# COMMUNICATIONS

RADIO
ENGINEERING

AUDIO-FREQUENCY
RESPONSE CHARTS

QUARTZ CRYSTALS
IN RADIO

THE STEADY STATE
RESPONSE OF CIRCUITS

OCTOBER
1942

LEWIS WINNER, Editor
F. WALEN, Associate Editor

# We See...

A NEW HIGH IN PREFERENCE RATINGS . . . A-1-j . . . for maintenance and repair, has been awarded to the operators of broadcasting, police, aviation and direction-finding facilities. Washington says that if the rules of the new order are followed carefully and operators do not use the components for any expansion, improvement or change of design, there is no reason why the new plan should not work with complete success. The rating, say the authorities, will actually be empowered to prompt the delivery of the required materials, when the request is made. In other words, says officialdom, the new rating is not just an attractive alphabetical reclassification, that just strikes well in print. It is a rating that will work, if the industry will cooperate, they say. Well, we know that the industry will cooperate. Need we say more!

Speaking about repairs, we see that tube repairing is again in the limelight. A large manufacturer . . . RCA, to be exact, . . . has decided to aid the repair program by instituting a new division, whose entire facilities will be devoted to the rebuilding of tubes. Harold F. Vance has been placed in command, with headquarters at Camden. Several independents have already expanded their tube rebuilding facilities and several other large tube manufacturers are leaning towards the establishment of such divisions. With such assistance in full swing, *communications* operators should be able to feel a bit chipper . . . at least for a while!

THE VITAL FACTOR THAT WOMEN "manpower" has become in our Nation today became more evident than ever before, when we read recently the report of a life insurance company on the subject. Said the report . . . "during the last decade, 2,500,000 to 3,000,000 women have been gainfully employed in this country. The rapidly increasing armed forces will now drain man power to the point where at least 2,000,000, but more probably 3,000,000 women will be *added* to the working

(*Continued on page* 48)

COMMUNICATIONS

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Member of Audit Bureau of Circulations.

**OCTOBER, 1942**

**VOLUME 22 NUMBER 10**

**COVER ILLUSTRATION**

A pair of the husky radio-frequency power tubes in the new 10 kilowatt transmitter of KMPC of Beverly Hills, California.

(*Photo by F. H. Ragsdale, KMPC*)

**DESIGN AND APPLICATION**



**METALS AND MINERALS IN COMMUNICATIONS**



**TRANSMITTER-RECEIVER DEVELOPMENT**



**CIRCUIT ANALYSES**



**MONTHLY FEATURES**



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*Near technical perfection is achieved through use of scientific instruments but the trained eyes of skilled workmen inspect completed units before they are passed along to the pumps*

# An important reason why Eimac tubes set the modern pace in communications

In the fabrication of plates, sealing of stems and leads, winding of grids... every tiny part must pass the rigid inspection of trained individuals, precision testing devices. At the end of each production line sits a group of hardboiled inspectors. All this checking and testing takes place before Eimac tubes reach the vacuum pumps. That's one of many reasons why Eimac tubes possess such uniformity of characteristics . . . why their performance records have made them first choice among world's leading engineers.

*Follow the leaders to*

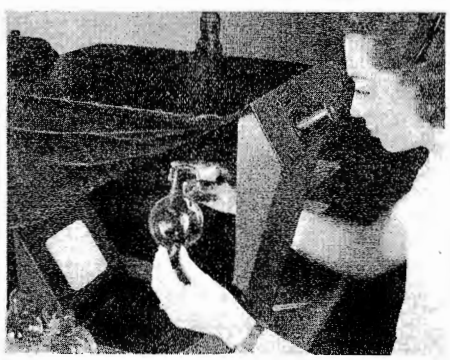
**Eimac TUBES**

*Manufactured by* **EITEL-McCULLOUGH, INC., SAN BRUNO, CALIFORNIA, U. S. A.**

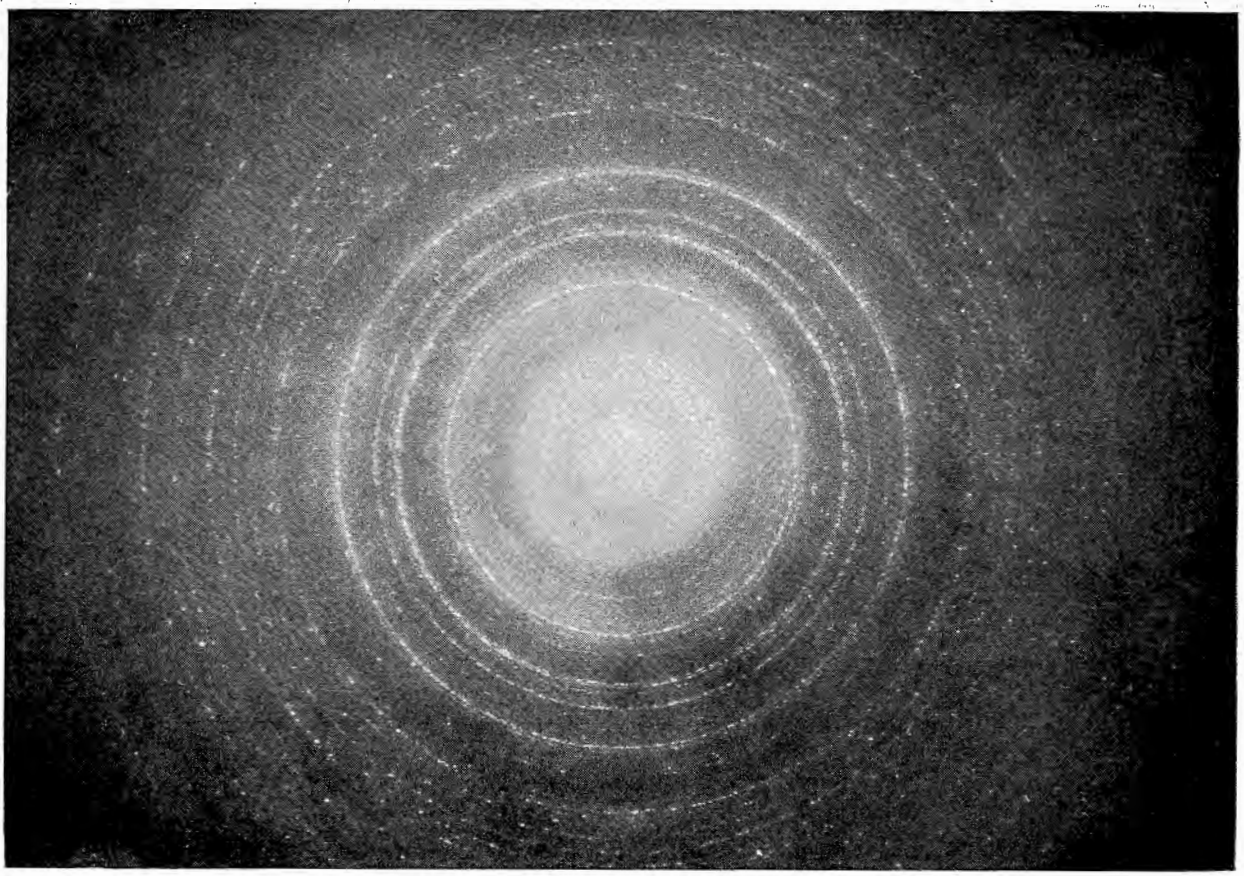
**Export Agents: Frazar & Co., 301 Clay St., San Francisco, California, U. S. A.**

Bead tester utilizes polarized light in search for stress points in glass beads which seal leads to bulbs


Polariscope is here used to inspect glass bulbs for flaws or strain which may occur during the shaping operations



General inspection bench where completed filament stems and assemblies are thoroughly checked for faulty construction



# A NEW ELECTRONIC SUN!

The famous RCA Electron Microscope has a new attachment—a diffraction camera, so that man's eye can see the enormously magnified structure of an infinitesimal object and actually determine its atomic design.

The *atoms* are not seen but the new adapter *finds out where they are.* The revealing picture looks like the midnight sun. But in reality this is not a picture of anything. It is the spirit of the crystal structure—an assembly of complex clues from which the mathematical detective can determine how the atoms take their orderly arrangements in various substances.

Scientists call the picture a diffraction pattern—a pattern from electrons, which found their way through the crystal lattice—that invisible, exquisite arrangement of atoms which nature fashions from humble table salt to the lordly diamond. It is a set of concentric circles, some diffuse, others sharp. From the dimensions of the circles and the intensities, the arrangement of the atoms in the material is determined, so that the crystal structure can be identified and analyzed.

Thus, RCA Laboratories open new and unseen worlds for exploration as the Electron Microscope coupled with the new diffraction camera sees deeply into electronic and submicroscopic realms.

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COMMUNICATIONS

LEWIS WINNER, Editor

# *An Analysis of*

# AUDIO-FREQUENCY RESPONSE CHARTS

by H. HOLUBOW

Research Engineer, Thordarson Electric Mfg. Co.

IN the design of audio frequency devices it often becomes necessary to calculate the insertion loss due to either series or parallel reactance. While the mathematical calculations are not difficult, nevertheless, a considerable amount of time may be saved by using graphical methods.

### *Insertion Loss Equations*

The circuit in Figure 1(A) shows a reactance X in series with the load resistance $R_L$. This reactance may be either inductance or capacitance, and may represent the leakage reactance of a transformer coupled stage at the higher frequencies, or the blocking condenser at the low frequency end. Without the reactance present the voltage across $R_L$ would be

$$E_2' = \frac{E_1 R_L}{R_G + R_L};$$

with the reactance in series as shown, the voltage

$$E_2 = \frac{E_1 R_L}{\sqrt{(R_G + R_L)^2 + X^2}}.$$

The insertion loss in decibels would be expressed as:

$$\alpha = 20 \log \frac{E_2'}{E_2} = 10 \log \left( \frac{E_2'}{E_2} \right)^2$$

$$\alpha = 10 \log \left[ 1 + \frac{X^2}{(R_G + R_L)^2} \right] \text{DB} \quad (1)$$

The alignment chart in Figure 2 is based on equation (1) and may be used to calculate the insertion loss due to a series reactance.

The shunting effect of the primary inductance in a transformer coupled stage at the low frequency end, or the shunting effect due to distributed or tube capacities at the high frequency is illustrated in Figure 1(B). Although this circuit is more complicated than the series circuit illustrated in Figure 1(A), it may be shown that the voltage

$$E_2 = \frac{E_1 R_L}{R_G + R_L} \cdot \frac{X}{\sqrt{\left( \frac{R_G R_L}{R_G + R_L} \right)^2 + X^2}};$$

and that

$$\frac{E_2'}{E_2} = \sqrt{\left[ \frac{R_G R_L}{X (R_G + R_L)} \right]^2 + 1}.$$

The insertion loss

$$\alpha = 10 \log \left( \frac{E_2'}{E_2} \right)^2 = 10 \log \left[ 1 + \left( \frac{R_G R_L}{X (R_G + R_L)} \right)^2 \right].$$

This expression may be simplified to the following:

$$\alpha = 10 \log \left[ 1 + \left( \frac{R_L}{X} \right)^2 \left( \frac{R_G/R_L}{R_G/R_L + 1} \right)^2 \right] \text{DB} \quad (2)$$

Equation (2) was used in construction of the chart in Figure 3.

An equivalent circuit of a line or the plate of a tube transformer coupled to an open grid is shown in Figure 1(C). When the primary impedance of the transformer is so high that the shunting effect can be neglected, the grid

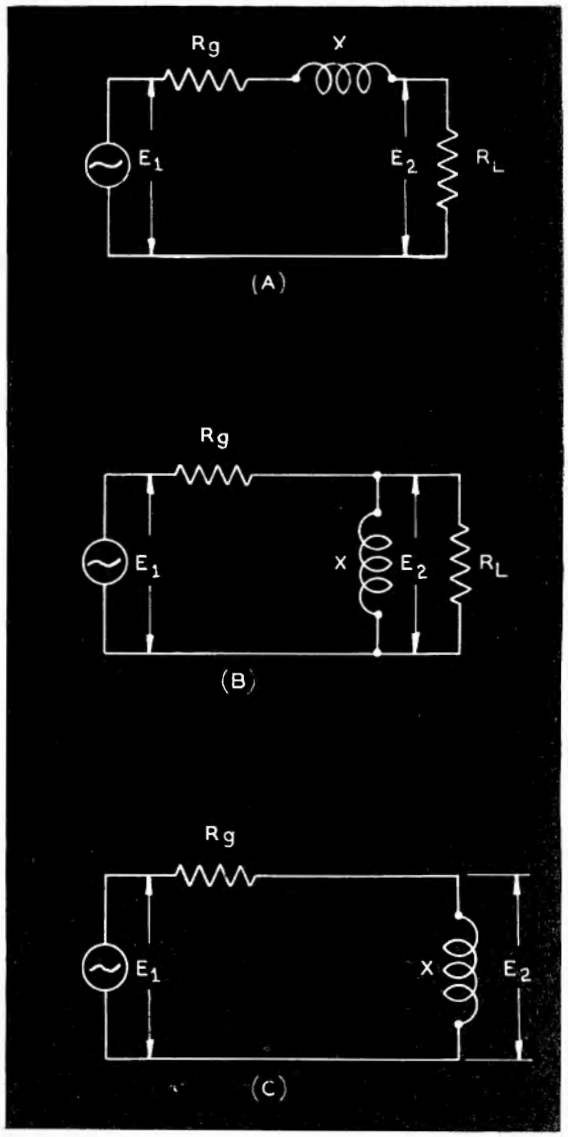



Figure 1

Three equivalent audio frequency circuits that have been used as a basis for computing of the two response charts shown on pages 6 and 7.

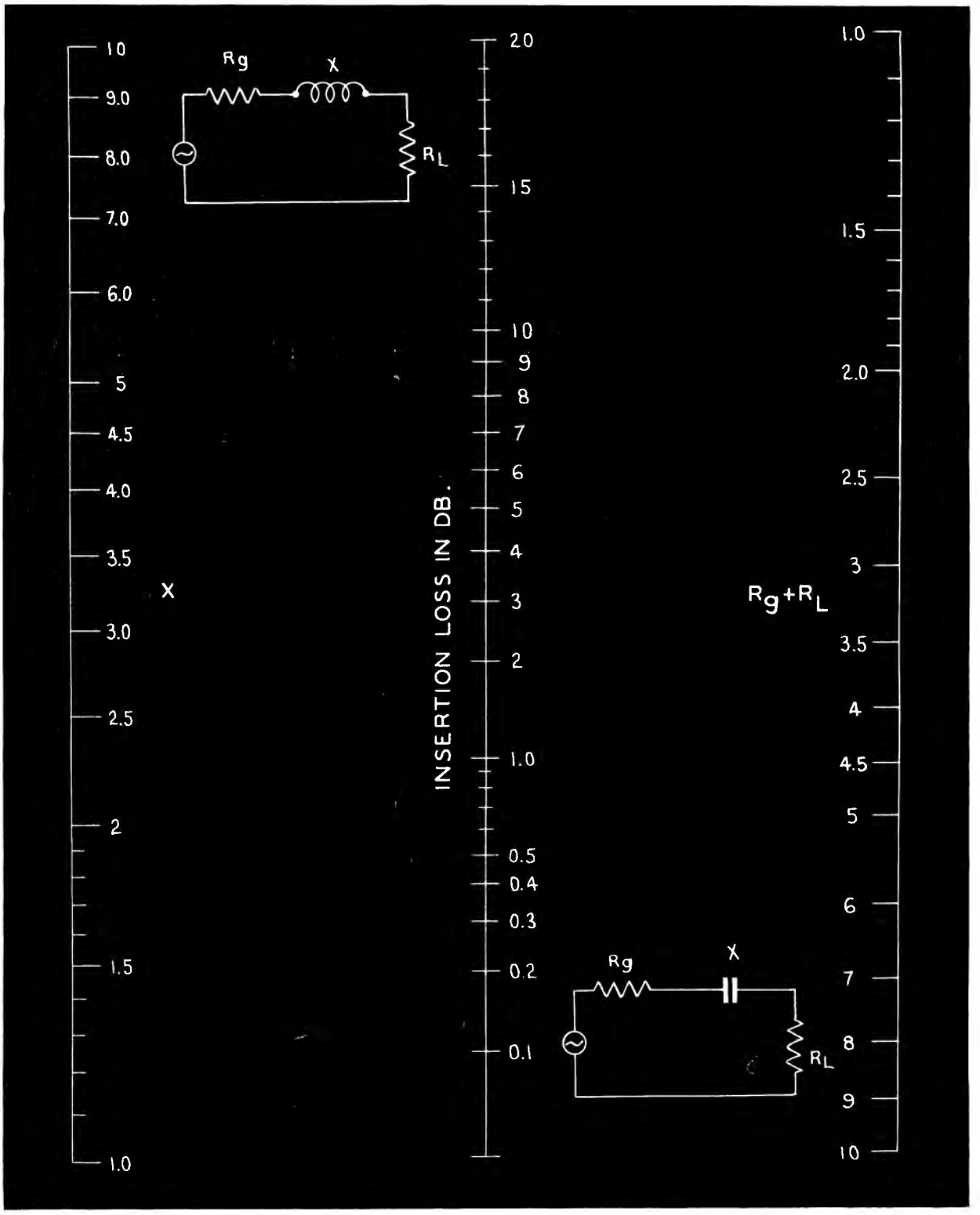



Figure 2
The insertion loss due to series reactance can be computed from this chart.

voltage $E_2^1 = E$. When the impedance is low the voltage

$$E_2 = \frac{E_1 X}{\sqrt{R_G^2 + X^2}},$$

and the insertion loss

$$\alpha = 10 \log \left( \frac{E_2^1}{E_2} \right)^2 = 10 \log \left[ 1 + \left( \frac{R_G}{X} \right)^2 \right] \text{DB} \quad (3)$$

From the similarity of equation (1)

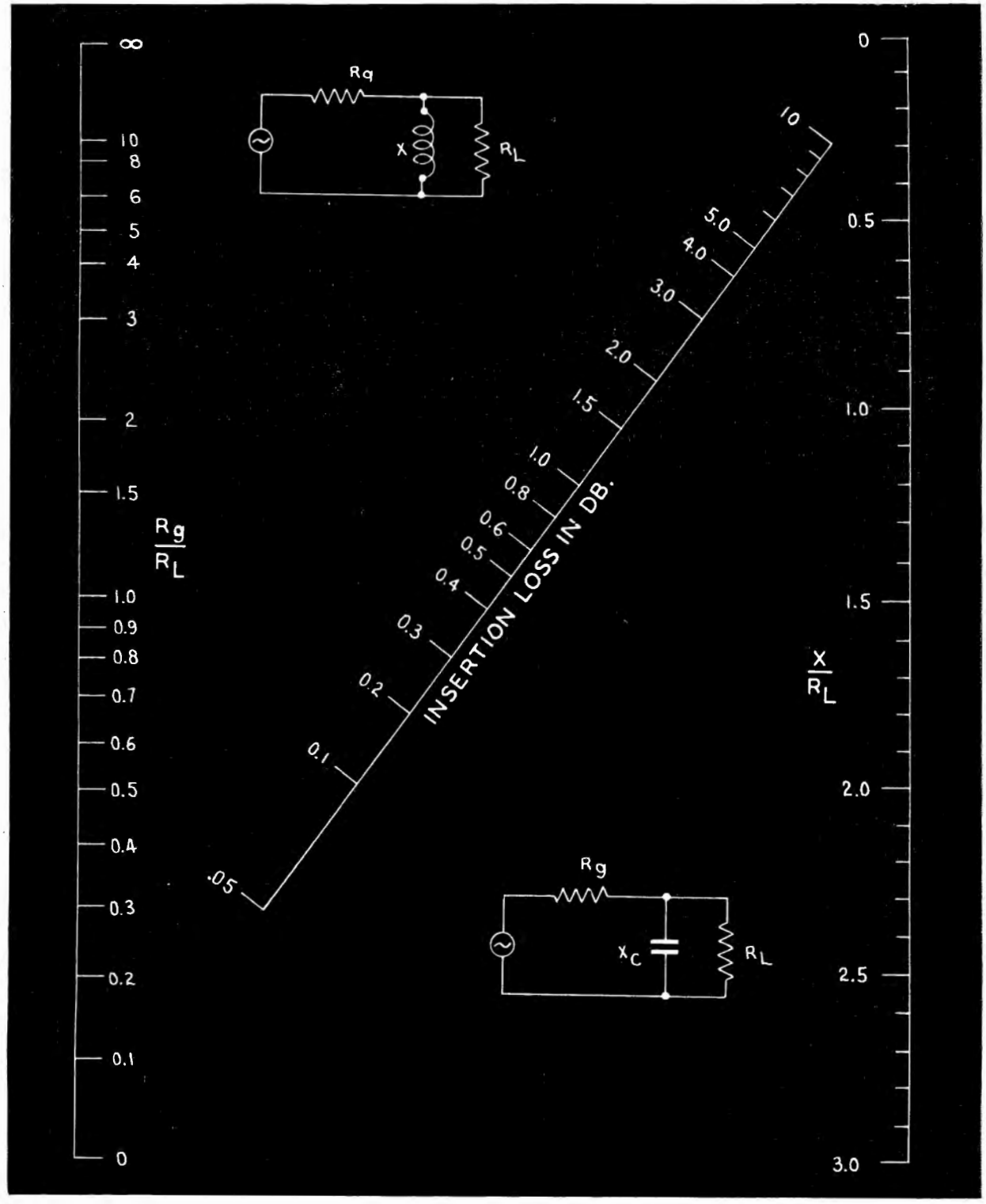



Figure 3
The insertion loss due to parallel reactance, either capacity or inductance, may be computed from this chart.

and (3) it becomes apparent that the chart in Figure 2 can be used to solve this circuit if the scales are interchanged; that is if $R_G$ is read on the X scales and X on the $R_G R_L$ scale.

In actual design, three of the four quantities involved $R_G$, $R_L$, $X_L$, and $\alpha$ are usually either given or assumed, and the fourth is to be determined. For example in the circuit 1(B) let us assume that $R_G = 10{,}000$, $R_L = 5{,}000$ and the insertion at 60 cycles is to be less than one. Making a straight line from $R_G/R_L = 2$ and $\alpha = 1$ we obtain $X/R_L = 1.32$. Thus we have $X = 6{,}600$ and at 60 cycles the inductance $= 6{,}600/21{,}760 = 17.6$ hy. As we can see, all the time to solve this circuit is only a small fraction of the time necessary for the customary mathematical calculation.

