COMMUNICATIONS

OCTOBER

★ RADIO ENGINEERING
★ U-H-F PRODUCT ENGINEERING
★ WAVE FILTER CIRCLE DIAGRAMS
★ ATTENUATOR DESIGN
★ PHASE CONTROLLED RECTIFIERS
★ AIRCRAFT COMMUNICATIONS

1943

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We See...

FROM WASHINGTON COMES A REPORT on *United States Communications in the War* that reveals a host of striking facts. Says the report. . . . (*1*)—Of the Signal Corps' $5,000,000,000 communications equipment program for this year, approximately 90% is destined to be spent on radio. (*2*)—Total radio production, which about a year ago was $30,000,000 a month, is now up to $250,000,000 a month. (*3*)—OWI's international programs are heard twenty-four hours a day in more than forty languages and dialects in more than 3,200 quarter-hour productions a week. (*4*)—The CIAA transmits 550 *s-w* programs a week ranging from five minutes to half-hour in length. (*5*)—The RID (Radio Intelligence Division of FCC) maintains twelve primary monitoring stations, ninety secondary monitoring stations, and three radio intelligence centers. Thirty two-men mobile units maintain a continuous listening-in patrol of the entire 5,000-mile coastline.

Communications appears to be doing quite a job!

EFFECTIVE OCTOBER 8 preference rating order P-133, in revised form, became the exclusive controlling order for obtaining maintenance, repair and operating supplies for communications and broadcast services. The AA-1 and AA-2 preference ratings, with allotment *MRO* symbol, still apply. However, the AA-2X rating is now replaced by rating AA-5 without the *MRO* symbol, for maintenance, repair and operating supplies of sound recording equipment in commercial, educational and industrial applications. In addition the use of ratings and allotment symbol to buy and repair a tube *is prohibited*, unless a person has in stock less than one new and rebuilt tube, or two rebuilt spare tubes per active socket.

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DON'T FAIL TO LEND A HAND to the National War Fund Drive. It's for all the relief agencies of the United Nations. Pitch in!—L. W.

COMMUNICATIONS

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OCTOBER, 1943
VOLUME 23 **NUMBER 10**

COVER ILLUSTRATION

Shading and monitoring consoles in control room at television station WRGB, Schenectady, New York.
(Courtesy, General Electric)

Published Monthly by the Bryan Davis Publishing Co., Inc.

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CRYSTALS

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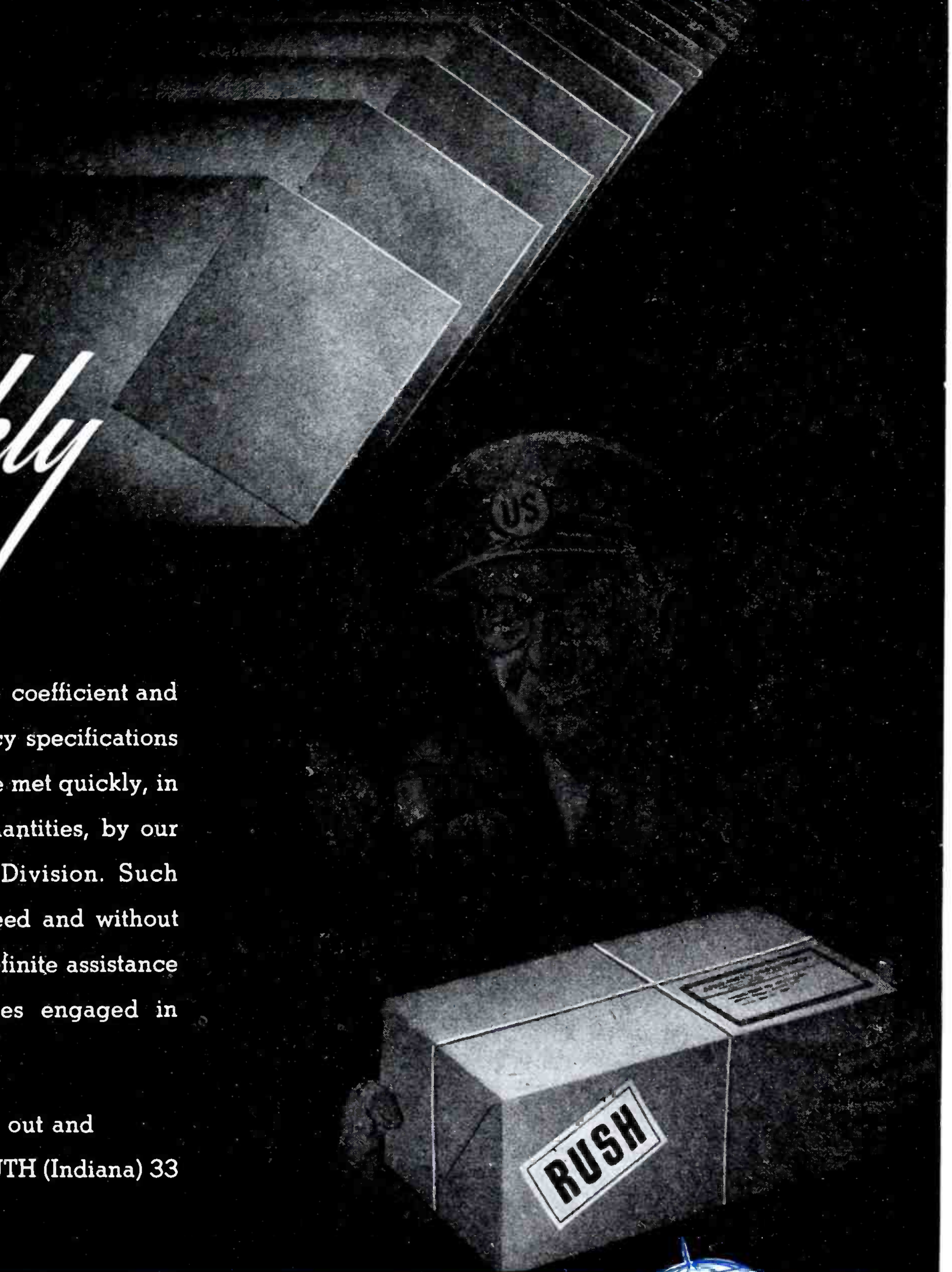

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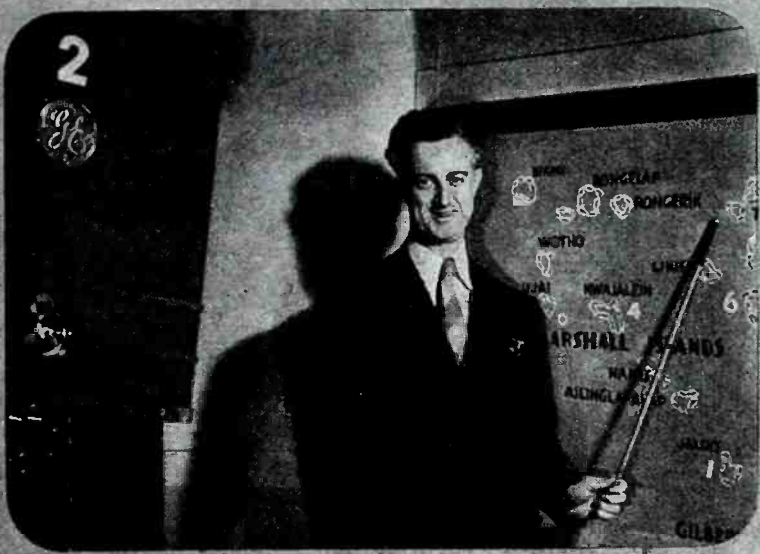
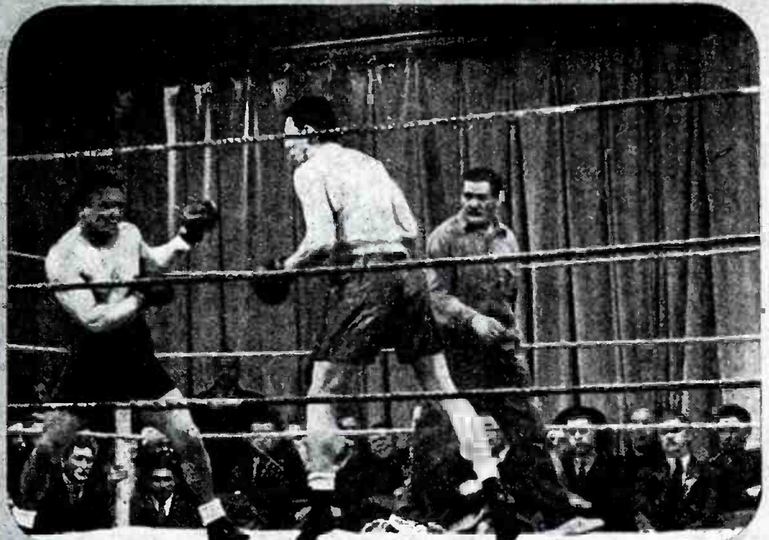


Gene O'Haire illustrates and analyzes war news with maps. This Wednesday night feature has a rating of 2.37 out of 3.00.



Amateur boxing matches draw a large studio audience. This feature has a rating of 2.35 out of 3.00.

Light operas and operettas are presented by well-known college and other amateur groups. A recent hit showed a rating of 2.26 out of 3.00.

A "home" program of helpful hints for the housewife suggests housekeeping time savers. The program rates 2.23 out of 3.00.

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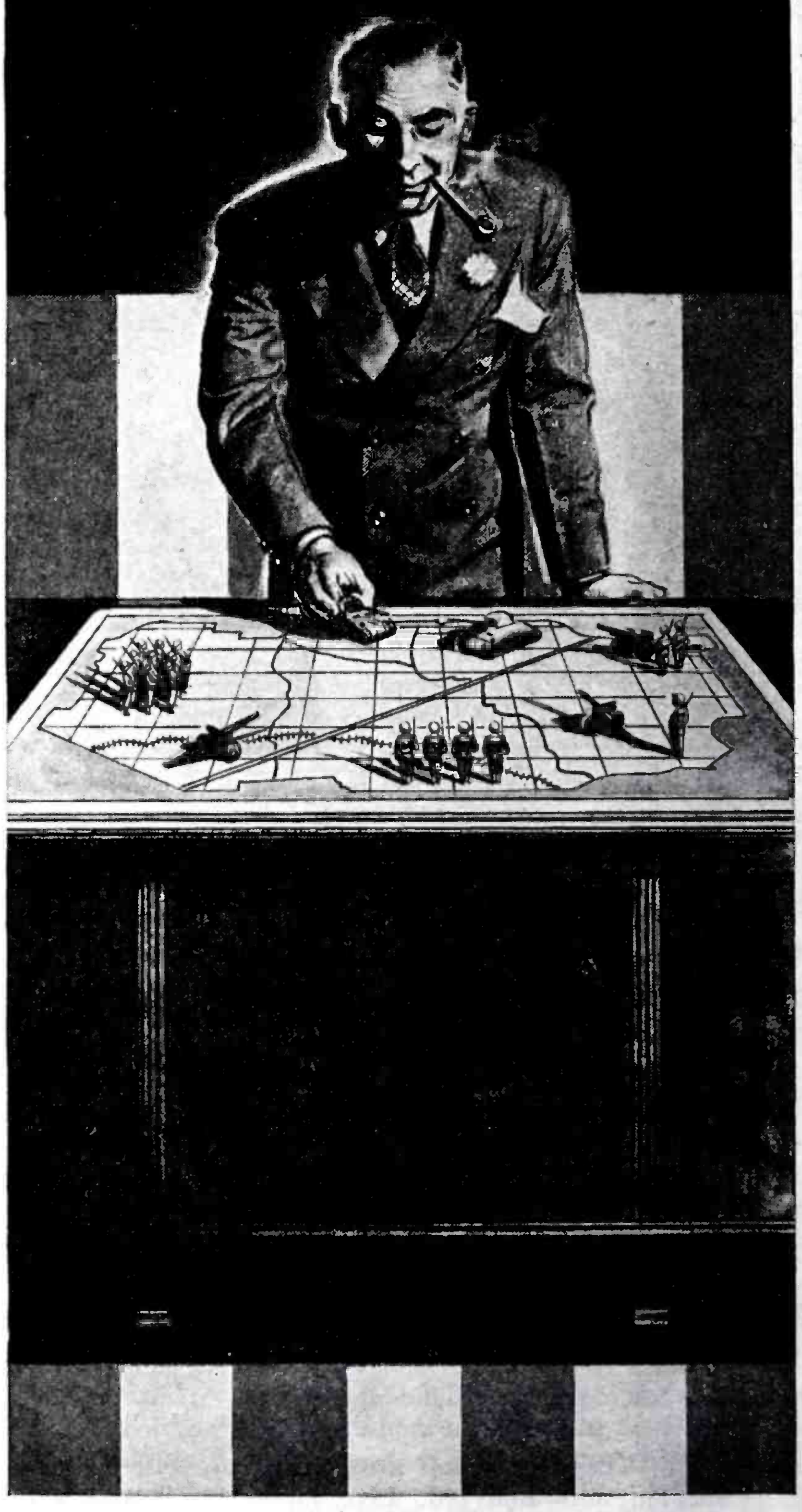

★ Here's how you—yes, YOU—can carry out a smashing "pincer movement" against the Axis. Swing in on one flank with increased production of war goods! Drive in on the other with redoubled purchases of War Bonds through your Pay-Roll Savings Plan!

You're an officer in both of these drives. Your personal leadership is equally vital to both. But have you followed the progress of your Pay-Roll Savings Plan as closely as you have your production?

Do you know about the new Treasury Department quotas for the current Pay-Roll Allotment Drive? *Quotas running about 50% above the former figures?* You see, these new quotas are based on the fact that the armed forces need more money than ever to win the war, while the average worker has more money than ever before to spend. Particularly so, on a *family income* basis—since in so many families several members are working, now.

Remember, the bond charts of today are the sales curves of tomorrow! Not only will these War Bonds implement our victory—they'll guard against inflation, and they'll furnish billions of dollars of purchasing power to help American business re-establish itself in the markets of peace.

So get this new family income plan working at once. Your local War Finance Committee will give you all the details of the new plan. Act today!

This advertisement prepared under the auspices of the War Advertising Council and the U. S. Treasury Department.

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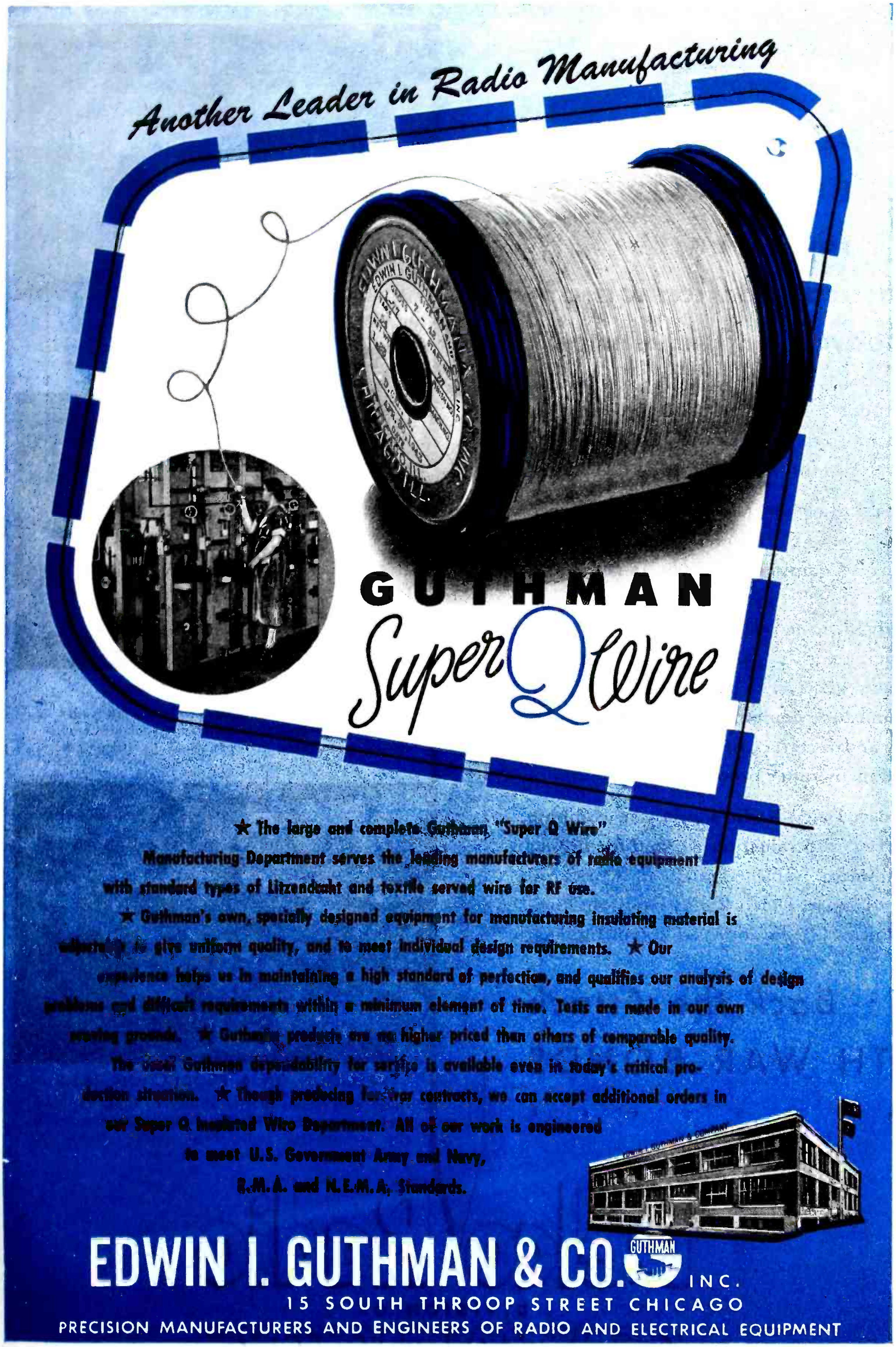

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If you think you may be able to employ two-way radiotelephone communication in your field, we would be pleased to discuss your problem without cost or obligation. We have nothing to sell since our entire output has been placed at the disposal of the United Nations all over the world!

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THIS will happen! The wartime development of the two-way radiotelephone for military purposes indicates beyond question that this unexploited new medium of communication will find many surprising applications in the social and business life of the nation after the war. It has been our privilege to pioneer in the development of the radiotelephone and bring to it several new and exclusive improvements that are proving their worth in every zone of battle in which the United Nations are engaged. Jefferson-Travis was making outstanding two-way radiotelephone equipment for peacetime purposes before Pearl Harbor—we will again after the war when this form of communication will enter your life as a proven convenience, safeguard and business requirement in Tomorrow's World!

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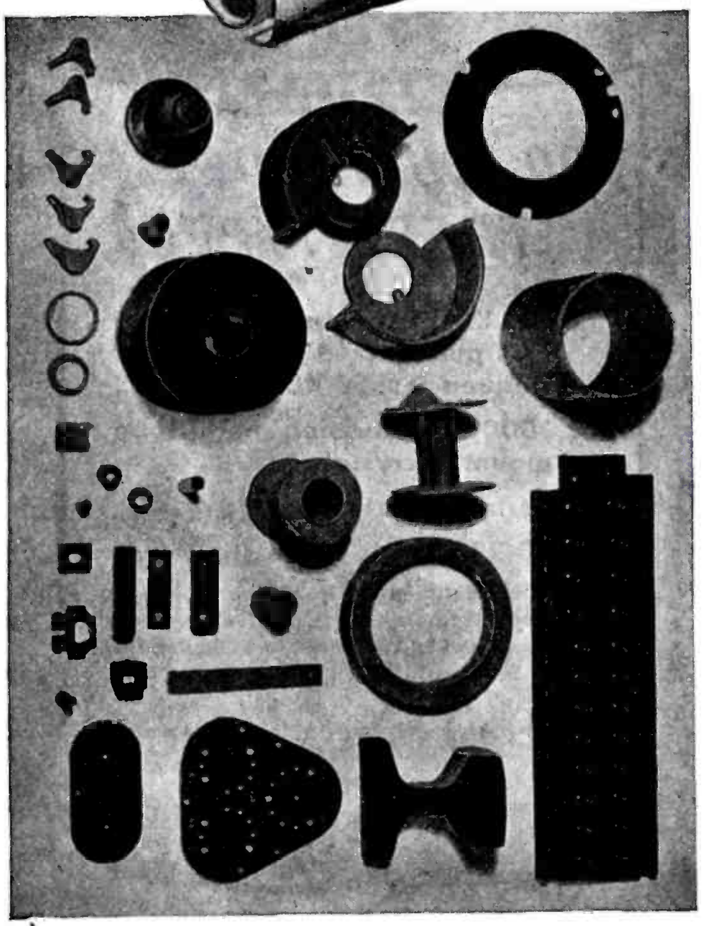

When a parachutist takes his final exam both his diploma and his life depend on the fitness of his rip cord.

Lives also frequently depend upon the fitness of inconspicuous radio and electrical parts of Formica laminated plastic used in war equipment — such parts as insulating spools, insulating spacers, breaker arms, radio tube socket bases, terminal strips, rheostat cores and other insulating parts.

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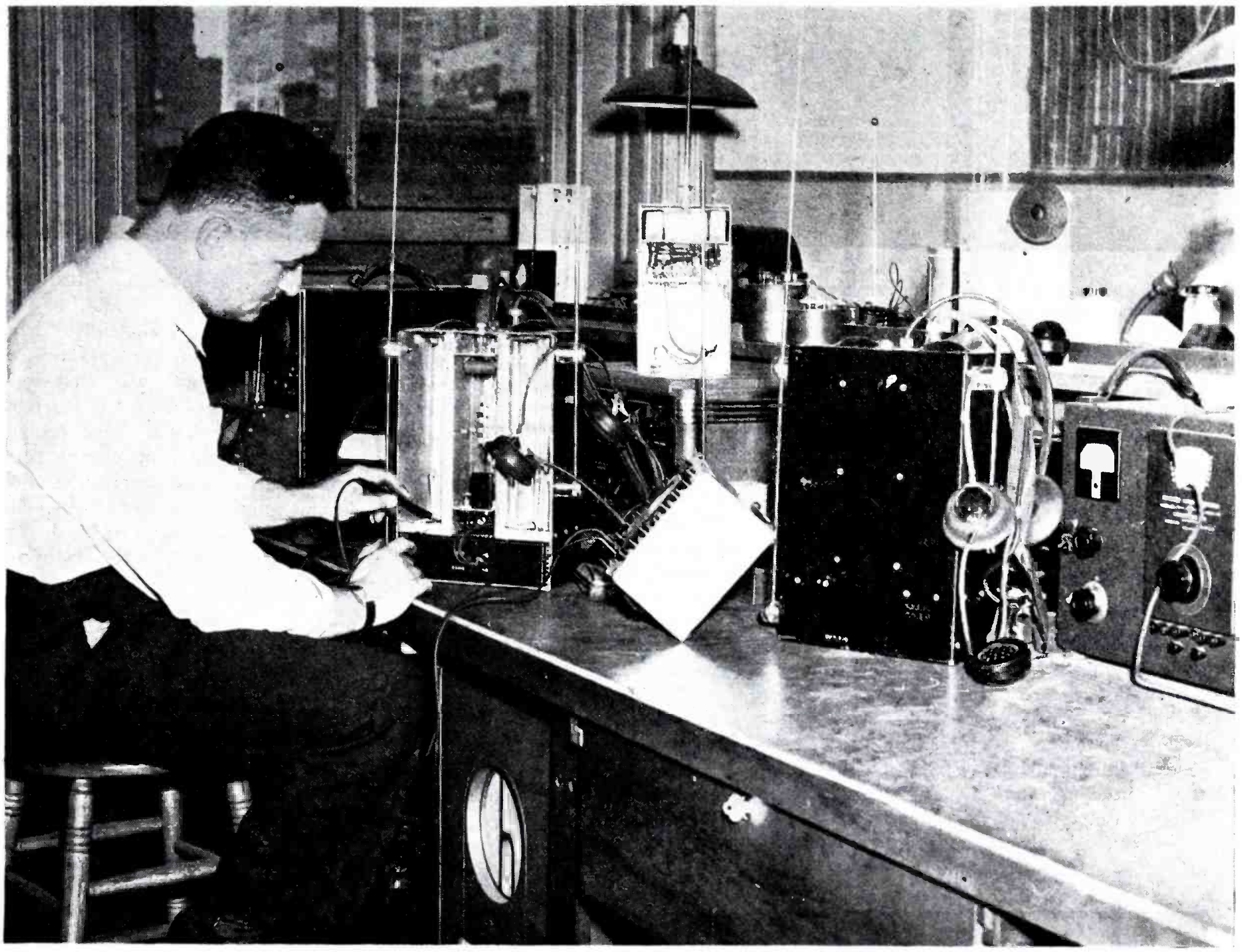
LEWIS WINNER, Editor

* * OCTOBER, 1943 * *



A section of the laboratory in which many u-h-f developments have been conceived.

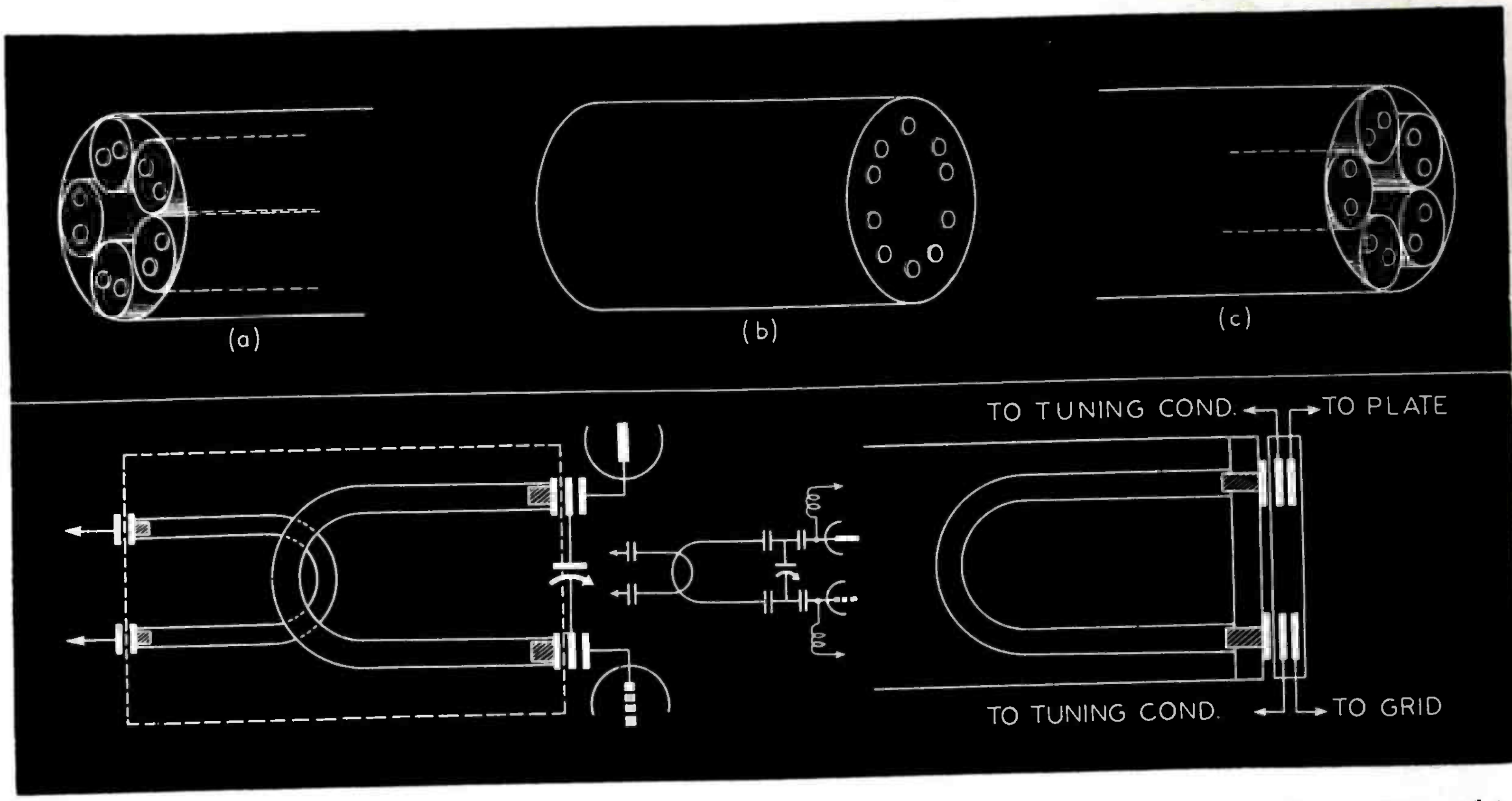
PRODUCTION ENGINEERING AT U-H-F

by ART H. MEYERSON

New York Fire Department Radio Laboratory

ULTRA high frequencies, specifically those frequencies lying between 100 and 200 megacycles, are rapidly becoming an important adjunct in the expanding field of communications. It is the purpose of this paper to discuss this spectrum in terms of its relationship to other frequencies, specifically broadcast and short-wave, its probable future development, and its commercial possibilities.

When this band is discussed in terms of megacycles, its full potentialities are not immediately evident. However, when discussing it in terms of broadcast frequencies, it assumes gigantic proportions. The broadcast band, in which the major portion of standard transmission and reception is



transacted, is roughly, one megacycle wide. Thousands of stations, and millions of receivers in the United States operate in this spectrum. Transport this band in the same terms of selectivity to u-h-f and it merely represents the band between, say, 120 and 121 megacycles. In other words, between 100 and 200 megacycles we have potentially 100 broadcast bands. The commercial possibilities of u-h-f are further displayed by its effective short range coverage. This, in effect, is equivalent to subdividing the country into small sections, where it is possible to duplicate frequency of operation within relatively short distances without cross-interference.

This particular factor is important in that the number of potential communication channels for the nation even for one frequency spectrum (100-200 megacycles) runs into hundreds of thousands. Such a multiplicity of

Mechanical and electrical illustrations of a suggested band-switching arrangement. At top, *(a)*, *(b)*, *(c)*, appear the end and overall views of the arrangement. Capacitive coupling used in this arrangement is illustrated by the diagrams below the mechanical illustrations.
(See page 19 for band-switch discussion)

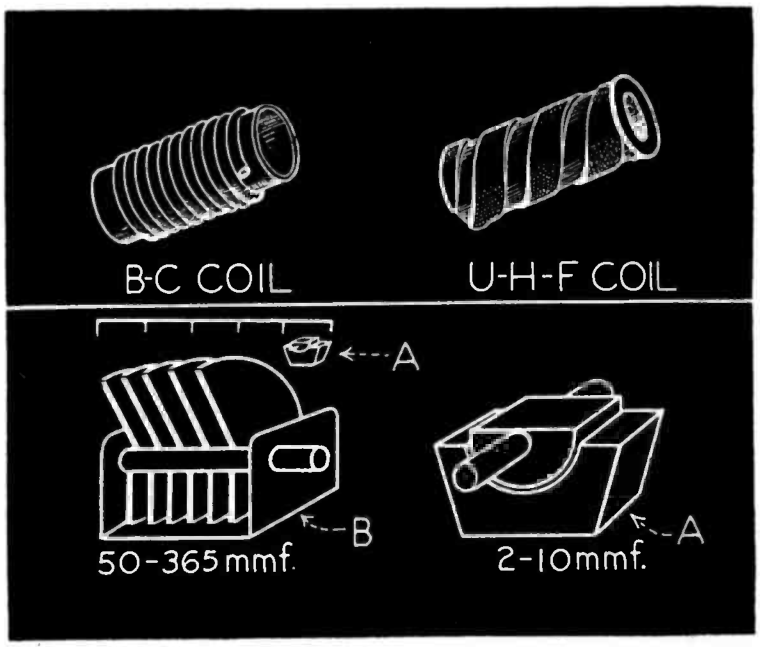
channels can become useful only if this band is properly exploited.

Proper exploitation involves the development of transmitting and receiving apparatus offering no more, or only slightly more production and assembly problems, than that of present day broadcast equipment.

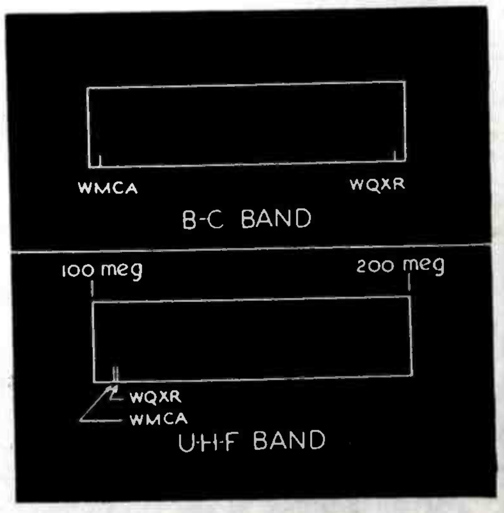
The writer is not acquainted with military developments along these lines. It is possible that the postwar release of these developments may radically change the present picture. This paper is based on those facts known to civilian engineers.

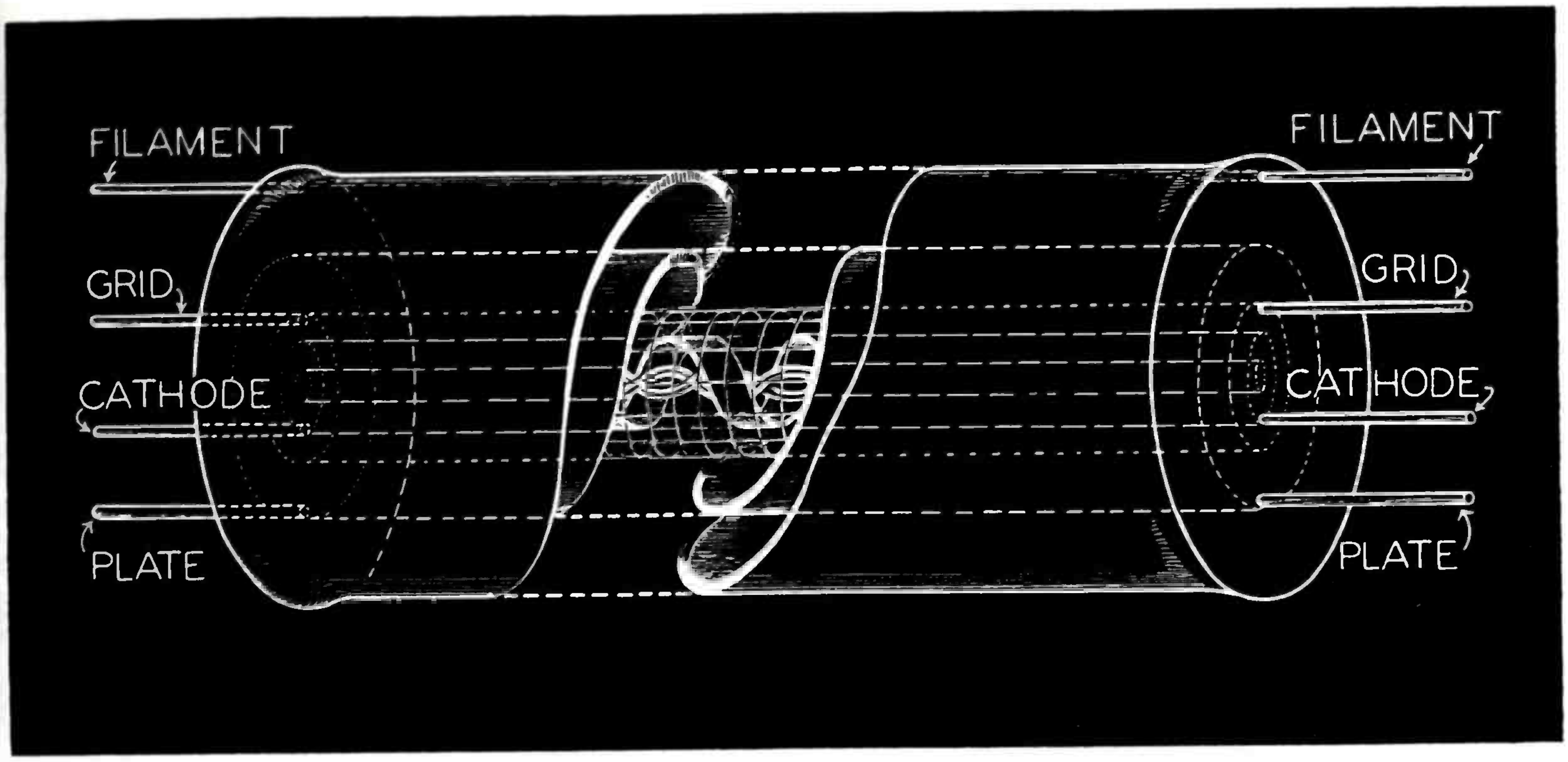
One thing is evident . . . broadcast engineering practice cannot be applied directly to u-h-f problems. Ultra high frequency reasoning should be divorced, but not completely, from broadcast and short-wave practice, in very much the same way that light and infra-red phenomena is from radio. Most engineers have become accustomed to think of circuit components in terms of micro-microfarards and microhenries. Present components built for use at u-h-f betray this. A new mode of analysis in relation to circuit parameters, parts, design and layout, is necessary. It therefore becomes an essential to scale down our thinking along these lines and "move the decimal point to the right." For example coils at u-h-f assume the proportion of 2.3 microhenries, as against 2,500 microhenries for broadcast, while a variation of .5 mmfd in a tuning condenser may cause a frequency deviation equivalent to several broadcast bands.

Whereas distributed capacity in a coil is a negligible factor at broadcast frequencies, at u-h-f it assumes tremendous importance. The numerical



In these illustrations the vast difference between u-h-f and b-c components is effectively shown. Note, for instance, the size of the broadcast condenser and the u-h-f condenser shown by the scale in figure at lower left. Band-widths at u-h-f and b-c are effectively illustrated in diagram at right. Note the distance between a pair of stations at approximately the upper and lower limits of a typical broadcast receiver and the appearance of these two stations on a u-h-f scale. These scales incidentally were drawn on a 100-cm length ratio.





A suggested u-h-f tube design with radial elements and dual terminations. Such construction has a particular advantage where concentric or resonant circuit elements are to be used.

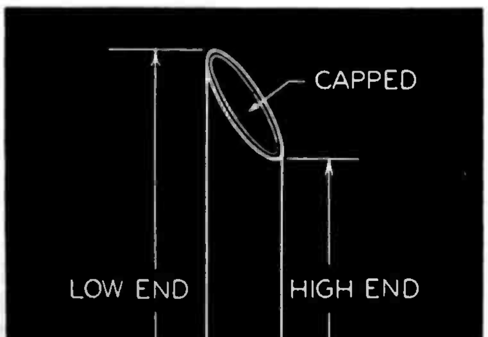
ratio between frequency, as measured in kc, and values of inductance and capacity measured in mh and mmfd is so great at u-h-f, that mentally the two are entirely out of proportion. In step with our mental concepts, should come a change in physical concepts. At present, micrometer exactness is required in the construction of u-h-f equipment. Thermal drift is such a tremendous factor at u-h-f that very exacting methods are a requisite for coil and condenser design. Methods must be devised so that physical size and tolerance will bear the same relationship to frequency at u-h-f that they do at broadcast.

The logical termination of these efforts should be straight-line frequency calibration in terms of kilocycles. This will probably result in new tuning methods. But we must not necessarily be tied down to frequency variation by the present accepted methods of capacity or inductance variation. For example, while not efficient, variation of the dielectric constant in condensers might offer possibilities as a tuning method.

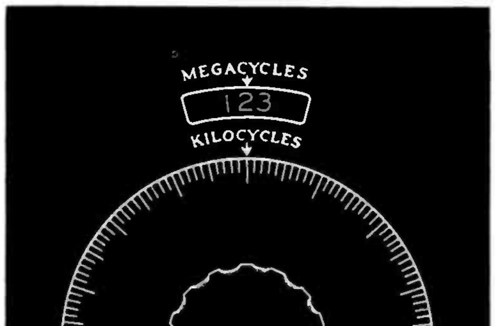
Another thought that might be expanded in relation to straight-line frequency control is some simplified form of continuous band change, very much like a step attenuator, working in conjunction with a calibrated dial movement, the band change to indicate the frequency in megacycles, and the dial in kilocycles. While the principle is not new, available models are mechanically too cumbersome. In line with this, advantage could be taken at u-h-f of the low reactance of small values of capacitance to remove that bugaboo of bandswitching contact resistance. The bandswitch point could become, instead of a direct contact point, a capacitive coupler between circuit elements and the tube. This would create several advantages. For one, the loading effect of the tube would be reduced, and secondly, small variations in the value of coupling capacitance would have a negligible effect on circuit stability and operation. The same line of thought might be applied throughout the whole r-f section for the transfer of r-f energy. For example, a capacitor of 100 mmfds has a reactance at u-h-f of only a few ohms, and by constructing it as an elongated cylindrical form, may be used to couple circuits which, by layout, would require several inches of wiring. The above mentioned type of construction would eliminate the faults inherent in bandswitching at points of r-f potential.

Another element that will have to advance co-incidentally is the u-h-f tube. Present available tubes, because of their low input admittance, are not ideally suited for u-h-f work. While some tubes give excellent performance at 150 megacycles, even slight variations in their input and output capacitances produce a condition where replacing tubes in r-f and oscillator circuits produce wide frequency variations in dial calibration. It is possible that some of the construction kinks used in tubes developed for v-h-f may eventually be adapted to u-h-f. The incorporation of circuit elements as part of the tube's con-

(*Continued on page* 108)



At left appears a theoretical representation of an aperiodic antenna. This picture is used to visually present the concept of an antenna designed for fairly uniform results over a band of u-h-f frequencies. At the right, appears a typical straight line frequency dial. Note that this dial provides an indication in megacycles and kilocycles, the two being additive.

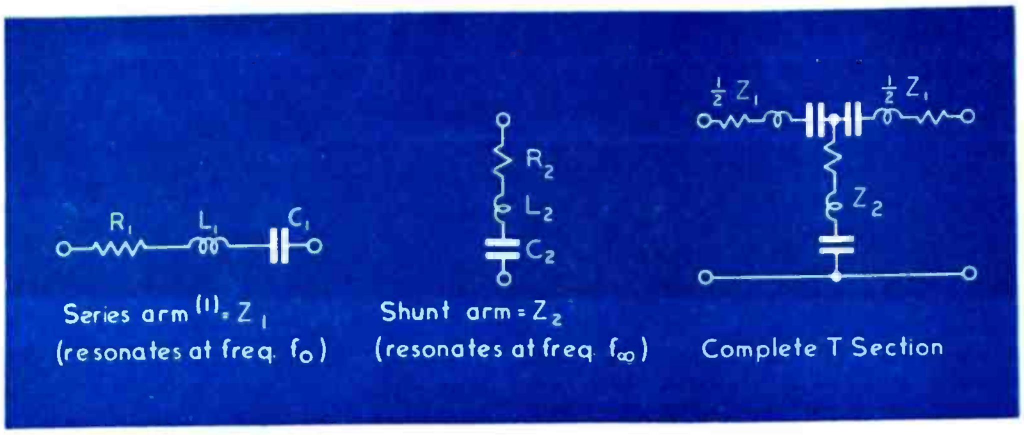


THE CIRCLE DIAGRAM

(PART ONE OF A TWO-PART PAPER)

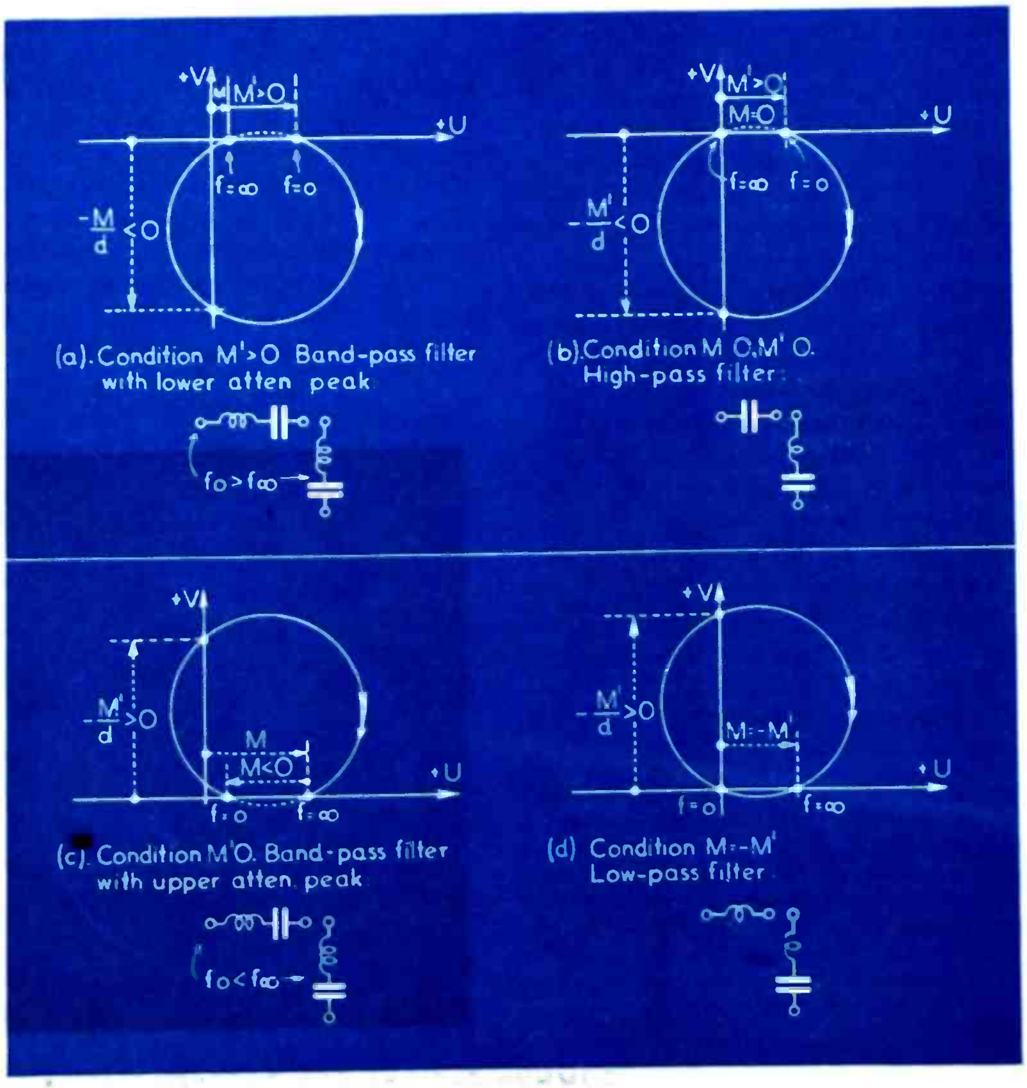
by PAUL J. SELGIN

Instructor, Electrical Engineering, Polytechnic Institute of Brooklyn



Figures 1 (top) and 2 (below)

In Figure 1, we have a four-element band pass filter of the monocyclic design. In Figure 2 (below) are illustrated the filter paths of monocyclic filters. In these filters, as the frequency is varied, the *filter point* describes one of the circles below, depending on the values of M, M' for the filter. In Figure 2*a*, we have a condition obtained when M' > O. Figure 2*b* applies when M = O, and M' > O. Figure 2*c* applies when M' < O, and Figure 2*d* applies when M = –M'.



THIS paper describes how a picture of the behavior of wave filters may be obtained by the use of simple graphical methods.

This type of analysis should be particularly useful when applied to filter networks in which dissipation plays a prominent part, such as those that act within a comparatively narrow range of frequencies.

Filter Point

When a ladder filter section is terminated by its image impedances, its propagation constant may be expressed in terms of the only variable $Z_1/4Z_2$. If the filter in question is ideal, or dissipationless, this variable is always real. If dissipation is present $Z_1/4Z_2$ may be expressed by the complex notation $U + jV$.

For a given filter section[1] at a given frequency, there is only one value of $U + jV$, connoting a point on a complex plane. If this point is known, the behavior of the filter at that frequency may be fully appreciated by the use of constant attenuation and constant phase contours drawn upon the same plane. Such contours are of fairly common use in filter work; they are a set of ellipses and a set of hyperbolae respectively, all of which are confocal.

A variation in frequency causes the filter point to describe a path on the complex plane. The term *filter path* may be applied to this ideal trajectory because it is characteristic of the particular filter in question. To be precise, it is characteristic of a particular set of numeric parameters which are common to any number of *omologous* filters whose impedance and attenuation characteristics differ only in scale.

If any of these numeric parameters is varied the filter point travels along a path of constant frequency. Here again, instead of frequency, the expression *frequency parameter* would be more appropriate, since any number of frequencies are transmitted identically by omologous filters as

[1]From now on the term *filter* will be used in place of *filter section* for brevity. A filter made up of several sections will be described as a *multiple filter*.

OF WAVE FILTERS

Simple Graphical Methods Provide Lucid Analysis Of Wave Filter Behavior

long as the frequency parameter, expressing their relationship to a reference frequency, stays the same. It is convenient to choose as reference frequency that at which the propagation constant is unity, i.e., $U = 0$ for a dissipationless filter. This frequency will be referred to as the *frequency of minimum loss,* although the definition is not strictly accurate unless d (dissipation factor) is small.

The intersection of a filter path with a path of constant frequency (frequency path) determines the filter point associated with that filter and frequency. The following discussion sets forth the steps leading to the equations of the paths and the way to draw them. This information is also contained in the circle diagram charts.

The usual distinctions between various kinds of filters made according to their purpose (high-low- and band-pass) need not apply to this type of analysis. It is more convenient to divide filters of the most common types into two general groups:

(a)—Monocyclic Filters

High-, low- and some types of band-pass filters fall into this group. The filter paths of all these are circles, or straight lines for limiting cases. The frequency of minimum loss is not near the middle of the transmitted band but at one end of it, and the attenuation has only one peak.

(b)—Dicyclic, or Confluent, Filters

Band-pass filters with attenuation peaks on both sides of the transmitted band are classed here. The filter path approximates the shape of an 8 (made by joining two circles). The filter point may be obtained without first drawing this, by the intersection of perfect circles. The frequency of minimum loss is somewhere inside the transmitted band.

Monocyclic Filters

Let the *4-element band-pass* filter, made up as shown in Figure 1 serve as an example of this category.

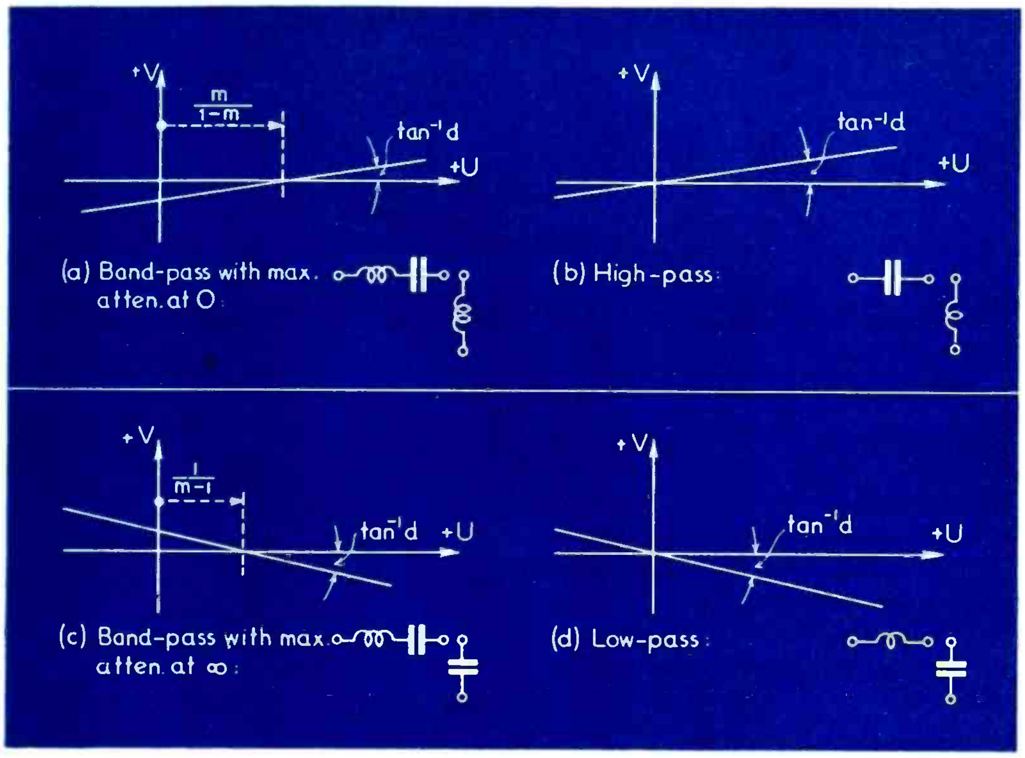


Figure 3
Filter paths of "prototypes". The circles in this case degenerate into straight lines.

Assume that each coil in the filter has an effective resistance such that $d = R/\omega L$ is independent of frequency[2], and that condenser losses are negligible compared with coil losses. We may then write (See Figure 1):

$$Z_1 = R_1 + j\left(L_1\omega - \frac{1}{C_1\omega}\right)$$

$$= L_1\omega\left[\frac{R_1}{L_1\omega} + j\left(1 - \frac{f_0^2}{f^2}\right)\right]$$

$$Z_2 = L_2\omega\left[\frac{R_2}{L_2\omega} + j\left(1 - \frac{f_\infty^2}{f^2}\right)\right]$$

[1]An equivalent filter would result if the arms were exchanged and replaced by their inverse impedances. Similar conclusions would follow.

[2]This assumption is not strictly true, but the final result does uot depend upon it. Filter paths are not circular if d varies with frequency, but as we are concerned with one frequency at a time we may give d its value for that frequency to obtain the correct filter point position. Moreover, the actual filter paths are very nearly circular because d affects their shape only slightly.

Let: $\left(\frac{f}{f_0}\right)^2 = x$ (frequency parameter)

$$\left.\begin{aligned} \frac{R_1}{L_1\omega} = \frac{R_2}{L_2\omega} &= d \\ \frac{L_1}{4L_2} &= M \\ (f_\infty/f_0)^2 &= n \end{aligned}\right\} \text{(filter parameters)} \qquad (1)$$

Therefore:

$$U + jv = \frac{Z_1}{4Z_2} = M\frac{d + j(1 - 1/x)}{d + j(1 - n/x)} \qquad (2)$$

This is an expression of the filter point coordinates in terms of four parameters, three of which are associated with the filter and one with frequency. An alternative, often more convenient, set of parameters is obtained by expressing M in terms of n and of a further parameter, m, related

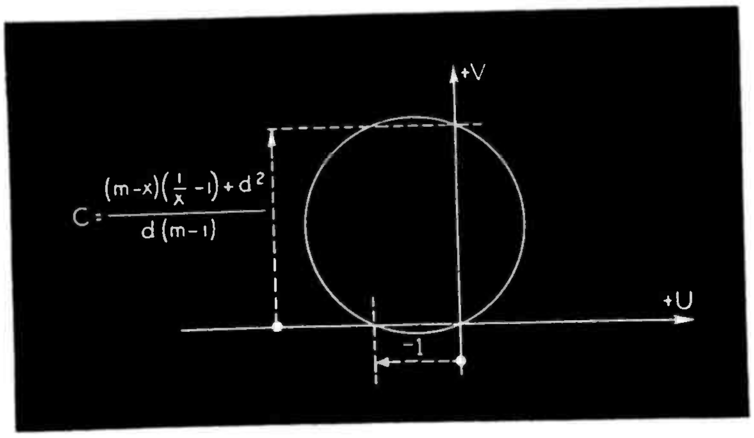


Figure 4
Frequency path of monocyclic filters. The filter point follows the circle shown when the quantity n is varied and the frequency is kept at some constant value. n is the parameter which distinguishes one section from the other in a multisection filter.

to the width of the transmission band.

The conditions:

$$d = 0 , \frac{Z_1}{4 Z_2} = -1$$

result in the following:

$$M = \frac{1 - n/x}{1/x - 1} = \frac{x - n}{1 - x} \qquad (3)$$

If $m = L_1 C_1 \omega_c^2$ is the value of x which makes *3* an identity, then:

$$f_c = \omega_c / 2\pi$$

is one of the cut-off frequencies. In fact, when substituted into the generic expression of $Z_1/4 Z_2$, the above value of frequency makes this equal to -1 (assuming $d = 0$). The other cut-off frequency is f_o, which makes $Z_1/4 Z_2$ equal to 0.

M may be replaced by the equivalent expression $\frac{m - n}{1 - m}$, thus:

$$U + jv = \frac{m - n}{1 - m} \cdot \frac{d + j(1 - 1/x)}{d + j(1 - n/x)} \qquad (4)$$

It should be noted that *m*, being equal to the ratio of cut-off frequencies squared, is constant for all filters belonging to the same multiple filter. Hence, frequency paths obtained by varying n alone, being loci of constant *m*, serve equally well for all sections of a multiple filter. This is why such frequency paths are chosen in preference to those obtainable by varying other parameters.

Equation of Filter Path

When the freqeuncy alone is variable equation *2* is the more convenient starting point. It may be written:

$$(U + jv) \cdot [dx + j(x - n)] = M [dx + j(x - 1)]$$

Hence, isolating the real and imaginary parts:

$$\begin{cases} xUdx - V(x - n) = Mdx & \text{(r.p.)} \\ Vdx + U(x - n) = M(x - 1) & \text{(i.p.)} \end{cases}$$

If x is factored out, the following are obtained:

$$\begin{cases} x = \dfrac{Vn}{V + dM - Ud} \\[2ex] x = \dfrac{Un - M}{U + Vd - M} \end{cases} \qquad (6)$$

Let:

$$U' = U - M ; \quad M' = M\left(\frac{1}{n} - 1\right) \qquad (7)$$

Then *5* may be written:

$$\left(U' - \frac{M'}{2}\right)^2 + \left(V + \frac{M'}{2d}\right)^2 = \left(\frac{M'}{2d}\right)^2 (1 + d^2) \qquad (8)$$

In *8* we have the equation of one of the circles shown in Figure 2 depending on the values of *M* and *M'*.

Figure 2a illustrates conditions obtained when $M' > 0$. Since:

$$M' = M\left(\frac{1}{n} - 1\right) = \frac{m - n}{1 - m}\left(\frac{1}{n} - 1\right) \qquad (9)$$

and *M*, which is a ratio of inductances (see equation *1*) cannot be negative, this is true when $n < 1$, i.e., when the shunt arm resonates at a lower frequency than the series arm. We conclude from this and from inspection of Figure 2a, having regard to the contours of constant attenuation, that the direction of travel along the filter path is clockwise for increasing frequencies. This is always true and may be proved in a general way be further analyzing equation *2*. The dotted part of the circle corresponds to negative values of frequency, hence it has no physical significance.

In the case of Figure 2a, this is the order of significant frequencies, from lowest to highest:

Zero frequency; maximum loss frequency; lower cut-off; higher cut-off; infinite frequency.

Figure 2b applies when $M = 0$, $M' > 0$. This is true only when both m and n are 0. The value of M' is then:

$$M' = \frac{(m/n - 1)(1 - n)}{1 - m} = \frac{m}{n} - 1$$

and expressing in terms of frequencies

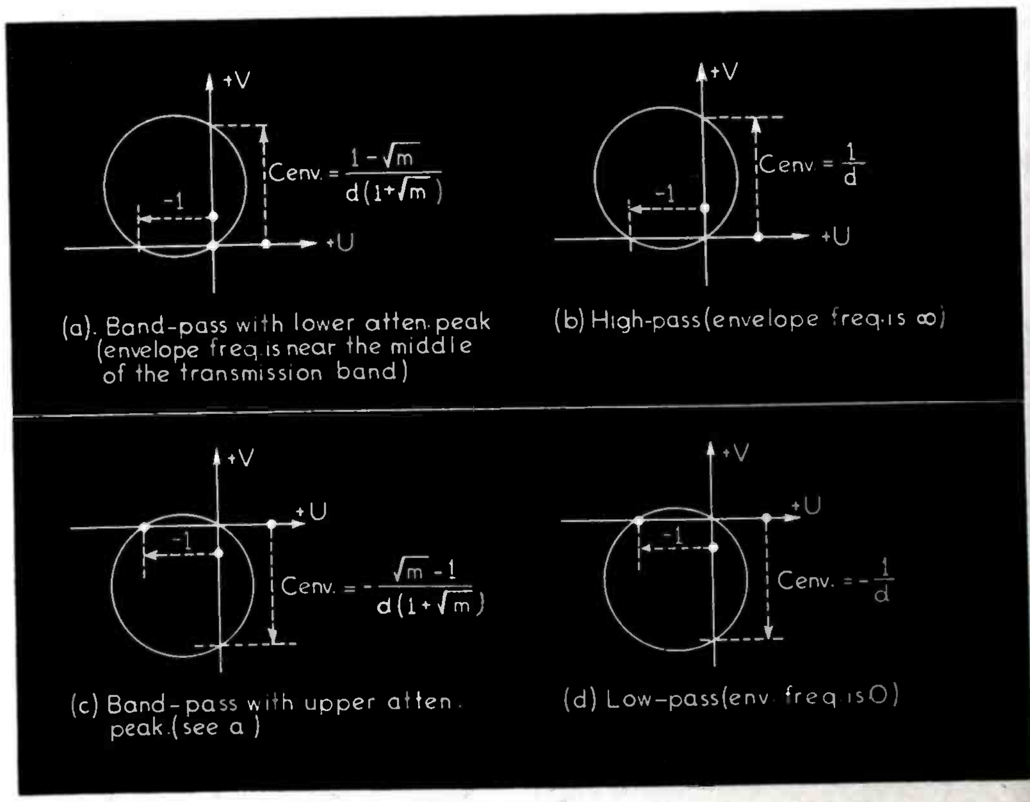


Figure 5
Envelope paths of monocyclic filters. All the filter paths associated with the same filter (each corresponding to a distinct frequency) are tangent to the envelope paths above. This makes their construction easier.

