket Club at Manheim and Morris Streets, in the outlying section of Philadelphia.

Television receivers installed in the ballroom of the club reproduced the new 441-line pictures as they came through the ether. This was the first demonstration of 441-line pictures.

The program presented many novelties designed to illustrate Philco's advances in television. The engineers ar-

FIG. 3. RECORDING CODE SIGNALS: "A," RECORDER; "B," VARIABLE-SPEED MOTOR; "C," AMPLIFIER-RECTIFIER-LIMITER; "D," VARIABLE-SPEED MOTOR.



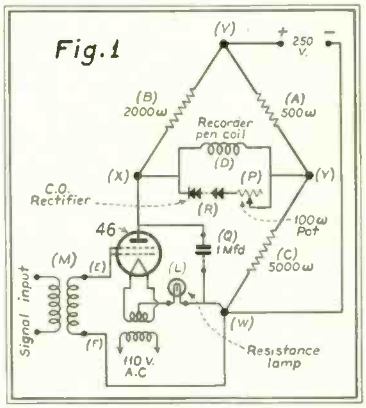
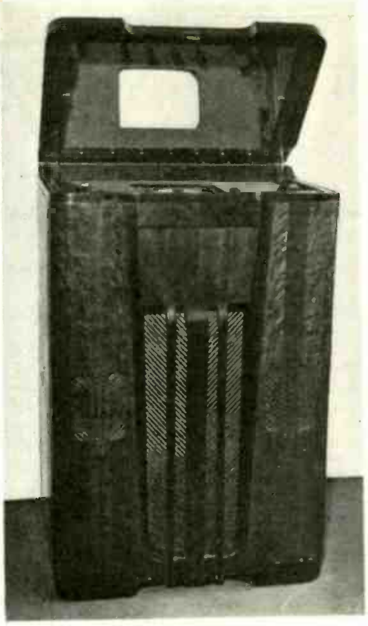


Fig. 1



THE PHILCO 441—LINE TELEVISION RECEIVER.

ranged in a unique way to show the increase in clearness in the pictures when the number of lines was increased from 345 to 441.

The program included a fifteen-minute television fashion show, presented by Bonwit-Teller of Philadelphia, and an interview with Boake Carter, famous Philco news commentator, quizzing Connie Mack, famous baseball manager, on 1937 baseball prospects.

Musical features from the movies and news reels were shown. Vocal numbers from the studio completed a well-rounded program.

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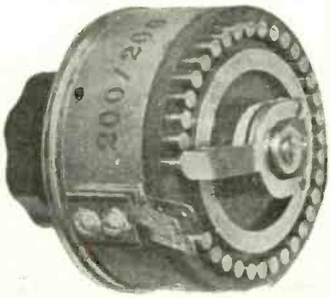
P-A INSTALLATIONS

(*Continued from page* 20)

It will be noted that this is a low-level system—that is, the mixing is accomplished ahead of the preamplifiers. The multiplicity of input points is presumably the reason for this. Referring again to Fig. 7, it will be seen that there are seven input lines to the equipment in the central control room. Two of these have "normalled-through" connections from the turntables and the receiver. The remainder are intended to be connected by means of patch cords to any of the incoming positions which are indicated at the left. The latter lead to various points in the arena, the exhibition hall and the theatre (which has its own public-address, sound-picture installation separate from the above).

Since the central control room is some distance removed and commands no

(*Continued on page* 25)



VETERAN WIRELESS OPERATORS ASSOCIATION NEWS

W. J. McGonigle, President, RCA Building, 30 Rockefeller Plaza, New York, N. Y.

MEETING

THE APRIL MEETING of the Veteran Wireless Operators' Association will be held at 6 p. m. on Monday, April 5, 1937, at Bonat's Restaurant, 330 West 31st Street, New York City. An interesting program is planned and your presence is earnestly requested. A delicious full-course dinner including a special cocktail is available for seventy-five cents.

BOSTON

CHARLES C. KOLSTER, chairman of the Boston Chapter of our Association, reports on their simultaneous cruise on the eleventh of February as follows:

"At 6:30 p.m. eighty officers and crew aboard the good ship Chamber of Commerce all set for the annual cruise. A splendid turkey dinner was served at 7 p.m., during which the Messrs. Curtis and Davidson entertained with piano and banjo selections, followed by the cowboy caravan from station WMEX. Chairman Kolster, acting in the capacity of master of ceremonies, explained the objects of the cruise and of the Association, and read the Boston Chapter message of greeting which had been dispatched to the New York cruise. Ed Gisbourne, of the public relations bureau of the Boston Edison Electric and Illuminating Co., was then introduced and entertained all present with an interesting talk. Ed, incidentally, was a Lieutenant in the United States Navy in the early wireless days and is the present holder of the Congressional medal of honor, presented for bravery in Mexico. He was also an operator at the original WBF and WSA wireless stations.