# MATERIEL CONSERVATION*

by **FREDERIC LUTHER**

Western Electric Company, Inc.

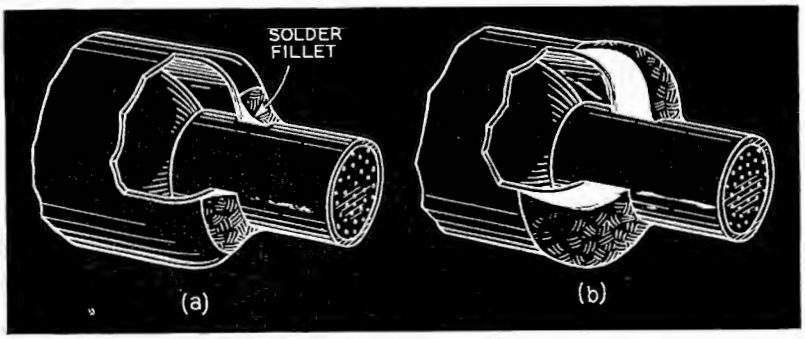
PRIORITIES, production boards, plant conversions, and rationing boards, tumbling over each other in rapid succession during the past two years, have brought home to 130 million Americans the grim lesson that we are facing the greatest test of national self-sufficiency this country has ever known. Stockpiles of imported raw materials have taken on new significance in our daily lives, and the current status of the availability of aluminum is a major topic for discussion not only in manufacturing centers but remote sections of the land.

As early as July, 1939, two months before war finally broke out in Europe, President Roosevelt set up a joint Army and Navy Munitions Board for coordinating the mobilization of industry with the needs of the armed forces. This board released, before the June, 1940, meeting of the ASTM, a listing of 29 strategic and critical materials, materials essential to our war program and not adequately available from our domestic sources of supply. These were . . . aluminum, antimony, asbestos, chromium, cocanut shell char, cork, graphite, hides, iodine, kapok, manganese, manila fiber, mercury, mica, nickel, opium, optical glass, phenol, platinum, quartz crystal, quinine, rubber, silk, tanning materials, tin, toluol, tungsten, vanadium and wool. It must be noted here that such a list is not final. It should be recognized that, due to extremely unstable conditions in the field of critical materials, statements made here cannot hope to represent the day to day changes in the picture. Additions such as magnesium, copper, zinc, cobalt, burlap, and jute have been made. Steps were taken immediately to lay in a supply of all these materials against the possible severance of our sea-borne supply lanes. Ten million dollars were earmarked by the Treasury for the creation of a reservoir of those items, and purchasers were encouraged to build up large stock piles of them.

### *Strategic Wire Materials*

Of the items on the strategic and critical list, several are of vital importance to our wire and cable activities. These are . . . aluminum, antimony, burlap and jute, copper, lead, silk, tin and zinc. Probably the most vital raw material to the war effort today is rub-

(*Continued on page* 11)




Figures 1 (top) and 2 (right)

In Figure 1, we see returned cable being stripped of its lead sheathing, which is melted and refined for reuse in making of new cables. In Figure 2 (a) appears the popular "V" joint that affords an effective saving of solder. In (b) we see the older and less economical cable solder joint.

*From a paper delivered before the Wire Association at their annual meeting, held in October, 1942.

# The BIG JOB

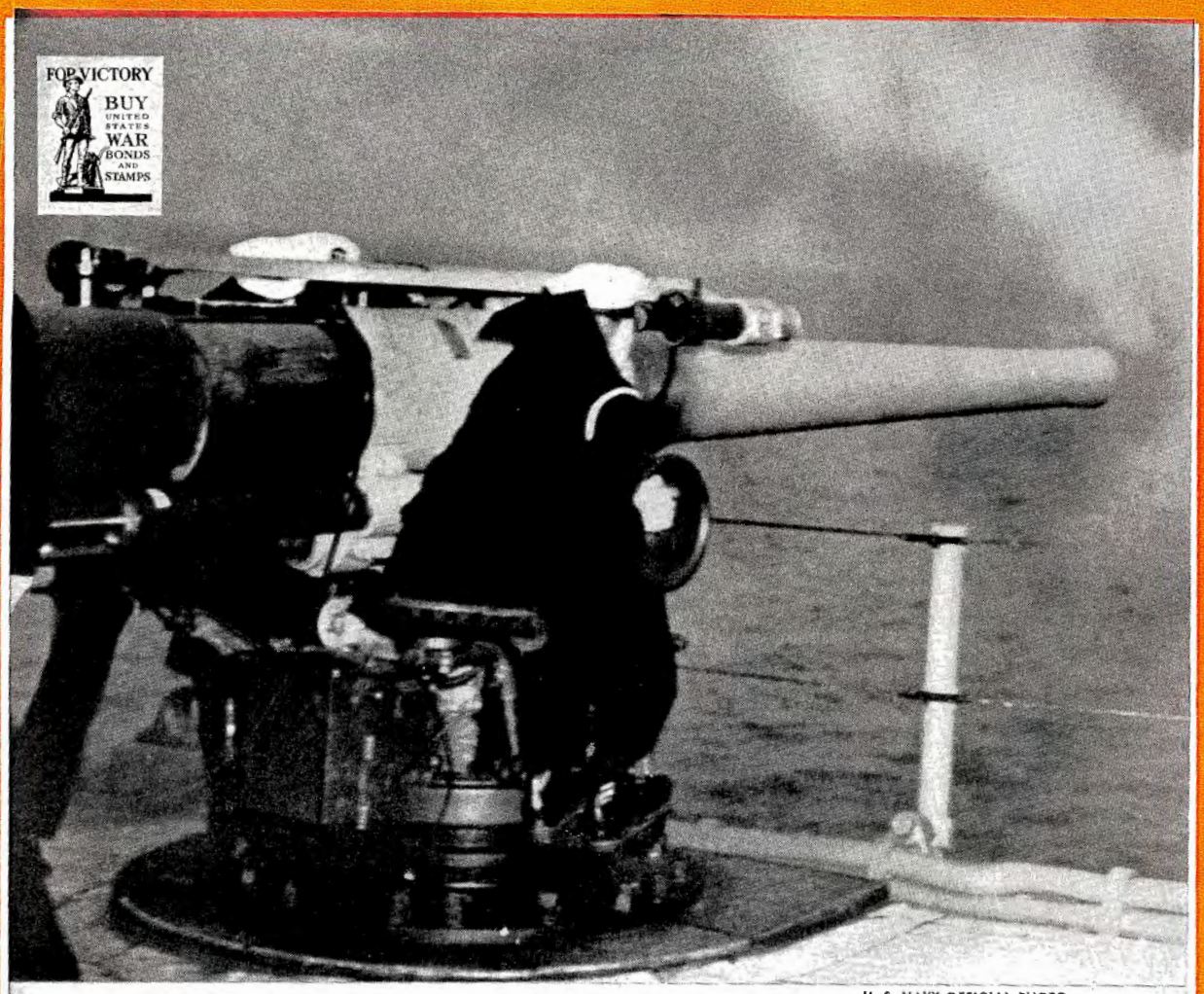
FOR Formica, as for many other companies, the essential task right now is to supply the front with war materials. Everything we have is going into that and it will continue to be our big job for the duration.

But so far we have been able to care for many users of building and furniture sheet, electrical insulation, chemically resistant parts and many other plastic laminated products—and we will continue to do so as long as we are able—to help war-essential civilian activities to continue here at home.

**THE FORMICA INSULATION COMPANY**

**4635 SPRING GROVE AVENUE, CINCINNATI, OHIO**

FORMICA




U. S. NAVY OFFICIAL PHOTO

# A man talks into a microphone

And somewhere . . . a pilot gets set to meet a foe he can't see . . . a tank rumbles into action . . . Navy guns begin to thunder. Coordination of forces, that is just one of the functions of radio communication in this war.

Today, Jefferson-Travis is working 100% on the production of radio communication equipment for the armed forces of the United Nations. And our entire Organization is dedicated to all-out production until Victory is won.

**JEFFERSON-TRAVIS RADIO MFG. CORP.**

*Manufacturers of Aircraft, Marine and Mobile Radio Communication Equipment*

NEW YORK, N. Y. WASHINGTON, D. C.

(*Continued from page* 8)

ber. So much publicity has been given in the press to this subject and the possible substitutes for this material, that it is not politic at this time to discuss it.

First on the list of discussion, therefore, is *aluminum.* As you know, aluminum was the first fully recognized bottleneck in our war effort. Enormous expansion of the aluminum industry has resulted in more than tripling the manufacturers' capacity since 1940, and a 50% increase over this year's highest level is scheduled for 1943. However, war needs alone in the third quarter of this year were expected to be left short to the tune of 35% of their demands. Consider the effects of this under-capacity of one-third, when the construction of even a light interceptor plane requires fully two tons of aluminum.

The Bell System engineers early recognized this critical state of affairs, and set about developing alternative materials where possible. Such replacement was difficult, as in the case of bus bars installed in battery rooms. Here aluminum was being used until we began replacing with copper. By making this replacement, even though the cross-section of the bar can be substantially reduced, the bar's weight will be increased by approximately 100%, and, in many cases, may necessitate the redesigning of support members.

Another way in which we have released aluminum from our operations is in the manufacture of switchboard cable. Here we long had used an aluminum foil tape for keeping out moisture. As the aluminum shortage appeared, we began to use paper tape coated with pliolite. Through such means we have been able to save, through actual replacement in manufacturing operations since the institution of the alternate material program, enough aluminum to build over 735 P-40 pursuit planes.

#### *Lead Sheathings Changes*

Years ago telephone engineers began to enclose underground and aerial cables in a sheath of lead. But trouble began to appear when cable-supporting rings eventually wore their way through the soft lead coating. Searching for an alloying material to strengthen the lead, we hit upon three percent tin. Due to factors such as the high price of tin, our search continued and finally ended in the adoption of a 1% antimony—99% lead alloy which has been the standard sheathing material for telephone cable for more than twenty years. Today, however, antimony has joined the list of critically scarce materials. Before the Sino-Japanese war started in 1937, our major supply came from China. Today, our most important source is Mexico, although Bolivia also mines antimony in some quantity, and some of our Western states produce the metal during wartime.

#### *Use of Calcium*

*Calcium* is another material which may be used in producing a strengthened lead alloy, and thus we are proceeding with lead-calcium studies. The Bell System has in operation today several hundred miles of this sheathing which has as yet shown no important defects. Field tests on our lead-calcium sheath for power cable by several manufacturers indicate that there are definite advantages in the use of this new alloy in the power cable field.

#### *Burlap and Jute Problems*

*Burlap and jute* are also important in our war economy. Jute is the fibre from the inner bark of a tall-slender-stemmed plant normally grown only in Asia. Used in making bagging, carpets, and burlap, it finds a telephone application in asphalt-impregnated form as the exterior coating of cable buried without conduit. We have succeeded in replacing these layers with a cotton wrapping, leno cloth.

#### *Position of Lead*

The position of *lead* is encouraging, for, although lead was placed on the critical list nearly a year ago, we find today that we are able to get as much lead as we need for the amount of cable we are allowed to make. Additional uses we have for lead in the Bell System are as solder and as rust-proofing paint. Our domestic mines, producing over half the world's supply of lead, have actually produced a small surplus this year, and there is little prospect of

(*Continued on page* 42)

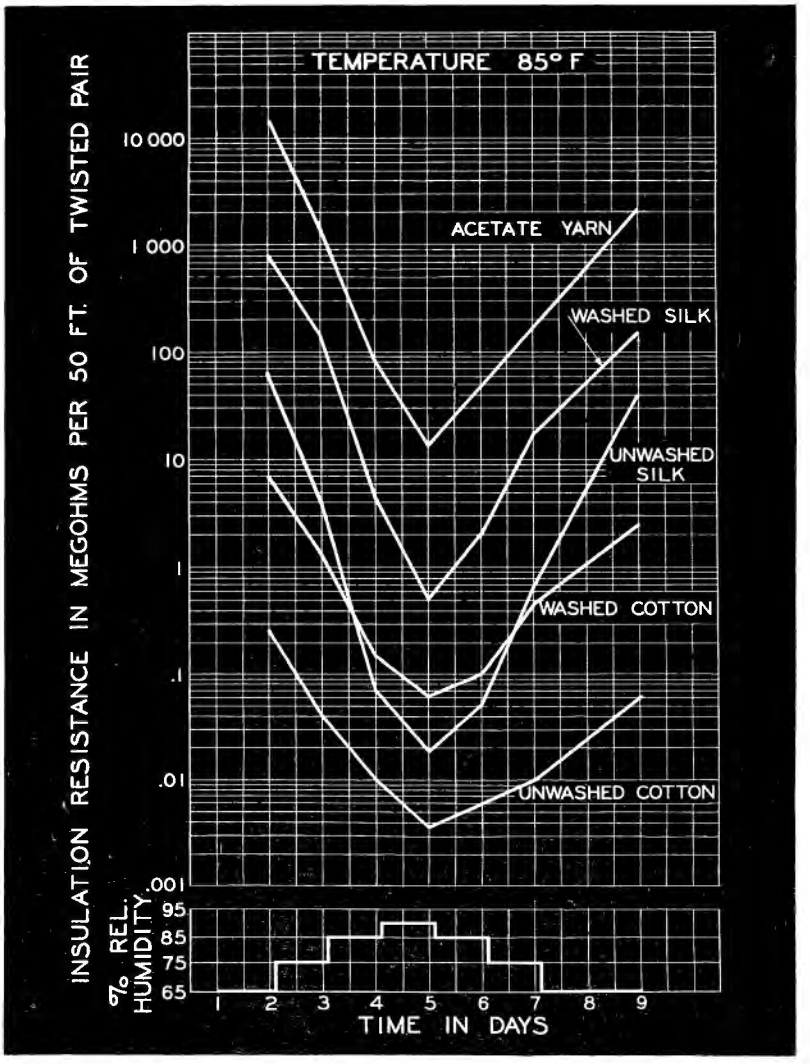



Figure 3

The characteristics of various types of substitute wire coverings.

# *Typical Equipment In*

# AIRCRAFT COMMUNICATIONS

**by CHARLES W. McKEE**

Supervisor of Aircraft Radio, Eastern Air Lines Inc.

A TYPICAL aircraft radio installation as used on commercial transports comprises the equipment needed to furnish two-way radiotelephone communication and radio navigational aids.

In this system simplex two-way communications is provided by the use of two communication units. Each unit consists of the transmitter, receiver and power unit. One unit is designated as a "standard two-way." It operates in the high frequency range of from 2.5 to 12 mc. Another unit designated as a "local two-way" operates in the ultra-high frequency range of from 140 to 143 mc.

***This is the second of a series of analyses of aircraft communication equipment and components. Serving as an advisory editor for this series is Frank Melville, world-famous transatlantic aircraft communications expert, and president of the Melville Aeronautical Radio School.***

### *Purpose of Two-Way Channels*

Standard two-way channels are selected within the 2.5 to 12 megacycles band to provide medium distance coverage for communications with nearby ground stations and also to provide channels for long distance coverage so that the plane may communicate direct, with the dispatch center. Available channels in the high frequency band will permit the selection of the channel best suited for a specified coverage with due consideration to the day and night as well as seasonal characteristic of high frequency propagation. Ultra-high frequency channels are used for local communications. This service is well suited for communications near the airport and will cover the operation of "landing" and "take-off" communications. Due to the fact that the 140 mc band transmission is limited to the optical path, a great reduction of inter-airport noise is realized. We refer, of course, to the adjacent airports, that are separated but a few miles. Also, the reduction of atmospherics on ultra-high frequencies as compared with the high frequencies is of great value in maintaining consistent communications.

### *Airport Traffic Control Channels*

In addition to affording communications with airline ground stations, certain channels have been selected to permit contacting of the airport traffic control tower. These channels are very important, since the procedure for the arrival and departure of aircraft is systematically handled to avoid the congestion of traffic at a busy airport.

### *Adverse Weather Problems*

During adverse weather when visibility is poor the Federal air traffic control supervises the aircraft traffic over a high density traffic air lane. (At all times, the atc controls the traffic over the established air lane through the company dispatcher and the company radio channels.) This is referred to as Range Control, but it is best described by the name "instrument weather traffic control." The airport traffic control functions only in the immediate vicinity of the airport. During the period of instrument flight weather, the range contral functions over specified sections of all routes that enter the airport as well as issue instructions to the Airport Control Tower. This procedure governs the altitude of flight, the order of landing and take-off of the planes, and in an emergency, to clear the traffic for an urgent aircraft landing.

Another type of communication is that which is referred to as "inter-plane." The 140.10 mc channel is assigned to all transport planes. Consideration is being given to the assignment of a high frequency channel for this purpose in addition to the ultra-high frequency channel. The value of the inter-plane channel is obvious as it provides for the exchange of weather information between passing planes, also a means of fast direct communications between planes approaching the airport during adverse weather conditions.

The reliability of the two-way communication system is greatly increased by the use of two complete independent communication units. While both units are required for normal service, the system is so arranged that in case of a failure of one unit, the aircraft involved is not completely cut off from radio contact with the ground.

The radio navigational aids used on board the aircraft include the radio beacon receivers, direction finder, automatic compass and marker receiver. This type of equipment on the aircraft is used in conjunction with certain ground facilities.

### *Two-Way Communication Units*

As we mentioned previously, in the two communication units used, each unit comprises a transmitter, receiver and power unit. A frequency channel selector, 14 position switch, is used to select one of the high or ultra-high frequency channels and to connect the microphone circuit and control circuit to

[1]The high frequency unit, No. 508, was described in September, Communications, pp. 12, 14, 15, 30 and 34.

the unit that is selected for service.[1]

#### *Voltage Input Relay Control*

Low voltage input is controlled through a relay by the master transmitter switch. This is done to avoid a long circuit carrying high current through the cockpit section to the control unit. With this switch in the "off" position, the two transmitters are inoperative; however, the microphone is connected through the two-way unit output tubes of the receiver. This connection is available for cockpit interplane communications between the pilots.

#### *Services Provided by Units*

The service obtained from the high frequency unit (508) is the reception and transmission on any of one of 10 selected channels at any one time. In the ultra-high frequency unit, four services are provided. Two independent r-f receiver sections are employed in the u-h-f unit. One section permits selection of the 140.10 mc interplane channel. Another independent section of this unit is equipped for the selection of any one of the six u-h-f airport control tower channels or the two-way communication channels. For u-h-f transmission, any one of four channels may be selected, viz., one of the three communication channels or the interplane channel.

#### *Use of Superheterodyne Circuit*

The aforementioned r-f sections of the u-h-f receivers employ the superheterodyne type circuit with crystal controlled heterodyne oscillators. An exceptionally good avc supplemented by a manual volume control is mandatory.

Individual switches are provided so that either pilot can independently select this receiver output for his headset. The switch marked local two-way connects to the headset all of the u-h-f channels that are selected by the "local 2-way" and "interplane" channel selector switches.

#### *Pretuned R-F Channels*

In one of the receivers there are two pretuned radio-frequency amplifier channels, one of which is tuned to 278 kc and the other to 362 kc. Radio frequency amplifier circuits rather than a superheterodyne circuit were chosen to avoid oscillator interference and to provide a reasonable stable channel without resorting to the use of crystal controlled oscillators. These channels are used for the low-frequency reception of the airport traffic control towers.

The ultra-high frequency channel provided in this receiver consists of a superheterodyne crystal control circuit which is pretuned to operate on one of the u-h-f channels.

The cockpit of a typical commercial transport showing the radio controls. At top, center, is the two-way radio control panel. At right is the pilot's jack box. In the foreground are the radio compass and marker controls. Forward of this control are the compass bearing indicators. At the top left of the instrument panel are the marker indicator lights. The function switch shown above, used to select the compass condition desired, provides selection of the beacon receiver, aural null d.f., aural null d.f. with beat frequency oscillator, or automatic compass. The function switch connects the loop rotator manual control in the circuit only when its service is required, that is; for aural null operation. The sensitivity control is connected in the circuit for all conditions except automatic compass, which uses audio volume control. The function switch accomplishes these circuit changes.

#### *Low-Frequency Channel Filter*

To avoid reception of beacon signals through the low-frequency channels a filter is used to reject the 1020 cps, which is the audio component of the beacon signal. Unintentional reception of a range station through the traffic control receiver mixed with the desired beacon signal from the beacon receiver would produce an error off course indication. In addition, the error caused by use of an antenna other than a type suitable for beacon reception and the use of avc would be introduced.

#### *Dual Audio Circuit Relays*

Relays are used in the dual audio circuits of this receiver to provide the amplifier needed in connection with the interfone circuit between the cockpit and the flight steward. A control switch marked radio-interfone when in the "interfone" position connects the headset and microphone to the first or second amplifier of dual amplifier. It also supplies low voltage to a vibrator power pack. And finally the switch disconnects all radio circuits from the headset and connects the headset to the

(*Continued on page* 47)

# *The Steady State*
# RESPONSE OF CIRCUITS

[*PART ONE OF A TWO-PART PAPER*]

**by D. L. WAIDELICH**

Assistant Professor of Electrical Engineering, University of Missouri

WITH the increased study of non-sinusoidal periodic waves has come the development of different methods of determining the steady state response of circuit to these waves. Nonsinusoidal periodic waves are encountered frequently, for example, in welding, television, and rectifier circuits, and their resolution has become of considerable importance. The subjects to be considered in this paper are a discussion of the steady state response of circuits and of the various analytical methods now used in determining this steady response, and the introduction of another method of obtaining the steady state.

### *The Steady State*

The conception of the steady state and the transient state is one that has permeated much of electrical and radio engineering and has been used more or less intuitively in many cases. For example the actual voice currents in telephony and radio are transients which approximate the steady state closely enough so that in many instances they are assumed to be in the steady state. In the calculation of steady state currents, however, a more exact conception must be used. In circuits with linear parameters each sinusoidal component of the periodic voltage applied to the circuit produces a current composed of two parts; the transient part which approaches zero as the time increases and the steady state part. The sum of these steady state parts is the steady state response of the circuit to the periodic voltage applied. This is the steady state as usually given in text books[1,2,3]. Another equivalent conception is that used in a recent analysis[4] in which in the steady state of all currents and charges at any time of one period are made equal to the same currents and charges at a time one period later. This is equivalent to the first conception since all sinusoidal functions will have the same values at times separated by one period. If more than one non-sinusoidal periodic voltage is applied to the circuit, the superposition theorem may be used, and the steady state effects of each voltage may be considered individually.