(see equation *1*)

$$M' = \left(\frac{f_c}{f_\infty}\right)^2 - 1 \qquad (10)$$

We conclude that f_o, frequency of minimum loss, is infinity, and that there is only one cut-off frequency (high-pass filter). The sequence of frequencies then is:

0 freq. — max. loss
— cut-off — ∞ freq.
(Min. loss)

Figure 2c applies when $M' < 0$. The condition $n > 1$ must be met and the sequence of frequencies is:

0 freq. — min. loss
(lower cut-off)
— upper cut-off — max. loss
— ∞ freq.

Figure 2a applies when $M = -M'$. Both *m* and *n* must be infinity. Then:

$$M = \frac{\dfrac{m}{n} - 1}{\dfrac{1}{n} - \dfrac{m}{n}} = \frac{n}{m} - 1 \qquad (11)$$

and in terms of frequencies

$$M = \left(\frac{f_\infty}{f_c}\right)^2 - 1$$

The sequence of frequencies (pointing to low-pass filter) is:

0 freq. — cut-off
(min. loss)
— max. loss — ∞ freq.

Prototype Sections

Each of the circles of Figure 2 becomes a straight line when:

$M' = +\infty$ (Figure 2a and 2b)

$M' = -\infty$ (Figure 2c and 2d)

These conditions are equivalent to the following:

$n = 0$, hence $f_\infty = 0$ (2a and 2b)

$n = \infty$, hence $f_\infty = \infty$ (2c and 2d)

Filters answering these requisites are known as *prototypes*. They have one element less than the generic, or *derived* types. The filter paths of prototypes are shown in Figure 3.

Frequency Paths

Going back to equation *4*, paths of constant frequency may be obtained by choosing *n* as the variable. These paths are common to all filters with the same value of *m*, i.e., with the same cut-off frequency ratio.

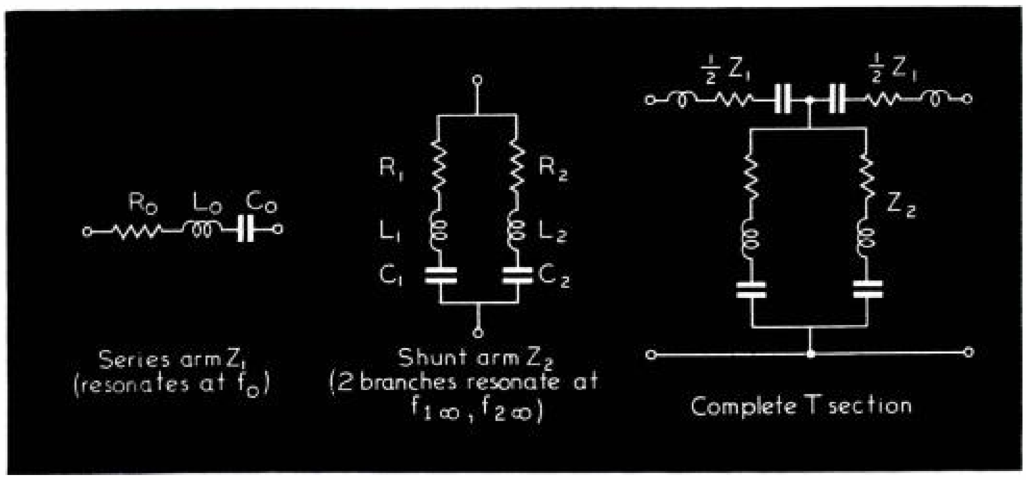


Figure 6
The structures considered in the discussion of dicyclic, or confluent, filters.

The frequency path equation is arrived at as follows:

$$\begin{cases} \left(nV + \dfrac{dx}{1-m}\right) = \dfrac{m}{1-m}dx + Vx - Udx \\ n\left(-V + \dfrac{x-1}{1-m}\right) = -Vdx - Ux + \dfrac{m}{1-m}(x-1) \end{cases}$$

Hence:

$$U^2 + V^2 + U + \frac{V}{1-m}\left[\frac{(m-x)(1-x)}{dx} + dx\right] = 0 \qquad (13)$$

Equation *13* is the equation of a circle as shown in Figure 4.

The expression of *C* in Figure 4 applies to all types. It may be simplified considerably when *m* is either *0* or ∞, which is true of high- and low-pass filters. A further simplification without appreciable loss of accuracy is obtained by neglecting d^2, provided the frequency is not close to either cut-off.

Each frequency path does not relate to a single value of *x*, but to two such values, as can be seen if the expression of *C* is considered. Similarly, each frequency path intersects a given filter path in two points. Going round the frequency path in a clockwise direction, the filter point relating to the *highest frequency* comes first.

Envelope Paths

In conjunction with each *m* value there is a particular frequency path which is tangent to all the filter paths of filters having that *m* value.

This may be called, in consequence, the *envelope path*. It is useful when dealing with multiple filters, in that a set of filter paths, designating possible sections which may be added in series, may be obtained as soon as the envelope path has been drawn.

By drawing one further circle (the frequency path relating to a given frequency) the behavior of the multiple filter at that frequency may be observed, thanks to the usual contours, and slight changes in the filter composition made accordingly. This is an accurate and flexible method, but it is unwieldly if the dissipation factor is small because of the size of the circles. However, when the filter action is confined to a narrow band of frequencies this limitation disappears.

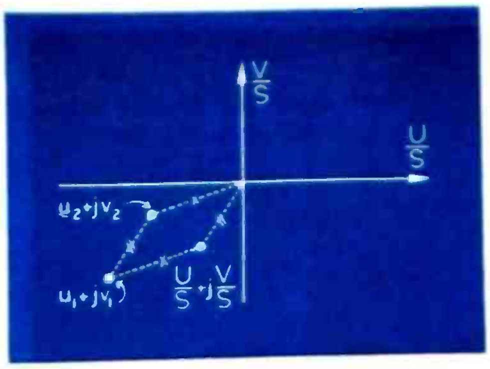
To find the envelope path equation, the derivatives of $U + jV$ with respect to *x* and *n* must be worked out and set equal to one another. This condition leads to the *x* value relating to the envelope path. Thus:

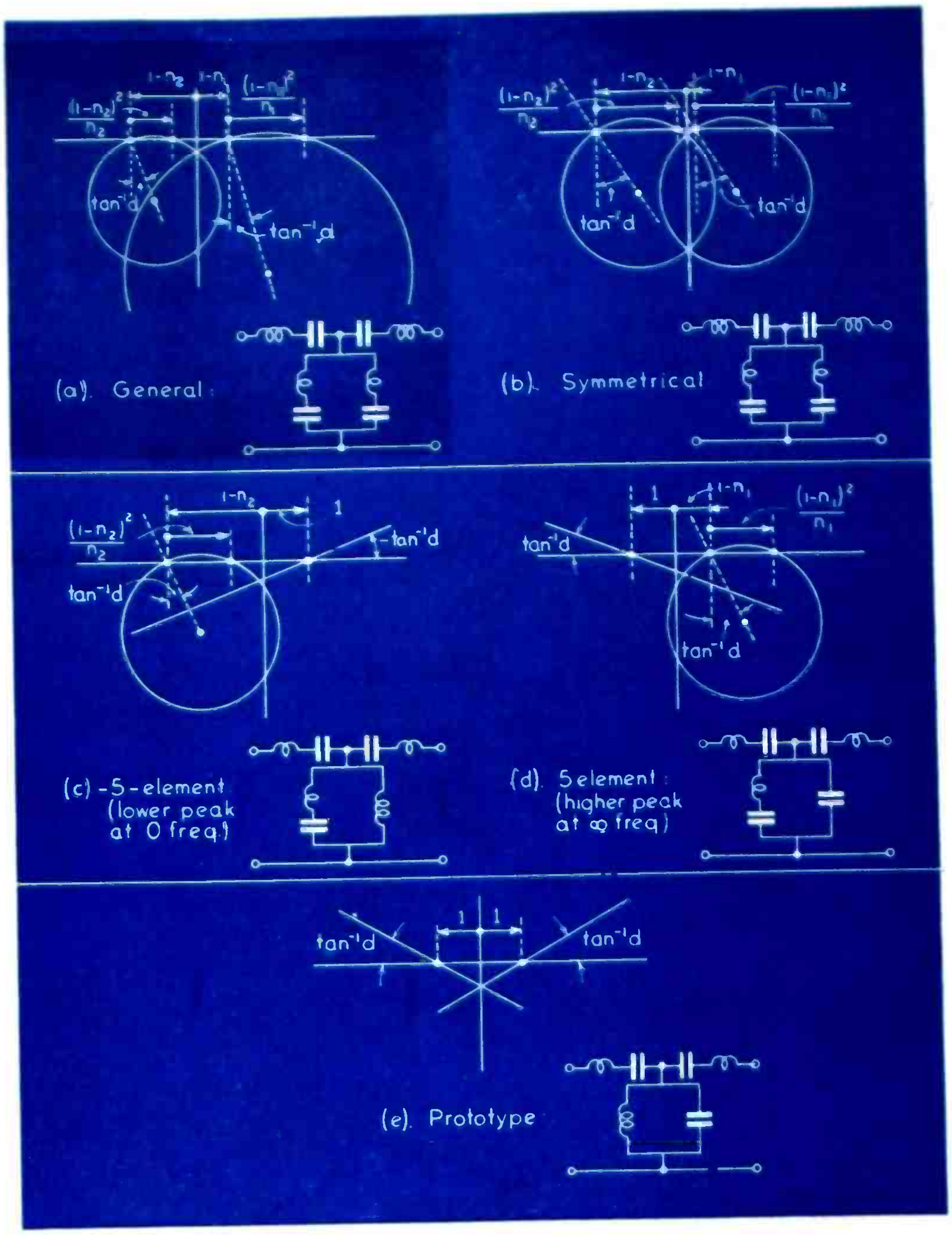
$$\frac{d}{dx}(U + jV) = \frac{(m-n)(1-n)(dj-1)}{(1-m)[dx + j(x-n)]^2 = D}$$

$$\frac{d}{dn}(U + jV) = \frac{[dx + j(x-1)]\,[j(n-x) - dx]}{D}$$

Comparison of the two last lines gives:

$$\begin{cases} (m-n)(r-n = x(m+1) & \text{(i.p.)} \\ (m-n)(1-n) = d^2x^2 + (x-1)(n-x) & \text{(r.p.)} \end{cases}$$





Hence:

$$m = x^2_{env}\,(1 + d^2)$$

and finally:

$$x_{env} = \sqrt{m(1+d^2)}\,; \quad C_{env} = \frac{1-\sqrt{m}}{d(1+\sqrt{m})} \tag{14}$$

Envelope circles relating to the 4 groups of monocyclic filters are shown in Figure 5.

Each envelope path, as distinct from other frequency paths, corresponds to a *single* value of frequency, a conclusion following from the existence of a single point of contact with filter paths, as well as from the expression of x_{env}.

The generic expression of C goes through a maximum, or a minimum, when $x = x_{env}$.

Dicyclic, or Confluent Filters

Consider the structure shown in Figure 6. If we let:

$$\left.\begin{aligned} x &= \left(\frac{f}{f_o}\right)^2 \text{(frequency parameter)} \\ d &= \frac{R_o}{L_o\omega} = \frac{R_1}{L_1\omega} = \frac{R_2}{L_2\omega} \\ n_1 &= (f_{2\infty}/f_o)^2 \\ n_2 &= (f_{2\infty}/f_o)^2 \\ M_1 &= L_o/4\,L_1 \\ M_2 &= L_o/4\,L_2 \end{aligned}\right\} \text{(filter parameters)} \tag{15}$$

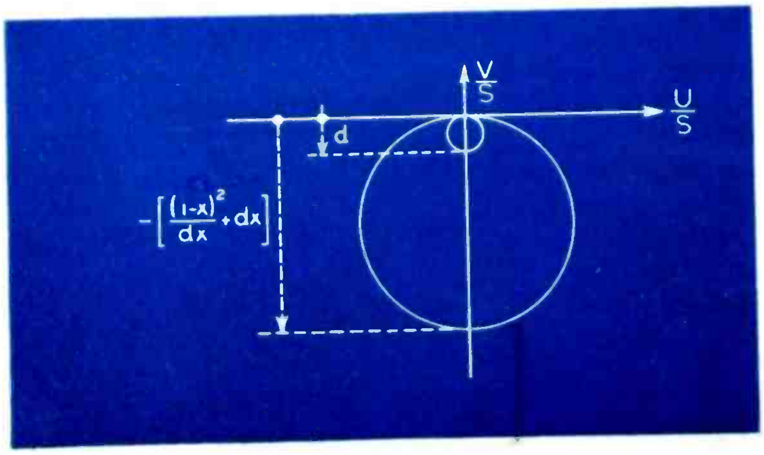
the filter point coordinates may be expressed as follows:

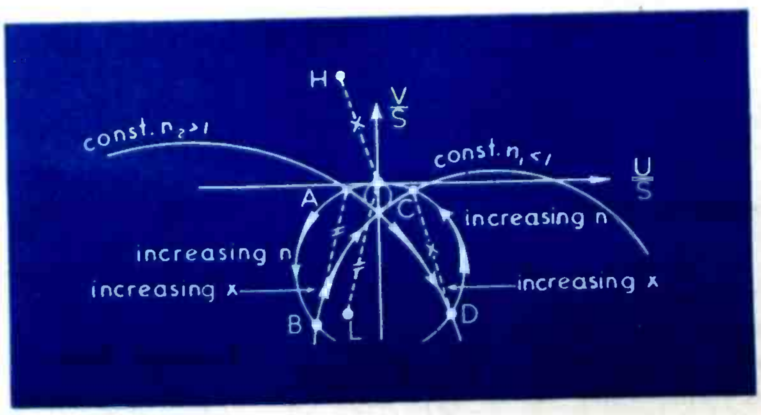
$$U + jV = M_1\,\frac{d + j\,(1 - 1/x)}{d + j\,(1 - n_1/x)} + M_2\,\frac{d + j\,(1 - 1/x)}{d + j\,(1 - n_2/x)} \tag{16}$$

This type of structure transmits two distinct bands of frequency when the four filter parameters above have generic values. We are, however, only

Figures 7 (upper left), 8 (top), 9 (lower left) and 10 (lower right)

Figure 7 illustrates filter point construction for confluent filters. In Figure 8, we have the constant n paths for confluent filters. For each *confluent* filter section (the term applies to sections with two attenuation peaks) there are two circles which define the section. Figure 9 illustrates the constant x path for confluent filters. Each of the circles corresponds to a particular frequency and can be used for all the sections of a multiple filter. In Figure 10, we have the intersection constant n and constant x paths. This is a method of obtaining a filter point. Actually, L and H are obtained because each constant x circle is valid for two distinct frequencies above and below midband.





concerned with *confluent* filters, i.e., filters of the type shown above, but transmitting two *adjoining* frequency bands which have the frequency of minimum loss as their common boundary.

This condition is reflected in the identity of the two roots of equation *16* obtained by solving for x after having set U = 0 and d = 0, thus:

$$M_1 \frac{x-1}{x-n_1} + M_2 \frac{x-1}{x-n_2} = 0$$

The two roots are:

$$x_1 = 1$$

$$x_2 = \frac{n_1 M_2 + n_2 M_1}{M_1 + M_2}$$

The condition $x_1 = x_2$ is fulfilled when:

$$M_1 (1 - n_2) = M_2 (n_1 - 1) \qquad (17)$$

Let:

$$S = \frac{M_1}{1 - n_1} = \frac{M_2}{n_2 - 1}$$

The expression of U + jV for confluent filters may then be written:

$$U + jV = S \left[(1 - n_1) \frac{d + j(1 - 1/x)}{d + j(1 - n_1/x)} - (1 - n_2) \frac{d + j(1 - 1/x)}{d + j(1 - n_2/x)} \right]$$

or, more briefly:

$$U + jV = S\,[(u_1 + jv_1) - (u_2 + jv_2)] \qquad (18)$$

where:

$$u_1 + jv_1 = (1 - n_1) \frac{d + j(1 - 1/x)}{d + j(1 - n_1/x)} \qquad (19)$$

and, likewise, $u_2 + jv_2$.

Expression of S

The filter parameters now include only d, n_1, n_2 and S. To find the value of S in terms of significant frequencies, x must be set at the values which make U = −1 with d = 0 (cut-off frequencies). This condition is expressed as follows:

$$S(x-1) \left[\frac{1 - n_1}{x - n_1} - \frac{1 - n_2}{x - n_2} \right] = -1$$

(*Continued on page* 78)

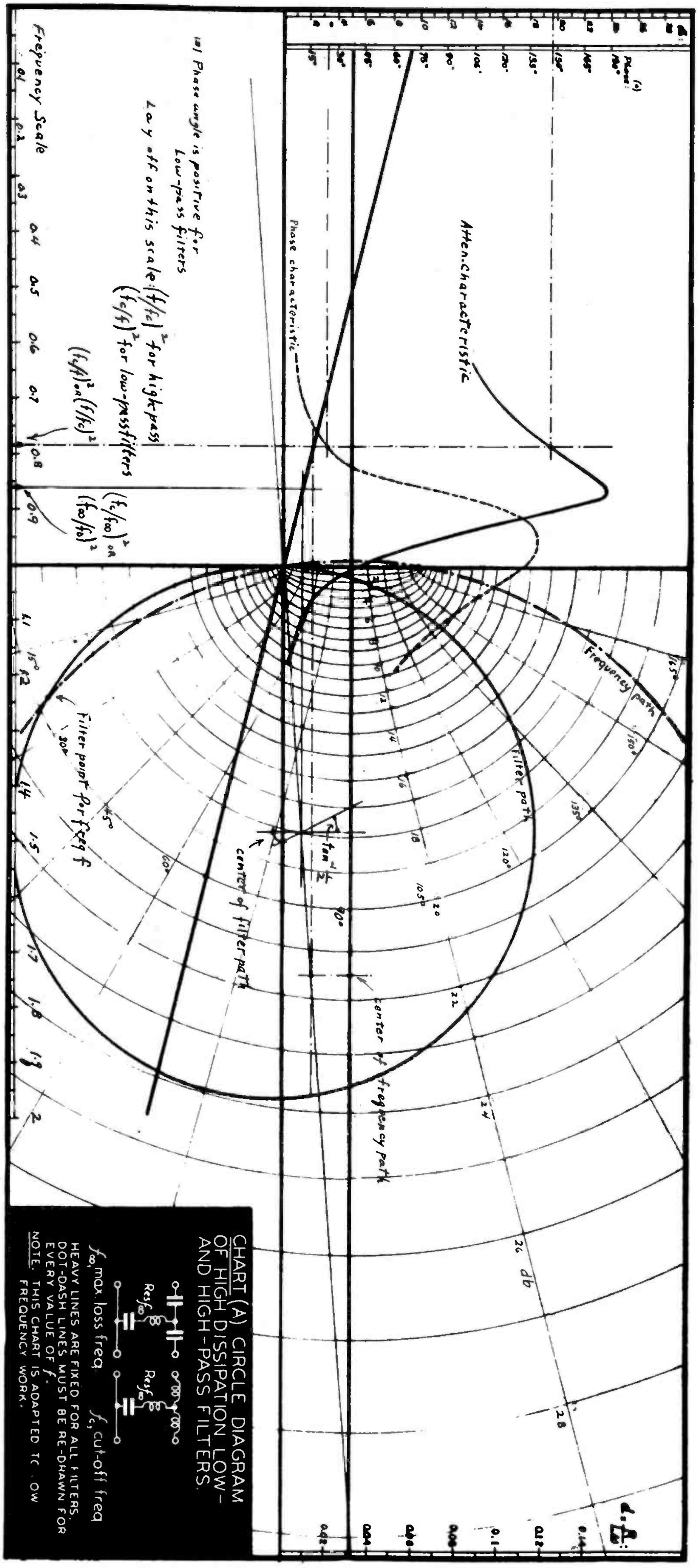
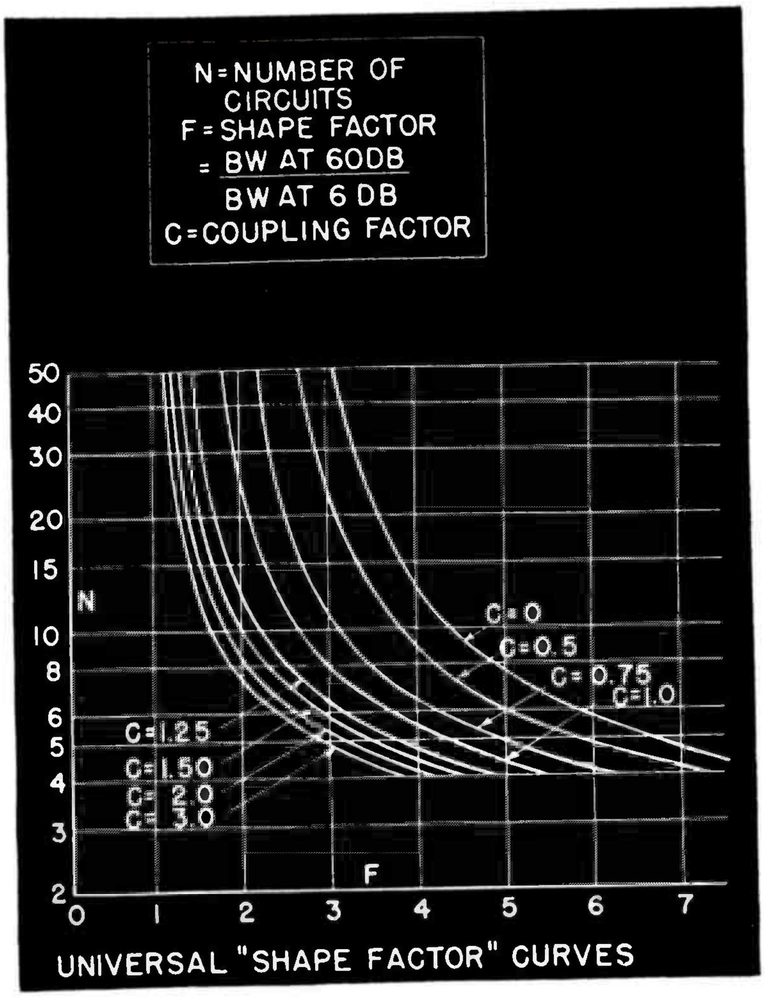


CHART (A) CIRCLE DIAGRAM OF HIGH DISSIPATION LOW- AND HIGH-PASS FILTERS.

f_∞, max. loss freq. f_c, cut-off freq

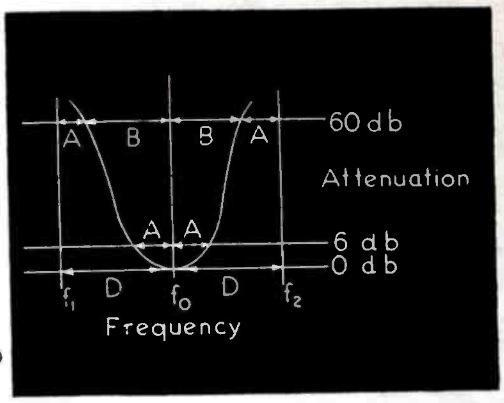
HEAVY LINES ARE FIXED FOR ALL FILTERS. DOT-DASH LINES MUST BE RE-DRAWN FOR EVERY VALUE OF f.

NOTE. THIS CHART IS ADAPTED TO LOW FREQUENCY WORK.



Figures 1 (right) and 2 (left)

In the paper by J. E. Maynard on i-f system design, selectivity, shape factors, etc., as illustrated here, will be analyzed.



THE ROCHESTER FALL MEETING

MANY interesting papers will be presented at the annual Rochester Fall meeting which will be held at the Sagamore Hotel in Rochester, New York, on November 8 and 9.

Maynard Paper on I-F Design

In a paper on i-f design, J. E. Maynard of the General Electric transmitter division, will show how the design of an i-f system, to meet specified requirements for modulation sidebands, frequency drift, accuracy of frequency setting and elimination of adjacent channel interference, may be worked out with the assistance of selectivity charts prepared for this purpose. A graphical presentation of such a problem is shown in Figure 1.

The frequency deviation A includes drift, frequency setting and modulation requirements. It is required to maintain the signal within a 6 db level of resonant frequency response. The adjacent signal at f_1 and f_2 is to be maintained at 60 db or more attenuation relative to resonant response. The undetermined quantity in the Figure is the frequency deviation B on the selectivity curve. This may be treated in relation to A.

Figure 2 shows the relation between the shape factor F and the number of tuned circuits in the amplifier for various proportions of critical coupling (by shape). The ratio B/A is plotted as shape factor F of an i-f system in this chart. The coupling factor C represents critical coupling at $C = 1.0$; 50% of critical coupling at $C = 0.5$; 50% over critical coupling at $C = 1.5$, etc. The number of circuits N is the count of tuned circuits, e. g., a pair of coupled circuits counts as two circuits.

This chart was derived by P. C. Gardiner of the G. E. transmitter engineering division from the universal selectivity curves of Figure 3. These curves represent the selectivity obtainable from a pair of coupled circuits. Non-symmetry due to variations directly and inversely related to frequency have been neglected and Q is assumed to be 5 or more. In general, good agreement with practical circuits is obtainable. The value of Q in primary and secondary is converted to an equivalent equal Q in terms of the geometric mean Q_0 and the arith-

(*Continued on page 84*)

PROGRAM

Monday, November 8

9:30 A.M. "Review of the problem: Demountable Versus Sealed-off Tubes"; *I. E. Mouromtseff, Westinghouse Electric & Manufacturing Company.*

"Crystals Go To War"; *Sound film in kodachrome, Reeves Sound Laboratories.*

2:00 P.M. "Design of I-F Transformers for F-M Receivers"; *William H. Parker, Jr., Stromberg-Carlson Company.*

"Twenty-Eight Volt Operation of Electron Tubes"; *Walter R. Jones, Sylvania Electric Products, Inc.*

"Vacuum Capacitors"; *George H. Floyd, General Electric Company.*

8:15 P.M. "The Signal Corps Looks to the Engineer"; *Major James I. Heinz, U. S. Army Signal Corps.*

Tuesday, November 9

9:30 A.M. Message of RMA Director of Engineering, *Dr. W. R. G. Baker,*

"Operating Characteristics of Ceramic Dielectrics with Constants Over 1,000"; *R. B. Gray, Erie Resistor Corporation.*

"A Chamber of Commerce War Research Committee"; *K. C. D. Hickman, Distillation Products, Inc.*

2:00 P.M. Report of RMA Data Bureau, *L. C. F. Horle.*

"New Low Loss Ceramic Insulation"; *Ralston Russell, Jr., and L. J. Berberich, Westinghouse Electric & Manufacturing Company.*

"Aids in the Design of I-F Systems"; *J. E. Maynard, General Electric Company.*

6:30 P.M. Banquet. Toastmaster—*R. M. Wise.*

[*An exhibit of the U. S. Army Signal Corps equipment will be a feature of both days.*]

John E. Maynard, Transmitter Division, General Electric, Schenectady, New York.

Mr. Maynard has been with General Electric since 1929. He is a graduate of the University of Washington: B.S. in E.E. He also has a M.S. in E.E. from Union College.

Mr. Maynard will discuss *Aids in the Design of I-F Systems*.

William H. Parker, Jr., project engineer, Stromberg-Carlson Company, Rochester, New York.

Formerly associated with Amrad Corporation, United American Bosch Corporation, Fada Radio and Electric Company, and Federal Telegraph Company. Mr. Parker attended M. I. T.

Mr. Parker's paper will cover *The Design of I-F Transformers for F-M Receivers*.

George H. Floyd, engineer, Tube Division, General Electric, Schenectady, New York.

Graduate of University of Arizona; B.S. in E.E.

Mr. Floyd will discuss *Vacuum Capacitors*.

Authors of Technical Papers Being Presented At Rochester Fall Meeting

Robert B. Gray, physicist, Erie Resistor Corporation, Erie, Pennsylvania.

Cornell University graduate; E.E. Formerly associated with Westinghouse Research Laboratories and University of Pittsburgh.

Mr. Gray will discuss *Operating Characteristics of Ceramic Dielectrics with Constants Over a Thousand*.

Walter R. Jones, manager, Commercial Engineering Department, Sylvania Electric Products, Inc., Emporium, Pennsylvania.

Cornell University; E.E. Formerly associated with Federal Radio Corporation. With Sylvania since 1929.

Mr. Jones will discuss *Twenty-eight Volt Operation of Electron Tubes*.

Ilia Emmanuel Mouromtseff, assistant manager of Electronics Engineering Department, Westinghouse, Bloomfield, New Jersey.

Graduate of Institute of Technology, Darmstadt, Germany. Mr. Mouromtseff has been with Westinghouse for twenty years. He assisted in the development of the first water-cooled transmitting tubes and the earliest u-h-f tubes for high output.

Mr. Mouromtseff will discuss *Demountable Versus Sealed-Off Tubes*.

Ralston Russell, Jr., ceramic research engineer, Westinghouse, East Pittsburgh, Pennsylvania.

Holds B.S., M.S. and Ph.D. Mr. Russell was formerly associated with General Motors, General Ceramics Company and Ohio State. He has been with Westinghouse since 1940.

He is co-author with Mr. Berberich of the paper on ceramics.

Leo J. Berberich, section engineer in charge of Physical and Electrical Section, Insulation Department, Westinghouse, East Pittsburgh, Pennsylvania.

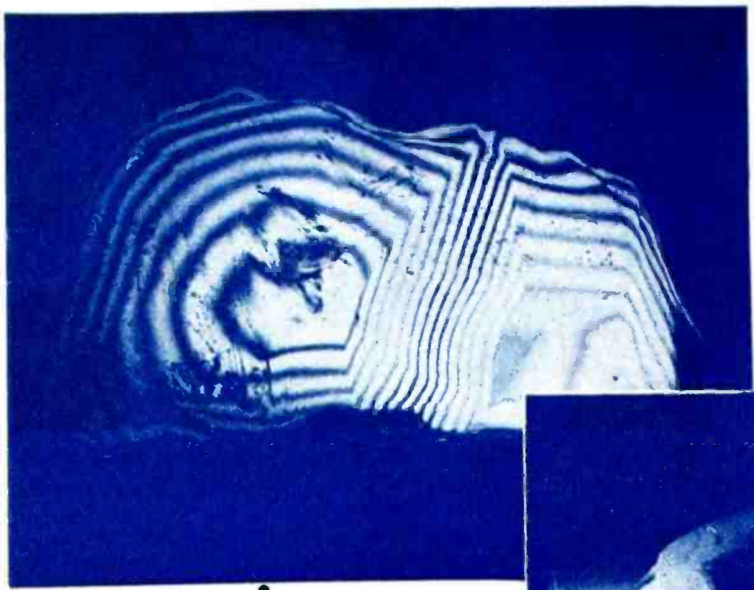
Graduate of Johns Hopkins; B.S. in E.E., Dr. of Eng. Formerly associated with National Bureau of Standards, Johns Hopkins University and Socony Vacuum Oil Company. With Westinghouse since 1937.

Mr. Berberich is co-author with Ralston Russell, Jr., of paper on *New Low Loss Ceramic Insulation*.

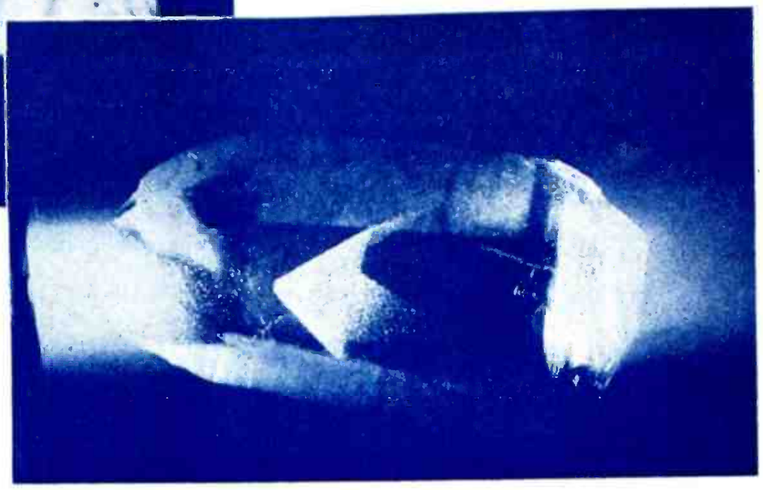
INSPECTION,

by SIDNEY X. SHORE

Project Engineer, Crystal Division, North American Philips Company, Inc.



Irregular quartz crystal viewed between crossed polarizers in inspection bath, showing two optical axes in the same crystal inclined to one another. Optical twinning is also evident by the kinks of the bright and dark bands. Specimens like these are quite rare and suitable particularly for museum pieces.



Phantom growth in mother crystal delineated by planes of bubbles. Two of the visible prism sides of the mother crystal show semi-opaque end crustations. The base of the crystal shows typical conchoidal fracture. Bubbles are apparent in the apex region.

This is the first of a series of articles covering a detailed analysis of crystal manufacture. In subsequent papers, Mr. Shore will discuss orientation, sawing and lapping, and finishing and testing.

THE imperfections and flaws found in quartz require a comprehensive program of consistent inspection, grading and classification.

Proper inspection must be carried out not only on raw quartz, but throughout the manufacturing process. Classification involves the separation of the faced and unfaced quartz. Faced quartz includes any *mother* having at least one fairly large sized smooth natural surface. Unfaced quartz may include completely unfaced and irregular quartz or river quartz having traces of the original surfaces which have been eroded and pitted out of true by rivers washing over the quartz.

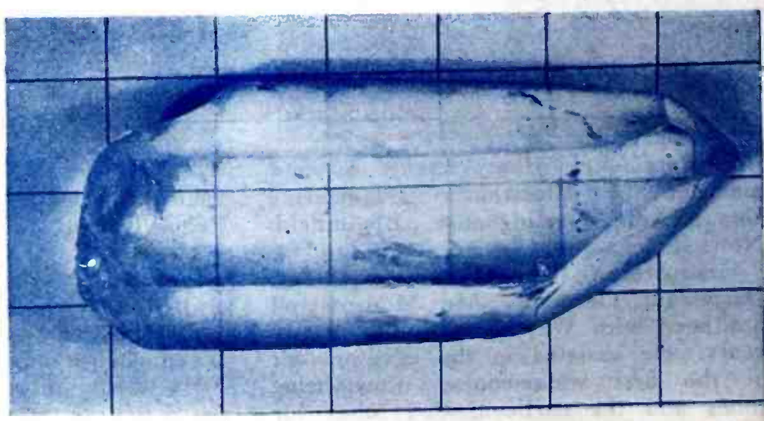
In grading, raw quartz is sorted according to size ranges. The ranges chosen prompt the processes used later on in orientation and sawing.

Visual inspection of each *mother* which follows the grading step involves many interesting processes. Equipment used includes an oil bath, a polarized light source and analyzer, and an arc lamp or equivalent bright light source. This inspection helps to estimate the final yield of finished crystal oscillator plates per pound of raw quartz. It is not used however as the final authority. Certain imperfections may be tolerated in varying degrees, under certain conditions, as we will show later. On the basis of the oil bath inspection, raw quartz may be classified as . . . less than 25% usable, 25% to 50% usable, 50% to 75% usable and over 75% usable volume of the total.

Imperfections often found in raw quartz include . . . optical twinning, electrical twinning, cracks, inclusions, veils, bubbles, needles, chuva, *ghosts* or phantoms. The only flaw which is never visible in the oil inspection bath is electrical twinning.

If we examined irregular quartz in air for physical imperfections and used an arc lamp as the light source we would be disappointed at the results. Even the natural faces of quartz and especially the prism sides are often pitted, striated and unclear. Much of the light is reflected and dispersed, and gleaming facets on the surface do not allow a very good internal inspection. Since quartz, when broken, has no sharply defined cleavage planes, preferring a direction approximating the major rhombohedral face, it often cleaves with conchoidal fracture leaving a ripple surface. Such is the nature of the surfaces of irregular

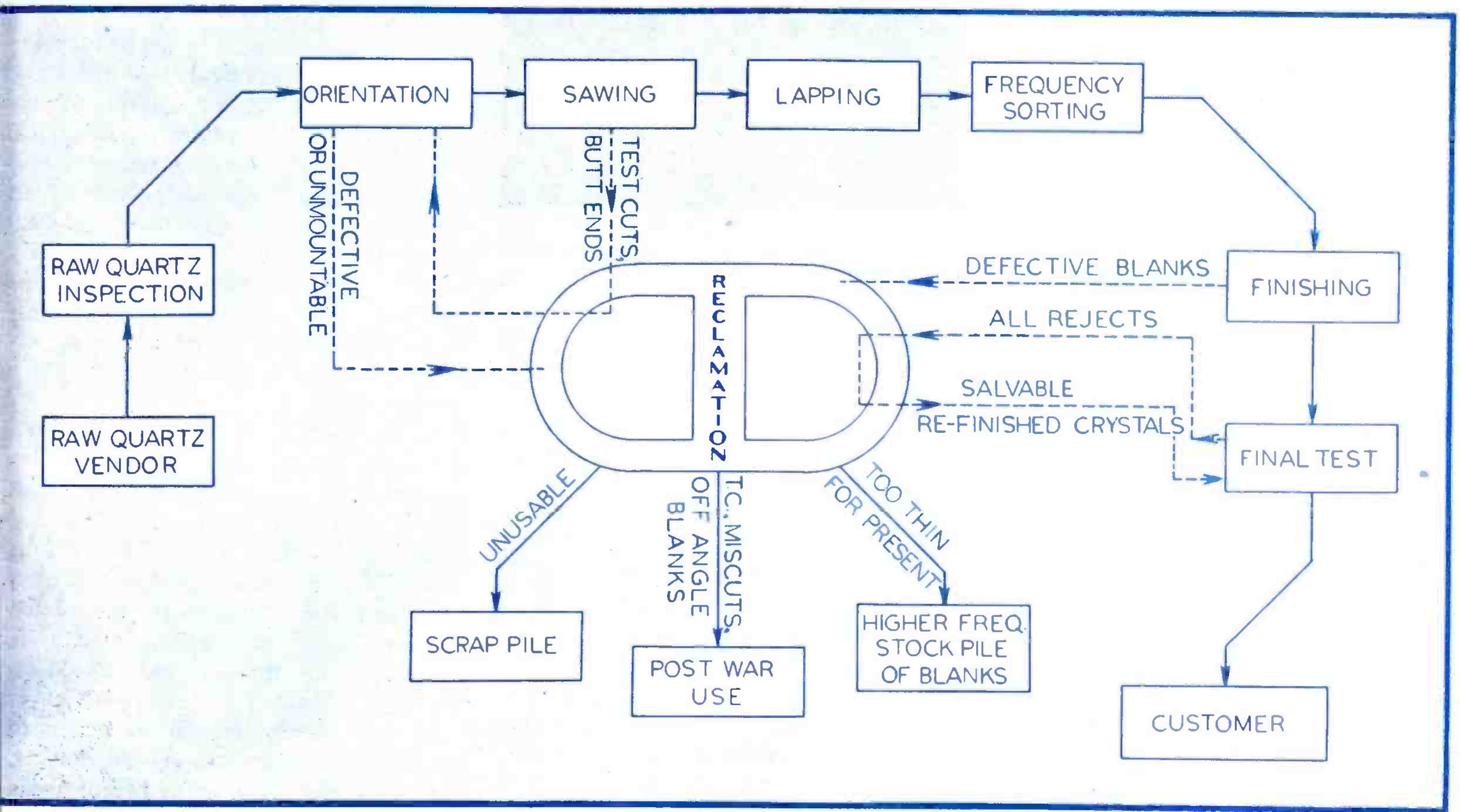
Regular prismatic quartz with *x* and *s* faces. Quartz with these faces is not found often. These faces sometimes help in determining the handedness of the quartz.



Regular prismatic quartz. It is clear, has well formed sides and apex. This is a desirable type of quartz for ease in orientation in sawing.

GRADING AND CLASSIFICATION OF QUARTZ

A Study Of Some Procedures In Current Use In Crystal Manufacture

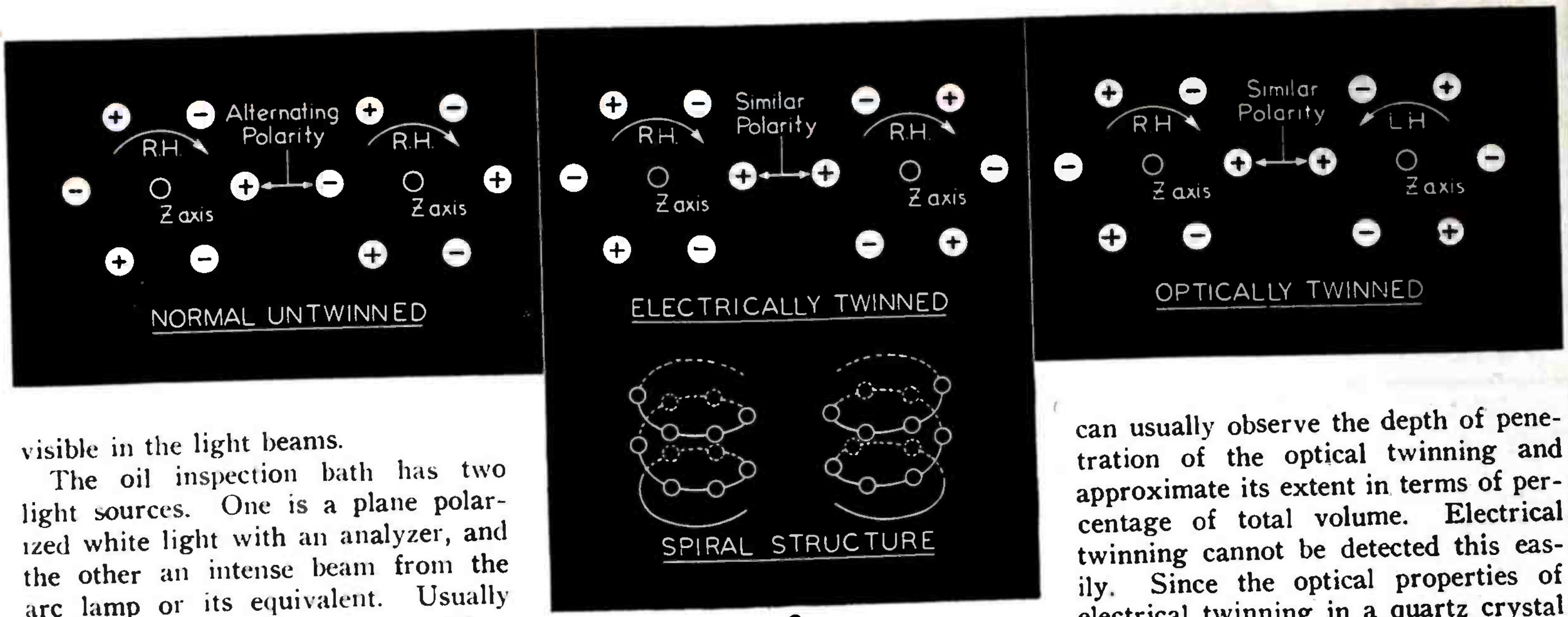


Material flow chart

quartz. Thus an air inspection of the interior is almost impossible.

Raw quartz inspection therefore is done in a fluid having an index of refraction approximately equal to the mean index of refraction of quartz, 1.546. Tricresyl phosphate was one of the early fluids used, but its harmful effect to the skin of many people caused it to be discontinued in favor of mineral oil with an index of about 1.47. This was less efficient but since it provided the hands with a *beauty treatment* while working it was preferred. However, after some usage it was discovered that the viscosity of the oil caused many air bubbles to be trapped causing difficulty in examination. Water was substituted for mineral oil to eliminate the air bubbles. Recently, though, a non-toxic and low viscosity oil (Socony Vacuum) was made available with an index of refraction ranging from 1.541 to 1.547. A clear piece of quartz seems to disappear when immersed in the new oil and only the interior is

Full double-ended crystals of regular prismatic quartz, showing an apex at each end. Crystal at left shows surface inclusions. Double-ended crystals are rare because quartz prospectors generally break the crystal when chopping it away from the bed.



Molecular structure of normal and twinned quartz. Silicon atoms are +, and — are two oxygen atoms SiO_2.

visible in the light beams.

The oil inspection bath has two light sources. One is a plane polarized white light with an analyzer, and the other an intense beam from the arc lamp or its equivalent. Usually these beams are projected perpendicular to one another through the bath and are individually controlled by foot switches.

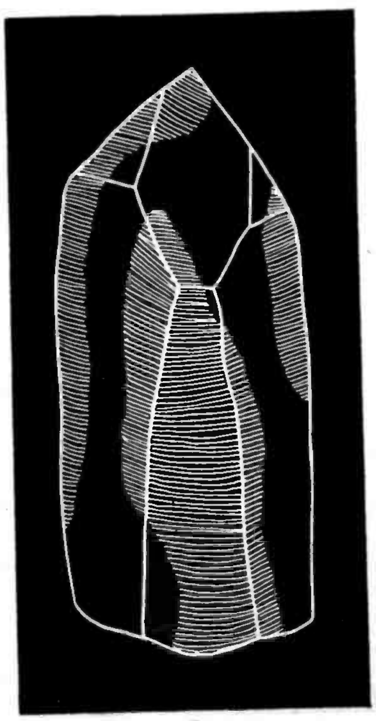
The molecular structure of normal quartz and twinned quartz, both optical and electrical twins, is important in inspection procedure.

Crystalline quartz is composed of silicon dioxide molecules which are found arranged in adjacent spiral strings with three complete molecules comprising each turn of the spiral. The spirals may be either right-handed or left-handed. The spiral axis is the Z-axis or optical axis.

One of the useful optical properties of quartz is its rotation of the plane of polarization, of plane-polarized light, traveling parallel to the optical axis. The angle of rotation depends on the length of path of travel parallel to Z and upon the wavelength of the light. If we orient ourselves so that we look along the Z-axis towards the source of plane-polarized light, the plane of polarization may be rotated clockwise or counterclockwise. For clockwise rotations we call the quartz right-handed; for counterclockwise rotations we call quartz left-handed.

If we represent each silicon atom in combination as a plus charge and each pair of combined oxygen atoms as a minus charge a symmetrical configuration of three plus charges alternating with three minus charges may be visualized in each deck of a spiral of repeating decks. There are many spirals of silicon dioxide molecules side by side, normally with parallel axes. If we were to take one deck of each of two spirals, side by side, and project on a plane perpendicular to Z, we would have the result shown above. For normal untwinned quartz all the spirals are of the same handedness, but the polarity of the adjacent spirals appears as if a 180° rotation about the Z-axis had been made. For optical twinned quartz, the spirals also appear to have been rotated through 180°. In addition the handedness of the spiral is also reversed.

We can see, therefore, that in using optical means for observing twinning only optical twinning will be visible. For when white polarized light reaches the reverse handed spiral, it is suddenly reversed in rotation. Thus that region displays a change in color when viewed through the analyzer. When the optical axis of the quartz is lined parallel to the direction of travel of the plane-polarized beam of light, optical twinning shows up as triangular patches of colored bands through the analyzer and is unmistakable. Optical twinning occurs in thin sheets parallel to the major rhomb faces. By gently rocking the optical axis off parallelism with the light beam, we can usually observe the depth of penetration of the optical twinning and approximate its extent in terms of percentage of total volume. Electrical twinning cannot be detected this easily. Since the optical properties of electrical twinning in a quartz crystal are similar to those of the main body of the quartz, polarized light is unchanged on crossing the twinning boundary and we see no abnormal effect. We must use other means for its detection.



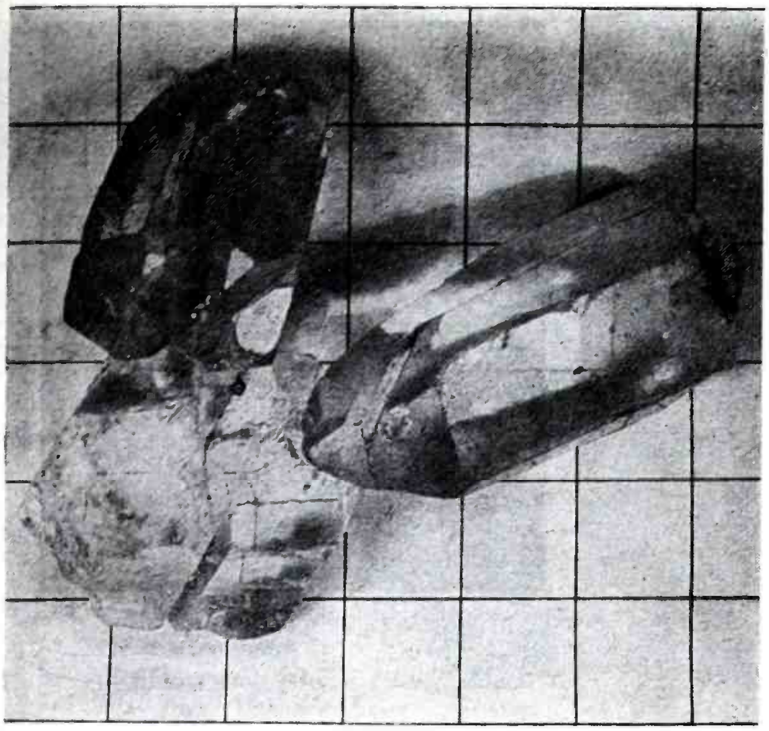
Electrically twinned raw quartz after sand blasting and etching. Shaded portions are electrical twin areas.

When the optical twinning has been observed and its extent noted, the inspector must then determine the extent of the remaining flaws. Now the arc lamp comes into use. This bright light source is unpolarized and is used to detect the other flaws mentioned previously. The mother quartz is submerged in the oil and placed in the light beam. It is examined carefully and slowly turned in order to enable the inspector to see all defects.

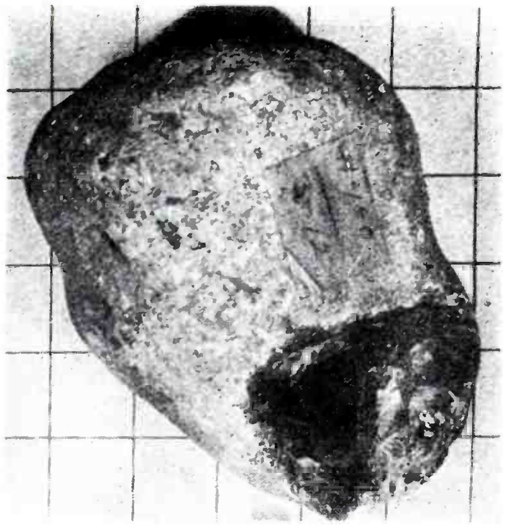
Cracks may show up as bright areas of reflection or darker lines or areas depending upon the angle of incidence of the light beam. If the width of the fissure is of the same order of magnitude as the wavelength of light the inspector may see Newton rings or colored light fringes as interference phenomena. Cracks are perhaps the most unfortunate type of flaw because they are not inherent in the growth of the crystal and generally occur when it is fully grown.

Cracks may be caused right at the quartz source where the prospector chips and breaks the raw rock out of its bed or away from clusters of crystals. Quartz may be found underground or on the earth's surface where erosion has worn away the top layers and exposed the crystals. The crystals may have become loosened and rolled down a mountain slope and cracked. Preventable cracks are those caused as a result of imprope packing for shipment. The directio and proximity of the cracks determin how the inspector will rate the quart in percentage usability. The *mothe* may be 25% usable for small oscillatc plates, but completely useless fc larger ones.

Inclusions are particles of foreig



Double and triple intergrowths of prismatic crystal. Intergrowths are often unsuited for crystal oscillator blanks.



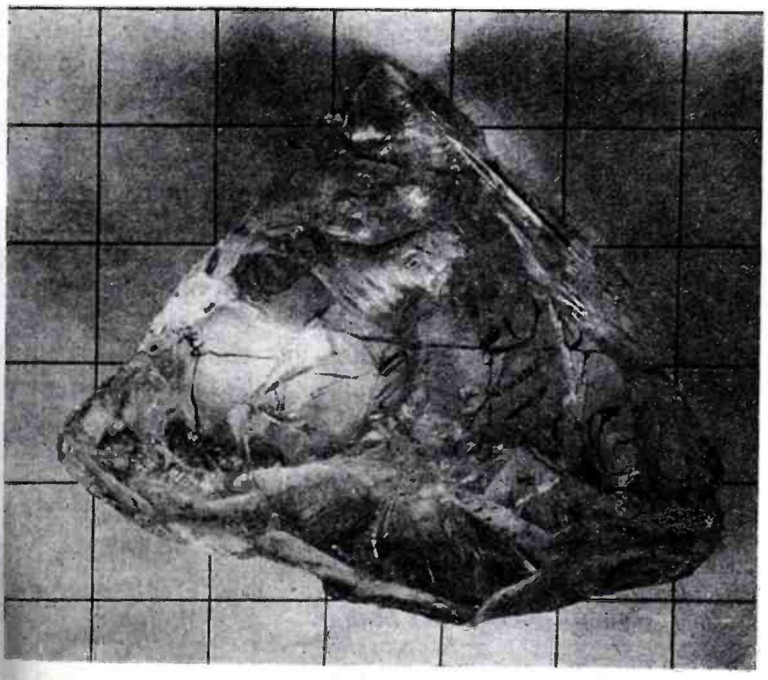
River quartz, showing the results of erosion of prismatic quartz lying in river bed for many centuries. This type of quartz is often of excellent quality because the surface imperfections have been eroded away.

matter occupying space within the normal volume of the mother quartz crystal. They may be *fools' gold* or iron pyrites crystals, chalcopyrites, iron ore, conglomerate rock matter, gold or in certain cases thin shafts of titanium oxide known as rutile needles. It is a rare case, indeed, where a finished oscillator plate containing inclusions like these will not fail the stringent temperature cycle test required. Therefore, this flaw contributes very definitely to the volume of unusable quartz. In the oil bath inspection, these impurities appear as opaque masses whichever way the quartz is turned, some small and some large, often close to the surface and sometimes protruding through the surface. These regions cannot be used for oscillator plates.

An interesting form of discontinuity within the volume of the mother quartz crystal is the bubble. Bubbles appear in much of the quartz inspected and may contain carbon dioxide, vapors and gases, or even liquids. They sometimes make the quartz take on the appearance of an effervescent drink when held in the bright beam in the oil inspection bath. They are usually milky or whitish in appearance. Bubbles which are easily visible in the bath may be detrimental to the operation of finished oscillator plates. Very small bubbles may, under some conditions, have little or no effect on the operation of the finished oscillator. Usually, the lower the frequency of the crystal the less will be the deleterious effect on trouble-free operation caused by bubbles. And this same factor will apply to the other flaws.

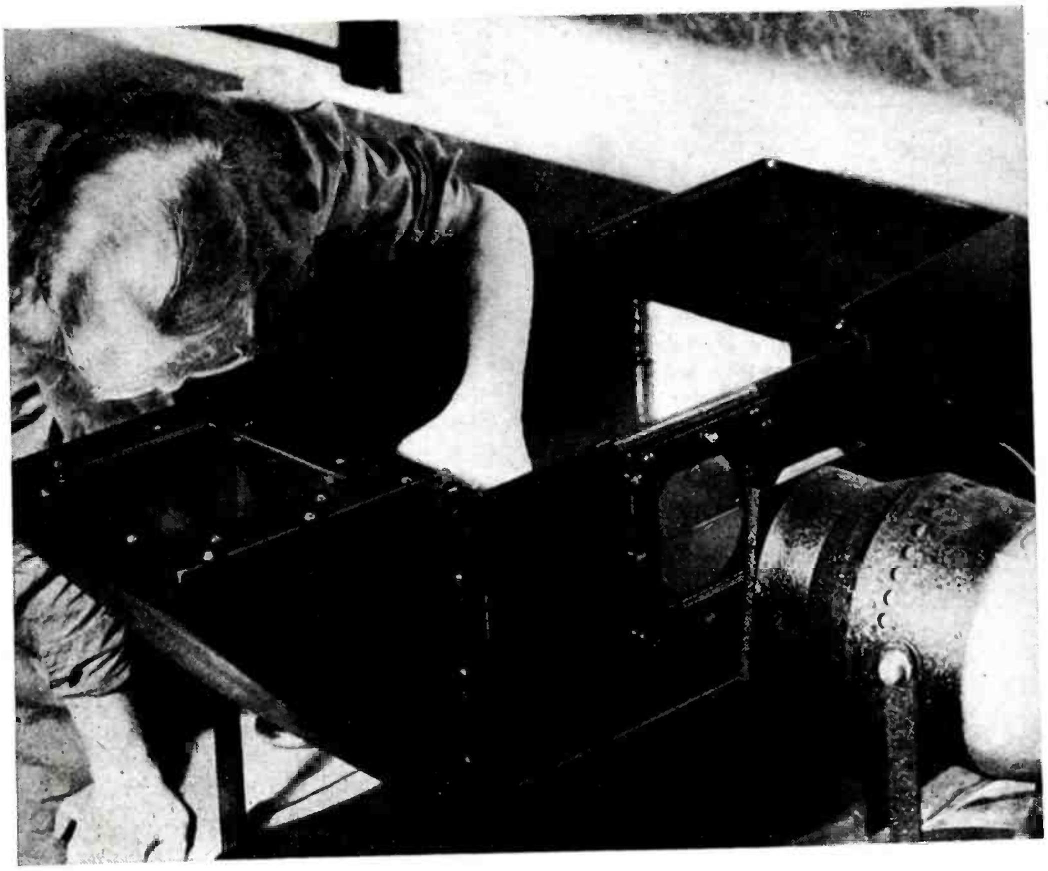
Sometimes we may see what appears to be a crack, but which is, on closer observation, a milky white wavy sheet of small bubbles. These sheets of bubbles are appropriately enough called veils. Veils are usually composed of minute bubbles and may be treated as such in inspection.

When we see what we believe to be veils absolutely parallel to some of the natural crystal surfaces, a careful observation will probably show a small image of the mother crystal outlined



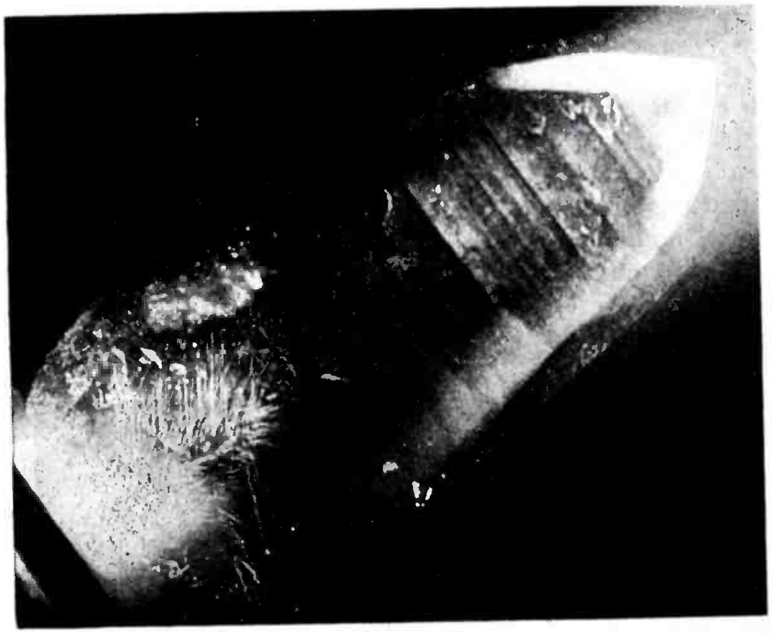
Irregular quartz. The quartz when broken shows surfaces of conchoidal fracture along poorly defined cleavage planes.

Portion of large prismatic crystal, showing cracks, chips, optical and electrical twinning surface patterns.



Raw quartz inspection tank having plane polarized light source with crossed polarizer as analyzer, plus high luminosity spotlight.

Double quartz crystal intergrowth viewed between crossed polarizers in oil bath. The line of sight of the camera is approximately parallel to the optical axis of the upper crystal. Optical twinning permeates this pair of crystals.



Large prismatic crystal viewed with spotlight illumination in inspection tank, showing very sharply defined phantom or ghost growing within the large crystal. Needles are apparent at base end of the crystal.

by bubbles or foreign included matter. This image is referred to as a *phantom* or a ghost. *Ghosts* may be formed by a deposition of foreign matter on the upper surfaces of a growing crystal at some early stage of its growth. Some mother crystals show many parallel ghosts within them indicating periodic depositions of the foreign matter on the upper surfaces. Possibly these crystals grew in caves or regions where periodic volcanic eruptions spread dust and ashes, or cave-ins spread particles of rock or other minerals through the air. A cessation of growth followed by rapid additional growths might account for *ghosts* formed by small bubbles rather than by inclusions.