"Irving Vermilya, popularly known as Amateur No. 1, early commercial ship and land station wireless operator, former owner of broadcast station WNBH and now referred to as the erstwhile capitalist from the Cape, was then introduced by Chairman Kolster and gave an interesting account of his wireless experiences dating back to 1901.

"J. Frank Sullivan, director of the Rhode Island Radio School, an old-time commercial radio operator and radio officer in an artillery unit during the World War, followed Mr. Vermilya with an interesting talk on the aims and purposes of our Association and stressed the objectives for which an organization of our type should strive.

"Letters and telegrams were read by the chairman from members who were unable to be present. One of the letters was from our good friend and secretary of our Chapter—Harry Chetham, who has been ill in the United States Naval Hospital, Chelsea, Mass. A Program, autographed by all present and accompanied by a letter from the chairman, was delivered to Harry at the hospital the following day."

And then Chairman Kolster adds in a short note: "I will send you a picture of the group when I get it. Please send me 100 applications. We are going to make a drive for new members and current dues from old members while the iron is hot. The cruise was obviously a success, for, as a result, some of the members have voluntarily paid up and others have requested applications. We plan on getting 100 new members."

Congratulations, Chairman Kolster, and onward to your self-set goal.

HONOLULU

WE TAKE this opportunity to express the gratitude of the Association to George Street and Arthur Enderlin, retiring chairman and secretary, respectively, of the Honolulu Chapter, for their excellent performance in office, and particularly for organizing one of our largest and most successful chapters in the "Paradise of the Pacific."

We welcome S. B. Maddams, Mackay Radio district manager, as chairman of the Honolulu Chapter, and H. F. McIntosh, engineer for the Mackay Radio Company, secretary of Honolulu Chapter for 1937.

Arthur Enderlin reports concerning their cruise on the eleventh of February:

"Our annual cruise came off on schedule in the Gold Room of the Alexander Young Hotel in Honolulu with forty members and guests present. Your telegram of greeting was read to those present.

"A tellers' committee appointed by Chairman Street, consisting of Messrs. M. D. Williams, C. G. B. Meredith and G. W. Clark, counted the ballots sent in by the chapter members and announced the results indicated above. George Street and Arthur Enderlin declined the nominations. Our new secretary may be reached at Box 2993, Honolulu.

"A. M. Da Vico, who is now mechanical superintendent of the Honolulu Plantation Company's sugar factory at Aiea, gave a talk on his early experiences as a radio operator. He was an operator six months before I was born, in 1902, working out here for the Interisland Wireless Company, now Mutual Telephone Co.

"A guest, radioman McCormick of the Navy, just arrived on one of the ships which flew in formation from San Diego a few days ago, spoke on this experience.

"Most of the radio organizations here were represented including Mackay Radio, RCA Communications, Globe Wireless, Interisland Airways, U. S. Army, U. S. Navy, Coast Guard, Broadcast Stations, Customs Department, Immigration Department, Federal Communications Commission and Amateurs. The Army was represented by Captain Roberts, Hawaiian Headquarters Signal Office and several NCO's; the Navy, by Lt. Griese, Asst. DCO, and several radiomen.

"I feel sure there will be a number of new members as a result of this most recent cruise. We should gradually climb up until we compare favorably, numerically, with all other chapters.

"Aloha to all the officers and members of our Association from the retiring Chairman George Street and myself."

Fine business, Arthur—a splendid report—and again thanks to yourself and George for your invaluable assistance in the past and your continued cooperation.

OFFICERS, DIRECTORS, AND COMMITTEE CHAIRMEN OF THE VWOA. SEATED, LEFT TO RIGHT: A. J. COSTIGAN, G. H. CLARK, WILLIAM J. McGONIGLE, C. D. GUTHRIE, H. F. COULTER, FRED MULLER, C. S. ANDERSON; CENTER, LEFT TO RIGHT: ARTHUR LYNCH, R. H. FREY, H. T. HAYDEN, JR., ARTHUR WALLIS, JOSEF ISRAELS, 2ND, PAUL K. TRAUTWEIN; BACK ROW, LEFT TO RIGHT: V. P. VILLANDRE, WM. C. SIMON, HARVEY BUTT, W. S. FITZPATRICK, H. H. PARKER, A. A. ISBELL, FRED McDERMOTT.