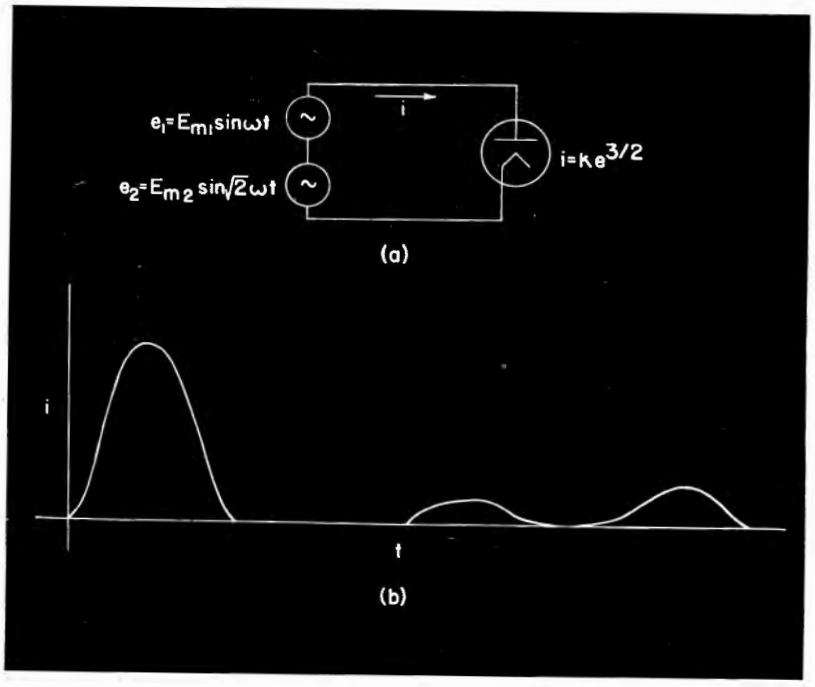



Figure 1

An example in which the usual conception of the steady state is not obeyed.

For non-linear circuit parameters the problem of determining the steady state is much more complicated, and in some cases a steady state as given above does not exist. To circuits in which the parameters are functions of time alone, the superposition theorem may be applied, but this theorem is not applicable to non-linear circuits in which the parameters depend upon the current or voltage. Each non-linear case must then be considered on its own merits, but the steady state for many cases may be calculated by putting the charges and currents at one time equal to the charges and currents one period later (or in some cases n periods later where n is an integer). This method, for example, has been used in rectifier analysis[5]. On the other hand an illustration will be given of a non-linear circuit with a current which is seemingly steady state and yet is not periodic since each current pulse differs from every other pulse. The non-linear element in the circuit of Figure 1(a) is a diode tube which conducts current only when the anode of the tube is positive with respect to the cathode and then with $i = ke^{(3/2)}$ where i and e are the current through and voltage across the tube respectively and k is a constant. The resulting pulses of current are shown in Figure 1(b). For circuit responses like that of the illustration a more general conception of the steady

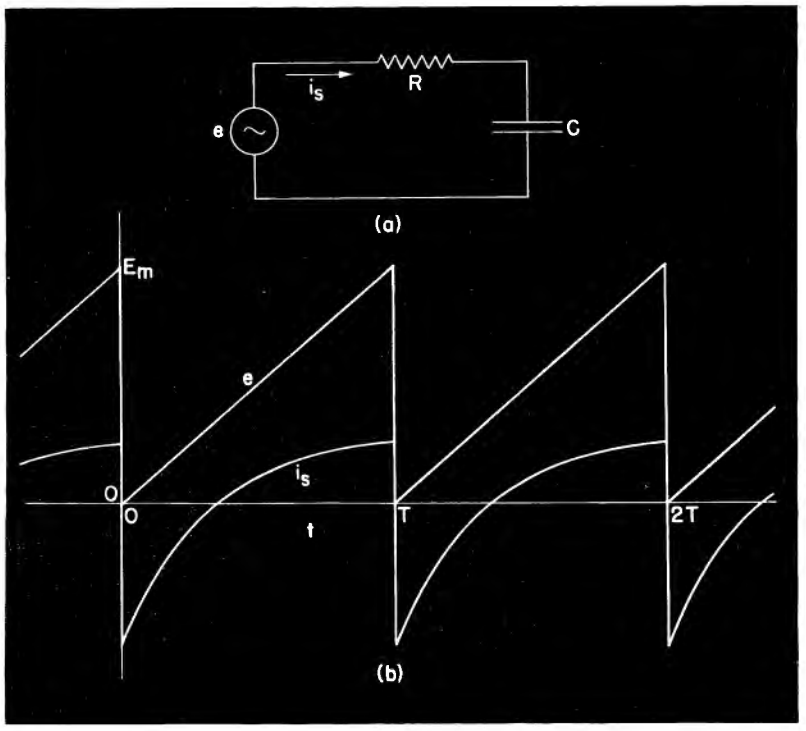



Figure 2

**The steady state response of an RC circuit to a sawtooth voltage wave.**

state seems to be required.

***Calculating the Steady State***

The steady state current of a circuit with linear parameters may always be and usually is presented in the form of a finite or infinite Fourier series. There is another way, however, in which many steady state currents may be presented, and this is in the form of a sum of these series where the sum may be expressed as a function of time which is repeated every cycle. Not all currents may be presented in this second form since the sum of any series have not been studied as yet. A square wave current may be expressed, for example, as a function of time which has the value (+ I) for the first, third, fifth, etc., half cycles and (— I) for the second, fourth, sixth, etc., half cycles, or it may be expressed as a Fourier series.

There are several methods of calculating the steady state currents, and these will be considered along with their advantages and disadvantages. The first method[3] consists in expanding the periodic voltage e(t) applied to the circuit into a Fourier series

$$e(t) = E_{DC} + \sum_{n=1}^{\infty} E_{mn} \sin (n\omega t + \theta_n) \quad (1)$$

where t is the time in seconds, $E_{DC}$ is the average or d-c voltage, $E_{mn}$ and $\theta_n$ are the maximum value and phase angle respectively of the nth harmonic voltage and the period of the voltage e(t) is $T = (2\pi/\omega) = (1/f)$. By use of the superposition theorem the nth harmonic steady state current is obtained from the nth harmonic voltage and the nth harmonic impedance. All of the currents are then added to produce the steady state current

$$i_s(t) = \frac{E_{DC}}{R} + \sum_{n=1}^{\infty} \frac{E_{mn}}{Z_n} \sin (n\omega t + \theta_n - \varphi_n) \quad (2)$$

where R is the d-c resistance of the circuit, and $Z_n$ and $\varphi_n$ are the magnitude and angle of the nth harmonic impedance. This method has the advantages of being straightforward and of showing the harmonic currents, but since the current is in the form of an infinite series, the wave form is often tedious to calculate, and the effects of changing parameters in the circuit may be difficult to estimate.

By putting the currents and charges at one value of time equal to the currents and charges one period later, the steady state response may also be found, and this may be called the second method. This method has been carried out using differential equations with the initial conditions as unknowns to be determined[4]. This may also be accomplished by using operators[5] or by using Laplacian transforms[7]. When using operators or Laplacian transforms the operational forms of the periodic voltages applied to circuits are useful and may be obtained rather simply[6]. The advantage of this method is in that if the voltage applied to the circuit is expressed as a sum function of a series, the current may oftentimes be expressed as a sum function also, and thus wave form plots may be easily done. On the other hand the initial conditions are unknowns and must be solved for from a system of linear equations. This solution may be tedious for many circuits.

It is possible to obtain the complete transient and steady state response of a circuit by the use of differential equations or operational methods and then by inspection determine which terms are the transient and which are the steady state terms[8]. This might be called the third method, and if the applied voltage is expressed as a Fourier series, the resulting current expression is a Fourier series also and thus has the disadvantages of the first method plus the added difficulties of obtaining and separating the transient terms. If the applied voltage is expressed as a sum function, each period (or perhaps part of a period) must be treated as a separate problem with the final currents and charges of one period equal to the initial currents and charges of the next period. This is repeated for period after period until the response for one period does not differ sensibly from that of the preceding period, and this response may then be taken as the steady state. This last way of obtaining the steady state has been called the "transient-series" method[4], and in general is very laborious. It is in most cases simpler and quicker to use the second method.

***Introduction of Another Steady State Method***

The steady state current of a circuit with a periodic voltage e(t) applied is

$$i_s(t) = A(o)\, e(t) + \int_o^{\infty} e(t-\tau)\, A'(\tau)\, d\tau \quad (3)$$

where A(t) is the indicial admittance of the circuit[9], i.e., the current resulting from the application of unit voltage to the circuit time $t = 0$ and $A'(t)$ is the derivative of A(t) with respect to t. The equation (3) may be used only when the infinite integral converges, and this convergence will be discussed in due time. There are several other useful forms of (3); two of which depend upon the periodicity of e(t). If the period of e(t) is $T = 2\pi/\omega = 1/f$:

$$i_s(t) = A(o)\, e(t) + \int_o^{T} e(t-\tau)\, f'(\tau)\, d\tau \quad (4)$$

where

$$f'(\tau) = A'(\tau) + A'(\tau + T) + A'(\tau + 2T) + \ldots\ldots$$

or

$$i_s(t) = A(o)\, e(t) + \int_{t-T}^{t} e(\tau)\, f'(t-\tau)\, d\tau \quad (5)$$

The indicial admittance A(t) may be found by the use of the differential equations for the circuit, but the quicker method is to find the operational impedance Z(p) of the circuit and by the use of a table of equivalent operational forms[10], A(t) may be obtained. Sometimes a graphical plot of A(t) can be obtained from oscillograms or other data, and this information can then be used in (3). If e(t) is expressed in the form of a Fourier series, equation (3) is the better form to use, although in most of these cases it is easier to use equation (2) directly. If e(t) is expressed, however, as a sum function, equations (4) and (5) are more applicable and give the result desired with much less effort than the second method outlined above. The use of equations (4) and (5) eliminates the necessity of solving for the initial conditions as is done in the second method. The expression for $i_s(t)$ in (3), (4), or (5) will give either a Fourier series or a sum function depending upon whether e(t) is expressed as a Fourier series or as a sum function. Graphical solution of these equations for $i_s(t)$ is also possible.

In equation (3) the periodic voltage e(t) must be used for an infinite number of cycles before time t, and hence all transient terms will have disappeared to leave only the steady state current. This fact connects this equation with the third steady state method outlined above.

The proof of the equation (3) has been outlined in Appendix I***, and the proof requires that the networks be dissipative in nature or in other words that the roots of Z(p) all have a negative real part. This is true for all physically realizable networks, and for many problems it would be sufficient to stop here. Non-dissipative networks (roots of Z(p) have a zero real part) are used, however, as theoretical approximations to dissipative networks which have relatively small amounts of resistance, and hence non-dissipative networks should be discussed also. In the following if a network has a Z(p) with at least one root having a zero real part, it will be classed as a non-dissipative network.

In non-dissipative networks there are an infinite number of steady state responses because some or all of the transient terms (providing their coefficients are not zero) will never die out and for each different value given to the coefficients of these terms a new steady state response will result. One of these responses must be chosen, and the one chosen in most cases is that approached by allowing the network to be dissipative and to have resistance and

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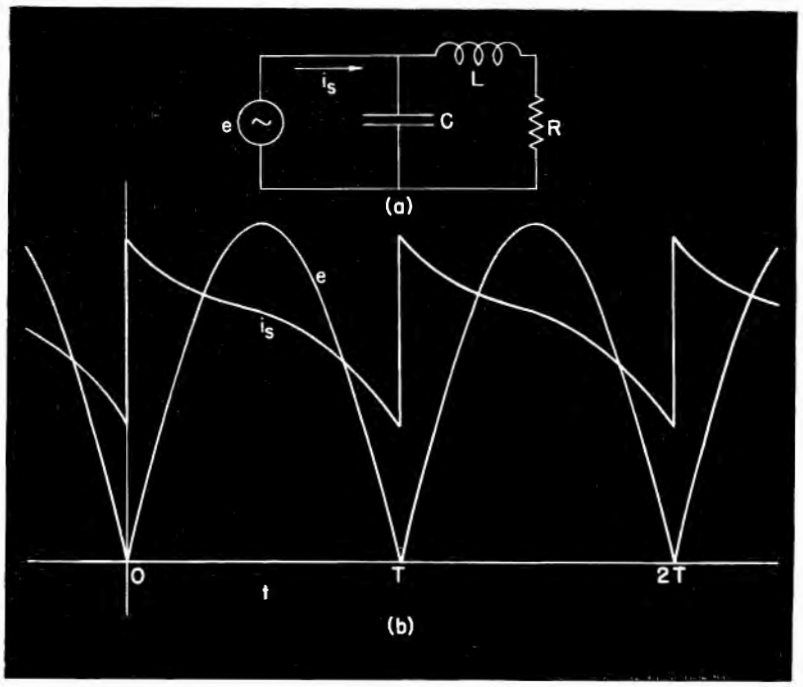


Figure 3

An example with a pure capacitance path through the network showing the steady state current.

then to make these resistances approach zero as a limit. This is equivalent to giving to the roots of Z(p) a negative real part, calculating the steady state response, and then taking the limit of the response as the real part of these roots approach zero. In addition this method is equivalent to putting the coefficients of the transient terms equal to zero and will produce the same result also as equation (2). To use equation (3) in calculating the steady state response of non-dissipative circuits there are then two methods available. The first consists in putting resistances in the circuit, calculating the response by the use of equation (3), and then allowing all of these resistances to approach zero as a limit to give the response of the non-dissipative circuit. The second method is a variant of the first and consists in using finite resistances in the circuit so small that they will not affect for all practical purposes the response of the circuit.

There are two other special cases which may be treated in the same way as other non-dissipative networks, but since these cases are encountered so frequently special forms of equation (3) will be given for them. The first of these is the case of a pure capacitive path through the network and can be recognized by the fact that Z(p) approaches zero as p approaches infinity, or in other words $p = \infty$ is a root of Z(p). In this case Z(p) can be expressed as the quotient of two polynomials in p:

$$\frac{1}{Z(p)} = \frac{a_{r+1}p^{r+1} + a_r p^r + \ldots + a_o}{b_r p^r + b_{r-1}p^{r-1} + \ldots + b_o}$$

where the a's and b's are real constants. By dividing the denominator into the numerator, 1/Z(p) may be written as:

$$\frac{1}{Z(p)} = \frac{a_{r+1}}{b_r}p + \frac{1}{\overline{Z}(p)} = Cp + \frac{1}{\overline{Z}(p)}$$

If now the $\overline{A}(t)$ corresponding to $\overline{Z}(p)$ is found*, the equation (3) becomes[11]:

$$i_s(t) = \overline{A}(o)\,e(t) + \int_o^\infty e(t-\tau)\,A'(\tau)d\tau + Ce'(t) \qquad (6)$$

In this equation e(t) must be continuous, or for practical voltages there must be no instantaneous jump in voltage.

The other special case is that of a pure inductive path through the network which can be recognized since Z(p) will approach zero as p approaches zero or in other works $p = 0$ is a root of Z(p). If a d-c voltage is applied to this circuit, there will never be a steady state since the current will increase without bound. For a steady state to exist in this case, e(t) must not have a d-c component, i.e., $E_{DC}$ must be zero. When a voltage e(t) without a d-c component is applied to a pure inductance L, the steady state current would be

$$i_s(t) = \frac{1}{L}\int_o^t e(t)\,dt - K$$

where the constant K may have an infinite number of values corresponding

*All the roots of $\overline{Z}(p)$ must have a negative real part.

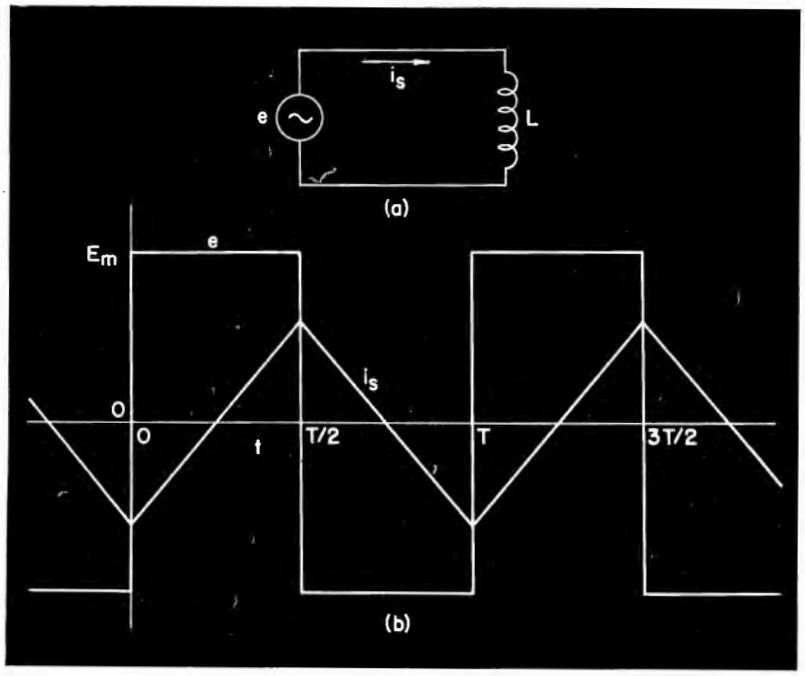


Figure 4
The steady state response of an inductance to a square voltage wave.

to the infinite number of steady state responses. For the particular response desired here, the constant K must be equal to the average value of $[(1/L)\int_o^t e(t)\,dt]$ where the average is taken over one period or an integral number of periods. Thus

$$K = \frac{1}{T}\int_o^T \left[\frac{1}{L}\int_o^t e(t)\,dt\right] dt$$

This particular value of K was chosen so that the average value of the steady state current over one period is zero. That the average value must be zero may be seen by considering the Fourier series expansion of the steady state current. For a general circuit now with a pure inductive path the reciprocal of the impedance Z(p) may be expressed as:

$$\frac{1}{Z(p)} = \frac{a_r p^r + a_{r-1} p^{r-1} + \ldots + a_o}{b_{r+1} p^{r+1} + b_r p^r + \ldots + b_1 p} = \frac{a_r x + a_{r-1} x^2 + \ldots + a_o x^{r+1}}{b_{r+1} + b_r x + \ldots + b_1 x^r}$$

where $p = (1/x)$ and the a's and b's are real constants. Again by dividing the denominator into the numerator 1/Z(p) may be written as:

$$\frac{1}{Z(p)} = \frac{a_o x}{b_1} + \frac{1}{\overline{\overline{Z}}(p)} = \frac{1}{\overline{\overline{L}}p} + \frac{1}{\overline{\overline{Z}}(p)}$$

If again the $\overline{\overline{A}}(t)$ corresponding to $\overline{\overline{Z}}(p)$ is found**, equation (3) becomes:

$$i_s(t) = \overline{\overline{A}}(o)\,e(t) + \int_o^\infty e(t-\tau)\,\overline{\overline{A'}}(\tau)\,d\tau + \frac{1}{\overline{\overline{L}}}\int_o^t e(t)\,dt - K \qquad (7)$$

where e(t) does not have a d-c component and where

$$K = (1/T)\int_o^T [1/\overline{\overline{L}}]\int_o^t e(t)\,dt]\,dt\ .$$

If there happens to be more than one pure capacitive or pure inductive path through the network, the procedure is the same as that above. It is quite possible that explicit expressions for $i_s(t)$ may be developed for some other special cases also.

The use of equation (3) for other problems such as transmission line problems has not been investigated as yet, but in any case the convergence of the integral will depend upon the form of A(t).

The total current response i(t) of a circuit to a periodic voltage applied at t = 0 is the sum of the steady state current and the transient current and is given by an expression[9] somewhat resembling equation (3):

$$i(t) = A(o)\,e(t) + \int_o^t e(t-\tau)\,A'(\tau)\,d\tau$$

The transient current $i_{TR}(t)$ is the difference of the total current and the steady state current and is expressed as:

$$i_{RT}(t) = i(t) - i_s(t) = -\int_t^\infty e(t-\tau)\,A'(\tau)\,d\tau \qquad (8)$$

Equation (8) must be used with the realization that the same restrictions apply to it as apply to equation (3).

### *Three examples*

The first example uses a periodic voltage much like the sweep voltage of a cathode ray oscillograph and applies it to a resistance and condenser in series. The circuit diagram is that of Figure 2(a), and the voltage is the "saw tooth" wave of Figure 2(b). The resulting steady state current is also shown in Figure 2(b) and has been drawn for $y = \omega CR = 2$. For this example Z(P) has one real negative root $(-1/RC)$, and equation (5) has been used to determine the steady state current. The details of the work are presented in Appendix II. * * *

The periodic voltage of the second example is one encountered in some rectifier circuits and is applied to the circuit of Figure 3(a) consisting of a pure capacitance in parallel with an inductance and resistance in series. The "sine loop" voltage applied and the resulting steady state current are indicated in Figure 3(b). This current has been calculated for the values $(\omega L/R) = 2$ and $\omega CR = 0.25$, and this particular circuit has been used to illustrate the effect of a pure capacitance path in the network.

The third example shown in Figure 4, consists in applying a "square" wave such as is used in testing amplifiers to a pure inductance and is intended to illustrate the calculation of the steady state current for a pure inductive path. The resulting steady state current has the triangular wave shape of Fig. 4(b). The current has also been calculated by assuming that the inductance has a resistance R and then allowing the resistance to approach zero. All of the above examples may be checked by the use of the Fourier series expansion.

### *Conclusions*

1)—The steady state may be specified exactly for linear networks, although for the non-dissipative linear networks one of the infinite number of possible steady states must be chosen and the one chosen in most cases is that approached by a dissipative network as all of its resistances approach zero. For a non-linear network it appears that a more general definition of the steady state is necessary.

