COMMUNICATIONS

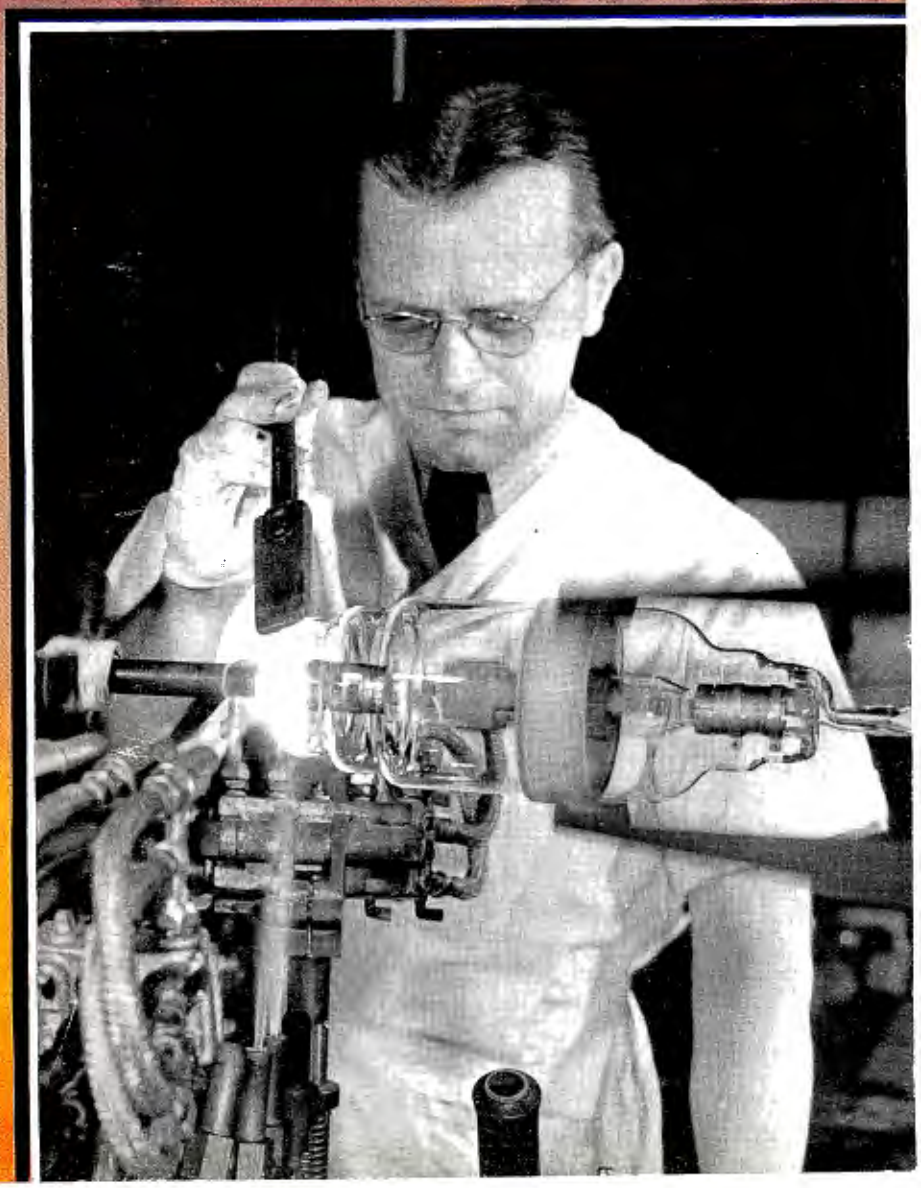
DIRECT FREQUENCY MEASUREMENTS

DIVIDING NETWORKS

NEW VERSATILE H-F TRANSMITTER

JUNE

1942



UNIPHASE

Stops Background Noise!

The Enemy of Sound Pickup

Photograph of F. M. Transmitter of Michigan State Police by courtesy of Motorola — Galvin Mfg. Corp.

FOR clear crisp signals, it's . . . F. M. to cancel static—and the Shure Super-Cardioid to eliminate background noise. That's the new way!

It's the Uniphase principle that does it in the Shure Super-Cardioid.

In the Uniphase, sound acts upon the outside of the diaphragm of the microphone and also enters the phase-shifting acoustic network within the microphone, where it acts upon the inside of the diaphragm. (See drawings.) When sound arrives from the front of the microphone, the inner pressure reinforces the outer pressure (Figure 1). When sound arrives from the rear, the inner pressure cancels the outer pressure (Figure 2). This principle results in a *Super-Cardioid Microphone* with a single moving coil. The *Super-Cardioid* pattern is symmetrical in both the horizontal and vertical planes. It has a wide-angle front pickup with 73% reduction of reverberation and random noise. The *Super-Cardioid Microphone* is unusually rugged.

These Uniphase Microphones are speeding production—giving better protection to Ordnance Plants, Airdromes, Docks, Army Camps, War Plants, Defense Control Centers, Police Transmitters and other vital centers.

Uniformity of performance is assured in Shure Cardioid Microphones because tolerances are held as close as .00025" in production. Because of unique processes, seven working days are necessary to complete a single microphone cartridge.

Such creative engineering and careful production are the American way. By pooling its engineering and production efforts America will insure Victory in the common struggle for Freedom and Independence.

FIGURE 1
Sounds entering from front.

FIGURE 2
Sounds entering from rear.

Send for Booklet No. 172C

It describes Super-Cardioid performance and the latest Shure Broadcast Microphone, the Super-Cardioid.

SHURE BROTHERS

Designers and Manufacturers of Microphones and Acoustic Devices

225 West Huron Street, Chicago, Illinois

SHURE

You can BEND and RIVET these Flexible Plastic Name Plates!

IN "PERMAPRINT" name and direction plates Formica has something to offer the manufacturer who has been requested by the War Production Board to discontinue use of metals for this purpose.

"Permaprint" name plates may be of a flexible type that can be bent to the contour of a curved surface, and can be riveted in place without danger of the material shattering. It is also available in flat, rigid types for flat surfaces.

All lettering is protected by a transparent plastic surface against wear or injury by grease or solvents.

The plates may have a white background and black lettering, or a black background and white lettering. Where it is essential that serial numbers form a part of the plate a strip of aluminum may be inlaid, and into this the serial numbers can be stamped easily by the usual methods.

Formica equipment for this product is large and it is available in full to those manufacturers of airplanes and other war equipment who must use non-metallic name plates.

FORMICA

The Formica Insulation Company • 4635 Spring Grove Avenue • Cincinnati, Ohio

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COMMUNICATIONS

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JUNE, 1942

VOLUME 22 NUMBER 6

We See...

IT'S HEADLINE TIME AGAIN for the 'communications-manpower-deferment' plan. Although interest in the cause actually never waned, the efforts to place a consistent deferment plan into effective operation, appear now to be reaching their greatest strength. For the WMP . . . the War Manpower Commission . . . under the leadership of Paul V. McNutt, is now surveying the manpower state of the industry, to learn the exact "status-quo" of stations and other allied units. One indication that any plan adopted will be extremely restricted comes from the recent license relaxation rulings of the FCC . . . rulings that lower the requirements for station operators considerably and admit women to operate, too. In addition, the increased schooling activities of both Federal and private institutions (endorsed by Federal authorities) also indicate that many new operating crews will be entering stations to replace drafted personnel. Just who constitutes the "extremely-essential" to station operations will thus have to be accurately determined in specific classifications, such classifications to be judged by the FCC, the Selective Service, as well as the WMP. These classifications would then be directed to the local boards for accurate guidance in their deferment operations.

AN UNUSUAL CAMPAIGN designed to induce members of Congress to lend their power towards the active production of replacement radio parts, will soon be introduced by a large mid-western parts manufacturer. Thousands of shop windows will display attractive posters reading . . . Radio Keeps the Public Informed . . . Keep 'em Playing . . . If You Agree, Will You Please Come in and Sign a Petition? And

(*Continued on page* 33)

COVER ILLUSTRATION

Jens Aakjer, Westinghouse craftsman in glass, sealing the filament mount (cathode) in a 400 watt tube. In this operation, the tube is placed in the jaws of a glass lathe, while the operator using a small metal paddle, shapes the hot glass as desired.

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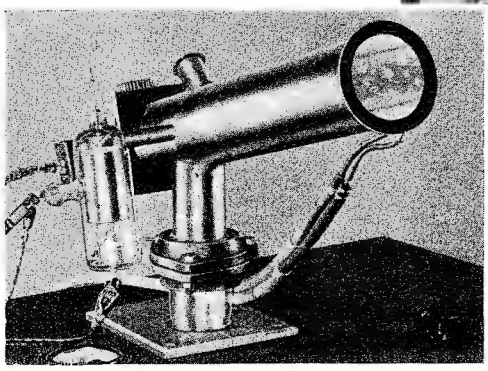
Filament Emission Makes the Modern World Go Around



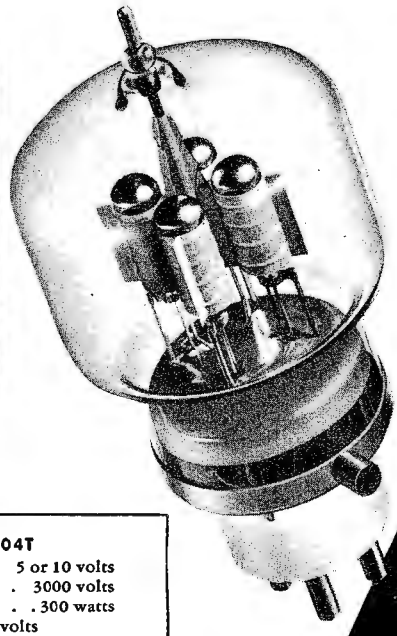
Close observation of the flow of electrons from a heated filament is made possible with this Electron Microscope. This instrument, designed and constructed in the Eimac laboratories, virtually gives a motion picture projection of the electron movement.

THE life of radio communications hangs by a tiny thread of filament wire. If the steady flow of electrons from the vacuum tube filaments ceases, the transmitter is off the air no matter how excellent the other components may be performing. To assure peak emission under the most severe operation conditions, many exacting tests are conducted during the process of manufacture.

Above is an Eimac technician checking an Eimac tube on the Peak Emission Tester. This device, designed and constructed in the Eimac laboratories, measures the flow of electrons emitted from the completed tube. Of a long series of filament tests conducted at various stages of manufacture, this test is the final. Other important controls are illustrated at left.

From beginning to end, Eimac tubes are designed and constructed to give vastly superior performance. The proof that they do is made clear by the fact that Eimac tubes enjoy first choice in the minds of leading radio engineers throughout the world.

Before filaments are sealed into the triode they are placed in a temporary vacuum where they undergo their first emission test. Thus faulty filaments may be weeded out without further processing.



EIMAC 304T

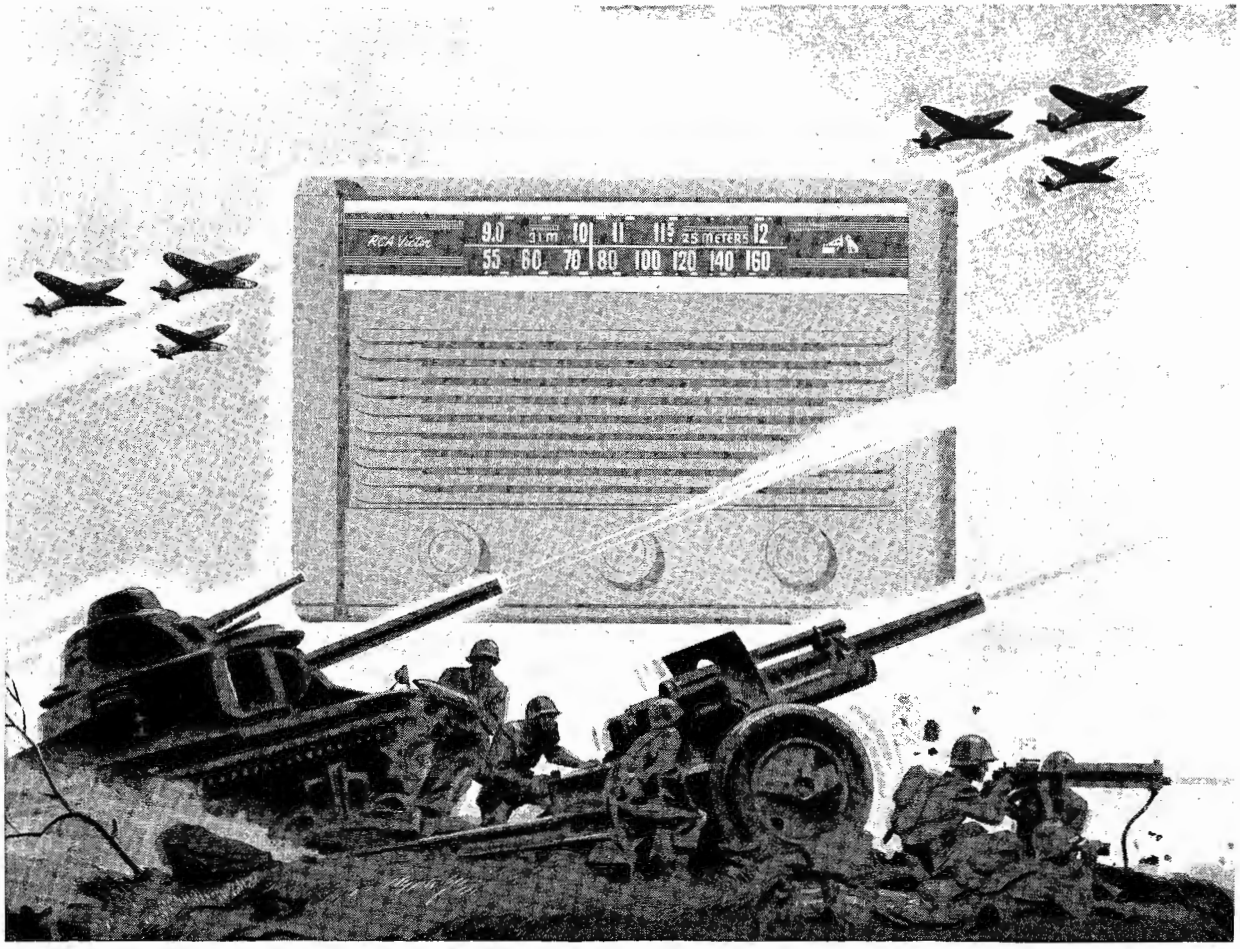
Filament Voltage	5 or 10 volts
Plate Voltage (D.C.)	3000 volts
Plate Dissipation	300 watts
Power Output 3000 volts at 75% eff.	900 watts

Follow the leaders to . . .

Eimac TUBES

Eitel-McCullough, Inc. San Bruno, California

FOREIGN DIVISION: **FRAZAR & CO., LTD.** 301 CLAY ST., SAN FRANCISCO, CALIFORNIA, U. S. A.



AGAINST THE BACKGROUND OF EXPERIENCE

Against the background of millions of radios built for American homes, RCA now is building radio apparatus to strengthen the world-wide life-lines of American communications ashore, afloat and aloft. Radio has gone to war!

Almost the entire development of radio as we know it took place during the two decades between the last war and this one. During that time, RCA Laboratories worked unceasingly to perfect existing devices and to invent new ones. Out of this research came the finest civilian radio equipment the world has ever seen... and the finest *military* radio equipment! For the RCA Manufacturing Company is today on a war footing.