P-A INSTALLATIONS

(*Continued from page* 23)

view of the pickup points, a portable control cabinet has been designed which can be used at all of the pickup points. This contains a four-position mixer, so connected that three of the positions are available for standard microphones, while the fourth is connected through five double-throw switches to ten input terminations intended for lapel microphones.

The two main channels are the racks at the left and right of Fig. 8. Each includes a rectifier, filter, preamplifier and voltage amplifier. On the two center racks may be seen the voltage amplifier used to feed outgoing lines, the radio receiver and the control and monitoring circuits. Practically all inter-amplifier connections are normalled through jacks for test and replacement convenience. These jacks are not shown in Fig. 7 as the arrangement is conventional.

Output switching circuits are provided so that any of the six amplifiers may be connected separately, or in combination, to any of three output lines, as shown in Fig. 7. These are the lines to the high-level outputs in the arena and exhibition hall. At each point two types of speakers—that is, high-frequency units and low-frequency units—are provided, and the usual dividing network arranged to feed these. An innovation is provision of a relay switching system which allows the low-frequency units to be included or eliminated, depending on the type of program in progress. In addition, the arena system has two complete and separate loudspeaker installations. One of these is the "projectilier" type and is placed in the center of the arena, as can be seen in Fig. 10.

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RECORDING HEAD

(*Continued from page* 16)

range instantaneous recordings—but it should be remembered that recording high frequencies requires extreme care besides using the finest equipment. It does not require much to lose the "highs" above 4,000 cycles. A loose sapphire in its holder—although not easily detected—is one cause; a needle screw that is not very tight is another reason; and if the needle is too far out of the head the flex in the shank will lose more "highs."

THE MARKET PLACE

NEW PRODUCTS FOR THE COMMUNICATION AND BROADCAST FIELDS

COAXIAL CABLE

A new heavy-duty coaxial cable has been announced by Victor J. Andrew, 7221 S. Francisco Ave., Chicago, Illinois. Type 22 cable, 0.643 inch in diameter, is supplied in lengths up to 500 feet on cable reels. Heretofore cable of similar size has been available only in short straight lengths, requiring assembly in the field. This size of cable is designed for broadcast stations as large as 1000 watts, and is capable of carrying a maximum power of 20,000 watts.

A-F SCHERING BRIDGE

The Type 716-A capacitance bridge is an audio-frequency Schering bridge, direct reading in both capacitance and power factor. Capacitances up to 1 mfd and power factor up to 6% (0.06 expressed as a ratio) can be read directly from the dial of the instrument. This range embraces most of the capacitances met in communication engineering: paper condensers, cables, slabs of solid dielectric, liquid in large cells, and ground capacitances of generators and transformers. The accuracy over the direct-reading range is, for capacitance, ± 2 mmfd for the air-capacitance range (100 to 1100 mmfd), and ± 2 mmfd multiplied by the decade multiplier setting for higher values. For power factor, the accuracy is ± 0.0005 or ± 2% of the dial reading. The power-factor dial is calibrated in power factor at 1 kilocycle. Other frequencies between 60 cycles and 10 kilocycles can be used, and power factor is obtained by multiplying the dial reading by the frequency in kilocycles.

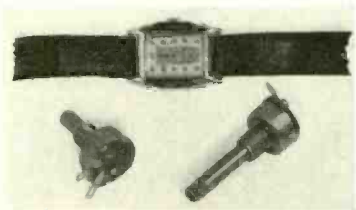
For greater accuracy, substitution methods can be used. The accuracy of power factor readings is then improved to ± 0.00005 or ± 2% of the *change* in power factor observed. Using a substitution method, a set of capacitance standards embracing both air and mica units may be intercompared to an accuracy of 0.02%.

Other types of capacitance bridge circuits can be used with this instrument, as, for instance, series and parallel resistance arrangements, by adding external resistors and precision condensers. This flexibility, combined with the high-accuracy and direct-reading feature, makes the bridge acceptable for a wide field of application.

Further information may be secured from the General Radio Company, 30 State Street, Cambridge, Mass.

CENTRALAB CONTROL

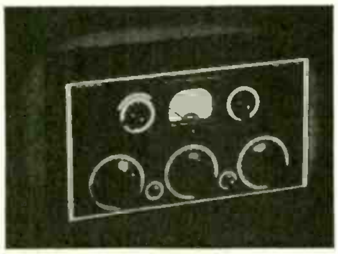
The latest control offered by Centralab, 900 E. Keefe Ave., Milwaukee, Wisconsin, is the "Submidget" shown in the accompanying illustration.