2)—The steady state response of a circuit may always be expressed in the form of the Fourier series expansion, but many may also be expressed as a sum function of the series. The Fourier series is useful in obtaining the amplitudes of the harmonic currents, but is

(*Continued on page* 46)

**All the roots of $\overline{\overline{Z}}(p)$ must have a negative real part.

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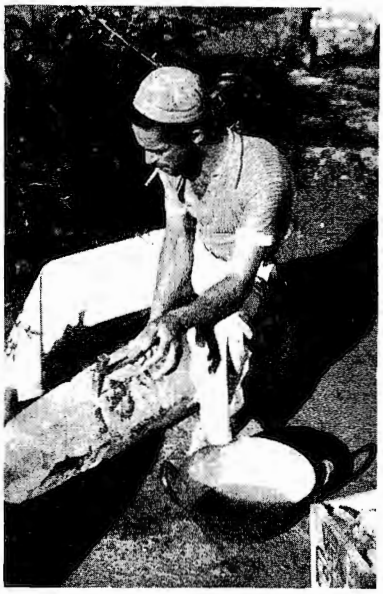
# QUARTZ CRYSTALS IN RADIO

by C. F. BALDWIN

Radio, Television and Electronics Department, General Electric Company

QUARTZ, one of the oldest substances to be found in the earth's crust, plays an extremely important part in some of the most modern of sciences, radio and television. Many minerals are used in infinitely larger quantities to fill the needs of man, but, in general, those which are used for exacting applications require some special treatment or alloying before they are ready for use. Even though used in extremely critical applications, quartz requires only straight fabrication to render it suitable for so-called oscillators, resonators and filters. It embodies certain unusual electro-mechanical characteristics to a degree which so far have not been duplicated, or closely approached, by man-made substitutes produced in the laboratory by the best scientific methods at our disposal. Moreover, quartz not only provides these essential requisites but does so in an extremely small and compact form. Although the mother crystal as mined may be large, the ultimate pieces or "blanks" cut therefrom and properly processed are small. Finished crystals are in general smaller in area than a postage stamp and about as thick as a piece of thin cardboard. The space which must be allocated in an equipment to accommodate the crystal unit, therefore, is small in comparison with that required for many other component parts. In fact, the crystal seems to be a "natural" for the applications to which it is inherently suited.

The number of crystals in use has increased greatly during the last few years until now they are indispensable in many branches of our communication system.



Figures 1 (top) and 2 (bottom)
At top appears a Brazilian native cutting off a clear portion of a large mother crystal. At bottom we see a typical quartz mining section in Brazil.

### *Function of the Crystal in Radio*

Radio equipment makes use of electrical networks of many kinds. Included among these are oscillator and filter circuits. The oscillator circuit produces radio signals, usually of high frequency or short wavelength. The output of such oscillators is amplified and radiated as radio waves, or if the communication range needed is small it may be put on the air without further amplification. In any case, it is necessary that the radiated signals be of an assigned and constant frequency in order that they be picked up at precisely the expected point of tuning in the associated receiving sets. Moreover, the ether today is crowded with radio signals of many different frequencies and it is only by the most careful assignment of frequency channels, and the extremely close adherence to assigned frequencies by the operating stations, that a completely chaotic condition of radio interference is prevented. For example, in the standard broadcast band alone there are roughly 1000 different stations operating within a band of about 1000 kc, and we are all familiar with the poor intelligibility that occurs when even two of these programs emerge from the loudspeaker simultaneously. The Federal Communications Commission can only assign a suitable "channel" to a transmitter and prescribe certain principles of control, but it is the responsibility of the radio engineer to design, and the manufacturing groups to build equipment which will meet frequency requirements.

Since the frequency of an oscillator is determined principally by the magnitudes of the reactive components used in the circuit, and since these components are ordinarily affected by aging and by changes in temperature (humidity and physical relationship) it is apparent that there could easily be serious variations in output frequency from time to time unless some kind of stabilization is applied.

This situation can be and has in some cases been well enough remedied for certain applications by means of very

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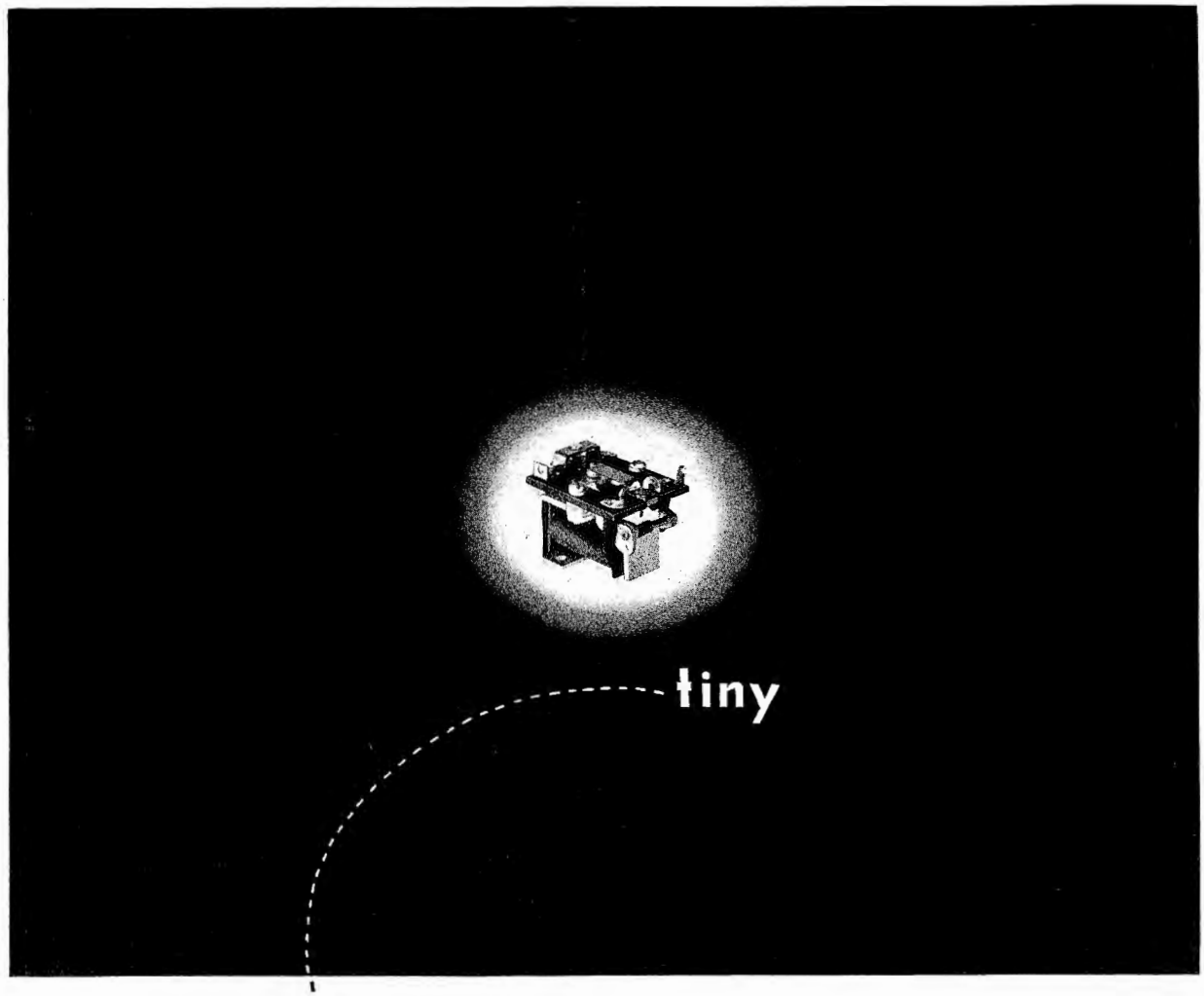


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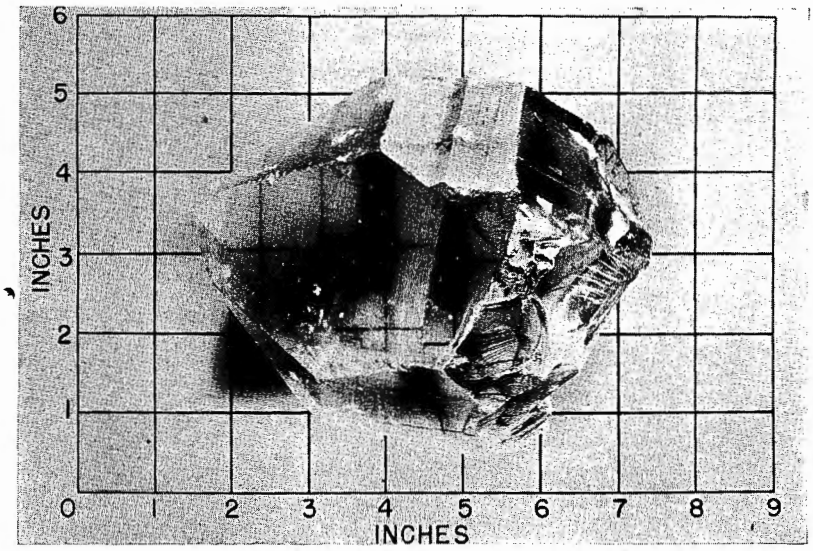
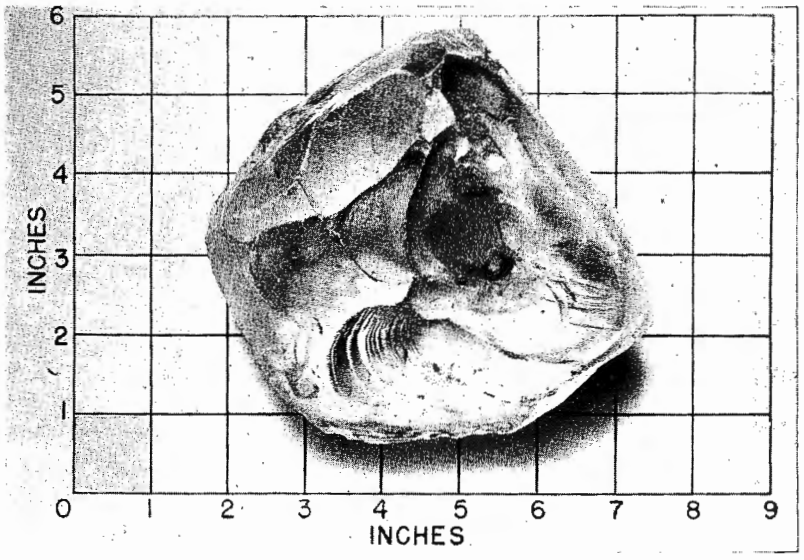



Figures 3 (left) and 4 (bottom)

In Figure 3 appears a raw quartz crystal of the peak prismatic type, shown against a scaled screen background to indicate relative size. In Figure 4, we have another raw quartz crystal, this one, however, of the irregular type. This type does not carry any faces at all, since they have been chipped off during mining. Thus the setting up of these stones for precise cutting in the crystal laboratory is more difficult, requiring the use of special optical and x-ray equipment.




specially designed coils, capacitors and resistors; by temperature compensation, temperature control, etc. The need existed, however, for a small compact and permanent circuit element which when inserted in the system would relegate the frequency effects of circuit components from a first order to a third or fourth order effect.

It has been found that a quartz crystal "plate," properly cut from the mother quartz and correctly ground and mounted, is exactly such a device.

In some applications the output of the crystal controlled oscillator is not "put on the air" at all, but its fundamental and harmonics are used to check and thereby afford a quick and simple means of correcting or adjusting the scale of a master oscillator. When used as a filter, such as in the i-f stages of a radio receiver, its value lies in its extremely sharp frequency discrimination.

***Source and Origin of Quartz***

Quartz, whose chemical name is Silicon Dioxide ($S_1 O_2$), is found principally in the states of Minas Geraes, Bahia and Goyaz, in the country of Brazil. It is obtained by simple mining and usually has to be transported several hundred miles to the seacoast for shipment. It is mined by natives using rather primitive methods. The difficulties encountered in actually getting the material out of the earth and to its destination are many. Typical of the problems encountered was the experience of an American buyer who awoke one morning in the mountains about 400 miles from Rio de Janeiro to find that his entire force of native miners had simply disappeared overnight, for no apparent reason, just as he was about to start mining on a paying scale. They were not seen again and apparently had remembered something they had to do back home. It was then necessary for the buyer to return to Rio and organize another expedition.

It is rather unique that quartz of good piezo-electric quality is not found to any great extent elsewhere than in Brazil. Even there the quality varies considerably with the region in which it occurs. In one locality the best looking material is found, but its actual value is reduced by a high percentage of "twinning"; in another, less desirable sizes and shapes occur, but the quality is better; in another the shape, size and quality are all good, but the quantity readily available is small, etc. In all of these regions the quartz appears in a variety of forms.

The "pyramid," or prismatic type (Figure 3), comes in the shape of a truncated hexagonal prism, terminated in a well formed peak or pyramid at one or both ends. These prisms are remarkably formed in that their flat faces make very definite angles with one another and with the various lattice planes and axes of the basic structure. This form is desirable because of the fact that the facial planes may be used as physical references for the precise orientation of the plates to be cut therefrom. It is frequently found, however, that the most beautiful of these contain the greatest amount of unusable material.

"Faced" stones are similar to the prismatic types, except that for one reason or another some of the faces have been destroyed and only two or three remain. These can be still used, with somewhat more difficulty, to indicate the correct blank orientation.

The "irregulars" (Figure 4) are those which carry no faces at all, due to their having been chipped off during the mining operation. The setting up of such stones for precise cutting in the crystal laboratory is more difficult in that special optical and x-ray equip-

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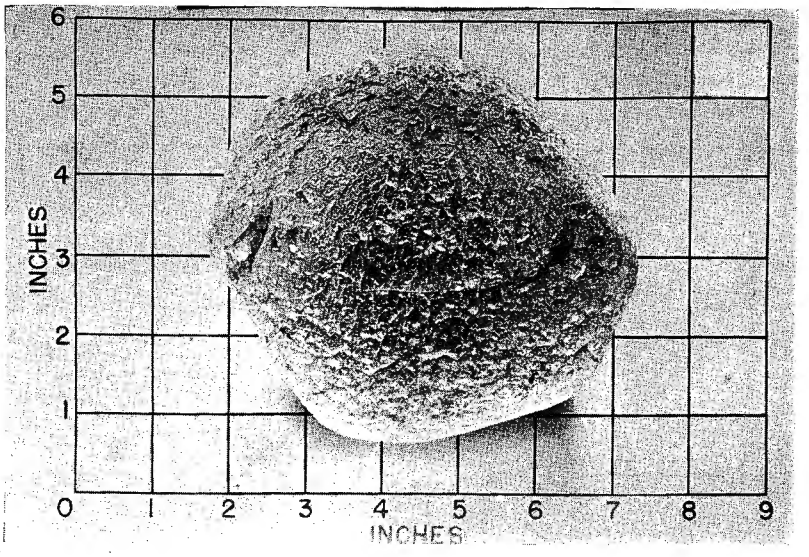



Figures 5 (left) and 6, 7 and 8 (bottom)

In Figure 5 appears a typical river quartz type crystal. These pieces come from basic rock from which they have been broken away and rolled around in river beds until the outer faces have been removed. Its shape is the result of constant abrasion. In Figure 6, we have an equivalent circuit of a quartz crystal. In Figure 7, the frequency-reactance characteristic of quartz crystal is shown, while in Figure 8 appears the frequency-impedance characteristic of a quartz crystal.

ment must be used to locate the direction of the various planes and axes. However, it is an ill wind that blows no good, and such pieces are frequently of better quality. This is because many of the defects in quartz occur near the surfaces and the chipping off which has taken place tends to remove much of the defective material.

"River" quartz (Figure 5) is an extremely interesting variation, from a geological standpoint. These pieces, which were broken from basic rock in some way ages ago, have been rolled around in river beds until the outer faces have been removed and by constant abrasion the entire piece has approached the spherical shape. These pieces also are high in usable content. Frequently they are opaque due to a gravelly surface formation which complicates their inspection and orientation.

All types are brought to this country for utilization and are sold at various prices per pound, depending upon the size, shape and quality. Since the lower grades cannot be used to good advantage, many inspections and gradings take place in Brazil in order to prevent the export of worthless material. At best, however, there are still some intangibles involved in the grading of quartz. One defect in particular known as "180° twinning" cannot be definitely detected until the piece has been cut open and acid etched. An experienced grader, by certain intelligent guesses based on symptoms which he has learned to diagnose, can keep the number of such cases to a safe minimum. Too exacting specifications may result in the securing of insufficient quartz; too lax requirements will result in serious manufacturing difficulties.

Quartz occurs in a great variety of sizes all the way up to 100 pounds. Specimens weighing five tons have been found, but are too large for commercial cutting; ½ pound to 10 pounds is the range most used today.

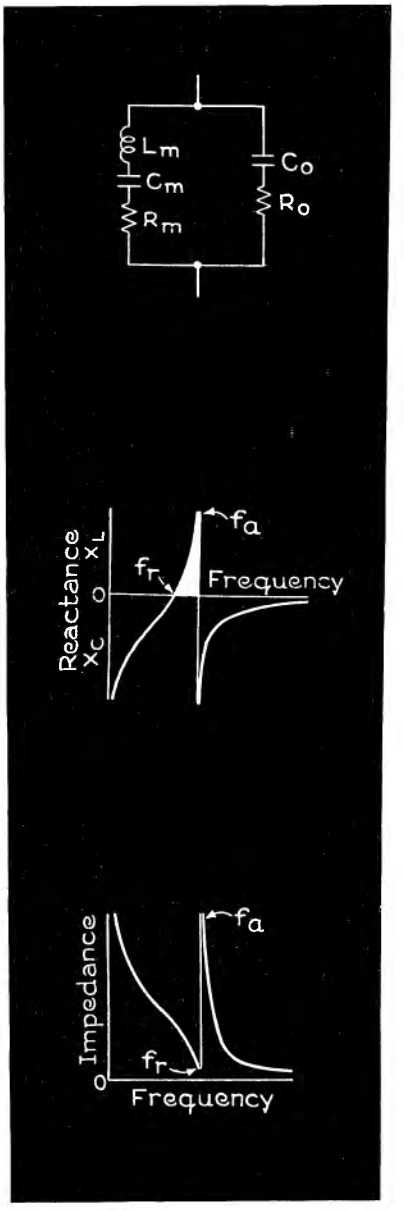
Good quartz generally is glass clear, but sometimes is smoky, or yellow. The rich yellow grades are known as "citrine" and are sometimes cut into gems closely resembling topaz. In fact, some "citrines" are more beautiful and iridescent than the genuine topaz. The yellow or smoky quartz in general works as well piezo-electrically as the clear variety. The milky type, however, is low in operating value and generally is not used.

### *The Nature of Quartz*

As stated previously, quartz is by composition $S_i O_2$. But the manner in which the atoms of silicon and oxygen are layed together is highly intricate. Silicon dioxide can be produced in the laboratory and to a higher degree of purity than has been achieved by Mother Nature. To so lay up the atoms or molecules that the resulting substance is piezo-electric constitutes a problem of considerable magnitude, however, and one which so far has not been fully solved.

Quartz has a hardness of 7, which is 3 points softer than diamond on the Mohs scale, but it is still a durable material. As such, it requires the same cutting and grinding procedure as precious stones. It is optically birefringent and possesses double refraction properties similar to calcite. It is slowly soluble in hydrofluoric acid and, in fact, etching with this acid is one means of locating certain faults and of cleaning the surfaces.

The term "twinning" as applied to crystal refers to a peculiar form of non-linear growth. Quartz possesses the power of rotating light traversing it in a direction parallel to the "optic" axis. Some crystals rotate the light in a



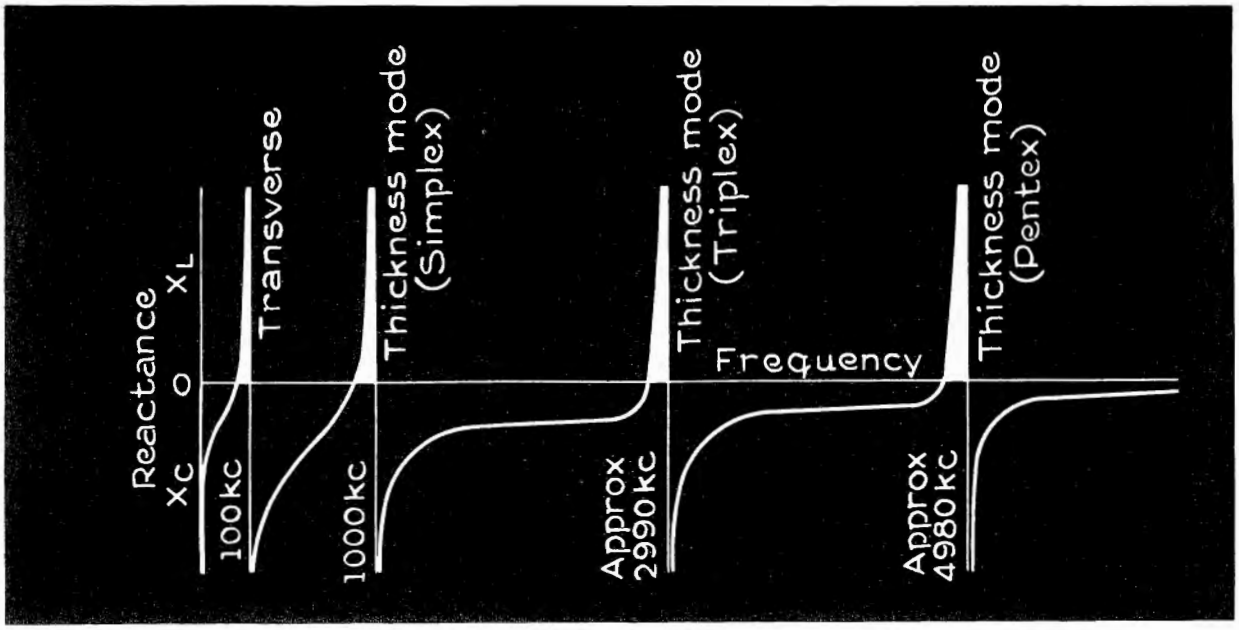



Figure 9

The frequency-reactance characteristics of quartz crystal, showing the various modes of oscillation.

right- and some in a left-handed direction and are called right-and-left-handed, accordingly. Unfortunately, a large percentage of the specimens found seem to have been unable to make up their minds during their million years of adolescence and as a result grow in both directions, i. e., right- and left-handed. In this way, an undesirable growth is formed which is sometimes called "random twinning." This type of twinning is visible under polarized light. In another form all parts of the crystal may be of the same rotation but due to a sort of growing together of two formations having opposite electrical polarities, the condition known as "180°" or "electrical" twinning occurs. This type of twinning is not visible under the polariscope, but is clearly brought out by hydrofluoric acid etching. There are many variations of these defects and there is also the so-called "needling" or threadlike intergrowth. This is visible under strong light converging within the crystal.

### *Historical Data*

It was discovered by the Curies about the year 1880 that quartz possessed what is known as the "piezo-electric" property. Briefly stated, this means that when the substance was pressed or squeezed in a certain direction electrical charges were developed at certain points on the quartz surface. (The prefix "piezo" is derived from the Greek word "Piezein," which means "to press.") This is known as the "direct effect." Later it was found by Lippman that the reverse was also true. If a potential difference were applied to the crystal in a certain way the crystal became deformed and remained so until the applied voltage was removed. This is now called the "indirect effect."