Some day, when peace returns, against this dual background of manufacturing experience in peace and war, RCA will turn from military to civilian radio—and gear its production to build new radio and television sets for the home—post-war radios designed to incorporate the latest scientific lessons and discoveries made in RCA Laboratories.

BUY U.S. WAR BONDS

Radio Corporation of America

PIONEER IN RADIO, ELECTRONICS, TELEVISION

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The Services of RCA: RCA Manufacturing Co., Inc. • R.C.A. Communications, Inc. • Radiomarine Corporation of America
RCA Laboratories • National Broadcasting Co., Inc. • Blue Network Co., Inc. • RCA Institutes, Inc.

DIRECT FREQUENCY MEASURMENTS

Featuring an Auxiliary Oscillator of Unique Design for Interpolation

by DON LANGHAM

WFBL Engineering

RELAY broadcast and communications transmitters of all types of service require some accurate method of measuring the carrier frequency to a tolerance designated by the FCC. If this can be accomplished by simple procedure, the accuracy is apt to be greater since there is a decrease in the "human element."

With this in mind, the equipment described here was designed to replace an unsatisfactory heterodyne frequency meter and calibrator unit in which inaccuracy was encountered from a complex dial reading system, switch contacts of varying resistance, incorrect dial spacing of harmonics on the various bands, etc.

Three pieces of equipment are involved: the receiver, interpolation oscillator and crystal harmonic generator. Almost any receiver capable of picking up the signal to be measured is acceptable. This will usually be one of the many good communication types on the market.

The interpolation oscillator itself may be calibrated against a frequency standard and used for direct measurement in many cases. However, it should be checked and corrected against a standard before measurements. This standard can be the 5 mc signal of WWV or almost any broadcasting station. However, it is desirable to include a multi-vibrator in the permanent setup since it gives a continuous check every 10 kc from 1000 kc up and is also necessary for accurate calibration of the entire dial range of the oscillator.

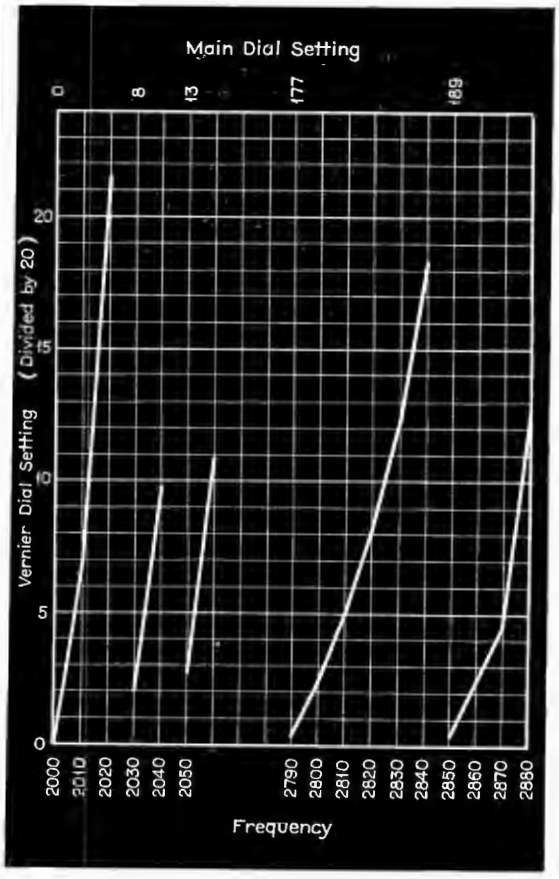
Simple, inexpensive crystal calibrator-multivibrators are available with a guaranteed accuracy of .01% and are extremely effective. The crystal frequency is sufficiently adjustable to allow beating WWV to within a cycle or two when the accuracy actually becomes a function of line voltage variation.

There only remains, then, the addition of an interpolation oscillator to measure any frequency which may not fall exactly on a multiple of 10. To obtain the greatest accuracy possible, this oscillator must be capable of reading to well within 50 cycles at the frequencies most widely used. At WFBL these are between 1600 and 3000 kc—the frequencies covering relay-broadcast work. The desired accuracy is mainly accomplished in the design of the oscillator, remembering that the accuracy decreases with an increase in frequency.

Construction of this unit now depends on certain specifications imposed at the outset. The dial system must allow reading to the desired accuracy. Vibration and high resistance must not occur through faulty construction and frequency shift due to line voltage variations must be negligible. It is also desirable to minimize drift due to tube element heating by keeping plate voltage low.

The electron-coupled oscillator is especially adaptable to this purpose because of its inherent stability. A simple grid tuned circuit utilizing a metal 6J7 is sufficient. A plate voltage of approximately 180 gives more than enough output and in addition allows the use of a power transformer with a low step-up ratio. Thus the step-up in line voltage

The short wave rack in the control room, with a 50 watt transmitter, communications type receiver, switch, VI and patch panel, interpolation oscillator and frequency standard.



A typical group of frequency curves on various bands, with settings of the vernier dial on the interpolation oscillator.

variation is small. No other means of voltage regulation is employed and actual operation showed that none was necessary. Average line voltage variation caused only a few cycle momentary shift in frequency.

Low L/C Ratio

In order to read the frequency in cycles the importance of the tuning system is obvious. For frequency stability the L/C ratio must be low. This means the tuning capacity will be sufficiently high that a small change will cause a prohibitive change in frequency unless a vernier capacity is employed in parallel with it. A tuning capacity of 350 mmfd is used with a parallel vernier of 20 mmfd. A third parallel capacity of 5 mmfd is also across these. This is simply a zero corrector to adjust the oscillator so that both dials read zero at 1000 or 2000 kc before making a reading. The inductances are so designed that with tuning capacities set at maximum and corrector at midway, one resonates at exactly 1000 kc and the other at 2000 kc.

Micrometer Dial

High-grade micrometer type dial assemblies are used in which a smooth action worm drive without backlash is a composite part.* The ratio is 20 to 1 and the dial scale is direct reading from zero to 500, in which each division is spaced ¼" apart, so that readings to tenths of a division are practical. The dial revolves 10 times to cover the full range.

Panel-Chassis Layout

In laying out the panel and chassis, solid construction and rigidity must be adhered to. The chassis is a standard heavy duty type; the dimensions 15" x 7" x 2½". The panel is eighth inch aluminum, 7" x 19", slotted for rack mounting. A dust and shield cover of thinner but rigid material is fitted over the chassis abutting the panel. Mounted in the back of the chassis are the a-c connections, fuse, and button type feed-through insulators for the output. No. 14 solid wire is used to prevent vibration and all connections are carefully made and soldered.

Coil Construction

The coils are bracketed to the chassis in a vertical position. Enough turns are wound on to resonate at a slightly lower frequency than 1 and 2 mc. Then, with both tuning condensers at maximum and corrector at midway, the coils are pruned a turn at a time until almost at resonance. When the oscillator begins to beat with the 1 or 2 mc standard signal, adjust the spacing of the last turn or so until in dead beat. When this is accomplished, the coils must be given a coating of "Q" dope to cement the turns firmly in place. If this procedure is followed, exact resonance can be maintained indefinitely with the use of the corrector to compensate for temperature changes and the effect of intangibles. Such accuracy is necessary only if it is desired to calibrate the oscillator itself and not if intended for use simply as an interpolation oscillator.

*National dial assemblies—PW-1

Coupling Crystal Standard

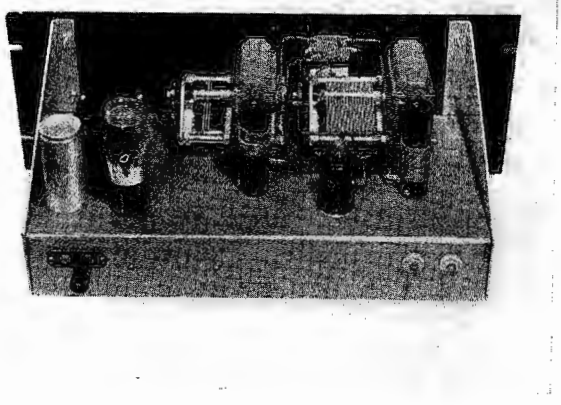
The crystal standard and oscillator are coupled to the receiver and the amount of coupling adjusted until a good balance is obtained in signal strengths. This is done by either connecting direct to the antenna post or winding a turn or two of wire about the lead-in if the signal is too strong. In this case it was found necessary to do this with the oscillator, but possible to couple the standard direct. Occasionally it is advantageous to remove or reduce the antenna when measuring if receiver signal strength is high.

Calibrating Oscillator

To calibrate the oscillator, allow all equipment to warm up at least two hours to minimize heating drift. Set both dials at zero with switch on coil 1 and adjust the corrector until exact resonance is obtained with the 1 kc signal from the crystal calibrator. Then proceed to make readings at every 10 kc by tuning the vernier until its range is exhausted. Then return the vernier to zero and increase the main dial reading until the next highest harmonic is encountered.

Setting Dial

It is desirable to set this at the nearest exact division lower in frequency and increase the vernier until resonance



Rear view of the interpolation oscillator. The specially wound coils are directly in back of the dial assemblies.

is obtained so that no fractions are involved on the main dial which would lead to reading errors. Continue these readings, charting them as: $C_m = 20$, $C_v = 57$, F = 1430 kc., etc., until 2000 kc is reached. Then switch to coil 2 and begin again until approximately 5 mc is reached or until the desired range is covered, usually around 3 to 4 mc. All frequencies above these can, of course, be measured with the use of harmonics.

Plotting the Chart

Thus a chart can be made to allow instant reading at any frequency divisible by ten and any frequency in between can be quickly measured by interpolation. For example, it is desired to measure a field transmitter with an operating frequency of 2352 kc. With the coil selector at the 2 mc position, set both dials at zero and dead beat the standard 2 mc signal by means of the corrector. Then, from the chart, set the dials at 2350 kc, the nearest lower frequency evenly divisible by 10. For instance, $C_m = 81$, $C_v = 89$, F = 2350 kc. Since the frequency to be read is greater than 2350, increase the vernier dial reading until the signal is encountered. Tune carefully to exact resonance. Reading the vernier as accurately as possible, suppose a reading of 113.3 is obtained. Now, by referring again to the chart we find that since a vernier setting of 89 equals 2350 kc and 201 equals 2360 kc, each dial division between these readings covers 90 cycles. Interpolating, the frequency is equal to 2350 kc plus [90 x (113.3 — 89)] cycles or 2350 + 2.187 kc = 2352.187 kc.

Front and interior views of the specially developed frequency measuring oscillator that affords an unusual degree of accuracy for direct measurement.

Vernier Dial Curves

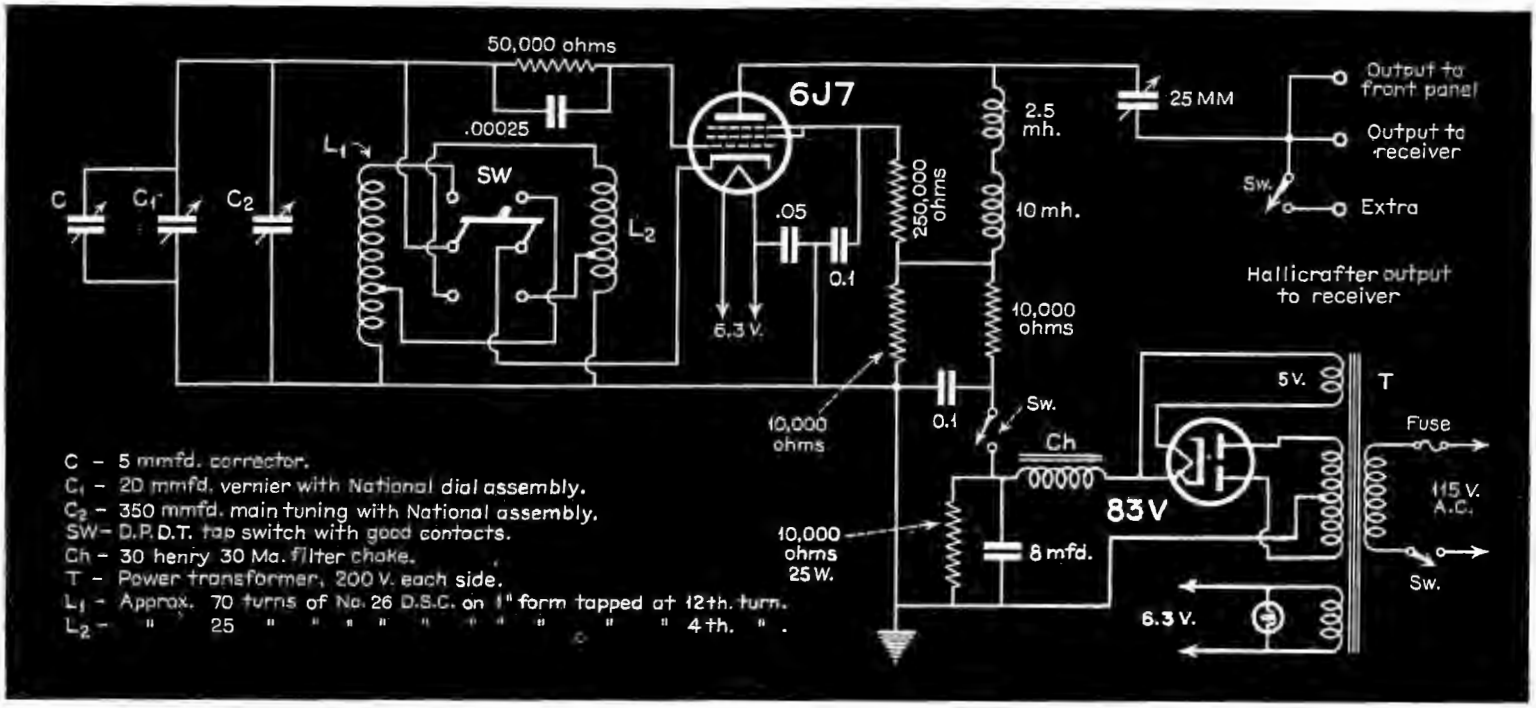
If a group of calibration curves on the vernier is prepared in advance, the frequency can of course be read directly from it. However, the chart and interpolation system is more accurate.

Accuracy Obtained

Increasing familiarity with the equipment coupled with careful reading and calculating will result in measurements within a few cycles. Cold equipment yields an accuracy of approximately .03%. When thoroughly warmed this is reduced to around .005%.

Other Uses for Oscillator

The oscillator can also be employed for other duties, such as: driver for r-f bridges, lining up of tuned circuits, and as an audio oscillator when its output is mixed with the standard to obtain beats of various frequencies. In this connection it is interesting to note from the calibration chart that certain 10 kc bands result in exactly 100 cycles per division. This allows a selection of fairly accurate audio frequency outputs from 0 to 10,000 cycles or beyond.



Circuit diagram of the interpolation oscillator for the calibrator unit. The third parallel capacity of 5 mmfd. across the tuning variable of 350 mmfd. is a zero corrector. It affords adjustment of the oscillator so that both dials read zero, at 1,000 or 2,000 kc, before making a reading. The inductances are designed so that when the tuning capacities are set at maximum and the corrector is at midway, one resonates at exactly 1,000 kc and the other at 2,000 kc.

The Calculation

OF EXPERIMENTAL ERRORS

An Effective Grouping and Analysis of Observational and Experimental Errors

by **DAWKINS ESPY***

Research Engineer, Columbia University
National Defense Research Laboratories

CALCULATION of experimental errors is an often encountered problem. In the following data, the general method of computing errors, is analyzed.