The controls are available in rheostat or potentiometer types with insulated or grounded shafts. It is of particular interest to those requiring a tone control with hollow shaft for installation in remote-control heads. In this connection, the volume-control shaft passes through the unit and concentric knobs are used for volume and tone control. Complete information may be obtained from the manufacturer.

REMOTE AMPLIFIER

United Transformer Corporation, 72 Spring Street, New York City, have announced the release of a remote-amplifier



kit. This unit provides a three-position mixer using isolation transformers for each input to prevent cross talk. This is fed into a four-stage high-gain amplifier with output for various broadcast line impedances and with a VI meter. This meter is also used for checking plate currents of all tubes. According to the manufacturer, the frequency response is uniform from 30 to 14,000 cycles with a power output of plus 7 db. This remote amplifier, Model 2A, is housed in a leather finished case. It is furnished without power supply, although a case can be obtained for a separate power supply. Total weight is less than 10 pounds.

THORDARSON TRANSFORMERS

Charles P. Cushway, general sales manager of the Thordarson Electric Manufacturing Company, Chicago, has announced a new series of transformers. The first models to be announced are four multi-match modulation transformers. Features of these units are the plug and jack type of connection panel; perfected engineering design worked out by President C. H. Thordarson and C. W. Hixson of the engineering department; and a modern, wrinkle finish, streamlined case offering economy of space for mounting.

The new plug-in type connectors have value in matching tubes and output quickly and accurately. The universal nature of the transformer is best illustrated by the fact that by using the table enclosed with each transformer any tube or tubes of the rated wattage of the transformer may be properly and instantly connected without soldering.

TRANSCRIPTION UNIT

Remler Company, Ltd., 19th and Bryant Streets, San Francisco, have announced a high-fidelity transcription unit suited for the continuous service required by broadcast stations. This transcription unit is designed to be mounted through the control table top and is constructed on a heavy cast-iron bed plate and framework. A condenser split-phase synchronous motor, mounted on rubber, drives a heavy 16-inch flywheel platter through a mechanical drive system designed to provide constant speed and freedom from "wows" at either 33⅓ rpm or 78 rpm. Speed is reduced to 33⅓ rpm by roller-bearing planetary mechanism with a speed-change lever mounted in the top of the turntable.

This transcription unit is furnished with an electromagnetic lateral pickup with a double-section equalizer network to compensate for the deficiency of bass response resulting from the mechanical limitation of lateral recordings and providing uniform response within 3 db from 45 to 6600 cps.

APPROVED TAYLOR TUBES

Taylor Tubes, Inc., 2341-43 Wabansia Ave., Chicago, have announced that the FCC has approved the following tubes for use in the last radio stage of broadcast transmitters:

High-level Modulation or Plate Modulation in Last Radio Stage

50 Watts	75 Watts	125 Watts	250 Watts
255	211	T155	T200
841A	203A	HD203A	204A
	211C		814
			822

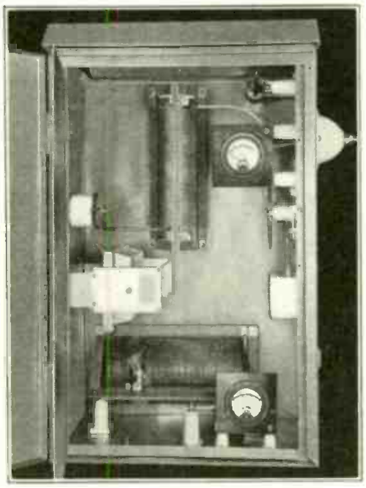
Low-Level Modulation or Last Radio Stage Operating as Linear Power Amplifier

25 Watts	50 Watts	75 Watts
203A	HD203A	T200
211		204A
211C		814
841A		822

These tubes may be listed in the table appearing on page 10 of the August, 1936, issue of COMMUNICATION AND BROADCAST ENGINEERING.

ANTENNA-COUPLING UNIT

The E. F. Johnson Company, Waseca, Minnesota, have announced their Type JA-



1001 antenna-coupling unit, designed to terminate unbalanced transmission lines, i.e., concentric, three or four-wire open, normally having characteristic impedances of 70 to 300 ohms, into antennae for the range of 550 to 1712 kc. The equipment is said to handle powers up to and including 1 kw with a large factor of safety. Similar units may be furnished for transmitters of greater output or for terminating balanced two, three, and four-wire transmission lines, as well as for frequencies outside the broadcast band.