Although these discoveries were later to become of considerable importance, they lay practically dormant until after the advent of radio. About 1920, Cady found that a crystal could be so fabricated and coupled to an oscillating circuit as to closely control the frequency of oscillation. This was because the crystal possessed a relatively high natural vibration frequency and by virtue of its piezo-electric property this natural vibration frequency could be readily coupled to an oscillating vacuum tube circuit. Electrically the crystal appears to the vacuum tube as a tuned circuit of extremely high "Q," having the reactive values necessary to sustain oscillation and to control the frequency of oscillation to a hitherto unknown degree of stability.

### *Electrical Characteristics of Quartz*

The piezo-electric effect is the basic property which gives to the crystal the characteristics necessary for frequency control. But the manner in which these properties appear merits further consideration.

In order to make use of the crystal as an oscillator, resonator or filter, it is necessary that it be mounted between metal electrodes of some kind which serve to set up the necessary field, and also to afford connections from the crystal to the associated circuit. Superficially, such a "sandwich" has the appearance of a simple capacitor with the quartz serving as the dielectric. It is a capacitor, but hardly a simple one. If measured at low frequency, or even at most high frequencies, it will appear as a capacitor of perhaps 15 micromicrofarads, depending upon the dimensions of the crystal and electrodes.

Such a device, however, in the vernacular of the patent attorney, is "a vibratile element" and it is "well known to those skilled in the art" that it has one or more natural periods of vibration. While the strings of a piano are tuned to vibrate at different low frequencies to produce the desired musical notes, such as 256 cycles per second for middle "C," etc., the crystal is tuned to vibrate at millions of cycles per second by properly adjusting its dimensions. If the crystal could be alternately squeezed and released at a rate corresponding to its natural frequency, the piezo-electric action would reach a maximum, and relatively high surface voltages would be developed. Conversely, if it is excited electrically at its natural frequency there will be a maximum of deformation; if the applied r-f voltage is high enough the blank will actually tear itself apart.

It is in this region of resonance that the crystal functions when used in conjunction with a radio circuit, and it is here that it exhibits its unusual characteristics.

Although there are ordinarily several points of resonance, it is customary to make use of but one in a given setup. Close together in the resonance region are the points of series resonance and of parallel, or anti-resonance. At series resonance the impedance is at a minimum and is a pure resistance; at anti-

(*Continued on page 37*)

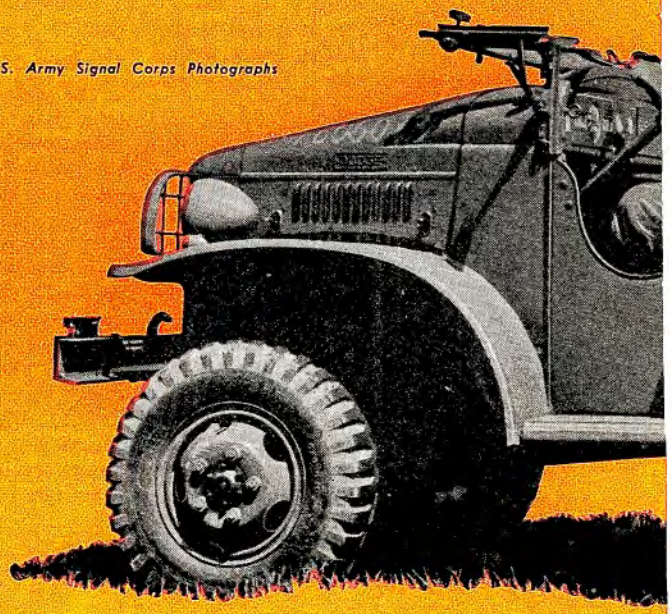
# Men wanted for the Signal Corps of the U. S. Army

***You can (1) serve your country, (2) learn the rapidly advancing science of electronics, (3) prepare yourself for a promising career after the war by joining "The Nerve Center of the Army" now.***

Men are needed now to man America's electronic weapons.

This is a war of communications. "The message must get through!" Radio communication equipment and electronic devices known only to the men of the U. S. Signal Corps are fighting the war on world fronts.

*U. S. Army Signal Corps Photographs*



Here is an outstanding opportunity for radio and communications men to do their part, and at the same time get the finest possible training in one of the brightest after-the-war industries.

The electronics field is still in its infancy. Ten years ago there were comparatively few electronic devices. Today there are more than a thousand kinds of electronic devices at work in factory, hospital, office, cotton mill, steel mill, the home and on the fighting front!

General Electric is a leader in electronic research. We are definitely interested in having available, when victory comes, trained men for the sales and service of future electronic devices. This is a highly specialized field, and good men will be in demand.

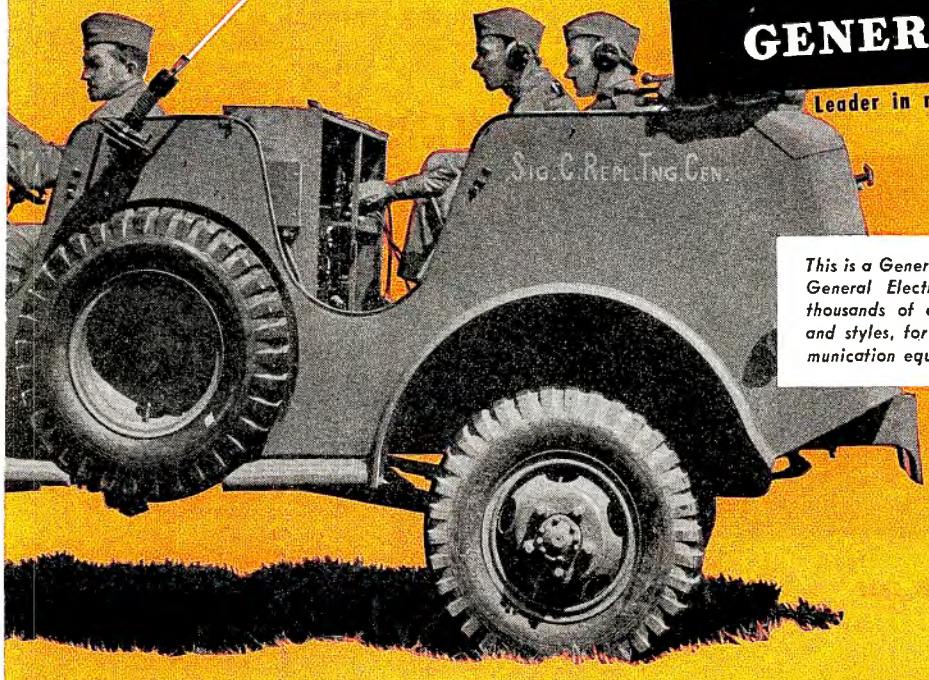
If you are now an expert in radio, or are ambitious and willing to learn at good pay, General Electric urges you to consider the Signal Corps now. The Signal Corps is also sponsoring courses in the fundamental theories of radio and electronics in many colleges and universities. . . . Get in on the ground floor today!

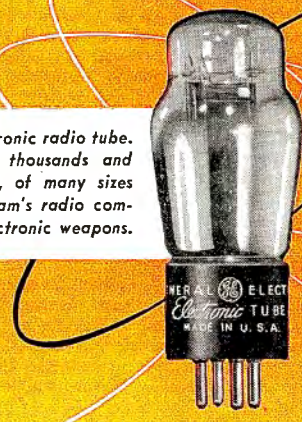
★ ★ ★

For further information regarding enlistment, call at the nearest Army Recruiting and Induction Station. Or write to "The Commanding General" of the Service Command nearest you. For Civilian Training information, call at any office of the U. S. Civil Service or U. S. Employment Bureau.

**GENERAL ELECTRIC**

**Leader in radio, television, and electronic research**




*This is a General Electric electronic radio tube. General Electric is building thousands and thousands of electronic tubes, of many sizes and styles, for use in Uncle Sam's radio communication equipment and electronic weapons.*

# NEWS BRIEFS OF THE MONTH...—

### NAVY ASKS FOR ENGINEERS

Among the most urgent needs of new officer personnel in the United States Navy is for professional technicians in engineering fields, the Director of Naval Officer Procurements, Chicago, has announced.

Perhaps first in the list are graduate electrical engineers, those mainly between 21 and 50 years who have followed electrical engineering since their graduation, and who have a knowledge of ultra-high frequencies, electronics and television. Those more familiar with power engineering likewise may find a place in the Navy which is interested in these men in ages up to 50 years. Electrical engineers are needed especially in the Navy's fields of radio and detection devices. Men with radio or communication engineering degrees may qualify for officers commissions as well. Waivers for minor physical defects often are obtainable.

A Petty Officer rating is offered to men with sufficient experience in radio to instruct classes in Radio Theory, Practical Operation, Code, or Maintenance.

The Navy has schools in several parts of the country to instruct enlisted men in radio, and it is for these schools that instructors are needed. The men that are selected will go through a refresher course at a Naval Aviation Service School where they will be instructed in use of the radio equipment used by the Navy.

In some cases men with B. S. degrees in mechanical or other engineering subjects and who have had experience in radio and electrical work may qualify for officer assignments in radio or electrical lines. Usually, however, degrees in engineering other than electrical tend to fit the applicant for other duty.

Another special officer procurement program under way is for college teachers of physics, or, chemical, diesel, electrical, mechanical, and radio engineering at Naval Reserve Midshipman Schools. Private school and junior college teachers and others qualified to teach those subjects in colleges are also being sought.

Either Ensign W. W. Hall, Room 300, or M. G. Miller, Room 1184, both in the Board of Trade Building, Chicago, will answer all requests for information.

* * *

### CANNON CATALOG

The Cannon Electric Development Company, Los Angeles, has just issued a new illustrated 16 page condensed catalog supplement covering the most popular types of electrical connectors.

The catalog deals briefly with the two leading types used in aircraft applications and details more complete information on connectors for radio microphones, sound equipment; power heavy-duty control circuits, public address systems and geophysical research; electronic low-level circuits and small power applications.

* * *

### RUNYON CBS VICE PRESIDENT JOINS NAVY

Mefford R. Runyon, CBS vice president, had been commissioned a Lieutenant Commander in the United States Naval Reserve. Commander Runyon will probably be assigned to work in Naval Communications after taking an indoctrination course at the Noroton Naval Radio Training School.

### ROCHESTER FALL MEETING, NOV. 9

The Rochester fall meeting will be held at the Sagamore Hotel, Rochester, New York on November 9. In addition to the presentation of engineering papers, the annual banquet will also be held on this date. There will be no exhibit, however. (*See page 49 for program.*)

### EXTENSION COURSE ON METERING

A revised extension course on metering of alternating current has been announced by the Westinghouse Electric and Manufacturing Company.

The book has 177 pages and 139 illustrations. The material is presented in an easy to understand manner, and the usual educational prerequisites are not necessary. This revised course has been brought up to date with respect to latest practice. The information, although prepared by Westinghouse engineers, applies with equal facility to any other make of meter.

A copy of extension course 10 on "Metering of Alternating Current" may be secured from the industrial relations department, Westinghouse Electric and Manufacturing Company, East Pittsburgh, Pennsylvania.

* * *

### BRITISH TELEVISION PATENTS TO RAULAND

The Rauland Corporation, Chicago, has acquired title to the American patents of the Gaumont-British Picture Company of America, Cinema-Television, Ltd., and Baird Television.

The Rauland Corporation has also taken over in its entirety the laboratory and engineering staff as well as the equipment of Cinema-Television, Baird Television and the Gaumont-British Corporation of America. This covers all of the United States interests of the parent Gaumont-British Company, Ltd., of London, England.

Headed by Dr. C. S. Szegho, Chief Research Physicist, the personnel has been added to the present laboratory and engineering staff of the Rauland Corporation.

* * *

### HALLICRAFTERS "E" PROGRAM BROADCAST

The presentation program of the Army-Navy "E" award to the Hallicrafters, Inc., of Chicago, was broadcast over the Columbia Broadcasting System, with W. J. Halligan, president, as the keynote speaker.

### FEDERAL TUBE DATA SHEETS

Six new folders with price lists and facts on Federal transmitting and rectifier tubes have been released by the Federal Telegraph Company, Inc., 200 Mount Pleasant Avenue, Newark, New Jersey. In the data, the characteristics of the various tubes are presented, in addition to circuit information. One of the bulletins released covers an interchangeability list.

* * *

### I R C ISSUES "E" DISPLAY CARD

In celebration of the winning of the Army-Navy "E" award, the International Resistance Company of Philadelphia have issued a display card that can be used for either counter or wall use. The display is 12 by 17 inches and has been sent to IRC jobbers.

* * *

### SOUTH BEND CATALOGS

Three new catalogs have been issued by the South Bend Lathe Works, South Bend, Indiana. One is an 8 page catalog No. 13 with full information on 13" Precision Lathes. Attachments, accessories and tools for use with the lathes are also listed. A portion of the catalog is devoted to the construction features of the quick change gear box, carriage, spindle bearings, motor drive, etc.

These lathes have a 13⅜" swing over the bed and saddle wings, 11/16" collet capacity, 1" spindle bore, and are made in several bed lengths that provide between-centers capacities of 16" to 52".

Another catalog, 100B, describes the entire line of lathes, toolroom lathes, and turret lathes. The engine lathes and toolroom lathes range in size from 9" swing to 16" swing. The turret lathes are made in three sizes, having 9", 10" and 16" swings. This catalog contains 48 pages, size 8½" x 11".

The South Bend Turret Lathes, numbers 1003-C and 1004-C, are described in still another catalog, 1004. In this, a four-page file size unit the new bench model turret lathes and their construction features are described. Convenient tabulated specifications list all the necessary information concerning capacities, feeds, speeds, and dimensions.

All catalogs are available gratis.

* * *

### DORHOFFER 10TH YEAR AT POLYMET

Murray Dorhoffer, sales manager of Polymet Condenser Company, is now celebrating his tenth year with that firm.

* * *

### AIRCRAFT DEVELOPMENT CORP. FORMED

The Aircraft Parts Development Corporation to handle research and development work on parts and materials for the aircraft industry, especially in the fields of fastening devices, powdered metals, and plastics has first been formed.

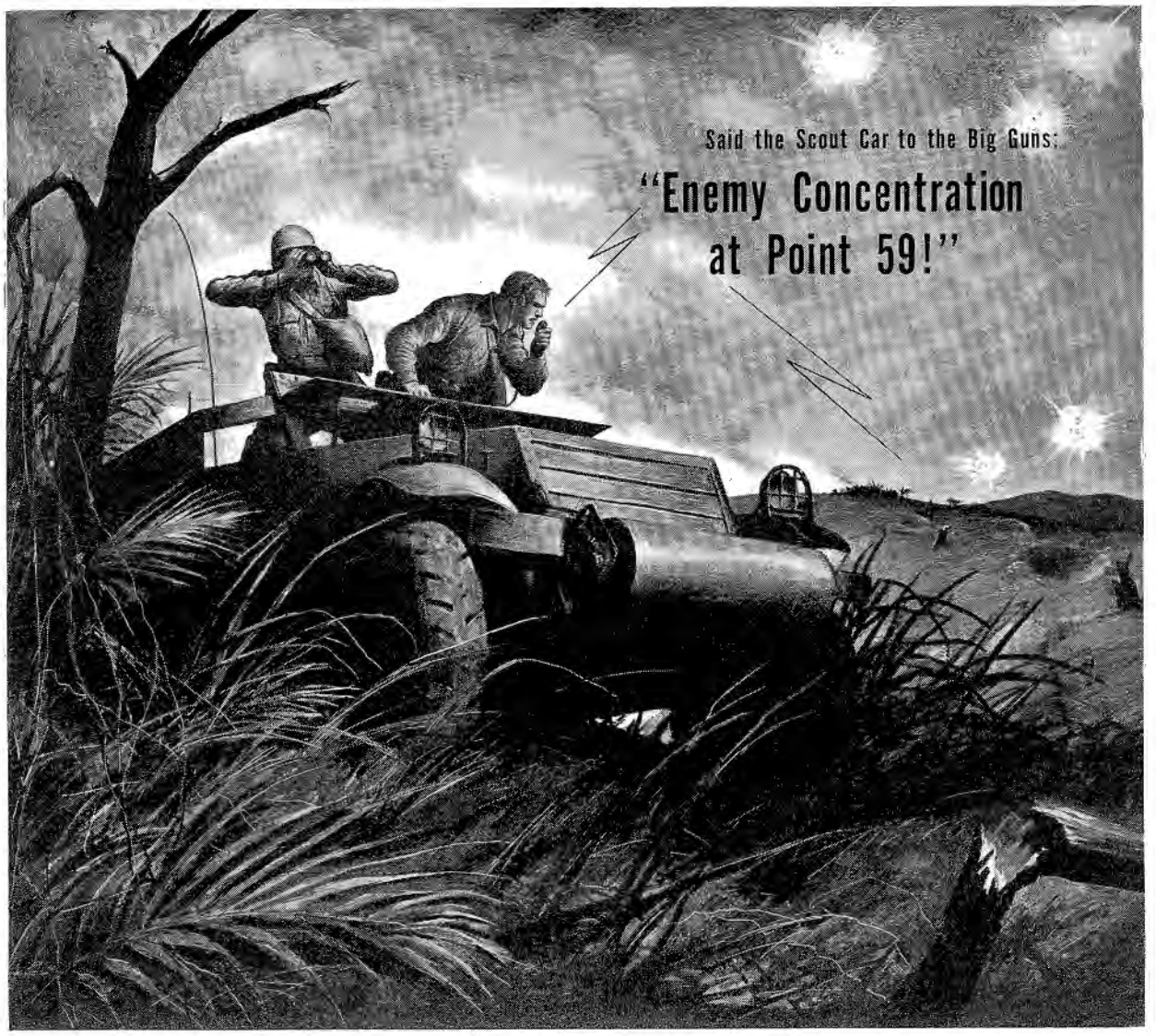
Facilities at Summit, New Jersey, include a fully equipped tool room, special experimental machinery, a powered metal experimental laboratory, and a pilot thermo-plastics plant.

* * *

### WESTINGHOUSE RECEIVES "E"

Rear Admiral William Carleton Watts of the United States Navy recently presented Army-Navy "E" pennants to five Pittsburgh-area plants of the Westinghouse Electric and Manufacturing Company "for

(*Continued on page 32*)




**They work together better...**
**because they can talk together**

In a war of movement
The scout car's job
Is to feel out the enemy
And report its information
Instantly to the main body.

So Uncle Sam's half-track scout cars
Are equipped
With modern radiotelephones
That flash the word to other units.

*Teamwork* like this
Is important
When minutes mean the difference
Between winning a battle
And disaster.

Modern communications equipment
Designed and manufactured
By I. T. & T. associate companies
Is helping Uncle Sam
Coordinate his fighting forces
On land, sea and in the air.

The broad peacetime experience
Of I. T. & T.
In the field of communications
Is proving its value in time of war.

**INTERNATIONAL TELEPHONE AND TELEGRAPH CORPORATION** *67 Broad Street, New York, N.Y.*

**IT&T**

*Associate Manufacturing Companies in the United States*
International Telephone & Radio Manufacturing Corporation
Federal Telegraph Company

# VETERAN WIRELESS OPERATORS ASSOCIATION NEWS

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

### LOS ANGELES

IN response to a telegram of congratulations from our president upon the occasion of the 69th birthday of the "Father of Radio," Dr. Lee de Forest, our honorary president, Hal Styles, chairman and founder of the Los Angeles-Hollywood chapter of our Association immediately arranged a surprise birthday party in his honor.

Hal reports . . . "We called a special meeting of the Los Angeles-Hollywood Chapter which was turned into a surprise party with approximately 100 old timers in attendance. Entertainment was furnished by the veteran musical comedy star Trixie Friganza and Larry Wayne, 12 year old 'world's greatest accordionist.' Many stories were swapped and we spent some time reading the log kept by George Newton, a member of our chapter, who was the wireless operator aboard the SS Robin Moor, which was torpedoed in the South Atlantic 'before Pearl Harbor.' Doc de Forest was delighted and evidently thrilled by this tribute from so many oldtimers.

"Many of our members are in Service these days holding commissions in the Army and Navy and some of them have gone back to sea in the Merchant Service.

"You will note from the list of members of our board of directors that we have a representative group from all branches of the industry. James Chapple of the Federal Communications Commission; Frederic H. Stephens of the Civil Aeronautics Authority; L. H. Bowman of the Columbia Broadcasting System; A. H. Saxton of the National Broadcasting Company; C. O. Slyfield of the Walt Disney Studios; Lt. Cmdr. E. H. Hansen, U.S.N., formerly of 20th Century-Fox Studios; W. H. Beltz of RCA Manufacturing Company; J. F. Dunn of the Mackay Radio and Telegraph Company; H. E. Austin of RCA Communications, Inc.; A. E. Jackson of the RCA Manufacturing Company; T. M. Gardner of the Radiomarine Corporation of America; H. Duke Hancock of station KGFJ and P. G. B. Morriss of Rancho Grande.

"It is with deep regret that we report the passing of one of our directors, a charter member of our chapter and a splendid fellow, Harrison Holliway, who was vice-president and general manager of KFI-KECA."

Sincere thanks, Hal, for a fine job on the birthday party and your splendid report.—M. C.

At the DeForest surprise party . . . left to right . . . Mort Smith; Dr. DeForest; Hal Styles, chairman of the Los Angeles chapter; Trixie Friganza, veteran musical comedy star, and Lt. Com. E. H. Hansen.

Photo by Harley Martin, Citizen-News

### CHICAGO

OUR sincere and heartfelt congratulations to Bill Halligan, for several years chairman of our Chicago chapter, upon the granting to his organization of the Army and Navy "E" Pennant for outstanding contributions to the "War of Production." Bill does a swell job in anything he tackles. He is a life member of our Association and a grand VWOA booster.

### AWARDS

THERE have been many cases in the recent past of outstanding devotion to duty on the part of radio officers in the Merchant Marine. One of the major functions of our Association is to accord suitable recognition to the heroes of these occasions. We urge all who have access to the records to submit a comprehensive report on cases of heroism on the part of radio officers on land, at sea, and in the air. We assure you the reports will receive thoughtful consideration. We are particularly anxious to have our Chapters nominate candidates for awards.

### SCHOLARSHIPS

WE have recently received several requests for information concerning the availability of Marconi Memorial Scholarships. We recently awarded two scholarships, one at RCA Institutes and the other at the Midland Television and Radio School and these are all that will be available until next year.