The photograph at left illustrates an excellent specimen of *ghost* formation by included foreign matter. Some *ghosts* have been formed by the growth of different colored quartz layers. Since there is no foreign matter between layers it would be safe to try to use this kind of quartz if it is untwinned. Very little or no harmful effect has been noted when cutting oscillator plates from these ghosts. The precise reason for the varying colors is still somewhat in doubt; it may be the result of microscopic included matter. Another theory supposes that a color change is produced by the proximity of radioactive ores. (The color changing effect of gamma and x-rays on some minerals is well known.)

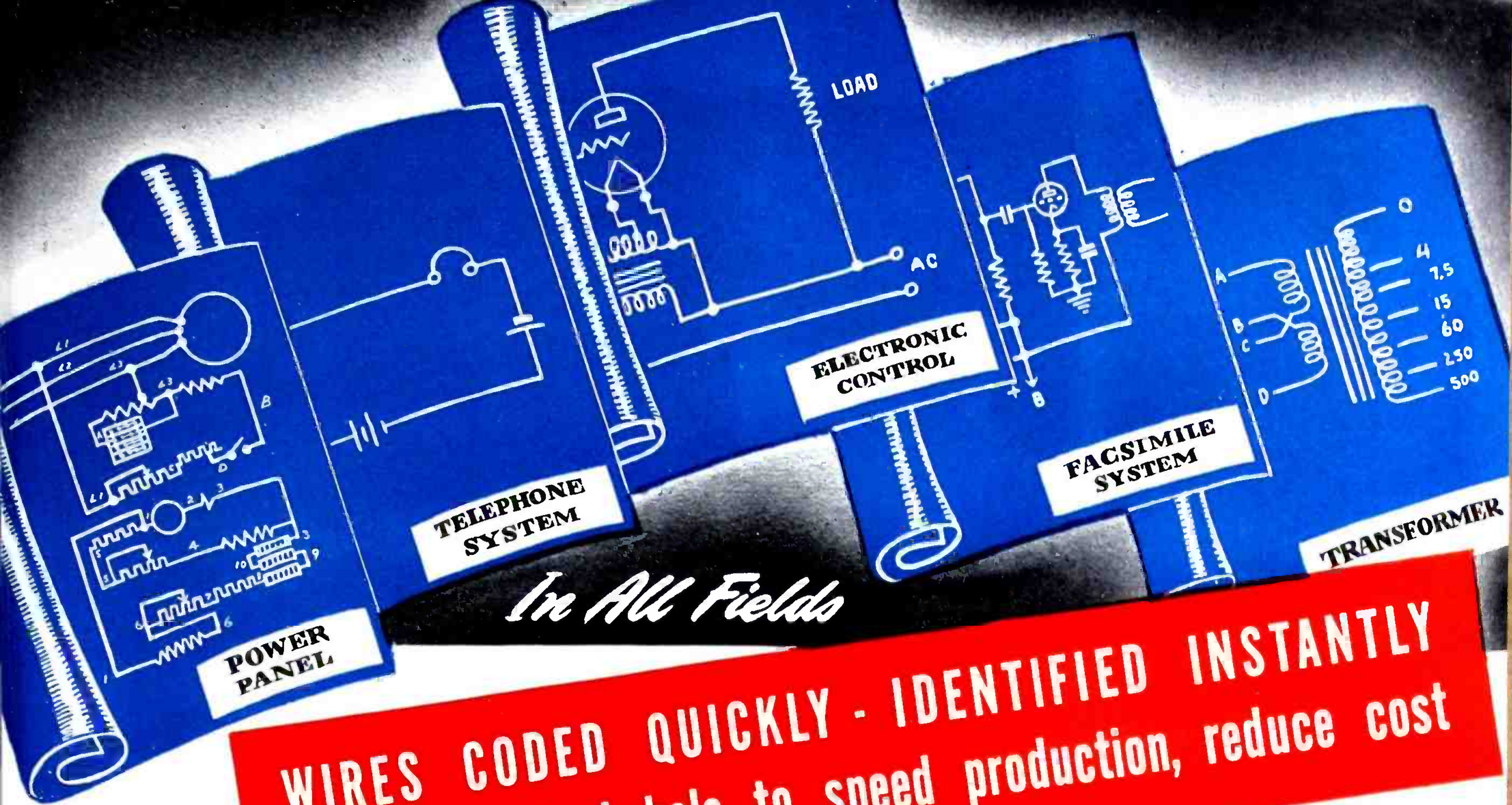
Sometimes oscillator plates may fracture along ghost boundaries. If the ghost is formed by large bubbles or by included solid matter the volume containing the boundary planes should not be used.

Needles may be characterized as elongated bubbles and the largest needles are found parallel to the rhomb

(*Continued on page* 110)

TYPE	**FACED**						**UNFACED**						**SCRAP**	
Weight Range	***100 to 1000 grams***			***1000 grams and higher***			***100 to 1000 grams***			***1000 grams and higher***			***All Weights***	
Per Cent Usability	25% to 50%	50% to 75%	75% and up	25% to 50%	50% to 75%	75% and up	25% to 50%	50% to 75%	75% and up	25% to 50%	50% to 75%	75% and up	10% and less	10% to 25%

The grading and classification of raw quartz



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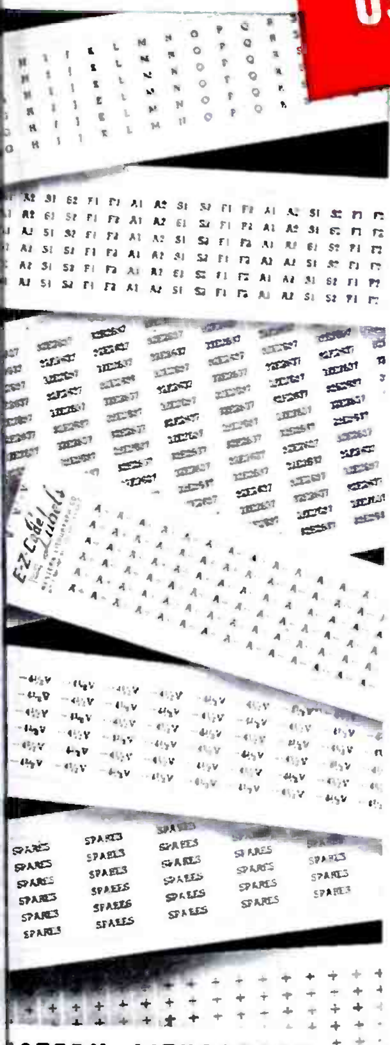

SCORES of prominent manufacturers and service organizations in the aviation, electrical and electronic fields are using these quickly-applied, easily-read wire identifiers to speed production, save man hours and reduce costs.

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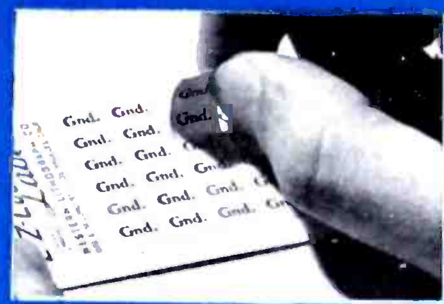
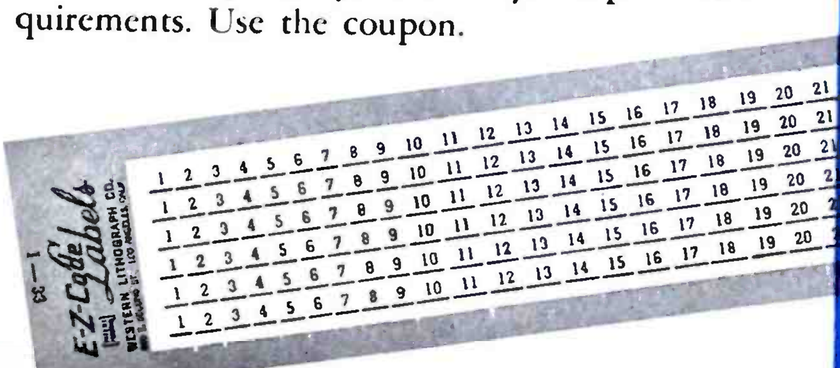


PEEL OFF STRIP

WRAP AROUND WIRE

EACH WIRE CODED



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TRAINING DRAFTSMEN

With Slide-Films

by L. S. METCALFE

THE shortage of trained mechanical draftsmen in the communications industry has prompted many intensive training programs.

In one of these programs, a novel series of slide-films has been introduced. In this series are 18 *reading* or discussional type slide-films, titled, *Mechanical Drawing and Drafting*. The purpose of these films is to speed up the process of training persons. The objective of this visualized material is to give the learner the broadest possible knowledge of mechanical drawing principles.

Each slide-film subject represents material for a single lesson or session. There is a total of 1,112 special photographs, drawings, charts, diagrams and pictorial exhibits in the series.

The discussional type of slide-film was selected since it permits a high degree of student *participation*. That is, under the guidance of the instructor the student, supplied with drawing board, pencil and necessary supplies and equipment for the lesson in hand, can follow the large illuminated pictured patterns of procedure. This method saves time and labor of the teacher.

As much as 50 per cent of the time ordinarily required to finish a mechanical drawing course, is saved by the addition of the visual slide-films.

Subjects in the series are:

Measurements and measuring (Part 1) . . . standard of measurement, work accuracy, discussion of the steel scale and its variations, dividers and calipers. (*Part 2*). . . . micrometer, (how it works, how to read it), discussion of the vernier scale principle, gauges and gauge blocks.

Scales and models . . . development of geometric construction.

Addition and subtraction in geometry . . . fundamentals of geometry (from the standpoint of constructions).

Multiplication and division in geometry . . . fundamentals of solid geometry (from the standpoint of constructions).

Angular measurement . . . systems of angular measurement, degrees, radians, trigonometrics as they are related to each other.

Construction . . . basic principles of geometric construction.

"T" squares and triangles (Part 1) . . . fundamental uses of a "T" square and the 45° and 30-60° triangles, tools and equipment needed; correct care and usage; setting up for drawing; reproducing margins and title block of standard drawing form; correct use of hands, pencil, triangle, and "T" square in drawing margins; layout of title block. (*Part 2*) . . . manipulation of triangle to obtain angle lines; construction of figures with pencil; "T" square; 45° triangle and rule-layout of vertical and horizontal lines; layout of angle lines-construction of figures using different triangle-duplication; drawing hexagons.

Geometric construction (Part 1) . . . material and tools needed and importance of using them correctly, how to draw a perpendicular bisector to a base line, dropping a perpendicular from a prick punch mark; bisecting an angle, drawing perpendicular at the end of a line, drawing a parallel line, layout of fillets between intersecting lines. (*Part 2*) . . . laying out of fillets between a line and a circle or arc, duplicating an angle with compass and straight edge, dividing a line, layout of angles with a protractor.

Drawing an anchor plate . . . list and pictures of tools needed; setup on the drawing board; layout of center-line and indication of holes and com-

(*Continued on page 122*)

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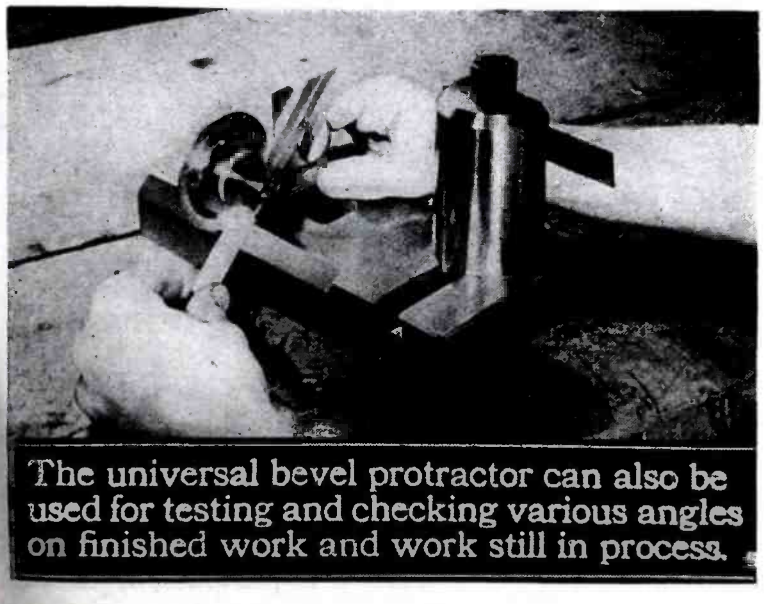
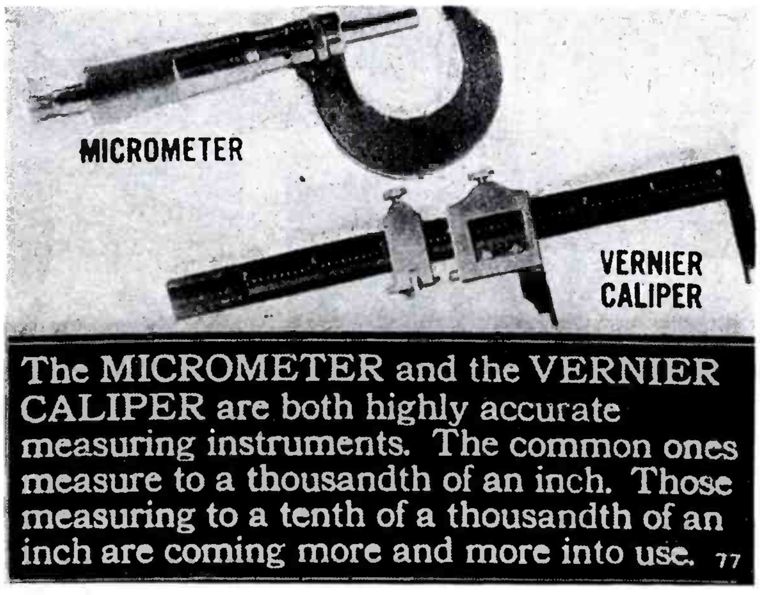
Typical views from slide-films used to train draftsmen in war training programs. Each film is numbered and corresponds to an equivalent printed lesson given to students.
(*All photos courtesy Jam-Handy Picture Service*)





THE ARMY AIRWAYS COMMUNICATION SYSTEM

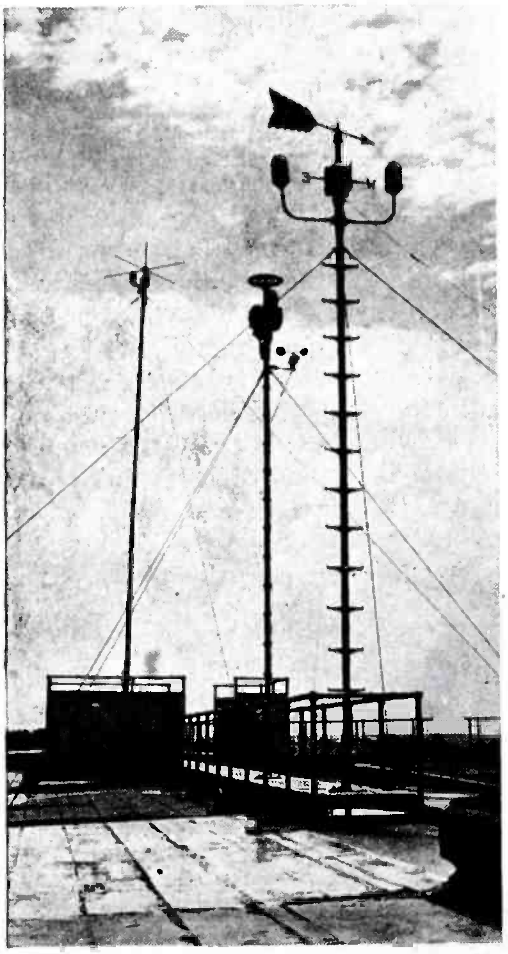
An Exclusive Presentation Of A Series of Photographs Of Installations Maintained And Operated by the AACS

[All photos courtesy of United States Army Air Force]

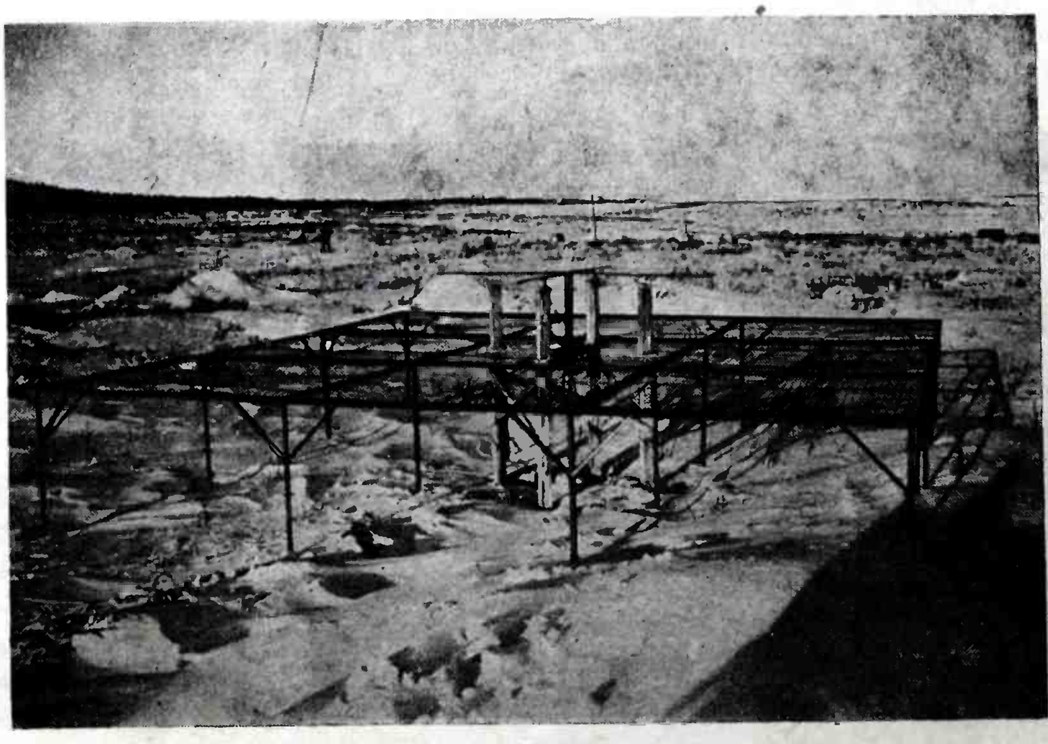
(Upper left) Operating an AACS air-ground position at a Northern base.

(Right) An AACS communications station in China.

(Below) A location or Z marker in the Far North operated by the AACS.

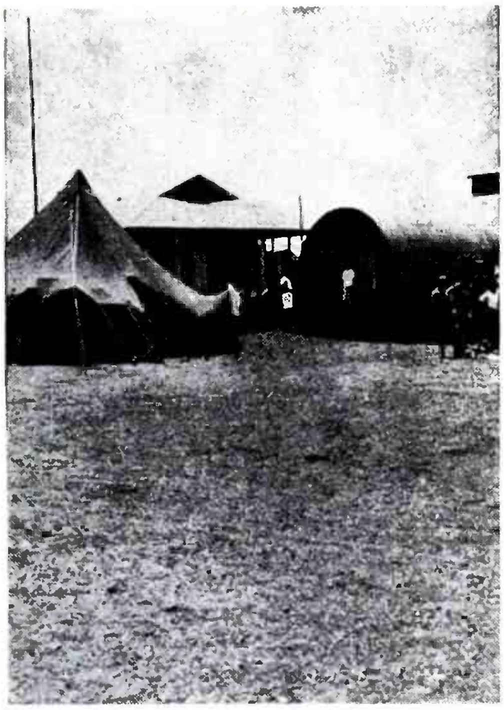


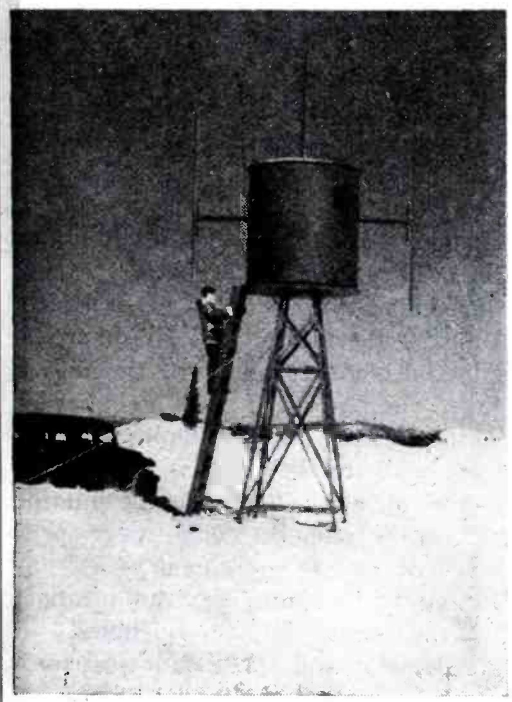
A v-h-f antenna and wind recording instrument located on top of an AACS airdrome control tower.

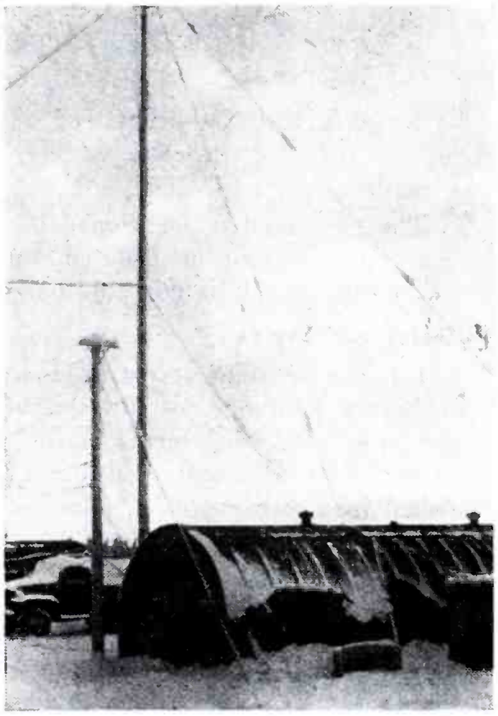


AACS station in India.

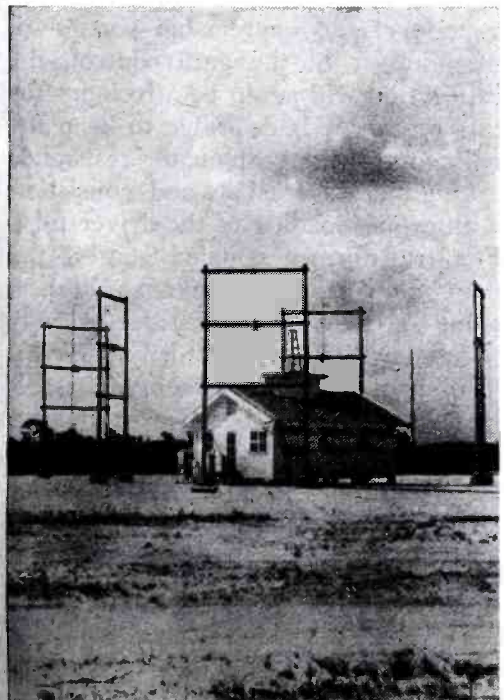

Interior of airdrome control tower.

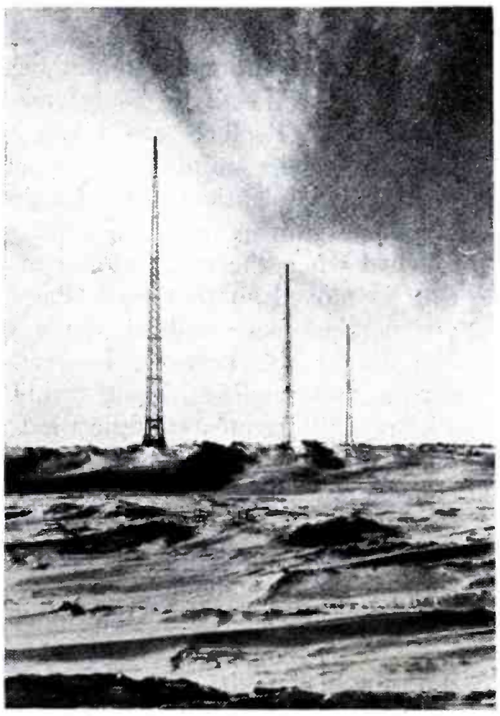

Part of installation in Africa.

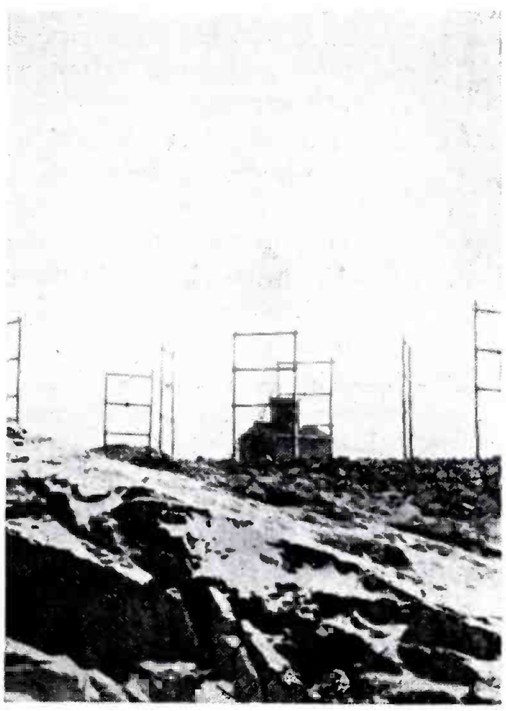

Ground direction finder at Northern base.


Far North communications station.


Ground direction finder at West Indies base.


Long-range ground-direction finder in West Indies.

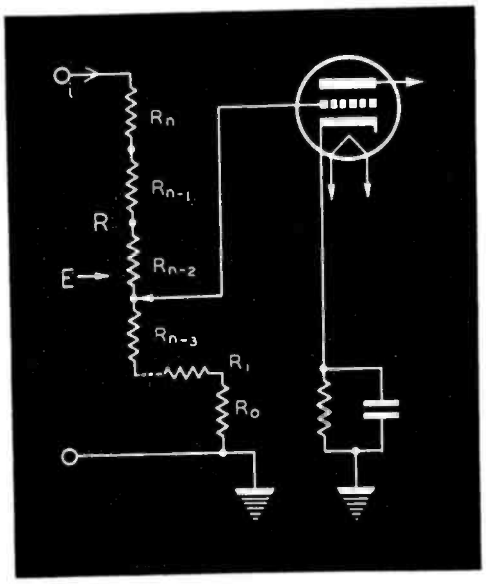

Simultaneous voice radio range on North Atlantic route.


Ground direction finder at Far Northern base.

ATTENUATOR DESIGN

For Amplifier Gain Controls

by PAUL B. WRIGHT
Communications Research Engineer



The resistance R is calibrated either in fixed steps or in terms of degrees of rotation of a continuously adjustable potentiometer and functions as a simple voltage divider. The division may be given any assigned amount, and forms an accurate means of adjusting the volume of an amplifier.

THERE are many methods that may be used to obtain variable gain in an amplifier. Some of these provide a direct control; others, indirect control.

Included among these gain systems are:

(*1*)—Attenuation pads placed at the input of the amplifier.

(*2*)—Tapped transformers, with, usually, variable secondary winding taps, and more rarely, variable primary taps.

(*3*)—Variable loss circuits utilizing non-linear devices such as copper oxide rectifiers, and auxiliary vacuum tube circuits.

(*4*)—Feedback circuits in the path of which are inserted variable loss devices.

(*5*)—Simple voltage dividers which may be placed at the input sides of any of the various stages of the amplifier. One having small step divisions and one having larger step divisions of gain may be used in an amplifier to control the gain over a very wide range of values to any practical degree of accuracy. The overall effects of two such voltage dividers will alter the gain by the numerical addition of their separate gain changes in decibels.

The gain control mentioned in (*5*) is the method that has been chosen for discussion and design in this paper.

Gains and Losses

Like most of the terms used in the technical language of the engineer, the usage of the terms *gains* and *losses* is purely relative, and is established by definition as so many decibels above or below an arbitrary reference point. The reference point used throughout this paper is the minimum gain obtainable (other than zero) from the amplifier when the attenuator, used as a voltage divider, is set for its maximum loss (other than infinite). All gains referred to in terms of decibels are gains taken relative to this minimum amplifier gain reference, while all losses referred to in terms of decibels are taken with respect to the minimum attenuator loss. This is identical to the maximum amplifier gain point. This point is reached when the attenuator arm setting is moved so that no voltage division takes place and all of the voltage across the network is available across the amplifier input terminals. Figure 1 illustrates configuration and connection, while Figures 2 and 3 show how such networks may be connected with other types of coupling.

This attenuator is one of the special cases of the so-called L type attenuator. An impedance match must always exist on the shunt side of the attenuator, if the calibration is to have any meaning. This may only be used in connection with class A or high fidelity types of amplifiers which do not draw any grid current other than the small displacement current through the grid to cathode capacitance of the amplifier tube. For the audio frequency range, this capacity is not troublesome, while for the higher radio frequencies, inductive shunt peaking of the driver stage and an R-C voltage divider at the input of the amplifier stage may have to be used. The effect of the capacity upon the attenuator calibration will be come more pronounced as the frequency is increased further into the radio range. At the very low frequencies, in impedance and resistance-capacity coupled stages, if the impedance of the coupling condenser used between the plate circuit of the driver and the attenuator is an appreciable portion of the total R of the gain control, the calibration will again be affected. For this reason, it is desirable to keep the gain control total attenuator resistance as high as is feasible and consistent with proper loading of the driver tube. For transformer coupled stages, the gain control should have as high a value of total resistance R, as may be used with it satisfactorily. Heavy loading of the transformer will result in decreased gain because of the increased losses in the transformer. The particular transformer characteristics will largely determine what value to use.

General Design Considerations

The actual determination of the resistance values to use for such gain controls depends upon several factors. These are, in addition to those con-

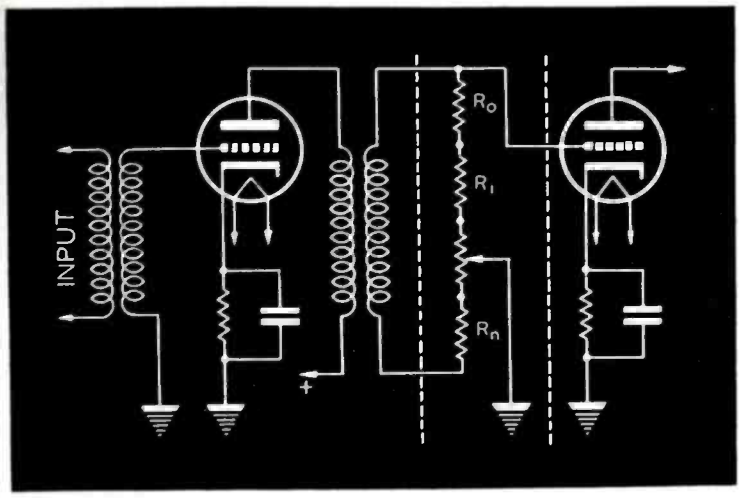


Figure 2

An alternate manner in which to connect the volume control using transformer coupled amplifiers.

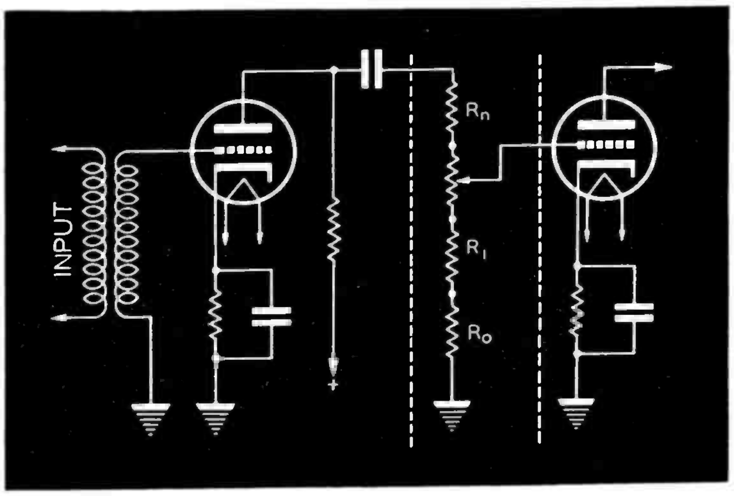


Figure 3

Illustrating use of volume control in a resistance-capacity coupled amplifier.

sidered in the preceding paragraph:

(*a*)—Total gain variation from the minimum to the maximum settings of the attenuator.

(*b*)—Gain per step for tapped attenuators, and gain per degree or division for stepless attenuators.

(*c*)—Number of steps for the tapped control, and number of divisions or degrees for the stepless attenuator, or continuously adjustable potentiometer.

Figures 1, 2, and 3 show representative configurations that may be used for these gain controls. Many other applications in calibrated volume indicator circuits, radio receivers, and recorder systems may present themselves. The design is basically the same for all of these applications, because the attenuator functions as a simple voltage divider. In a general way, it may be said that voltage dividers of this type should be designed so that a definite fixed percentage of voltage change over that existing one step or division before the change, should take place. Let us take a case where a change in voltage is made corresponding to a change of *1* decibel from any original value. The voltage change that must take place then, is 112.2 per cent of the original, if *a gain*, and a change to 89.12 per cent of the original, if a loss. A further change to a total of *2* decibels will require that the voltage become 125.9 per cent of the original or 12.2 per cent greater than the *1*-decibel gain, if a gain, and 79.4 per cent of the original or 12.2 per cent less than the 1-decibel step, if a loss. If we follow this systematically for the number of steps required, we will arrive at the percentages required. This is not a very useful form for practical engineering work, for it is incomplete, and lacks the additional information required for design mentioned earlier.

The present paper is an attempt to correlate and systematize the methods required to obtain such designs, and to simplify the numerical work that is necessary to calculate even the simplest network of this type.

Four methods may ordinarily be used for such calculations. These are:

(*1*)—Arithmetical,
(*2*)—Logarithmic,
(*3*)—Slide rule,
(*4*)—Calculating machine.

The calculating machine is, of course, the most convenient and easiest to use, and gives results to the highest degree of accuracy possible for the given data. Arithmetical methods give identical results to those of the calculating machine with the exception that they are much more laborious and always admit greater possibility of error. Logarithmic methods, with a good table, give accurate results to the same precision as the machine and arithmetical methods, within the scope of the data as normally furnished or available. The slide rule gives results that are rough and ready by comparison with the other methods, but for many purposes, may be quite sufficiently accurate. A ten-inch rule will give an average of slightly better than one per cent, while a twenty-inch rule will give better than one-tenth of one per cent on portions of the scale. Since most commercial types of resistors run from about zero to as high as ten per cent, and precision resistors from one-tenth to one per cent, slide rule results would suffice for the majority of applications.

However, to satisfy the requirements of the most exacting laboratory equipment, as well as all others needing less accuracy, complete tables have been calculated for the functions necessary to determine the actual values of the elements required. The gain range covered is from 0.1 to 100 decibels, utilizing any value of load resistance, *R*, and any number of steps from 1 to 10. For any intermediate values not given directly, the tables may be readily interpolated. Or if desired, calculations from the equations given in the theoretical portion of this paper may be employed. Likewise, for any number of steps greater than 10, calculations may be made from the equations in the text.

Analytical Design

The following definitions and nomenclature will be used throughout the text.

$k_s = \dfrac{e_n}{e_{n-1}}$ = the voltage ratio per step or division.

$k_t = E/E_o$ = the voltage ratio of maximum to minimum gain.

$DB_s = 20 \log_{10} k_s$ = decibels gain per step.

$DB_t = 20 \log_{10} k_t$ = maximum possible variation in gain.

R_o = Resistance required for minimum specified gain of the amplifier, or maximum loss of the attenuator other than infinite).

R = Total resistance of the attenuator.

R_n = Resistance of the individual elements which compose the attenuator.

E = Total voltage across *R*.

E_o = Voltage across the resistance R_o.

e_n = Voltage across each individual resistance R_n.

$K = R_n/R_o = (k_s^n - k_s^{n-1})$, a function of the gain per step.

$c = (k_s - 1)$, also a function of the gain per step. Used in calculation

Table 1

R_o / 10^m

Total Gain in Decibels	R = 1 x 10^m	R = 2 x 10^m	R = 3 x 10^m	R = 4 x 10^m	R = 5 x 10^m	R = 6 x 10^m	R = 7 x 10^m	R = 8 x 10^m	R = 9 x 10^m	R = 1 x 10^{m+1}
1	.891251	1.782502	2.673753	3.565004	4.456255	5.347506	6.238757	7.130008	8.021259	8.91251
2	.794327	1.588654	2.382985	3.177308	3.971640	4.765970	5.560289	6.354616	7.148955	7.94327
3	.707946	1.415892	2.123838	2.831784	3.539730	4.247676	4.955622	5.663568	6.371514	7.079460
4	.630957	1.261914	1.892871	2.523828	3.154785	3.785742	4.416699	4.047656	5.678613	6.309570
5	.562341	1.124682	1.687023	2.249364	2.811705	3.374046	3.936387	4.498728	5.061069	5.623410
6	.501187	1.002374	1.503561	2.004748	2.505935	3.007122	3.508309	4.009496	4.510683	5.011870
7	.446684	.893368	1.340052	1.786736	2.233420	2.680104	3.126788	3.573472	4.020156	4.466840
8	.398107	.796214	1.194321	1.592428	1.990535	2.388642	2.816749	3.184856	3.582963	3.981070
9	.354813	.709626	1.064439	1.419252	1.774065	2.128878	2.483691	2.838504	3.193317	3.548130
10	.316228	.632456	.948684	1.264912	1.581139	1.897368	2.213596	2.529824	2.846052	3.162280
15	.177828	.355656	.533484	.711312	.889140	1.066968	1.244796	1.422624	1.600452	1.778280
20	.100000	.200000	.300000	.400000	.500000	.600000	.700000	.800000	.900000	1.000000
25	.056234	.112468	.168702	.224936	.281170	.337404	.393638	.449872	.506106	.562340
30	.031623	.063246	.094868	.126492	.158114	.189736	.221361	.252984	.284605	.316228
35	.017783	.035566	.053348	.071131	.088914	.106696	.124481	.142262	.160045	.177828
40	.010000	.020000	.030000	.040000	.050000	.060000	.070000	.080000	.090000	.100000
45	.005623	.011246	.016870	.022492	.028117	.033740	.039364	.044984	.050611	.056234
50	.003162	.006324	.009487	.012649	.015811	.018972	.022136	.025298	.028461	.031623
60	.001000	.002000	.003000	.004000	.005000	.006000	.007000	.008000	.009000	.010000
70	.000316	.000632	.000949	.001265	.001581	.001897	.002214	.002530	.002846	.003162
80	.000100	.000200	.000300	.000400	.000500	.000600	.000700	.000800	.000900	.001000
90	.000032	.000064	.000095	.000126	.000158	.000190	.000221	.000253	.000285	.000316
100	.000010	.000020	.000030	.000040	.000050	.000060	.000070	.000080	.000090	.000100

This table gives the value of R_o required for any given value of R and specified total gain. For example, if R = 1,000,000 ohms = 1 x 10^m = 10^m = 10^6, and the total gain is 25 db, R_o / 10^m = R_o / 10^6 x .056234 or R_o = 10^6 x .056234 = 56,234 ohms.

of the attenuator elements from the series expansions involving c.

The value of the resistance required for R_o is determined either arbitrarily for minimum gain without regard to matching of R to the driver stage, or from the criterion of a matched load, the number of steps and their magnitude of loss per step. This implies that the value of the minimum gain may be chosen in advance. This, however fixes the total value of R that

Table 2

Log_{10} R_o

Total Gain in Decibels	R = 1 x 10^m	R = 2 x 10^m	R = 3 x 10^m	R = 4 x 10^m	R = 5 x 10^m	R = 6 x 10^m	R = 7 x 10^m	R = 8 x 10^m	R = 9 x 10^m	R = 1 x 10^{m+1}
1	.950000	.251030	.427121	.552060	.648970	.728151	.795098	.853090	.904242	.950000
2	.900000	.201030	.377121	.502060	.598970	.678151	.745098	.803090	.854242	.900000
3	.850000	.151030	.327121	.452060	.548970	.628151	.695098	.753090	.804242	.850000
4	.800000	.101030	.277121	.402060	.498970	.578151	.645098	.703090	.754242	.800000
5	.750000	.051030	.227121	.352060	.448970	.528151	.595098	.653090	.704242	.750000
6	.700000	.001030	.177121	.302060	.398970	.478151	.545098	.603090	.654242	.700000
7	.650000	.951030	.127121	.252060	.348970	.428151	.495098	.553090	.604242	.650000
8	.600000	.901030	.077121	.202060	.298970	.378151	.445098	.503090	.554242	.600000
9	.550000	.851030	.027121	.152060	.248970	.328151	.395098	.453090	.504242	.550000
10	.500000	.801030	.977121	.102060	.198970	.278151	.345098	.403090	.454242	.500000
15	.250000	.551030	.727121	.852060	.948970	.028151	.095098	.153090	.404242	.250000
20	.000000	.301030	.477121	.602060	.698970	.778151	.845098	.903090	.954242	.000000
25	.750000	.051030	.227121	.352060	.448970	.528151	.595098	.653090	.704242	.750000
30	.500000	.801030	.977121	.152060	.198970	.278151	.345098	.453090	.454242	.500000
35	.250000	.551030	.727121	.852060	.948970	.028151	.095098	.153090	.404242	.250000
40	.000000	.301030	.477121	.602060	.698970	.778151	.845098	.903090	.954242	.000000
45	.750000	.051030	.227121	.352060	.448970	.528151	.595098	.653090	.704242	.750000
50	.500000	.801030	.977121	.152060	.198970	.278151	.345098	.453090	.454242	.500000
60	.000000	.301030	.477121	.602060	.698970	.778151	.845098	.903090	.954242	.000000
70	.500000	.801030	.977121	.152060	.198970	.278151	.345098	.453090	.454242	.500000
80	.000000	.301030	.477121	.602060	.698970	.778151	.845098	.903090	.954242	.000000
90	.500000	.801030	.977121	.152060	.198970	.278151	.345098	.453090	.454242	.500000
100	.000000	.301030	.477121	.602060	.698970	.778151	.845098	.903090	.954242	.000000

Only the mantissa portion of the logarithma is given. The characteristic must be obtained by inspection from *Table 1*, and the given data specifying the value of R to be used for any required total gain range. For example for R = 500,000 ohms and a total gain of 10 db, R = 5 x 10^5 = 5 x 10^m. R_o / 10^m = 1.581139. R_o = 10^6 x 1.581139. Log_{10} R_o = 5 + 0 + .198970, or Log_{10} R_o = 5.198970.

Table 3

K

Gain per Step in db	Number of Steps 1	2	3	4	5	6	7	8	9	10
0.1	.01158	.01171	.01185	.01199	.01213	.01226	.01241	.01255	.01270	.01284
0.2	.02329	.02384	.02439	.02496	.02554	.02613	.02675	.02737	.02800	.02865
0.3	.03514	.03638	.03766	.03897	.04035	.04177	.04323	.04476	.04632	.04796
0.4	.04713	.04935	.05167	.05412	.05665	.05934	.06212	.06506	.06812	.07133
0.5	.05926	.06276	.06648	.07042	.07460	.07902	.08369	.08866	.09391	.09948
0.6	.07152	.07663	.08212	.08801	.09428	.10102	.10825	.11599	.12429	.13317
0.7	.08393	.09097	.09860	.10688	.11585	.12558	.13611	.14754	.15992	.17334
0.8	.09648	.10579	.11599	.12718	.13945	.15291	.16766	.18384	.20157	.22102
0.9	.10918	.12109	.13431	.14898	.16524	.18329	.20329	.22549	.25010	.27741
1.0	.12202	.13690	.15362	.17235	.19339	.21698	.24346	.27317	.30649	.34390
2.0	.25892	.32597	.41037	.51663	.65039	.81879	1.03080	1.29770	1.63370	2.05673
3.0	.41254	.58272	.82312	1.16269	1.64235	2.31985	3.27691	4.62875	6.53829	9.23556
4.0	.58489	.92700	1.46918	2.32850	3.69043	5.84893	9.26994	14.69185	23.28493	36.90435
5.0	.77828	1.38400	2.46114	4.37658	7.78279	13.83999	24.61138	43.76584	77.8279	138.3999
6.0	.99526	1.98581	3.96220	7.90566	15.77385	31.47287	62.7968	125.2963	249.9987	498.8126
7.0	1.23872	2.77315	6.20831	13.89869	31.11529	69.6582	155.9459	349.1182	781.582	1749.74
8.0	1.51189	3.79768	9.53936	23.96179	60.19928	151.1887	379.7678	953.936	2396.179	6019.93
9.0	1.81838	5.12489	13.44395	40.70843	114.7323	323.3595	911.351	2568.534	7239.11	20402.60
10.0	2.16228	6.83772	21.62278	68.3772	216.2278	683.772	2162.278	6837.72	21622.78	68377.2

This table gives the constants to be used with R_o of *Table 1* to obtain the values of the resistances required for the gain control steps. For example, for a total resistance $R = 200{,}000$ ohms; total gain $= 20$ db in five steps of 4 db each,

$R_o = 10^5 \times .200000 = 20{,}000$ ohms
$R_1 = 20000 \times .58489 = 11{,}697.8$ ohms
$R_2 = 20000 \times .92700 = 18{,}540$ ohms
$R_3 = 20000 \times 1.46918 = 29{,}383.6$ ohms
$R_4 = 20000 \times 2.32850 = 46{,}570$ ohms
$R_5 = 20000 \times 3.69043 = 73{,}808.6$ ohms

may be used. Hence if the total value of *R* is chosen for a definite relative gain variation, this will automatically fix the value of R_o that must be used to obtain the specified gain per step or division.

Assuming a total resistance of *R* ohms and R_o arbitrary, from Figure 1,

$$E = i\,R \tag{1}$$

and

$$E_o = i\,R_o \tag{2}$$

The maximum voltage ratio is, from *1* and *2*, and the definitions:

$$k_t = \frac{E}{E_o} = \frac{R}{R_o} = 10^{\frac{DB_t}{20}} \tag{3}$$

The maximum gain variation is therefore:

$$DB_t = 20 \log_{10} k_t = 20 \log_{10} \frac{R}{R_o} \tag{4}$$

The loss per step is:

$$DB_s = 20 \log_{10} k_s = 20 \log_{10} \frac{e_n}{e_{n-1}} \tag{5}$$

Solving *3* for the resistance to use for minimum gain,

$$R_o = R \cdot 10^{-\frac{DB_t}{20}} = \frac{R}{k_t} \tag{6}$$

The voltage across $R_o + R_1$ is:

$$e_1 = i\,(R_o + R_1) \tag{7}$$

The ratio of the voltage of the first step to that of the minimum step, from equations *7* and *2* is:

$$\frac{e_1}{E_o} = \frac{i\,(R_o + R_1)}{i\,R_o} = 1 + \frac{R_1}{R_o} \tag{8}$$

The ratio of the voltages of the second and the first step is:

$$\frac{e_2}{e_1} = \frac{i\,(R_o + R_1 + R_2)}{i\,(R_o + R_1)} = 1 + \frac{R_2}{R_o + R_1} \tag{9}$$

While for the *n*th step to the $(n-1)$th step, the voltage ratio is

$$\frac{e_n}{e_{n-1}} = \frac{i\,(R_o + R_1 + R_2 + \ldots + R_{n-2} + R_{n-1} + R_n)}{i\,(R_o + R_1 + R_2 + \ldots + R_{n-2} + R_{n-1})}$$

$$= 1 + \frac{R_n}{R_o + R_1 + R_2 + \ldots + R_{n-2} + R_{n-1}}$$

$$= 1 + \frac{R_n}{\sum_{k=o}^{k=n-1} R_k} \tag{10}$$

By definition,

$$k_s = \frac{e_n}{e_{n-1}} \tag{11}$$

hence from *10* and *11*,

$$k_s = 1 + \frac{R_n}{\sum_{k=o}^{k=n-1} R_k} \tag{12}$$

Solving *12* for R_n,

$$R_n = (k_s - 1) \sum_{k=o}^{k=n-1} R_k \tag{13}$$

From *10*,

$$\sum_{k=o}^{k=n-1} R_k = (R_o + R_1 + R_2 + R_3 + \ldots + R_{n-2} + R_{n-1})$$

$$= R_o + \sum_{k=1}^{k=n-1} R_k \tag{14}$$

Using *14* in *13*,

$$R_n = (k_s - 1)\,[R_o + \sum_{k=1}^{k=n-1} R_k] \tag{15}$$

For simplification, we may write:

$$c = (k_s - 1) \tag{16}$$

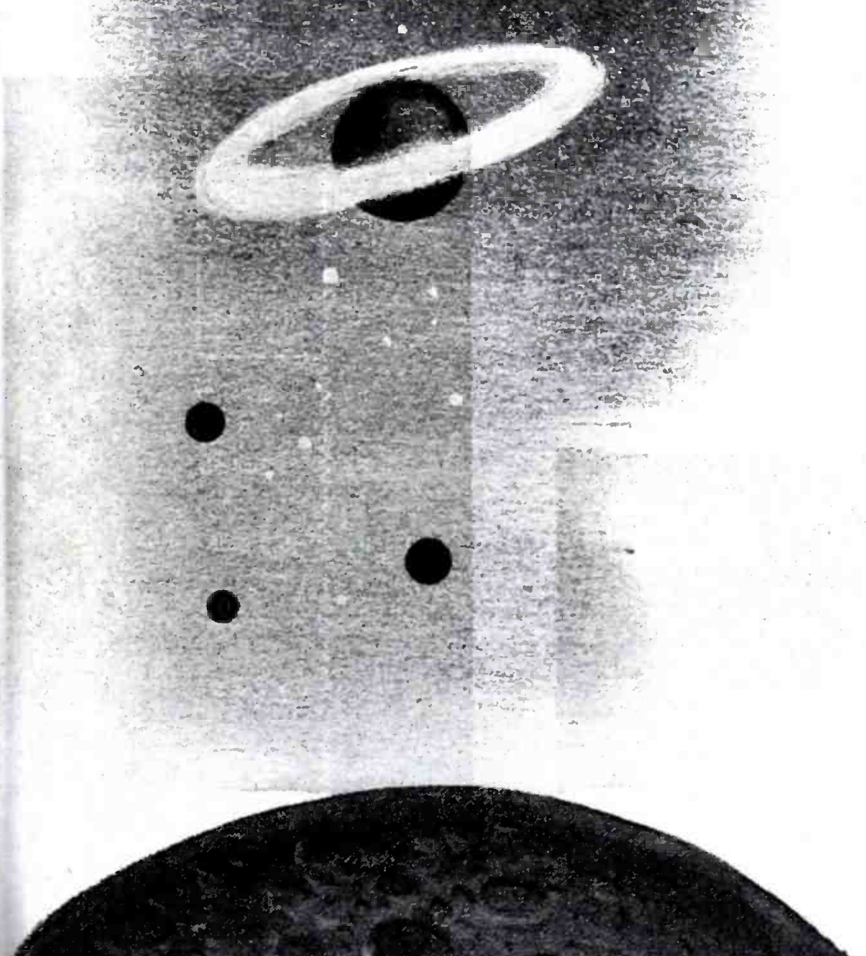
and equation *15* becomes,

$$R_n = c\,[R_o + \sum_{k=1}^{k=n-1} R_k] \tag{17}$$

From 17, the values of the individual elements may be assigned. Thus:

$$R_1 = c\,(R_o + o) = c\,R_o \tag{18}$$


The biggest thing in the world to come
is the smallest object in the universe!




STANCOR

Table 4

Log_{10} K

Gain per Step in.db	*Number of Steps* 1	2	3	4	5	6	7	8	9	10
0.1	.06371	.06856	.07372	.07882	.08386	.08849	.09377	.09864	.10380	.10856
0.2	.36717	.37731	.38721	.39724	.40722	.41714	.42732	.43727	.47716	.45712
0.3	.54580	.56086	.57588	.59073	.60584	.62086	.63578	.65089	.66577	.68088
0.4	.67330	.69329	.71324	.73336	.75320	.77335	.79323	.81331	.83327	.85327
0.5	.77226	.79768	.82269	.84770	.87274	.89829	.92267	.94773	.97271	.99774
0.6	.85443	.88440	.91445	.94453	.97442	.00441	.03443	.06442	.09444	.12428
0.7	.92392	.95890	.99388	.02890	.06390	09968	.13389	.16891	.20390	.23890
0.8	.98444	.02444	.06442	.10442	.14442	.18444	.22443	.26444	.30443	.34443
0.9	.03814	.08311	.12811	.17313	.21812	.26314	.30812	.35313	.39811	.44312
1.0	.08643	.14301	.18645	.23641	.28643	.33642	.38643	.43643	.48642	.53643
2.0	.41317	.51318	.61318	.71318	.81317	.91317	.01317	.11317	.21317	.31318
3.0	.61547	.76546	.91546	.06546	.21546	.36546	.51546	.66546	.81546	.96546
4.0	.76707	.96708	.16707	.36708	.56708	.76708	.96708	.16708	.36707	.56708
5.0	.89114	.14114	.39113	.64113	.89114	.14114	.39113	.64113	.89114	.14114
6.0	.99794	.29794	.59794	.89794	.19793	.49794	.79794	.09794	.39794	.69794
7.0	.09297	.44297	.79297	.14297	.49297	.84297	.19297	.54297	.89297	.24297
8.0	.17952	.57952	.97952	.37952	.77959	.17952	.57952	.97952	.37952	.77959
9.0	.25968	.70968	.12853	.60968	.05969	.50969	.95969	.40969	.85969	.30969
10.0	.33491	.83491	.33491	.83491	.33491	.83491	.33491	.83491	.33491	.83491

Only the mantissa portion of the logarithm is given in this table. The characteristic must be obtained by inspection from *Table 3* and the specified values of gain per step and number of steps. For example, for five steps of 4 db each the logarithms are respectively 9.76707-10; 9.96708-10; 0.16707; 1.36708 and 2.56708.

This table may be used in conjunction with *Table 2* to simplify calculations in the majority of cases. Only addition is needed in the use of the logarithm tables. The element values are then obtained from a table of anti-logarithms directly or from a table of common logarithms to the desired degree of accuracy.

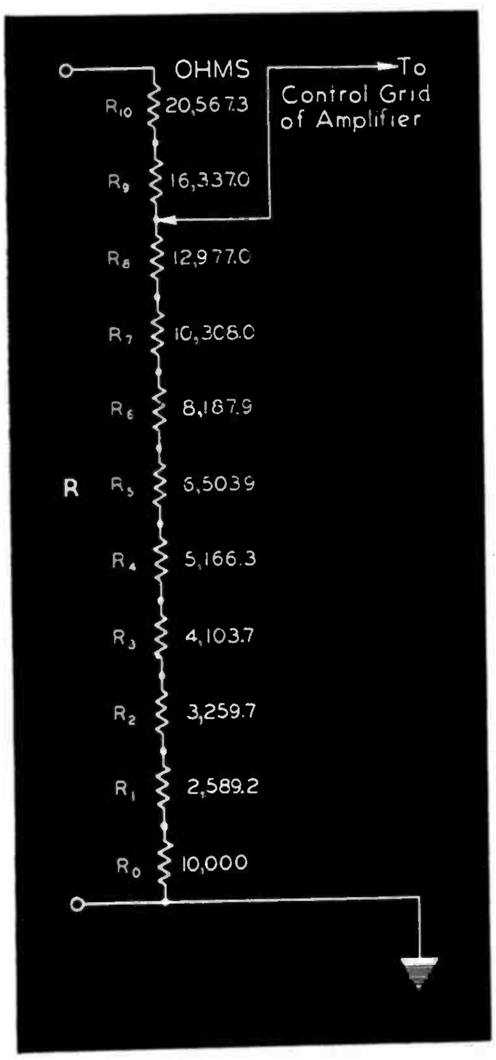
$$R_2 = c\,(R_o + R_1) = c\,(R_o + c\,R_o) = c\,R_o\,(1 + c) \tag{19}$$

$$R_3 = c\,(R_o + R_1 + R_2) = c\,[R_o + c\,R_o + c\,R_o\,(1 + c)] = c\,R_o\,(1 + c)^2 \tag{20}$$

. . . .

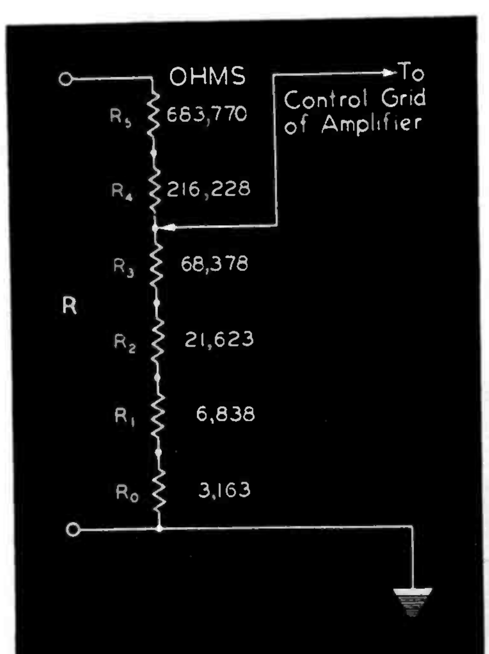
$$R_{n-1} = c(R + R_1 + R_2 + \ldots + R_{n-3} + R_{n-2}) = c[R_o + cR_o + cR_o\,(1 + c) + \ldots + cR_o(1 + c)^{n-4} + cR_o(1 + c)^{n-3}] = cR_o(1 + c)^{n-2} \tag{21}$$

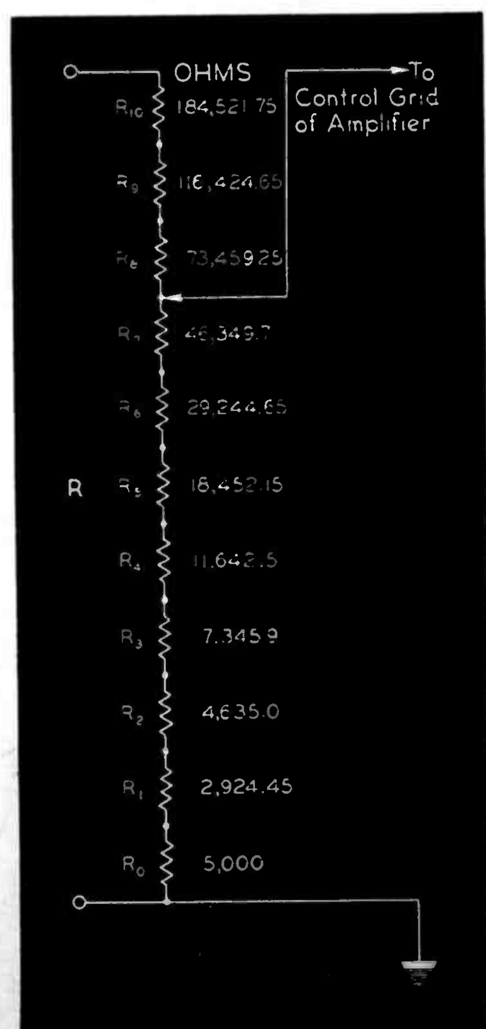
(*Continued on page* 112)

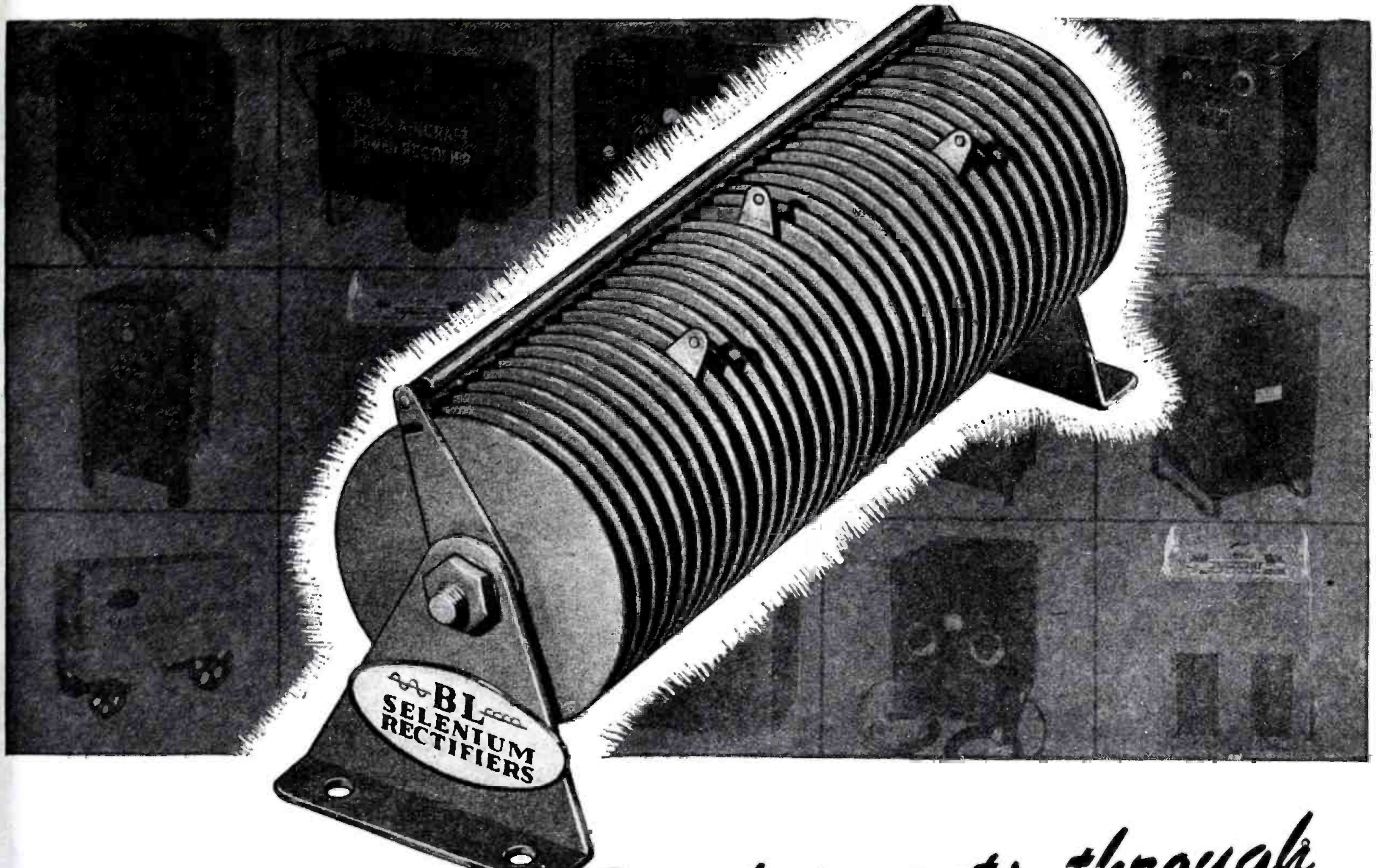


Figures 4 (left), 5 (right), 6 (below)

In Figure 4, the volume control provides a load of R = 100,000 ohms, having 10-2 db steps, giving a control range of 20 db. In Figure 5, we have the volume control range of 40 db in 10 steps of 4 db each, giving a load of R = 500,000 ohms. Figure 6 shows a variation in gain from minimum to maximum of 50 db, obtained in 5 steps of 10 db each, with loading of R = 1,000,000 ohms.