The unit may be mounted in the transmitter room to couple a transmitter directly to the antenna or as a harmonic filter as it has high attenuation of r-f harmonics.

The equipment is housed in a heavy, welded-steel cabinet, copper plated and finished with a durable paint for outdoor service. Special care was taken to make the unit weatherproof and provide sufficient ventilation. The outer door is fitted with a tumbler lock.

CABLE CONNECTOR

A new cable connector is now supplied as standard equipment with Amperite velocity microphones, models RBMn and RBHn, at no extra cost. The cable connector is of the positive three-pin type. A locking ring is said to eliminate the possibility of pulling the connectors apart, or loose contacts.

The body of the connector holding the cable is made extra long to prevent the leads from shorting. By putting the cable connector on the shock absorber and not on the microphone itself, mechanical noises due to moving the cable, do not reach the microphone.

Further information may be secured from the Amperite Company, 561 Broadway, New York City.

LAFAYETTE SOUND SYSTEMS

A new series of Lafayette sound systems has been announced by the Wholesale Radio Service Company, Inc., 100 Sixth Avenue, New York City. In these systems the components making up the entire system are matched to obtain the best results. Complete information on the Lafayette "Co-ordinated" sound systems may be obtained by writing the New York office of Wholesale Radio Service Company or any of their branches at 901 W. Jackson Blvd., Chicago, Illinois; 430 West Peachtree Street, N.W., Atlanta, Georgia; 219 Central Avenue, Newark, New Jersey; 524 E. Fordham Road, New York City, and 90-08 166th Street, Jamaica, Long Island, N. Y.

A-C GENERATING PLANTS

D. W. Onan and Sons, 43 Royalston Ave., Minneapolis, Minn., are announcing a new styling on models of Onan alternating-current generating plants in sizes 350 to 1000 watts which reduces weights and dimensions. These models are of streamline, fully enclosed, and symmetrical design. They are small, compact and operate on gasoline, generating alternating-current electricity. Literature is available.

RCA-808

The RCA Radiotron Division, RCA Manufacturing Co., Inc., Harrison, New Jersey, have announced the 808, a three-electrode transmitting tube of the high-mu type for use as r-f amplifier, oscillator, and Class B a-f amplifier. In r-f service this tube may be operated at maximum ratings at frequencies as high as 30 megacycles.

The tentative characteristics and operating conditions are as follows:

TENTATIVE CHARACTERISTICS

Filament voltage (a-c or d-c)	7.5 volts
Filament current	4.0 amps
Amplification factor	47
Direct interelectrode capacitances	
grid-plate	3 mmfd
grid-filament	5 mmfd
plate-filament	0.2 mmfd
Bulb	G-22
Top cap	medium metal
Side cap	small metal
Base	medium 4-pin bayonet

The maximum plate dissipation is 50 watts for Class C telegraph and Class B services.

CIRCUIT BREAKER

The instrument shown in the accompanying illustration, known as "Re-Cirk-It"

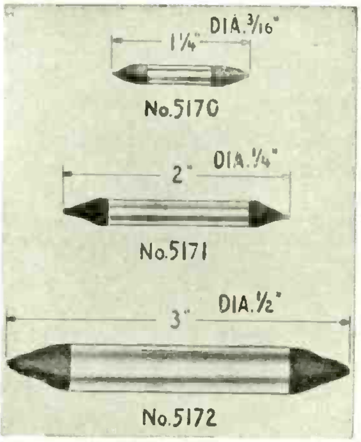
breaker, has been announced by the Heinemann Electric Co., Trenton, N. J. It has been designed to prevent accidental overloads or short circuits injuring tubes, transformers, condensers, etc., and is available in capacities ranging from 50 ma up to 35 amperes.

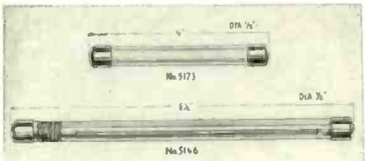
The Re-Cirk-It breaker has a tumbler handle, switching current on and off under normal circuit conditions. There are two types: instantaneous-trip and time-delay action.

NEON TEST LAMPS

Two new types of neon test lamps have been developed by the Sundt Engineering Company, 4238 Lincoln Ave., Chicago, Illinois. These tubes are classified as the electrodeless type and the current-measuring type.