The Scholarships are awarded to the top ranking contenders in a contest conducted among the seniors in high schools throughout the country under the auspices of the American Institute of the City of New York and Science Service.

### REMINISCING . . . WITH BILL FITZPATRICK, CHARTER MEMBER

THIS war hasn't reached Old Bill Fitzpatrick — our never-failing supply source for cribbing material for this page—but he has plenty of memories of the last one. He recalls especially the glitter of the sun on a German submarine which rose to the surface within a stone's throw of Bill's ship and the exciting zig-zag chase that followed. (If you read more of Bill's stuff in the next issue you'll know that he, and the ship, escaped). And the night when he saved the ship from heading directly toward another submarine by signalling to it with a pocket flashlight. That was just after the blowing up of the Diamond Shoals Lightship. And the lead code books, to be thrown into the sea in case of capture of the vessel.

Bill made a trip to London during the thick of the war, and recalls standing at Longitude ZERO at Greenwich, with one foot on the East side of the world and the other on the West. While on this trip, incidentally, Bill received an English "wireless" license, one of only three ever issued to other than British subjects.

Why do you oldtimers permit Bill Fitzpatrick to do all the reminiscing?

(*Continued on page* 32)

# NEWS BRIEFS

(*Continued from page 28*)

high achievement in the production of war equipment." Selected to receive the awards were the Transformer Division at Sharon, Pa., and the East Pittsburgh Division, which includes the porcelain plant at Derry, Pa., Nuttall Gearing Works in Pittsburgh's Lawrenceville section, and plants at East Pittsburgh and Trafford, Pa.

* * *

### *B-L SELENIUM RECTIFIER BULLETIN*

A new bulletin R-40, on selenium rectifiers has been prepared by the Benwood Linze Co., 1815 Locust St., St. Louis, Mo.

Covered in the bulletin is general information on selenium rectifiers, including their assembly, plate sizes, efficiency, input voltage, stability, cooling, regulation, etc.

Illustrations including graphs covered by the text matter, are included in the bulletin.

A copy may be obtained by addressing the company.

* * *

### *NEW RCA LABORATORIES DEDICATED*

The new RCA Laboratories with 150 laboratory bays, at Princeton, New Jersey, were recently dedicated.

Lieut. Gen. James G. Harbord, chairman

(*Continued on page 33*)

# VWOA NEWS

(*Continued from page 30*)

Gilson Willets, charter member and chairman of our San Francisco Chapter emulated Bill last month. Let's hear from some of you other oldtimers with stories of the past—or the present, for that matter, if there is anything happening these days that is not a military secret.

How many of you know that the idea of a "radio oldtimers association" was first thought up by Pete Podell and Jim Maresca, who brought the plan to Bill Fitzpatrick (of whom you have already heard) early in 1925. The three "founders" joined with Gilson Willets and Sam Schneider in the control room of broadcasting station WRNY (remember) to draw up plans for what was first known as "Old Time Radio Operators." The first meeting was held at the Roosevelt Hotel, New York City, on October 15, 1925. At the next meeting, a month later, the name of our organization was changed to its present one. William S. Gill, elected president at that meeting, was thus VWOA's first leader. A year later, Jimmie Maher originated the idea of an annual "Cruise" for the year-by-year reunion of oldtimers of wireless, which leads us to begin thinking of the Eighteenth of the series, to arrive four months hence. Keep the evenings around February 11th, 1943, free from other engagements, brothers (and their sisters) and let's have an attendance which will top all others.

of the board of Radio Corporation of America, presided and introduced the speakers: Major General Dawson Olmstead, Chief Signal Officer of the Army, Col. David Sarnoff, U. S. Army Signal Corps, and Otto S. Schairer, vice president in charge of RCA Laboratories.

These new laboratories have facilities the development of electronics, sound-acoustics, chemistry, physics, mechanics, and optics, from which grow many by-products and branches . . . cathode ray tubes, fluorescent materials, lenses and photography.

* * *

### *BAKELITE PLASTIC BOOKLET*

A 24 page booklet, entitled "Bakelite Laminating Plastics" has been published by Bakelite Corporation, New York City. It tells what laminated plastics are and describes their various types, including molded-laminated stock, engraving sheet stock, fluorescent and phosphorescent sheet stock, and densified-laminated wood.

The booklet is profusely illustrated with photographs showing the manufacture of laminated materials and their essential uses in the electrical, automotive, aircraft, and chemical industries.

* * *

### *WALKER NAMED AUREX S-M*

L. T. Walker has been named sales manager of the Aurex Corp., Chicago, makers of hearing aid instruments.

* * *

### *NEW I T & T PLANT*

The International Telephone and Telegraph Corporation will construct the first unit of a new factory to be located in New Jersey, which will evenually become the home of I T & T's research and manufacturing operations in the United States.

* * *

### *SYLVANIA COLOR CODE CHART*

A Color Code, RMA Standard, Resistor Chart has been prepared by Sylvania Electric Products, Inc. On the back side of the chart is Ohm's Law and the mathematical formulas for Ohm's Law.

Copies are free for the asking.

* * *

### *DETECTOR SPEEDS TUBE PRODUCTION*

Increased production of high-power radio tubes being built at the Westinghouse Lamp Division for the armed forces, has been made possible by the development of a mechanical detector that automatically sorts filaments by spectroscopic analysis.

Known as a thorium detector, the device was invented by Dr. N. C. Beese, laboratory staff physicist. It is credited with cutting hours and guesswork from the necessary testing of wires before they are used in radio tubes.

Introduction of a small percentage of thorium into a tungsten wire increases its ability to emit electrons and gives increased efficiency to certain types of tubes. The thorium detector, with the aid of a spectroscope, the optical instrument used in observing visible images of the color spectrum, detects the presence of any appreciable amount of thorium in tungsten wire.

Until recently, thoriated tungsten filament wire could only be detected by chemical or mechanical analysis. In the former process, wire was dipped in several acid solutions and the residue examined for thorium content. The other method consisted of heating the wire and if it snapped

(*Continued on page* 34)

# NEWS BRIEFS

(*Continued from page 33*)

very easily, it was considered to have thorium in it.

The new thorium detection process eliminates any possibility of guess work and speeds up the testing of wire. The method consists of introducing a sample of pure tungsten or thoriated tungsten wire into an electric carbon arc. As it burns completely, visible results are observed by means of the spectroscope. Two lines appear in the spectrum if the wire is pure tungsten; four appear if it contains any thorium.

A portion of every roll of tungsten wire now passes the watched "eye" of the sensitive instrument before being cut and made into small filaments. The sorting process separates the thoriated tungsten wire from pure tungsten wire.

* * *

### WARD LEONARD WINS "E"

The Ward Leonard Electric Co., Mt. Vernon, New York, was recently awarded the Army-Navy "E" pennant for high achievement in the production of war equipment.

* * *

### SOLAR ELECTROLYTIC CAPACITOR CATALOG

A new 32 page catalog devoted exclusively to the description of d-c type electrolytic capacitors has just been issued by the Solar Manufacturing Corp., Bayonne, N. J. The catalog, known as number 12, section A, contains electrical and mechanical data particularly prepared for the designing engineer.

Copies of the catalog are available to all who make a letterhead request.

* * *

### PLASTIC FOLDER

A folder with data on plastic parts for war production has been prepared by Creative Plastics Corp., 963 Kent Avenue, Brooklyn, New York. Copies are available free.

* * *

### NEW PANEL INSTRUMENTS CATALOG

A 12 page catalog describing all their 3" and 4" panel instruments, has just been issued by Roller-Smith, Bethlehem, Penn.

In addition to a complete listing and prices, the various types of cases are illustrated, dimensions and listings of a complete line of shunts are given and RT current transformers for ratios up to 500/5 are illustrated and described. Dimensions and mounting details on all standard panel instruments are shown.

Copies of the catalog, 4120, can be secured without charge.

* * *

### TUBE BASE CONNECTIONS DATA

The element connection and base layout of over 600 different types of radio tubes are shown in a new bulletin released by the Weston Electrical Instrument Corporation, Newark, N. J.

Originally designed for use with the Weston method of selective analysis, but now used with all methods of servicing, this folder permits rapid socket selection for practically any tube now in commercial use.

Tube base connections are illustrated by diagrammatic sketches of the bottom view of socket or base of tubes; constituting valuable reference material on tube circuits for service organizations and dealers. A tube base chart is also included which indicates the proper base to use for any of the various tubes listed. A copy is free for the asking.

* * *

### RAYMOND ROSEN AIDS SIGNAL CORPS

Raymond Rosen of Raymond Rosen and Company, Philadelphia, Penn., has been appointed civilian recruiting aide for the Army Signal Corps.

All men in Pennsylvania, southern New Jersey and Delaware interested in enlisting for the Army Signal Corps are advised to immediately contact Lt. S. D. Distelhorst, Room 623, Customs House, 2nd and Chestnut Sts., Philadelphia, Penna.

* * *

### TENNY HIGH ALTITUDE CHAMBER CATALOG

An illustrated, twelve page, two color booklet, showing and describing high altitude chambers with temperature ranges from —70° to 140° F. has been released by Tenny Engineering, Inc., 8 Elm Street, Montclair, N. J.

Also illustrated and described are the weathering cabinets, constant temperature bath tables, and temperature and humidity cabinets. A listing of installations of Tenny equipment giving the purposes for which it is used and the specifications for individual installations is also included. This information booklet will be sent on request to any engineer or laboratory technician.

* * *

### TUBE LIFE BOOKLET

A pocket size booklet "Thirteen Ways to Prolong Tube Life" with several helpful hints on getting the longest service from electronic tubes has been prepared by Heintz and Kaufman, Ltd., 1011 Tanforan Avenue, South San Francisco, Calif.

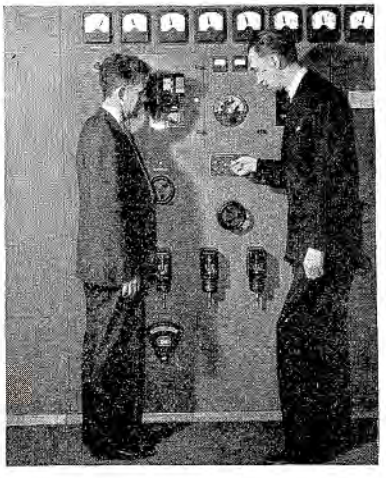
It considers plate dissipation, proper tuning of circuits, reduction of "no-signal" plate current in class B audio amplifiers, minimizing stray circuit losses in class C stages, adjusting grid drive, maintaining rated filament voltages, preventing parasitic oscillations and other subjects. Copies are available free.

* * *

### G. E. DEDICATES 100 KW TRANSMITTER

Robert E. Sherwood, (right in photo below), director of the overseas branch of the Office of War Information, threw the switch setting into operation the new 100 kilowatt transmitter of General Electric's short wave station WGEO in Schenectady.

(*Continued on page 35*)



Assisting was W. J. Purcell, engineer G.E. broadcasting.

* * *

### *HENRY A. HUTCHINS*

Ever since Pearl Harbor, Henry Hutchins, general sales manager of National Union has felt the urge to return to the Naval Service to do his bit.

Henry up and did it, and is now Lieutenant Commander Hutchins, U. S. Naval Reserve on active duty.

* * *

### *OHMITE EXPANDS*

Another expansion in factory space and production facilities has been made by the Ohmite Manufacturing Company, 4835 Flournoy Street, Chicago, Ill.

* * *

### *STEWART-WARNER WINS "E"*

The Stewart-Warner Corporation, Chicago, Ill. received the "E" flag for outstanding war-time performance, recently.

The ceremony was held at Soldier Field, Chicago, prior to the Army War Show.

Brig. Gen. Donald Armstrong, until recently in command of the Chicago ordnance district, presented the award to the company, and Commander W. W. Weber, representing the navy, delivered individual insignia for employes. Frank A. Ross, senior vice president and Frank A. Hiter, vice president and general sales manager were among those who represented the corporation in the ceremony.

* * *

### *EITEL-McCULLOUGH WINS "E"*

The coveted Army-Navy "E" flag has been won by Eitel-McCullough, Inc., transmitting tube manufacturers. The award was made at their San Bruno, California plant, on the same day that the factory was also celebrating their eighth anniversary.

The presentation of the pennant was made by Colonel Ira H. Treest to both W. W. Eitel, president, and J. A. McCullough, vice-president.

Congratulatory letters from such ranking Government officials as Cordell Hull, Major General Roger B. Colton, of the Signal Corps, and Commander J. B. Dow, head of the Radio and Sound Branch of Ships at Washington, D. C., were received.

The presentation activities were described in both a special "E" program and a special edition of "Eye Mac" news, the plant paper. In this issue, incidentally, appeared an interesting biographical sketch of Mr. Eitel and Mr. McCullough, and the events that led to the development of the famous HK354 tube. Other behind the scene activities are also described.

*Official U. S. Signal Corps Photo*

(Left to right) Jack McCullough, Eimac employee, and Bill Eitel.

# BOOK TALK . . .

**The following books have been submitted to the Editors for review in a future issue of COMMUNICATIONS.**

## ULTRA HIGH-FREQUENCY

*By J. E. Brainerd* (Editor), Professor in Moore School of Electrical Engineering, University of Penn.; *Glenn Koehler*, Assistant Professor of Electrical Engineering, University of Wisconsin; *Herbert J. Reich*, Professor of Electrical Engineering, University of Illinois, and *L. E. Woodruff*, Assistant Professor of Electrical Engineering, Massachusetts Institute of Technology . . . New York: D. VanNostrand Co., Inc.

• • •

## MATHEMATICS FOR RADIOTRICIANS

National Radio Institute, Washington, D.C.

• • •

## MICROWAVE TRANSMISSION

*By J. C. Slater*, Professor of Physics, Massachusetts Institute of Technology . . . New York: McGraw-Hill Book Co.

• • •

## A-C CALCULATION CHARTS

*By R. Lorenzen* . . . New York: John F. Rider Publisher, Inc.

• • •

## NEW COMMERCIAL AND TECHNICAL DICTIONARY

*Compiled by Antonio Perale Guerro* . . . Brooklyn, New York: Chemical Publishing Company.

• • •

## ELECTRICAL FUNDAMENTALS OF COMMUNICATION

*By Arthur L. Albert*, Professor of Communication Engineering, Oregon State College . . . New York: McGraw-Hill Book Company.

• • •

## ELECTROMECHANICAL TRANSDUCERS AND WAVE FILTERS

*By Warren P. Mason*, Ph.D., Member of the Technical Staff of Bell Telephone Laboratories, Inc. . . . New York: D. Van Nostrand Company, Inc.

• • •

## HANDBOOK OF TECHNICAL INSTRUCTION FOR WIRELESS TELEGRAPHISTS . . . SEVENTH EDITION

*By H. M. Dowsett*, M.I.E.E., F. Inst. P., and *L. E. Q. Walker*, A.R.C.S. . . . London, England: Iliffe and Sons, Ltd.

## QUARTZ CRYSTALS

(*Continued from page* 25)

resonance it is at a maximum and is again a pure resistance. These two points are only a few hundred cycles apart, but in this short interval the impedance increases from a hundred ohms or so at series resonance to perhaps a megohm or more at anti-resonance. This is due to the extremely high "Q" of the crystal, and it accounts for the very steep frequency impedance characteristic obtained. Moreover, in this interval the characteristic changes from capacitative to inductive. Over a narrow region then our "sandwich" has become an inductance. The crystal can be quite accurately illustrated by the equivalent circuit shown in Figure 6. In this circuit, $C_o$ and $R_o$ represent the usual electrostatic capacitance and loss resistance of the crystal unit as measured by any convenient method while $L_m$, $C_m$ and $R_m$ are the electrical counterparts of the mechanical inductance, capacitance and resistance as brought into play by the electro-mechanical forces developed. Figures 7, 8, and 9 show typical crystal frequency characteristics.

Circuits of this general type, having two degrees of freedom, are of course common in radio. Very uncommon, however, are the relative values of the active and reactive components in the series branch, and the small size of the element in which they appear. $L_m$ may be in the order of henries, $C_m$ a fraction of a micromicrofarad, and $R_m$ only a few ohms. An inspection of these values shows at once that the ratio of reactance to resistance is enormous. The "Q" may be in the order of 100,000 or so as compared with a few hundred for a man-made coil and capacitor assembly of much greater dimensions. It is this property which enables the crystal to control the frequency of the oscillator to within narrow limits.

Although a crystal possesses the ability to resonate at several frequencies, there are in general only three principal modes of legitimate vibration. These are: (a) The "contour mode" (transverse) determined mainly by the length or width of the plate. (b) The "thickness mode" (simplex) whose frequency is determined mainly by the thickness of the plate. (c) The "multiplex modes" (triplex, pentex, etc.) which are odd mechanical harmonic vibrations.

The "contour mode" is used mainly for frequencies below 300 kc; the "thickness mode" for 300 kc to 10 mc, and the "multiplex" for frequencies above 10 mc.

### *Quartz Fabrication*

The processes involved in the manu-

(*Continued on page* 40)

# THE INDUSTRY OFFERS

### BALL MEASURING ANVIL

The George Scherr Company, Inc., 128 Lafayette St., N. Y. C., has just developed a ball measuring anvil for use on the Scherr comparitol for the inspection and measuring of extremely thin pieces, such as crystals, laminations, shims, extremely small gages and other flat work.

With the ball anvil, the material is placed between a flat feeler point and the round ball surface. All danger of distorting or bending the shim or lamination out of size a few ten-thousandths due to measing pressure of the instrument are said to be eliminated.

The instrument may also be used to check the flatness or parallelism of long thin pieces in all positions and on all parts of the work.

* * *

### PETER JENSEN CREATES NEW NEEDLE

A new type of phonograph needle has been developed by Peter L. Jensen, Jensen Industries, Inc., 737 N. Michigan Ave., Chicago, Ill.

The compliance of the needle is said to give it a shock absorbing characteristic which permits it to glide along smoothly in the groove and also reduces materially the needle scratch.

By making the needle known as the Jensen Concert needle, rigid in a crosswise plane, all the frequencies in the record are said to be transmitted without loss to the mechanism in the pick-up, but the flattened cross section causes less air to be agitated direct, and the result is a noticeable reducion in "needle talk." With this new type needle it is said that it is no longer necessary to close the top on the phonograph in order to eliminate the objectionable scratch, hiss and talk which emanates directly from the needle.

The needle point itself is made from an alloy of precious metals.

Jensen Industries are at present also producing pivots and bearings tipped with the same wear-resisting alloy used in the needles. These special products are used in high quality measuring instruments used by our Army and Navy.

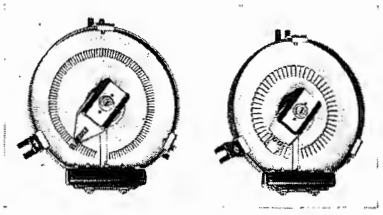
### PRESSED STEEL RHEOSTATS

Pressed steel rheostats with solid rectangular contacts are now being made by Ward Leonard Electric Co., Mt. Vernon, N. Y.

Rectangular contacts are available in small and large sizes. Small rectangular contacts can be furnished on thirteen inch or smaller rheostats. Large rectangular contacts can be furnished on eight inch or larger rheostats.

Rheostats with rectangular contacts can be furnished with complete enclosures, fitings for conduit connections, motor drives and with accessories for floor, back-of-board, and concentric mounting. Fixed and adjustable stops to protect control equipment can be provided.

These and other rheostats are listed in a new sixteen page Bulletin 60, available on request.



* * *

### IDEAL ELECTRIC ETCHER

A new model etcher to cover an extremely wide range of etching heats has been marketed by the Ideal Commutator Dresser Co., Sycamore, Ill.

This unit called the number 18 "machine shop" metal etcher has 14 heats from 115 to 1,300 watts.

* * *

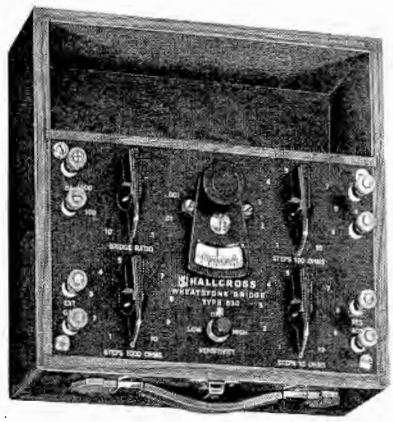
### INDOOR OIL CIRCUIT BREAKERS

New 15,000 volt oil circuit breakers for indoor service, classes 150-TCR-3 and 250 TCR-3, are described and illustrated in a new 12-page publication, Catalog 3350, just released by the Roller-Smith Company, Bethlehem, Pennsylvania. These breakers are of the oil tight single round tank type, single throw, and are available in 2 and 3 pole designs.

* * *

### SHALLCROSS BRIDGE BULLETIN

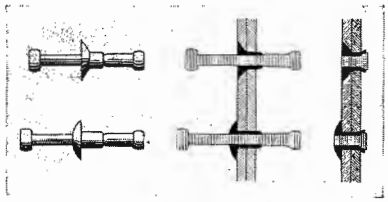
A new bulletin, D-1, with data on the 630 Wheatstone bridge, 621-A per cent limit bridge and the 638-I Kelvin Wheatstone bridge, has been released by the Shallcross Manufacturing Co., Collingdale, Penn.




### AIRCRAFT TYPE RIVETS

Rivets for use in pressurized cabin construction that will withstand considerable pressure have been developed by Cherry Blind Rivet Co., Los Angeles, Calif.

Although designed primarily as a production speed-up for the difficult riveting jobs, tests show that Cherry Rivets hold as high a pressure as a conventional rivet, due to the uniformity of head formation and shank expansion and the clinching action secured through the Cherry riveting process. Standard drilling and dimpling tools are used to apply them. The only special tool required is the gun which is used to pull the stem or mandril with sufficient force to head the rivet on the blind side and break the stem. As the mandril is pulled through the rivet a tulip head is formed on the blind side and the pieces being riveted are securely clinched together.



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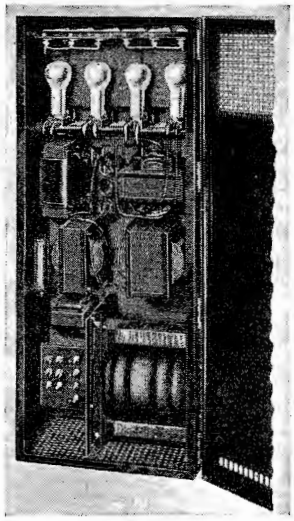
### A D-C POWER SUPPLY

To provide continuous direct current for the operation of d-c or battery-operated equipment, Standard Transformer Corp., 1500 N. Halsted Street, Chicago, Ill., have developed a new type power supply.