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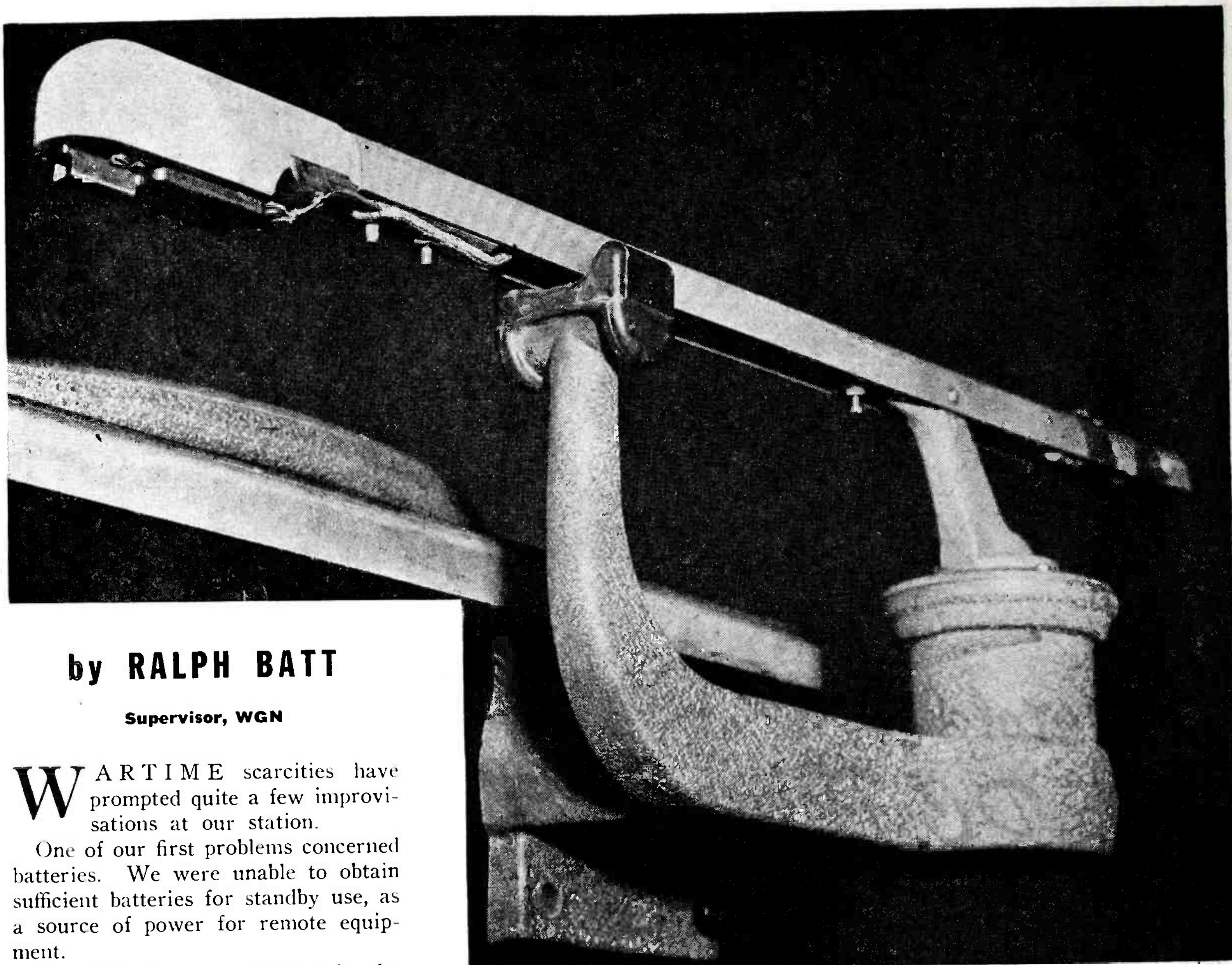
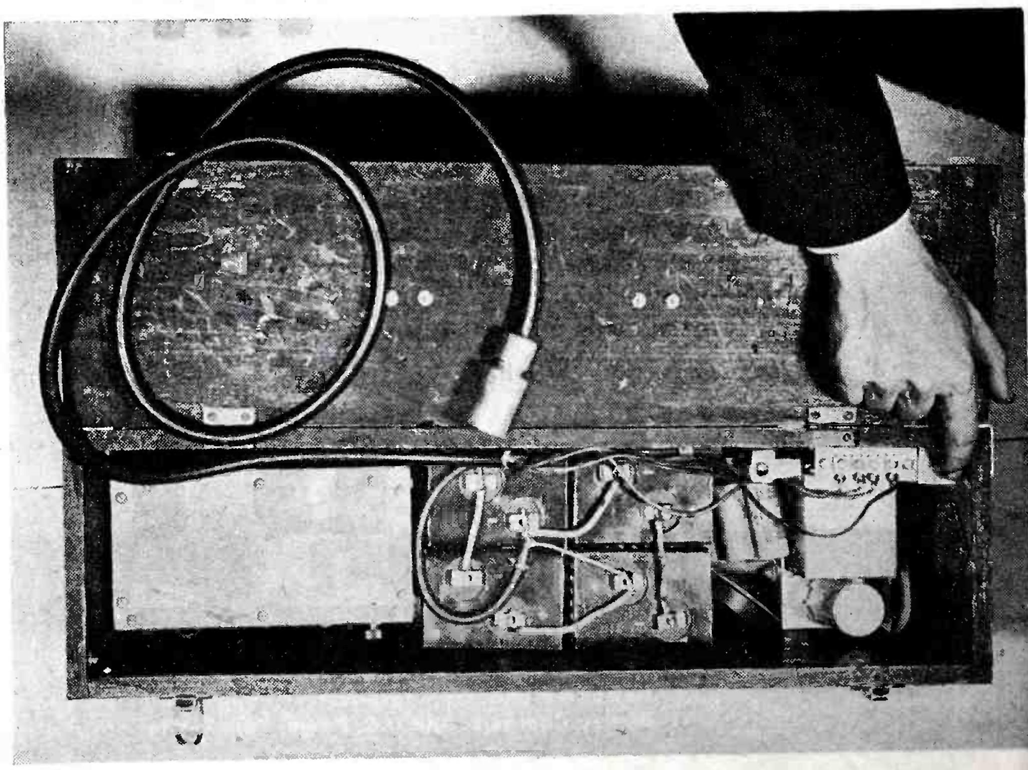


Improvised composite pickup arm, with crystal replacement cartridge in hollowed-out wooden head. Counter balance was achieved by added weights. (Below) Vibrator power supply utilized when *B* batteries could not be obtained.



by RALPH BATT

Supervisor, WGN

WARTIME scarcities have prompted quite a few improvisations at our station.

One of our first problems concerned batteries. We were unable to obtain sufficient batteries for standby use, as a source of power for remote equipment.

This difficulty was overcome by the use of a vibrator with its properly matched and shielded transformer.* The vibrator was powered by either a small six-volt wet cell or from four three-volt dry cells, connected in series-parallel.

For audio work a special filter section had to be added to reduce the low frequency or audio hum to a minimum. We accomplished this by the use of a capacitor input type filter. Values to meet the requirements were found to be an 8-mfd first condenser and a 16-mfd second condenser. The choke was a 15-henry unit. This choke must have a low d-c resistance value to secure a maximum output voltage. The choke we are using has a d-c resistance of 230 ohms, although one of a value up to 400 ohms can be used satisfactorily, depending upon the load current.

The vibrator, filter section and battery source are mounted compactly into a small carrying case with power

(*Continued on page* 122)

*Mallory Vibrabak.

AT THE SMPE CONFERENCE

In Hollywood

WARTIME developments in sound recording and reproduction were spotlighted at the fifty-fourth semi-annual technical conference of the Society of Motion Picture Engineers, held from October 18 to 22, at the Hollywood-Roosevelt Hotel in Hollywood, California.

The papers presented covered a wide range of subjects, including acoustical research, new sound recording installations, postwar television planning, amplifiers, speakers, and transformers.

Dr. Olsen on Acoustics

Discussing acoustical research, Dr. Harry F. Olsen of the RCA Laboratories, Princeton, New Jersey, described modern facilities for development and research in all branches of acoustics. His analysis included a description of the new RCA acoustic laboratories which has a free field sound room, large sound stage, standard living room, soundproof room for life tests, dust-free rooms, magnetizing facilities, live room, field laboratory and towers, and conventional communication laboratories.

In the acoustic unit, the free field sound room has been designed to combine acoustical conditions as obtained in free space outdoors with ideal and normal test conditions. The large sound stage is for tests of sound pickup in standard conventional settings. By a change in *acoustics* the sound stage may be converted into a small theater for sound reproduction tests. In the living room laboratory has been incorporated the acoustical equal of the ideal living room in which sound instruments such as radios and phonographs may be developed and tested for normal home use. The soundproof room has been provided with special walls and doors for testing loudspeakers at high levels without annoyance to adjoining rooms, while the dust-free rooms are used for assembling magnetic structures. For testing of sound absorbing materials, the live room is used. The conventional laboratory bays include all types of measuring equipment: oscillators, amplifiers, recorders, bridges, etc. Multiple audio-frequency lines are provided so that laboratories may be interconnected. And to conduct free field response, power and life tests, a remotely located field laboratory has been constructed.

These acoustic research facilities have already provided vital design data, explained Dr. Olsen. And future research will undoubtedly reveal many solutions to many acoustic problems now puzzling science, said Dr. Olsen.

200-Mil Push-Pull Recorder

A 200-mil push-pull sound recording system, truck-mounted, for use in a studio or on location, was described by L. D. Grignon of 20th Century-Fox Film Corporation, Beverly Hills, California. The presentation prepared by Mr. Grignon and J. P. Corcoran, also of 20th Century-Fox, described a new 200-mil push-pull modulator, limiting amplifier, together with test and lineup equipment so arranged as to make it possible for relatively inexperienced personnel to operate same without undue supervision.

Multi-Cellular Speaker

Three members of Altec-Lansing Corporation, Hollywood, California, presented papers on loud speakers, transformers and amplifiers. The loudspeaker discussion included a description of a new duplex speaker, by J. B. Lansing. The speaker, according to Mr. Lansing, has a unit that is capable under proper loading conditions of reproducing a frequency range of from 50 to 15,000 cycles. The unit consists of essentially a multi-cellular horn mounted within the foci of a low frequency horn. The speaker has been designed to have a solid angle of coverage of 60°.

Wide-Range Transformers

Ercell B. Harrison of Altec-Lansing described transformers now being made for audio frequency power work, as well as chokes used in rectifier circuits. The paper covered a description of transformers which are used over wide-frequency ranges. Mr. Harrison also discussed methods of shielding to prevent pickups from stray electromagnetic and electrostatic fields.

250-Watt Class B Amplifier

The discussion of amplifiers presented by John Hilliard, included an analysis of a 250-watt class *B* audio unit used for high powered public address and calling systems. Economy of weight and regulation in this amplifier is achieved by using the transformers described by Mr. Harrison.

Postwar Television

Postwar television planning and requirements served as the basis of a paper by Klàus Landsberg, director of television, W6XYZ, Television Productions, Inc. (subsidiary of Paramount Pictures, Inc.), Hollywood, California.

Mr. Landsberg explained that if, at the end of the war, the returning soldiers, war workers and the public in general are not to be disappointed by a new delay of television due to differences in opinions regarding the technical form best suited for television, it is the responsibility of those active in television and those intending to enter the television field after the war, to plan now. The television industry must plan, among itself and with other industries which are affected by this new medium. The creation of a radio technical planning board and its work must, therefore, be greatly appreciated and supported by the television industry, pointed out Mr. Landsberg.

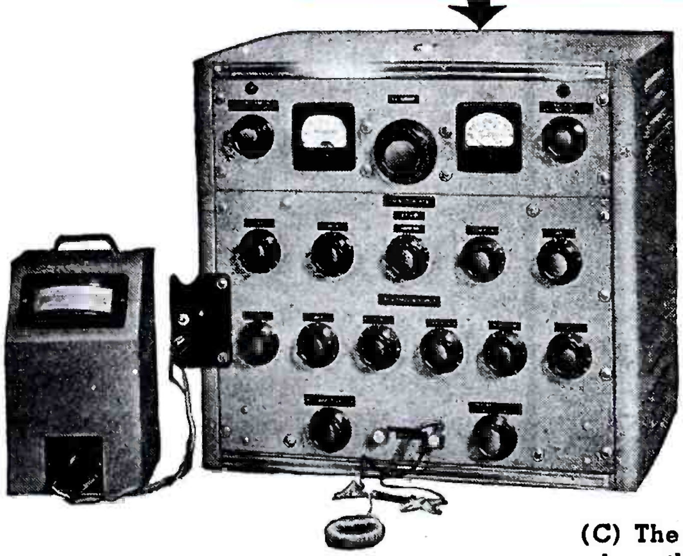
In planning for television there are outstanding two questions, said Mr. Landsberg. Have there been any developments that will revolutionize television and should color be incorporated into these plans? If revolutionary developments have been made they are not and cannot be known now, he explained. It is certain though that thorough experimentation and testing of such developments would be necessary. Time for this could not be found until after the war when the majority of qualified engineers, now occupied with more urgent tasks, can be released for this work. This would undoubtedly delay television for many years.

Demonstrations of color television have proven its possibility, but much work is required before it is simplified and foolproofed sufficiently to be put into use by the layman. Electronic means of color scanning must be de-

(*Continued on page* 104)

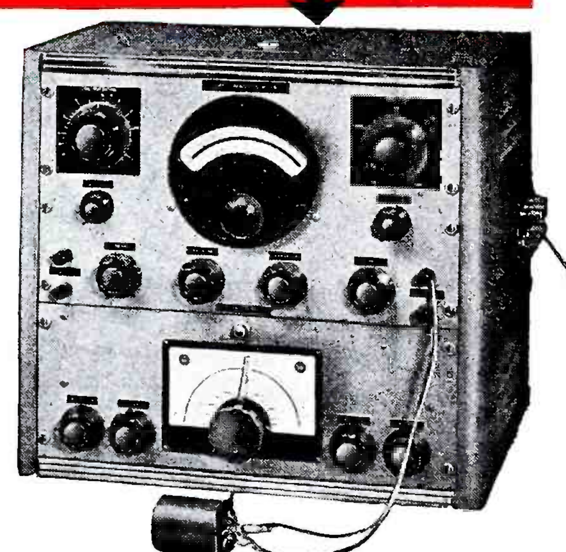
(A) Filter performance is dependent upon three major factors, basic design... Q of coil and capacitor elements... and precision of adjustment. The superiority of UTC products in this field has been effected through many years of research and development on core materials and measuring apparatus. We illustrate below a typical filter formula and some of the UTC apparatus used to determine quantitative and qualitative values:

$$\frac{(1C\pi^2 f_\infty - 1)\left(\frac{1}{Q^2} + 1 - \left(\frac{f_\infty}{f}\right)^2\right)}{\frac{1}{Q^2} + \left(1 - \left(\frac{f_\infty}{f}\right)^2\right)} = U_\infty \text{ (ATTENUATION CONSTANT)}$$



(B) The UTC inductance bridge is capable of four digit accuracy and covers a range from extremely low values to over 100 Hys. The effective resistance and inductance values are direct reading, eliminating the possibility of error in conversion.

(C) The UTC oscillator is direct reading, where the frequency desired is set as in a four digit decade box, and is accurate within 1 cycle at 1,000 cycles. The range is 10 cycles to 100 kc. Accuracy of this type is essential with filters having sharp attenuation characteristics. This instrument is augmented by a UTC harmonic analyzer for the output measuring device.



(D) The UTC Q meter is a unique device which has helped considerably in the development of the special core materials used in our filters. It is also of importance in maintaining uniform quality in our production coils. The Q is read directly and covers the entire range of possible Q factors over the entire audio frequency band.

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THE COMPLEX VARIABLE

A Description of Application To The Solution Of Two-Dimensional Field Problems

(PART TWO OF A TWO-PART PAPER)

by SIDNEY FRANKEL

Radio Engineer, Federal Telephone & Radio Corp.

EVERY solution of Laplace's equation is potentially a solution of some electrostatic problem. For any particular problem, however, it is not sufficient merely to find a solution of this equation. Certain *boundary* conditions must be satisfied as well. These ideas will be developed below where necessary.

To return to equations *17*a and *17*b, they are special cases of Laplace's equation with

$$\frac{\partial^2 \phi}{\partial z^2} = 0$$

Any charge-free electrostatic field which varies in two dimensions only and is constant with respect to the third dimension satisfies these equations. Conversely, any function which satisfies these equations can be the solution for the potential of some electrostatic field. Thus it follows that both the real part and the imaginary part of an analytic function of a complex variable can represent the solution to some electrostatic problem.

For example, returning to equation *16*b and Figure 6, since both u and v satisfy Laplace's equation, either can represent an electrostatic field. If we suppose that $v(x, y)$ represents the potential of some field, then the curves $v(x, y) =$ constant, must represent equipotential lines (more strictly, the traces of equipotential cylinders). These equipotentials are shown in Figure 6. In particular, for $v = 0$, we get $xy = 0$ so that $x = 0$, $y = 0$ are traces of the planes representing $v = 0$. Now if these planes are replaced by thin conducting planes at zero potential (grounded), then the equipotentials represent a possible field in the neighborhood of a square corner. For the field to exist at all there must be charges in the space away from the corner. For example, with charges in the first quadrant only, the system of curves in the remaining quadrants should be ignored. The accuracy of Figure 6 depends on how far away from the corner the charges are. There is always a sufficiently small neighborhood of the origin in which the accuracy is as good as one desires.

Other functions, of course, yield other solutions. Another interesting function is

$$w = \sqrt{z} \tag{20}$$

Caution must be exercised in employing this function. In the first place it is not analytic at $z = 0$, although it is analytic at any other point however near to $z = 0$[6]. In the

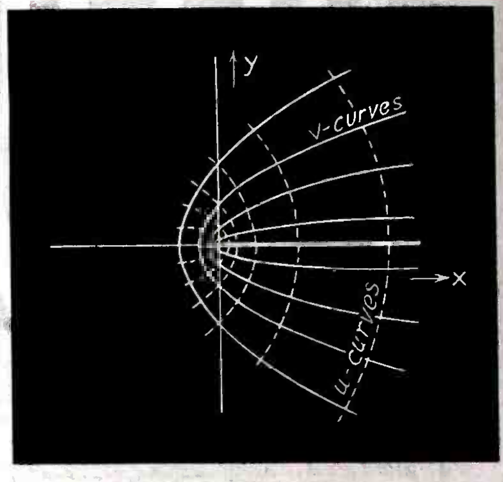

Figure 11
The electrostatic field around the edge of a thin semi-infinite conducting plane, represented by plotting the analytic function $w = \sqrt{z}$, parametrically in the z-plane.

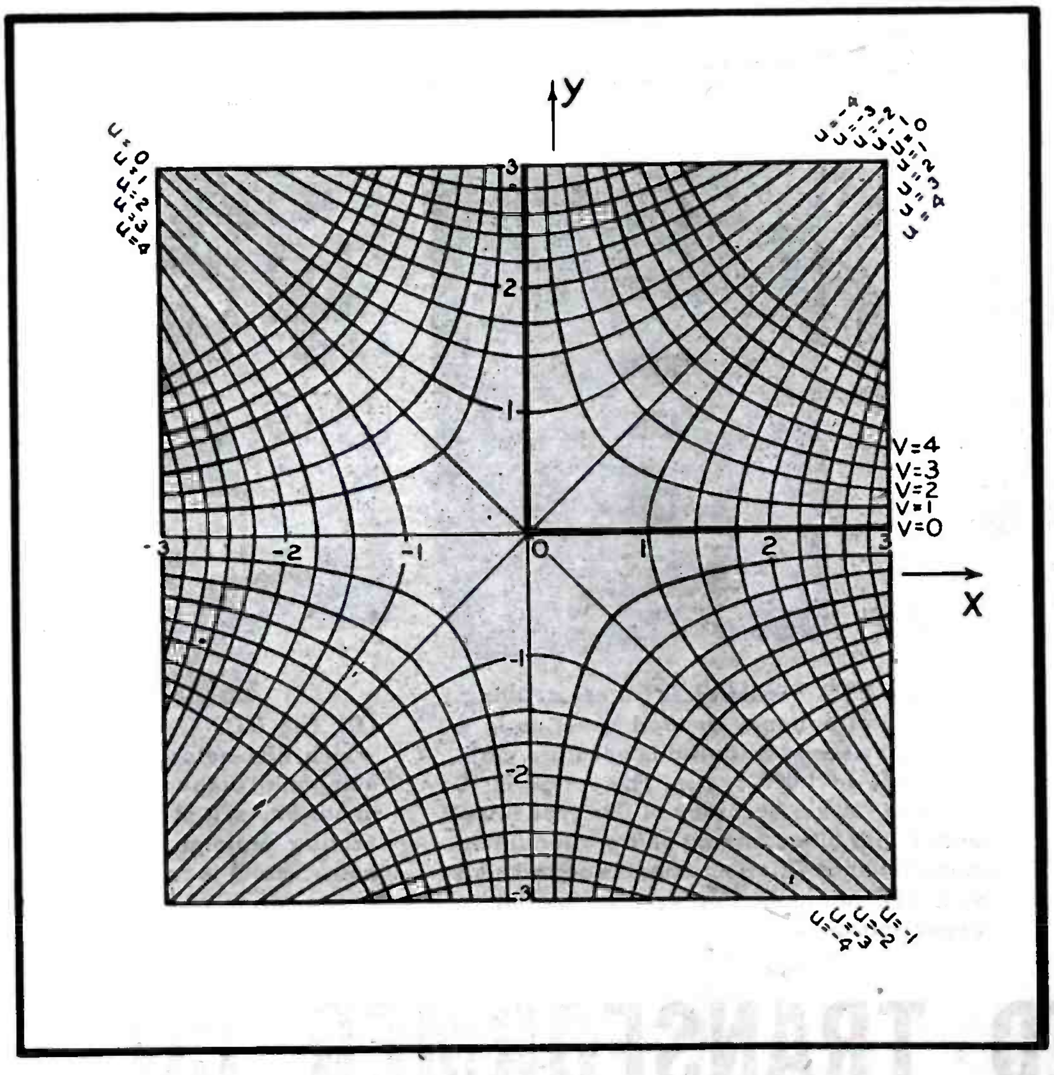

Figure 6
The analytic function $w = z^2$ plotted in parameter form in the z-plane. As a particular case, if the positive x- and y-axes represent intersecting semi-infinite conducting planes at zero potential, the v-curves are traces of equipotential surfaces and the u-curves are field lines.


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second place, as might be suspected, the function is not single-valued; this is a further cause of trouble which need not concern us at present.

To determine the functions u and v we proceed as follows:

$$w^2 = (u + jv)^2 = (u^2 - v^2) + j2uv = z = x + jy$$

so that

$$\left.\begin{aligned} u^2 - v^2 &= x \\ 2uv &= y \end{aligned}\right\}$$

Eliminating v from these equations

$$y^2 = -4u^2x + 4u^4 \qquad (21a)$$

With u as parameter, this represents a series of x-parabolas, open to the left.

Eliminating u

$$y^2 = 4v^2x + 4v^4 \qquad (21b)$$

With v as parameter, this represents a series of x-parabolas, open to the right.

Both families of curves are shown in Figure 11. If we choose the v-curves as equipotentials, then in particular we get, for $v = 0$, the degenerate parabola represented by the positive x-axis. If this is replaced by a thin conducting semi-infinite plane sheet, then the equipotentials represent the field around the edge of a semi-infinite plane.

In both Figures 6 and 11 we have not said much about the u-curves. In the case of any analytic function it can be shown that the u-curves are orthogonal to the v-curves, and that if one set of curves is taken as the equipotentials, the other set represents the lines of force.

The procedure described above is known as the method of conjugate functions. It has the serious drawback that one does not know in advance what type of function to select to solve a given electrostatic problem. This situation is greatly relieved by the use of a general formula known as the Schwarz-Christoffel transformation, a discussion of which is beyond the scope of this paper.[2,5]

One of the most important functions for the solution of electro-static problems is the logarithmic transformation

$$w = \log z \qquad (22)$$

All logarithms will be taken to the Naperian base unless otherwise stated.

In studying the logarithmic transformation it is convenient to write, in accordance with Figure 1,

$$\left.\begin{aligned} x &= r\cos\theta \\ y &= r\sin\theta \end{aligned}\right\} \qquad (23)$$

so that

$$z = x + jy = r(\cos\theta + j\sin\theta) = r\varepsilon^{j\theta} \qquad (24)$$

where

$$\left.\begin{aligned} r &= \sqrt{x^2 + y^2} \\ \theta &= \tan^{-1}\frac{y}{x} \\ \varepsilon &= 2.718\ldots \end{aligned}\right\} \qquad (25)$$

Then equation *22* becomes

$$\left.\begin{aligned} w = \log z &= \log(r\varepsilon^{j\theta}) = \log r + j\theta \\ &= \log\sqrt{x^2 + y^2} + j\tan^{-1}\frac{y}{x} \\ &= u + jv \end{aligned}\right\} \qquad (26)$$

Thus

$$\left.\begin{aligned} u &= \log\sqrt{x^2 + y^2} \\ v &= \tan^{-1}\frac{y}{x} \end{aligned}\right\} \qquad (27)$$

Considering the second of these equations first, we have

$$y = \tan v \cdot x \qquad (28)$$

For fixed values of v this represents a family of straight lines passing through the origin (Figure 12). The field lines are given by

$$x^2 + y^2 = \varepsilon^{2u} \qquad (29)$$

a series of concentric circles. This represents the field due to two semi-infinite conducting planes lying in the same geometric plane and charged to potentials zero and π respectively.

On the other hand, we can take the curves of u = constant (equation 29) to be the equipotentials, which are therefore concentric circles (Figure 13). The potential at any point is given by

$$\Phi = u = \log r \qquad (30)$$

to which a constant should be added for accuracy. The field lines are then radials and the field intensity is

$$E_r = -\frac{\partial\Phi}{\partial r} = -\frac{1}{r} \qquad (31)$$

We can replace the inner core of this field by a wire of radius b, center at the origin. The field at the surface of this wire is, by equation *31*

$$E_s = -\frac{1}{b} \qquad (31_s)$$

and is normal to the surface of the wire. By Gauss' electric flux theorem,[8]

$$\int_0^{2\pi} E_s \cdot r\,d\theta = \frac{q}{k}$$

where q is the charge per unit length on the conductor and k is the absolute dielectric constant of the medium outside the wire.* Performing the integration we get

$$q = -2\pi k$$

Conversely, if the charge per unit length of the wire is λ, the field strength is

$$E_r = \frac{\lambda}{2\pi k r}$$

and the potential is

$$\Phi = -\frac{\lambda}{2\pi k}\log r + \text{const.} \qquad (30a)$$

A case of great importance arises from the function

$$w = -\frac{\lambda}{2\pi k}\log\frac{z - a}{z + a} \qquad (32)$$

In equation *32*, as $z \to a$

$$\begin{aligned} w_a \to -\frac{\lambda}{2\pi k}\log(z - a) &+ \frac{\lambda}{2\pi k}\log 2a \\ &= -\frac{\lambda}{2\pi k}\log(r_1\varepsilon^{j\theta}) + \text{const.} \end{aligned}$$

where

$$z = a + r_1\varepsilon^{j\theta_1}$$

Thus

$$u_a \to -\frac{\lambda}{2\pi k}\log r_1 + \text{const}$$

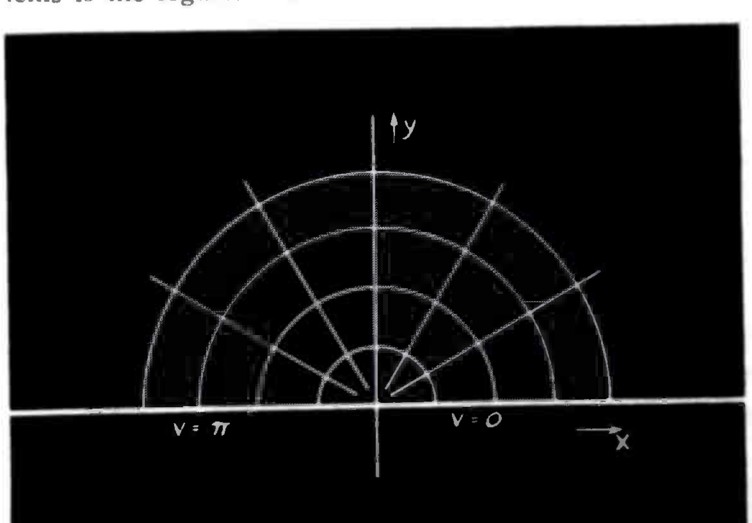
Similarly, as $z \to -a$

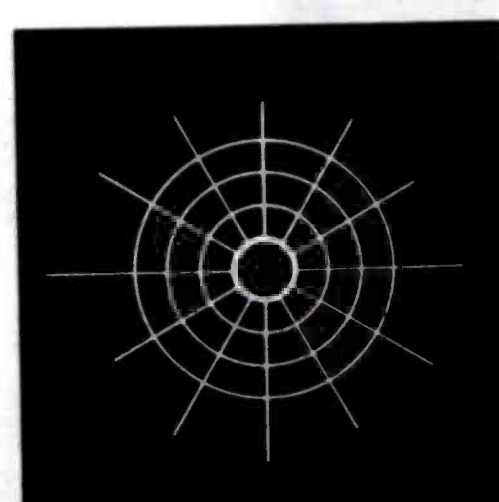
$$u_{-a} \to \frac{\lambda}{2\pi k}\log r_2 + \text{const.}$$

for

$$z = -a + r_2\varepsilon^{j\theta_2}$$

*The value of k for air is $8.854(10)^{-12}$ farad/meter.





Figures 12 (left) and 13 (right)
Left: potential field of two semi-infinite conducting planes at different potentials and lying in the same geometric plane. Mathematically the two planes meet at the origin. Physically they must be separated by an infinitesimal amount to maintain different potentials. At right: the potential field around a cylindrical wire. The same analytic function is used to represent this field as that of Figure 12, namely, $w = \log z$.

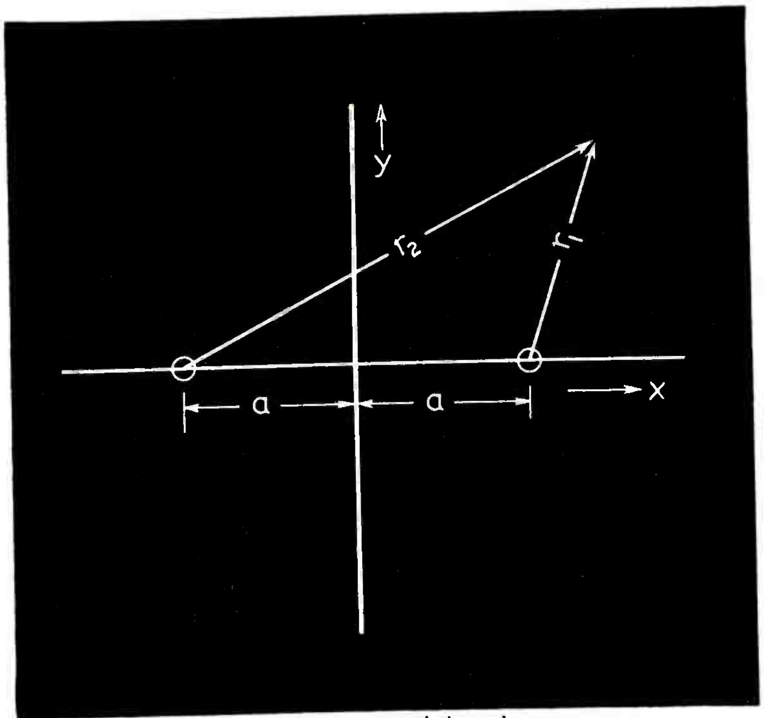
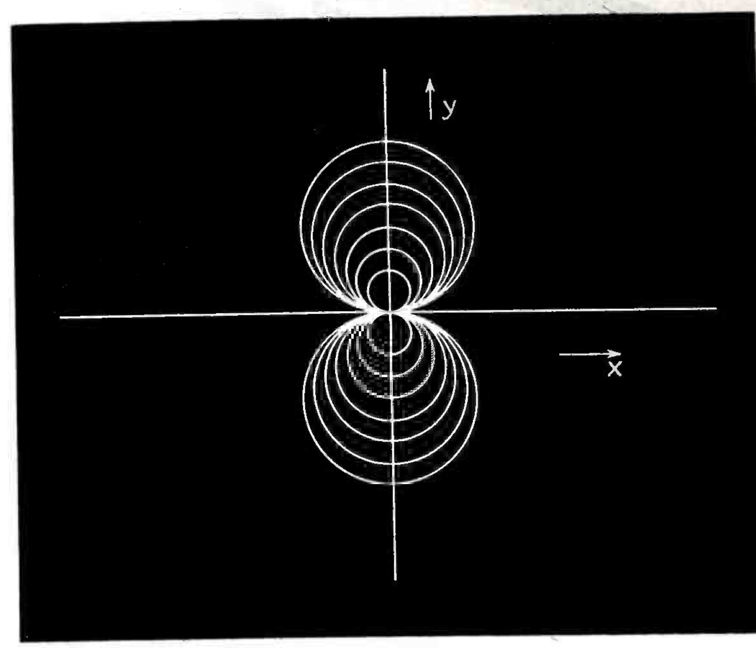


Figure 14 (above)
Arrangement of two-wire transmission line. The electrostatic field of this configuration is readily studied with function $w = \log z$, when wire diameters are small compared to spacing.

Figure 15
The field lines of a linear dipole oriented along the x-axis. The linear dipole is a limiting case of a parallel wire line of infinitesimal wires; as might be expected, it is represented by a function which is a limiting case of the function for parallel wire lines.



Thus, according to equation *30*a, the real part of equation *32*, namely

$$u = -\frac{\lambda}{2\pi k} \log \frac{r_1}{r_2} \qquad (33)$$

represents the potential due to two filaments of charges λ and $-\lambda$ per unit length located at $z = a$ and $z = -a$ respectively (Figure 14). If the filaments are very small wires of radius b (i.e., a parallel wire line), then the potential at the surface of the wire at $z = a$ is

$$u_1 = -\frac{\lambda}{2\pi k} \log \frac{b}{2a}$$

since $r_1 = b$, $r_2 \doteq 2a$. Similarly,

$$u_2 = -\frac{\lambda}{2\pi k} \log \frac{2a}{b}$$

The potential difference is

$$u_1 - u_2 = -\frac{\lambda}{\pi k} \log \frac{2a}{b}$$

and the capacitance in farads per meter is

$$C = \frac{\lambda}{u_1 - u_2} = \frac{\pi k}{\log \frac{2a}{b}} \qquad (34)$$

An interesting case occurs in Figure 14, if we are interested only in the field at comparatively large distances from the wires; that is, at distances great compared to the distance between the wires. Thus, in equation *32* we can rewrite the transformation as

$$w = -\frac{\lambda}{2\pi k} \log \frac{1 - \frac{a}{z}}{1 + \frac{a}{z}}$$

$$= -\frac{\lambda}{2\pi k} \left[\log \left(1 - \frac{a}{z}\right) - \log \left(1 + \frac{a}{z}\right) \right] \qquad (35)$$

For "the magnitude of $\frac{a}{z}$" we write $\left|\frac{a}{z}\right|$. Thus for the case under consideration, $\left|\frac{a}{z}\right| << 1$ so that we can certainly expand the logarithmic functions in Taylor's series[6]

$$\log \left(1 - \frac{a}{z}\right) = -\frac{a}{z} - \frac{a^2}{2z^2} - \frac{a^3}{3z^3} - \ldots$$

$$\log \left(1 + \frac{a}{z}\right) = \frac{a}{z} - \frac{a^2}{2z^2} + \frac{a^3}{3z^3} - \ldots$$

and equation *35* becomes

$$w = \frac{\lambda}{\pi k}\left(\frac{a}{z} + \frac{a^3}{3z^3} + \ldots\right)$$

$$= \frac{\lambda a}{\pi k z}\left(1 + \frac{a^2}{3z^2} + \ldots\right) \qquad (36)$$

Now we introduce the concept of permitting the distance, *a*, between the wires to decrease indefinitely and the charge, λ, to increase indefinitely in such a way that the product λa approaches a finite limit, *m*. We can designate the resulting configuration as a *linear dipole* and define *m* as the *dipole moment*. Passing to the indicated limits in equation *36*, we find that all terms except the first become zero and the result is

$$w = \frac{m}{\pi k z} \qquad (37)$$

The real part of the inverse transformation yields the potential field of a linear dipole. This potential is therefore

$$u = \frac{mx}{\pi k (x^2 + y^2)} \qquad (38)$$

The equations of the field lines, on the other hand, must be given by the imaginary part

$$v = -\frac{my}{\pi k (x^2 + y^2)} = \frac{-dy}{x^2 + y^2}, \quad d = \frac{m}{\pi k}$$

or

$$x^2 = \frac{c}{v} y - y^2 \qquad (39)$$

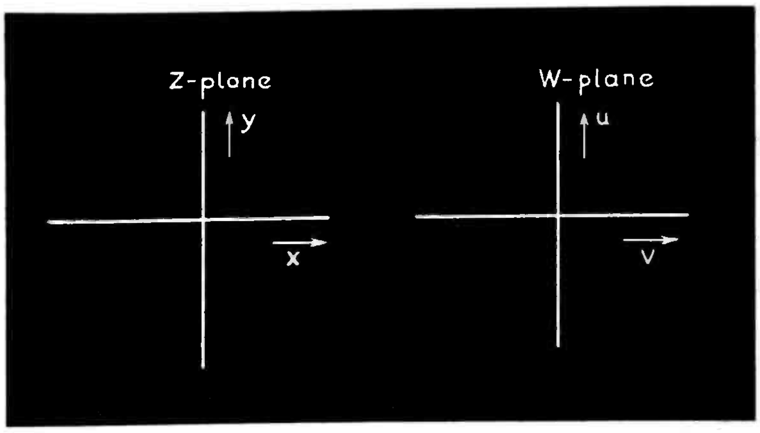
which, again represents a family of circles in the *z-plane*. The field lines represented by equation (39) are plotted in Figure 15.

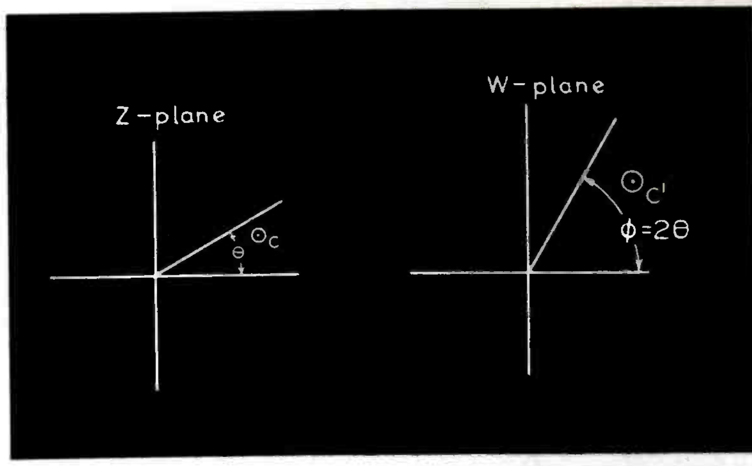
Conformal Transformations

In the preceding discussion we have occasionally used the word *transformation* to characterize an analytic function of the form

$$w = f(z) \qquad (40)$$

without taking the trouble to explain the appropriateness of this termi-





Figures 16 (left) and 17 (right)

Figure 16: points of the z-plane are made to correspond to points of the w-plane by means of the function $w = f(z)$. Figure 17: by means of the transformation $w = z^2$, a ray at angle Θ in the z-plane is transformed to a ray at angle $\phi = 2\,\Theta$ in the w-plane.

nology. We will now introduce the set of concepts which justifies its use. For this purpose we suppose that we have two planes (Figure 16), one of which we call the z-plane, and on which we plot values of $z = x + jy$, and the other of which we designate as the w-plane, and on which we plot corresponding values of $w = u + jv$. To take a concrete example we might consider the function

$$w = z^2 \tag{5}$$

For any point in the z-plane we locate its corresponding point in the w-plane by computing the value of w from the given value of z by means of equation *5*. For example, to the point $z = 10$ in the z-plane corresponds the point $w = 100$ in the w-plane; to the point $z = 3 + j4$ corresponds the point $w = -7 + j\,24$, etc. Thus to every point in the z-plane corresponds at least one point in the w-plane, and conversely. The points of the z-plane are said to be *transformed* to the corresponding points of the w-plane. The advantage of this concept is not apparent until we select a particular curve or a particular region in the z-plane and determine the corresponding curve or region in the w-plane. Thus, let us consider the transformation of points in the z-plane lying on the ray

$$y = ax \tag{41}$$

to points in the w-plane, when the w-plane is related to the z plane by means of equation *5*. As has been seen previously, any point in the z-plane may be represented as

$$z = r\,\varepsilon^{j\theta} \tag{42}$$

where

$$r = \sqrt{x^2 + y^2}$$

$$\theta = \tan^{-1}\frac{y}{x}$$

Equation *41* represents a ray passing through the origin in the z-plane (Figure 17). For this locus, θ is constant; in fact,

$$\theta = \tan^{-1} a$$

All values of z which lie on this line are therefore obtained by assigning to r all values from zero to infinity.

Now by equations *5* and *42*,

$$w = r^2\,\varepsilon^{j2\theta} = R\,\varepsilon^{j\Phi}$$

where

$$R = r^2$$

$$\Phi = 2\,\theta$$

In the first place since θ is constant, Φ is also constant. The locus in the w-plane is also a ray, but its angle to the real axis is twice that of the ray in the z-plane. Furthermore, since r extends from zero to infinity, R covers the same range. We can say that the whole region enclosed in the angle θ in the z-plane becomes transformed to a region enclosed by the angle Φ in the w-plane. A particular case of interest occurs when $\theta = \dfrac{\pi}{2}$, in which case the first quadrant in the z-plane transforms to the upper half-plane in the w-plane.

Next suppose we have a small circle of radius ρ in the z-plane, with center at the point $z = \zeta$. Then any point on this circle is represented by

$$z = \zeta + \rho\,\varepsilon^{j\theta}$$

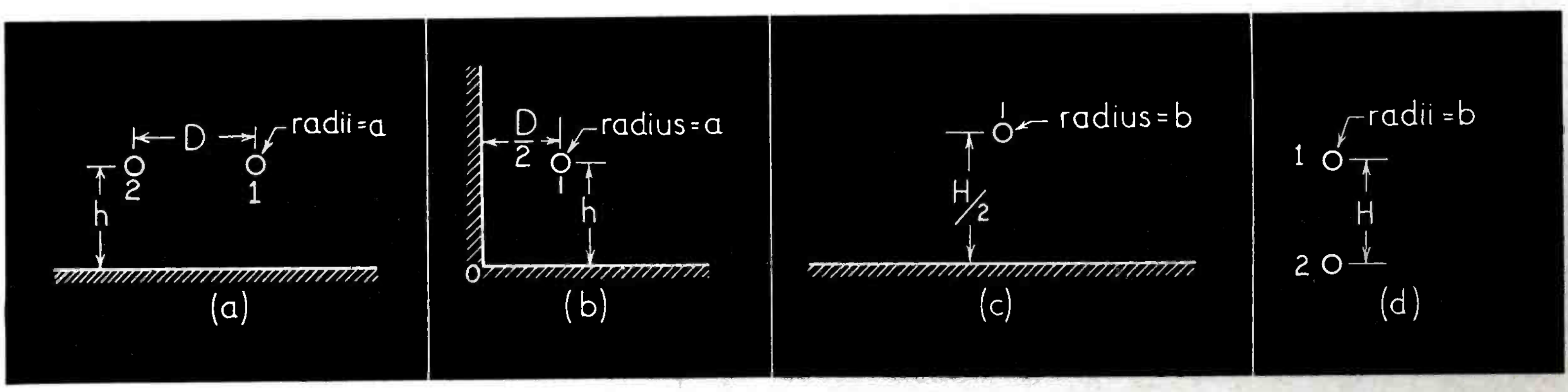
θ being the only variable. To what shape does this circle transform in the w-plane? We can make use of Taylor's theorem for functions of a complex variable, which has exactly the same form as Taylor's theorem for functions of a real variable, namely,

$$w = f(z_0 + h) = f(z_0) + f'(z_0)\,h + f''(z_0)\frac{h^2}{2!} + \ldots\ldots$$

provided the various derivatives indicated exist and the series converges. Writing $z_0 = \zeta$, $h = \rho\,\varepsilon^{j\theta}$,

Figure 18

In *a* is a balanced two-wire transmission line near plane ground. In *b* appears a single-wire line near a corner substituted for *a*. In *c* we have *b* transformed to a single wire near plane ground. In *d* is a two-wire line in free space substituted for *c*. Thus the problem of two wires in free space is substituted for the problem of two wires near plane ground.



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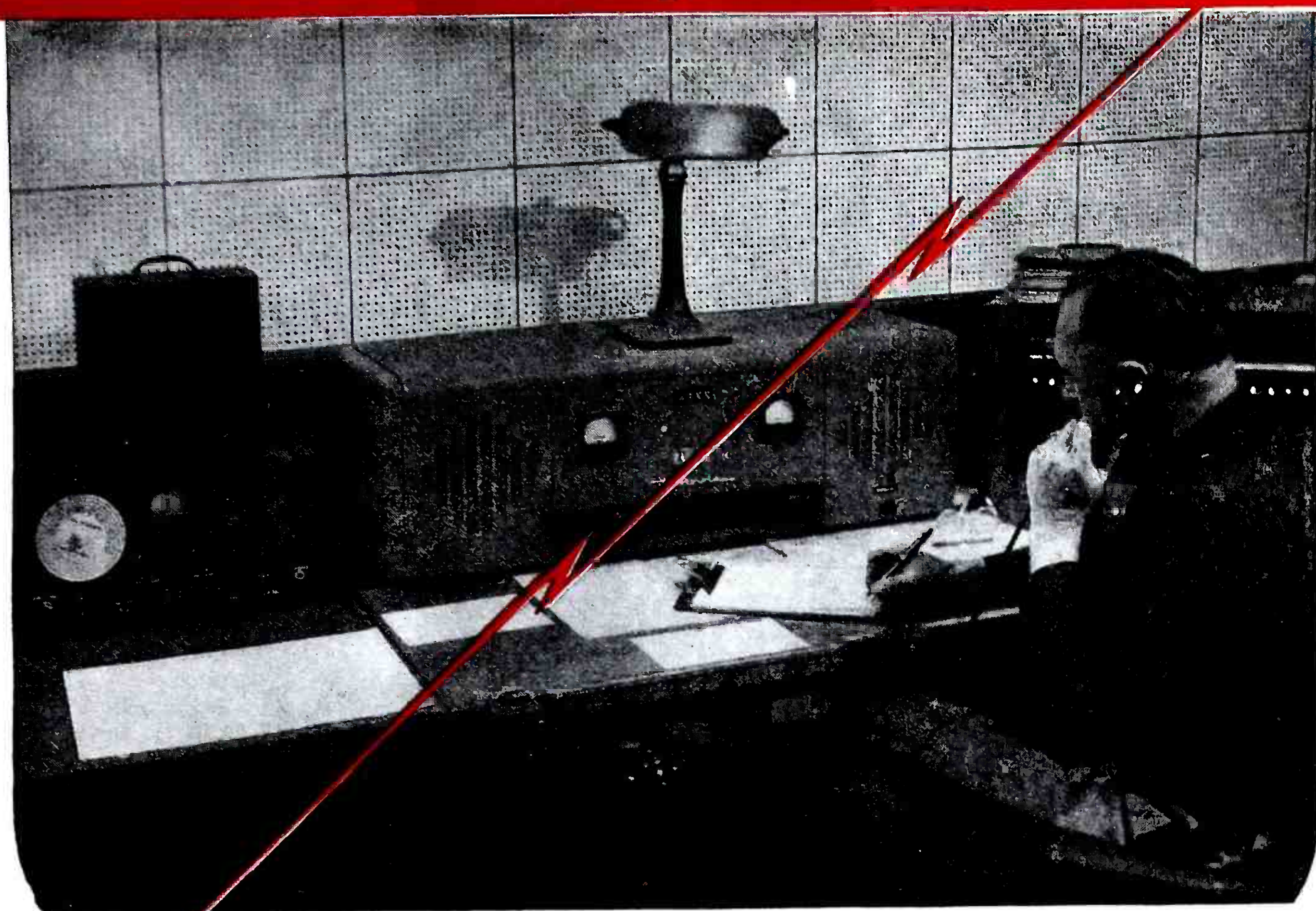

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$$w = f(\zeta + \rho\,\varepsilon^{j\theta}) = f(\zeta) + f'(\zeta)\,\rho\,\varepsilon^{j\theta} + f''(\zeta)\,\frac{\rho^2\,\varepsilon^{j2\theta}}{2!} + \ldots.$$

Now is ρ is sufficiently small, w may be approximated by the first two terms of the series; thus

$$w \doteq f(\zeta) + f'(\zeta)\,\rho\,\varepsilon^{j\theta} \qquad (43)$$

$f'(\zeta)$ is in general a complex quantity and may be written $f'(\zeta) = M\,\varepsilon^{j\beta}$ where M and β are real. Equation *43* then becomes

$$w \doteq f(\zeta) + M\,\rho\,\varepsilon^{j(\theta+\beta)}$$

But this is again the equation of a circle, with center now at $f(\zeta)$ and radius $M\rho$, or M times the original radius. The quantity M is called the *magnification factor*. Because the circular shape is preserved for *small* circles, the process is known as *conformal transformation*. It can be shown that any very small figure, regardless of shape located at a point ζ, is transformed conformally by means of an analytic function $f(z)$ so that the new figure is similar to the original, but magnified by a factor

$$M = |\,f'(\zeta)\,|$$

rotated by an angle β, and moved to a new position $f(\zeta)$. Thus, if in Figure 17, the circle C is located at $z = \zeta = 1 + j$ and has a radius $\rho = .01$, we get

$$\begin{aligned} w &= (1 + j + .01\,\varepsilon^{j\theta})^2 \\ &= (1+j)^2 + 2(1+j)(.01)\,\varepsilon^{j\theta} + .0001\,\varepsilon^{j2\theta} \\ &\doteq 2j + .02\sqrt{2}\,\varepsilon^{j(\beta+\pi/4)} \end{aligned}$$

The new circle at C' has a radius $2\sqrt{2}$ times the old. The magnification is

$$\begin{aligned} M &= |\,f'(\zeta)\,| = |\,d/dZ\,(Z^2)\,|_{z=\zeta} \\ &= |\,2\zeta\,| = 2\,|\,1 + j\,| = 2\sqrt{2} \end{aligned}$$

as expected.

These concepts may be used to investigate electrostatic fields of certain configurations in terms of fields already known. Thus, to take a simple example, suppose we know the capacitance per unit length of a two-wire transmission line in free space and we wish to compute the capacitance per unit length of a balanced two wire line situated near ground as shown in Figure 18a. First, we know that the capacitance required is ½ the capacitance of one wire (say wire No. 1) to ground. By the well-known theory of electrical images, this latter capacitance is the same as the capacitance to ground of the single wire shown in Figure 18b. If we call the capacitance of Figure 18a C_z, then that of Figure 18b is $\frac{C_z}{2}$. Next, by equation *5*, we transform the configuration of Figure 18b into that of Figure 18c as previously discussed with respect to Figure 17. Call the capacitance of this configuration $\frac{C_w}{2}$. Finally, again by the method of images, change this to the configuration of Figure 18d, in which the capacitance between wires is given by the well-known formula for small wires,

$$C_w = \frac{0.308}{\log_{10}\dfrac{H}{b}}\ \text{mmf./in.} \qquad (44)$$

Without going into detail concerning the theory we can say that in order to determine C_z it is only necessary to determine H and b in terms of h, D and a by means of transformation equation *5*. Thus, in Figure 18b, taking O as the origin of coordinates in the z-plane, the wire is located at

$$Z_0 = h + j\frac{D}{2}$$

The corresponding point in the w-plane is

$$w_0 = z_0^2 = \left(h^2 - \frac{D^2}{4}\right) + j\,h\,D$$

Since the ordinate is the coefficient of j, or hD this gives

$$\frac{H}{2} = hD, \text{ or } H = 2\,h\,D \qquad (45)$$

Since the magnification is

$$\left|\frac{dw}{dz}\right|_{z=z_0} = |\,2\,z_0\,| = 2\sqrt{h^2 + \frac{D^2}{4}},$$

we have

$$b = a\left|\frac{dw}{dz}\right|_{z=z_0} = 2a\sqrt{h^2 + \frac{D^2}{4}} \qquad (46)$$

Substituting equations *45* and *46* in equation *44* we get for the configuration in Figure 18a,

$$C_z = \frac{0.308}{\log_{10}\dfrac{Dh}{a\sqrt{h^2 + D^2/4}}} = \frac{0.308}{\log_{10}\dfrac{D}{a\sqrt{1 + (D/2h)^2}}}\ \text{mmf./in.} \qquad (47)$$

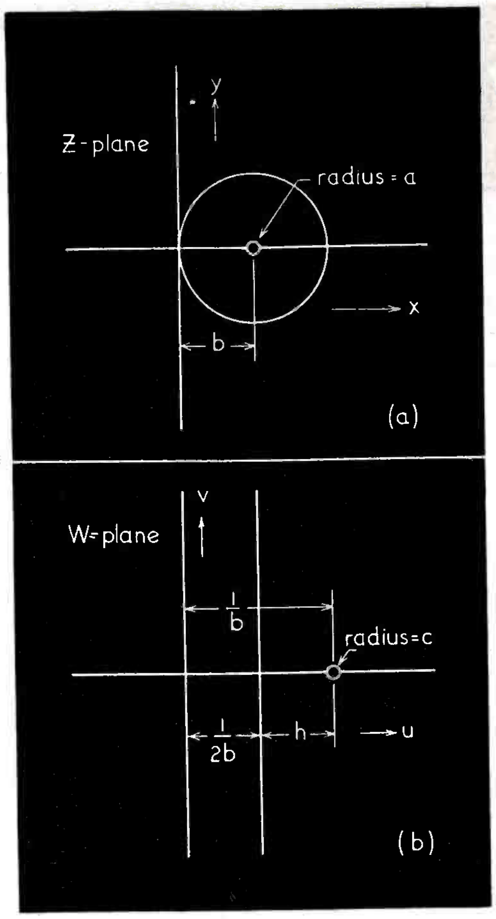


Figure 19
In *a* we have a concentric line with small inner conductor. In *b* is a single wire near ground substituted for *a* by means of the conformal transformation w = 1/z.

To illustrate the method further we will work out two examples using the inverse transformation

$$w = \frac{1}{z}$$

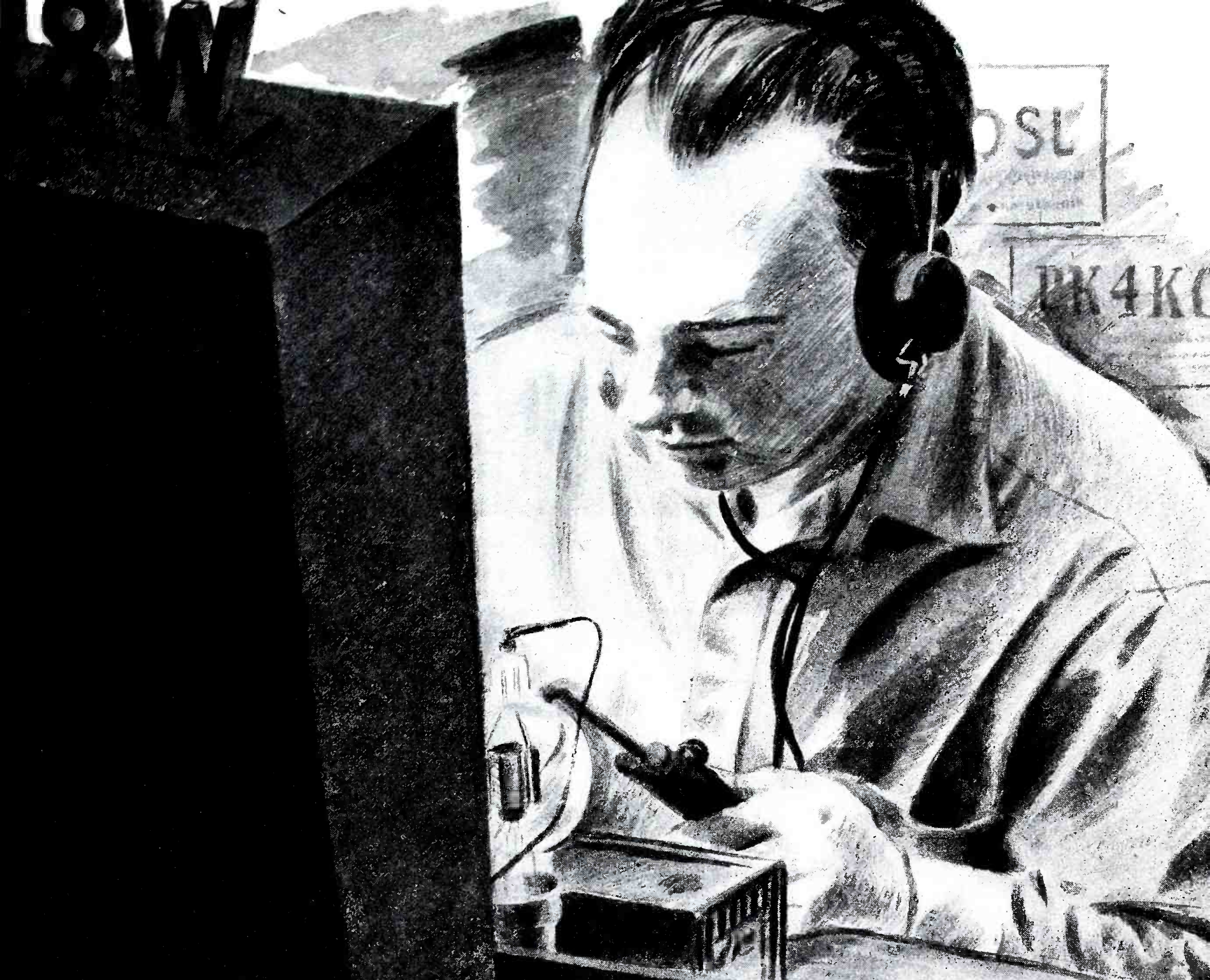
which has already proved so useful in the construction of circle diagrams and in obtaining the field of a linear dipole.