To begin with, there are several important types of errors; instrumental, personal, analytical, residual, and observational. Such errors as are due to the deviations in standards as the inaccuracies in meter scale calibration, the effect of temperature and atmospheric pressure on the values of circuit elements, and the existence of thermal emf at joints of unlike metals, are classified as instrumental. Errors resulting from the natural physical tendencies of the observer to, for example, read a meter always too high or too low, are known as personal errors. These may be reduced by employing several observers or a mechanical means of recording the results. A miscomprehension of the principle of an experiment can very often cause method or analytical errors. Errors resulting from the misuse of the apparatus are also in this class.

*On leave-of-absence from Research Dept. of KFI-KECA. Los Angeles, California.

Secret of Reliable Results

The secret of really reliable experimental results is to use several competent observers, different sets of apparatus, and varied methods. Consistency achieved otherwise may be misleading.

Manufacturers, or the standards laboratories usually specify what is known as the residual error, the limit of calibration of the standard. Errors due to mere probability that each experimental reading will be incorrect by a given amount are called observation errors, and may be determined by the laws of probability.

Two Necessary Factors

Thus, it would seem that in general we are required to know two things in calculating experimental errors, i.e., a method of calculating the probable observational error, and a method for combining the observational error with the other known errors.

Probable Errors

It is well known that observational errors are more frequently small than large with extremely large errors being very unlikely, and positive and negative being equally likely. Therefore, a large number of readings will help bring about an average which is close to the true value.

Plotting Errors

From the accompanying charts the probable error e of a series of n readings and the probable error of the mean E can be determined. The equations for these two quantities take the following form:

$$E,\ e = \Sigma d \times \varphi \quad \ldots\ldots\ldots\ldots\ldots\ldots (1)$$

when Σd is the arithmetical sum of the deviations of the readings from the mean, and φ is a function of n, the number of readings. The values of

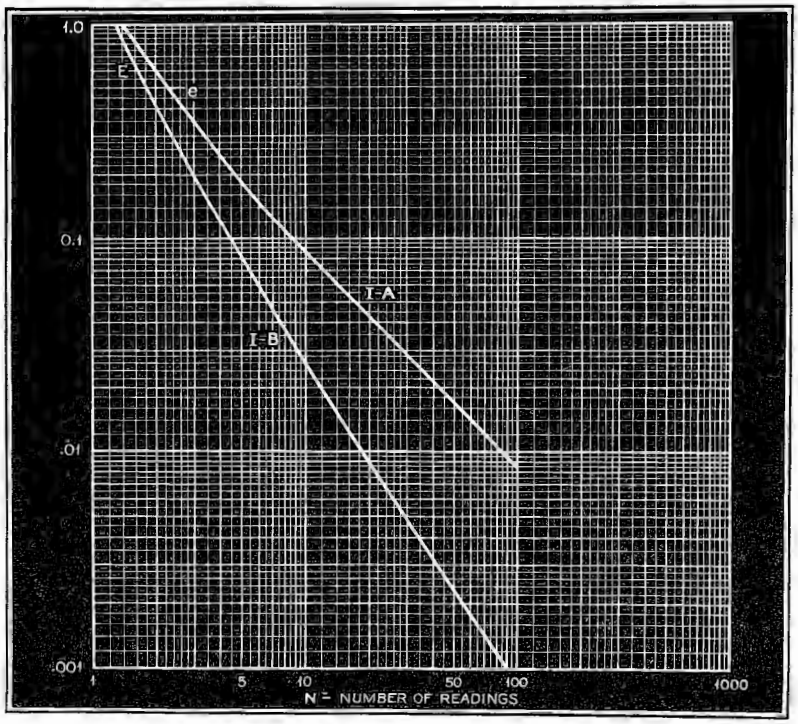


Figure 1
The probable error factor curves.

the function φ for both E and e is given as a function of n, as n varies by curves I-A and I-B, Figure 1. Both E and e may be determined readily by applying formula (1) where φ is determined from curve I.

Normal Curve of Error

The curves shown in Figure 2, are very useful when working with computation and prediction of errors. It is called the normal curve of error, and may be used in the following manner. The curve follows an equation of the form:

$$y = ce^{-at^2}$$

where y is the frequency of the occurrence of an error of magnitude t, and c and a are constants. If the experimentor takes a large number of observations, the normal curve may be interpreted as being an indication of the manner of distribution of the experimental readings. The curve shows that there will be a number of readings close to the true value of the quantity under test, but that the number drops off fairly rapidly as we depart substantially from the true value. Naturally, the relation of the ordinate to abscissa must be set according to the experiment and so it is necessary to fit the curve to the set of data at hand. It is usually desirable to fit the curve at its maximum value of ordinate, and where its ordinate reaches the half value.

Accumulative Area Plotting

A plot of the accumulative area as one departs from the center or true value axis is given. The ratio of the area corresponding to a value of t to the total area gives the percentage chance of the error falling within that area, or in other words, having an error equal to or smaller than the value t used. Since the area curve is plotted to give the area on each side of the center axis it should be multiplied by a factor of two to get the total area enclosed by a given value of t, and since the total area under the curve was set equal to unity, the area enclosed by a given value of t is the same as the ratio of this value to the total area.

Combining Errors

In combining all the errors present in an experiment, the following formula is used:

$$\text{Total error} = \sqrt{E^2 + R_1^2 + R_2^2 + {}_3{}^2 \ldots}$$

where E is the probable error of the mean, and R_1, R_2, R_3 . . . . , are the residual errors in the standards and other circuit elements influencing the accuracy of the results.

Example

Suppose that the following readings have been taken in determining mutual inductance by the bridge method.

	Readings	Deviations from Average
Mutual in mh =	7.85	.05
	7.95	.05
	7.9	.00
	7.92	.02
	7.98	.08
	7.84	.06
	7.87	.03

Sum of readings = 55.31; average = 7.90 and number of readings = 7

Sum deviations $\Sigma d = .29$

Then the multiplying factor, φ, for $n = 7$ is found from curve I-A to be .13 and thus

$e = \Sigma d \times .13 = .29 \times .13 = .038$

and from curve I-B

$E = \Sigma d \times .048 = .29 \times .048 = .014$

so on a percent basis

$$E = \frac{.014}{7.9} = .19\%$$

Assume the residuals of the two resistors in the bridge to be .1% and the residual of the capacitor to be .2%

The total error δ is:

$$\delta = \sqrt{(.19)^2 + (.1)^2 + (.1)^2 + (.2)^2} = \sqrt{.0961} = .31\%$$

and .31% of 7.9 is .02459

So the answer would read

$$\underline{M} = 7.90 \pm .03 \text{ mh}$$

[*In the February, 1942, issue of* COMMUNICATIONS, *appeared an article on Empirical Equations, by Dawkins Espy. Since some of the data then presented will prove helpful to those applying the methods suggested in this current article, the following excerpts are presented . . . "The engineer often encounters related groups of data which he would like to express algebraically. The resulting equations are called empirical equations. There are many methods of determining the proper equation, but perhaps the simplest and most useful of these is the method of averages.*

"A general method can be adopted and is readily applicable to any of the equation forms that will be described. First, the proper form is determined. Then, numerous equations using corresponding data are formed. These are divided into a number of different groups according to the number of forms that the unknowns take. When placing the equations into the various groups, one should place alternate equations in a given group in the case of two groups, every third equation in a given group in the case of three groups, etc.

"The equations in these various groups are then added, resulting in a number of equations equal to the number of constants involved. The equations thus determined are then solved simultaneously for the values of the constants, and these values are substituted back in the original form, thereby yielding the desired empirical equation. A check may be had on the accuracy of the resultant empirical equation by substituting the various values of the independent variable and calculating corresponding values of the dependent variable, and then comparing these with the actual experimental values of the dependent variable. The error in each case may be marked plus or minus according to whether the calculated value is greater or smaller than the observed value. If the sum of the positive and negative errors are approximately equal, the points are very nearly equally distributed on either side of the empirical curve, thus indicating that a satisfactory empirical equation has been evolved."]

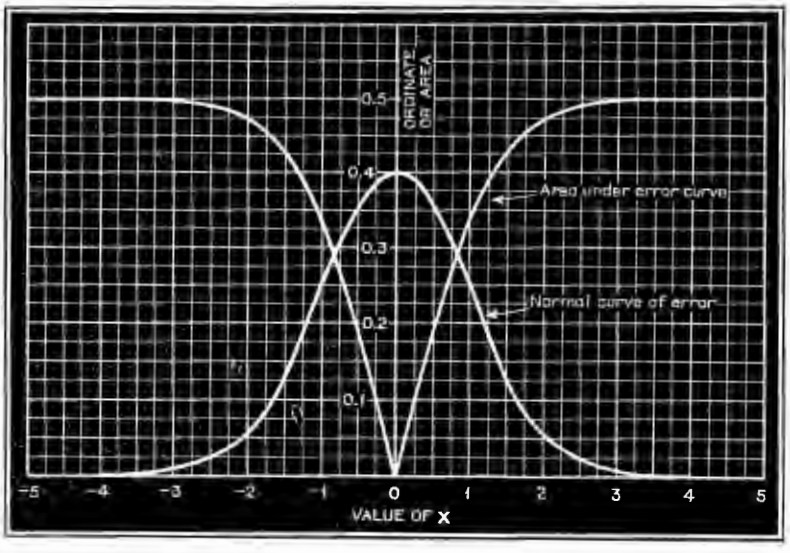


Figure 2

A Combination Radiotelegraph-Broadcast

H-F TRANSMITTER WITH MANY NEW FEATURES

by F. D. WEBSTER* and R. E. DOWNING

Federal Telegraph Co., (Associate of I. T. & T. Corp.) Newark, N. J.

IN 1940, due to the demand for increased radio communications facilities from Lima, Peru, to the exterior of Peru, it was decided to install an additional high power short-wave radiotelegraph transmitter. Based on the experiences gained in the operation of existing radio circuits, and the operating requirements of the new circuits, specifications were prepared for such a transmitter (recently completed, and now in operation), which is described in this article.

Versatility, flexibility and dependability are among the many features of the equipment. Versatility, for instance, is attained by making the transmitter capable of operation on any frequency between 5.7 and 22 mc, with crystal control or with self-excitation; for cw or mcw telegraphy or by means of a separate modulator for telephone or broadcast; for 1 kw or 30 kw of r-f on telegraphy or 9 kw on telephony or broadcast, and for operation into a balanced transmission line of 600 ohms surge impedance with any standing wave ratio up to two to one.

Flexibility is achieved by construction of the equipment in four mechanically separate units and by the provision of controls which permit rapid and convenient transfer to any type of operation. The four units comprise an r-f driver, power amplifier, 3000-volt rectifier and 10,000-volt rectifier. For telephone operation two more units are required, namely, a speech amplifier and a modulator.

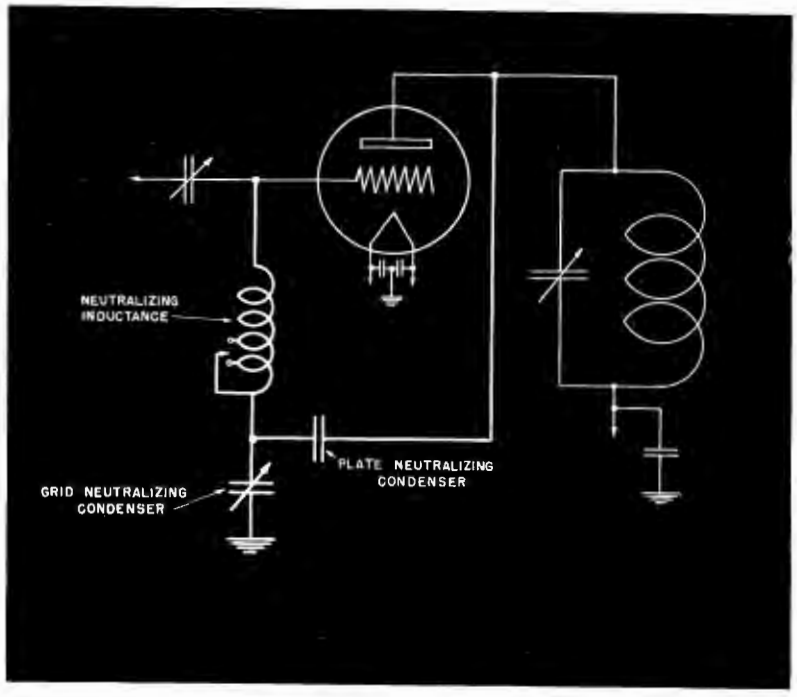
Dependability is insured by the design of each component so that it will reliably meet the electrical and mechanical operating field conditions. Protective features include special provisions for safeguarding both personnel and equipment.

Voltage breakdown, which is an ever-present hazard due to the high voltages produced in radio equipment of this power, is minimized by adequately spacing and insulating all components, by avoiding sharp edges on metal parts—and by installing corona shields and horn gaps where applicable.

There are six pre-set frequencies. Changes can be made between any 2 pre-set requencies in less than 5 minutes.

In the frequency control, the crystal is ± 0.01% of specified frequency; temperature coefficient less than 2 parts per million per degree Centigrade. The self-excited output frequency can be set within 0.5% of any frequency. Output frequency remains within 0.01% of the

*Formerly with Federal Telegraph Co.



Left, front view of the radio-frequency driver unit. Above, the Lange neutralizing circuit, used in this unusual transmitter.

original frequency during any period of 15 minutes continuous operation, and within 0.1% of the original frequency during a period of 12 hours continuous operation.

On any multiple of the carrier frequency, the harmonic output is at least 45 db below the carrier. The output circuit is designed for two-wire connection to the antenna.

The transmitter is so arranged that the final amplifier and main high voltage rectifier can be removed from the circuit and the transmitter operated with a power output of 1 kw. Output terminals, coupling circuits and a special switch are provided for this purpose on the next to the last amplifier stage.

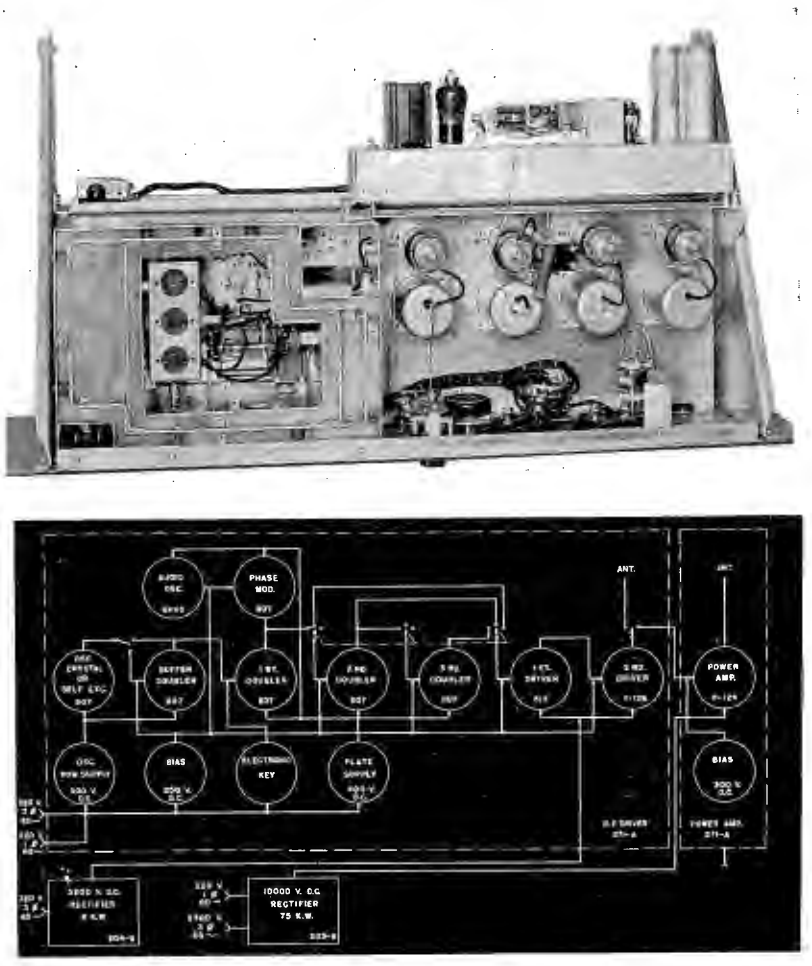
No vacuum tube operates with a filament voltage in excess of the value recommended for normal tube life. During the starting sequence, the filament current in no tube with directly heated filament and plate dissipation in excess of 100 watts exceeds 175% of the filament current of the same tube when completely heated.