This unit employs gaseous type builb rectifiers, has a two-section filter and a special "built-in" automatic voltage regulating device. It delivers 110 volts d-c at currents up to 15 amperes. The input circuit is designed to permit use on a-c lines of various voltages. Its height is 48 inches, width is 19½ inches, and depth is 12½ inches.

Units of this type are available in a

(*Continued on page* 40)



## THE INDUSTRY OFFERS . . . —

(*Continued from page* 38)

variety of physical mounting styles and can be made for operation on various line potentials and frequencies.

* * *

### *NEW DISC CONTAINER*

A new type of recording disc shipping container has been produced by the Gould-Moody Co., 395 Broadway, N. Y. City.

It is known as PacKARTON and is made of a perfected, light-weight corrugated container that safeguards the shipment of delicate glass base records via air, railway or truck. Successful two-way shipping tests have proved the value of suspension-cushioning principles utilized in this construction.

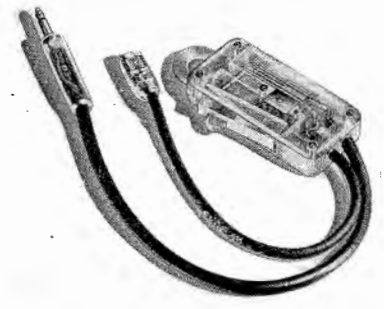
The new package is dustproof, needs no excelsior or paper wadding to prevent contents from sliding.


* * *

### *ARH PHONO-SWITCH*

The American Radio Hardware Company, 476 Broadway, N. Y. City, has developed a new double circuit microphone switch designed for use by an operator, particularly aircraft operators, wearing heavy mittens. It is so constructed as to permit easy on and off switching; remains in open position normally and can be looked into closed position.

Known as the SW-141 Switch, it is 4 15/32" overall in length by ¾" thick by 1¾" wide. High impact strength Tenite II is used in its construction. The switch is mounted on sturdy brass brackets, with blades made of a phosphor bronze material. It is heavily nickel plated, with bakelite insulation. Cordage clamps for taking up cable strain are provided as an integral part of the housing.



* * *

### *SOUND APPARATUS CELEBRATES 10TH YEAR*

The Sound Apparatus Company, New York, N. Y., celebrated its 10th anniversary on October 1st. Arthur W. Niemann is founder and sole owner of the company. He is known throughout the country for his developments on direct disc recording equipment and has a number of advancements in the technique of recording and reproducing to his credit.

Realizing the importance of automatic graphic recording of sound and electrical intensities, Niemann devoted his entire research along these lines. He contributed substantially to the development of automatic high speed power level recorders and to automatic frequency response recording equipment.

Another Niemann development of interest to electrical engineers, an automatic graphic high speed vacuum tube voltmeter, will shortly be announced.

• • •

## QUARTZ CRYSTALS

(*Continued from page* 37)

facture of crystal oscillators by various makers may differ in detail, but are much the same basically. The problem consists of selecting pieces of raw quartz and converting them into small and accurately dimensioned plates, which when mounted in their associated holders can be made to oscillate and meet certain requirements for frequency, activity, temperature coefficient, and longevity. The steps involved may be broadly stated as follows: (1) Inspection of raw quartz for flaws by arc light and polariscope, and after cutting by hydrofluoric acid etching. (2) Location of the optical and electrical axes by facial form, optical means or x-ray. (3) The cutting out of the small rough blanks from the mother quartz, generally with diamond charged saws, at approximately the angles necessary to produce crystals of low temperature-frequency coefficient. (4) The precise measurement of the angles of cut by x-ray or other method and the application of correction as needed. (5) The precision machine lapping of these blanks to nearly the finished thickness. (6) The individual "finishing" of each blank to exact frequency by hand lapping or equal. (7) The mounting of the finished plates in their holders. (8) Final testing.

Stated glibly in this manner, the procedure sounds simple. This is not exactly the case. However, once the correct methods have been selected and applied, and very rigidly supervised and maintained, it is entirely possible for the various stages to assume the status of a production line with a resultant high level of output.

It is nevertheless, at best, a somewhat temperamental production line in that quartz oscillators cannot always be made on a strictly dimensional basis. The dimensions necessary to produce a crystal of a given frequency and activity are not always exactly the same. They vary slightly with the angle of cut, the type of finish, and to some extent with the quartz itself. Hence the final operation of "finishing" is to some extent a cut-and-try procedure which recognizes these facts. The smallest error at one stage may cause considerable difficulty during later operations, and it is often extremely difficult to immediately locate and correct the cause of failures.

Constant supervision of the most minute nature is essential to provide a smooth flow of the product from one operation to another.

Because crystal manufacture is a highly specialized procedure, many special precautions and arrangements are necessary in order that satisfactory results may be consistently obtained. Cleanliness is essential, and emphatically so during the last stages of grinding and mounting. For this reason, it is important that the final operations at least be performed in a clean and dust-free room. A speck of dirt (or moisture) on the face of a crystal may change its characteristics entirely. Or a scratch from a granule of coarse abrasive on a fine grinding plate will cause complications. In general, it is an advantage to segregate the entire work from other types of manufacturing and to some extent to subdivide the work itself.

### *Conclusion*

The following facts pertaining to quartz crystals as used in radio may be of interest:

Many crystals are less than twelve thousands of an inch thick.

For the higher frequencies the faces are made flat to less than one wavelength of light.

The thickness of the finished plate should not vary more than a few millionths of an inch.

The frequency determining dimension must be correct to a millionth of an inch, or so.

The activity determining dimensions may need to be correct to one millionth of an inch.

The angles of cut must be accurate to a few minutes of the angle. These are not ordinary mechanical angles, but must be measured from atomic planes in the mother quartz which can be detected only by such means as x-ray.

A crystal may vibrate one hundred trillion times a day and yet it must continue to do so continually without change for an indefinite period.

It is indeed fortunate for the art of communication that Mother Nature has provided us with a device so simple and small which is capable of such extraordinary and dependable performance.

Even though only a few grams of quartz may be used for each transmitter, the conditions which would ensue without it could be chaotic indeed.


THIS is more than a war of mechanical monsters clashing in the night . . . more than a war of production.

It is a war for markets—*your* markets! The Axis wants your business—wants to destroy it once and for all.

With so much at stake, there is no doubt you will want to do everything you can to meet this Axis threat. Two ways are open: Speed production and put 10 percent of your income into WAR BONDS! The only answer to enemy tanks and planes is *more* American tanks and planes—and your regular, month-by-month purchases of War Bonds will help supply them. Buy now *and keep buying.*

THE GOAL: 10% OF EVERYONE'S INCOME IN WAR BONDS

When you install the Pay-Roll War Savings Plan (approved by organized labor), you not only perform a service for your country but for your *employees.* Simple to install, the Plan provides for regular purchases of War Bonds through voluntary pay-roll allotments.

Write for details *today!* Treasury Department, Section R, 709 12th St. NW., Washington, D. C.

EVERYBODY EVERY PAYDAY 10%

# War Savings Bonds

This space is a contribution to Winning the War by

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*Cut-away view shows several of the outstanding features of one of the most widely used Ohmite Resistors.*

1. Ohmite vitreous enamel holds the wire in place on ceramic core—insulates and protects the winding—dissipates heat rapidly—withstands humidity.
2. Evenness of winding prevents "hot spots" and failures—and makes for long, reliable service on the job.
3. Resistance wire both mechanically locked and brazed to copper terminal lugs, assuring perfect electrical connection between lugs and wire.
4. Mounting brackets hold resistor firmly yet resiliently in place. Easy to mount—easy to remove.

More than sixty different core sizes make possible an almost endless variety of regular or special resistors to meet every need. Ohmite Engineers are glad to help you on any resistor problems in connection with Governmental or Industrial requirements.

Write on company letterhead for complete, helpful 96-page Catalog and Engineering Manual No. 40.

OHMITE MANUFACTURING CO.
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BE RIGHT WITH ★ OHMITE
Rheostats · Resistors
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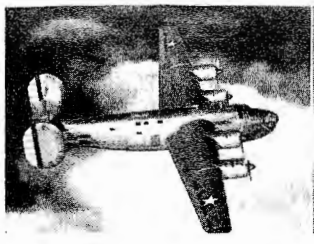

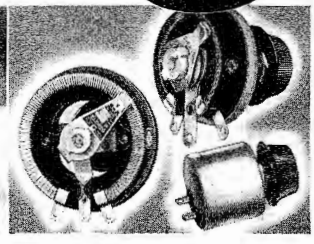

# MATERIEL CONSERVATION

(*Continued from page* 11)

having to melt up Junior's set of toy soldiers for some time to come.

***The Tin Situation***

*Tin* is a different matter, as every housewife knows from the current campaigns for washed and flattened food cans. We long have been extravagant in our use of tin, and the United States has used more tin than any other country in the history of the world. Tin goes back a long way, and the British Isle were known to the ancient Greeks as the Tin Islands as long as 2,500 years ago; the famous British mines of Cornwall have held out right up to the present time. By far the greater supply of our tin came, however, from Malaya and the Netherlands East Indies, with all the rest of the world producing only 10% of the supply. In addition to having been used for such purposes as weighting silk dresses, tin finds a major use as an alloy of lead in making solder, that prime essential to electricians everywhere. Surprisingly, re-processed tin from tin-plated food cans often is purer than the so-called "virgin" metal arriving from smelters, and we are using in our solder all the reclaimed tin we can obtain.

That we are attempting to cut down on the great amount of solder, with its valuable tin content, which is used in the far-flung operations of the Bell System is shown in new manufacturing and application techniques worked out recently. One of the chief ingredients of solder is tin and efforts have been directed towards the reduction of this critical material in solder for both connecting and wiping operations.

Another means whereby the amount of tin consumed is reduced is through the introduction of methods requiring less solder when sealing cable ends at the factory. On large cables this is accomplished by means of a lead antimony disc inserted in the ends of the cable, and sealed with a small amount of solder, in place of the high tin content slug formerly used. Small cables are sealed by the pinch seal method which eliminates solder entirely.

In the field large amounts of solder have been saved through the introduction of the "Victory Joint" over the method formerly employed, as illustrated in Figure 2.

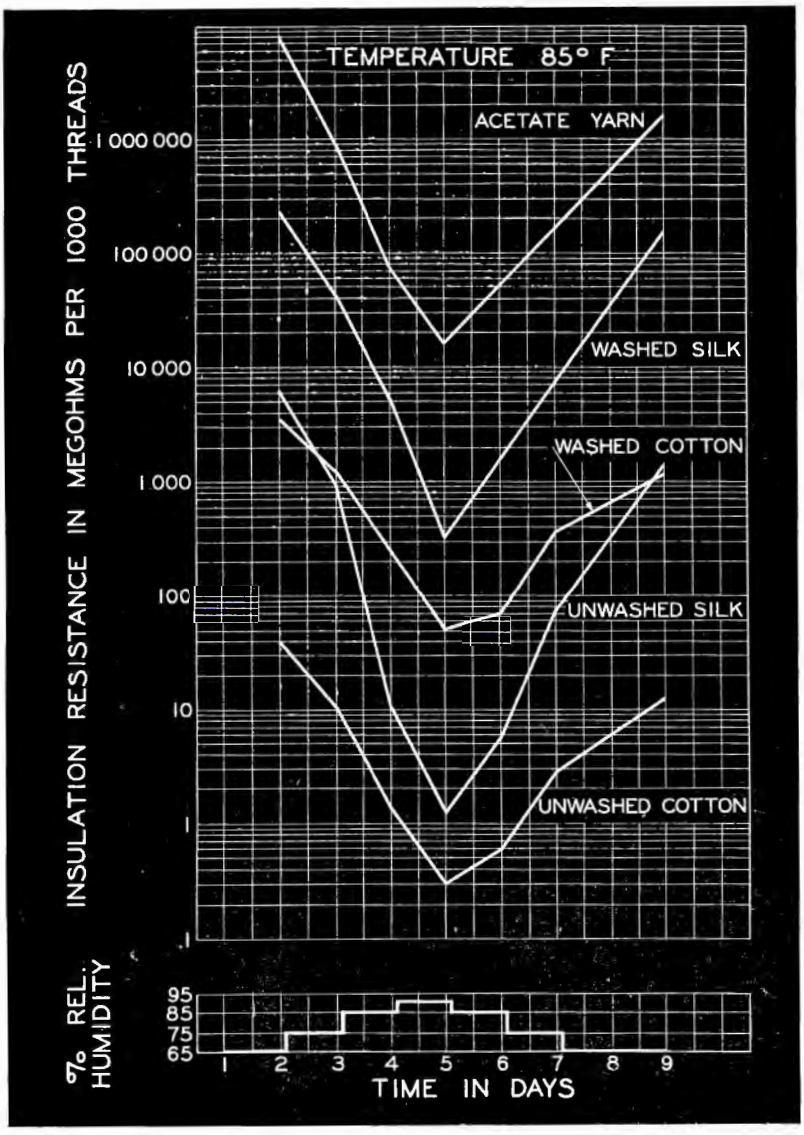


Figure 4

Chart showing relative merits of silk, acetate yarns and cottons.

***Silk Substitutes***

*Silk,* of course, is entirely unobtainable now, but our laboratories have been working for years on replacements for silk. This turned out to be quite a job, for not only is silk the strongest and most elastic natural fibre known to man, but its dielectric features were unequalled by most of the alternate materials originally suggested.

Rayon is superior to silk in dielectric properties although not its equal in abrasion resistance. Nylon, which has come into the picture more recently, is superior to silk in both physical and electrical properties. Consequently, the replacement of silk insulation has been on the following basis . . . (1) Rayon has been substituted where silk was formerly used under an outside protective coating of cotton. (2) Nylon has replaced silk where that material was formerly used alone. (3) Cotton has replaced silk in a few instances where silk braid was formerly used for good appearance.

On the other hand, it was found that the insulating properties of ordinary cotton are adversely affected by humidity, even when the cotton has been impregnated. Accordingly, a washing treatment was developed whereby we remove the soluble sodium and potassium salts normally present in the cotton. This operation is known as the Western Electric process of purification. It has been found that cotton purified by this process has insulating values

(*Continued on page* 45)

U. S. NAVY OFFICIAL PHOTO

# "ADOLPH, did you mean it?"


Less than four short years ago you inserted the following travel ad in one of our finest magazines:

Remember it? You actually invited us. Now, take a good look at that convoy on one of the sea lanes, crossing the Atlantic . . . to Germany. The air lanes are open, too.

And we, Adolph, are doing our utmost to produce a sufficient amount of materiel*, so that our "travellers" will not disappoint you.

*Typical users of UTC materiel are . . . RCA, GE, Western Electric, Westinghouse, Bendix, Farnsworth, IBM, Philco, etc. . . .

**UNITED TRANSFORMER CO.**

150 VARICK STREET ★ NEW YORK, N. Y.

EXPORT DIVISION: 100 VARICK STREET NEW YORK, N. Y. CABLES: "ARLAB"

COMMUNICATIONS
19 E. 47th St., N. Y. C.

Please enter annual subscriptions (12 issues) for each of the undersigned for which payment is enclosed at the rate of $1.00 each. (This rate applies only on 4 or more subscriptions when occupations are given.) Foreign Subscriptions are $2.00 each.

Name .....
Street .....
City-State .....
Occupation or title .....
Employed by .....
Nature of business .....
(State if Manufacturer, Broadcast Station, etc.)
Product .....

Name .....
Street .....
City-State .....
Occupation or title .....
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(State if Manufacturer, Broadcast Station, etc.)
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Product .....

Name .....
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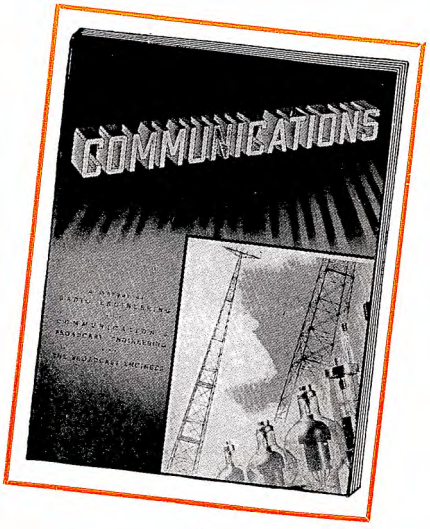
Occupation or title .....
Employed by .....
Nature of business .....
(State if Manufacturer, Broadcast Station, etc.)
Product

# Today, Mr. Engineer,

## *more than ever before*

# YOU MUST READ

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# MATERIEL CONSERVATION

(*Continued from page* 42)

of the order of 50 to 200 fold as compared with unpurified cotton under humid conditions. By a "boiling out cycle" certain natural oils and waxes present in the cotton, which would be damaging to the insulating properties are removed. For use, however, in insulation in non-telephonic applications such as sealed unit refrigerators, it is desirable to remove certain other oils and waxes, since a leaching action takes place with the leached impurities causing a stoppage of a capillary-type expansion valve common in these refrigerators. In such applications, the oils or waxes are emulsified or dissolved by a bleaching operation before purification, and are removed during the washing process. Either the regular purified or the bleached and purified materials can be applied to wire with the regular equipment used for this purpose.

#### *Critical Status of Zinc*

*Zinc* has become extremely critical today and has been on the 100% allocation list since June 1st. Found almost everywhere man mines lead (except in the great mines of Missouri), zinc has played an important part in industry for many years. Alloyed with copper it forms brass, a corrosion-resistant metal. So many uses has zinc that the WPB still has no adequate estimate for our overall requirements for the metal, other than that we are terribly short of having enough. Zinc coating, or galvanizing of iron prevents rust and long has been used for so protecting our outside hardware, such as cross-arm braces, messenger wire clamps, and through bolts. In some cases we have been able to eliminate the use of zinc by coating the hardware with lead or painting to inhibit oxidation, and the satisfactory results of our tests along this line have been borne out by trials conducted by the ASTM.

#### *Copper Problems*

*Copper* in the communications field is one of the most difficult to replace. To a large extent, there is no commercially-acceptable substitute for its current-carrying uses. Since it is the kernel of our wire and cable manufacturing operations, our position is particularly critical.

During its long history through the ages copper has maintained its early importance, and today it is second only to iron in industrial value. Its excellent conductive features made it of great importance to the earliest electricians, and we find that today a large percentage of all the copper used goes into the electrical industry. Although not as ductile as either silver or gold, a copper billet 4 x 4 x 54 inches will draw into a 2,500 mile strand of 42 gauge wire.

This country's situation on copper is rather paradoxical; we have the greatest reserves of copper ore in the world, we produce half the world's total output, and we have ten times the amount Germany has; yet our copper shortage is such that about 20% of the copper needed for our war industries during the third quarter of this year couldn't be supplied. Just stop to think . . . in four minutes a machine gun in action uses 30 pounds of copper . . . enough to draw into a mile and a half of telephone wire.

We have made many changes in our copper consumption program, such as using copper covered steel instead of bronze for line wire and for drop wire, thus releasing not only the copper but also the 3% of tin which composed the bronze. We also use steel, of course, for our open wire exchange lines. And we plan to attach our drop wire to customers' premises with steel instead of copper clamps. As for the non-electrical uses of copper, they are already practically non-existent in the Bell System. Copper for conductors is still the nation's biggest use, and one of our biggest headaches.

#### *Priorities Difficulties*

We have discussed alternates or substitutes for old standby materials. But, with priorities lists changing so rapidly, we sometimes must find substitutes for substitutes as these, in turn, become scarce. Such an occurrence may be seen in the case of the aluminum tape used to make switchboard cable moisture-proof. No sooner had we selected a pliolite tape to do the job than pliolite went on the critical list because of its rubber content. Undaunted, our engineers went to work again and came up this time with a grease-proof tape of kraft paper surfaced with an amorphous wax. Another example is seen in the composition of our bus bars, described earlier in this paper as having gone from aluminum to copper. With copper so scarce, we have been looking for a substitute for that material, and it is entirely within the realm of possibility that our bus bars may see another change.

Scrap and rejected parts from Western Electric's manufacturing operations, as well as junked telephone equipment, long have been returned to our smelting furnaces to be melted down and recast. Most of the wornout and obsolete metal items collected throughout the entire Bell System is sent to our great salvage and reclamation plant at Nassau, to join other scrap purchased from outside sources. Here it is reduced to billets and pigs under strict laboratory control, after which over 95% of our total Nassau output is allocated directly to the Army and Navy or eventually finds its way into non-telephonic war industries. The rest is sent back into the manufacturing plants of Western Electric, where new parts are machined from the reclaimed and reprocessed metals.

#### *Time a Prime Element*

Of prime importance in the conservation program is one valuable commodity rarely associted with metals, that commodity of which we are perhaps shortest . . . *time*. We are particularly interested in saving time in our manufacturing operations, for we must get the communications apparatus to the armed forces before they can take the field.

We have gone heavily for the saving of time by farming out our contracts. Thus, our latest figures show that 48% of all our war contracts have been subcontracted.

In our own plants we have vastly expanded the number of employees. Since we hired our first woman worker nearly 70 years ago as a magnet winder, the employment of women has been no novelty to us. But, since Pearl Harbor, our employment of women has risen astronomically, and we are using them in unusual jobs ranging from methods investigators to welders and test engineers.

The question is properly raised as to what general characteristics are sought and what are found in our alternate materials program. Generally, we may say that we tolerate no more impairment of service quality today, when a pilot's life may depend on an ungarbled radio-telephonic message, than we did before the world turned upside down. We do, however, usually find a shorter life, with consequent earlier replacement, in our substitute materials. And sometimes . . . not always . . . we find a slight increase in initial cost. It should be borne in mind, however, that in order to introduce many of these changes extensive development work and tool expenditures have been necessary.

#### *Post-war Outlook*

As for the outlook for the future in a post-war world, who can doubt that the impetus given creative research by the necessities of this war can result in anything but the greatest technological advance, accompanied by the highest standard of living the world has ever known. Already, we have investigated

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## CIRCUIT RESPONSE ANALYSIS

(*Continued from page* 18)

almost useless in finding the waveform of the current, while the sum function enables the waveform to be calculated very readily and also makes clearer the effect of varying the circuit parameters.

3)—This sum function has been calculated heretofore by two general methods both of which become rather tedious in most cases. Another method of calculating the sum function is introduced in this paper and has the advantages of being less tedious and more straightforward. This last method will also give the Fourier series expansion if it is wanted, and may be extended in addition to problems other than circuit problems.