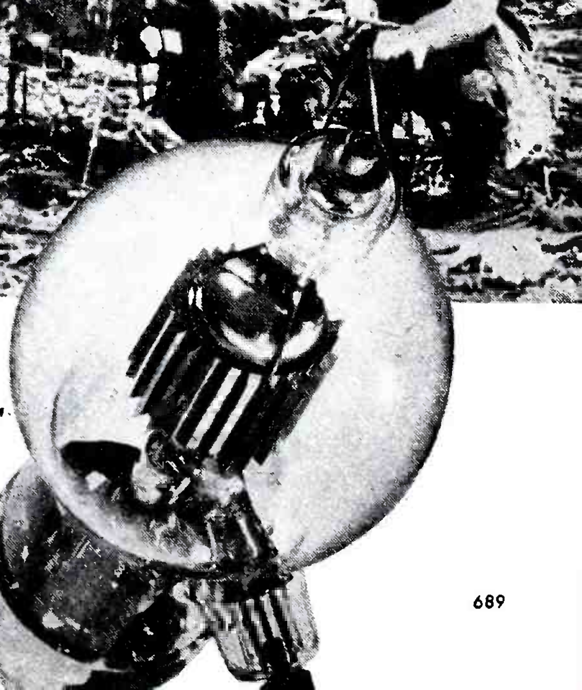
In the first example we compute the capacitance of a concentric line for small inner conductor from the capacitance of an open wire line. In Figure 19a, the concentric line is shown in the z-plane, the outer conductor of radius b being situated with its center on the x-axis distant b to the right of the origin, so that the equation of the trace of the outer conductor is given by

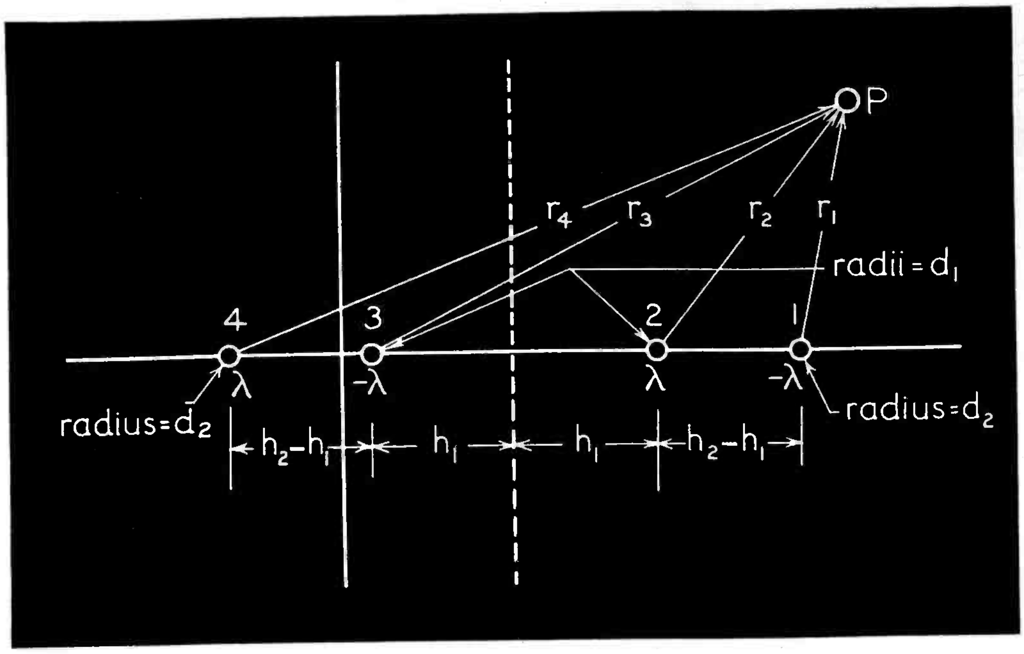
$$y^2 + x^2 - 2\,b\,x = 0 \qquad (48)$$

By virtue of the inverse transformation we have

$$z = x + jy = \frac{1}{w} = \frac{1}{u + jv} = \frac{u}{u^2 + v^2} - j\,\frac{v}{u^2 + v^2}$$







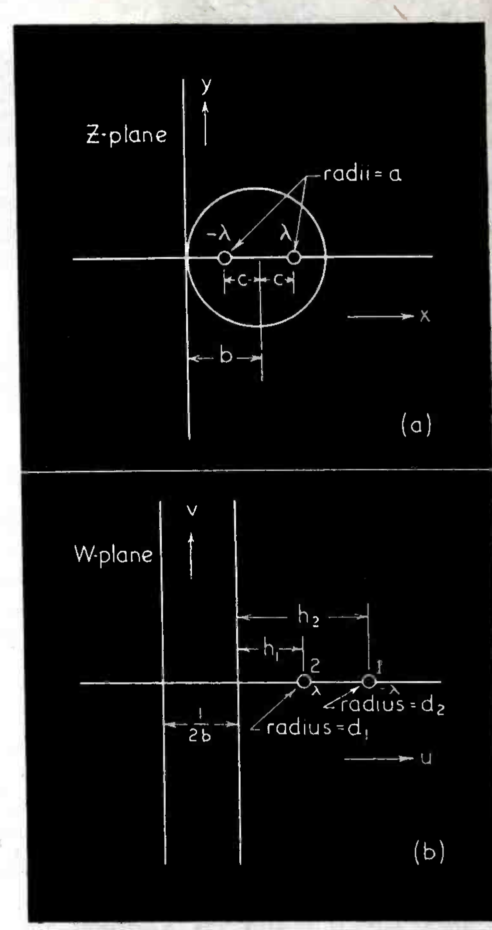


Figure 20 (a and b at right; c above)

In *a* is a balanced two-wire line in circular conductor. In *b* we have a balanced two-wire line above plane ground substituted for *a* by means of the conformal transformation w = 1/z. In *c* is a four-wire colinear system in free space substituted for *b* by virtue of the theory of electrical images.

i.e.,

$$\left.\begin{aligned} x &= \frac{u}{u^2 + v^2} \\ y &= -\frac{v}{u^2 + v^2} \end{aligned}\right\} \qquad (49)$$

Substitution of equations *49* in equation *48* for x and y yields

$$\frac{u^2 + v^2}{(u^2 + v^2)^2} - \frac{2\,b\,u}{u^2 + v^2} = 0$$

which reduces to

$$1 - 2\,b\,u = 0$$

or

$$u = \frac{1}{2b} \qquad (50)$$

In the *w*-plane this represents the equation of a straight line parallel to the *v*-axis and distant $\frac{1}{2b}$ from that axis (Figure 19b). The center of the concentric line, (b, o) is transformed, by means of the inverse equations

$$\left.\begin{aligned} u &= \frac{x}{x^2 + y^2} \\ v &= -\frac{y}{x^2 + y^2} \end{aligned}\right\} \qquad (51)$$

to the point (1/b, o) in the *w*-plane. Thus the transformed configuration is that of a circular wire above ground. Its capacitance to ground is twice that of two wires in free space. By equation *44* and Figure 19b, we have, therefore,

$$C_w = 2\,\frac{0.308}{\log_{10}\frac{2h}{c}} = \frac{0.616}{\log_{10}\frac{2h}{c}} \qquad (52)$$

However, we have, from Figure 19b,

$$h = \frac{1}{b} - \frac{1}{2b} = \frac{1}{2b}$$

and since $|dw/dz| = |1/z^2|$, we have

$$c = a\,(1/b^2)$$

Putting these values for *b* and *c* in equation *52,* we have for the concentric line with small inner conductor

$$C_2 = \frac{0.616}{\log_{10}\frac{2\,(1/2b)}{a\,(1/b^2)}} = \frac{0.616}{\log_{10}\frac{b}{a}} \qquad (53)$$

It happens that this formula can be shown by other means to be true for any size of inner conductor. This particular example was selected to illustrate the method in terms of familiar concepts rather than because it possesses any particular virtues for the solution of this particular problem.

We conclude the discussion of electrostatic field problems with the solution of the balanced two-wire line enclosed in a circular conductor (Figure 20a). From the previous discussion it is readily seen that for small wires this transforms, by means of equation *20* to the configuration of figure 20a, where

$$\left.\begin{aligned} h_1 &= \frac{1}{b+c} - \frac{1}{2b} = \frac{b-c}{2b\,(b+c)} \\ h_2 &= \frac{1}{b-c} - \frac{1}{2b} = \frac{b+c}{2b\,(b-c)} \\ d_1 &= \frac{a}{(b+c)^2} \\ d_2 &= \frac{a}{(b-c)^2} \end{aligned}\right\} \qquad (54)$$

By the method of images, the field to the right of the plane in Figure 20b is the same as the field to the right of the dotted line in Figure 20c.

By arguments similar to those in deriving equation *33,* it can be shown that the potential at a point, P

(*Continued on page 116*)

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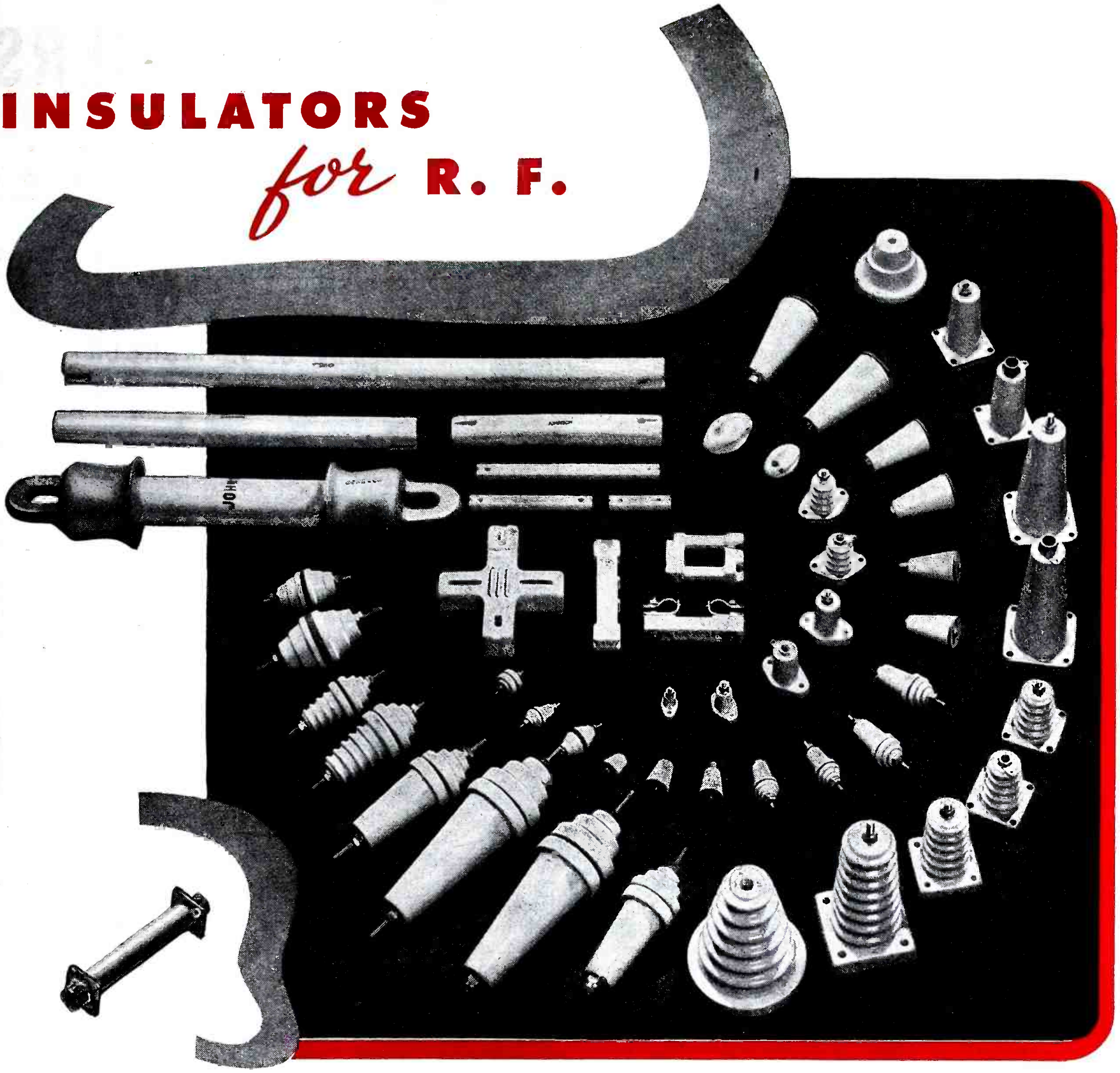
INSULATORS *for* R. F.



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An Analysis of Their Behavior

by S. J. MURCEK

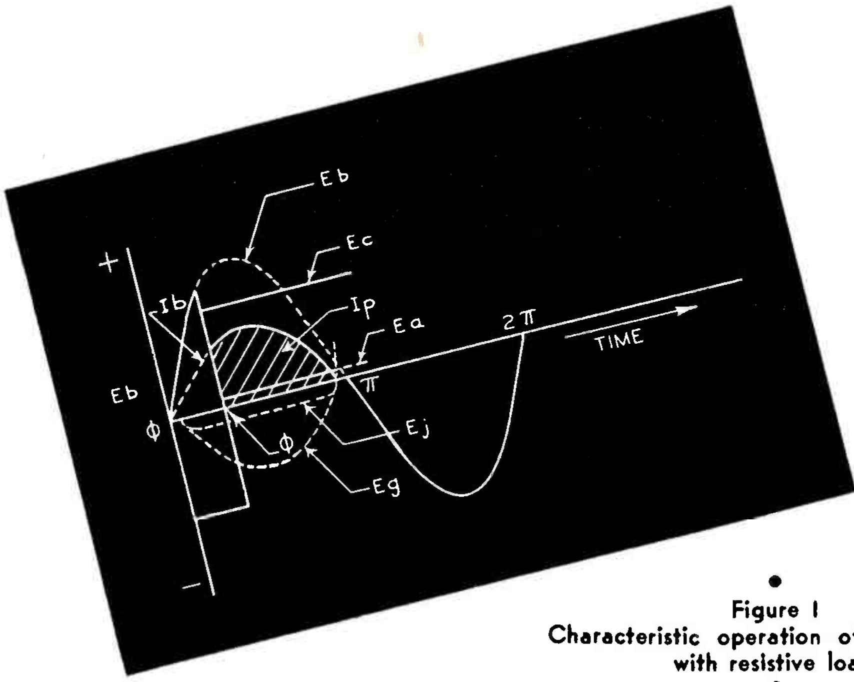


Figure 1
Characteristic operation of a thyratron with resistive load.

HEATING with r-f has become an important production factor. Although the principles of r-f heating are quite familiar to the radio engineer, its application to industrial processes has posed many unusual problems. This is especially true where mass production systems are concerned.

The fundamental factor governing operation of the modern mass production system is speed. Unit factors are viewed in such respect to this factor that corrections or alterations in unit product considerations affect enhancement of the basic speed factor. Thus, certain processes, such as heat treatment, are arranged to provide adequate processing of the unit product in unit time. The production of tinned steel strip may be taken as an example illustrative of these principles.

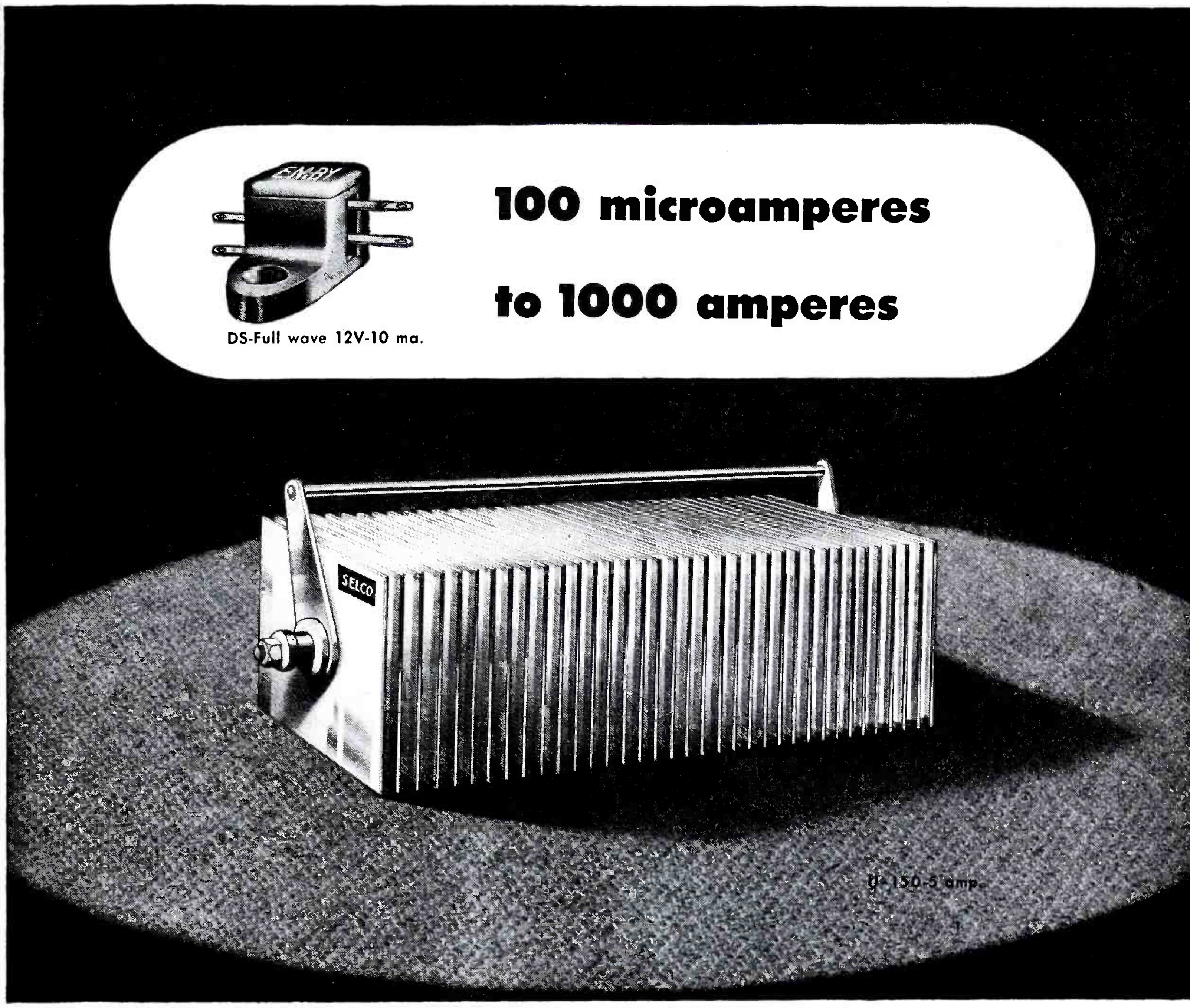
Steel strip, in such a production system, is coated with a layer of electrolytic tin. This coating is, in the crystalline state, characteristic of electrolytic coatings, being reduced to the even, homogeneous state desired by users of the product, by application of fusing temperatures. These operations are carried out at high speeds, often approaching 1,000 feet per minute. The speed may vary considerably with various factors affecting the electroplating section of the processing line. Hence, the heat treatment of the plated metal must vary, in degree of heating, with the speed of the metal strip. Other factors requiring compensation of the fusing temperature include ambient operating temperature, mass of the product, and variation in power supply systems operating the complete production system.

It has been stated that the prime factor governing the operation of such a production system is speed. In the tinned strip system described, therefore, means must be provided for the facile and rapid variation in the fusing temperature applied to the moving product. This requirement has been complicated by the addition of automatic control to the heat treating system, the automatic control tending to provide rather precise control of the treatment temperature. Such requirements dictate the considerations under which the heat treating equipment must operate. Since, in many of these processing systems, r-f induction heating provides the basis for the heat treatment section of the production system, the problem resolves itself into one involving the control, in power output, of a high power radio frequency system.

An effective means of varying the power output of an r-f oscillator or final amplifier stage is by variation of the voltage applied to the plate circuit system involved. In the past, this has been accomplished by means of an a-c induction voltage regulator incorporated into the power supply rectifier. However, the induction regulator itself introduces an appreciable time lag into the control system. Such regulators affect control in voltage through displacement, mechanically, of the rotor with respect to the stator, the displacement being produced by means of a small motor equipped with a worm gear reduction train. It appears that the induction regulator system must, eventually, be superseded by a more rapid and readily controlled system, preferably one in which the control may be applied directly with the control voltage from the automatic indication equipment. The only means of such control, at this writing, which suits all these requirements, is the phase-controlled thyratron rectifier. Such rectifiers are already being applied in numerous industrial applications.

Though the conventional thyratron or grid-controlled gas rectifier is generally well understood, a brief review of the characteristics of this tube lends itself well to the explanation of certain peculiarities in its use as a controlled rectifier.

Essentially, the thyratron is a conventional triode, or even a tetrode, in which the tube atmosphere has been purposely adulterated with any one of the noble gases, such as neon, argon, or mercury vapor. The introduction of the gas or vapor affects the characteristics of the tube materially. Foremost, the grid maintains control over the tube only when negative with respect to the tube cathode, and this prior to the application of the plate voltage. Once the grid-to-cathode voltage is reduced to a critical value, this varying with the gas or vapor contained in the tube atmosphere, a portion of the tube atmosphere ionizes, the grid having no further control over the tube plate current after this occurence. The plate current characteristics of the tube are then similar to any hot cathode gas or vapor rectifier, in that the plate-to-cathode voltage is low, and practically constant



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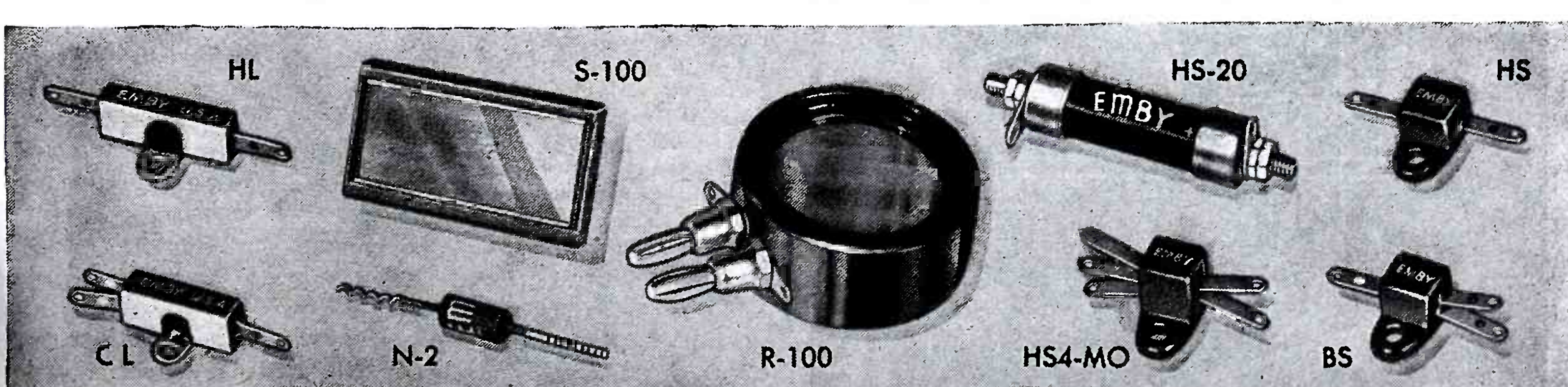

regardless of current conducted through the tube. Grid control may be secured once again only by first placing the control grid negative with respect to the cathode, then interrupting the plate current, or reducing it to a low critical value. These, generally, are the characteristics of the thyratron when operated from continuous currents which do not approach zero volts during their application to the thyratron system.

Resistive Load Operation

When the thyratron operates from an alternating voltage source, it ceases to conduct during the negative alternation of each cycle, functioning as a rectifier. Hence, grid control may be secured during any of the negative alternations. Moreover, during the first positive half-cycle of the applied voltage wave train, decrease of the grid voltage to the critical value may not result in the complete conduction of the entire positive alternation, the latter being conducted only partially. This condition is illustrated in Figure 1. Here, E_b is the thyratron plate-to-cathode voltage, and I_b the load current conducted by the tube. Evidently, the load is purely resistive, since the load current is in phase with the applied voltage. At the time ϕ in the alternation shown, the grid-to-cathode voltage is altered in such a manner that the grid swings positive. Here, the grid voltage falls to zero, passing through the critical grid voltage E_j, at which instant the tube gas ionizes and the tube begins to conduct. The current conducted by the tube in this alternation is represented by the area I_p, which is but a portion of potential total load current, I_b. During the conduction period, the plate-to-cathode voltage decreases to a relatively constant value E_a, which is the critical voltage drop characteristic of the gas or vapor present in the tube atmosphere.

The total current which may be conducted by the thyratron can readily be represented thus:

$$i = \int_0^{\pi} \frac{I \sin\omega t \, d\omega t}{2\pi}, \text{ where} \qquad (1)$$

i is the current conducted by the tube (average), *I* the crest tube current, and ω is the angular velocity, if the applied voltage wave is sinusoidal in form. The current is integrated over the entire cycle, since the representation of Figure 1 is that of a half-wave rectifier which conducts only the positive half-cycle of each complete cycle. This expression reduces to:

$$i = 0.318\ I, \text{ where}$$

i is the average current conducted by any half-wave rectifier.

However, in the instance of Figure 1, the conduction is not over the entire positive alternation. Consequently, expression *1* may be limited to the condition shown in Figure 1. Thus:

$$i_o = \frac{I}{2\pi}\int_{\phi}^{\pi} \sin\omega t \, d\omega t, \text{ where} \qquad (2)$$

i_o the *base-limited* current conducted by the thyratron, and ϕ is the lag angle in the grid voltage with respect to the plate-to-cathode voltage wave. From this, it is quite evident that the average current, or even voltage, conducted by any thyratron rectifier which employs an a-c grid voltage, similar in frequency but variable in phase relationship to the applied voltage wave form of control, may be readily varied through the expedient of increasing or decreasing the *phase lag* of the a-c grid voltage, with respect to the cathode-to-plate voltage wave. This is the fundamental concept of rectifier thyratron phase-control.

The peculiar form of the critical grid voltage wave in Figure 1 is largely due to the manner in which the positive grid current is limited. Normally, the critical grid voltage might be representated by the a-c negative alternation E_g, in which the instantaneous value of this voltage with respect to the tube cathode, represented by the zero voltage axis, is directly dependent on the plate-to-cathode voltage. Typical control characteristics for a thyratron tube are given in Figure 2, in which E_B is the tube plate-to-cathode voltage, and E_G is the grid-to-cathode voltage. If the real plate-to-cathode voltage is E_p as is indicated here, the negative grid voltage required to maintain the tube atmosphere non-conductive is obviously E_g, an a-c voltage having quite the form, but not the amplitude of the impressed plate-to-cathode voltage. It should be observed that conduction by the tube is not possible until the impressed plate-to-cathode voltage exceeds the characteristic ionization potential. Hence, the grid voltage critical characteristic is non-sinusoidal in this region. Further, since the grid current, when the control grid is positive with respect to the cathode, must be limited, it is conventional to insert a rather high resistance in series with the grid. Under this condition, when the plate is positive with respect to the cathode, the grid-plate capacity is sufficient to introduce a portion of the plate-to-cathode voltage in series, effectively, with the control grid, producing the critical grid wave form E_j. Such a theoretical conception of the composition of the critical grid voltage is sufficient indication that the a-c grid control voltage, to be effective in providing phase-control, must be several times the magnitude of the crest critical grid voltage.

Radiation Control

Since the radio engineer's most effective means of control over objectionable radiations from power r-f equipment is, admittedly, the application of plate voltages having the least possible ripple modulation to such equipment, the application of power outputs from a phase-controlled rectifier system would require, apparently, considerable filtering. The application of such a rectifier, then, reduces to selection of a phase-controlled rectifier in which the d-c ripple modulation over the desired control range is within the ripple factor of an economical filter.

An exemplary circuit for a base-controlled rectifier is shown in Figure 3. The a-c power is drawn, in this circuit, from a conventional three-phase system, and is converted into four-phase power through application

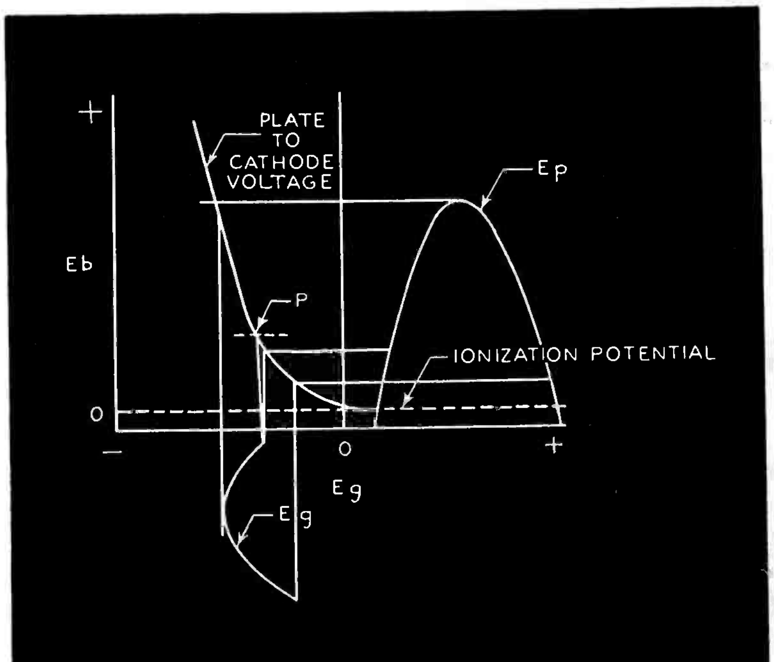

Figure 2
Typical control characteristics of a thyratron tube. Here E_b is the tube plate-to-cathode voltage and E_g is the grid to cathode voltage. Since the real plate-to-cathode voltage is E_p, the negative grid voltage required to maintain the tube atmosphere nonconductive is E_g.

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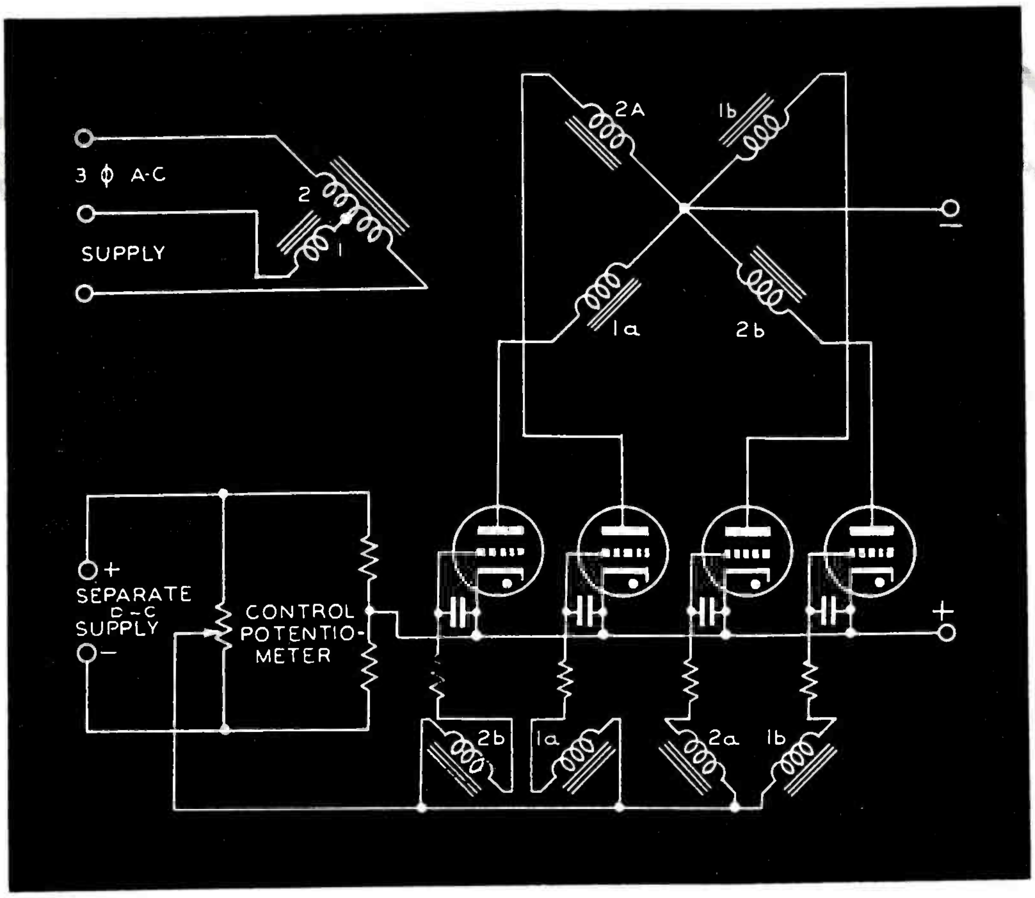
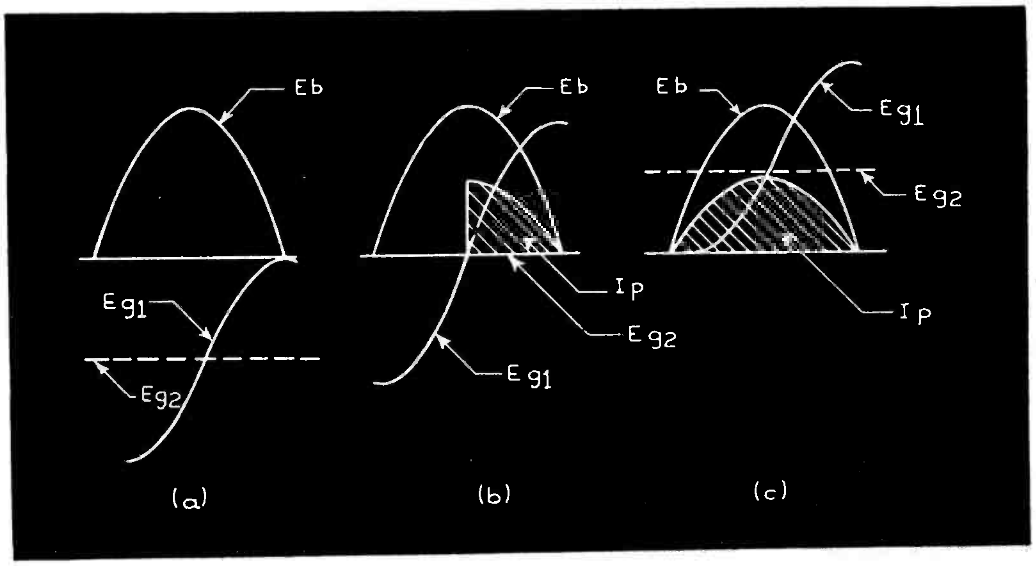


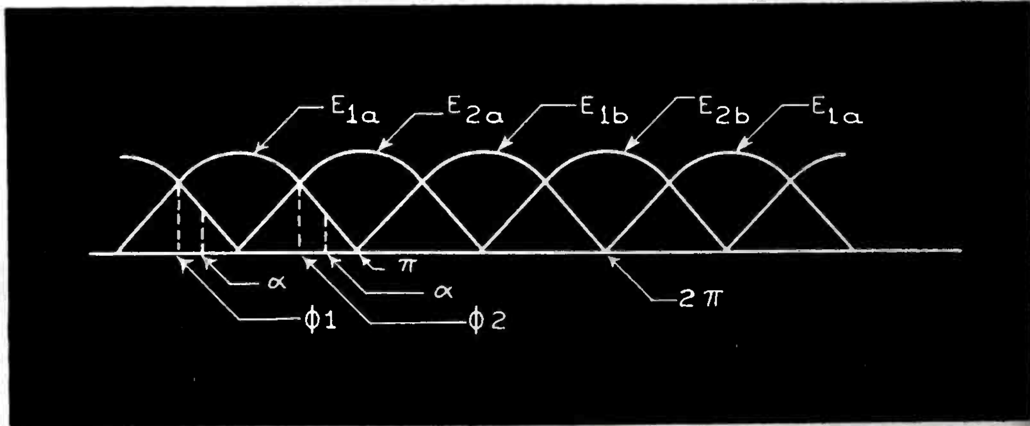
Figure 3
A phase-controlled rectifier wherein a-c power is derived from a three-phase system and converted into four-phase operation.

of the familiar Scott *T* arrangement. The rectifier proper consists of four phase-controlled thyratrons; hence the system is in the four-phase half-wave classification. It should be taken into consideration that the a-c components of the grid voltages lag the anode voltages applied to the tubes by 90°, these a-c grid components being conveniently derived directly from the plate system transformer. Control over the thyratrons is effected by the grid voltage d-c component, which is variable in magnitude and is reversible in polarity with respect to thyratron cathodes. This follows, since the cathodes of the thyratrons are connected with the voltage divider center tap, the latter being connected across the separate control d-c power supply. This is also true of the control potentiometer. The variable contact of the control potentiometer thus varies the d-c voltage and polarity of the thyratron control grids with respect to the cathodes.

Operation of the rectifier is illustrated briefly, in the graphs of Figure 4. In Figure 4*a*, the grid d-c component of one of the thyratron grids is indicated as E_{g2}, the a-c component being shown as E_{g1}. Since the d-c component of the grid voltage is extreme negative with respect to the tube cathode, represented by the zero axis of the a-c plate voltage wave E_B, the grid voltage modulation peaks, remaining negative with respect to the tube cathode, do not swing the tube grid positive with respect to the former electrode. Hence, at this time, the tube does not conduct. In Figure 4*b*, the d-c grid voltage component is zero, and the tube conducts at 90°. Full *forward* conduction is obtained in Figure 4*c*, wherein the d-c component of the grid voltage is sufficiently positive to maintain the grid positive over the duration of the entire positive alternation in the plate voltage. Manipulation of the d-c control voltage, therefore, effects variation in the average current output of the rectifier system.

A pattern of the output voltages provided by the rectifier in Figure 3 is shown in Figure 5. The plate voltages are represented by the half-cycles $E_{1a\ 2a\ 1b\ 2b}$. Each positive alternation is displaced by 90° with respect to the adjacent pulses, in a symmetrical pattern. Consideration of these voltages indicates that, with resistance loading, the load current is commutated from the preceding to the succeeding pulse at the angles ϕ_1, ϕ_2, etc., where the voltages pass through equality. Here, the total amplitude of the ripple voltage is at its minimum.





Figures 4 (above) and 5 (right)
In Figure 4 *a*, the grid d-c component of one of the thyratron grids in the phase-operated unit shown in Figure 3 is indicated as E_{g2}, the a-c component being shown as E_{g1}. In *b*, the d-c grid voltage component is zero and the tube conducts at 90°. In *c*, we see *full forward* conduction. Here the d-c component of the grid voltage is sufficiently positive to maintain the grid positive over the duration of the entire plue alternation in the plate voltage. In Figure 5, appears a pattern of the output voltages provided by the rectifier illustrated in Figure 3. The plate voltages are represented by the half cycles $E_{1a,\ 2a,\ 1b,\ 2b}$.

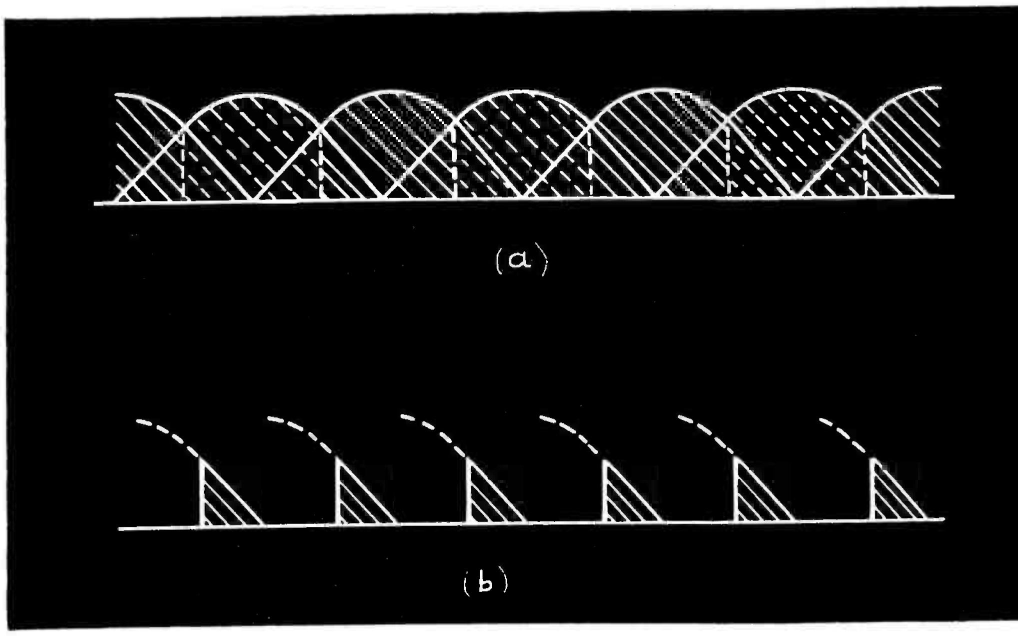


Figure 6
In *a*, appears the pattern of the current delivered to the filter system input terminals. In *b*, the pattern shown results when the thyratrons are restricted to conduction late in each half cycle.

The current delivered to the filter system input terminals is given in the pattern of Figure 6*a*. It is observed that the current is conducted by each thyratron only over half of each alternation, conduction beginning, with commutation, after the first quarter, and ceasing after the third quarter, in each alternation. From this, it follows that the similar instance involving the output voltage may be written as follows:

$$e = \frac{E}{\frac{\pi}{2}} \int_{\phi_1 + a}^{\phi_2 + a} \sin \omega t \, d\omega t, \text{ where} \qquad (3)$$

e is average voltage, and *E* the crest voltage provided by each tube. The form of the rectifier d-c output voltage from *3*, indicates ready analysis with respect to the ripple voltage components contained. Further, it is observed that each rectified voltage pulse approaches square-topped form; therefore, the curvature of each voltage pulse-crest will decrease with an increasing number of rectifying phases.

Application of phase-control to the thyratron rectifiers alters the character of each voltage pulsation considerably. In Figure 6*b*, the thyratrons are restricted to conduction late in each half-cycle. The *current* ripple, under extreme phase control, increases considerably. However, in the instance of Figure 5, it may be seen that the voltage ripple increase may be restricted by restricting the phase-control lag angle to a value less than half the conduction angle. The average voltage delivered by the rectifier to the load, if the latter is a resistance, may be found from:

$$e = \frac{2E}{\pi} \int_{\pi/4 + a}^{3/4\pi + a} \sin \omega t \, d\omega t, \text{ where} \qquad (4)$$

$\frac{\pi}{4}$ is the origin of the conduction and $\frac{3\pi}{4}$ is its angular limit. The phase control angle, which is variable, is given by α. However, the expression *4* is a special case of the original expression *3*, which is the rectifier average output voltage. Hence, limitation of the phase-control lag angle must inevitably limit the range over which the rectifier voltage output may be varied.

Here, an important detail of the phase-control must be taken under consideration. In Figure 6*b*, and also from Figure 5, as the phase lag control angle is increased, it approaches the primary limits imposed by the points of inflection in each phase voltage, at the angle $\frac{\pi}{2}$ in each instance. If the lag angle α is increased to these limits, each of the thyratrons, will evidently, conduct at the 90° angle. It is possible to increase the angle of phase lag beyond these limits, in which instance the average voltage output must be given in two expressions, including *4*, since the function is then discontinuous. However, nothing is to be gained from such an expedient insofar as limitation of the output ripple voltage is concerned, the ripple voltage exceeding any acceptable limit once the points of discontinuity are attained. Extension of the lag angle will, however, increase the range of control over the average voltage output (Figure 6*b*), each phase conduction angle decreasing with increases in the angle α. Thus, it may be deduced that an increase in the possible phase lag angle, below the limits of discontinuity, with small ripple voltages, woud appear to be a theoretical possibility.

It has been stated that an increase in the number of rectifying phases would prove advantageous from the aspect of decrease in the curvature, in the maximum voltage region, of each conduction period. This suggests that application of phase-control to an increased number of rectifying phases would also tend to increase the phase lag angle permissible with minimum increase in the ripple output voltage. Figure *7* is a partial pattern of a six-phase half wave output system. In this pattern, the commutation of the load current occurs at the angles $\frac{\pi}{3}$ and $\frac{2\pi}{3}$, respectively, for the two succeeding rectified alternations. The average voltage for which this wave is a representation may be readily found, then, through application of these new limits to expression *3*. It must be further observed that conduction of the load current now exists only over one-third of each alternation. Hence, the average expression for the six-phase half-wave system of Figure *7* may be written as:

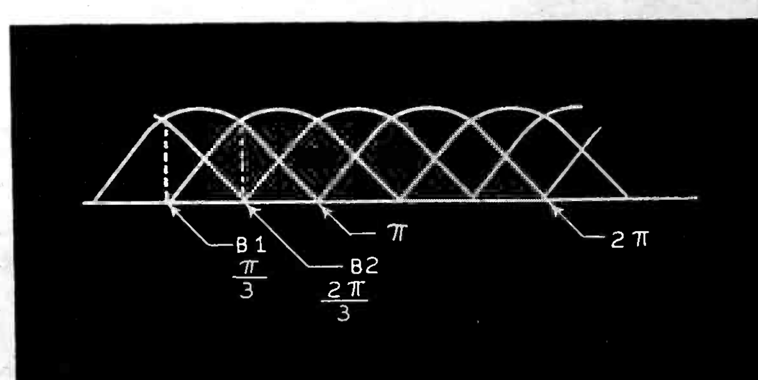
$$e = \frac{3E}{\pi} \int_{\pi/3 + a}^{2/3\pi + a} \sin \omega t \, d\omega t,$$

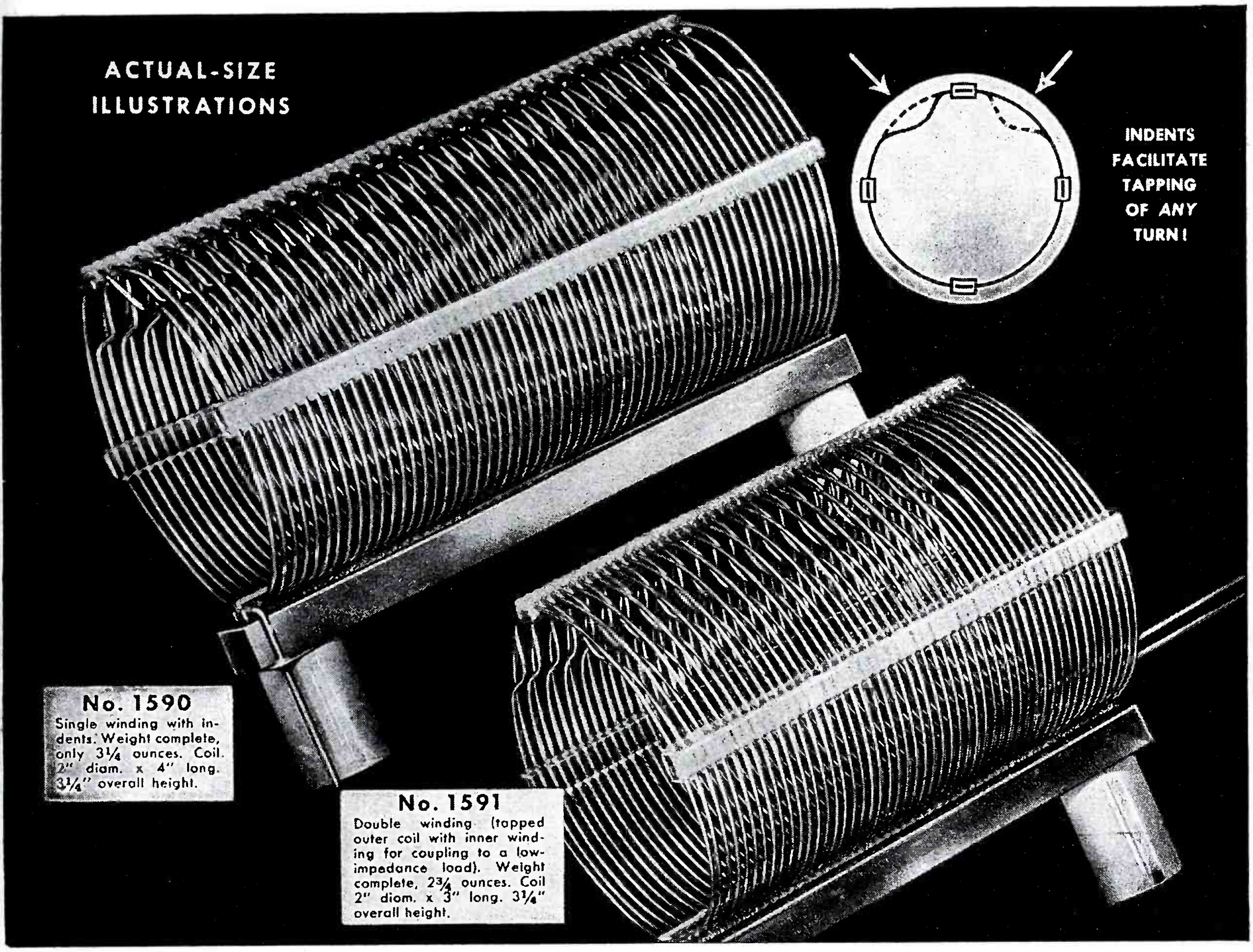
in which *e* is the average voltage delivered to the output terminals of the rectifier.

In the case of the four-phase half-

(*Continued on page* 120)

Figure 7
A partial pattern of a six-phase half-wave output system.





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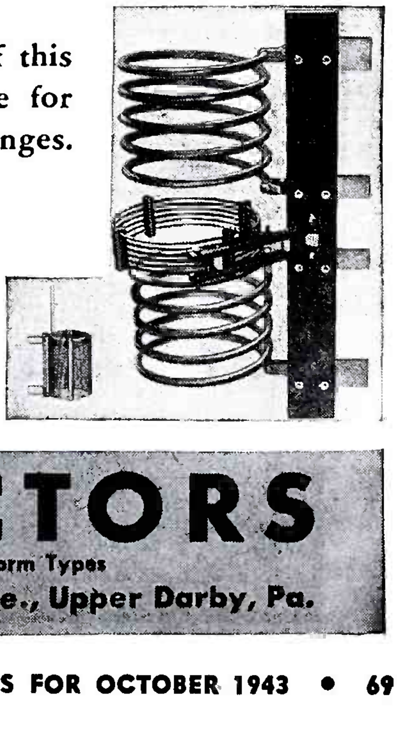

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RSS AND PARALLEL R-X SLIDE RULES

by WARREN G. BROWN

IN the July issue of COMMUNICATIONS* an excellent method of solving parallel resistor problems by means of a reciprocal slide rule was described. With this slide rule as a basis of thought, two additional types of scales have been developed. They solve a number of interesting problems. The first scale (*A*) solves problems of the form $X = \sqrt{A^2 + B^2}$, in which any of the quantities may be unknown. The second scale (*B*) solves problems of the form

$$|Z| = \frac{1}{\sqrt{\frac{1}{R^2} + \frac{1}{X^2}}}$$

Problems of the first scale (*A*) occur in finding the magnitude of the impedance of series reactance and resistance, the effective value of superimposed currents or voltages of different frequencies, the admittance from susceptance and conductance, and the hypotenuse of a right triangle. Any number of squared terms may be under the radical.

The second scale (*B*) applies to problems met when parallel resistors and condensers or inductances are used. The two elements beneath the radical must be at right angles in an electrical problem as shown in Figure 1.

Scale (*A*) is illustrated in Figure 3. Since the ratio of the largest number *5* to the smallest number *0.5*, is only ten to one, it is necessary to have three scales to cover the complete range to best advantage. Three separate scales could be made, but it is more convenient to put three sets of numerals along the same scale. The two other sets, covering a range of from *0* to *10* and from *0* to *20*, are obtained by multiplying the original scale by *2* and *4* respectively. To prevent confusion each set of numerals should be lettered in a different color if possible. A little more care is needed in reading the outside scales because the major divisions are

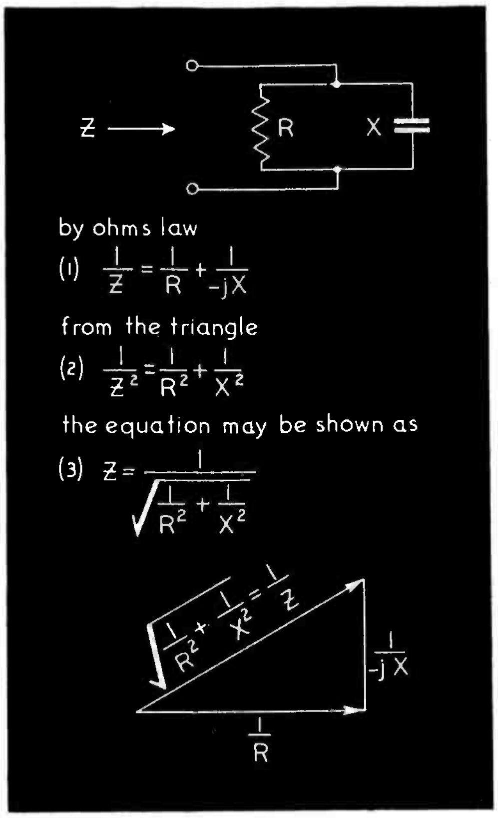


Figure 1

marked for the inside scale. As an example take the point *7* on the outside scale. There is no division opposite this point because it corresponds to *1.75* on the inside scale. Marking an odd point such as *1.75* would only serve to make the inside scale harder to read also.

Both scales are shown with the zero at the left end. This approach was followed since it simplifies the project of laying out the scales. The two scales may be lined up and the lines drawn across both of them at the same time. Of course the same thing may be done with the reciprocal slide rule. When using the rule it makes very little difference in which direction the scales read.

All of the divisions shown in the sketch are not given in the table. The scale is linear enough so that the divisions may be divided in halves or

*Robert C. Paine, *A Reciprocal Slide Rule;* pp. 16, 17, 86, 91.

See page 72 for RSS and Parallel R and X scales.

fifths without appreciable error. This may be done by eye. The distances in the table are given to the nearest tenth of a millimeter but they do not have to be laid out that accurately. This accuracy may be approached with good technique or special equipment. Too many divisions should be avoided when the scales must be marked by hand. Even when using a fine drawing pen the lines obtained are much wider than those on a 10″ slide rule. It is not difficult to interpolate between divisions up to 5 mm apart.

Figure 2 shows how the length of the hypotenuse of a right triangle having legs of *3* and *4* units may be obtained. The answer *5,* happens to be at the limit of the scale, but the problem could be worked on the next scale easily. The best way to become familiar with these scales is to try out a few well known combinations. The readings should come out well within one millimeter of the correct point if reasonable care has been exercised in calibration.

Referring to scale (*B*) (Figure 3), if there are several resistors or several reactors the resultant resistance and the resulting reactance may both be found separately on the reciprocal slide rule and then substituted in the equation by means of this scale. The reciprocal slide rule will solve any parallel impedance probem if the two impedances are at the same angle or are separated by 180°. This scale will solve any parallel impedance problem, if the two impedances are at right angles. Between the two scales any problem of this type could be solved, although series circuits would have to be converted into parallel circuits first. It should be noted that only two terms may be put under the radical in an electrical problem. The slide rule could handle more terms but the an-

(*Continued on page* 120)

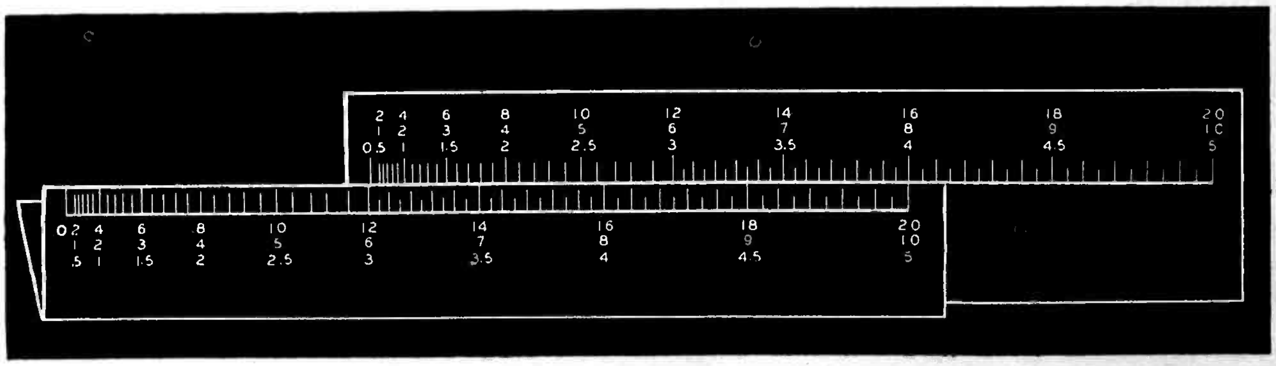
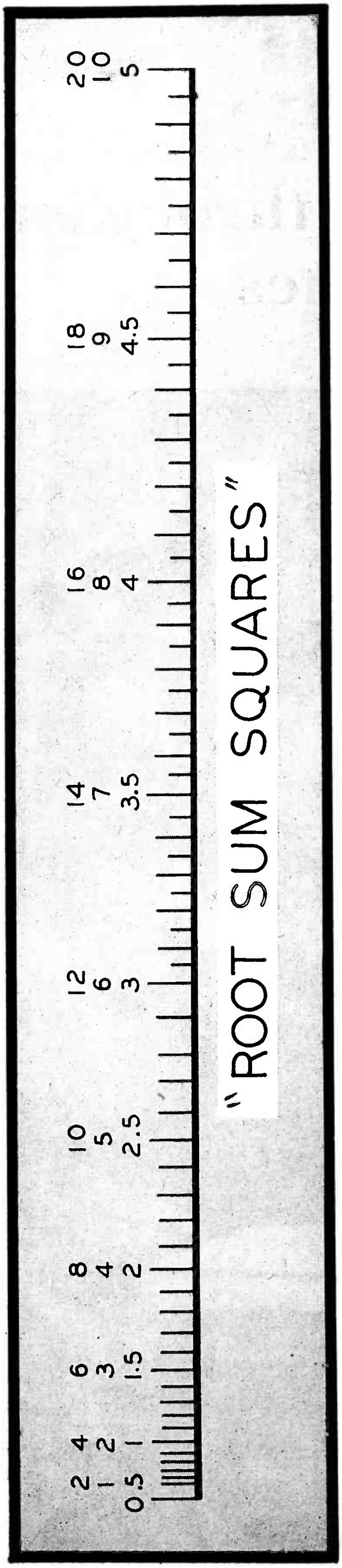


Figure 2
Scale *A* (RSS scale) arranged in typical slide rule fashion to show its use. In this particular figure, the scales are placed to show how the length of the hypotenuse of a right triangle having legs of three and four units may be obtained.

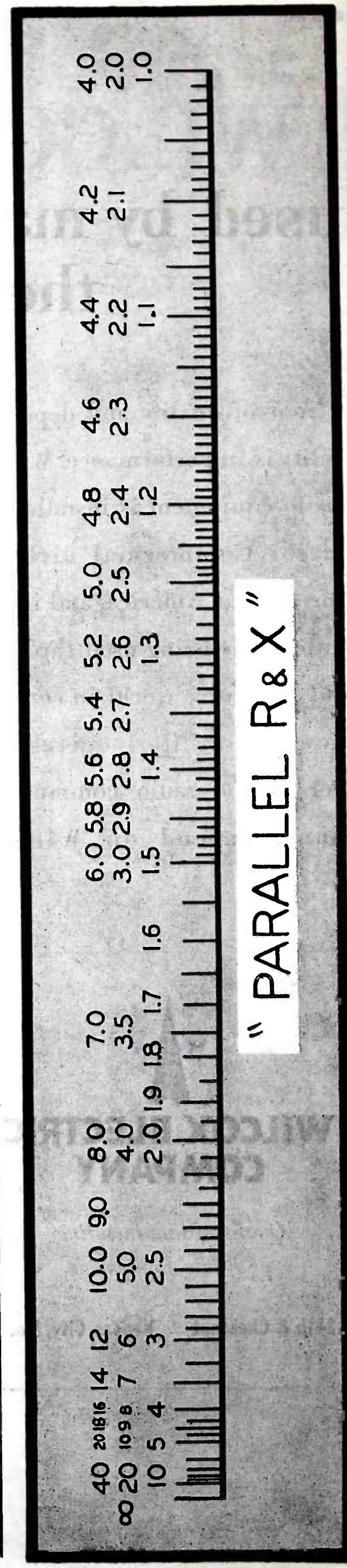


Scales for Figure 3(A)
RSS Scales

No.	Cm.	No.	Cm.
0.0	0.00	2.8	7.84
0.5	0.25	2.9	8.41
0.6	0.36	3.0	9.00
0.7	0.49	3.1	9.61
0.8	0.64	3.2	10.24
0.9	0.81	3.3	10.89
1.0	1.00	3.4	11.56
1.1	1.21	3.5	12.25
1.2	1.44	3.6	12.96
1.3	1.69	3.7	13.69
1.4	1.96	3.8	14.44
1.5	2.25	3.9	15.21
1.6	2.56	4.0	16.00
1.7	2.89	4.1	16.81
1.8	3.24	4.2	17.64
1.9	3.61	4.3	18.49
2.0	4.00	4.4	19.36
2.1	4.41	4.5	20.25
2.2	4.84	4.6	21.16
2.3	5.29	4.7	22.09
2.4	5.76	4.8	23.04
2.5	6.25	4.9	24.01
2.6	6.76	5.0	25.00
2.7	7.29	(Values given to the nearest .1 mm)	

Scales for Figure 3(B)
Parallel RxX Scales

No.	Cm.	No.	Cm.
∞	0.00	1.90	6.93
10.0	0.25	1.80	7.72
9.0	0.31	1.75	8.16
8.0	0.39	1.70	8.65
7.0	0.51	1.65	9.19
6.0	0.69	1.60	9.76
5.0	1.00	1.55	10.41
4.75	1.11	1.50	11.11
4.50	1.23	1.45	11.89
4.25	1.38	1.40	12.75
4.00	1.56	1.35	13.72
3.75	2.04	1.30	14.79
3.25	2.37	1.25	16.00
3.0	2.78	1.225	16.63
2.9	2.97	1.200	17.36
2.8	3.19	1.175	18.08
2.7	3.44	1.150	18.90
2.6	3.70	1.125	19.75
2.5	4.00	1.100	20.66
2.4	4.34	1.075	21.63
2.3	4.73	1.050	22.68
2.2	5.16	1.025	23.78
2.1	5.66	1.000	25.00
2.0	6.25	(Values given to nearest .1 mm.)	