Controls are provided for adjusting and indicating the filament voltage of all tubes except the oscillator which is regulated automatically.

The transmitter keys satisfactorily up to 400 wpm. The output during spacing intervals is essentially zero. Electronic keying is used and is provided with a control on the front of the transmitter for controlling the weight of the keyed characters, i. e., changing the percentage marking and spacing on dots.

Power required is a 2300-volt and a 220-volt supply, both three-phase 60 cycle.

Each unit of the transmitter is equipped with controls for starting and stopping that unit. The keying circuit permits the transmitter to be keyed from the power amplifier, from the driver or remotely. It may be locked in the key-down position by means of a switch on the driver unit. The 3,000-volt plate voltage can be applied to the driver by push-button stations on the power amplifier or on the 3,000-volt rectifier. A plate supply control on the power amplifier prevents that unit from being connected simultaneously to more than one 10,000-volt rectifier.



At extreme top appears a top view of the oscillator-multiplier tray. Below is a block diagram of the transmitter.

The R-F Driver Unit

The r-f driver unit includes in one metal cabinet, the oscillator, buffer-doubler, 3 doubler and 2 driver stages, with the phase modulator and all power supplies except the plate supply for the two driver stages. The oscillator covers a frequency range of 980 to 1,460 kc when self-excited and 1,960 to 2,920 kc when crystal controlled. Selection of any one of six crystals or self-excited operation on any one of four frequency ranges is provided by a single switch. The buffer-doubler stage operates as a frequency doubler and isolates the oscillator from the first doubler stage which is keyed and modulated. It is used only for self-excited operation and is disconnected for crystal operation by means of a switch. Another switch is provided whereby one, two or three doubler stages may be connected in the circuit, the number of stages chosen depending upon the desired output frequency. The output of the doubler stages is applied to the first driver stage which employs a beam type power amplifier tube. This in turn excites the final driver stage. The output of the final stage may be supplied to the power amplifier or, through an Alford network (a special type balancing network), to an antenna.

Frequency Control

The oscillator is installed in a constant temperature oven. The oscillator and the thermostatically controlled oven heater each have an individual power switch; both switches are connected to the power mains by a circuit which is independent of the rest of the equipment. The arrangement permits either the oven or the oscillator or both to be continuously energized or to be energized sufficiently in advance of the operation of the rest of the equipment to allow the temperature to stabilize. The oscillator filament and plate voltages are maintained constant within 1 percent independently of line voltage fluctuations between 170 and 250 volts. This is accomplished by an automatic voltage regulator which employs the properties of a magnetically saturated iron core and a partially resonated circuit. In this way, the principal causes of oscillator frequency deviations are eliminated.

Oscillator Temperature Control

Whereas a high degree of temperature control would not be required with the low temperature coefficient crystals employed, a rather close control of temperature of the electric oscillator components is considered desirable. Therefore, a device has been included with the oscillator oven which may be adjusted

to compensate for heat leakage which may take place despite the dual insulation used about the oven. It consists of a heat conducting vane with a part of its surface outside the oven and thus exposed to ambient temperature. The portion of the vane inside the oven is in close proximity to the thermostat. The whole assembly is arranged to be adjustable so that more or less heat, as desired, may be transferred from the vicinity of the thermostat to the outside, thus permitting maintenance of the temperature inside the oven within close limits. The inner oven is lined with heavy metal to provide great heat inertia so that fluctuations in temperature of the outer oven, where the heaters and thermostat are located, will not be transferred to the inner oven, or at least will be greatly retarded. Thus, if falling ambient temperature depresses the inner oven temperature, the vane is moved nearer to the thermostat to withdraw heat faster from the thermostat; this causes the latter to be closed a greater proportion of the time, thereby raising the average temperature of the outer oven and maintaining the desired temperature of the inner oven.

The temperature of the inner oven thus is held within close limits without requiring a thermostat so sensitive as to need an auxiliary relay system to handle the heater circuits.

The filament by-pass condenser.

Keying

On-off keying of the transmitter is employed for both cw and mcw telegraph operation; it is accomplished by applying to the control grid of the first doubler stage, when the key is open, fixed bias sufficient to block the tube. When the key is closed the bias is reduced to the normal operating value. The key controls the grid bias of the doubler stage through an electronic keying circuit which includes a weight control. The weight control allows the relative duration of marking and spacing pulses for dots to be adjusted. A filter is inserted between the electronic keyer and the doubler grid circuit to shape the telegraph characters and minimize key clicks. A monitor consisting of a diode rectifier electrostatically coupled to the r-f output is provided so that, by connecting an oscilloscope to its output, the shape of the telegraph characters can be observed. The keying circuit allows the transmitter to be keyed at any speed up to 400 words per minute.

Phase Modulation

Tone modulation for mcw telegraphy is obtained by phase modulation which is indistinguishable from frequency modulation when a single constant modulating frequency is used. It has the advantage over the latter of not affecting the carrier frequency and thus eliminates the necessity for special frequency control circuits. This type of modulation was adopted in preference to amplitude modulation because it produces a distinctive signal that is more easily read through interference and, in addition, it generates multiple sidebands which contribute to reduction of selective fading. Further, it accomplishes these results with a minimum of equipment and power consumption.

Lange Neutralizing Circuit

The r-f driver unit output stage employs an air-cooled triode (Type F-128-A) operating as a neutralized power amplifier. It embodies the Lange neutralizing circuit which accomplishes neutralization by a principle entirely different from other commonly used circuits; with the tube grid-plate capacitance, it forms an unsymmetrical bridged T network. The series element connected to the grid is a tapped inductance, the series element connected to the plate is a fixed condenser and the shunt element which connects to ground is a variable condenser. One of the advantages of this circuit is that any two elements may have any desired value. When these two values have been chosen, the value of the third element is fixed by the relation for neutralization. The arrangement used in this equipment has been found highly convenient. In this case, the plate neutralizing condenser is fixed and has a capacity approximately equal to the tube grid-plate capacity. The grid neutralizing condenser is variable with an average capacity about four times that of the plate neutralizing condenser. The inductance is tapped at such intervals as to permit neutralization within the range of the variable condenser over the complete range of frequencies. Neutralization is obtained by adjustment of the variable condenser.

Output Circuit

The output circuit of the r-f driver unit consists of two tuned circuits inductively coupled. Five adjustments are provided, thereby allowing the most effective condition to be obtained for any load or frequency. This type of output circuit also effectively reduces harmonics.

A switch is provided in order that the r-f driver output may be connected either to the power amplifier or to an antenna through a balanced transmission line. Although the output stage uses a single ended circuit, a balanced output is provided suitable for feeding a two-wire transmission line by employing a special type balancing network. The latter consists of two identical tapped inductances and a variable condenser connected in star. The condenser leg connects to ground and the two inductance legs connect to the two sides of the transmission line. One transmission line conductor connects to the high potential side of the driver output stage. The network is balanced for only one frequency so that for each frequency the proper tap on the inductances must be selected and the variable condenser adjusted until no parallel current flow into the output circuit; a condition which is approximately achieved when the two r-f meters in the transmission line indicate equal currents.

Antenna Meters

The antenna is fed from the transmitter through a two-wire transmission line for which two terminals are included in the driver unit. These terminals are connected to the output of the special type balancing network by heavy conductors. Electromagnetically coupled to each of these conductors by means of a small shielded and grounded loop of wire is a thermocouple. The thermocouples supply the two r-f ammeters located on the front panel of the r-f driver unit. The coupling between the conductor and the loop is adjustable

and is set to give a correct indication of transmission line current at that point. This arrangement prevents the antenna meters from being damaged by lightning.

Power Amplifier Unit

The power amplifier unit employs a water-cooled triode with a six-strand filament (Type F-124-A) in a neutralized amplifier circuit. The tube requires a total filament power of 5.6 kw at 27.2 volts, representing 206 amperes in a single-strand filament and 68.7 amperes per strand in a six-strand filament connected three-phase. The six-strand filament thus permits the use of conductors and terminals in the filament circuit of a more convenient size. An additional advantage is that the filament may be supplied from a three-phase source resulting in a reduction in hum modulation from the filament. Filament starting current surges are limited by high reactance filament transformers. The rated filament voltage is obtained for various line voltages by a three-phase continuously adjustable autotransformer.

Parasitic oscillations are frequently present on the filament leads of high power tubes if the filament is not bypassed to ground for radio frequencies at the filament terminals. For this reason, each filament strand is bypassed to ground at the tube terminals by an assembly of mica condensers of original design. The connection to each tube filament terminal is made by a clamp with a large hexagonal head screw. Each clamp is attached to a circular plate provided with holes to pass the clamps for the other terminals. The six plates are stacked vertically with a grounded plate at each end and between each of the other plates. All the plates are separated by sheets of mica. The grounded plates are connected to the tube cap by a clip and to ground by a short heavy strap. The terminal clamps are located so that the assembly fits over the tube terminals and is supported on them. The filament supply leads are flexible stranded conductors and are attached to the same condenser plates as the corresponding clamps but to the opposite surface by means of special terminals. This condenser unit is compact and convenient to attach to the tube. The use of hexagonal head screws on the clamps renders practicable the removal of the assembly when it is at operating temperature by loosening the screws with a wrench.

This stage employs the Lange neutralizing circuit previously described. The fixed condenser in the branch to the plate comprises four vacuum condensers in a series parallel connection, giving a capacity approximately equal to the tube grid-plate capacity. At the high voltages involved in this unit (18,000 volts), the vacuum condensers represent a large saving in space over an equivalent fixed air condenser.

Bias Supply

Included in the power amplifier unit is a 450-volt fixed bias supply which biases the tube to cut-off when the r-f drive is removed. Under normal operation, the tube employs grid leak bias and the fixed bias is made ineffective for all grid leak bias voltages larger than that of the fixed bias by connecting the fixed bias supply in parallel with the grid leak bias through a pair of high vacuum rectifier tubes. These two rectifier tubes are connected in parallel and prevent the grid current from flowing in the fixed bias supply. The amount of grid leak bias must be greater for telephone operation than for telegraph. The grid leak resistor has the proper value for telephone operation but with a section short circuited by the normally closed contact of a relay to give the correct resistance for telegraphy. For telephone operation, the relay is energized and removes the short circuit.

Water Cooling System

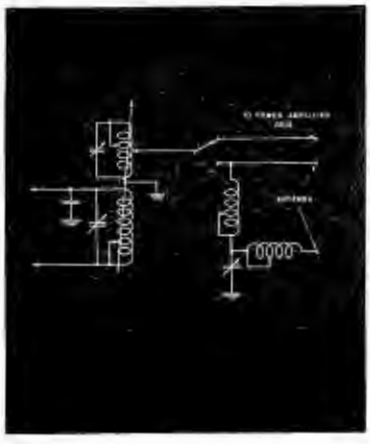
The power amplifier water cooling system is designed for connection to the water mains and requires 16 gallons per minute at 45 pounds per square inch pressure. The water system cools both the tube and the plate tank inductance. Loss of radio frequency power in the water system is minimized by the use of porcelain water coils. A contact-making flow meter is included which causes the unit to be shut down whenever the water flow drops below a safe amount. It is also arranged so that if the filament power is applied before the water is turned on a warning signal is given. Further, an outflowing water temperature indicator is provided which causes the power to be removed if the water temperature becomes excessive. A part of the circulating water is caused to flow through the copper tubing of the main plate tank inductance to provide cooling for the coil.

Plate and Output Circuits

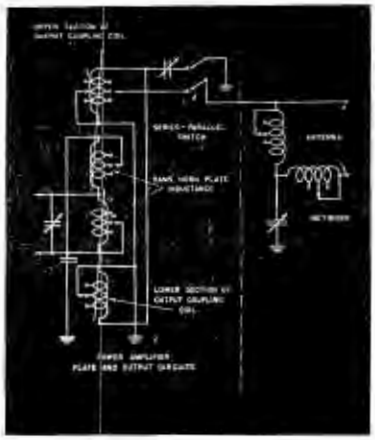
The plate tank inductance is a "rams horn" type coil; that is, it consists of two equal sections connected in parallel and wound in opposite directions along a common axis so that their fields reinforce each other. Water is supplied to this coil through a porcelain insulating water coil and enters the tank coil at each end of the "rams horn," exhausting at the center into the side of the tube water jacket. Power is taken from the plate circuit by a coupling coil, which is likewise in two sections connected in parallel and wound so that the two sections are aiding. A section is located at each end of the plate inductance. This type of coil construction provides increased mutual inductance which is especially advantageous at the higher frequencies where only a small portion of the total inductance is in use. The output coupling coil is tuned by a variable condenser which may be connected either in series or parallel; selection is made by a special switch fitted with an interlock which removes the plate voltage before a change can be made. This feature adds to the convenience of adjusting the transmitter and facilitates obtaining the optimum adjustment under various operating conditions.

Changes in tuning ranges are effected by short circuiting the proper number of turns of each coil, shorting bars of various lengths being supplied for this purpose. These bars are fastened to the coil by screws with large hexagonal heads for which a special wrench is provided so that the frequency can be changed even when the

(*Continued on page 27*)



The driver output circuit.



The power-amplifier plate and output circuits.

DIVIDING NETWORKS FOR TWO-WAY HORN SYSTEMS

by COLIN A. CAMPBELL

Chief Engineer, Altec Lansing Corporation

A MODERN sound-reproducing system embraces such a tremendous range of frequencies that the task of designing a suitable speaker appears insurmountable, especially if size and cost are considered. To date, most satisfactory operation is had by using two speakers which are complementary to each other, one for the low frequencies and one for the high-frequencies.

A necessary part of a two-way horn system is the dividing network which separates the output of the audio amplifier so that each speaker receives only its intended frequencies.

Most high-frequency speakers have metal diaphragms coupled to a multicellular horn which loads the diaphragm so heavily it moves only a few thousandths of an inch, even at high power levels. A typical high-frequency unit will not operate below its normal cutoff frequency, since the diaphragm is not loaded sufficiently to limit its travel to a safe value. Thus, the dividing network protects this unit at high power levels.

Low-frequency speakers are of the familiar paper cone type, necessarily large, with heavy moving parts. At frequencies in the 1,000 and 2,000 cycle range the paper cone may develop standing waves, generating sub-harmonics as well as higher order harmonics. The fundamental mode of vibration uses the circumference as a node; other modes have radial or circular nodes, each readily recognized. If the speaker cone is made strong enough to handle the bass, the high-frequency response is poor, due to the large mass; consequently a dividing network is used to restrict the operating range.