The electrodeless tubes operate on the same principle as a condenser. Electrons flow between the two metallic caps deposited on the outside tips of the tube, with the neon gas acting as a conductor between the caps. In normal practice, the





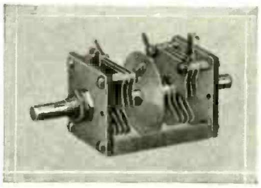
current-light ratio is very high, especially when the frequency is about 5,000 cycles, and the current drain rarely exceeds 3 or 4 microamperes.

Because of their high impedance, these tubes may be operated in circuits of very high voltages and low currents without causing any appreciable change in the normal operation of the circuit. Among the applications for this type of tube are diathermy output indicators, transmitter and radio-frequency pilot lights, insulation and condenser testing, and auto-ignition testing.

The current-measuring type is of the internal-electrode glow-tube type. The length of glow along the 6-in electrode is a measure of the current passing through the tube. For this reason, it may not only be used for direct-current measurements, but also for indicating the relative current in radio-frequency circuits. The intensity of the current will cause a bright glow to creep up within the tube along the electrode. In direct discharge work, however, the current passing through the tube must be limited to less than 10 ma. This may be accomplished by use of the proper shunts and series resistors. Applications for this type of tube are transmitter adjustments, radio-frequency measurements, current readings, radio-receiver output meters, etc.

CARDWELL CONDENSERS

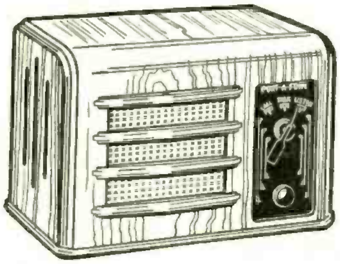
The Allen D. Cardwell Mfg. Corp., 81 Prospect Street, Brooklyn, N. Y., have



made available a complete line of 10 standard double-section equivalents of stock Trim-Airs. They can be furnished either with a circular shield as illustrated or with a square shield that is removable from the nickeled brass tie rods. A 1/4-inch shaft extends at the rear for additional ganging.

COMMUNICATION SYSTEM

Electronic Devices, Inc., with general offices at 626 Broadway, Cincinnati, Ohio, and factory at Warren, Pa., recently announced the development of a new system of inter-department communication. The new device is called Port-A-Fone, and the company states that all the user has to do is to plug the cord into the electric light socket, speak normally, and the voice is carried over the power lines to the other unit or units in other departments.



SOME NOTES ON

TUNED - COUPLED CIRCUITS

(Continued from page 7)

half way between them. Let Δf_c be the difference between any arbitrary frequency f and the center frequency f_c. Then, if we introduce the abbreviations

$$v_c = \frac{4\pi L}{\sqrt{R_1R_2}}\,\Delta f_c \quad \text{and} \quad v_d = \frac{4\pi L}{\sqrt{R_1R_2}}\,|f_c - f_1| \;\overline{\wedge}\; \frac{4\pi L}{\sqrt{R_1R_2}}\,|f_2 - f_c| \qquad (13)$$

the secondary current is given by

$$y_2 = \frac{2s}{\sqrt{(1+s^2+v_d^2)^2 + v_d^2\,(b-2) + 2v_cv_d\left(\frac{R_2}{R_1}-\frac{R_1}{R_2}\right) - 2v_c^2\left(s^2+v_d^2-\frac{b}{2}\right) + v_c^4}} \qquad (14)$$

In this expression, v_c is the quantity which is proportional to frequency, and all other quantities are constant. It will be noted in (6) that the frequency variable appears only in even powers, which means that the resonance curve is symmetrical. But in (14) the frequency variable also appears in the first power, which means that the curve will be unsymmetrical unless the circuit resistances are equal. If this last condition is fulfilled, then the resonance curve of a pair of circuits which are not tuned exactly alike will be perfectly symmetrical. In practice, symmetry will not usually be encountered, since the circuit resistances will be made unequal by the damping effects of the tube which drives the filter, or by the antenna circuit which is coupled to it.

In Fig. 2 is shown the great effect which detuning has upon the shape of the resonance curve when the ratio of the resistances is approximately 10 to 1 and the coupling index equals $\sqrt{5}$. It is not necessary that the two circuits be so widely different in resistance in order to produce an appreciable amount of dissymmetry. Fig. 3 shows a curve for the case in which one circuit has a resistance only 50 percent greater than that of the other. This condition may easily occur in practice.