Destination Known

Somewhat at the mercy of the elements, a paratrooper can't always select the exact spot for his landing. But he will approach his objective.

With new applications for electronic devices appearing rapidly, we can't be very specific about our peacetime program now. One thing is certain, however... *we know where we are going.* If past performances and present accomplishments are any indication, we can anticipate our postwar objectives and plan for them accordingly. Specialists in the electronic field for almost a quarter century, ours is a progressive organization, with perfectly coordinated labor-management relations. Ever on the alert for new ideas, we cannot help but compile an enviable record of advanced designs and applications, many of which appear to be suited for postwar civilian requirements. Today, 100% in vital war work, production schedules occasionally permit us to accept additional contracts of a similar nature. May we be of service to you?

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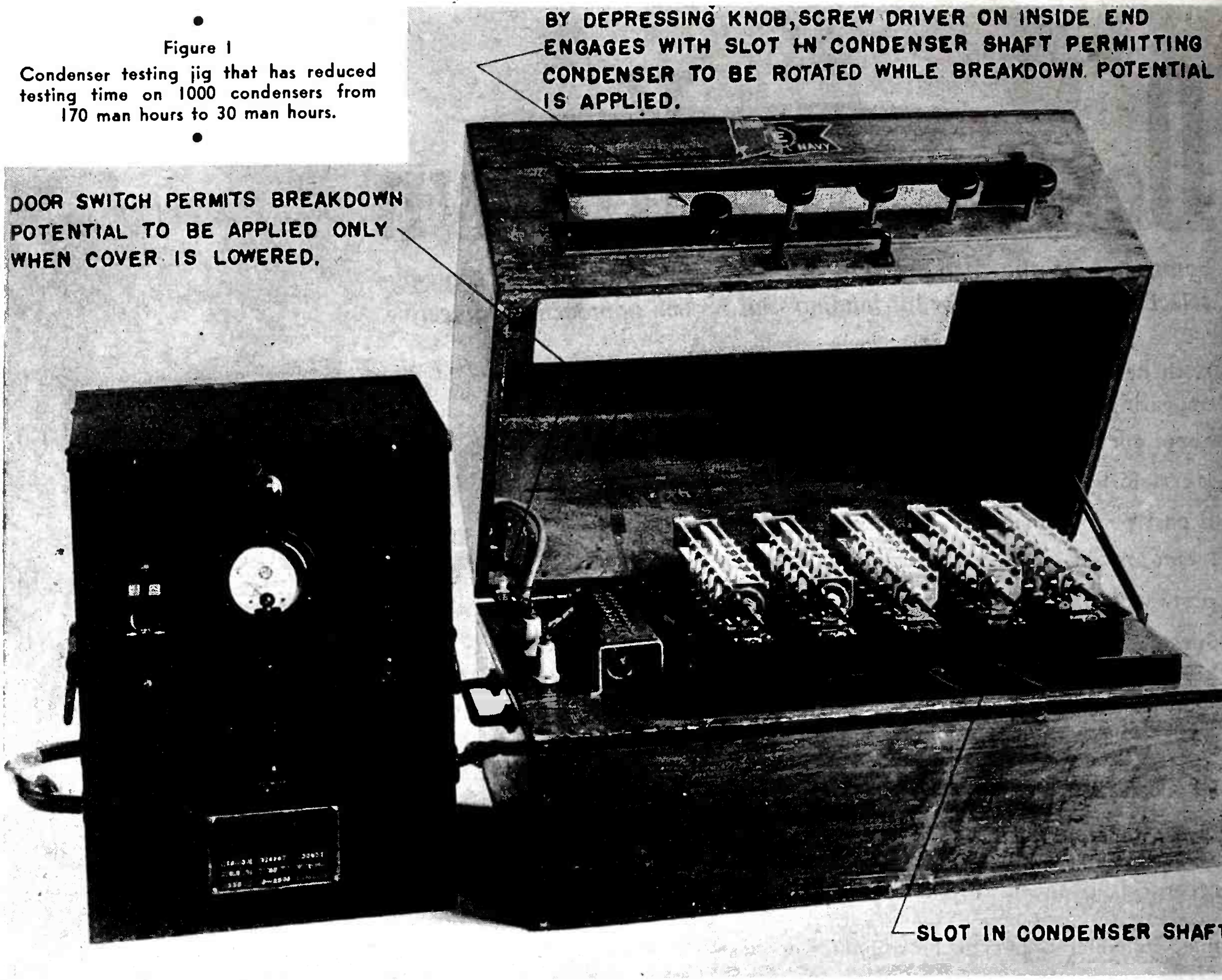


Figure 1
Condenser testing jig that has reduced testing time on 1000 condensers from 170 man hours to 30 man hours.

PRODUCTION AIDS

War Production Drive Award Winners

THE communications industry can well be proud of its vast army of war workers. Their award winning production-aid suggestions in the WPB War Production Drive have been responsible for the saving of millions of dollars and hundreds of thousands of invaluable man-hours. And the campaign is far from over. Daily hundreds of suggestions roll into Washington headquarters . . . suggestions that are speeding production schedules to new highs every minute.

Through the courtesy of the WPB, a few of these amazing time-saving suggestions that have won WPB Production Awards, are presented.

Condenser Testing Jig

In Figure 1 appears a condenser testing jig suggestion sent in by E. M. Bercvarick, of Western Electric, that has reduced the time for testing 1,000 condensers from 170 man-hours to 30 man-hours or 140 man-hours savings. This jig has been used already on 19,000 condensers.

On the 1,000-volt breakdown test on condensers now requiring two men, one man can be spared by means of this jig. One man was formerly required to turn the condenser shaft, while the other applied the 1,000 volts. The motor will now turn the shaft.

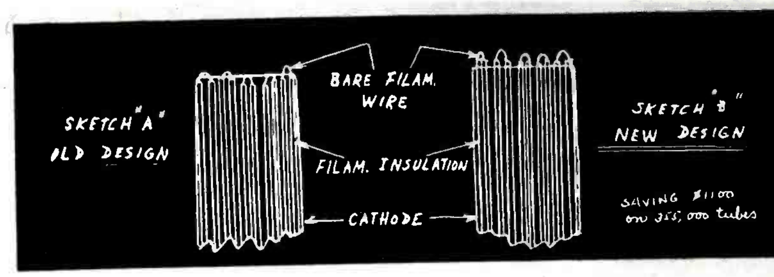
To insure variable condensers not breaking down under service conditions, a current of 1,000 volts is applied between plates, which is considerably more than service application. The use of two men on this operation was instituted in order to locate breakdown points with greater ease than is generally possible under power drive. By compromising on this suggestion, a manually operated jig was provided, which eliminated the extra man and retained the desirable feature of manual operation. As this is a continuous production job, the effect of this suggestion has been to release many man-hours for use on other work.

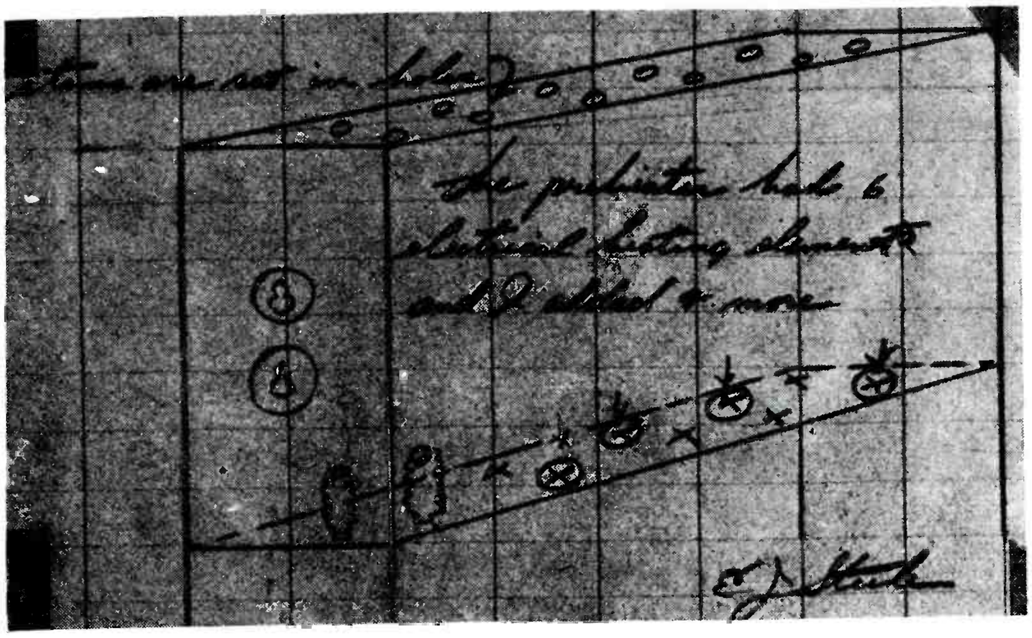
Tube Sealing Suggestion

As a result of the suggestion of Edward Steel of RCA, shown in Figure 2, a 3% reduction in main sealing shrinkage was obtained on type 815 power tube. Material or tube shrinkage saving will be $2,050 a year.

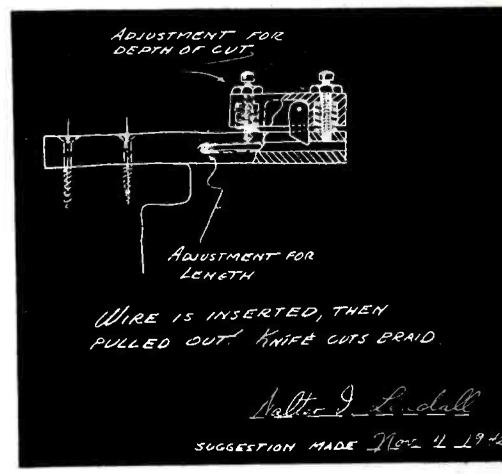
Mounts on power tubes are usually annealed and preheated to bring the stem temperature up and to avoid cracked seals. By adding four additional heating elements and improving

Figure 2 (below)
The suggestion of Edward Steel that affected a 3% reduction in main sealing shrinkage on type 815 power tubes.





Figures 3 (top) and 4 (below)
The suggestion of William J. Carlin appears in Figure 3. Figure 4 shows the unique wire braid shielding stripper developed by Walter G. Lindall.



the existing technique, better control of the main sealing-in operation was obtained.

The idea behind adding four heating elements to the type 815 pre-heater at the main sealing machine was to increase the temperature of the stem press, "it being a pressed glass stem" so that the temperature of the glass and the temperature of the sealing pin would be approximately equal. This in turn somewhat rectified the difference in the co-efficient of expansion between the metal and glass.

Filament Redesign

In Figure 3 appears an award winning suggestion of William J. Carlin, RCA.

In the past, on two receiving tubes, the filament apices were designed to be positioned in the cathode as at "*A*" and 2% to 3% heater-cathode shorts were common. With a redesign of the filament these apices were positioned above the cathode as per *B*, the bare heater to cathode shorts were reduced about 1%.

Wire Braid Shield Stripper

A unique wire braid shielding stripper to remove metal shielding from wire ends, that has saved 75% in production time, is shown in Figure 4. It was conceived by Walter I. Lindall of the Submarine Signal Company.

By the old method using scissors, one hour and thirty minutes was required to remove metal shielding from 100 wire ends or fifty-five seconds each. The time required for the same quantity with the improved stripper is twenty-five minutes or fifteen seconds each.

Glass Cutting

A glass cutting and splicing technique that on a gross production of 20,000 a year at 30% shrinkage (the material saving versus cost of salvage will amount to $7,500 per year), was developed by L. Cronin of RCA. It is shown in Figure 5.

Previously, no attempt was made to salvage an expensive anode (P-351-B1) for a special power type tube. These anodes were merely discarded for scrap copper. Then this glass cutting and splicing technique and recovery process was developed, and a salvage group was set up, with 40% of shrinkage tube anodes now being salvaged.

The copper anode has glass sealed to paper thin copper on either end. Previously, the glass was broken off in haphazard manner in order to save the internal elements. This anode can be saved by making hot cuts as indicated with sealing fires and splicing

(*Continued on page* 106)

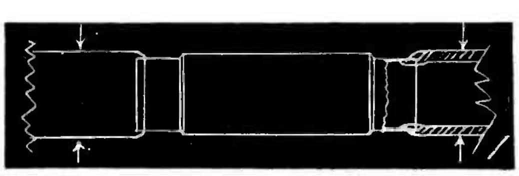


Figure 5
Glass cutting and splicing technique developed by L. Cronin that will save $7,500 a year.

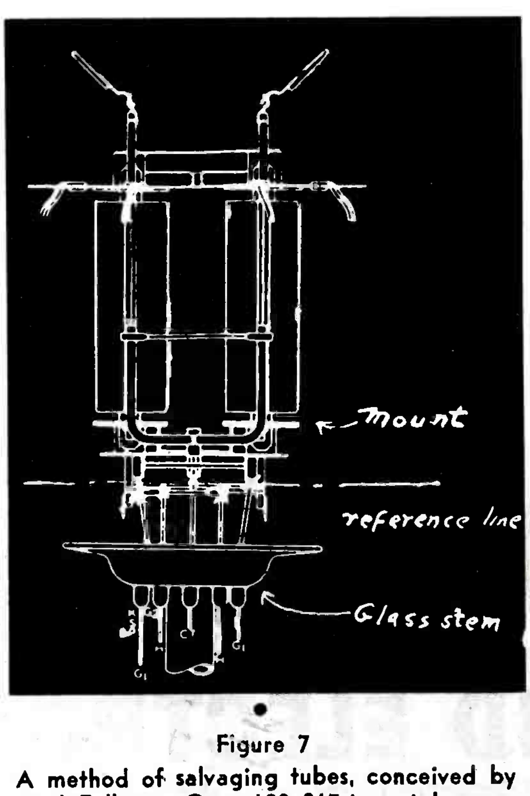


Figure 7
A method of salvaging tubes, conceived by Fred Follmer. Over 100 815-type tubes are recovered every month with this method.

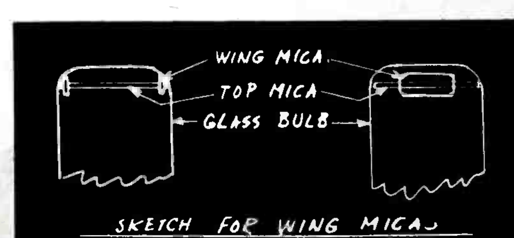
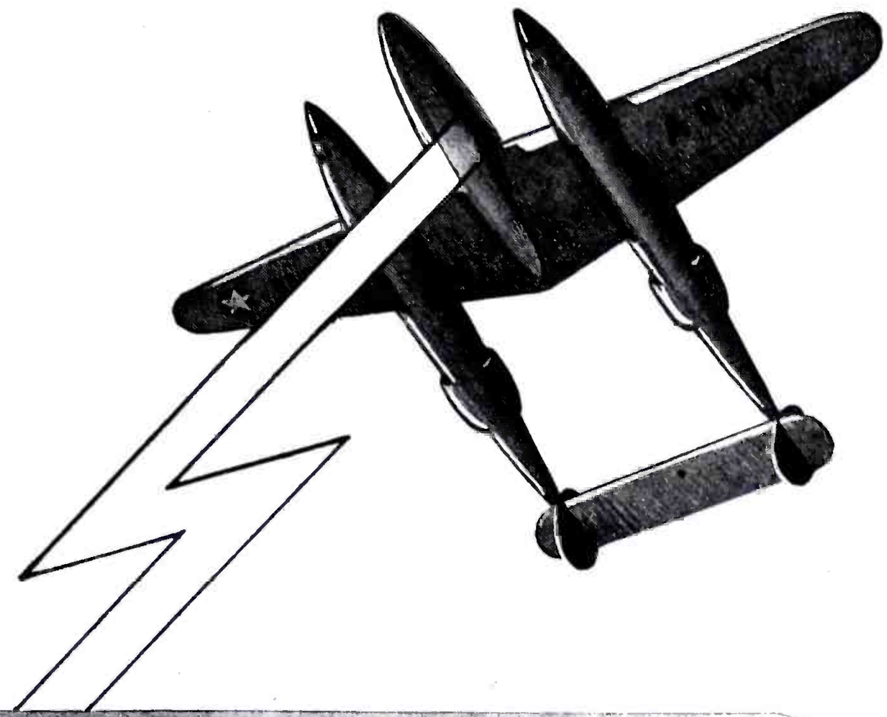
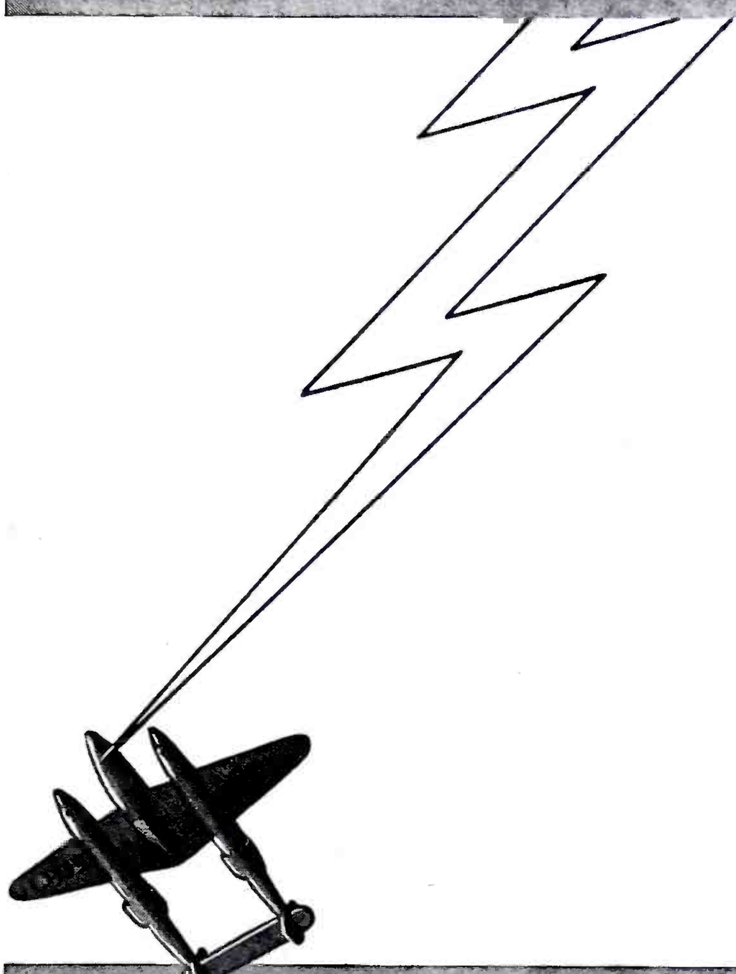


Figure 6
A suggestion eliminating the necessity of side, wing, or positioning micas on two types of receiving tubes, proposed by W. J. Carlin.



"ORANGE LEADER CALLING . . ." "ROGER!"



Pre-operational checking of transmitters helps make sure that messages will be received. Browning Frequency Meters (types S1 and S2) have for some years provided simple, comparatively inexpensive means for such checking. Type S2 is accurate to within .005%. They are easy to operate. They stand up under hard use. Full details are given in literature available upon request.

The balanced-capacitance Browning Signal System for plant protection without guard patrols is another product of Browning Laboratories research. A descriptive folder will be mailed when requested.

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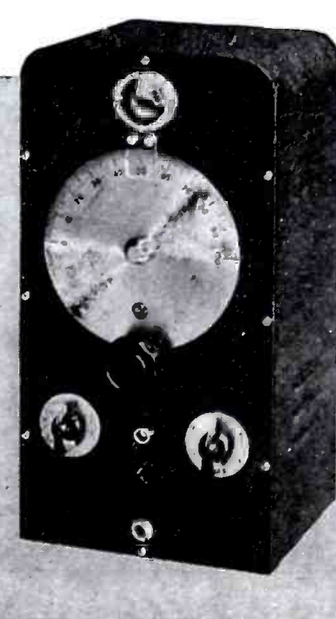
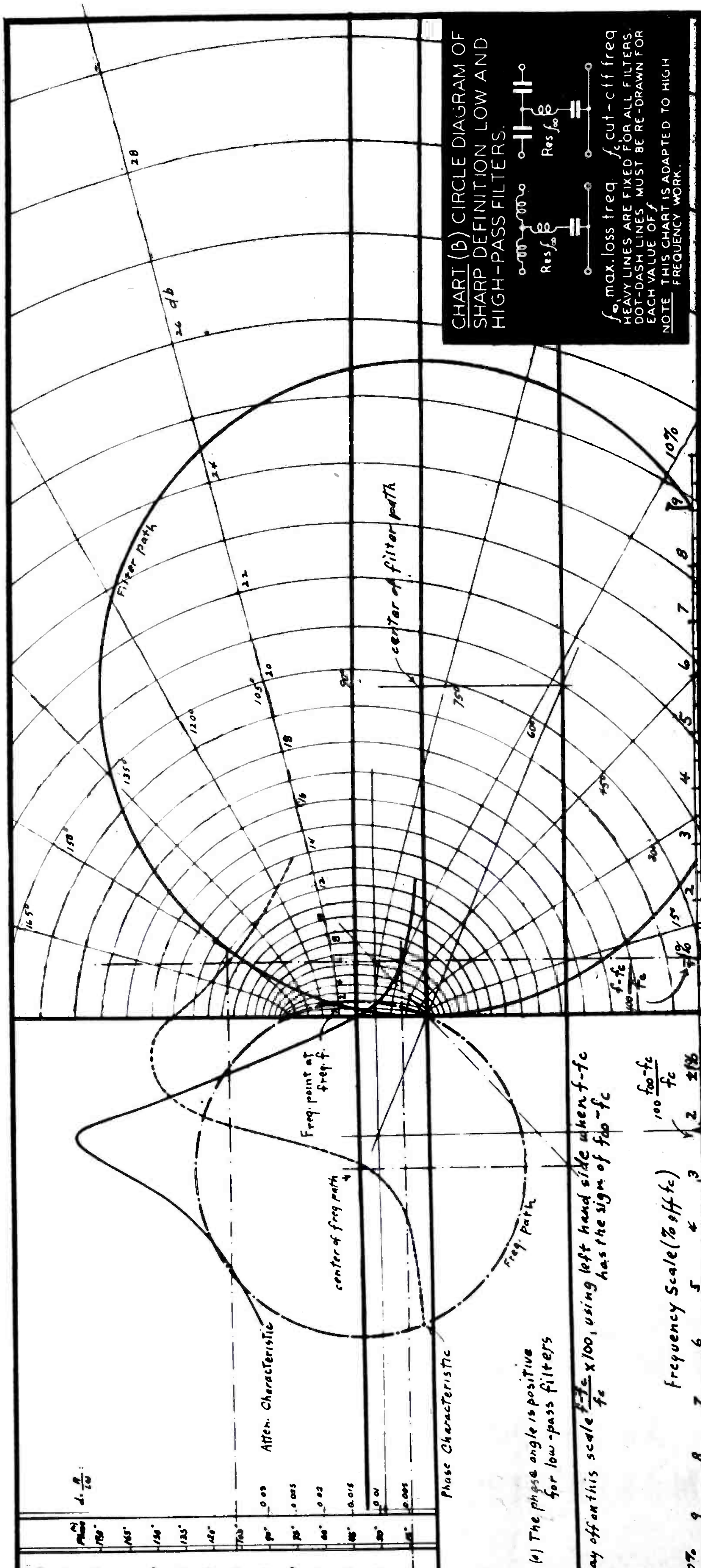




THE CIRCLE DIAGRAM

(*Continued from page* 25)

hence:

$$S(1-x)^2(n_2-n_1) = (x-n_1)(n_2-x) \tag{20}$$

$$[S(n_2-n_1)+1]\,x^2 - 2\left[S(n_2-n_1)+\frac{n_1+n_2}{2}\right]x + S(n_2-n_1)+n_1n_2 = 0 \tag{21}$$

Let m_1 and m_2 stand for the two roots of *20* i.e., for the squares of the ratios of cut-off frequencies to minimum loss frequency. And let:

$$P = S(n_2-n_1)$$

Then:

$$m_1m_2 = \frac{P+n_1n_2}{P+1} = \frac{S(n_2-n_1)+n_1n_2}{S(n_2-n_1)+1}$$

and finally

$$S = \frac{1}{n_2-n_1}\left(\frac{1-n_1n_2}{1-m_1m_2}-1\right) \tag{22}$$

Symmetrical Filters

This group includes confluent filters in which

$$n_1n_2 = 1$$

Frequencies of maximum loss and cut-off frequencies are then symmetrically spaced about the minimum loss frequency, provided a log scale is considered. In fact, the value of m_1m_2 (see the preceding discussion) is now:

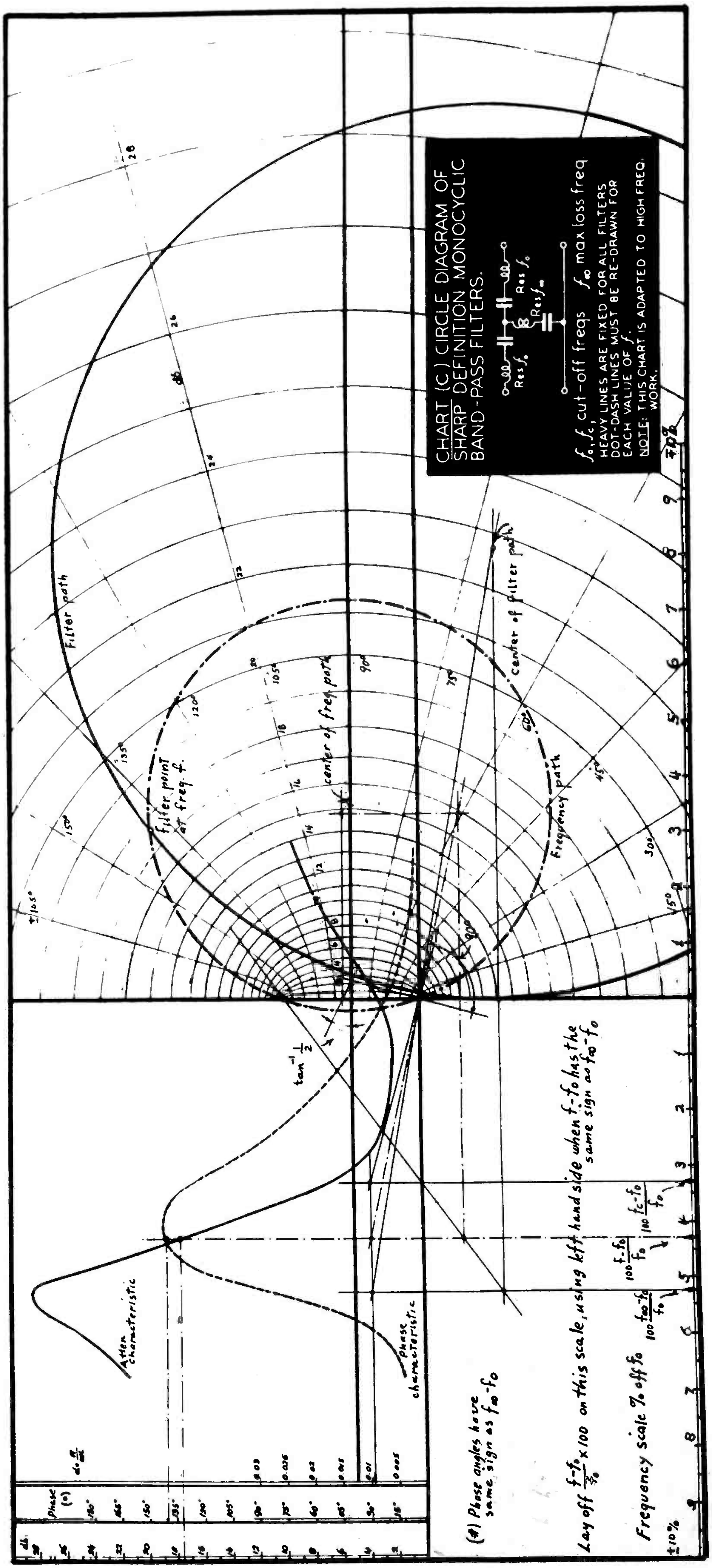
$$m_1m_2 = \frac{P+n_1n_2}{P+1} = 1$$

The expression of S given in equation *22* is meaningless in this case. The true value of S results by adding the two roots m_1 and m_2:

$$\frac{m_1+m_2}{2} = \frac{P+\dfrac{n_1+n_2}{2}}{P+1}$$

hence:

$$S = \frac{1}{n_2-n_1}\left[\frac{2-(n_1+n_2)}{2-(m_1+m_2)}-1\right] = \frac{1}{1-n_1^2}\left[m_1\left(\frac{1-n_1}{1-m_1}\right)^2-n_1\right] \tag{23}$$



Equation *18* may be expressed graphically as shown in Figure 7. The two points of coordinates u_1, v_1, and u_2, v_2, may be located on the U/S, V/S plane by intersecting paths of constant *n* with a path of constant *x*. It is understood that these paths no longer represent loci of the filter point when certain parameters are varied. They are merely the loci expressed by the equation:

$$u + jv = (1 - n)\frac{d + j(1 - 1/x)}{d + j(1 - n/x)} \qquad (25)$$

where $u = U/S$ and $v = V/S$. Two such loci, or *constant-n paths* are obtained if *x* is varied and *n* is kept constant at the values n_1, n_2. A third path (constant-*x*) connotes variation of *n* with *x* kept at some given value. The two former are distinctive of each filter section; the latter of each frequency.

Constant n Paths

If equation *25* is compared with equation *2* relating to monocyclic filters, it can be seen that the only difference is in the value of *M*, which for monocyclic filters is always a positive quantity, and is now replaced by the expression $1 - n$, the sign of which depends upon *n*.

Consequently, constant-*n* paths of confluent filters are obtained in the same way as the filter paths of Figure 5, having let

$$M = 1 - n\,, \quad M' = M\left(\frac{1}{n} - 1\right) = \frac{(1-n)^2}{n}$$

There are two constant-*n* paths for each confluent filter. These are shown, for each of five possible conditions, in Figure 8.

Constant-x Paths

From equation *25* we obtain:

$$\begin{cases} udx - v(x - n) = (1 - n)dx & \text{(r.p.)} \\ vdx - u(x - n) = (1 - n)(x - 1) & \text{(i.p.)} \end{cases}$$

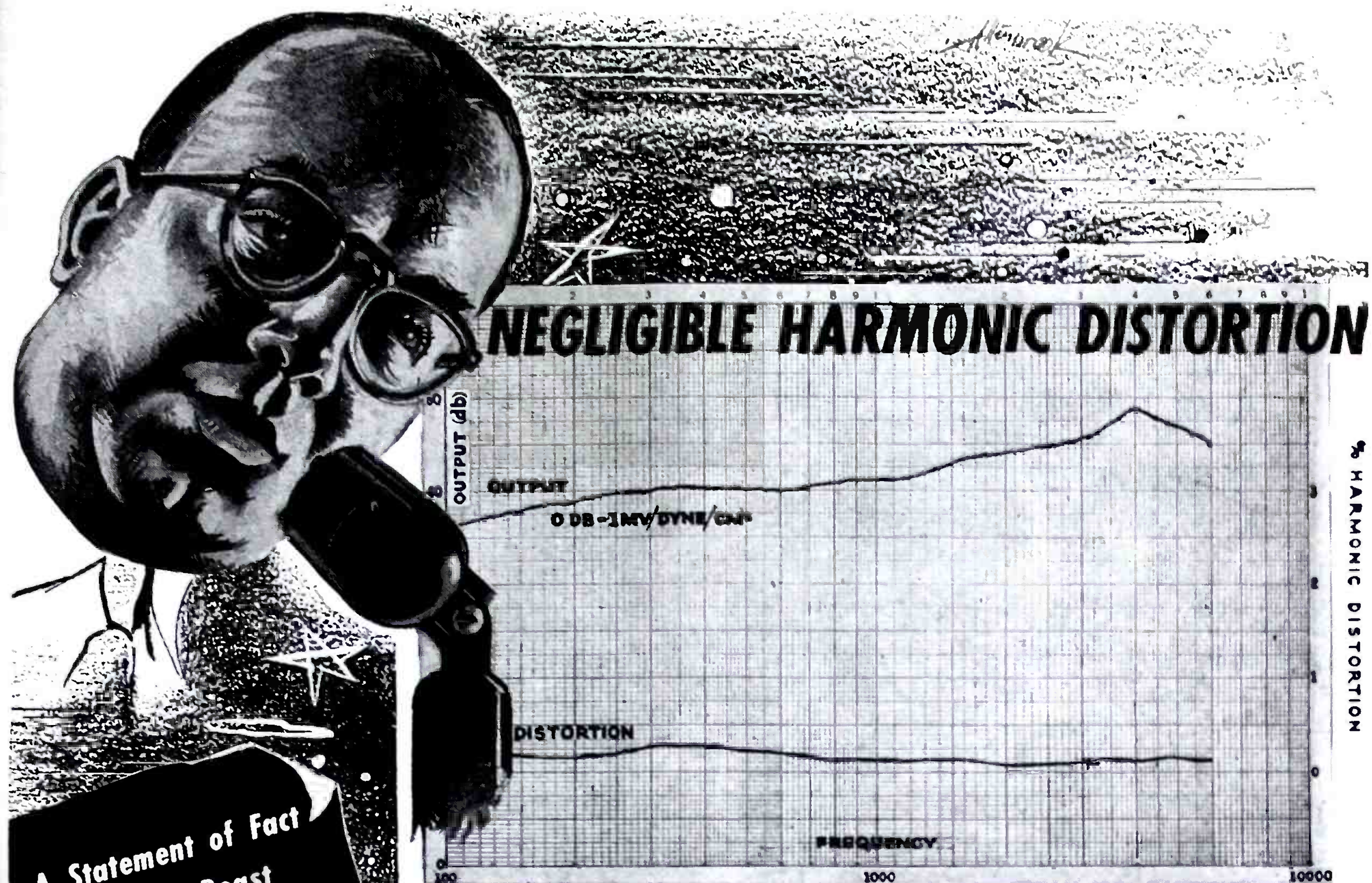
Hence:

$$n\left(\frac{v}{d} + x\right) = x\left(1 - n + \frac{v}{d}\right)$$

$$n(1 - x + n) = 1 - x + x(u + vd)$$

and finally:

$$u^2 + v^2 + v\left(\frac{(1-x)^2}{dx} + dx\right) = 0 \qquad (26)$$



A Statement of Fact —Not a Boast

Every microphone manufactured by Electro-Voice has been designed and developed by our engineers—many in collaboration with the U. S. Army Signal Corps.

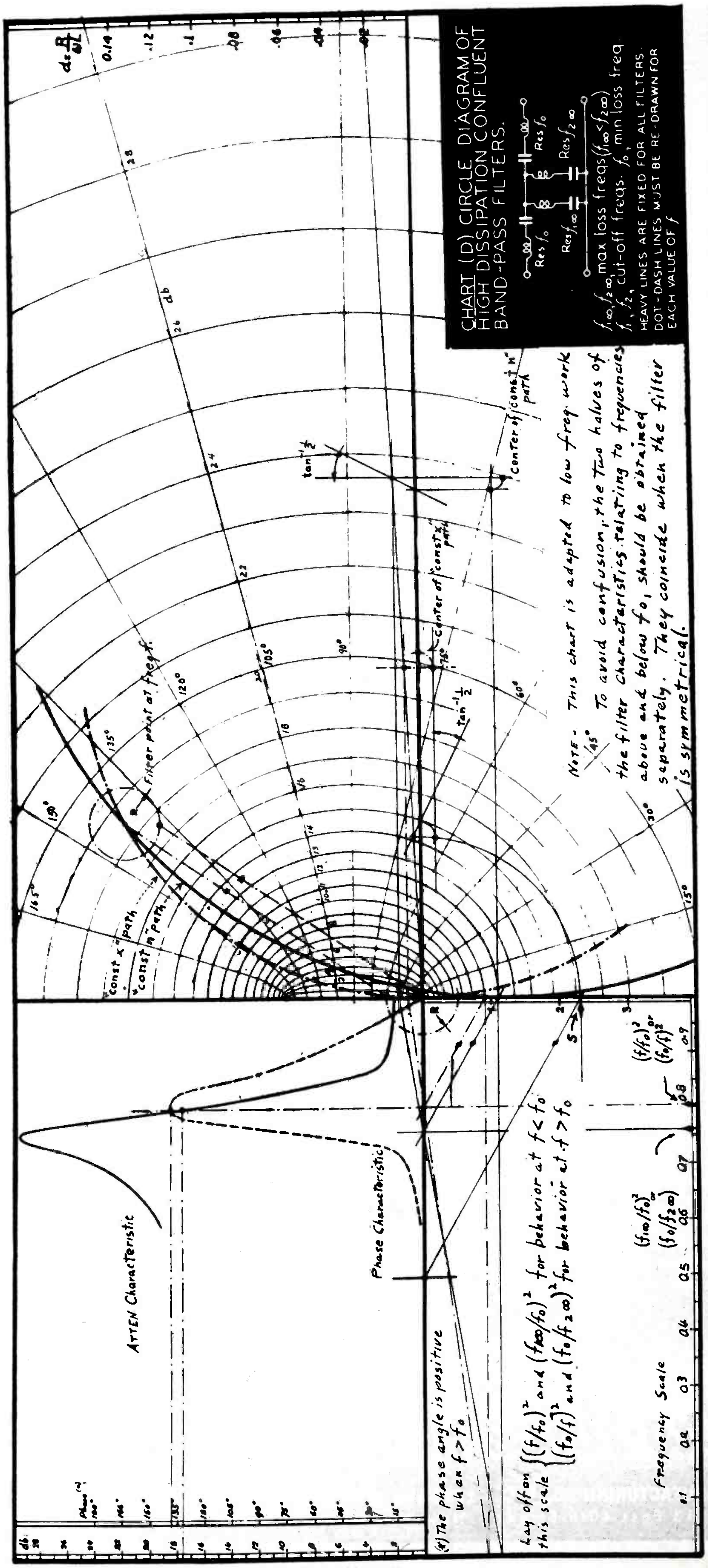
Harmonic distortion is the addition of spurious frequencies to the fundamental in definite harmonic relationship. Though the frequency curve may be excellent, harmonic distortion turns up as raspy reproductions, with an unnatural twang, in microphones, amplifiers and speakers. Five percent is considered a satisfactory upper limit for good reproduction, and as much as fifteen percent is allowable for speech communication.

Now come new Electro-Voice Dynamic Microphones with radical innovations in diaphragm fabrication, reducing harmonic distortion to a lower degree than hitherto possible. Cleaner, crisper, more highly intelligible reproductions are achieved. New Electro-Voice Dynamic Microphones are aiding both the CAA and the Signal Corps in securing improved communications. If you are a manufacturer of war equipment, details will be sent upon request.

The Harmonic Wave Analyzer measures the presence of spurious frequencies introduced by microphone distortion. To the ear, such frequencies give the feeling of ragged and false speech quality that may be unintelligible under the stress and strain of battle. Electro-Voice engineers have found a way to eliminate harmonic distortion in microphone design, as proved by the Wave Analyzer; and the completely natural reproduction from the new Electro-Voice microphones.

Electro-Voice MICROPHONES

ELECTRO-VOICE MANUFACTURING CO., INC. • 1239 SOUTH BEND AVENUE • SOUTH BEND, INDIANA
Export Division: 13 East 40th Street, New York 16, N. Y. — U. S. A. Cables: ARLAB



Equation *26* represents a circle as shown in Figure 9. When x = 1, i.e., at the frequency of minimum loss, the circle becomes tangent to all the *constant-n* paths, and its diameter is then equal to *d*.

Each constant-*x* path corresponds to two distinct values of frequencies such that their product approaches f_o.

Direction of travel of u + jv points along constant-*x* circles is *anti-clockwise* for increasing values of *n*. Direction of travel along constant-*n* paths is *clockwise* for increasing values of *x*. Consequently (see Figure 10), points like *A* and *B* refer to the lower of the frequencies represented by a given path, and so does point *L* (having coordinates U/S and V/s). The reverse is true of points *C*, *D* and *H*.

Points *H* and *L* describe, with varying frequency, a path similar in all but the scale to the filter path proper. This is a fourth order curve, approximating two circles joined together, as shown roughly in Figure 11.

Circle Diagram Charts

We may conclude from the foregoing discussion that in every case there exists a graphical procedure whereby the filter point, connoting the vector quantity Z_1/Z_2, hence the filter behavior at some frequency, may be determined. Such a procedure involves the tracing of circles whose center coordinates may be evaluated from suitable design coefficients. It is not necessary to resort to calculation for this purpose, since the expressions for the coordinates are simple enough to permit the use of geometric constructions.

The series of charts show how this may be done in a number of cases.

The charts have been classed in two categories. This distinction has reference to the frequency range in

(*Continued on page* 109)

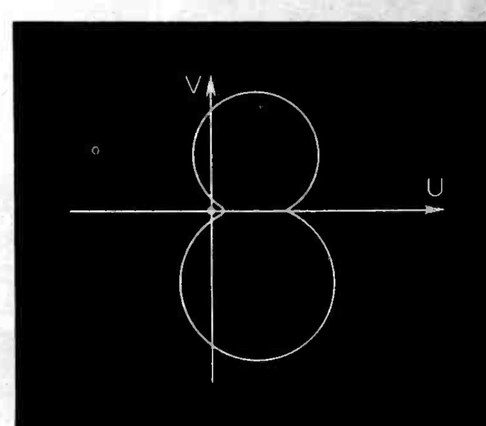
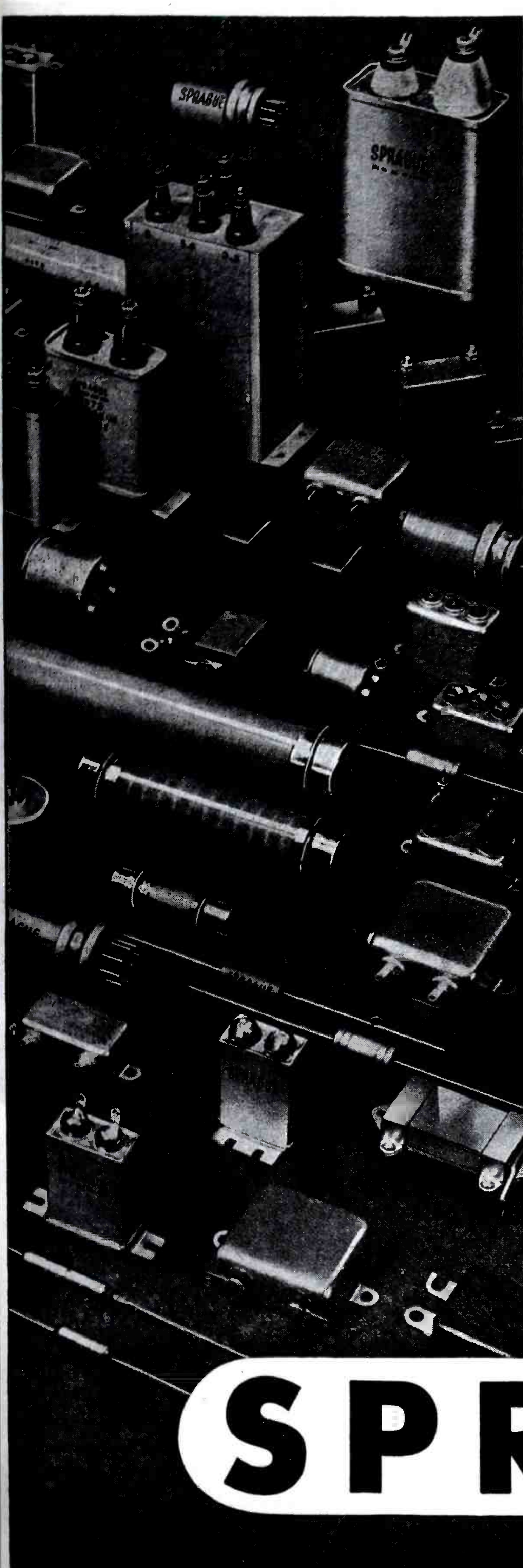


Figure 11

Filter path of a confluent filter. If all the points like *L* and *H* (Figure 10) are joined together, the *filter path* is obtained. This is not circular, but approximates the two circles joined together by a chord.



"Plus ça change plus c'est la même chose"*

***(THE MORE IT CHANGES, THE MORE IT IS THE SAME THING)**

Over 95% of Sprague capacitors being produced today are different from those of pre-war days—and a lot of hard, painstaking and fast work has gone into making the necessary changes to meet wartime conditions. The primary insulation, the basic dielectric, the fundamental processes—these did not spring full fledged over night, but are "the long result of time." These processes produced good condensers before the war, are producing good condensers now to meet war specifications—and will produce good post-war condensers. Specifications change, the condensers change to meet them, but always Sprague condensers are good condensers. 'Plus ça change——' "

SPRAGUE SPECIALTIES COMPANY, NORTH ADAMS, MASS.

ARMY E NAVY

NOTE TO SUPPLIERS

Just as we do our best to make Sprague a good place from which to buy, so do we aim to make it a good place to which to sell. We are always open to suggestions, new ideas, and all the other helps that suppliers are often so well equipped to give. Although we buy carefully—just as we manufacture carefully—we aim to back this buying with the same courtesy, consideration, and loyalty we ourselves like to receive.

SPRAGUE

CAPACITORS **KOOLOHM RESISTORS**

ROCHESTER FALL MEETING

(*Continued from page* 26)

metic mean Q_A. This equivalent Q then relates the selective variable S to frequency deviations in comparison with resonant frequency f_o. The coupling factor C is related to the coefficient of coupling (K) between circuits through the geometric and arithmetic mean Q.

Gray Paper on Ceramic Dielectrics

Some of the operating characteristics, advantages and disadvantages of ceramic dielectric materials, which have extremely high dielectric constants, will be analyzed in a paper by Robert B. Gray, physicist of Erie Resistor Corporation.

Data at present available is temperature variation of capacity and power factor, frequency variation of capacity and power factor, voltage coefficient, stability with age, stability on voltage test and humidity resistance. Characteristics of one type of material that will be discussed, appear in the graph, Figure 4.

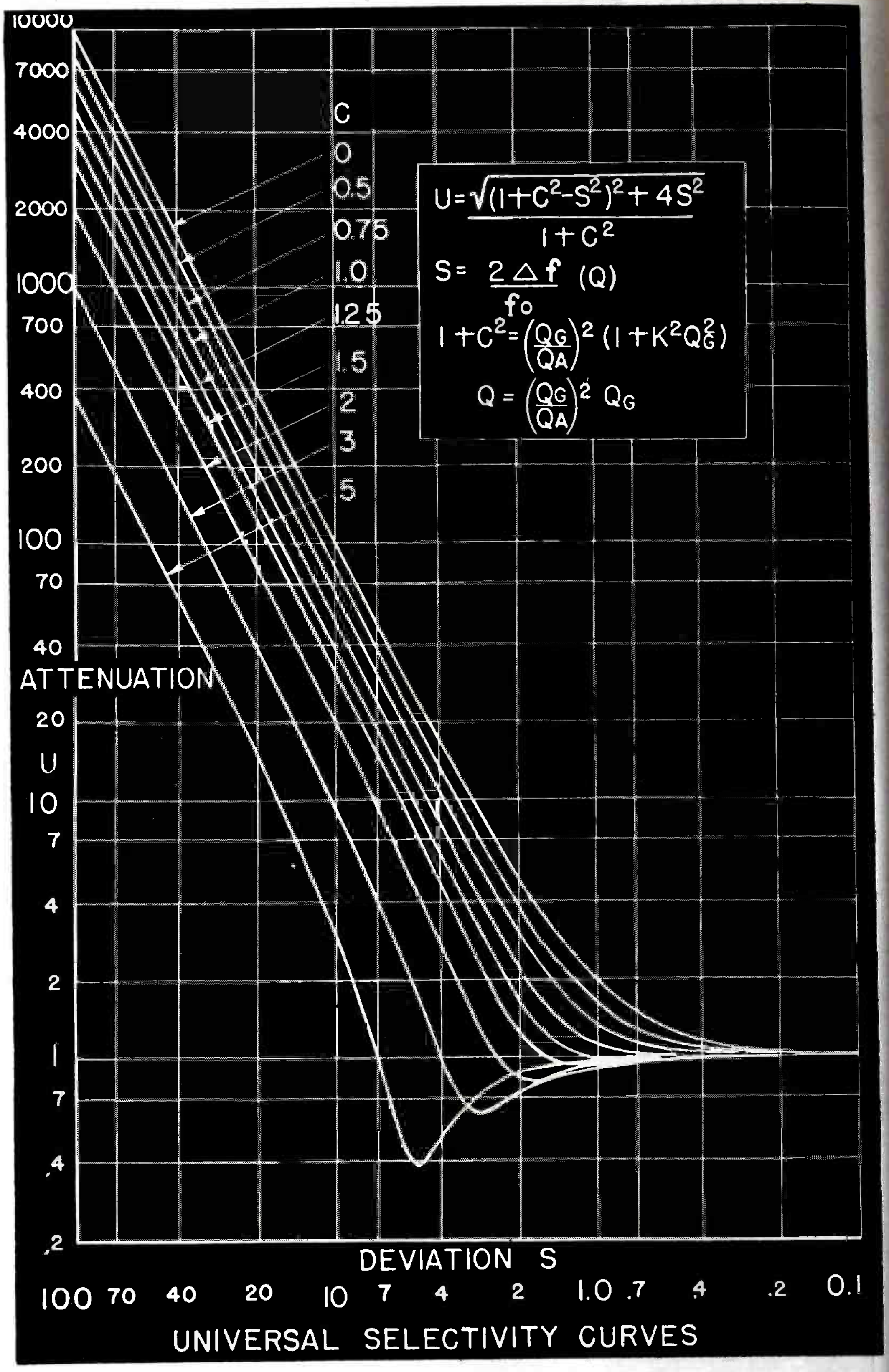
F-M I-F Design by Parker

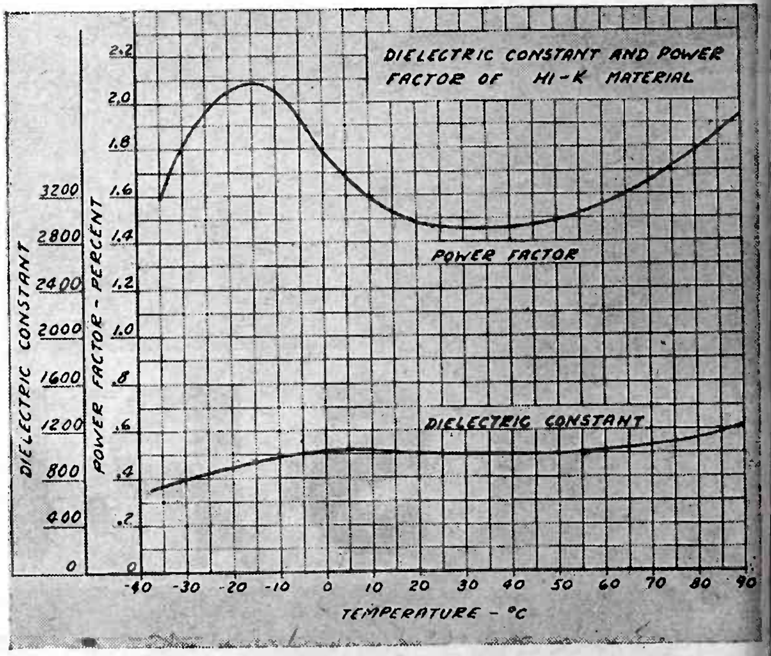
Because of the severe selectivity requirements imposed by the f-m band of 42 to 50 mc, the superheterodyne receiver has been the only satisfactory type so far developed for this use. Consequently, all the problems of spurious response, gain, selectivity, and stability which have faced the designer of a-m equipment used on the broadcast and short-wave bands, must be faced by the designer of f-m receivers.

With the increasing popularity of f-m resulting in more and more transmitters in close proximity laying down strong local fields, the use of high values of intermediate frequencies becomes mandatory in order to reduce the spurious responses. Higher values of intermediate frequency make the realization of satisfactory gain and stability more difficult. Hence, the design engineer is forced to compromise on some value of intermediate frequency which will result in acceptable gain and stability with the minimum of spurious responses. With better components and improved technique, desired values of gain and circuit stability can be attained at higher frequencies with consequent reduction in spurious responses.

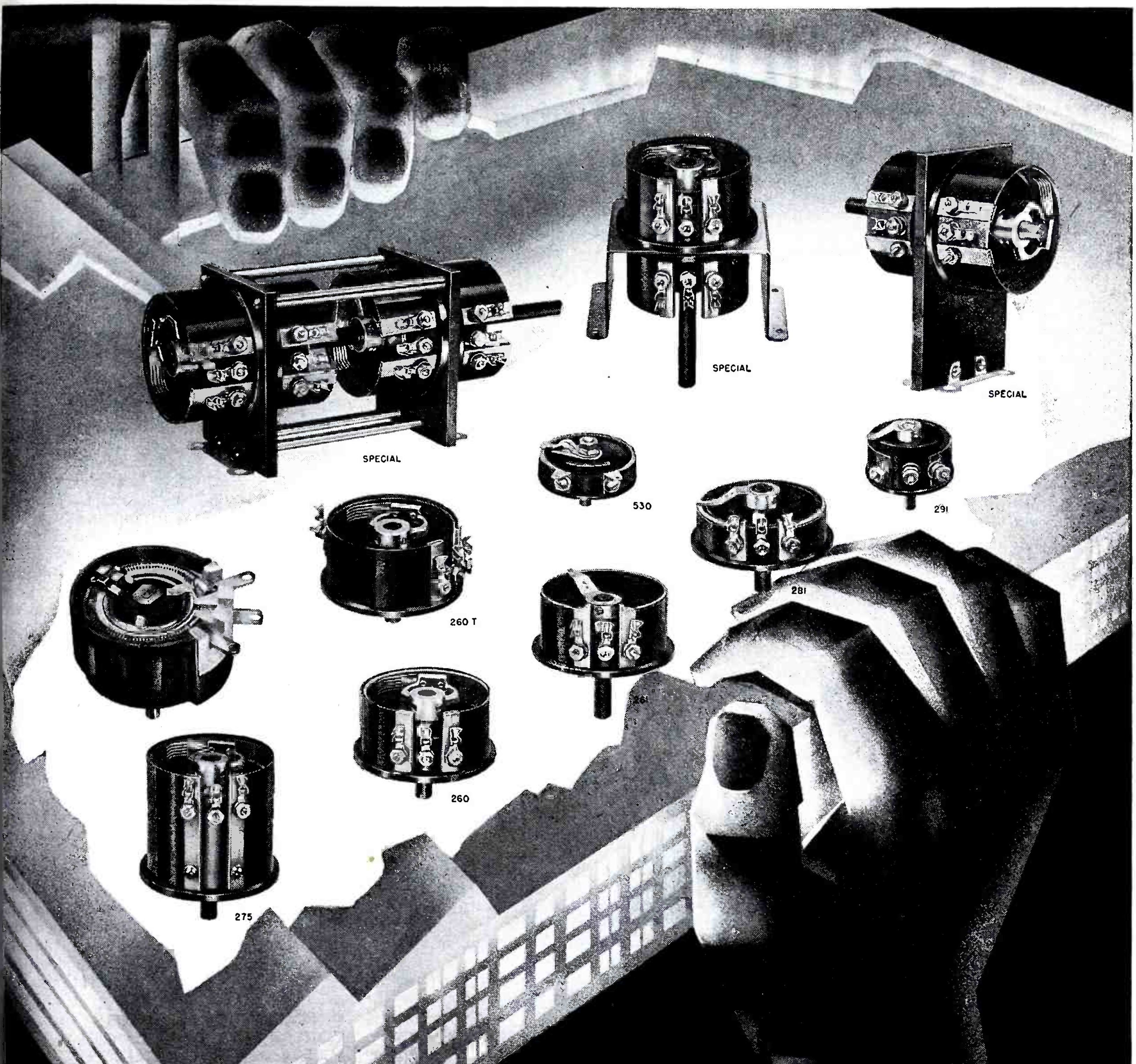
These problems will be analyzed in a paper on i-f transformer design for f-m receivers by William H. Parker, Jr., of Stromberg-Carlson. He will take each of several popular values of intermediate frequency between 1700 kc and 16.0 mc and present quantitative and comparative data which should be of value

(*Continued on page* 105)





Figures 3 (top) and 4 (right)
Figure 3 illustrates the universal selectivity curves that P. C. Gardiner of General Electric used to prepare chart shown in Figure 2. These data will be discussed by Mr. Maynard in his paper on i-f systems. In Figure 4, appears the characteristics of one type of ceramic that will be analyzed by R. B. Gray of Erie Resistor.



DEPENDABILITY AND PRECISION

Superbly engineered . . . mechanically and electrically, DeJur wire-wound potentiometers perform their functions dependably. There's a DeJur potentiometer to fill your needs. Here, we illustrate a few . . . however, we can and do produce these units to required resistances. We will gladly furnish technical data upon request.

ARMY E NAVY

Awarded for Excellence in Production and Quality of Material

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NEWS BRIEFS OF THE MONTH . . . —

WPB ISSUES MONTHLY PRIORITY GUIDE

A new monthly publication, *Products and Priorities,* describing products, materials, and services handled by the War Production Board is being released by WPB.

The issues will include all information formerly contained in *Priorities* and in *Product Assignments,* both of which will be discontinued. A year's subscription of thirteen issues may be obtained for $2.00 from the Superintendent of Documents, U. S. Government Printing Office, Washington, D. C. Single issues will be available at 20 cents each.

Persons who now subscribe to *Priorities* will receive the new publication for the balance of their regular subscription. *Product Assignments* had not been available for public distribution.

A feature of *Products and Priorities* is a master alphabetical index listing every product, material, or service which comes under WPB supervision or control. This simplifies the location of the numbers of any applicable WPB orders and forms, all necessary CMP references, and the WPB Division and section responsible for the product, material, or service.

The publication also includes a list of Claimant Agencies, Claimant Agency program symbols, etc.

* * *

WALKER ELECTED APCO PRESIDENT

Frank W. Walker, chief engineer of the forty-four f-m station Michigan State police network, was elected president of the Associated Police Communication Officer, Inc., at the close of the tenth annual War Communications Conference at Madison, Wisconsin.

Ero Erickson, supervisor of the Illinois State police radio system at Chicago, was chosen secretary-treasurer.

Ray Groenier, conference chairman, was elected first vice-president; R. M. Jones, Birmingham, Alabama, second vice-president, and Wm. E. Taylor, Baltimore, sergeant-at-arms.

A large postwar planning committee was selected at the conference to prepare a program anticipating postwar police radio technical and frequency allocations requirements, in co-operation with the FCC, IRE and RMA. Talks covered recent priority developments affecting radio equipment. Frank McIntosh of WPB, spoke on priorities. Representatives from the OCD outlined progress of the WERS program.

RADIO AND RADAR DIVISION DEPARTMENTS ORGANIZED

Organization of the departmental setup of the Radio and Radar Division of the WPB to clarify spheres of activity has been announced by Ray C. Ellis, Director of the Division.

The new setup includes three assistant directors: Sidney K. Wolf for production, J. W. Abney for internal management, and Harold Sharpe for labor.

The Radio and Radar Division is the focal point for the electronic, test equipment and industrial instrument industries and the Government claimant industries interested in their products. The Division is responsible for having radio and other electronic equipment and components produced to meet the demands of the Armed Services and the contractors to the Services, as well as to maintain essential civilian equipment.

* * *

STAR ADDED TO SOLAR "E" FLAG

The Solar Manufacturing Corporation, 285 Madison Avenue, New York City, with plants in Bayonne and West New York, New Jersey, has been awarded a white star for its "E" flag.

* * *

LT. PRINCE HONORED AT ASSOCIATION LUNCHEON

At its August luncheon meeting the Association of Electronic Parts and Equipment Manufacturers of Chicago honored its executive secretary, Kenneth C. Prince, before leaving for Princeton University, where he will begin his training as a Lieutenant (jg) in the United States Navy.

Lt. Col. John M. Niehaus, labor officer, United States Army Signal Corps, and Albert A. Epstein, assistant director of the Sixth Regional War Labor Board, friends of Lt. Prince, addressed the members.