Energy for the low-frequency speaker is at a premium, since the comparatively small angle of spherical distribution of a multicellular horn makes the high-frequency speaker more efficient. Usually the high-frequency speaker is fed with a resistor which balances its efficiency to the low-frequency speaker.

The device to accomplish this end has the general classification of a wave filter. There are three common types of wave filters:

1)—A *low-pass filter* passes all frequencies up to a certain point, and attenuates all the frequencies above this point.

2)—A *high-pass filter* attenuates all frequencies up to a certain point, and passes all the frequencies above this point.

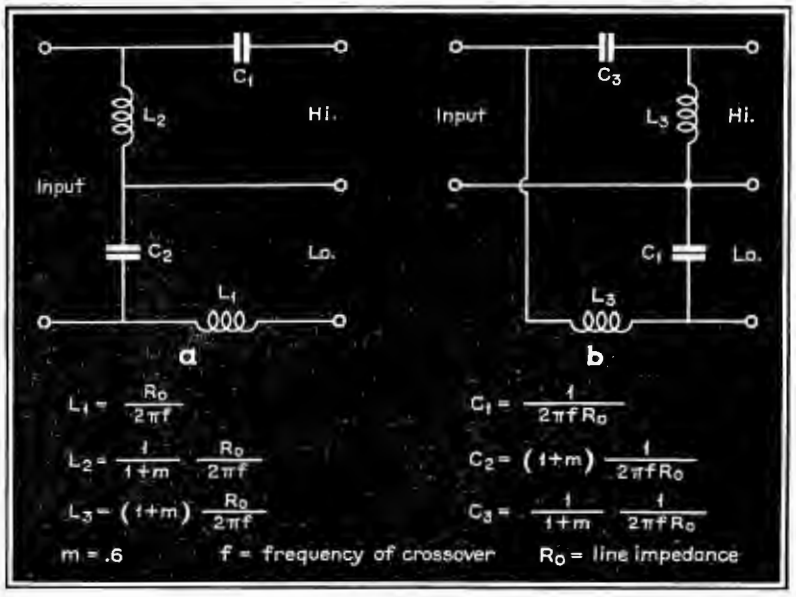
3)—A *band-pass filter* passes a group of frequencies and rejects all above and below this range.

Now, a dividing network is a combination of a low-pass and a high-pass, connected to a common source, but to two separate loads, and so arranged that the desired characteristic is obtained.

When the reflection through a filter is resistive, it transmits; when the reflection is reactive, it attenuates. To state this in another way, take, for example, a 500-cycle, filter-type dividing network. The low-frequency speaker receives energy from the amplifier for all frequencies up to 500 cycles, at which point it is attenuated 3 db. At 1,000 cycles the attenuation is 12 db more than at 500, or a total of 15 db; at 2,000 cycles the attenuation is 12 db more than at 1,000 cycles, or 27 db, etc. The same holds true for the high-frequency unit, except that the attenuation is in the opposite direction. This unit receives all of the energy above 500 cycles, at which point it is attenuated 3 db. At 250 cycles the attenuation is 12 db more than at 500 cycles, or 15 db; at 125 cycles, 12 db more than at 250 cycles, or 27 db, etc. At the crossover frequency, (the frequency at which the high and low-frequency

Figures 1 and 2

Figure 1, top, illustrates thee constant-resistance type of divided network circuit. In this circuit, both the inductances and the capacitors are of the same value. Figure 2, right, illustrates the "M" derived or filter type of network circuit.



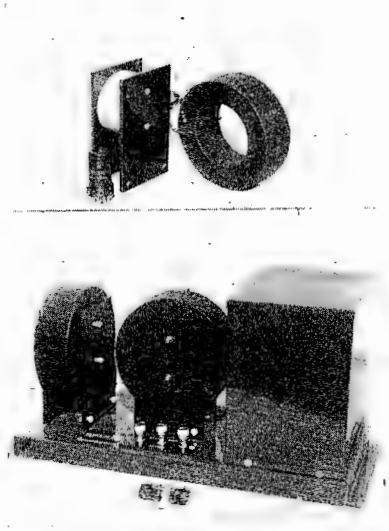
speakers receive the same amount of energy) half of the sound comes from the low-frequency speaker and half from the high-frequency speaker, or, stated in other words, each speaker is down 3 db, but because there are two speakers the average level remains constant. (A power loss of one half is 3 db).

The 500-cycle crossover has become the most popular for large commercial sound systems such as theaters, while the 800-cycle is the most satisfactory for small review rooms and home use.

Best speaker design calls for a voice coil impedance between 6 and 24 ohms, and standard practice places the dividing network between the output transformer of the amplifier and the speakers. The crossover frequency is usually between 300 and 800 cycles per second, at which point the attenuation to each channel is 3 db, and the rate of attenuation from this point is 6 to 18 db per octave, depending on the type of network.

Two types of networks are in use: the "M"-derived type, and the constant-impedance type, and both may have a shunt or series connection.

1)—The *"M"-derived* types are shown in Figure 2 in which "a" is the series connection and "b" the parallel connection. Condensers and inductances shown are for a crossover of 500 cycles per second and a line impedance of 12 ohms. Both are "half sections" and produce an attenuation rate of 12 db per octave, which is the accepted standard suggested by the Academy of Motion Picture Arts and Sciences. A close comparison of the series and parallel types shows that only two-thirds as much capacity is required for the latter as for the former, and that, furthermore, the parallel type allows less transmission loss since the current for the low-frequency speaker has to pass through only one inductance, while in the series type it must pass through both. It is to be noted that the parallel type network is especially suited to amplifiers which have one side of the output circuit grounded, since one side of the input of the network is common to the output. An accidental ground on the output side of the series type may produce some very weird effects, while a ground in the case of the shunt type merely shorts out the high-frequency speaker or the low-frequency speaker, as the case may be.



Figures 4 and 5
Figure 4, top, a 400 cycle coil and mount. Figure 5, bottom, a 400 cycle network. The resistor shown reduces power to h-f unit.

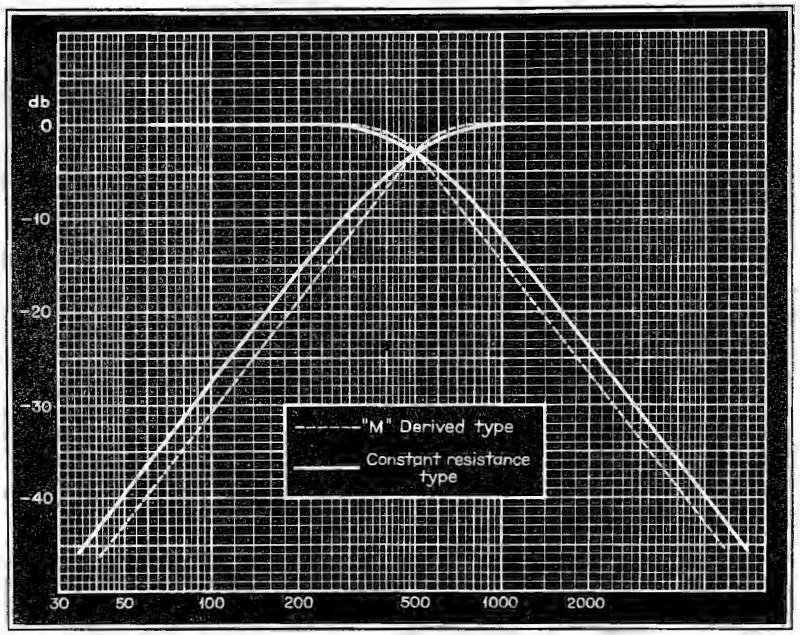


Figure 3
A graphical comparison of the transmission characteristic for a derived type and constant-resistance type circuit.

2)—The *constant-resistance* types are diagrammed in Figure 1. These are especially interesting to a manufacturer because both the inductances are the same value, as are the capacitors. A 12-ohm load connected to the high-frequency output and a 12-ohm load connected to the low-frequency output reflect 12 ohms to the input terminals for all frequencies, hence the name "constant-resistance."

A graphical comparison of the transmission characteristic for a derived type and constant-resistance type is shown in Figure 3.

Design Data

In dividing networks for other than 12-ohm impedance, the capacitors are inversely proportional to the impedance and the inductances are directly proportional. Thus, a 200-ohm network for 500 cycles would have capacitors 12/200 times those shown in Figure 1 and Figure 2, while the inductances are 200/12 times those shown. The same rule applies for different cross-over frequencies—an 800-cycle network has ½ the inductance values of a 400-cycle network and ½ the capacitor sizes.

The d-c resistance of the inductors determines the insertion loss in the pass bands of the network, and consequently it must be kept at a minimum if amplifier power is to be conserved. For example, a 12-ohm parallel type network with L = 6.6 millihenry and 1-ohm d-c resistance, has an insertion loss of less than 1 db; to be exact:

$$E \text{ ratio} = 12/13$$
$$20 \log 1.135 = .68 \text{ db}$$

If an inferior design was used which allowed a 2-ohm coil resistance, the insertion loss would be 1.56 db. If a 100-watt amplifier was used, only 70 watts would be available for the speakers and the lost power of 30 watts would appear as heat in the network coil. There would also be a further loss of power due to mismatch between the amplifier and load, since the 2-ohm d-c resistance of the inductance adds to the 12-ohm speaker load, making the reflected load 14 ohms.

It has been pointed out that the d-c resistance of network coils is the important factor so far as loss through the pass bands is concerned. The problem becomes an economic one because the larger the physical size of the coil,

(*Continued on page* 21)

NEWS BRIEFS OF THE MONTH...

WFIL OFFERS SCHOOLING

Recognizing the urgent need of the Navy for men experienced in sending and receiving code, station WFIL, Philadelphia, Pa., is establishing a class in which young men of draft age will be given an opportunity to learn code sending and receiving, along the lines laid down by Naval authorities. These classes will be conducted by WFIL engineers.

Roger W. Clipp, vice president and General Manager of WFIL, has volunteered the use of studio facilities. He has also volunteered to provide typewriters, telegraph keys, equipment for automatic tape transmission and receiving, etc.

The course will be under the constant direction and supervision of qualified naval officers.

Enrollment date will be announced over WFIL in the very near future. The class is expected to require approximately eight weeks of training on the basis of two classes per week.

* * *

NON-MAGNETIC BEARING DATA

Three new types of non-magnetic radial and pivot bearings are described in a new folder, published by Miniature Precision Bearings, Keene, New Hampshire.

This series has races and balls of Berylco 25.

* * *

JOHN MECK MOVES

John Meck Industries, manufacturers of Audiograph sound systems and "Electro-Siren" air raid alarms, have recently moved from Chicago to a new location at Liberty and Pennsylvania Avenues, Plymouth, Indiana.

* * *

ADRIAN MURPHY TO SIGNAL CORPS

Adrian Murphy, executive director of CBS television, reported recently for duty as a First Lieutenant in the Signal Corps of the United States Army.

Leonard Hole has been named acting executive director of Columbia's television. Hole was formerly manager of CBS television operations. He has been with CBS since 1935.

* * *

ROY FAULKNER APPOINTED

Roy H. Faulkner has been appointed vice-president of General Broadcasting System, Inc., and its affiliates, Motion Picture Productions, Inc., and the Emerson Corporation.

Mr. Faulkner has been president of the Auburn Automobile Company, president of the Pierce Arrow Sales Company, vice-president of the Aviation and Transportation Corporation, and president of the Columbia Axle Company.

* * *

SCRAP DRIVE NETS 763 TONS

A million-and-a-half pounds of scrap metal, enough to build a U. S. Navy mine layer, or to make twenty-two 30-ton tanks for the Army with enough left over for three Army "peep" cars, has been salvaged from the Camden plant of the RCA Manufacturing Company in the first quarter of 1942. The material included steel, aluminum, brass, bronze, copper, lead, nickel, tin, zinc, mica, etc.

AEROVOX COMMEMORATES 20TH ANNIVERSARY

The twentieth anniversary of the Aerovox Corporation was recently celebrated at a dinner at the New Bedford Hotel, New Bedford, Mass. S. I. Cole, president, received a citation setting forth his achievements and leadership during the past two decades. In addition to the citation, Mr. Cole was presented with a gold watch key, carrying the company's well-known octagonal capacitance-resistance seal and embellished with a diamond, and engraved on the reverse side with the details of the presentation. Other officials of the organization were likewise presented with parchment-inscribed citations and token keys.

* * *

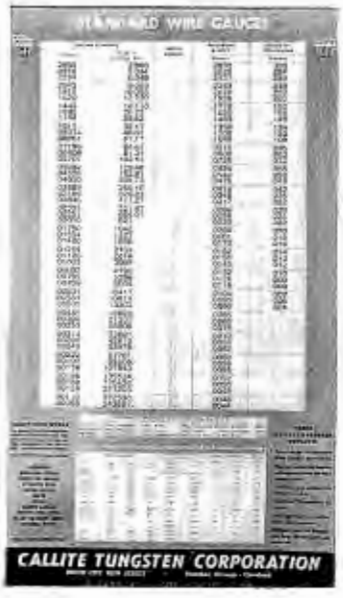
WALL CHART OF WIRE DATA

A wall chart which incorporates much basic and frequently used wire data is being offered without charge by the Callite Tungsten Corporation, Union City, N. J., to engineers and specifiers of wire and wire products.

The data presented consist of three tables. The first of these gives wire dimensions for all sizes from 1 to 50 in B. & S., Washburn & Moen, and Stubs (or Birmingham) gauges, and in addition includes feet per pound for each size in the B. & S. gauge. These latter figures are given for 5% prosphor bronze wire. The second table supplies the conversion factors to simplify calculating feet per pound for wire of 15 different common metals and alloys. Third is a table showing the composition and physical properties of this same group of metals and alloys.

The chart is approximately 36 inches high by 21 inches wide. It is lithographed in two colors on heavy paper stock, bound top and bottom with metal.

Engineers and others having use for one of these charts may obtain same by addressing a request to the company.



SCHAIRER HONORED

Otto Sorg Schairer, vice president of the Radio Corporation of America, in charge of RCA Laboratories, was awarded an honorary degree of Doctor of Engineering by the University of Michigan. The degree was in recognition of "the unusual achievements of one of the University's alumni in the conduct and administration of scientific research for industrial purposes."

Dr. Schairer was graduated from the University of Michigan with an A.B. degree in 1901, and received his B.S. degree in electrical engineering in 1902.

* * *

JACK DeWITT LEAVES WSM

Jack DeWitt, WSM chief engineer, has left WSM for the duration to work on Government equipment at the Bell Laboratories in Whippany, New Jersey. His successor is George Reynolds, WSM veteran engineer. Mr. DeWitt was connected with Bell Laboratories before becoming WSM's chief engineer.

Walter E. Bearden, also of the WSM engineering staff, has also left WSM to do work with the Columbia University Branch of the National Research Council. Bearden will be stationed at Lakehurst, N. J.

* * *

NEW SECTIONAL RESISTOR BOOKLET

A new 8-page catalog section on sectional resistors for a-c and d-c circuits, non-inductive, wire wound, and hermetically sealed, is announced by the Westinghouse Electric and Manufacturing Company, East Pittsburgh, Pa.

The booklet outlines the features of the resistors with emphasis on their construction, flexibility, and interchangeability. The booklet also contains illustrations of the various parts of the sectional resistor, plus installation and application photographs and data. The last two pages are devoted to tables giving size, voltage resistance and price.