4)—This new method is not directly applicable, however, to non-dissipative networks, but methods of solving these networks are given. Examples of the solution of both dissipative and non-dissipative networks are given in Appendix II of the paper.

5)—An expression for the transient current of a network is also given.

(*To be continued in November* COMMUNICATIONS.)

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[11]See reference 10, pages 63-67.

## MATERIEL CONSERVATION

(*Continued from page* 45)

some 5,000 items considered for possible alternative use, with from one to several hundred individual parts represented in each item. Already, we have active substitution programs under way on 80 critically scarce materials.

No, just as airplane radio communication saw its birth in Western Electric's laboratories and manufacturing plants during the last war, we sh-'l one day look back on this period of mighty effort and count the benefits, many of them unknown and unrecognized until long after the initial discovery, which emanated from the telephone industry.

# AIRCRAFT COMMUNICATIONS

(*Continued from page* 13)

amplifier regardless of the position of the airport audio selector switch.

Operation control, for the use of the interfone is accomplished by the manipulation of one switch. The return of this switch to the "radio" position will provide for the previously radio operating setup. Each of the two pilots are provided with an interfone switch which provides for independent operation of the interfone.

### *Tunable Beacon Receiver*

The beacon receiver used is a tunable type and covers the 200 to 400 kc band. Remote tuning of this type receiver is accomplished by use of a mechanical cable associated with a drive unit and a tuning unit. The latter two devices essentially consist of a gear train to provide a high speed rotation of the mechanical cable to insure smooth operation. The tuning control unit dial is calibrated in kilocycles at 3 kilocycles intervals. A dial lamp is provided and the intensity of the light is controlled by a mechanical shutter.

In this unit a superheterodyne type circuit is employed. It consists of an r-f amplifier, converter, heterodyne oscillator, i-f amplifier, infinite impedance detector, first audio and dual audio output tubes. This circuit is quite conventional except for the detector circuit.

### *Infinite Impedance Detector*

The input impedance of this detector represents practically a pure capacitative reactance which becomes a part of the tuned circuit without loading of the i-f output circuit, with resultant improvement in gain and selectivity. This arrangement functions as a linear detector and in that respect is similar to the conventional diode detector. The modulation capability is better than that of the diode type of detector. For the reception of simultaneous range and phone transmission, which consist of single sideband modulation (30%) and voice modulation (70%), the beacon receiver detector must possess linear characteristics to avoid distortion. A detector that is other than reasonably linear on single sideband modulation and speech modulation 30% and 70% exceeded respectively, will result in distortion.

### *Peculiarities of Detector*

The infinite impedance detector circuit has the disadvantage of not being capable of providing avc voltage which is possible with the diode detector. However, the anti-block avc that is required in the beacon receiver is obtained by employing a diode section of the first a-f tube to develop this voltage.

### *Direction Finder Attachment*

This attachment used in conjunction with the standard beacon receiver employs a high impedance antenna of the shielded type. One side of the loop winding which has 32 turns, is encased within an aluminum shield and connected to a pin plug in the loop yoke. The other side of the loop winding is grounded.

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# AIRCRAFT COMMUNICATIONS

(*Continued from page* 47)

The loop mounting which supports the loop is secured to the structure of the plane. This mount is equipped with a receptacle to engage the pin plug of the loop antenna also a key-way and coupling nut for the purpose of securing the loop in position. The loop mount, which is an aluminum casting, houses the gear train used to rotate the loop antenna.

The gear train of the loop mount is mechanically connected to the loop rotator by means of a flexible shaft. A gear reduction of 264 to 1 is provided between the flexible shaft and the loop. This high ratio permits an accurate adjustment of the loop position and insures smooth operation. The loop rotator is located on the engine control pedestal in a position in line with the vision to the flight instrument panel. The rotator is equipped with a pointer and an azimuth dial. This circular dial is calibrated for two 180 degrees sections which are corrected for the loop quadrant error. The direction finder as the name implies operates on the aural-null principle. The crank-handle of the azimuth control (loop rotator) is used to rotate the loop. The azimuth pointer is so geared that it rotates at the same speed as the loop.

The voltage developed across the loop winding is fed to a loop coupling unit through a low loss high impedance line. The purpose of the loop coupler is to provide a high impedance termination that is reasonably near the loop antenna.

Essentially the unit consists of an amplifier tube with associated tuning condenser and load coils to tune the loop antenna to resonance. A trimming condenser is used to track the loop tuning condenser with the beacon receiver tuning condenser which are mechanically operated in tandem. The remote tuning unit of the standard beacon receiver is mechanically connected to the receiver and loop coupler by the use of a flexible shaft through the associated gear trains in the drive units. A low impedance loop could be used in conjunction with a low impedance line with connection direct to the receiver input with proper matching network. While this scheme is simple from a mechanical standpoint, the high impedance type results in obtaining a much higher gain.

A loop-beacon antenna switch box is used to provide a method to switch the loop antenna or the beacon antenna under thoroughly shielded conditions. In order to completely isolate these antennae the shielding of the switch must be such that with the switch in the loop position a signal input of one volt into the antenna at the frequency to which the receiver is tuned will be more than 60 db down.

In addition to the two 180 degree calibrated azimuth dial sections of the control, the "homing" position is marked. With the loop in this position, a null is given when the plane heading is directly toward or away from the station. This feature is used for certain orientation problems, but is not generally used to fly to a station, as it is a negative (no signal) indication when used with the aural null direction finder. To position the loop according to the "rain static" indication as shown on the dial, it is set for maximum signal when the aircraft heading is in line with the station. The loop is used in this position to fly the radio beacon during rain static conditions. The shielded loop, of course, greatly reduces the effects of rain static.

Aerodynamically the loop presents minimum drag when in the rain static position. The drag is increased 5 to 6 times (at 200 miles per hour) when the loop is in the homing position. This condition refers to a loop that is not encased in a streamlined housing.

The radio compass provides three services, viz., conventional beacon reception, aural null (D.F.) and automatic compass. The principle of operation of the automatic compass is described in another section. The operation as a beacon receiver and D.F. is conventional.

The operation controls of the compass are . . . control unit that provides a means for remote tuning of the receiver to the desired frequency and to select the frequency band. The compass volume is a tandem operated sensitivity and audio volume control. The loop rotator is an electrical control for manual operation of the loop rotation. Manual operation of this control effects the loop motor control circuit in the same manner as the thyratron circuit in the automatic compass function.

## WE SEE

(*Continued from page* 2)

population." And from the reports of many in *communications* . . . plants, stations, studios and the like . . . a large percentage of this new "manpower" is already a dominant factor. In 1943, it seems as if most of the signs will read . . . "women at work." —L. W.

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Sagamore Hotel, Rochester, N. Y., November 9th, 1942

9:30 *A. M.*-12:30 *P. M.*

Symposium of Radio Production under War Conditions:

Opening Address by W. R. G. Baker, Director RMA Engineering Dept.

Addresses by:

Lieut. Commander A. B. Chamberlain, Radio Branch, Bureau of Ships, Navy Dept.

Captain Billings MacArthur, U. S. A. Army-Navy Communications Production Expediting Agency.

F. S. Barton, British Air Commission, on "German Aircraft Radio Equipment."

2:00-4:00 *P. M.*

Technical Session on Radio Equipment Production:

Flexibility in Communication Equipment Production, J. J. Farrell, General Electric Co., Schenectady, N. Y.

Radio Production Test Methods, Harry Rice, Sperry Gyroscope Co., Garden City, N. Y.

Photographic Templates, E. C. Jewett and C. D. Tate, Eastman Kodak Co., Rochester, N. Y.

7:00-10:00 *P. M.*

Rochester Fall Meeting Dinner. Speaker to be announced.

## GROUNDED-PLATE F-M AMPLIFIER NOTES

IN the grounded-plate amplifier* recently developed for use in f-m transmitters by A. A. Skene of the Bell Telephone Laboratories, one of the unique features is the combining of the functions of the plate by-pass condenser and the air-duct. This duct, according to Mr. Skene is made of dielectric material and plated with silver inside and out to form the two plates of a cylindrical condenser. The outer surface is grounded and the inner surface is connected to the cooling fins of the plate. Such an assembly, says Mr. Skene, is easy to construct. And this form of con-

(*Continued on page* 50)

*December, 1941, COMMUNICATIONS, pp. 14, 15, 24.

## GROUNDED-PLATE F-M AMPLIFIER NOTES

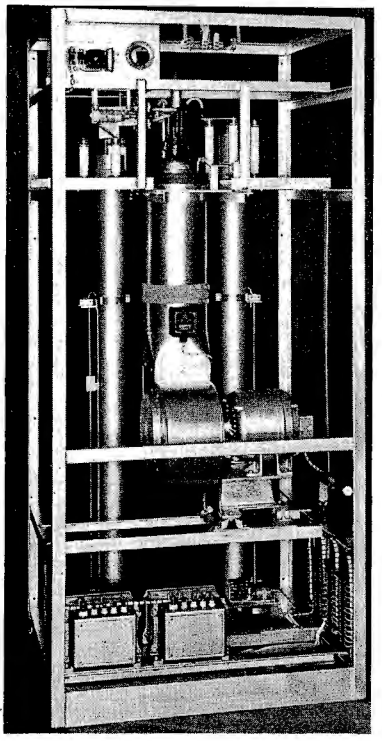
(*Continued from page 49*)

denser gives a uniform current distribution over the conducting surfaces.

These three tubular structures are evident from the view shown herewith. The central tube is the air-duct and the plate blocking condenser, while the tubes on each side of it are the two coaxial structures. The common ground plate lies transversely across the amplifier, says Mr. Skene, and besides serving as a common ground is also used as a supporting member. The output of the transmitter passes from the filament to the transmission lines through an adjustable inductance used to adjust the impedance of the output circuit. Since both ends of this coil are at radio-frequency potential, a short-circuited coaxial structure is not the convenient device to employ. Thus, for this inductance a coil with an adjustable copper slug to vary the reactance is used.

The grounded plate amplifier is used in the 10 kw f-m transmitter of W71NY in New York City.

In this new circuit it will be recalled, the plate tuning coil is replaced by a coil between filament to ground. If a pair of copper tubes in parallel are used to form this coil, the filament leads may then be threaded through the bore of one of the tubes. Thus the grid driving potential can be supplied through an inner conductor of the other, according to Mr. Skene. The copper tubes are connected to the filament through condensers at the filament end of the coil, while the other end of the coil is grounded. In this way it is possible to deliver the filament current and grid driving voltage at the required circuit points, while the sources, viz., driver and filament transformers, are maintained at ground potential. Since it is essential to be able to dajust the reactance of this inductance, mechanical difficulties would be invited if the usual coil adjustments were used. By using a coaxial transmission line less than a quarter wave in length, which is short circuited by an adjustable bridging connector at the far end, this difficulty may be avoided. This section of line has a positive or inductive reactance, which is variable with an adjustable bridging connection. The structure used to replace the tubing coil consists essentially of two concentric systems. Here the innermost conductor carries the r-f driving potential, while its upper end is connected to the grid through a blocking condenser.



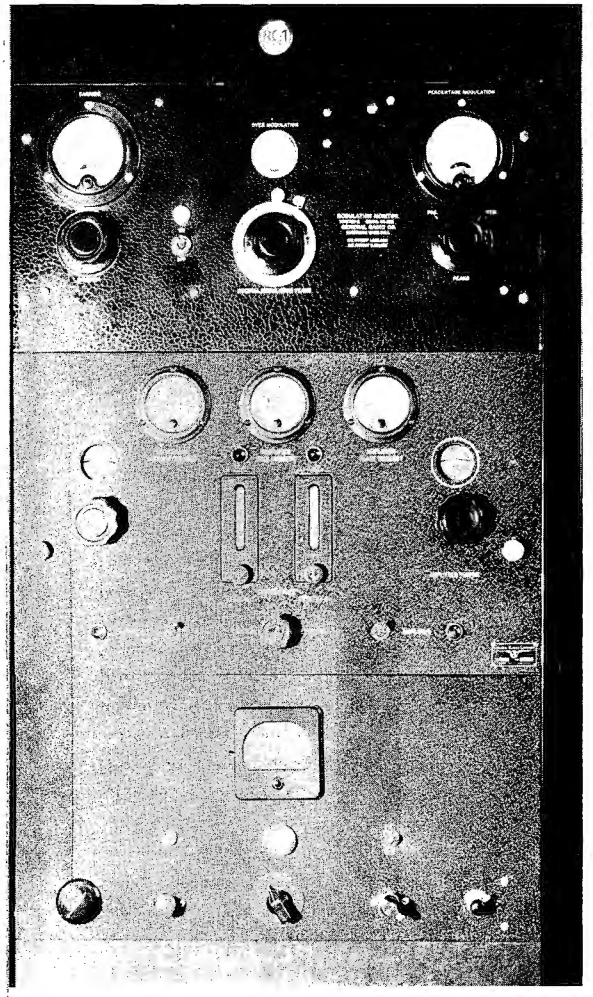
The three tubular structures in the F-M amplifier system.

A short circuited coaxial structure is also used for the neutralizing inductance. This is connected between the grid and plate in series with a blocking condenser, according to Mr. Skene. This coil carries a large current and must be continuously variable and adequately shielded. To meet these conditions with a grounded-plate is fairly simple, since only an inductance-to-ground is required with a blocking condenser to isolate the d-c grid bias potential.

Since the filament of the tube is at a high r-f potential, it is possible to supply filament current without requiring operation of the filament transformer at a high potential above ground. In addition it is necessary to supply r-f driving potential between the grid and filament from the driver unit, one side of which is grounded.—Donald Phillips.

# THE O'BRIEN PROGRAM FAILURE ALARM

A TYPICAL installation of the O'Brien carrier and program line alarm that was described in the August, 1942 issue of COMMUNICATIONS by Elwin J. O'Brien, Ass't Professor of Electrical Engineering, University of North Dakota, is illustrated below. This is the unit that is in operation at radio station KILO-KFJM, and has saved many man-hours, relieving as it does the necessity of aurally monitoring the program. The unit also indicates to the announcer any transmission failure.—Elliott Marshall.



In this unit, the modulated carrier is rectified in the first tube, and after passing through a limiting stage is again rectified to provide the control voltage for the relay tube. The limiter makes the d-c component of voltage across the RC circuit independent of percentage modulation. The grid circuit of the relay is connected across the time delay RC network. The cathode current with zero grid voltage is approximately 1.4 milliamperes. The voltage across the delay network, on modulation is applied to the grid and causes about 5.5 milliamperes to flow.

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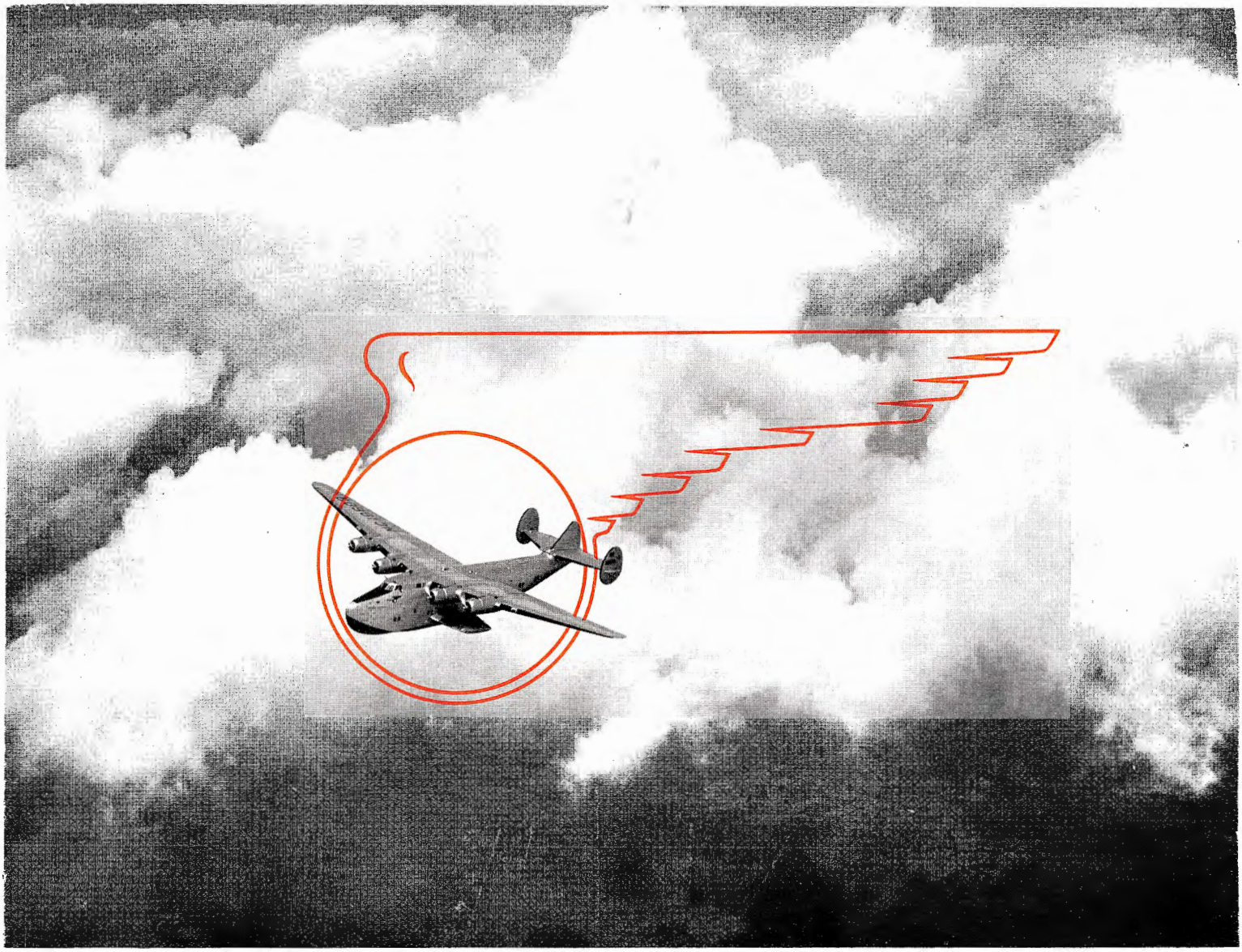

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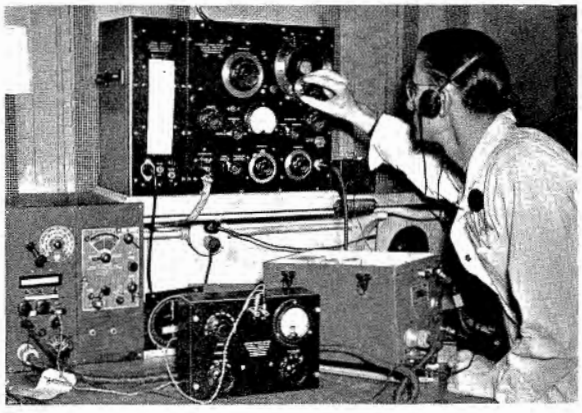

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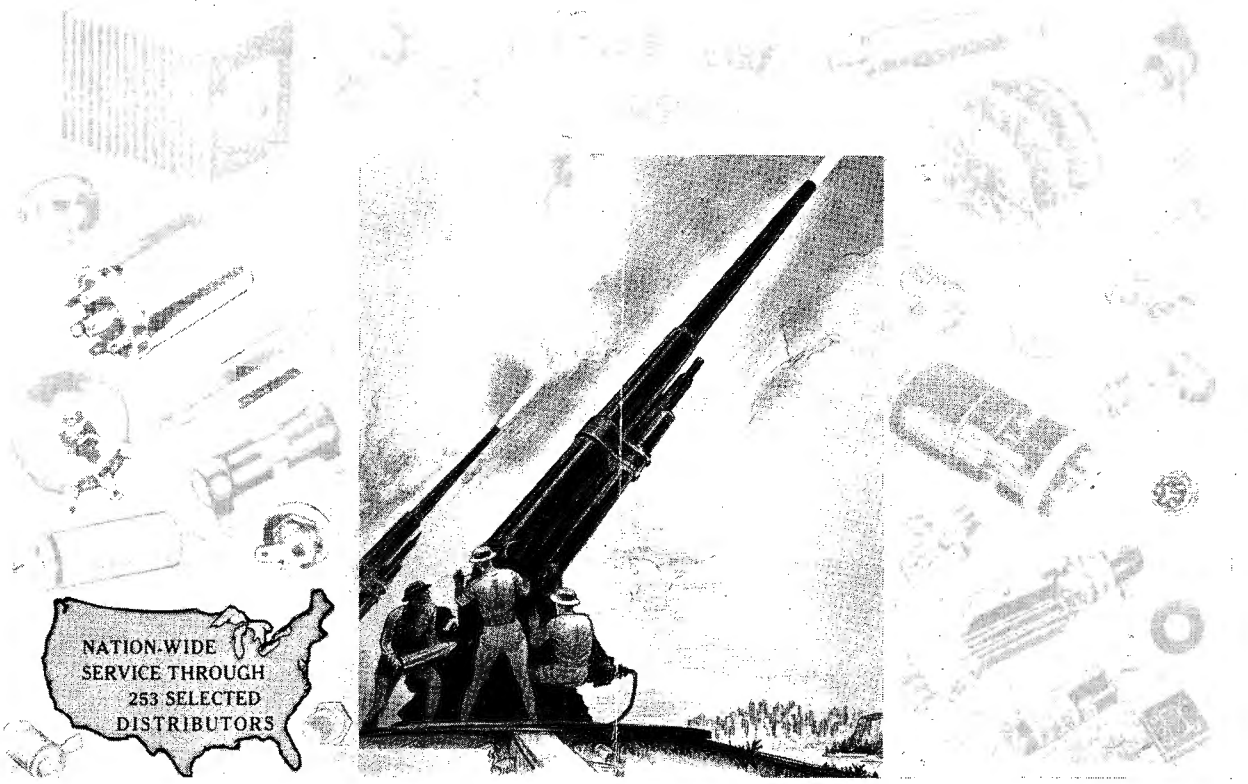


In the laboratories of a leading institution, electronic wizards have worked out a Yankee invention that's going to help Uncle Sam's anti-aircraft gunners bring 'em down far more often.

It's an electrical control apparatus that works in conjunction with a modern listening device. When a plane is heard . . . within a radius of 30 miles . . . this new electronic instrument predicts the plane's course mathematically, then helps aim and fire anti-aircraft guns automatically. Its accuracy is uncanny.

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