An election of officers for the ensuing year was also held at this meeting. P. H. Tartak, president of the Oxford-Tartak Corporation, Chicago, was elected chairman. E. G. Shalkhauser, president of Radio Manufacturing Engineers, Inc., Peoria, Illinois, was named vice chairman. Helen A. Staniland, vice president of Quam-Nichols Company, Chicago, was re-elected treasurer. Lewis G. Groebe, associated with Lt. Prince in the practice of law, was elected secretary pro tem.

FM BROADCASTERS NAMES NEW OFFICERS

At a recent meeting of FM Broadcasters, Inc., L. W. Herzog, W55M, Milwaukee, was named secretary-treasurer. He succeeds Robert T. Bartley, former vice-president of the Yankee Network, Boston, who has filled the job since FMBI'S formation in January, 1940. Mr. Bartley tendered his resignation following his recent appointment as NAB war director.

C. M. Jansky, Jr., of Jansky & Bailey, was made technical advisor of the association.

A new engineering committee was also named and W. R. David of General Electric was selected as its chairman. Others on the committee are Everett Dillard, K49KC, Kansas City; Dr. Ray H. Manson, W51R, Rochester; Franklin M. Doolittle, W65H, Hartford; and C. M. Jansky, Jr., W3XO, Washington.

Three new members were also admitted to FMBI, boosting the total to 65. The trio includes Marcus Loew Booking Agency (W63NY-WHN), New York City; WJJD, Inc., Chicago, Ill.; and the Piedmont Publishing Co. (WSJS) Winston-Salem, N. C.

* * *

DU MONT ENGINEERS PRESENT PAPER ON CATHODE-RAY TUBES

The Radio Club of America inaugurated its fall season program with a paper *Considerations in the Application of Cathode-Ray Tubes in Equipment,* by Dr. P. S. Christaldi, chief engineer, and I. E. Lempert, cathode-ray tube engineer, Allen B. Du Mont Laboratories, at a meeting at Columbia University.

The characteristics of commercially-available types of cathrode-ray tubes were discussed, with special emphasis on the use of published specifications when designing equipment. Several applications of cathode-ray tubes were described, illustrated by slides and demonstrations.

* * *

CHICAGO SIGNAL CORPS CONTRACTORS WELCOME MAJOR GENERAL INGLES

Signal Corps contractors in Chicago welcomed Major General Harry C. Ingles upon his first visit to the city since his appointment as Chief Signal Officer, with a dinner at Chicago's Lake Shore Club.

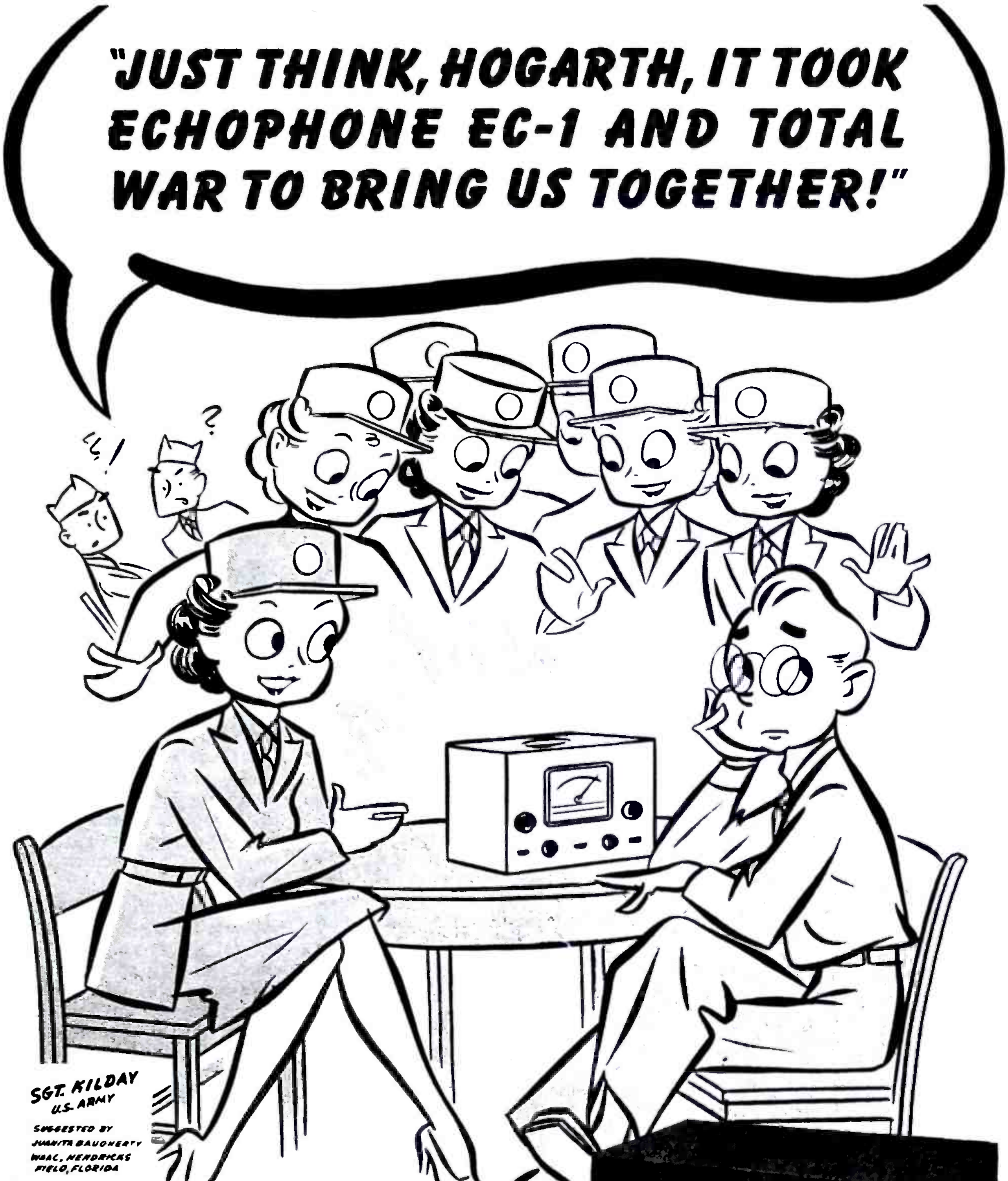
Among those who attended were: W. J. Halligan, R. E. Samuelson and R. C. Russell of Hallicrafters; E. N. Rauland; Major Edward W. Medberry; Lieutenant Com-

(*Continued on page* 97)

Left to right: Ray S. Gronier, 1943 conference chairman; Ero Erickson, Frank W. Walker, and J. M. Wherritt, APCO bulletin editor.

Back row, left to right: J. J. Kahn, president, Standard Transformer Corporation; Lieutenant Kenneth C. Prince; Paul H. Tartak, president, Oxford-Tartak Radio Corporation. Front row, left to right: Lieutenant Colonel John M. Niehaus, Albert A. Epstein, and Helen A. Staniland.

W. J. Halligan, Major General Harry C. Ingles, Lieutenant Colonel John M. Niehaus, Brigadier General Edgar L. Clewell, and Paul Galvin.



Echophone Model EC-1

(Illustrated) a compact communications receiver with every necessary feature for good reception. Covers from 550 kc. to 30 mc. on three bands. Electrical bandspread on all bands. Six tubes. Self-contained speaker. Operates on 115-125 volts AC or DC.

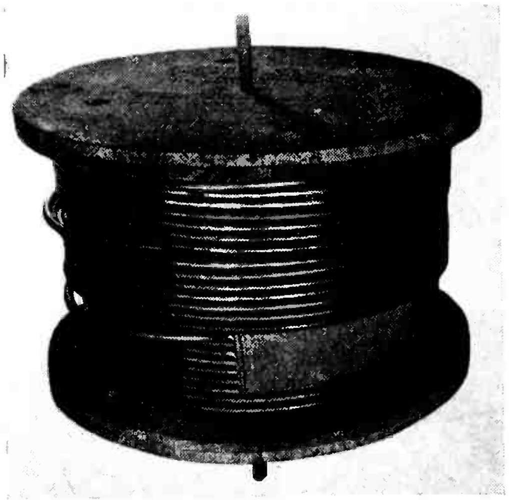
ECHOPHONE RADIO CO., 201 EAST 26th ST.. CHICAGO, ILLINOIS

THE INDUSTRY OFFERS

CONTINUOUS LENGTH SOFT COPPER COAXIAL CABLE

Soft temper ⅞" copper coaxial cable may now be obtained in continuous lengths up to several thousand feet, from the Andrew Company, 363 East 75th Street, Chicago 19, Illinois.

The cable is wound on wooden reels and is electrically identical to rigid cables of the same size. Considerable time and labor is said to be saved in installation because the cable is easily uncoiled and bent by hand to the desired contour, and connectors, junction boxes and expansion fittings are not necessary. So that all splices are pressure tight and foreign matter and moisture excluded during shipment, the cable may be fitted at the factory with Andrew glass-insulated terminals and shipped under pressure.



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CAPACITRON OIL CAPACITORS

A *Lok-Seam* oil capacitor, said to be the first 100% automatically sealed rectangular oil capacitor is now being produced by Capacitrons, Inc., 318 West Schiller, Chicago 10, Ill.

The *Lok-Seam* is said to eliminate solder entirely. Both the top and the bottom of the steel container is automatically double rolled, crimped and sealed with a *uni-temp* plastic mass. This entire series of operations is performed automatically on the *Lok-Seam* machine.

Bulletin 101 supplies data on types available at this time.

* * *

WATER-TIGHT LAMPHOLDER

A water-tight lampholder with a keyless composition base, rated 660 watts, 250 volts, is now available from the C. D. Wood Electric Company, Inc., 826 Broadway, N. Y. City. It is molded ot low moisture absorbtion composition.

THORDARSON FLASHTRON

Flashtron, an electronic package unit, is now available from Thordarson Electric Manufacturing Company, Chicago, Ill.

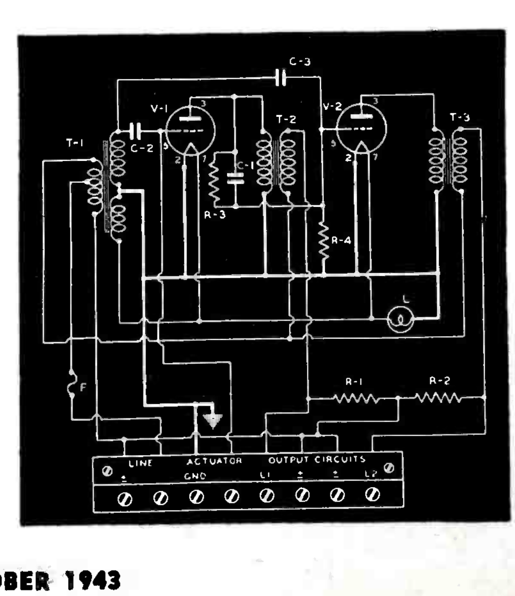
Flashtron incorporates two grid controlled rectifier tubes. Each of these tubes controls power to separate output circuits through suitable transformers. The interconnection of the tube elements is such that only one circuit is operating at any given instant and one of the circuits is always functioning (Patent 2,208,235).

In service, an actuator or primary sensitive element (bourdon tube, thermostat, etc.) with its electrical contacts, is connected to the grid circuit of one of the tubes of the Flashtron. The output circuits are connected to a suitable bi-directional motor or other reciprocal control (valve, etc.). When the contacts oi the actuator approach the closed position, the tube releases power to its output circuit operating the motor or control in a given direction. The change in direction immediately reflects its action to the actuator, opening the contacts and restoring the first tube to a non-operating condition. The second tube then functions. This changes the direction of operation and the cycle repeats itself. The valve is constantly re-set to the desired position in exact response to the primary sensitive element which is actuating the Flashtron. Visual observation of the grid control tubes operating many times a second indicates the control obtained with the system.

A typical application is the controlling of steam pressure. A bourdon tube is fitted with a pair of contacts to operate the Flashtron at a pre-set pressures. The output circuits are connected to a bi-directional motor operating a steam valve. Control of pressure is said to be so perfect that there is practically no movement of the motor or valve except to compensate for differences in boiler pressure or load.

The Flashtron operates with and supplies to the output terminals 115 volt, 50-60 cycle current. It should be noted that one of the actuator connections is at ground potential which simplifies the primary sensitive element. The potential applied to these contacts does not exceed 15 volts rms, .001 ampere.

The unit is housed in an all-steel box 11½"x7⅛"x3⅝".

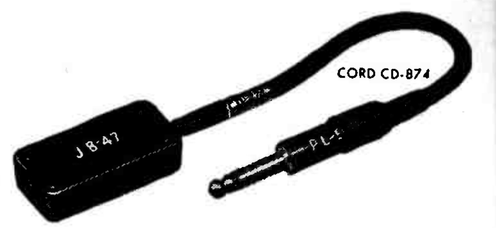


JUNCTION BOX SET

A junction box assembly is now available from Trav-Ler Karenola Radio & Television Corp., 1038 W. Van Buren St., Chicago 7, Ill.

This unit consists of a length of two-conductor, tinsel cordage with a two-conductor plug attached to the cordage on one end, and a junction box attached on the other end. The junction box (JB-47) has a two-piece bakelite plastic case. The lower section of this case has two silver-plated copper terminal jumpers, and four terminal binding posts for the necessary connections. A tight-fitting neoprene jacket sleeve makes a close seal over the end of the plug, which is connected to the cordage.

The complete cord set, or any integral part, can be furnished promptly.



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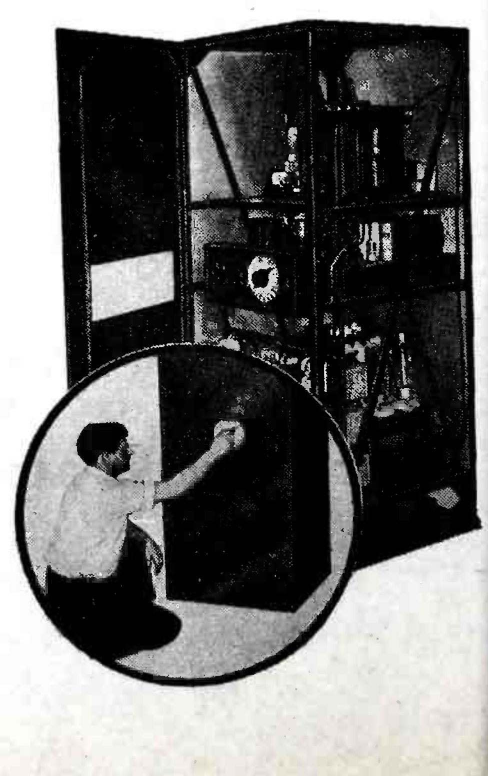
VARIABLE FREQUENCY ELECTRONIC GENERATOR

An electronic generator capable of delivering power with good regulation and waveform over a frequency range of 300 to 3500 cycles, has been developed by Communications Measurements Laboratory, 120-24 Greenwich Street, N. Y. City.

This generator CML 1400 includes a variable-frequency oscillator, followed by several driver stages. The output stage employs a pair of 833-A tubes in class B. Because of the high impedance of such a power source, the regulation of generators of this type is quite poor, ordinarily. The CML 1400 is said to overcome this difficulty by means of a control circuit which maintains output voltage at a sub-



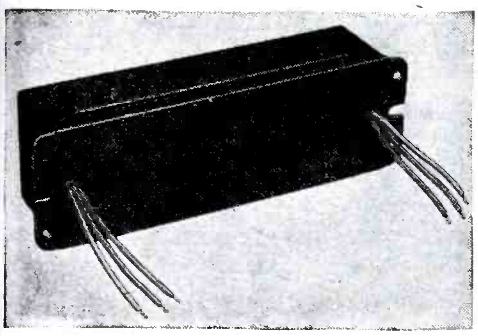
stantially constant level from no load to full load.

Power output is 1400 watts at 120 volts rms, with a load of unity power factor.

* * *

BALLASTS WITH BOTTOM LEADS

To facilitate installation and reduce the use of critical metals Jefferson Electric Company, Bellwood, Illinois, have provided fluorescent lamp ballasts with leads out of the bottom. This makes possible direct mounting of the ballast on shallow wiring channels, no wider than needed to enclose the leads. Ballasts with bottom instead of end leads are available at present in the popular capacities—two-lamp and three-lamp 40 watts, two-lamp and four-lamp 100 watts.



* * *

SPEED CAMERA

To photograph split-second action of high speed equipment, an 8000-frame a second camera has been developed by Bell Telephone Laboratories, and manufactured by Western Electric.

This camera, known as the Fastax, uses 8 mm and 16 mm film, sometimes at the rate of 70 miles an hour. It has an exposure period of 33 millionths of a second.

Bell Telephone Laboratories' scientists have made with this camera such diverse cinematic studies as the action of the vocal cards in producing speech and the explosive short circuiting of wires carrying heavy currents of electricity.

The Fastax camera can be operated at slower speeds, too. It is thus invaluable in determing stress and impact conditions of new equipment designs under test; color, black and white and polarized light pictures having been taken of these tests. The middle speeds (1,500 to 4,000 frames per second) have been used to study automatic operations, to study the laboratory-controlled breakage of parts and the causes of noisy operation in machines.

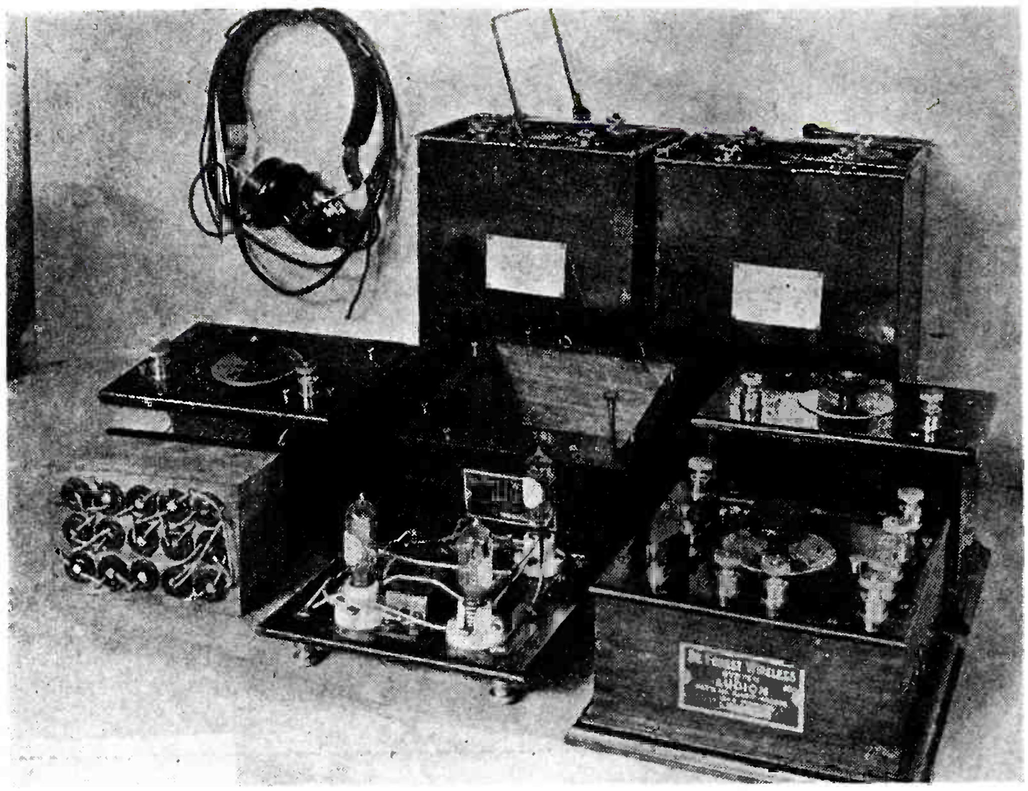
The Fastax employs continuous film drive, as distinguished from the stop-expose-advance cycle of the professional and amateur slow motion cameras. Exposure of successive *frames* is accomplished by a revolving prism acting as an optical compensator. Hence the images travel in synchronism with the film past the film gate during the exposure period.

The object under study is illuminated by the continuous concentrated light of high intensity lamp filaments instead of the intermittently flashing gaseous discharge lamps as in the case of stroboscopic cameras. This basic principle enables the Fastax to photograph self-luminous objects such as fusing lamp filaments, or to make high speed analyses

(*Continued on page* 92)

VETERAN WIRELESS OPERATORS ASSOCIATION NEWS

W. J. McGONIGLE, President   RCA BUILDING, 30 Rockefeller Plaza, New York, N. Y.   GEORGE H. CLARK, Secretary



Early de Forest receiver, 1906, installed at Key West station.
(*Courtesy Clark Radio Library*)

Personals

AN interesting note recently came in from "Bill" Halligan, president of Hallicrafters. "Bill" is a life members of our Association and an extremely enthusiastic booster of VWOA. Many thanks, "Bill," and best of luck. . . . Saw Paul Godley, well known radio engineering consultant, recently. He evinced an interest in becoming a life member of the Association. Paul was the radio amateur who went to Europe for the first trans-Atlantic tests of short-waves by American amateurs, under the auspices of the American Radio Relay League. At a later date we will include a biographical sketch of Paul's radio career. . . . We haven't had word from Hal Styles, chairman, and Mack Scheaffer, secretary of the Los Angeles-Hollywood chapter of VWOA lately. Probably they, too, are busy with activities aiding the War effort. . . Our sincere congratulations to W. A. Ready, president of the National Company, and honorary member of our Association, and the men and women of the National Company upon receiving the Army-Navy "E" for excellence in war production. Due to pressure of war work, Mr. Ready was unable to visit with us at the Astor during our last Dinner-Cruise. We look forward to seeing him at our next one in February, 1944. . . . And the rest of you keep that in mind. February, 1944, at the Astor. Exact date later. . . . We always wondered what the "V. L." stood for in John V. L. Hogan's name. We now know. It's *Vincent Lawless*. A pioneer in the radio field, JVLH has long been a member of VWOA. . . . We have a letter from J. McWilliams Stone, president of the Operadio Corporation, desiring information on becoming a life member. Mr. Stone was a wireless operator in the early days of the art. When we obtain more information we will include a biographical sketch in this page. In the meantime a cordial welcome to Mr. Stone. . . . Our sincere thanks to George H. Clark for his efforts in preparing material for the Year Book and the Year Book Supplement (copies of which can be secured by sending fifty cents to the secretary together with your name and address), and securing notes for this page each month. A few more Georges and we would have an easy time of it. . . . W. S. "Bill" Fitzpatrick did a grand job of *reminiscing* in several issues past. Perhaps the picture included on this page, of early wireless equipment, will bring back memories to many of us. If so, and particularly if you ever used that ancient stuff, please send in a few notes. Don't worry about composition . . . just scribble a few lines and we will do the rest. . . . Our good wishes to Ludwig Arnson, president of the Radio Receptor Company, who received a star for their Army-Navy pennant. . . . We are very anxious to obtain details of heroism on the part of wirelessmen, past and present, and naturally of participants in the present global conflict to be included in the 1944 Year Book. If you know of such cases please bring them to our attention. Should you lack complete details we shall be glad to communicate with the proper authorities. . . . Our belated congratulations to Colonel A. W. Marriner, formerly Director of Air Corps Comcunications, upon his recent promotion to the rank of Brigadier General. . . . W. C. Simon, our hard-working Treasurer, tells us that our bank balance is well in the *black*. . . . It has been some months since we heard of the doings up Boston way. . . . A *cocktail* party will soon be given to the radiomen of the Armed Services in New York.

Dues

LOOK in your wallet and see whether you have a *1943 membership card*. If not, please forward a check for two dollars to the secretary and unless you have been delinquent for several years) you will promptly receive one. When you do send in your dues be sure to include your latest address together with a few notes on your present business connections. If you have had interesting experiences in radio, let's have them for inclusion in this page. Each month *LW* has a real job securing sufficient material for this page from this correspondent, because we have a *real* job getting ideas from *you*.

Make it easier for all of us by sending in interesting anecdotes frequently.

THE INDUSTRY OFFERS . . . —

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by polarized light. The wide choice of light sources permits the use of many film types including color film up to 1,000 frames per second.

* * *

DIRECT READING FREQUENCY METER

A direct reading frequency meter for a range of 50,000 cycles has been announced by North American Philips Company, Inc., through its Industrial Electronics Division, 419 Fourth Avenue, New York City.

The meter can be used for testing quartz crystals, for use in a wow meter for phonograph motors and for experimental work as the base of a frequency modulation indicator.

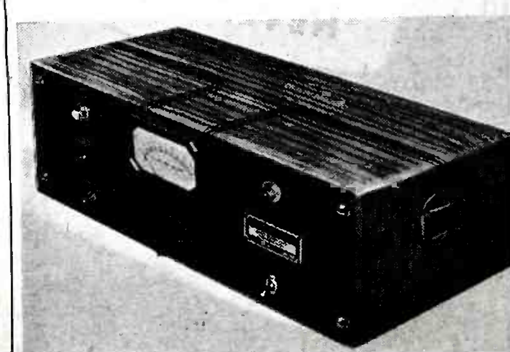
When combined with a photoelectric cell, light source and amplifier, the instrument can be used as a speed indicator to read speeds.

No auxiliary amplifiers are needed to drive a recorder. An overload cut-out protects recorder from damage.

The maximum frequency is 50,000 cycles with six ranges, 0-100; 0-500; 0-1000; 0-5000; 0-10,000; and 0-50,000. An accuracy of 2% is said to be retained over the entire range. Each frequency range can be individually adjusted for maximum accuracy.

Frequency is indicated directly on front panel of meter or on separate recorder. The meter has an input impedance of 100,000 ohms or over. Stability is said to be maintained with line voltage variation between 105 and 125 volts.

The meter is designed either for relay rack or cabinet mounting.



* * *

HIGH-SPEED HAND SANDER

A light-weight, high-speed hand sanding unit has been developed by the Sundstrand Machines Tool Company, Rockford, Illinois.

The machine weighs less than 6 pounds, has a speed of 3500 oscillations per minute and can be equipped with different types of sandpaper attachments for large or small, wide or narrow, flat or curved abrading surfaces on metal, wood, plastics, or composition.

Operation of the machine is obtained with pad movements started and controlled by a palm lever fitted at top of the machine housing. When machine is gripped to operate, the reciprocating action of pads starts. Upon release, the machine automatically stops.

This Sander is said to be free from vibration.

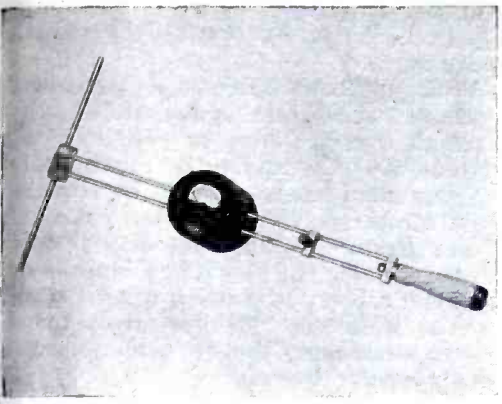
* * *

ERCO RESONANCE METER

A resonance meter known type mw-60, has been developed by Erco Radio Laboratories, Inc., Hempstead, N. Y.

The indicator can be used for determining resonance in oscillators and transmitters, standing wave ratios, etc.

It is adaptable for field or laboratory measurements.



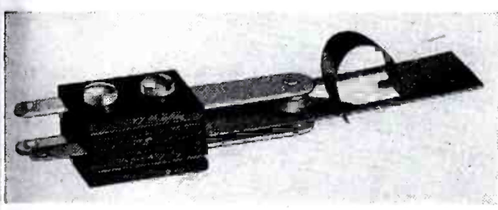
* * *

OPEN BLADE SNAP-ACTION SWITCH

A small open blade snap-action switch is now being made by Aero Electric Company, 1319 Superior Avenue, Cleveland, Ohio.

A patented rolling spring is said to produce a positive snap-action with less than 6 oz. operating pressure. The engineering design and operation of the rolling spring switch is said to minimize contact burning because of its extremely fast action. This switch is also designed to permit both pre-travel and over-travel.

It has a rating of 15 amps. on 125 volts a-c. Overall size is 3 1/16"x11/16"x½". Made in single pole, single or double throw, set and return types. Also assembled to suit the needs of relay builders.



* * *

POCKET SIZE GAGE

A pocket size, *three-point pipe gage* for instantaneous measurement of all sizes of pipe from ⅛" to 12", has been announced by the Three-Point Gage Company, 3821 Broadway, Chicago, Ill.

This gage consists of two pivoted steel plates with edges curved at three points for contact with the pipe to be measured, together with scale which automatically registers not only the pipe size in terms of inside diameter but the drill size for tapping.

An advantage claimed for this new gage is that it is necessary to contact only a small section of the pipe contour and that it will measure pipe in any position, even against the wall or in a corner, and will measure a covered pipe if there is a small opening near a union or other fitting where the gage may be slipped in. It is also maintained that the gage can be applied in dark places and taken to the light for reading.

The gage is constructed of steel with deep etched numerals, and the size when closed is 2½" x 4¼".

* * *

RUBBER TO METAL BOND

A method of bonding natural or synthetic rubber to metal, or plastics to metal has been announced by The U. S. Stoneware Company, Akron, Ohio.

The new method, known as Reanite Bonding Process, is said to develop a bond between rubber and metal ranging

(*Continued on page* 94)

THE INDUSTRY OFFERS . . . —

(*Continued from page* 93)

from 900 psi to as high as 200 psi on a pull test. This compares with bonds ranging from 250 to 400 obtained by present methods.

While the bond develops its maximum strength at room temperatures, its strength over a range of —40°F to as high as 300°F is said to be substantially stronger than bonds obtained by conventional processes.

The Reanite Bonding Process is said to be suitable for bonding natural or synthetic rubber, or plastics, to almost all metals: iron, steel, stainless steel, magnesium, aluminum, aluminum alloys, copper, bronze or brass.

In application, the surfaces to be joined are brushed, sprayed or dipped with Reanite. After being permitted to dry for an hour the surfaces are joined and the unit vulcanized by any of the conventional methods.

The Reanite Bonding Process may also be used to bond metal to metal, or leather or wood to metal or to each other.

The Reanite joint is said to be unaffected by fresh or salt water, and is noncorrosive to metals.

* * *

PLASTICS METAL PLATING

A process by which plastics, glass, or any non-conductor can be plated with any of the plating metals, has been announced by Precision Paper Tube Company, Special Products Division, 2023 West Charleston Street, Chicago 47, Illinois.

The process can be used on convex and concave surfaces, convolutions, corners and recesses. The metal plating is said to be permanent.

* * *

TWO-POLE CONTINUOUS DUTY CONVERTERS

A line of two-pole rotary converters has been announced by the Kato Engineering Co., Mankato, Minnesota.

These new units are available in 225 and 350 volt-amperes continuous load capacities at 3600 rpm with 40°C temperature rise. Available for changing 32, 110 or 220-volts direct current to standard 110-volts, 60-cycle, a-c. These converters are said to keep radio interference down to a minimum and to provide best possible wave forms to facilitate all phases of radio filtering.

* * *

HYDROGEN GAS PURIFIER

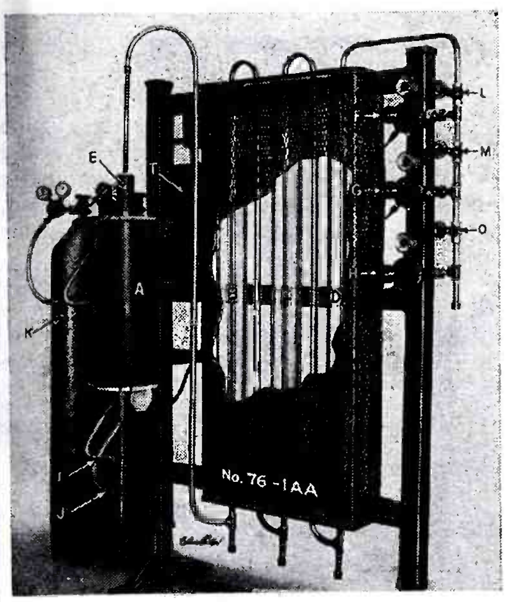
An electric hydrogen gas purifying unit is now being manufactured by the Eisler

Engineering Co., Newark, New Jersey.

The hydrogen gas, to be purified under a pressure of 30 to 50 lb. per square inch, passes first through an electrically heated furnace *A*, which holds a calorized seamless steel tube *E*, containing small pieces of pure copper for removing oxygen. Then the gas moves progressively through three glass containers *B*, *C* and *D*, each 4 feet long and 3 inches in diameter, filled with purifying ingredients such as caustic potash or sodium lime. From the last glass tube *D*, the purified gas enters a manifold with three outlets *L*, *M* and *O* leading to three different supply lines, from where it may be directed to small furnaces or other places where purified hydrogen is required. Each of the supply lines is controlled by one adjustable diaphragm reducing valve *F*, *G* and *H*, providing a possible reduction of pressure down to ½ pound per square inch.

The electric oven operates on 110 or 220 volts. An autotransformer is provided for regulating the heat, which never should be over a maximum of 1200°F. Best results are reported at 980°F.

All parts of the equipment are mounted on a frame of heavy square steel tubing. Removable caps on top and base of the glass dryers permit easy filling with chemicals and occasional cleaning of these containers without any trouble. The glass dryers are made of transparent pyrex glass.



* * *

G. E. INDICATOR LAMP

A small molded plastic indicator lamp has been announced by the speciality division of G. E. Special feature is a lock-on color cap which the manufacturers say cannot be shaken loose or freeze to the base. As many as five circuits can be identified on one panel by the use of five different color caps—amber, red, green, white and blue.

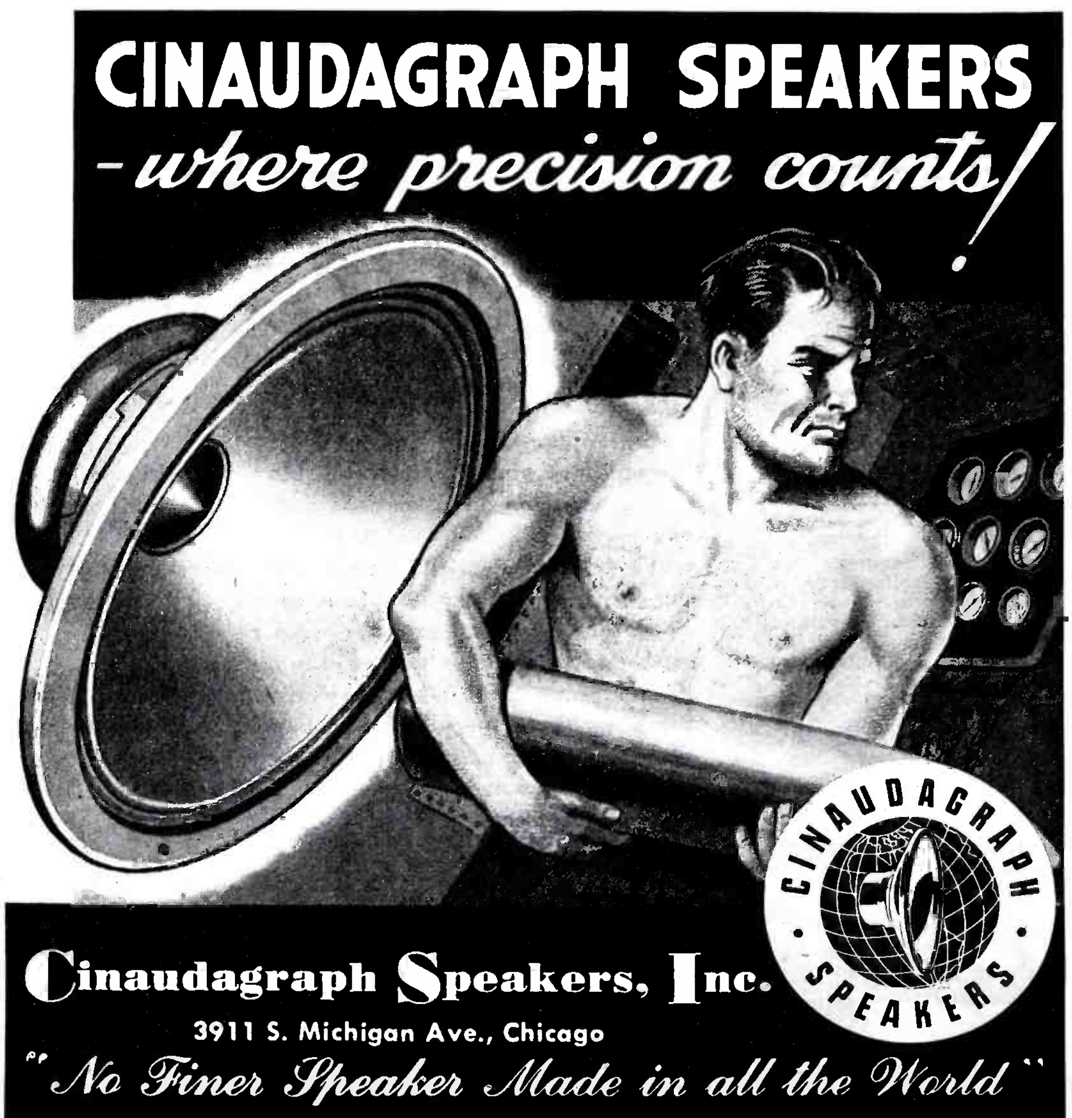
The lamp is supplied ready for mounting. The base is mounted directly to the back of the instrument panel and the color cap is screwed into the base through the panel. A coil spring applies constant pressure to the base of the lamp bulb to maintain a good electrical contact. The lamp takes 6 to 8-volt bulbs.

* * *

DEMONSTRATOR BOARD

A 5-tube a-c/d-c superhet demonstrator board for training programs is now avail-

(*Continued on page* 96)

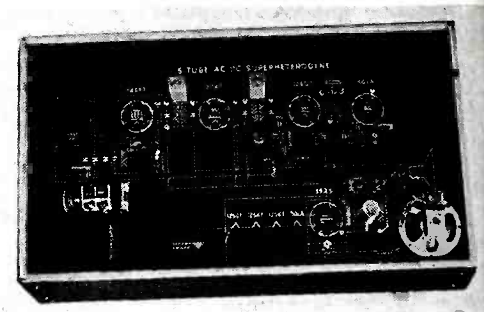


THE INDUSTRY OFFERS . . . —

(*Continued from page* 95)

able from Lafayette Radio Corporation, 901 West Jackson Boulevard, Chicago, 7, Illinois and 265 Peachtree Street, Atlanta, 3, Georgia.

It is laid out in bread board style with the parts mounted in position for quick removal and replacement to demonstrate function at each part in the circuit. Terminals are provided at all tube elements for measurement of voltages and signals. Jumpers are provided to open condenser, resistor and coil circuits and to short out these circuits wherever no damage will result. Schematic diagram is in color according to the RMA codes. Tubes are included.

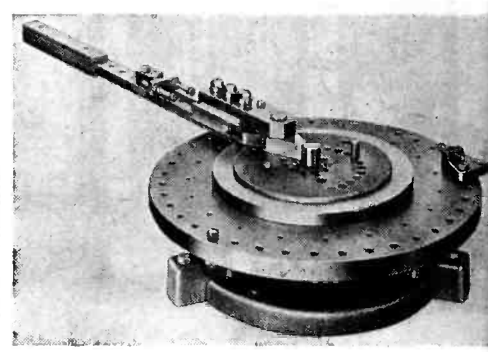


* * *

DI-ACRO BENDER

A bender that permits increased diamater forming has been developed by the O'Neil-Irwin Manufacturing Company, Minneapolis 15, Minnesota.

This new bender has a radius capacity with conversion of approximately nine inches. The length of operating leverage is thirty-five inches. It has an automatic and reversible forming nose. In addition, it features two-way action and right or left-hand mounting or operating.

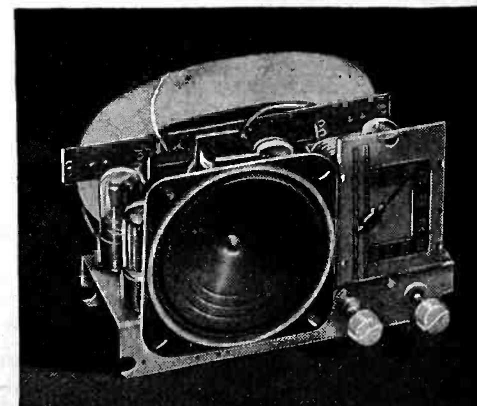


* * *

ALLIED RADIO TRAINING KIT

A 5-tube superheterodyne receiver kit for training programs has been announced by Allied Radio Corporation, Educational Division, 833 West Jackson Boulevard Chicago 7, Illinois.

(*Continued on page* 125)



NEWS BRIEFS

(*Continued from page* 86)

mander George C. Norwood; Colonel Charles N. Sawyer; Lieutenant Colonel John M. Niehaus; Brigadier General Edgar L. Clewell; Paul Galvin; Colonel Lester J. Harris; Lieutenant Colonel Samuel R. Todd; Major Henry S. Billington and Major George E. Phelps.

* * *

HAZELTINE HOLDS "E" CEREMONIES

The "E" pennant was presented to Hazeltine Electronics Corporation recently at plant ceremonies in Little Neck, L. I. Admiral H. G. Bowen, USN, presented the flag, which was accepted by William A. MacDonald, president of Hazeltine. Colonel O. C. Maier, USA, Signal Corps, presented the "E" pins. The address of welcome was delivered by the Hon. Newbold Morris, president of New York City Council.

* * *

SCHRAMM JOINS CLAROSTAT

Emil O. Schramm, Jr., has joined Clarostat Manufacturing Company, Inc., Brooklyn, N. Y., as purchasing agent.

Mr. Schramm has been engaged in radio engineering, research and servicing since 1923. He attended Brooklyn Polytechnic, M.I.T., and graduated with his engineering degree from the University of Southern California. Prior to joining Clarostat he was with the War Department as an ANEPA field expediter.

* * *

KELLEY-KOETT EXPANDS

A new building will soon be added to the plant of the Kelley-Koett Manufacturing Company, Covington, Ky., manufacturers of x-ray equipment. A. H. Feibel is president of the company.

* * *

AUTOMATIC PRODUCTION TESTER BULLETIN

A 6-page folder describing the Rotobridge automatic high speed production circuit tester has been released by Communication Measurements Laboratory, 120 Greenwich Street, N. Y. City. The Rotobridge is said to test a circuit a second and check circuit resistance values as low as .001 ohms with Wheatstone bridge precision.

* * *

PHILIPS SEARCHRAY DATA

Two 4-page folders describing the Searchray have just been issued by the industrial electronics equipment division of the North American Philips Company, Inc., 419 Fourth Avenue, New York City. A. E. Snyder is manager of this division. Two Searchray types, the 80 and 150, are on demonstration, upon request.

* * *

NOREM NOW ASS'T PROFESSOR AT SYRACUSE UNIVERSITY

Bert H. Norem has been appointed assistant professor of administrative engineering in the College of Applied Science, Syracuse University, Syracuse, N. Y.

* * *

RIVETING CHART

A 20"x30" wall chart with essential information on Cherry Blind riveting for aircraft plants, schools, field service depots, engineering departments, etc., has

(*Continued on page* 98)

NEWS BRIEFS

(*Continued from page 97*)

been published by Cherry Rivet Company, 231 Winston Street, Los Angeles 13, Cal.

A feature of the chart is a scale reproduction of both countersunk and brazier head rivets. Three columns of rivets serve as a guide to rivet sizes for three types of installations. One column covers flush riveting; another, combination of machine countersunk or dimpled top sheet and machine countersunk bottom sheet; and the third column shows proper sizes for brazier head riveting in various thicknesses of material.

* * *

J. KERR NOW G. E. EASTERN AREA TUBE REP.

Joseph A. Kerr, former radio representative with G. E. Metropolitan Distributing Branch in New York City, has been appointed tube representative for G. E. electronics department.

* * *

WOOL FELT BOOKLET

A 28-page booklet on felt has been issued by the Felt Association, Inc., New York. Called *Felt Facts,* the booklet tells the story of the manufacture and uses of wool felt, which has been employed as an alternate for rubber, cork, certain fabrics and plastics. Copies are available free of charge from Korbel and Colwell, Inc., 480 Lexington Ave., New York City.

* * *

RCA WINS THIRD "E" FLAG STAR

The Camden plant of RCA Victor Division has been awarded the third star for its Army-Navy "E" pennant.

The original "E" pennant was received by RCA in January of 1942.

* * *

RAYTHEON PLANS POSTWAR PROGRAM

Plans for the postwar activities of Raytheon Production Corporation were discussed at a meeting in Chicago, recently.

Attending the meeting were general sales manager E. S. Reidel, and A. E. Akeroyd, F. E. Anderson, Fred Simmons and Russ Lund, from the Newton, Mass., plant.

* * *

STANDARD DESIGN PRESSED STEATITE LISTINGS

A detailed listing of standard pressed steatite parts for which tools are already available has been issued by Henry L. Crowley & Company, 1 Central Ave., West Orange, N. J.

The listings are in the form of detailed and dimensional drawings of bushings, trimmer-condenser bodies, terminal strips, tube sockets, tube parts, coil bases, variable-condenser end pieces, oscillating-crystal cases, etc., with corresponding part numbers. Well over a hundred standard parts are listed, with more to follow in supplementary bulletins issued from time to time. A copy of this catalog is available to anyone designing or producing equipment utilizing steatite, writing in on his business letterhead.

* * *

C. A. PRIEST APPOINTED TRANSMITTER DIVISION MANAGER

C. A. Priest has been appointed manager of the transmitter division of the G. E. electronics department. In this capacity, Mr. Priest will assume the responsibility for the operations of the Syracuse, New York plant of the division, and will have his headquarters in that city. Mr. Priest was engineer of the radio transmitter engineering division at Schenectady before his new appointment.

* * *

DISTRIBUTORS DISCUSS PROBLEMS WITH RCA OFFICIALS AT SPECIAL MEETING

About 200 RCA Victor distributors and their executive personnel gathered recently at the Waldorf-Astoria in New York to hear officials of the RCA Victor Division discuss mutual problems and current thinking on postwar distribution.

Represented were wholesalers for all of RCA products including radios, phonographs, records, tubes, parts, and commercial sound. Similar meetings were held in Chicago, San Francisco and New Orleans.

H. C. Bonfig, general sales manager, opened the New York meeting. L. W. Teegarden, assistant general sales manager, discussed the part which wholesalers will play in the postwar distribution of RCA products. Vance C. Woodcox, director of commercial research, told of the scientific studies being conducted by RCA.

E. W. Engstrom, director of research of the RCA Laboratories, described the consolidation of RCA's extensive research activities at Princeton, N. J., and Thomas F. Joyce, manager of the radio, phonograph and television department, outlined the RCA current advertising programs.

* * *

G. E. RESIN AND INSULATION MATERIALS SALES DIVISION GOES TO SCHENECTADY

The resin and insulation materials division of the G. E. appliance and merchandise department has moved its sales and order service headquarters office to Schenectady, N. Y., from Bridgeport, Conn.

* * *

THROAT MICROPHONE BULLETIN

Universal Microphone Co., Inglewood, Cal., has published a catalog describing throat microphone type T-30-S.

Descriptive data includes the functions, wearing methods, handling, resistance, current, repairing, dimensions and component weights.

* * *

BRANDT, HENYAN, LUCAS IN NEW G. E. POSTS

Arthur A. Brandt has been made general sales manager of G. E. electronics department.

George W. Henyan has been made assistant to the vice president and V. M. Lucas has been appointed manager of the Government division.

* * *

G. A. PRICE NEW V-P AT WESTINGHOUSE

Gwilym A. Price has been elected vice president of Westinghouse Electric and Manufacturing Company, Pittsburgh, Pa.

* * *

NEW ALUMINUM DEOXIDIZING METHOD

A new principle of aluminum deoxidizing is said to have been evolved by the technical process division of Colonial Alloys Company, Philadelphia, Penna.

This new principle embodies the use of an alkaline solution known as *deox-aluminum* which is used as a dip, at room or elevated temperatures, from about 10 seconds to 1 minute.

Deox-aluminum is supplied as salts and is mixed with water by the user in the amount of about 12 ozs. of salts per gal-

(*Continued on page* 100)

NEWS BRIEFS

(*Continued from page 99*)

lon of water. The solution may be kept in a container of steel, wood, or glass or rubber lined tanks, or any alkaline resisting material.

The bath may serve both as an aluminum anodizing rack stripper and as a general cleaning method to supplant conventional systems.

Samples are available.

* * *

SCOPHONY AWARDED NEW PATENTS

Basic U. S. patents 2,330,171 and 2,330,-172, issued as part of the group of patents covering the Skiatron system, a new television projection unit, have been granted to Scophony Corporation of America, 527 5th Avenue, N. Y. City. According to Arthur Levey, president of SCA, the patented systems provide large-screen projection.

The inventions were conceived by Dr. A. H. Rosenthal, director of research and development of SCA.

* * *

EXPANSION BOLT CATALOG

A 20-page catalog with data on expansion anchoring devices has been released by the Chicago Expansion Bolt Company, 2240 West Ogden Avenue, Chicago 12, Illinois.

Items covered by the new catalog include expansion bolts, expansion nuts, anchoring units, toggle bolts, lead woodscrew shields, lag screw shields, single and double machine bolt shields, hook bolts and drilling devices.

* * *

FIFTH "E" FLAG TO RCA

The Indianapolis plant of the RCA Victor Division has won the Army-Navy "E" pennant. This is the fifth such award to be won by RCA.

* * *

PHILIPS TO MOVE OFFICES

North American Philips Company, Inc., Dobbs Ferry, N. Y., will move its commercial and administrative departments, late in November, to the Pershing Square Building, New York. Philips Export Corporation, with offices in the Hotel Roosevelt Building, New York, will also move here. The industrial electronics equipment division in New York will move to the new location, too.

The change will not affect production personnel at the three plants in Dobbs Ferry and Mount Vernon, N. Y., and Lewiston, Maine. The purchasing department will remain at Dobbs Ferry.

* * *

SUN RADIO CHANGES NAME

The Sun Radio Co., 212 Fulton Street, New York City 7, has changed its name to Sun Radio & Electronics Co. The company was established in 1922.

* * *

SHEA NOW P. M. OF ECA

H. Gregory Shea has been appointed production manager of Electronic Corporation of America.

* * *

BEN MILLER TO REPRESENT RADIO ESSENTIALS

Ben Miller has been appointed manufacturer's representative of Radio Essentials, Inc., for Southern Wisconsin and Illinois with headquarters at 149 West Ohio Street, Chicago, Illinois. Mr. Miller was formerly sales manager for Meissner Mfg. Co.

Herman Smith president of Radio Essentials, Inc., who announced Mr. Miller's appointment, also announced that Irving Rosen will be his representative contacting distributors in metropolitan New York.

* * *

WILLIAM LODGE RETURNS TO CBS

William B. Lodge, for the past eighteen months associate director of the Airborne Instruments Laboratory of Columbia University, Division of War Research, has returned to the general engineering department of CBS.

Lodge first joined the Columbia Broadcasting System in December 1931. He was engineer in charge of radio frequencies division when he left the network for his recent special war post. For the present Lodge will divide his time between CBS and the Airborne Instruments Laboratory. He will supervise the operations of the CBS general engineering department during the current leave of absence of E. K. Cohan, CBS director of engineering.

* * *

WORNER PRODUCTS RENAMED

The Worner Products Corporation will hereafter be known as Worner Electronic Devices. And after November 1st, they will occupy new quarters at 848 North Noble Street, Chicago 22, Illinois.

* * *

ZENITH F-M U-H-F BIBLIOGRAPHY

A new edition of the u-h-f reference guide, published last year, has just been released by Zenith Radio Corporation, 680 North Michigan Avenue, Chicago, 11, Illinois. This issue has also been prepared by Elizabeth Kelsey. It's an interesting presentation, replete with information that engineers will find most useful. Papers on u-h-f and f-m that have appeared in the past ten years are effectively cataloged. In addition a section has been devoted to short biographical sketches of outstanding u-h-f and f-m specialists.

As long as copies last, they are available gratis. Send your request to Miss Kelsey.

* * *

PRESS WIRELESS WINS WHITE STAR

The Hicksville, Long Island, plant of Press Wireless, Inc., has won a white star for their "E" flag.

* * *

IDEAL COMMUTATOR LEAFLETS

Two new leaflets covering Wire Nuts and Safe-T-Grip fuse pullers have been released by the Ideal Commutator Dresser Company, 1288 Park Avenue, Sycamore, Illinois.

* * *

AEROVOX FILTER DATA

Three releases of the Aerovox Research Worker covering design data for m-derived type filters have been released by the Aerovox Corporation, New Bedford, Massachusetts.

In these interesting releases appear data on low and high pass filters, frequency charts and series-derived band filter charts.

* * *

BELL SOUND SYSTEM BULLETIN

A thirty-two page catalog, No. 38, describing amplifiers, inter-communicators, public address systems, etc., has been released by the Bell Sound Systems, Inc., 1183 Essex Avenue, Columbus, Ohio.

* * *

SAYRE M. RAMSDELL, DEAD

Sayre M. Ramsdell, president of the Sayre M. Ramsdell Associates advertising agency, died at his home recently. He was 45 years of age. Among the principal clients of the agency are Philco Corporation and National Union Radio Corporation.

* * *

AERO NEEDLE OFFERS COUNTER CARD

A counter card featuring the Aero point *III* phonograph needle is now being of-

(*Continued on page* 107)

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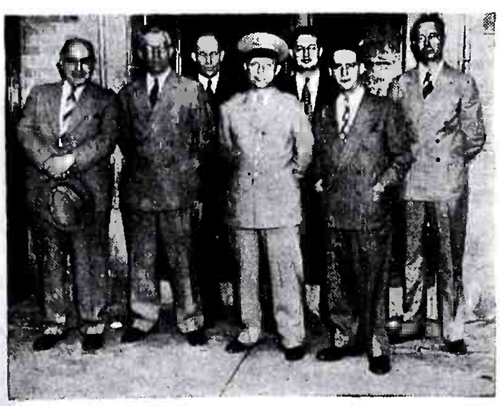
ARMY OFFICIAL VISITS SONOTONE PLANT



Left to right: L. G. Pacent, president, Pacent Engineering Corporation, N. Y. (consulting engineers to Sonotone); Dr. Fred W. Kranz, vice-president and director of production, Elmsford plant; A. J. Harris, plant manager, Martlex plant; Capt. A. C. Anderson, S.C., chief, Special Products Section; J. Leggio, U. S. Signal Corps inspector; I. I. Schachtel, vice-president, Sonotone Corp., and Robert L. Lewis, vice-president, Pacent Engineering.

RTPB HOLDS FIRST MEETING; DR. BAKER APPOINTED CHAIRMAN

THE Radio Technical Planning Board held its first meeting September 29, at the Roosevelt Hotel, New York City, N. Y. Voting sponsors represented at the meeting were American Radio Relay League; FM Broadcasters, Incorporated; Institute of Radio Engineers; National Association of Broadcasters, and Radio Manufacturers Association.

Other sponsors present, but not yet qualified to vote, were: The American Institute of Electrical Engineers; Aeronautical Radio, Incorporated; International Association of Chiefs of Police, and National Independent Broadcasters.

Dr. W. R. G. Baker, vice president of General Electric, was appointed as chairman of the new RTPB for a term of one year. A plan of organization and procedure was adopted at this meeting.

According to organization and procedure plan, the objectives of the RTPB shall be to formulate plans for the technical future of the radio industry and services, including frequency allocations and systems standardization, in accordance with the public interest and the technical facts, and to advise government, industry, and the public of its recommendations. Such planning shall be restricted to engineering considerations.

The RTPB will be representative of the many branches of the radio field

Haraden Pratt, who represented the IRE a[t] the RTPB meeting.

)r. W. R. G. Baker, who was appointed RTPB chairman for a one-year term.

nd will call upon technical experts rom all branches to assist in the work f planning in conformity with its bjectives.

Such studies, investigations, recom- nendations, and standards as are re- uired to attain its objectives, will be leveloped. The board will also con- ider and appropriately act upon sug- estions or requests for recommenda- ions from branches of the govern- nent or important groups in the radio ield.

The sponsors of the RTPB shall be hose non-profit associations and so- ieties which have an important in- erest in radio and which indicate a villingness to cooperate in achieving he objectives of the RTPB.

Those sponsors who agree to con- ribute in the first year of operation sum of one thousand dollars or more o the financial support shall be des- gnated *contributing sponsors.* The ninimum qualifying sum for subse- uent years shall be set by the ad- ninistrative committee not less than ixty days before the close of the perating year.

No sponsor shall be obligated for a ontribution greater than that to vhich it agrees in advance, nor shall he RTPB incur financial obligations t any time exceeding the total sum f contributions previously agreed pon by the sponsors.

The board shall be composed of ne person or his alternate selected by ach sponsor, both to be selected by ach respective sponsor, and of the hairman of all panels.

SMPE CONFERENCE

(*Continued from page* 48)

veloped, pointed out Mr. Landsberg.

All these considerations point to the necessity of deciding whether we should plan for immediate postwar television or for a later, maybe much later time. To answer this one question, Mr. Landsberg said, we must ask several others. Above all can television with its present standards and present state of the art give a high quality service or not? Mr. Landsberg believes that the experience of the past years enables us to answer with an emphatic yes. "Television is ready to give an excellent service!" he emphasized.

And said Mr. Landsberg . . . "the quality of television pictures today is such that it can be compared to the quality of sixteen millimeter motion picture film. With improvement of circuit components and tubes for the transmitter as well as the receiver, particularly the improvement of camera tubes and cathode ray receiver tubes, so much better quality of images can be obtained without a change in the system that it seems doubtful that different systems will become necessary.

"Wartime mass production of similar equipment has shown the way for production of television receivers below $100.00.

"Projection of high quality television pictures to theatre screen size is no longer a laboratory dream.

"With new types of camera tubes no excessive light level is required for a television pick-up.

"Through progress made in u-h-f transmitter tubes and antenna design a signal strength adequate to give practically interference-free reception even in poorest receiving localities can be produced.

"Relay transmitters make linking of cities and trans-continental television possible.

"All these facts prove that black and white television is ready now to give a highly adequate service with presently used systems and standards.

"Undoubtedly the addition of color is desirable, but should be perfected and thoroughly tested prior to its incorporation into standards and public service. Technicolor motion pictures although highly perfected have to this day not replaced black and white film.

"Another consideration in television planning is the frequency band television stations should occupy. This is important since an always larger spectrum is made useful for radio services, because always new services desire space in the ether. Television, I believe, would encounter difficulties in moving to higher frequencies where multipath transmission becomes a more serious factor, since reflected signals are a greater hazard to picture transmission than to many other services. Still, television will require more room in the frequency spectrum; plans must be made to obtain it.

"When the end of the war approaches, the first group of men released from war work will be the designers. At that time, which may be well before the war's end, standards for television must be ready so that they can design the receiver and projector models, which are to be put into production right at war's end, if such production shall help cushion against sudden work and employment stoppage."

The technical portion of Mr. Landsberg's paper covered a discussion of new types of camera tubes, projection systems, transmitting antenna, color systems, background projection, lighting equipment, relay transmitters, present standards and various proposed standards.

ROCHESTER FALL MEETING

(*Continued from page* 84)

to the engineer in the development of future intermediate frequency amplifier systems.

Jones to Discuss 28-Volt Operation

An analysis of the Sylvania 28D7 power output tube and its power supplies, will be presented by Walter R. Jones, manager, commercial engineering department, Sylvania.

Considerable interest in the operation of radio equipment directly from the battery source in airplanes has arisen since the introduction of this tube. With this tube is has been possible to obtain power outputs on the order of 200 milliwatts under resistance-coupled drive conditions, and when the tube is transformer driven as high as 750 milliwatts can be obtained. Type 28D7 in reality consists of two beam tetrodes in one envelope with both control grids and both plates brought out separately. The two units may be connected as cascade amplifiers, both sections in parallel, or as push-pull amplifiers.

With the output tube problem for 28-volt application solved, it became desirable to learn if standard receiving tubes would give reasonable performance with 28-volt supply or whether a new line of tubes would be necessary to produce equipments capable of giving satisfactory performance. Fortunately, it developed that standard receiving tubes may be employed quite satisfactorily with seemingly remarkable results. Input loading effects, especially at the higher frequencies, have to be recognized and provisions must be made to reduce these effects as much as possible. The operating conditions of tubes under rated conditions do not always serve as an indication of the performance to be expected under low plate voltage conditions; that is, tube types having the highest mutual conductance under 250-volt conditions will not necessarily have higher mutual conductance under 28-volt conditions. The performance of high mu triode tubes under low voltage conditions is not too satisfactory; whereas, low mu triodes operate very well.

It has been possible to build superheterodyne receivers operating up to 50 megacycles and higher for 28-volt operations having sensitivities comparable to those obtained with 250-volt plate supplies. If proper precautions are observed, considerable savings in set and motor generator

(*Continued on page* 106)

PRODUCTION AIDS

(*Continued from page 76*)

glass to glass in the conventional manner to the required length. This method was made practical by redesigning the featheredge specifications to give a seal that would not become porus or weakened materially in subsequent processing. It has been found that this method is superior to one that removes the glass from the sealing surface since the original seal is left intact.