A copy of catalog section 43-820 may be secured from department 7-N-20.

* * *

AIR CIRCUIT BREAKER CATALOG

Low-voltage air circuit breakers designed for use on a-c up to 600 volts and d-c on 250 or 750 volts are described and illustrated in a new 12-page publication, Catalog 2150, just released by the Roller-Smith Company, Bethlehem, Pennsylvania.

These breakers, Type HD, are available in sizes ranging from 600 to 6,000 amperes a-c, and 600 to 10,000 amperes d-c. They can be furnished in 1, 2, 3, and 4-pole models for either manual or electrical closing. Live front, dead front and steel enclosed designs are available.

The catalog lists closing and tripping currents, shows typical methods of making connections to large breakers, gives dimensions of both manual and electrical designs, and indicates the number and size of terminals for various capacity breakers.

Copies can be obtained without charge.

* * *

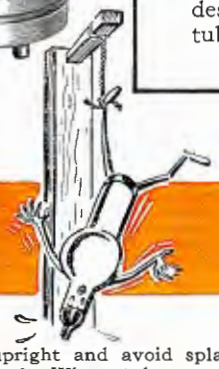
DATA ON FINISHES

A booklet on U. S. Government Specification Finishes has been published by Maas

(*Continued on page 23*)

How to Get Longer Life from Your MERCURY-VAPOR TUBES

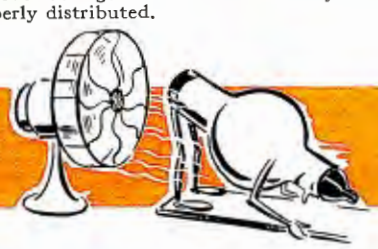
Here's a four-word formula to make your mercury-vapor tubes last longer—"Handle carefully; operate conservatively." Below are a few suggestions to help you put this formula into effect. They will help prevent many of the causes of tube failure, such as: loss of emission, high arc-drop, cathode bombardment, arc-backs, the liberation of gas, and cathode failure. These safeguards are applicable to such tubes as the following General Electric mercury-vapor rectifiers: GL-266B, GL-857B, GL-866A/866, GL-869B, GL-872, GL-872A. For more complete instructions on operation and handling, write for Bulletin GEH-977B. Also list the types of G-E mercury-vapor rectifiers you are now using. We shall be glad to send you complete service information designed to help you get the most out of your mercury-vapor tubes. *General Electric, Schenectady, N. Y.*



1
Keep tubes upright and avoid splashing mercury around. When tubes are first placed in operation, be sure to apply cathode voltage *alone* until mercury is properly distributed.

2
Keep condensed mercury temperature within limits recommended by tube manufacturer.

3
Be sure cathode base, not the anode end, is coolest part of tube. Don't let drafts blow on tubes. Never allow the mercury to condense at the anode end.



4
If you use forced air against the bottom of the tube, keep the blower on for a few minutes after shutting filaments down.

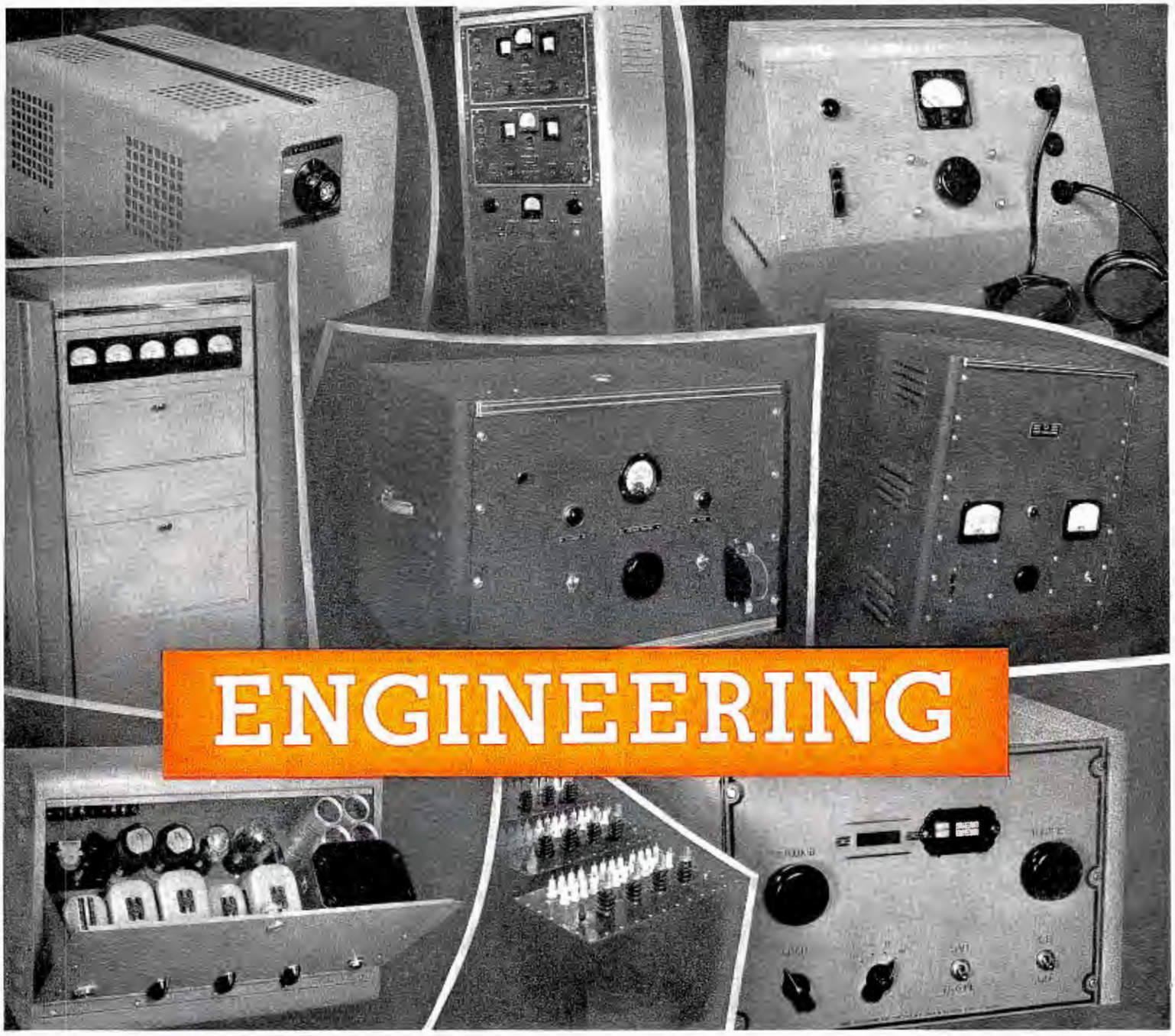
5
Allow plenty of filament warm-up time before applying anode voltage.

6
Keep peak inverse anode voltage and peak current as low as possible for satisfactory operation. Use adequate protective devices for overload and arc-back protection.

7
Do not allow the cathode voltage (measured at the pins) to deviate more than five per cent from the rated value.

8
Don't overload tubes, even for short periods. Maintain full cathode voltage during standby operation when tube is operated without load.

9
Protect the tubes adequately against the effects of r-f.



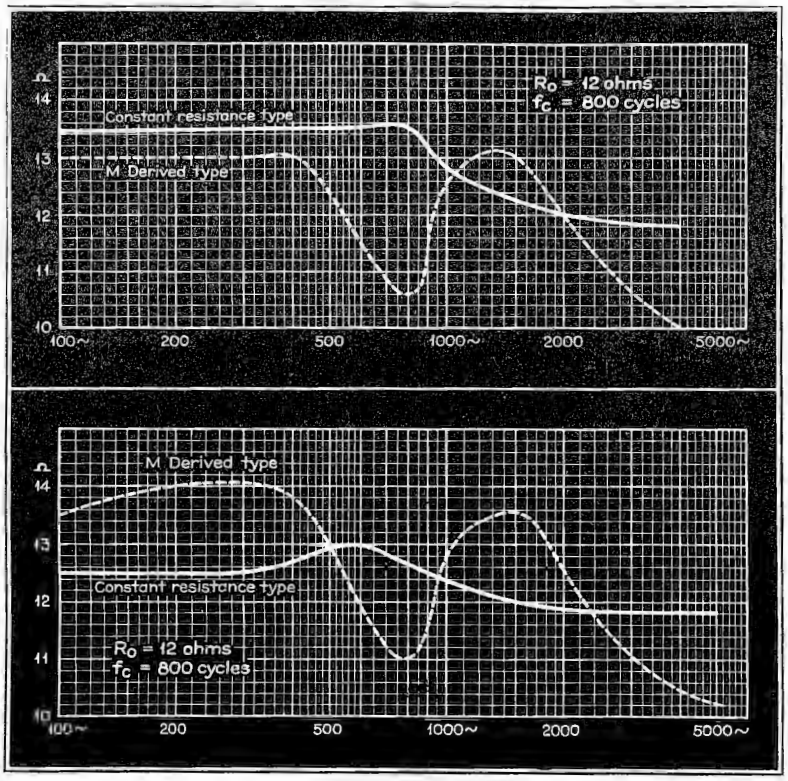
UTC has always been a leader in transformer engineering. In pre-war years, UTC earned an enviable reputation for making possible the job that "couldn't be done". It was only logical, therefore, that when special war requirements came up, UTC was one of the first looked to for the solution of new problems.

The research and development in both engineering and production methods for these new designs are naturally cumulative. They are yours for the asking on your present war problems, and assure a continuance of UTC's reputation as "leaders of the field" when victory is ultimately gained.

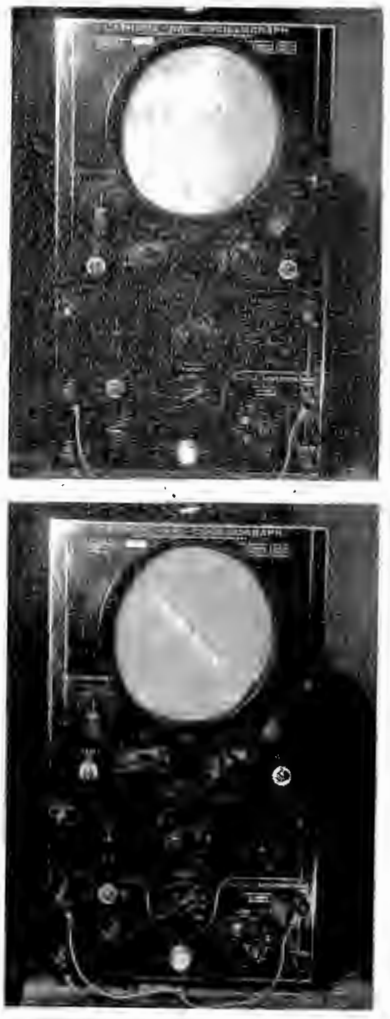
UNITED TRANSFORMER CO.
150 VARICK STREET ★ NEW YORK, N. Y.
EXPORT DIVISION: 100 VARICK STREET NEW YORK, N. Y. CABLES: "ARLAB"

DIVIDING NETWORKS

(*Continued from page* 16)



Figures 6 and 7
Figure 6, top, illustrates results of resistance substitution type. Figure 7, bottom, illustrates the resistive component as measured with a G.R. 650A impedance bridge.



Figures 8 and 9
Figure 8, top, elipse on oscillograph showing the phase difference other than 180° ("M" derived type at crossover). Figure 9, bottom, the straight line or no phase difference of the constant resistance type at crossover frequency.

the lower the d-c resistance for a given inductance, but, at the same time, the general coil dimensions must be considered. The greatest ratio of inductance to resistance consistant with winding ease is produced by the form shown in Figure 4. The coil is wound on a rigid steel former, the wire being fed with an automatic tension device to give uniformity. They are easily held to 1 percent of the proper inductance.

The average power required to operate a theater speaker for a typical scene is a small fraction of a watt, and at 12 ohms the average voltage across the network is less than one volt, so the problem of selecting condensers is not a particularly difficult one. The peak v. at 100 w. is only 50 v. for a sine wave.

Electrolytic condensers are not used because their capacity is not constant during life and the effective series resistance is rather high for efficient performance. Paper-wound condensers are used exclusively for wave filters as their capacity does not change appreciably and losses are negligible at a-f.

It is very difficult to manufacture condensers of exact capacity, so the capacitor blocks are made up of large sections with small ones added to "pad up" to required size. Each block must be checked on a capacity bridge and given individual attention. Inductances are finished with wrapping tape and impregnated for permanence of form.

Inductance and capacitors maintained within 5% of theoretical size will hold the finished network to 5% of designed cross-over frequency, even if the errors are off in the same direction. The resonant frequency of a circuit varies as the square root of the inductance or capacity, so an inductance 3% high would have to have a capacity of 5% high to produce a cross-over frequency 5% low. If the capacitor and inductor were off 5%, but in different directions, the cross-over frequency would be correct, but the circuit Q frequency would be different, resulting in a different attenuation characteristic.

It is possible to reduce the number of turns required for a given inductance by using iron core in place of air. The design of such a device for other than wave filters is comparatively simple, since exact values of inductance are not required; for example, a filter choke for power supply.

In comparing air core to iron core for dividing networks, we find that iron core offers a saving in space and cost, has lower d-c resistance, and is less affected by surrounding objects, especially when they are iron. The difficulty here is the design of the magnetic circuit. The a-c permeability of the core material must remain absolutely constant throughout the operating range. An ordinary coil with iron core will change its inductance with different voltages across its terminals, and it is also affected by frequency. The tendency is for the inductance to increase as the applied voltage is increased, and, at the same time, the lower the frequency, the greater the inductance. Such a coil would naturally be unsuited for wave filters.

However, the problem has a solution, and networks have been built that have insertion losses of a few tenths of 1 db, through the pass bands, occupying about

(*Continued on page* 29)

VETERAN WIRELESS OPERATORS ASSOCIATION NEWS

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

REMINISCENCES OF DR. de FOREST

"WHEN a man of my apparent age expresses himself, his readers naturally expect a recounting of history. And in ancient days at least the elder men were supposed to be endowed with a gift of prophecy. Herein I propose to inflict upon you a little of both, for some of my earlier prophecies are now history.

"It is not often the happy lot of a prophet to witness within a few years, or even in his lifetime, the fulfillment of his prophecies originally made before a world of indifference, a world of skeptics. Yet such a situation has come to pass in the radio world. Like a tidal wave, the attitude of press and public, of government officials and business directors, toward radio broadcasting, toward the radio telephone itself, has mounted from the indifference of thirty years ago to a magnitude of interest which I had dimly foreseen in 1907 and '08, and which I had then fondly hoped to witness within my lifetime; hoped to have an active part in bringing to pass.

"American Wireless began with this century. Its growth prior to 1903 was too infantile for comment here. With the reporting of the International Yacht Races that summer, the newspaper reading public began to become aware that telegraphic press dispatches without wires were possible, and possibly useful. At the World's Fair of St. Louis, worthy prototype of expositions many thousands of visitors witnessed the dispatch and reception of wireless messages, first across the Fair grounds, then between St. Louis and Springfield, and finally to Chicago—300 miles overland, establishing for the infant medium a startling world's record here in America.

"But simultaneously, in far Eastern waters, American operators were demonstrating to the whole world the matchless value of wireless in war press dispatching. The London Times dispatch boat, equipped with American apparatus, was by this means scooping in a startling manner the press of the entire world! Then for the first time was the value of wireless in war convincingly demonstrated.