EFFECT OF RESISTANCE IN THE COUPLING IMPEDANCE

If the coupling impedance is a complex quantity, which we may represent by $r + ju_o$, and if we introduce the new abbreviation

$$t = \frac{r}{\sqrt{R_1R_2}} \quad \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots (15)$$

then the secondary current of the circuits tuned alike is given by

$$y_2 = \frac{2\sqrt{s^2+t^2}}{\sqrt{(1+s^2-t^2)^2 + 4s^2t^2 - 4stv\sqrt{b+2} - 2v^2\left(s^2-t^2-\frac{b}{2}\right) + v^4}} \qquad (16)$$

Here, again, it is evident from the form of the denominator that the resonance curve will be unsymmetrical, since a term in the first power of v is present. However, this dissymmetry will not vanish when the circuit resistances are equal, as was the case with the dissymmetry caused by detuning. In Fig. 4 is shown a curve for $t = 0.2$ and for $s = 2.0$. These curves have been computed for the case of capacity coupling. If a common inductance were used as a coupling element, the high-frequency peak would be raised and the low-frequency peak depressed.

The effects of detuning and of resistance have been considered separately, since this gives a clear picture of what happens with a minimum of complication, but no great difficulties are encountered if the two are considered together. It is evident that under certain circumstances detuning may cause a dissymmetry in one direction and resistance in the coupling impedance may have the opposite effect; and that, consequently, the two effects can be made to cancel, resulting in a symmetrical curve. This, of course, is a very special case, and in general a dissymmetry due to either detuning or coupling resistance will predominate. The accompanying table will show clearly the kind of dissymmetry that is to be expected in any given case.

• • •

TWO-TERMINAL EQUALIZERS

(*Continued from page* 11)

The equalizer capacity C_e is finally obtained from

$$C_e = \frac{1}{(2\pi f_3)^2 L_e} \text{ farads} \qquad \ldots\ldots\ldots\ldots (13)$$

As a typical example it is desired to equalize 10 miles of 19-gauge telephone cable to 3000 cycles per second when terminated in a 500-ohm load resistance and connected to a sending-end generator with an impedance matching the characteristic impedance of the transmission line. The cable characteristics are as follows:

0.064	mfd capacity per mile
86	ohms resistance per mile
0.896	micromho leakage at 800 cycles (leakage proportional to the frequency)
1	mh inductance per mile

If perfect equalization is to be obtained at $f_1 = 100$, $f_2 = 1500$ and $f_3 = 3000$ cycles, the equalizer constants as obtained from the above equations will be

Series-Admittance Equalizer			Shunt-Impedance Equalizer		
$R_e =$	7840	ohms	$R_e =$	95	ohms
$C_e =$	0.0961	mfd	$L_e =$	15.03	mh
$L_e =$	29.3	mh	$C_e =$	0.1877	mfd

The cable, equalizer and overall attenuation characteristics are illustrated in Fig. 4. The series and shunt-equalizer attenuation characteristics are identical due to the exact mathematical relation between the equalizers. It will be seen that the attenuation is substantially constant over the required range of frequencies.

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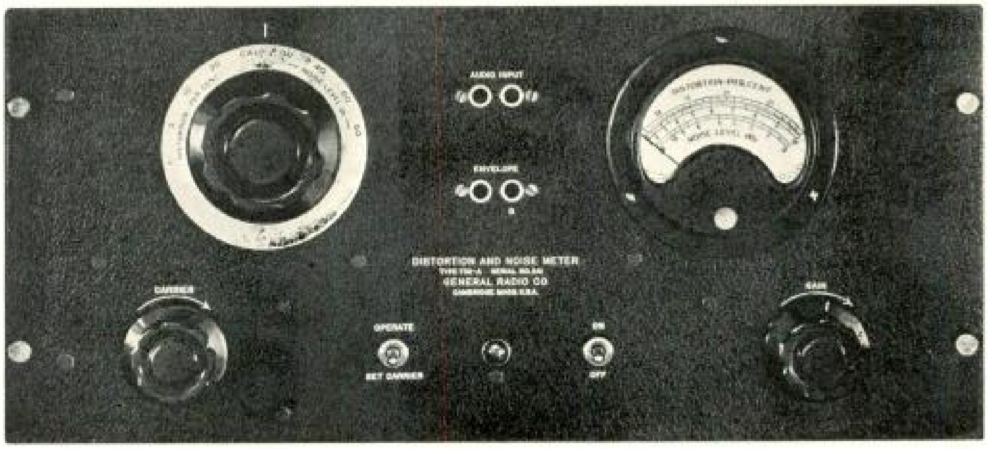

to the Metropolitan Opera House

WITH THE G-R TYPE 732-A DISTORTION-NOISE METER

● UNAVOIDABLE and serious distortion may be introduced in *any* broadcast transmitter through changes in tube or circuit characteristics. A high-quality station may go haywire without the operating staff being aware of any trouble. With The G-R Type 732-A Distortion and Noise Meter the total distortion can be measured in ten seconds. Many stations are using this instrument to check distortion and to log its amount periodically to insure continual high-class operation.