A suggestion eliminating the necessity of side, wing, or positioning micas on two types of receiving tubes which have a yearly production of approximately 855,000, is shown in Figure 6. Devised by W. J. Carlin of RCA, it affords a direct labor saving of 1,330 hours per year and a direct material saving of $1,440 a year.

The wing micas as shown were originally designed to position the mount in the glass bulb. These micas were also the means of reducing vibration on this tube type under consideration. However, after a series of tests it was decided that positioning of mount and vibration limits could be successfully met by using the top mica as the positioner and vibration cushion. Standardization for this change has been placed.

A method of salvaging tubes, proposed by Fred Follmer of RCA, is shown in Figure 7.

This suggestion proposed a way to salvage tubes that are rejected due to cracked bulbs, stems or flares by removing the cage and rewelding it onto a new stem. With this idea it has been possible to recover over 100 shrinkage tubes per month.

Savings for the first year were estimated as $822.49 in material and 194 man-hours.

The suggestion stated that on the 815 and similar type tubes, shrinkage due to cracked flares, poor seals, lead wires missing, and other types of pre-exhaust shrinkage might be saved by cutting the cage portion of the mount away from the stem at the point where it was welded and rewelding to a new stem. This will work only on mounts that have not been mishandled, causing internal electrical shorts.

The mount above the reference line is cut from its several wires and electrical connectors and rewelded to a new stem.

IN recognition of the tremendous potential worth of practical ideas for improving the job from the men who do the job, the War Production Board, under the leadership of Donald Nelson, set up a system of national honors for the suggestions which in actual industrial usage prove to be of value in increasing production. Labor-Management Committees have been established in 2,400 plants in which 5,000,000 war workers are fighting the "Battle of Production." Union representatives comprise the labor half of the committees in all plants where there is a recognized labor organization.

Throughout the country, Labor-Management Committees have been encouraging workers to write out their ideas, and drop them in suggestion boxes conveniently located in the plant. If a worker thinks that he is doing two operations where only one is necessary, or that a substitute raw material might be more effectively used, or that a mechanical adjustment in his machine would make his work more efficient, or if he has any other ideas for improving and increasing production, he can make his contribution to the suggestion box in the knowledge that his proposal will receive careful consideration.

Both management and labor representatives on the Committees review suggestions for merit. If they are found to be useful, they are adopted in the plant. If the Committee considers the suggestion to be of enough value to have promise of broader application throughout industry, it is submitted to War Production Drive Headquarters, where it is reviewed by the Board for Individual Awards, composed of technicians and engineers in various industrial fields. Four grades of awards are given, proportionate to the breadth of application of the idea. Almost 1,000 workingmen have already received recognition from the government. Of these, 14 have received the highest award—the Citation for Production Ideas, which is "a citation for a suggestion making an outstanding contribution to the war production program of the United States."

So that these building blocks in the country's War Production program may be available to every plant in every industry, War Production Drive Headquarters has a nation-wide exchange service. A pamphlet briefly describing the award winning suggestions is available on request, and war plants interested in specific items may write for a fuller description, and blue prints if necessary.

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ROCHESTER FALL MEETING

(*Continued from page 105*)

equipment can be realized by the application of tubes under 28-volt operating conditions.

Floyd's Paper on Vacuum Capacitors

This paper will describe the properties, characteristics and uses of the vacuum capacitor, particularly two General Electric vacuum capacitors, the GL-1L38 and the GL-1L22. Design considerations will be discussed from the viewpoint of both the designer and the manufacturer. Capacitance formulas and the deriving of the equation for energy loss will be discussed. The effects of humidity, temperature and vibration on this type capacitor will also be analyzed.

NEWS BRIEFS

(*Continued from page* 101)

fered by the Aero Needle Company, 737 North Michigan Ave., Chicago.

The card contains 13 packaged needles. Aeropoint phonograph needles incorporate the exclusive shock-absorbing curved spring design engineered by Fred Williamson.

* * *

R. L. DRAKE COMPANY MOVES

R. L. Drake Company has moved from Piqua, Ohio, to their own building at 11 Longworth Street, Dayton 2, Ohio. Products made by Drake consist of interference filters, radio frequency coils, radio and electronic equipment.

* * *

HOWARD W. BENNETT NOW G. E. SPECIALTY DIVISION MANAGER

Howard W. Bennett has been made manager of the G. E. specialty division. In this capacity, Mr. Bennett will be responsible for the engineering, manufacturing, and sales operations of that division.

* * *

FOURTEEN COMPANIES ADDED TO RMA ROSTER

Fourteen new member companies have been elected to membership of RMA. The new RMA member companies are Ansley Radio Corporation, Long Island City, New York; Felt Products Mfg. Co., Chicago, Illinois; A. W. Franklin Mfg. Corp., New York, New York; The Jackson Electrical Instrument Co., Dayton, Ohio; E. F. Johnson Co., Waseca, Minnesota; Majestic Radio & Television Corp., Chicago, Illinois; Merit Coil & Transformer Corp., Chicago, Illinois; James Millen Manufacturing Co., Inc., Malden, Mass.; Poray, Inc., Chicago, Illinois; Rocke International Electric Corp., New York, New York; Sound, Inc., Chicago, Illinois; Syracuse Ornamental Company, Syracuse, New York; United Electronics Company, Newark, New Jersey, and Wm. T. Wallace Mfg. Co., Peru, Indiana.

* * *

REVELATION PATENTS MOVES

The Revelation Patents Co., Inc., has

(*Continued on page* 123)

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WIRE RECORDER DEMONSTRATED

Colonel E. M. Kirby, Chief of the Radio Branch of the Army's Bureau of Public Relations, demonstrating two models of General Electric's magnetic wire recorder at a recent meeting of the Associated Press Managing Editors Association in Chicago.

U-H-F PRODUCT ENGINEERING

(*Continued from page* 19)

struction may offer possibilities. This is a development which can only be realized at u-h-f. Again, it is not necessary that we be tied down to octal or loctal base construction. Radial elements, with dual termination seem to offer distinct advantages, particularly where concentric or resonant circuit elements are to be used.

There is one particular u-h-f problem that must be solved. This problem concerns contact resistance. Methods for eliminating contact resistance, particularly in tube mounting are necessary. Here is a tough one that should interest metallurgists or electrochemical engineers.

Suitable insulating material poses another problem. We could use an insulator having the dielectric constant of polystyrene, the ease of handling of lucite, and the rigidity of steatite. The dielectric constant is usually limited because of dust conditions, unless construction is such as to make r-f circuits dust tight. This presents another problem in design.

Antenna tolerances at u-h-f are quite sharp. In covering a wide band of frequencies, say 110 to 140 megacycles, there is bound to be mismatch at the terminal frequencies, when a simple antenna of intermediate frequency resonance is used. Where the antenna is physically a part of the receiver, it should be fairly easy to resonate it over the band by either physical or electrical means. However, when the antenna is coaxially fed from some distant point, it presents a difficult problem. Here again, some thought may produce some new ideas on *aperiodic* antenna construction. This is vital, when good reception and high efficiency are essential factors. This factor is particularly important in commercial applications such as aircraft or ship intercommunication.

A necessary adjunct to all this is the development of test equipment built along new principles to operate efficiently in the *u-h-f* spectrum, particularly for line production. This field, in which civilian development was abruptly terminated by our entrance into the war, will probably be the laboratory for technological advancements that will be eventually adapted for commercial and home use.

While resonant and concentric line frequency control are adequate for some uses, there is no substitute for crystal control, as exemplified at the lower frequencies. This is particularly important for the transmitter. A method of fundamental u-h-f frequency control without doubling or tripling, is a necessity if broadcast selectivity is to be attained at u-h-f.

Developments of the crystal type advocated would have the additional benefit of further opening those bands lying above 200 megacycles. Since communication is not the only function served by radio, clear cut methods of design may develop improvements in frequency generation useful in other fields.

All u-h-f developments appear to be focused on two essential facts; the need for the development of new lingual technique and mental concepts, and new methods of physical construction based on basic radio theory. While all the problems at u-h-f have not been detailed here, some of the basic problems that warrant attention have been outlined.

THE CIRCLE DIAGRAM

(*Continued from* page 82)

which the charts are most conveniently used.

Filters designed for comparatively low frequencies operate over relatively wide bands and may be constructed with highly dissipative (low Q) components—in a relative sense.

Conversely, filters for high frequency operation work within a comparatively narrow band, and a low value of d are essential in this case. The term *sharp definition filters* has been used with reference to this group.

The high frequency charts differ from the others in the choice of the frequency scale. The approximation:

$$1 - (f/f_o)^2 = 1 - 2f/f_o$$

permits the use of a more convenient scale without appreciable error. Furthermore, neglecting d with respect to unity simplifies the construction.

Other simplifications have been introduced, resulting in a consistently small error, always such as not to influence appreciably the accuracy inherent in these or any other graphical methods.

[*To be Continued*]

CRYSTAL MANUFACTURE

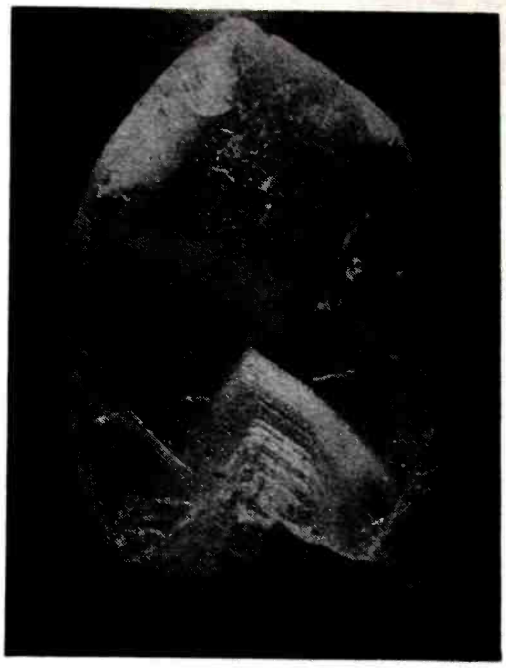
(*Continued from page* 32)

faces of the raw quartz. If the density of these needles in a particular volume of quartz is fairly low, it may be worthwhile to try to use that volume, but if the density is high it would be safest to set that volume aside as unusable, at least for the present.

Blue needles are found oriented in various directions and generally do not interfere with operation of medium high frequency oscillator plates. These are very fine needles and their name is derived from their definite bluish white tint.

A rarer type of flaw is chuva. It consists of many needle-like filaments with bubbles spattered on them and glistens much like a spider web with fine water drops on it in the sunlight. Chuva in small quantities may have little or no effect on the finished oscillator plate performance.

Let us recall that no notice of electrical twinning has thus far been made. One simple, but inaccurate way, is to examine the natural surfaces of the rock for apparent fissures other than cracks, or for irregular stepped surfaces which follow no definite pattern. These surface manifestations of electrical twinning, plus others not so easily visible are shown up very clearly simply by sandblasting the entire surface of the mother quartz and etching it for several hours in hydrofluoric acid or hot ammonium bifluoride. The extent of penetration of the twinning can be guessed from its contour lines on the surface. The guess may not always be too accurate. The twinning will show up dark areas adjacent to light areas, varying in brightness as the quartz is turned under the light source. If the quartz is not sandblasted prior to etching, the smooth natural surfaces will take much longer to etch sufficiently for us to follow the twinning borders, easily. Optical twinning also shows up nicely as a result of the etching. It shows up as very regular geometric patterns, triangles, trapezoids or other quadrilateral and triangle combinations, and usually as many small individual



Opaque phantom growths showing multitudinous layers parallel to the apex bases of the mother quartz crystals. Thin veils may be seen near the phantom growth.

Same crystal as shown on page 32, lower left, viewed parallel to optical axes between crossed polarizers showing optical twinning around edges and irregular discoloration volumes within crystal. Phantom appears as the core of much lighter color than the remainder of the mother crystal.

areas. Electrical twinning boundaries are generally irregular in shape.

There was a time when colored or smoky quartz was considered unfit for use as oscillator plates. As mentioned earlier, the cause of the coloring is not completely determined, but the processing of oscillator plates from *smoky* quartz and their final operation seems no different from those made from clear quartz. Inspection of *smoky* quartz in the oil bath sometimes is very difficult or impossible because of its opacity. Surface examination is the substitute in such cases, and since they are rare do not influence our over-all accuracy of classification greatly.

As the inspector completes his examination he integrates the objectionable flaws which he has seen and estimates the approximate extent of usable volume of the mother crystal. His judgment will place raw quartz of equal yield possibilities in the same group. Later on, when the quartz is issued to the saws the production manager need only know what quality rock is being cut and he can plan all machine and labor time for the subsequent operations on the basis of estimated yield of blanks per pound of rock.

A competent raw quartz inspector tries to keep in touch with the needs of the production processes and should know how the actual yield compares with his estimated yield.

From the classified raw quartz bins the individual *mother* is taken and prepared for proper sawing. This preparation process, called orientation, will be discussed next month.

(All photos by Harvie Scheetz)

Portion of quartz crystal showing many small askew outcropping growths of tiny fully formed crystals.

ATTENUATOR DESIGN

(*Continued from page* 44)

Finally, the nth element is:

$$R_n = c(R_o + R_1 + R_2 + R_3 + \ldots + R_{n-2} + R_{n-1})$$
$$= R_{n-1} + cR_{n-1} = R_{n-1}(1 + c)$$
$$= cR_o(1 + c)^{n-1} \qquad (22)$$

Expanding equation *22* by the binomial expansion theorem:

$$R_n = cR_o\left[1 + \frac{n-1}{\underline{|1}}c + \frac{(n-1(n-2)}{\underline{|2}}c^2 + \ldots + \frac{(n-1)(n-2)(n-3)\ldots(n-r)}{\underline{|r}}c^r + \ldots\right] \qquad (23)$$

$$= R_o\left[c + \frac{n-1}{\underline{|1}}c^2 + \frac{(n-1)(n-2)}{\underline{|2}}c^3 + \ldots + \frac{(n-1)(n-2)(n-3)\ldots(n-r)}{\underline{|r}}c^{r+1} + \ldots\right] \qquad (24)$$

The expansion will have n terms in the brackets and since for this attenuator, n is always positive, if continued, the expansion would give an infinite series which converges when c is numerically less than 1.

When c is greater than 1, for convergence of the series, we must have the expansion:

$$R_n = cR_o(c + 1)^{n-1}$$
$$= cR_o\left[c^{n-1} + \frac{n-1}{\underline{|1}}c^{n-2} + \frac{(n-n)(n-2)}{\underline{|2}}c^{n-3} + \ldots + \frac{(n-1)(n-2)(n-3)\ldots(n-r)}{\underline{|r}}c^{n-1-r} + \ldots\right] \qquad (25)$$

$$= R_o\left[c^n + \frac{(n-1)}{\underline{|1}}c^{n-1} + \frac{(n-1)(n-2)}{\underline{|2}}c^{n-2} + \ldots + \frac{(n-1)(n-2)(n-3)\ldots(n-r)}{\underline{|r}}c^{n-r} + \ldots\right] \qquad (26)$$

Since c is a numeric, it is much easier to use either logarithms or tables of the c function to obtain the required element values.

If we allow n to take on successive values of 1, 2, 3, . . . $(n-1)$, n, equations *24* and *26* become the identities given in equations *18* to *22* inclusive.

Substituting equation *16* in *22*, we obtain:

$$R_n = R_o(k_s^n - k_s^{n-1}) \qquad (27)$$

which may be compactly written as

$$R_n = R_o K \qquad (28)$$

It may also be noted by comparing equation *28* with equations *24* and *26* that the quantities within the brackets in each of these equations are also equal to K, or

for $c < 1$,

$$K = \left[c + \frac{n-1}{\underline{|1}}c^2 + \frac{(n-1)(n-2)}{\underline{|1}}c^3 + \ldots + \frac{(n-1)(n-2)(n-3)\ldots(n-r)}{\underline{|r}}c^{r+1} + \ldots\right] \qquad (29)$$

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and for $c > 1$

$$K = \left[c^n + \frac{(n-1)}{\underline{|1}} c^{n-1} + \frac{(n-1)(n-2)}{\underline{|2}} c^{n-2} + \ldots + \frac{(n-1)(n-2)(n-3)\ldots(n-r)}{\underline{|r}} c^{n-r} + \ldots \right] \quad (30)$$

For $c = 1$, from equations *22* and *28*:

$$K = 2^{n-1} \quad (31)$$

and equation *28* becomes for this special case,

$$R_n = 2^{n-1} R_o \quad (32)$$

which gives an attenuator having 6.02 db change per step in which the values of the steps taken on successive values of R_o, $2R_o$, $4R_o$, $8R_o$, $16R_o$, $32R_o$, etc.

The form used for the calculation of *Table 1* is given by equation *6,* and that for *Table 3* is given by equation *27,* although equations *24* and *26* could have been used and have given the same degree of accuracy in place of *27.* Since *27* becomes *28* when

$$K = (K_s^{\,n} - k_s^{\,n-1}) \quad (33)$$

the design procedure becomes one of repeated application of the product of two numbers; to wit, R_o and K. R_o is given by *Table 1*, and K by *Table 3*. The finding of the element values is therefore all contained in equation *28,* or

$$R_n = R_o K \quad (28)$$

The calculation of the product of the two numbers is greatly facilitated in most cases by the use of logarithms, because the logarithms may be added together and the anti-logarithm or number corresponding to the addition may be found either from a table of anti-logarithms or of logarithms directly. *Table 2* is the logarithm of *Table 1,* while *Table 4* is the logarithm of *Table 3.* Only the mantissa portion of the logarithm is given. The characteristic must be obtained by inspection from the given R_o or K, as the case may be.

With a simple, continuously variable potentiometer, the procedure is to calculate the required element values from equation *28* by means of the tables. When with a Wheatstone bridge, ohmmeter or other suitable measuring device, the required values may be measured. By setting the bridge or device used to the value needed, then rotating the knob or shaft until bal-

(*Continued on page* 114)

ance or required reading is obtained, the successive values may be obtained. A pointer or marker on the knob used in conjunction with polar coordinate paper similar to K + E 358-31 or 343B, will be of assistance in setting the potentiometer accurately.

If a linear type of potentiometer is used, logarithmic spacing of the coordinate points will result, but if a non-linear or logarithmic type of potentiometer is used, a linear scale with equally spaced divisions may be obtained. Various manufacturers produce such potentiometers, and they are widely used as volume or gain controls in radio receivers. Hence a potentiometer should be chosen which, if possible, should give the required resistance values with linear spacing of divisions, or degrees with rotation of shaft.

For the stepped attenuators, either stock-rated values, or percision resistors may be used, depending upon the degree of accuracy needed.

Typical examples of the theory given are shown in Figures 4, 5 and 6.

Example 1: Assuming that the transformer secondary loading of Figure 2 is to have 100,000 ohms total resistance in *R,* what element values should be used to provide a control range of the amplifier from minimum to maximum of 20 db using 2 db steps?

Solution 1: The total control range is 20 db in steps of 2 db each; hence 10 steps will be needed in addition to the minimum step. From *Table 1,* for a total gain of 20 db, $R_0/10^m = 0.100000$. Since $R = 1 \times 10^m = 10^m = 10^5$ ohms, $R_0 = 0.1 \times 10^5 = 10{,}000$ ohms. From *Table 3,* the value of *K* for 2 db per step, and for steps from *1* to *10* are given. Equation *28* states that $R_n = R_0K$; hence applying the product of the two numbers R_0 and *K* successively, for steps *1* to *10* inclusive,

				ohms
R_1 =	10,000 ×	0.25892	=	2,589.2
R_2 =	10,000 ×	0.32597	=	3,259.7
R_3 =	10,000 ×	0.41037	=	4,103.7
R_4 =	10,000 ×	0.51663	=	5,166.3
R_5 =	10,000 ×	0.65039	=	6,503.9
R_6 =	10,000 ×	0.81879	=	8,187.9
R_7 =	10,000 ×	1.03080	=	10,308.0
R_8 =	10,000 ×	1.29770	=	12,977.0
R_9 =	10,000 ×	1.63370	=	16,337.0
R_{10} =	10,000 ×	2.05673	=	20,567.3

The sum of R_0, R_1, R_2, etc., to R_{10} = R = 100,000 ohms. These values are shown on Figure 4.

Example 2: Assume that we have an amplifier giving a gain overall of 80 db. We wish to control the gain in 4 db steps and have a minimum overall gain of 40 db, what element values should be used? It is desired to use a 500,000-ohm total load resistance for the job.

Solution 2: A 40 db range of control will require 10 steps of 4 db each. *Table 1* gives for $R_0/10^m$, using a total gain of 40 db, the value 0.050000. Since $R = 5 \times 10^m = 5 \times 10^5$, $R_0 = 10^5$ 0.050000 = 5,000 ohms. From *Table 3, K* is given for steps *1* to *10* inclusive for 4.0 db per step. Applying equation *28* successively for $R_n = R_1$ to R_{10} inclusive, we obtain the required values of

R_1 =	5,000 ×	0.58489	=	2,924.45
R_2 =	5,000 ×	0.92700	=	4,635.0
R_3 =	5,000 ×	1.46918	=	7,345.9
R_4 =	5,000 ×	2.32850	=	11,642.5
R_5 =	5,000 ×	3.69043	=	18,452.15
R_6 =	5,000 ×	5,84893	=	29,244.65
R_7 =	5,000 ×	9.26994	=	46,349.7
R_8 =	5,000 ×	14.69185	=	73,459.25
R_9 =	5,000 ×	23.28493	=	116,424.65
R_{10} =	5,000 ×	36.90435	=	184,521.75

The sum of R_0, R_1, R_2, etc., to R_{10} = R = 500,000 ohms. These values are shown on Figure 5.

Example 3: Using a stepless potentiometer of 1-megohm total resistance, at what values of resistance should degree or division marks be placed to provide a total variation in gain of 50 db in steps of 5 db each.

Solution 3: Ten steps will be required of 5 db each. From *Table 1*, $R_o/10^m = 0.003162$. Here, $R = 10^6 = 10^m$, or $R = 0.003162 \times 10^6 = 3{,}162$ ohms. Logarithms may be more conveniently used than longhand multiplication for this case. Using *Table 2* we find that the $\log_{10}R_o = 0.500000$ to which, by inspection of the number of places to the left of the decimal point of R_o, we add one less than the four figures of R_o, or three for the characteristic. By using *Table 1*, another method of solution presents itself. The characteristic is, by inspection, equal to the number of zeros to the right of the decimal point taken from 9.00000 — 10 or 7.00000 — 10. To this, we add the value of *m* which is 6 in this case, getting 6+ 7.00000 — 10 = 13.00000 — 10 = 3.00000. The logarithm of R_o therefore = 3.00000 + 0.50000 = 3.50000. This logarithm may now be added to the logarithms of *K* in *Table 4*. The characteristic to be added to the mantissa in *Table 4* is obtained from *Table 3* by inspection, giving 9.00000 — 10, 0,0,0,0, 1,1,1,1, and 2 respectively for the characteristics of steps *1* to *10* to be added to the mantissas given in *Table 4*. After adding each pair of logarithms together, the anti-logarithms are then found from any table of common logarithms.

The work may be arranged as follows for convenience:

$$\log_{10}R_o = 3.50000, \quad R_o = 3{,}162.3$$
$$\log_{10}(R_oK) = \log_{10}R_o + \log_{10}K$$
$$\log_{10}R_n = 3.50000 + \log_{10}K$$

$\log_{10}K$	$\log_{10}R_n$	R_n
9.89114—10	3.39114	$R_1 =$ 2,461.16
0.14114	3.64114	$R_2 =$ 4,376.63
0.39113	3.89113	$R_3 =$ 7,782.69
0.64113	4.14113	$R_4 =$ 13,839.8
0.89114	4.39114	$R_5 =$ 24,611.6
1.14114	4.64114	$R_6 =$ 43,766.3
1.39113	4.89114	$R_7 =$ 77,826.9
1.64113	5.14113	$R_8 =$ 138,398
1.89114	5.39114	$R_9 =$ 246,116
2.14114	5.64114	$R_{10} =$ 437,663

The total of $R_o + R_1 + R_2 + \ldots + R_9 + R_{10}$ should equal the value of *R*. Adding up these values, we obtain 1,000,004.38 for the total calculated resistance, or an error of less than one-half of one-thousandth of one per cent, which shows the order of magnitude of error when using logarithms.

One additional example is illustrated in Figure 6. The details of solution are omitted, but may readily be checked by the methods shown in examples *1*, *2* or *3*.

COMPLEX VARIABLE

(*Continued from page 60*)

(Figure 20c) may be given by

$$u = -\frac{\lambda}{2\pi k} \log \frac{r_1 r_3}{r_2 r_4} \qquad (55)$$

the meaning of the r's being indicated in Figure 20c. At the surface of wire *1*, we have, for small wires,

$$\begin{aligned} r_1 &= d_2 \\ r_2 &= h_2 - h_1 \\ r_3 &= h_2 + h_1 \\ r_4 &= 2\,h_2 \end{aligned}$$

so that the potential at the surface of wire *1* is given by

$$u_1 = -\frac{\lambda}{2\pi k} \log \frac{d_2\,(h_2 + h_1)}{2h_2\,(h_2 - h_1)} \qquad (55a)$$

At the surface of wire *2*,

$$\begin{aligned} r_1 &= h_2 - h_1 \\ r_2 &= d_1 \\ r_3 &= 2\,h_1 \\ r_4 &= h_2 + h_1 \end{aligned}$$

and the potential at the surface of wire *2* is

$$u_2 = -\frac{\lambda}{2\pi k} \log \frac{2\,h_1\,(h_2 - h_1)}{d_1\,(h_2 + h_1)} \qquad (55b)$$

The potential difference between the two wires is, from equations *55a* and *55b*,

$$V = u_1 - u_2 = -\frac{\lambda}{2\pi k} \left[\log \frac{d_2\,(h_2 + h_1)}{2\,h_2\,(h_2 - h_1)} - \log \frac{2\,h_1\,(h_2 - h_1)}{d_1\,(h_2 + h_1)} \right]$$

$$= \frac{\lambda}{2\pi k} \log \frac{4\,h_1\,h_2\,(h_2 - h_1)^2}{d_1\,d_2\,(h_2 + h_1)^2}$$

The capacitance between wires, in farads per meter, is

$$C_w = \frac{\lambda}{V} = \frac{2\pi k}{\log \dfrac{4\,h_1\,h_2\,(h_2 - h_1)^2}{d_1\,d_2\,(h_2 + h_1)^2}} \qquad (56)$$

Finally, to obtain the desired result we have to substitute equations *54* in equation *56*. Thus we get

$$C_z = \frac{2\pi k}{\log \left[\dfrac{2c\,(b^2 - c^2)}{a\,(b^2 + c^2)} \right]^2}$$

$$= \frac{\pi k}{\log \left[\dfrac{2c}{a} \left(\dfrac{1 + \gamma^2}{1 - \gamma^2} \right) \right]}, \quad \gamma = \frac{c}{b} \qquad (57)$$

where $k = (10)^{-9}/36\pi$ for air.

Applications to Electric Circuit Theory

Space does not permit a discussion of the applications of the theory of functions of a complex variable to electric circuit theory. This would involve development of the theory of integration in the complex plane, the theory of residues, and a modification of Fourier transform analysis sometimes known as the Mellin Inversion Theorem. For a resume of these methods the reader is referred to a symposium on *Advanced Methods of Mathematical Analysis As Applied to Electrical Engineering* published in *Electrical Engineering*.*

*Vol. 61 (1942), pp. 84-88, 139-143, 197-205, 248-256, 302-309.

MODULATION WAVES

by PAUL K. HUDSON

Assistant Professor Electrical Engineering
University of Idaho

TO facilitate the presentation of the theory of modulation to *first year* classes in Radio Engineering, the writer has plotted a number of sine waves, shown on opposite page, that illustrate some of the basic principles.

Curve *one* represents a carrier wave of ten cycles per second, while curve *two* represents an audio wave of one cycle per second. When these two voltage waves are applied to a nonlinear impedance, the current that flows will have six component waves. These component waves will have frequencies respectively equal to the frequencies of the two original voltage waves, frequencies that are twice the original frequencies, and frequencies that are equal to the sum and difference of the original frequencies. Curves *three* to *eight* represent these component waves. There is also a direct current component that is not shown. All modulation terms above the second order have been neglected to simplify the presentation. The amplitudes of the current waves depend upon the nonlinear impedance and the modulation factor. For this particular illustration the operating point was taken at (1, 1) on the curve $i = ke^2$ and $E_1 = E_2 = 0.5$ volt. The modulation factor was unity.

The equations of the various curves are:

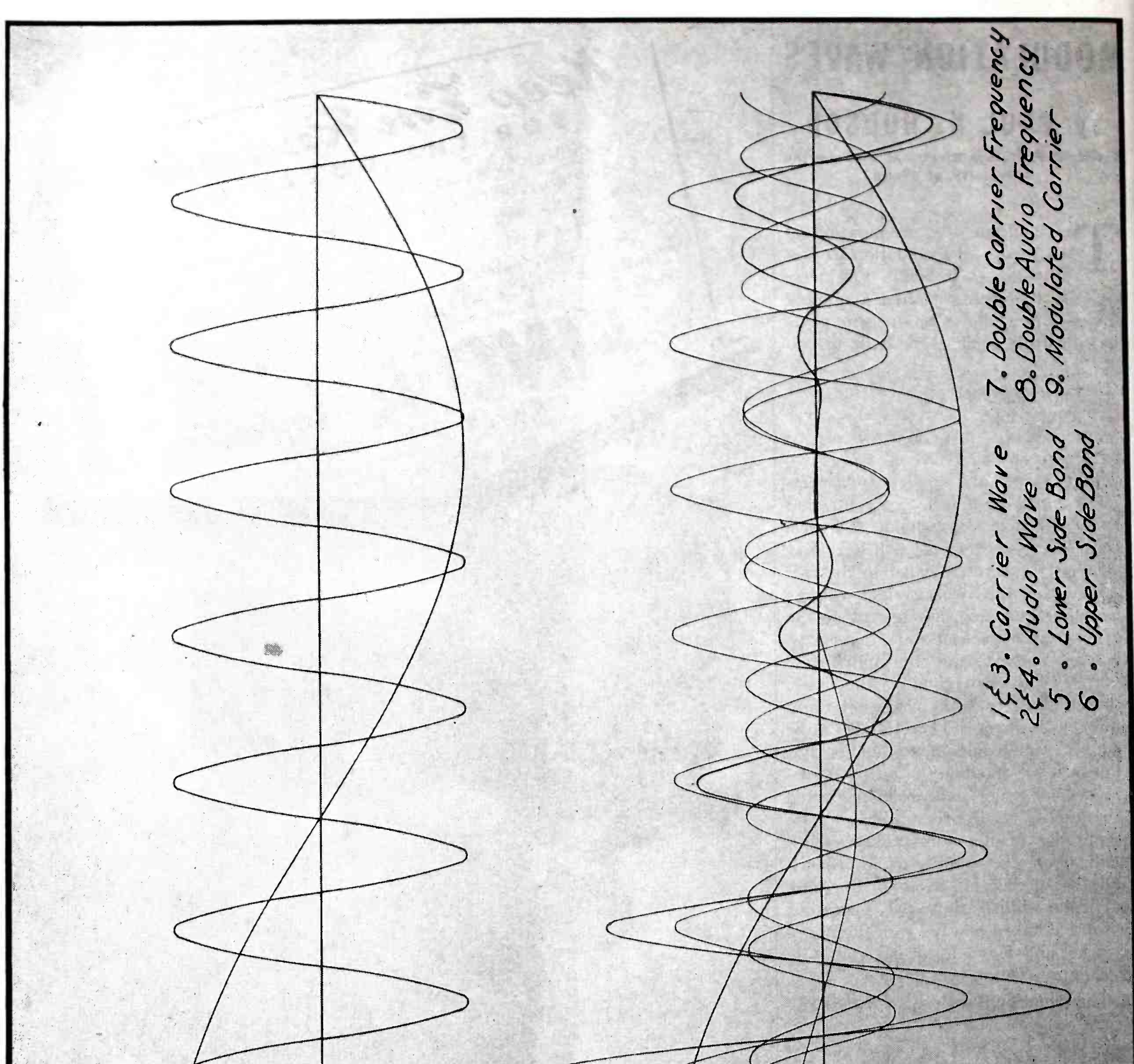
(*1*)—$e_1 = E_1 \sin \alpha t$
(*2*)—$E_2 = E_2 \sin \beta t$
(*3*)—$i_3 = C_1 E_1 \sin \alpha t$
(*4*)—$i_4 = C_1 E_2 \sin \beta t$
(*5*)—$i_5 = C_2 E_1 E_2 \cos (\alpha - \beta) t$
(*6*)—$i_6 = - C_2 E_1 E_2 \cos (\alpha + \beta) t$

(*7*)—$i_7 = - \dfrac{C_2 E_1^2}{2} \cos 2 \alpha t$

(*8*)—$i_8 = - \dfrac{C_2 E_2^2}{2} \cos 2 \beta t$

Of course the theory of amplitude modulated waves is not new. There are many treatises on the subject. The point to be illustrated here is that the modulated carrier (curve *nine*) is the sum of the unmodulated carrier and the two side band frequencies. Since these waves are plotted sine waves, this principle can be demonstrated with ordinary mechanical dividers at any point on the modulated carrier.

[See page 118 for *sine wave* plots.]



1 & 3. Carrier Wave
2 & 4. Audio Wave
5 . Lower Side Bond
6 . Upper Side Bond
7. Double Carrier Frequency
8. Double Audio Frequency
9. Modulated Carrier
1
2
3
4
5
6
7
8
9

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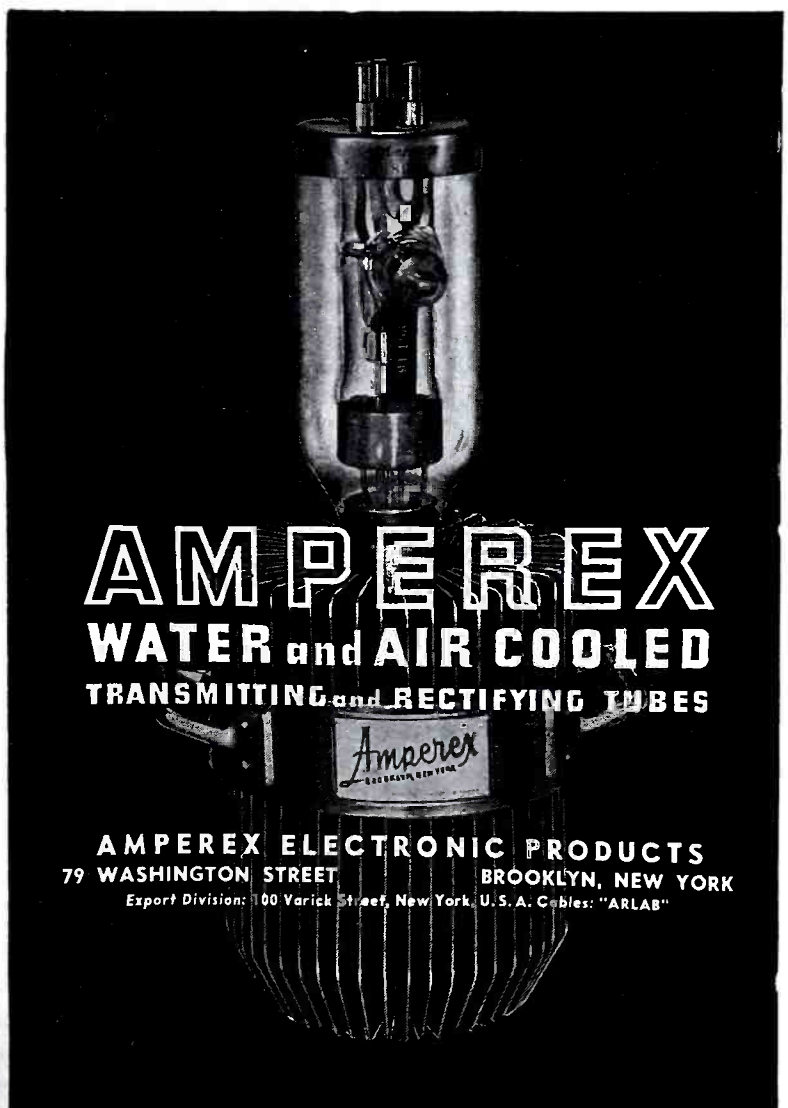

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RSS AND PARALLEL R-X SLIDE RULES

(*Continued from page* 70)

swer would have no electrical significance.

This scale is plotted from the equation $L = \frac{25}{N^2}$, where L is the distance from the left index in centimeters. This scale also covers just the ten-to-one ratio so that three ranges are used. The same considerations enter into the reading of these scales as in the case of the first scales. Finer divisions are needed because the scale is compressed at the left end, and expanded at the right end. The scale is so far from linear at the left end, that interpolating over several millimeters would be quite inaccurate.

To obtain the impedance of a condenser having a reactance of, for example, 2 ohms in parallel with a 1.5-ohm resistor we use scale B (Figure 3). Answer is 1.2 ohms. This is the same as the impedance of a condenser with 1.5 ohms reactance in parallel with a resistor of 2 ohms, because the angle of the impedance is not found. As with the other scales the decimal point may be moved an equal number of steps for each scale to solve problems with high or low impedances. Thus the same setting would be used for a 2,000-ohm condenser with a 1,500-ohm resistor to give 1,200-ohms impedance. The reactance may be either inductive or capacitive.

The author chose a length of 25 centimeters for these scales so they could be easily put on the body of a \$.25 slide rule from the five and ten cent store. This makes a sturdier, more permanent base. When buying one of these slide rules for this purpose try to get one without the magnifier. The magnifier is so powerful that when it lands over certain parts of the scale no divisions are visible. It spreads out the space between divisions so far that you can't see the divisions unless it is right over them. The painted scales should be scraped off then a good grade of white paper cemented on. The paint is dissolved by the cement and gets rather messy if it is left on. After the scales have been laid out and numbered they may be varnished or covered by a thin coat of cement to protect them from dirt.

If a good centimeter scale is not available, use the L scale on a ten-inch slide rule, or any engineers' scale. The L scale on a ten-inch slide rule is just 25 centimeters long and is divided into 500 divisions of 0.5 mm each. A factor of .04 should be used to multiply all the distances in the tables if the L scale is used. A factor can easily be found that will work with an engineers scale. The length does not have to be 25 cm. The original scales are about 24 cm long, but 25 cm makes the length of the new scales the same as that of the ten-inch slide rule scales. The square root of *25* is *5*, so that the calculations are much simpler. It may be seen that the distance from the left index to a division on the RSS scale, in centimeters, is equal to the square of the number at that division on the inner scale.

This slide rule may also be used in conjunction with an ordinary slide rule either as a check or to find the magnitude of the impedance while the other finds the angle. In a large number of problems the angle of the impedance is not required so the standard slide rule won't be required.

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PHASE-CONTROLLED RECTIFIERS

(*Continued from page* 68)

wave rectifier system, for which *4* gives the average output voltage, the phase lag angle permissible before reaching the limits of discontinuity is equivalent to the angle existing between the final phase inflection point in a given alternation (Figure 5), and the preceding commutation angle, or the point of inflection of the alternation under consideration itself. In the instance of the four-phase system, this angle is, then, equivalent to $\frac{\pi}{4}$. A similar inspection of the pattern for the six-phase system gives the angle α as $\frac{\pi}{3}$. From the preceding, therefore, it is quite self-evident that the permissible phase-control lag angle increases with an increasing number of rectifying phases. A second inspection of the two respective output voltage patterns is sufficient to show that the change in the average output voltage with the maximum permissible increase in the phase-control lag angle is greater in the case of the six-phase system, than is true of the four-phase pattern. Theoretically, therefore, an increase in the number of rectifying phases increases the permissible lag angle together with the accompanying increase in the output voltage control range.

Practically, however, the increase in the number of phases increases the initial cost of the rectifier assembly, although an economy is effected in the amount and extent of filtration required. Despite the increase in the initial outlay, certain inherent advantages make increase of rectifying phases the economically sound procedure. Obviously, in r-f heating systems, the power supply rectifier must be depended upon to provide a large continuous current. Therefore, with an increase in the number of rectifier phases, the load current to be conducted by each thyratron is decreased appreciably. It is axiomatic that high current capacity tubes are infinitely more expensive than their smaller counterparts. Consequently, failure of one thyratron would, in the case of a great number of phases, require a low replacement outlay. Further, where the number of the rectifier phases are small in number, failure of a single tube would require loss of service until the defective thyratron could be replaced. In the preceding instance, however, failure of one tube would not necessitate loss of service, since the remaining tubes could be depended upon to provide the load current for a reasonable period during which the defective tube could be secured and replaced, without taking the rectifier out of service at any time.

With respect to the extent of filtration required before practical application of the rectified and filtered power might be accomplished, it may be stated that the usual filter assembly utilized with the average single-phase full wave system would be more than adequate, even beyond the discontinuity limits discussed here. Effectively, this means that less filtration must be included in the output system of a multi-phase phase-controlled rectifier, than is true of the simple single-phase full-wave rectifier output, where such a rectifier is not subjected to phase-control. The economy effected is considerable.

From this study of the phase-controlled rectifier system, then, it is apparent that r-f generator power outputs might be most effectively controlled through phase-shift control of the power supply rectifier. For the speed of response lends itself well to applications involving automatic control of the r-f system output energy. The limitations of such a controlled system, with respect to the magnitude of the developed ripple voltage modulating the d-c plate power supply voltage are shown to be within reasonable output filter range, especially if the number of rectifying phases are increased. In this respect, certain commercial advantages are ascribed to the increase in the number of phases, though the initial outlay through increase in rectifier phases, is similarly increased.

The phase-controlled thyratron rectifier system, though discussed with respect to r-f heating oscillators and amplifiers, may be readily applied where an extensive range of rapid control over a source of d-c energy is required. This would be true in voltage-regulated plate supply rectifiers in transmitters.

•

TRAINING DRAFTSMEN

(*Continued from page* 35)

plete horizontal dimensions; layout of verticals, layout holes with arcs and circles; drawing horizontal object lines, vertical diagonal object lines; darkening object lines; extension and dimension lines light; drawing dimension arrowheads; lettering the plate.

Layout tools and measuring instruments . . . what layout work is, tools used, use and care of measuring instruments.

•

SOLVING WARTIME SHORTAGES

(*Continued from page* 46)

outlet facilities for the several types of remote equipment we use.

The need for additional transcription turntables arose and finding none available at our convenience we designed just what we wanted along this line.

The design was conventional with the exception that additional working area was left to facilitate easy installation and maintenance of the turntable motor and filter switches, together with sufficient air circulation.

The cabinet itself was constructed by the carpenter shop upon which a Presto motor and turntable was mounted. To this cabinet a pickup arm was installed (either of the current conventional type or a composite unit). In the composite unit we utilized an old RCA vertical playback arm from which we had removed the playback head and the counterweight. To this we attached a crystal replacement cartridge mounted in a hollowed-out wooden head. Sufficient weight was added to the opposite end of the arm to counter-balance the light crystal unit.

Upon the revision of our frequency modulation schedule, all equipment, including two transcription turntables were moved from a studio to our f-m transmitter location. We then had to solve the problem of supplying sufficient amplification from the output of these tables to our f-m console. This meant amplifiers that were capable of overcoming the low working levels of these turntables, which is approximately 70 decibels down (zero level .006 watts). In addition we had to account for the insertion loss of additional filters to compensate on certain types of transcriptions used. It was also necessary to secure a response and noise level that conformed with frequency modulation standards.

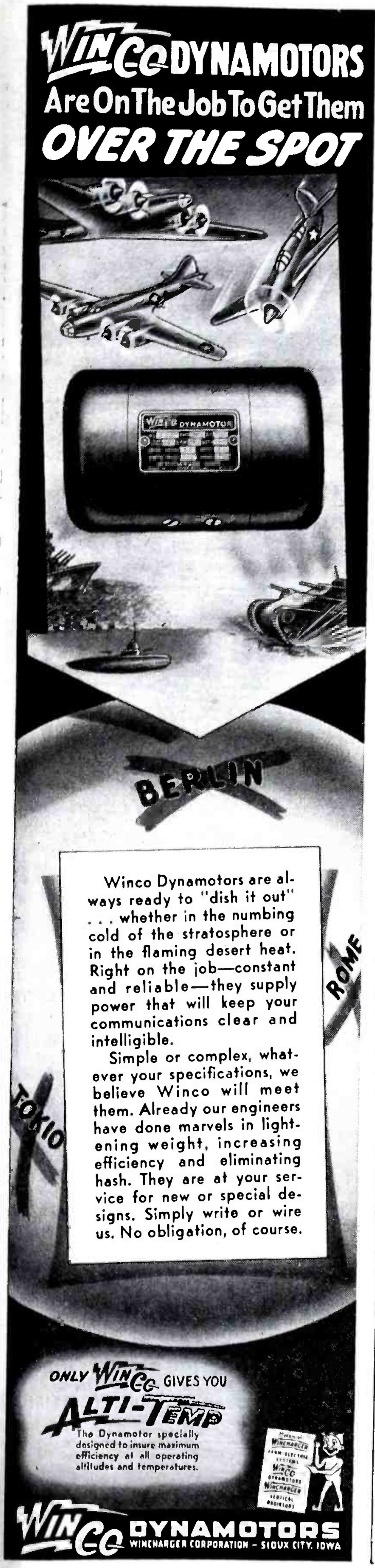
To accomplish this we installed an amplifier which had a gain of approximately 100 db.

The output from each of the two turntables was fed directly into input transformers of two single stage preamplifiers. A 6S7G tube operating as a triode was used in each single amplifier. The transformer output of each of these stages was fed to two corresponding H-type attenuators. This facilitates mixing, if necessary.

The attenuators were paralleled and transformer-coupled to a 6C5G tube which was in turn resistance-capacitance coupled to another 6C5G, both operating as triodes. The output of this second tube was transformer coupled to two 6C5G tubes operating in *push-pull*. The output transformer matched these tubes to a 500-ohm load. This in turn was fed directly into our f-m console.

This amplifier gives a uniform response of from 30 to 10,000 cycles within plus or minus 1 db. Its hum and noise level is 60 db below program level.

Final touches are put on transcription turntable by WGN Engineer Ralph Batt.



NEWS BRIEFS

(*Continued from page 107*)

leased quarters at 236 High Street, Newark, N. J.

* * *

WESTINGHOUSE HEAT-TREATING ATMOSPHERES DATA

Four basic heat-treating atmospheres, endogas, exogas, monogas and ammogas, are described in a 16-page booklet announced by Westinghouse Electric and Manufacturing Company, East Pittsburgh, Penna.

Providing nine variations of gases from which the proper atmosphere for any heat-treating process may be selected, these four basic atmospheres are said to meet all requirements of annealing, brazing, hardening, tempering, gas carburizing, sintering, and normalizing. The booklet explains the chemical reaction, composition cost, application and equipment needed for each atmosphere. Illustrations include photos of typical furnace applications, and schematic arrangement and flow diagrams for endogas generator, exogas generator, carbon dioxide remover for monogas, and ammonia dissociator. Charts for quick selection of atmosphere and equipment also appear.

* * *

TELEVISION SERIAL NOW ON WRGB

A serial type of production via television was recently begun at the G. E. television station WRGB.

For the experimental production, the actors did not wear makeup or costumes and read their parts from script.

From time to time production, *The Martins,* will be presented over WRGB employing different techniques. The station is asking that its audience offer criticisms and constructive suggestions.

* * *

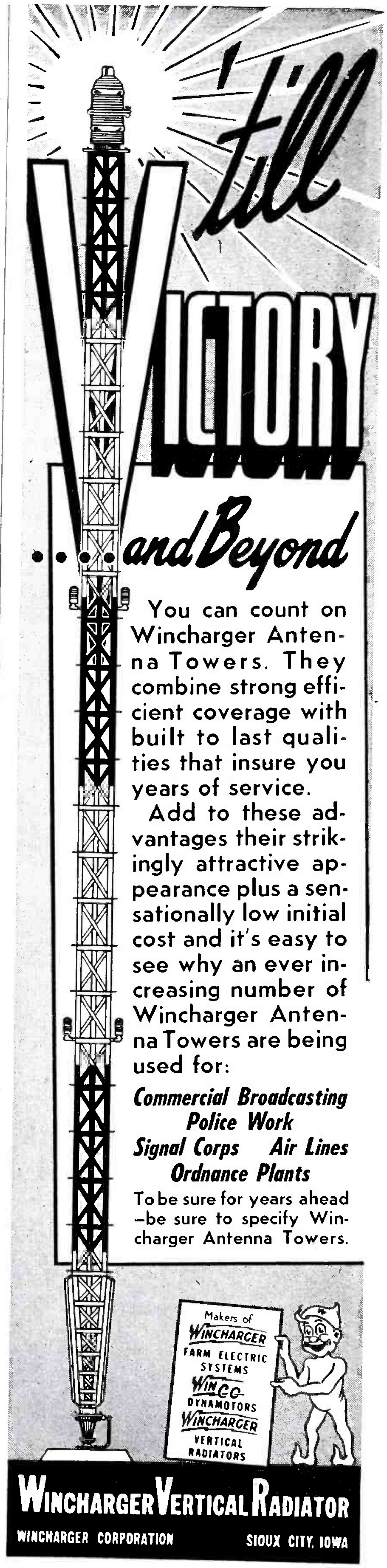
J. EARL SIMONDS RESUMES PLASTIC CONSULTING

J. Earl Simonds, who recently resigned as Eastern technical director of the Plastics Industries Technical Institute, has resumed his consulting practice with offices in the Channin Building, 122 East 42nd St., New York, N. Y. He will specialize in analysis and evaluation of commercial aspects of new plastic and

•

SWOPE INSPECTS G.E. CRYSTAL PLANT

Gerard Swope, president of General Electric, (center) inspecting one of the crystal manufacturing operations at a G.E. plant. C. A. Priest is at left and W. D. Maroney at right.



NEWS BRIEFS

(*Continued on page 123*)

resinous material, plant layout and installation.

* * *

DE WALD EXPANDS

The DeWald Radio Mfg. Corp., 440 Lafayette street, New York, has acquired additional manufacturing facilities at 761-765 Broadway, New York City.

* * *

"E" TO RUDOLPH WURLITZER

The Rudolph Wurlitzer Co., of North Tonowanda, N. Y., has been awarded the Army-Navy "E" flag.

* * *

FRED KAHN JOINS TEMCO

Fred J. Kahn has been named vice-president in charge of sales engineering of Transmitter Equipment Manufacturing Company, 345 Hudson Street, New York City.

* * *

ELECTRONIC ENTERPRISES TUBE BOOKLET

A booklet with data on electronic power and transmitting tubes has been issued by Electronic Enterprises, Inc., 65 Seventh Avenue, Newark, N. J.

Tubes described include mercury vapor rectifiers and power amplifiers, etc.

* * *

H. R. SHARPE NOW IN WPB RADIO AND RADAR UNIT

Harold R. Sharpe has been appointed assistant director for labor in the radio and radar division of WPB, of which Ray C. Ellis is director. Mr. Sharpe will handle labor problems, determining manpower needs in critical plants and areas. He also will analyze individual plant manpower requirements, upon request, in conjunction with Selective Service National Headquarters, and advise regional WPB radio specialists on labor problems.

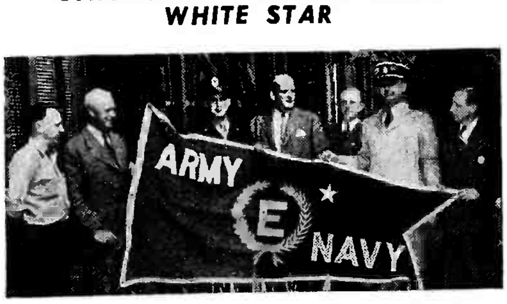
* * *

ATTENUATOR BULLETIN

A thirty-two page catalog covering data on a variety of attenuators, db meters and decade boxes, has been published by the Cinema Engineering Company, 1508 West Verdugo Avenue, Burbank, California.

* * *

STROMBERG CARLSON WINS WHITE STAR



Left to right: Thomas Reed, vice-president of Rochester Independent Workers; Wesley M. Angle, company president; Lt. John T. McMahon, Army Signal Corps; Sidney R. Curtis, general superintendent; Dr. Ray H. Manson, vice-president and general manager; Lt. R. G. Wyld, U.S.N.R., and L. J. Harris, Navy inspection official.

VICTORY MODEL TRANSFORMER CHOKE BULLETIN

A four-page leaflet describing victory model transformers and chokes has been released by the Standard Transformer Corporation, 1500 North Halsted Street, Chicago, 22, Illinois.

* * *

LUCITE MOLDING POWDER BULLETIN

Heat-resistant lucite molding powder is described in a twelve-page technical bulletin released by the E. I. Du Pont de Nemours and Company, Inc., Wilmington, 98, Delaware.

In the bulletin will be found data on physical and electrical properties of this new type of lucite.

* * *

VIBRATOR BOOKLET

A twelve-page manual describing low, medium and high power vibrators has been released by the Electronic Laboratories, Inc., Indianapolis, Indiana. In addition to technical data, the bulletin contains schematic diagrams of various types of vibrators.

* * *

NEW YORK POLICE DEPARTMENT TO FLASH PICTURES OF MISSING PERSONS OVER DU MONT TELEVISION

The Bureau of Mission Persons of the New York City Police Department will utilize the facilities of the Du Mont Television Station, W2XWV, to flash pictures of mission people.

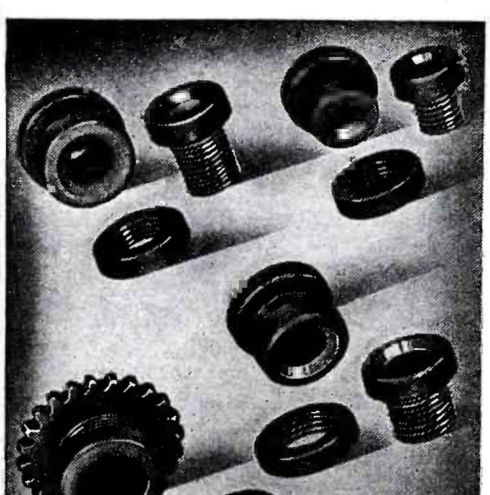
W2XWV operates every Sunday night at 8:30 o'clock on television channel #4 (78 to 84 megacycle band).

THE INDUSTRY OFFERS . . . —

(*Continued from page* 96)

PLASTIC INSULATING GROMMETS

A new line of 100% phenolic plastic insigned by Nathan R. Smith Manufactur-by Creative Plastics Corporation, 970
Known as the Smith-Swich, it is said These new grommets are available in four standardized sizes. Holes are concentric, with all corners chamfered, avoiding wire chafing. All threads are lubricated. To promote easy gripping and conservation of assembly time, all parts are matte finished.



* * *

SHEET FORM PLASTICERAMIC

The plastic material *plasticeramic*, is now available in sheet form from Printloid, Inc., 93 Mercer Street, New York 12, N. Y. The material which is mottled gray in color has a specific gravity of 1.358; heat distortion of 184°-187° F.; water absorption, 24 hrs. is 0.046%; tensile strength of 3,240 lbs. per sq. in.; dielectric constant at 300 kc (dry) of 2.55; dielectric constant, 300 kc (96 hrs. water immersion) of 2.60; power factor, 300 kc. dry (also 96 hrs. water immersion) of 0.04%, and loss factor, 300 kc, dry (also 96 hrs. water immersion) of 0.1%.

* * *

THREE TUBES ANNOUNCED BY RCA

Three new tubes, for use in connection with WPB rated orders, have been announced by RCA. They are 6AK6, power amplifier pentode (miniature type); 12L8GT, twin pentode power amplifier, and 9006, u-h-f diode (midget type).

The 6AK6 is for use either singly or in push-pull in the output stage of compact, lightweight equipment. In class A service, a single 6AK6 can handle a maximum-signal power output of 1.1 watts with 10 per cent distortion. Its electrical characteristics are essentially the same as those of the octal-glass type 6G6G. The 12L8GT is useful in the output stage of compact, light-weight equipment where moderate power is desired. The 9006 is suitable for u-h-f use as a rectifier, detector, or measuring device. The resonant frequency of the 9006 is approximately 700 megacycles.

FOOT SWITCH

A heavy duty foot switch has been designed by Nathan R. Smith Manufacturing, South Pasadena, Calif.

Known as the Smith-Switch, it is said to free both the operator's hands for handling work.

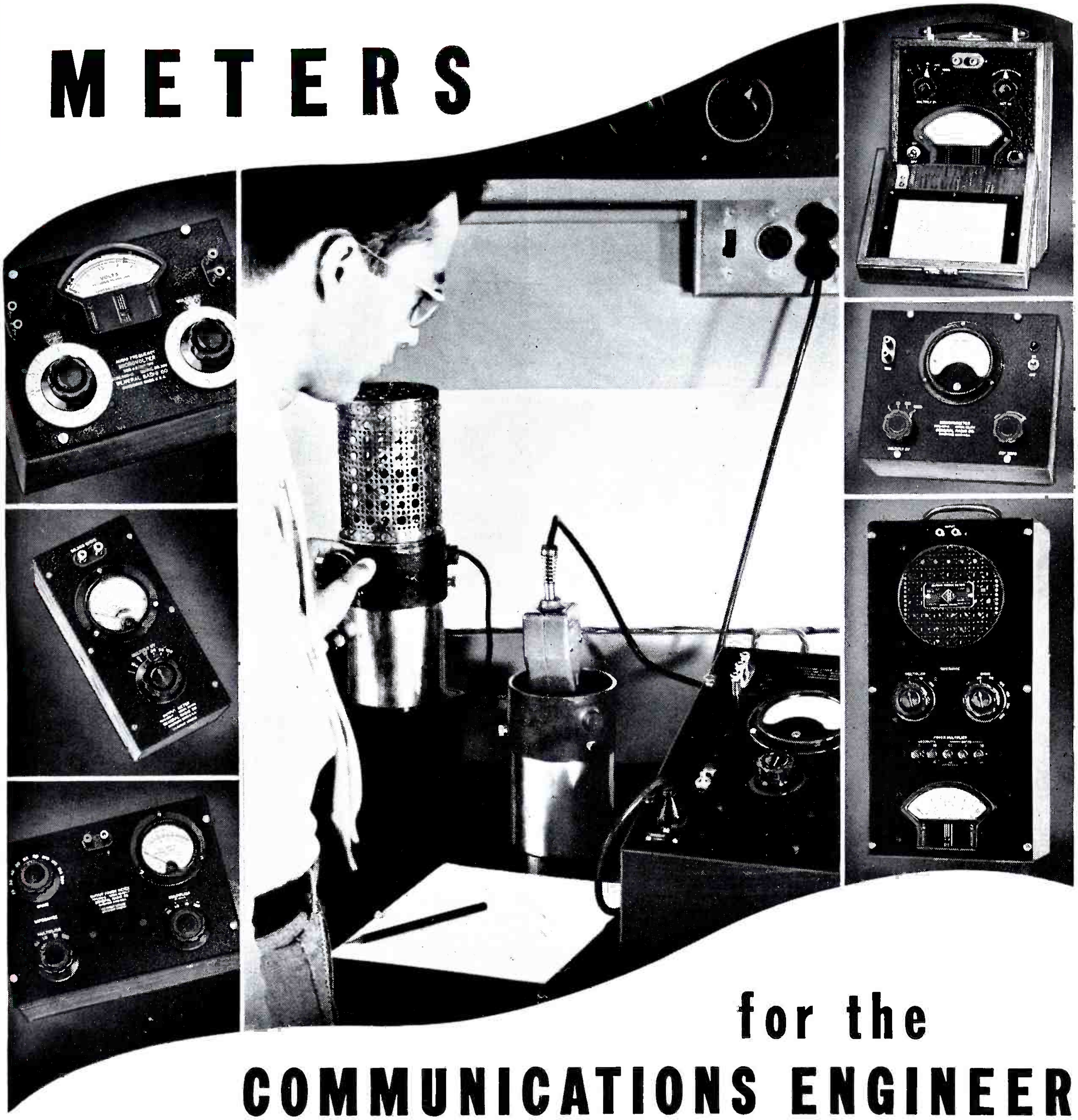
Phosphor bronze springs and ¼" tungsten points are mounted on a bakelite interior. The case is heavy duty rubber,.

Contact capacity of the switch is 10 amperes at 125 or 5 amperes at 220 volts a-c. Overall size is 4½" x 2⅜".

ADVERTISERS IN THIS ISSUE

COMMUNICATIONS — OCTOBER, 1943

METERS



for the COMMUNICATIONS ENGINEER

Quantitative measurements of the performance of electrical circuits depend upon instruments for the measurement of voltage, current and power. Limited-range, single-frequency instruments are adequate at power frequencies, but measurements at communication frequencies require specialized types covering wide ranges of frequency and voltage.

Since 1915, the General Radio Company has been building these special-purpose meters for the communications industry. The present line includes both copper-oxide and vacuum-tube types covering a frequency range from d-c to ultra-high radio frequencies, and a voltage range from 50 millivolts to 300 volts.

In war time as well as in peace, the leading communication laboratories are equipped with General Radio instruments, backed by 28 years of experience in designing and building high-quality apparatus.

ARMY E NAVY

Because all our facilities are devoted to war projects, these meters are at present available only for war work.

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NEW YORK 6 LOS ANGELES 38

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