"Not in season, it is true, to be of much service during the World War I, but the exigencies of that war, especially in the United States, brought about an intensive development of power tubes for transmitter purposes which greatly accelerated its perfecting. Incidentally, also, the war developed tens of thousands of radio amateur operators, the necessary nucleus for the rapid growth of radio audiences ready for the advent of broadcasting.

"So incomparably superior has the radio transmitter tube and its circuits proven to all earlier methods, that when the Radio Corporation of America was formed in 1919 all further efforts to develop the gigantic arcs and huge high-frequency electric generators were definitely abandoned.

"Those gargantuan electro-magnets of the post-war arc machines have, however, abundantly justified their existence and design, as alone making possible today that terrific atom smasher, the Cyclotron, the invention of Professor Lawrence of the University of California, which has already added immeasurably to our knowledge of the building blocks of the universe, and potentially of possible aid (by means of neutrons and gamma rays) in cancer research, whose value to humanity may well outweigh that of all long distance radio signalling.

"And so the three-electrode tube, beginning in 1916 and again after the war's radio ban was lifted in 1920, began to bring into existence the instrumentality, destined to be comparable as to its influence on the mind and manners of mankind with the discovery of printing by Gutenberg.

"With the amazing growth of this broadcast idea in only a little more than 20 years, you all are too familiar to render it needful for me to here outline.

"So that today here in America we have over 900 broadcasting stations, the important ones all connected to one of three nation-wide networks, over 50 million radio receiving sets, a radio manufacturing industry which ranks with the largest enterprises in the nation, and all exerting over our Nation's policies, politics and the home lives, and modes of thought, of its citizens, with which you are all so intimately and personally acquainted as to render emphasis here quite unnecessary, and quite hopeless to attempt.

"And what modern radio has accomplished in America it has achieved, only in lesser degree, in all civilized lands. So that the development of the radio today is the most striking example I know of the truth of that homely old adage, 'Great oaks from little acorns grow'. And incidentally, the first audions were suggestive in size and shape of the humble acorn! I can still vividly remember the day, back in 1906, when I strode up Fourth Avenue from McCandler's Lamp factory to my little laboratory at 19th Street, with the entire world's supply of radio tubes in my pocket—just 2 in number!

"Let me call to your attention the fact yet not generally recognized outside of the medical profession and their thousands of patients—the benign field of radio or short wave therapy.

"For the past five years the healing profession has been coming more and more to a realization of the remarkable effects obtained in an amazing array of human diseases or maladjustments by the simple submission of the patient's body or his limbs, to a concentrated electro-magnetic field of high, or ultra-high, frequency. So that today it is estimated that over fifty thousand radio therapy emitters are now in operation, in physicians' offices, in all leading hospitals, on every United States war vessel, and in an increasing number of Army and Veterans Administration hospitals.

"And this obviously brings me again to the value of radio in warfare. Beyond question radio in field and base hospitals, as well as between the national headquarters and the firing lines, will soon begin to prove of a new, benign and life-saving value, most especially for pneumonia victims, in shortening the periods of convalescence, and for restoring the wounded more quickly to service.

"And yet today the tale of RADIO and its multi-fold mission to mankind has scarcely begun to be unfolded.

"I have indeed been fortunate, even beyond all my powers of present realization, to have had a part in its initial unfolding."

NEWS BRIEFS

(*Continued from page* 18)

& Waldstein Company, makers of industrial finishes, Newark, New Jersey. The booklet provides makers of armament products with essential information on M. & W. finishes that have been made to conform with various U. S. Government specifications. Copies will be sent, on request, to engineers, purchasing agents, and others requiring this information.

* * *

RCA ILLUSTRATED BROCHURE

A 44-page illustrated brochure, titled "RCA, What It Is, What It Does," has been published by the Department of Information, RCA. Designed to give a complete picture of RCA's wide scope of activities in radio and electronics, the booklet is now being circulated to a list of several thousand persons in radio and allied fields, government officials, business men and college and public libraries.

* * *

CLUB HEARS ABOUT GIANT OSCILLOGRAPH

At a recent meeting the Radio Club of America heard a paper on the 20-inch Cathode-Ray Oscillograph, by Dr. Thomas T. Goldsmith, Jr., Director of Research of the Allen B. Du Mont Laboratories, Inc., Passaic, N. J.

The giant 20-inch diameter cathode-ray tube oscillograph recently developed by the Du Mont organization has a huge screen that permits a critical study of intricate oscillograms. It also affords a means of demonstrating oscillography, particularly in the lecture hall and classroom.

Among the details dealt with in the paper were operating circuits, special applications for material testing, circuit analysis, circuit time constants, square wave tests, lissajous patterns, frequency measurements, etc.

* * *

BANKS AT NEW ADDRESS

The Banks Manufacturing Company has moved to 1105 West Lawrence Avenue, Chicago, Illinois.

* * *

BUTCHER, CBS V-P, TO NAVY

Harry C. Butcher, Columbia Broadcasting System vice-president in charge of Washington operations, was called to active duty in the Navy as a Lieutenant Commander, USNR.

He is attached to the Office of the Director of Naval Communications.

* * *

GENERAL CEMENT CATALOG

A variety of items for use in maintenance, repair and general shop applications are described and illustrated in the latest catalog released by General Cement Mfg. Co., Rockford, Ill.

* * *

LANGEVIN MOVES

The Langevin Company have moved to 37 West 65th Street, New York City.

* * *

CARBONYL IRON POWDER DATA

Advance Solvents and Chemical Corp., 245 Fifth Ave., New York City, has just re-

(*Continued on page* 33)

THE INDUSTRY OFFERS . . . —

SHAKEPROOF COWL FASTENER

The aviation division of Shakeproof, Inc., 2501 N. Keeler Avenue, Chicago, has introduced a new cowl fastener.

The fastener is said to reinforce rather than weaken the adjacent structural area, presenting no stress hazards, providing limited deflection with high initial axial tension. It is also said to compensate for the usual variation in commercial aluminum sheet thicknesses, and will not bind when used on curved surfaces.

Among the specific applications of this fastener are cowls, fairing surfaces, wing inspection plates, door fastenings, terminal box covers, radio equipment covers, landing gear covers, battery compartment box lids, ammunition and machine gun bay covers, paneling, flooring, etc.

The fasteners are manufactured in two sizes to conform to AN strength classifications 5 and 7 (up to 500 and 700 pounds tension respectively), and with flush, oval and wing head studs. Standard units are available to accommodate total material thicknesses ranging from .035 to .254.

A new 28-page catalog explains the features and advantages of these fasteners and contains complete engineering and procurement data. Engineers, buyers and production men may obtain copies by directing a request on company stationery.

* * *

FIVE KW GENERATOR

A 5-kw generator of the revolving armature type for two or three wire service is now being produced by the Kato Eng. Co., Mankato, Minn.

The design is also available with three phase, three wire and three phase four wire. The latter permits operating three phase equipment and single phase equipment may be operated by connecting from the fourth wire to any one of the three phase wires, the usual voltage combinations being 208/120 or 220/127. Voltage regulation is said to be less than 8%, that is, voltage change between no load and full load with 3% speed change doesn't vary more than about 8%.

* * *

HIGH SPEED AUTOMATIC PRESS

A new Diebel hi-speed stamping press has

(*Continued on page* 25)

been announced by the Di Machine Corporation, division of Diebel Die & Mfg. Co., 3654 Lincoln Ave., Chicago.

The press atuomatically produces small stampings of metal, fibre, plastics and other materials at adjustable high speeds of 180, 370 and 500 strokes per minute. Feeding mechanism is built in and handles strip or coil stock equally well.

A folder may be obtained by writing the manufacturer.

* * *

SOLAR HIGH VOLTAGE FILTER CAPACITORS

Mineral oil impregnated capacitors with a wide range of capacities in d-c voltage ratings from 6000 to 25,000, enclosed in heavy gauge steel containers, welded oil tight and hot tinned, are being manufactured by Solar Mfg. Corp., Bayonne, N. J.

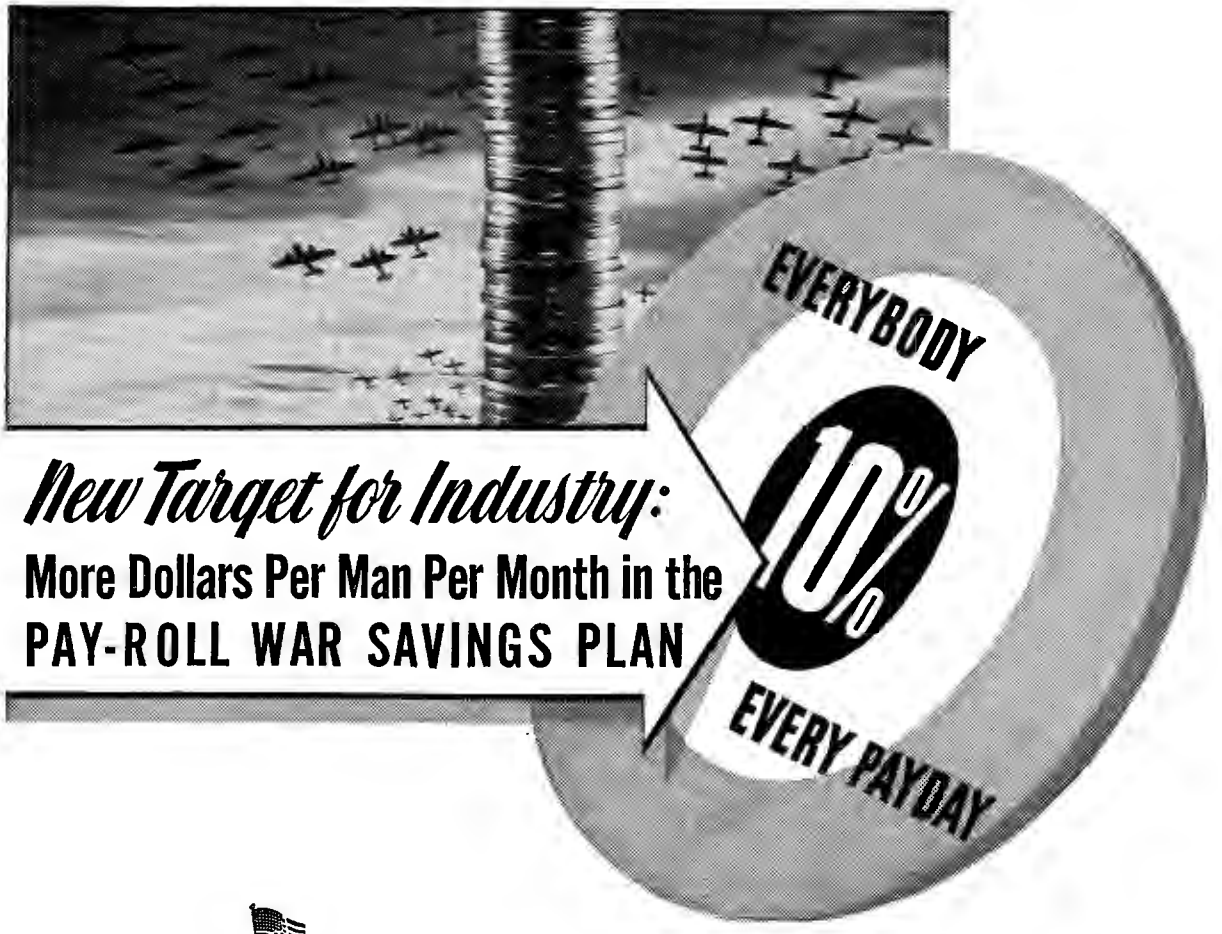
Wet process poreclain insulators are proportioned to withstand potentials in excess of the rated voltage of the capacitor. Case and terminals are bonded together by gasket material, treated to insure an oil tight joint under extreme temperature conditions. Capacitors range from .5 mfd. to 5 mfd., and are known as the Type X J type.

Illustration below shows size contrast of New XJ and smaller capacitors.

* * *

TRAVELING COMMUNICATIONS

Palm microphone, head band receiver and the connecting equipment for the familiar "Walkie-talkie" type equipment is being made by the Kellogg Switchboard & Supply Company of Chicago.



New Target for Industry:

More Dollars Per Man Per Month in the PAY-ROLL WAR SAVINGS PLAN

TO WIN THIS WAR, more and more billions are needed and needed fast—AT LEAST A BILLION DOLLARS A MONTH IN WAR BOND SALES ALONE!

This means a *minimum* of 10 percent of the gross pay roll invested in War Bonds in every plant, office, firm, and factory in the land.

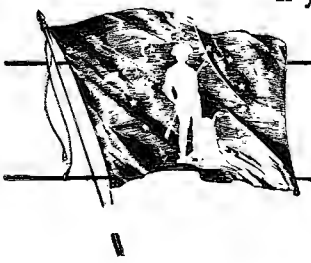
Best and quickest way to raise this money—and at the same time to "brake" inflation—is by stepping up the Pay-Roll War Savings Plan, having every company offer every worker the chance to buy MORE BONDS.

Truly, in this War of Survival, VICTORY BEGINS AT THE PAY WINDOW.

If your firm has already installed the Pay-Roll War Savings Plan, *now is the time—*

1. To secure wider employee participation.
2. *To encourage employees to increase the amount of their allotments for Bonds, to an average of at least 10 percent of earnings—because "token" payments will not win this war any more than "token" resistance will keep the enemy from our shores, our homes.*

If your firm has not already installed the Pay-Roll War Savings Plan, *now is the time to do so.* For full details, plus samples of result-getting literature and promotional helps, write, wire, or phone: War Savings Staff, Section E, Treasury Department, 709 Twelfth Street NW., Washington, D. C.



U. S. War Savings Bonds

This space is a contribution to America's all-out war program by

COMMUNICATIONS

VERSATILE TRANSMITTER

(*Continued from page* 13)

coils are at operating temperature.

Air condensers have proved more satisfactory than mica condensers for plate by-pass in high frequency and high power transmitters. For this reason, the plate by-pass condenser is a three-plate fixed air condenser incorporating a frame partition as one plate.

The plate tank tuning condenser and the output coupling condenser are both individually shielded. The shielding not only makes the circuits less critical to adjust at the higher frequencies, but equalizes the voltages on the condensers thereby minimizing possible flashovers due to misadjustments or standing waves on the condenser frames.

The output coupling circuit connects to a special type balancing network which, except in size, is identical with the one in the r-f driver unit. The use of two tuned and inductively coupled circuits reduces harmonic radiation.

3000-Volt Rectifier Unit

The 3,000-volt rectifier unit is rated at 8 kw and supplies d-c voltages of 3,300, 3,000, 2,800 and 2,200 volts. The rating of this unit is much larger than the power requirement of an r-f driver unit so that capacity is available for supplying two driver units and two modulators simultaneously if desired. It is energized from the 220-volt, 60-cycle, three-phase mains. Six type F-353-A mercury vapor tubes in a three-phase full-wave rectifier circuit are utilized.

Any one of the above mentioned d-c voltages is obtained by turning a handwheel located on the front panel. This handwheel actuates tap switches on the three-phase plate transformer; they connect to taps on the primary windings. It also actuates an interlock switch to open the primary oil circuit breaker and to remove voltage from the transformer before the taps are changed. Voltages of one-half the normal voltages can be obtained by operating the unit as a half-wave three-phase rectifier. A terminal is provided for this purpose, connecting to the neutral point of the wye-connected plate transformer secondaries. One-half voltage operation will be used only when the r-f driver is modulated for telephony or broadcast.