The Type 732-A Meter in addition is invaluable in checking and isolating noise throughout the entire system from audio line to antenna. Measurements may be made to locate accurately, simply and rapidly

- Residual Noise Level
- Excessive Hum
- Noisy Transmitter Tubes
- Unbalanced Rectifiers
- Noise in A-F Amplifiers
- Noisy studio—or pick-up lines

Distortion from 0.2% to 30% is read directly on a large-scale meter. The noise or hum range is 30 db to 70 db below the value of the modulated carrier, or 65 db below an audio-frequency signal of zero level.

As a companion instrument, the Type 733-A Oscillator is designed for use as the constant-frequency 400-cycle tone.

Both the Type 732-A and Type 733-A instruments are completely self-contained, self-operated, relay-rack mounted, a-c operated and furnished complete with tubes and accessories necessary for immediate operation.

With these two instruments your station can be maintained to its design-performance characteristics with very little additional effort on the part of the operating staff.

● Federal Communications Commission Rule 139, paragraph A requires that no broadcast transmitter have more than a total of 10% combined audio harmonic when operated at a modulation level of at least 10 per cent. Systematic use of the Type 732-A Distortion and Noise Meter will tell you immediately whether or not this rule of the Commission is being complied with in your station.

Write for Bulletin 121-K for complete information.

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Type 733-A Oscillator: . . . . $ 62.00

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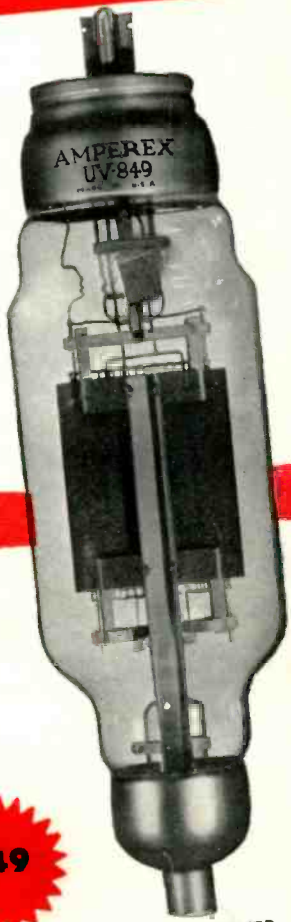
It is the perfection by the Amperex engineering staff of an evacucation technique and processing for the graphite anode which invests AMPEREX TUBES with that extra margin of efficiency reflected in unusually long life, superior performance and consequent operating economy.



204-A

AIR COOLED TRIODE, R.F. POWER AMPLIFIER, OSCILLATOR CLASS B MODULATOR

CHARACTERISTICS

Filament potential, volts	11
Filament current, amps.	3.85
Amplification factor	25
Plate dissipation (maximum), watts	250

$95

212-E

A.F. AMPLIFIER, MODULATOR R.F. OSCILLATOR, AMPLIFIER

CHARACTERISTICS

Filament voltage	14
Filament current	6
Average characteristics with plate potential of 1500 volts and grid bias of	—60
Plate resistance, ohms	1900
Mutual conductance, micromhos	8500
Maximum D.C. plate current, milliamperes	300

The AMPEREX 212-E is interchangeable with the WE 212-D or 212-E of any other make

$75

849

MODULATOR, A.F. POWER AMPLIFIER, R.F. POWER AMPLIFIER, OSCILLATOR

CHARACTERISTICS

Filament potential, volts	11
Filament current, amps.	5
Amplification factor	19
Transconductance (micromhos)	6000
Plate dissipation (maximum), watts	400

$160

Rarely, if ever, will an AMPEREX tube cause a deflection in the grid current meter. Rarely, if ever, will an AMPEREX GRAPHITE ANODE show even a faint blush of color when operated within its recommended ratings. It is the black body and rough surface heat radiating properties of these specially processed anodes which keep them operating black and cool. The comparatively cold anode prevents spotty heating of the glass envelope with its resultant gas evolution and keeps the temperature of the grid well below the point where grid emission is formed.

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