Filament voltages are held constant under line voltage fluctuations by an automatic voltage regulator of the saturated core type.

Tube temperatures are maintained within proper operating limits by a blower operating into a duct which dis-

(*Continued on page* 28)

VERSATILE TRANSMITTER

(*Continued from page 27*)

tributes the cooling air to each tube.

10,000-Volt Rectifier Unit

The 10,000-volt rectifier is a self-contained unit rated at 75 kw and is adequate for supplying a power amplifier and modulator or two power amplifiers. It employs six type F-369-A mercury vapor tubes in a three-phase full-wave rectifier circuit. By replacing these tubes with type F-357-A tubes its rating can be increased to 110 kw. The d-c output voltage is adjustable in five steps, namely, 10,000, 9,750, 7,500, 6,300, and 5,000 volts, by primary taps on the plate transformers controlled by a handwheel with which an interlock switch is associated to disconnect the power whenever the taps are changed. Two power supply sources are required: (1) 220 volt, 60 cycle single-phase for the filaments and control circuits; (2) 2,300 volt, 60 cycle, three-phase for the plate circuit. The filament voltage is stabilized by automatic voltage regulators which also limit current surges occurring when voltage is applied to the filaments. Tube temperatures are controlled by air cooling provided by a blower working into a duct system.

Plate power is applied to the rectifier through a primary oil circuit breaker equipped with undervoltage, a-c over-current and d-c over-current protection. The d-c voltage is supplied to one or both of two power amplifiers through oil switches which can be closed electrically only at push-button stations on the respective power amplifiers. They can be opened or closed manually at the rectifier and are opened automatically when the rectifier plate power is disconnected.

When plate voltage is applied to a mercury vapor rectifier, the filter condenser offers a very low impedance to the transient so that a current surge occurs which frequently damages the tubes in the absence of preventive measures. In this unit, a charging resistor is connected in series with the filter condensers; a relay with normally open contacts operates to short circuit this resistor 1/25 second after the plate voltage is applied.

Puncture of the filter reactor insulation by overvoltages set up by keying or switching transients is prevented by thyrite disks connected between the reactor output terminal and ground. The reactor is connected in the low potential or negative lead to minimize voltage strain on its insulation; it is also protected by a sphere gap.

STATION SAFETY DATA

Since larger cities are particularly vulnerable to gas attacks, because of the pockets formed by skyscrapers, extra precautions are essential, said J. D'Agostino of NBC, recently. Stations should see to it that their ventilating systems and other gas precautions are in order. For protection against gas, suitable chemical warfare manuals are available. These should be studied carefully. The problem of fire protection is one involving more than the mere placing of fire extinguishers about the plant. Not only is personnel training essential, he explained, but it is also necessary to have a full knowledge of the various types of extinguishers. This is important since there are a variety of chemicals in extinguishers, some of which do not mix well with gases, that may also be present during a fire, said Mr. D'Agostino.

In a discussion about bombing, W. P. Mitchell of WJR said that he had made a study of films of actual bombings and reports, and learned that a 500-pound bomb hitting within 200 or 300 yards of a transmitter will smash all tubes by concussion. Thus, he explained, he had set up two additional racks of tubes in the basement on springs capable of floating with each concussion.

DIVIDING NETWORKS

(*Continued from page* 21)

one-half the space of convention types, and built at about one-half the cost.

The most critical test for an iron core device is the intermodulation test, which will show up any non-linearity in the core material.

Intermodulation

Intermodulation is a new dynamic method of measuring distortion developed by the motion picture studios. "Intermodulation" is the term applied to the process whereby two different signals are combined to produce a complex signal. It is similar to the process of modulation whereby audio frequencies are combined with r-f to produce a modulated carrier wave.

To combine two different frequencies, some kind of a non-linear voltage-current device must be used. In radio circuits this takes the form of a plate detector, grid-leak detector, or a simple diode. Such devices are not limited to vacuum tubes, since electrolytic action will do very nicely, as will a copper-oxide rectifier or our old friend galena or carborundum. Even magnetic circuits will perform this function, but this characteristic is a distinct disadvantage in ordinary circuits.

The intermodulation test as applied to sound circuits is produced by introducing two different frequencies, such as 50 cycles and 1,000 cycles, at the input to an amplifier and then examining the amplifier output for the sum or difference frequencies, 1,050 cycles or 950 cycles, etc. Naturally, the output of the amplifier is mostly 50 cycles

(*Continued on page* 34)

A 800 cycle system for home use or small auditoriums

BOOK TALK . . .

FUNDAMENTALS OF VACUUM TUBES

***By Austin V. Eastman*, Associate Professor of Electrical Engineering, University of Washington. . . . 584 pp. . . . New York: McGraw-Hill Book Co. . . . . $4.50.**

In this second edition, an effective engineering analysis of vacuum tube laws and applications, as of current practice, is presented. As in the previous edition, a simple knowledge of calculus suffices for an understanding of the mathematical analyses.

There are twelve chapters, devoted to electronic emission; construction of vacuum tubes; high vacuum thermonic tubes (diodes, triodes, multi-grid tubes, etc.); gas-filled thermonic tubes (diodes, triodes, screen grid tubes); photosensitive devices (photoelectric tubes, photoconductive cells, photovoltaic cells); special types of tubes; rectifiers; the vacuum tubes as a control device (high-vacuum tubes, gas-filled tubes; photoelectric tubes); audio frequency amplifiers (voltage amplifiers, power amplifiers); radio frequency amplifiers (voltage amplifiers, power amplifiers); oscillators (power oscillators, frequency controlling oscillators, miscellaneous oscillators), and modulators and demodulators (amplitude modulation, square-law modulators and demodulators, linear modulators, linear demodulators, miscellaneous modulators and demodulators and frequency and phase modulation).

The text is well illustrated with 463 illustrations and 15 tables.—*OR.*

• • •

GASEOUS CONDUCTORS

***By James D. Cobine*, Assistant Professor of Electrical Engineering, Harvard University. . . . 606 pp. . . . New York: McGraw-Hill Book Co. . . . $5.50.**

For those engineers interested in high voltage work in the lamp and tube industry, this is an appropriate text book. There are three parts, the first of which discusses the physical concepts of the kinetic of gases, atomic structure, ionization and emission. The second part covers a study of space charge, breakdown of gases, and the characteristics of the spark, glow and arc discharges. In the last part, the engineering applications of discharge phenomena in circuit interrupters, rectifiers, light sources and oscillographs are analyzed.

In these analyses appears such helpful data as physical characteristics of

rectifiers, of both the glass tube and steel tank types, as well as an interpretation of the effects of circuit constants on the characteristics of arc interruption. Various types of single tube rectifier circuits and the resultant waveforms are also effectively discussed.—*OR.*

• • •

THE SUPERHET MANUAL

Edited by F. J. Camm, Editor of Practical Wireless, Practical Mechanics and Practical Engineering....First American Edition....180 pp....Brooklyn, New York: Chemical Publishing Company, Inc..... $2.50.

In this book we have a simplified discussion of the superheterodyne that should prove useful to the student. Appearing are chapters on fundamentals of radio, problems of selectivity, tube fundamentals, superheterodyne principles, general design data, antenna design, variable selectivity, noise suppression, a-v-c, cathode-ray servicing, etc. —*OR.*

• • •

THE MATHEMATICS OF WIRELESS

By Ralph Stranger....First American Edition. . . . 215 pp. . . . Brooklyn, New York: Chemical Publishing Company, Inc. . . . $3.00.

A simplified presentation of the rudiments of mathematics are offered in this revised edition. Topics covered include arithmetic, algebra, geometry, powers and roots, trigonometry, the mathematics of wavelengths and frequencies, differential calculus, integral calculus, logarithms, the slide rule, curves, etc. The chapter on the slide rule with some effective microphotographs of scales is particularly interesting. Also presented are condensed root tables.—*OR.*

• • •

AN INTRODUCTION TO THE OPERATIONAL CALCULUS

By Walter J. Seeley, Chairman of the Department of Electrical Engineering, Duke University....167 pp....Scranton, Pennsylvania: International Textbook Company....$2.00.

A new and effective interpretation and analysis of operational calculus is offered in this new book. The development of the text in this book has been prepared for the undergraduates, but it is also suitable for the practicing engineer.

The contents include differential

(*Continued on page 32*)

(*Continued from page* 31)

equations; first order linear differential equations; higher order linear differential equations; operational methods of solving differential equations; solution of equations by the partial fraction method; circuit analysis; alternating electromotive forces; the heaviside expansion theorem and operational methods; circuit analysis by operational formula; non-unit function emf's, and a table of formulas, including Carson's expansion theorem, gamma functions, operational formulas for sinusoidal emf's.—*OR.*

• • •

ACOUSTIC DESIGN CHARTS

By Frank Massa, B.S., M.Sc., in Charge of the Acoustic Division, The Brush Development Company. . . . 289 pp. . . . Philadelphia, Penn.: The Blakiston Company. . . . $4.00.

Those engaged in the construction or design of electro-acoustic equipment will find in this compact volume one of the most complete series of design charts ever published. In the 107 full-page plates, displaying over 750 curves, acoustic theory has been converted into practical data of quantitative value which may be used without complex computations and interpretations.

Treated are the fundamental relations in plane and spherical sound waves; attenuation of sound and vibration; mechanical vibrating systems; acoustical elements and vibrating systems; radiation of sound from pistons (direct radiator loud speakers); directional radiation characteristics; reverberation and sound reproduction; exponential horn loud speakers, electro-magnetic design data, etc.—*OR.*

• • •

TABLE OF NATURAL LOGARITHMS

By National Bureau of Standards. . . . 1941 XVIII plus 501 pp. . . . Washington, D. C.: United States Department of Commerce, National Bureau of Standards. . . . $2.00 (buckram binding).

The present tables extend the range of all existing tables of natural logarithms and provide a smaller tabular interval. They will be particularly convenient for engineers and other practical computers who have frequent use of natural logarithms and wish to obtain them with the least possible effort and time. The tables are not intended to take the place of the common logarithms as a multiplying and dividing tool, but rather to

furnish values of natural logarithms where directly needed.—*OR.*

TABLES OF THE MOMENTS OF INERTIA AND SECTION MODULI OF ORDINARY ANGLES, CHANNELS, AND BULB ANGLES WITH CERTAIN PLATE COMBINATIONS

By National Bureau of Standards....1941 XIII plus 197 pages....Washington, D.C.: United States Department of Commerce, National Bureau of Standards....$1.25

These tables were computed at the suggestion of the Technical Division, Bureau of Marine Inspection and Navigation, Department of Commerce (recently transferred to the Coast Guard, Navy Department) and should be of value to engineers who use combinations of plates and rolled shapes in the design of structures. The last 14 pages contain schedules of properties of plates, ordinary angles, channels, etc.—*OR.*

NEWS BRIEFS

(Continued from page 23)

leased an effective technical loose-leaf brochure on G. A. W. Carbonyl Iron Powders. Among the data included are distinguishing and fundamental characteristics of iron powders, graphs of relative Q values as against frequency of Carbonyl Iron Powders, powder metallurgy and a discussion of applications.

Featured, also, are unusual photomicrographs of various types of iron powder. These photos have magnifications of from 400 to 2,000. The brochure includes a listing of literature on powered irons for reference requirements. Available to engineers only by written request on business stationery.

WE SEE . . .

(Continued from page 2)

hundreds of thousands of petitions will await such signatures that will undoubtedly be pouring in. Signed petitions will be returned to the manufacturer, who will in turn do the rest. Such concerted action, in which the utmost of cooperation is assured, is certain to prompt action!

THERE'S A NEW BOOKLET out called "Plant Efficiency" that everyone should read. It's been published by the Division of Information of the WPB and is available from regional and local offices of the WPB in 120 cities. Offices of the Division of Information, OEM, can also supply. Chapters in the booklet deal with lighting, maintenance and repair, cutting tools, government standards, plant protection, pooling facilities, priorities, conversion, etc. Nuff sed . . get your copy today!—L. W.

DIVIDING NETWORKS

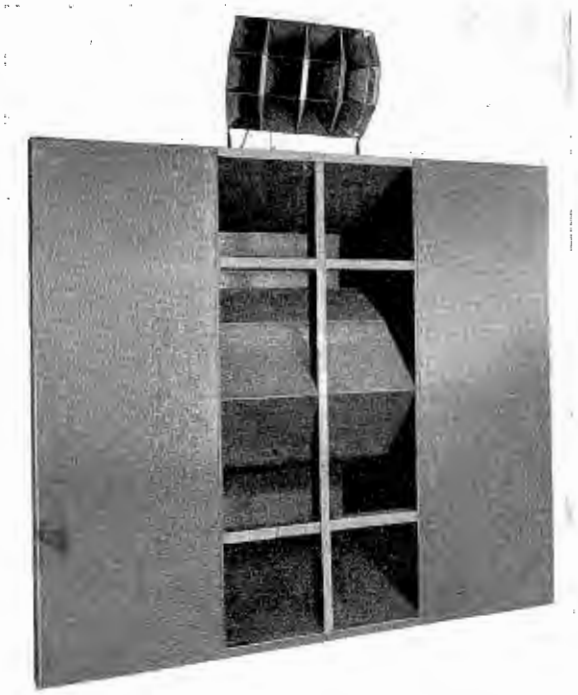
(Continued from page 29)

and 1,000 cycles, but if intermodulation is present, there will be some modulation products of frequencies other than 50 cycles or 1,000 cycles. These frequencies can be separated by the use of filters and measured to quite a high degree of accuracy in the intermodulation measurement.

One of the most common offenders in distortion is the magnetic circuit such as is used in audio transformers, especially at low frequencies where the flux density usually rises to an excessive value. In the case of a transformer with iron core, current flows in the primary circuit, magnetizing the core material, producing in turn, voltage and current in the secondary circuit. Where high flux density is reached, the flux is not proportional to the current. This is called a non-linear characteristic and will result in a change of wave form, whether it is a 60-cycle power transformer or a microphone transformer. The distortion as determined by the intermodulation method is expressed as a ratio of the desired (50-cycle) signal to the undesired (1,050-cycle).

As mentioned previously, the capacitors from necessity have to be measured for exact capacity. Leakage is relatively unimportant as long as the impedance is low (such as 12 ohms), and the inductances maintain themselves if the number of turns is exact.

After assembly, the unit is given ordinary mechanical inspection along with insulation breakdown. The final performance test is unique in accuracy and simplicity. A sine wave of the cross-over frequency is applied to the input terminals and a dummy load connected to the output. The high-frequency section goes to the vertical plate of a cathode-ray oscillograph, the low-frequency section to the horizontal plate, and the common point is grounded to the oscillograph. If the network is perfect, the voltage across each load resistor is equal, making a 45-degree trace on the screen. Any error in inductance or capacitor, or any mistake in wiring, is at once apparent. Phase difference is shown by an ellipse rather than a straight line. The "filter type" networks all show an ellipse, inclined at 45 degrees (Figure 8). The inclination of the trace shows the relative amount of signal across the load resistors, while the opening in the ellipse shows the phase difference between the two circuits. A difference in phase means that the signal will arrive at the speaker voice coil terminals at different times and that they may partially reinforce or cancel one another. Obviously, this is most important near the cross-over frequency. The space phasing in a two-way horn system is also quite critical. If the high-frequency units and low-frequency units are connected to the dividing network so that they are out of phase, the two speakers will cancel each other, with a resulting "hole" in the response characteristic at the cross-over frequency. The openings of the high-frequency and low-frequency horns should be approximately in line.



A theatre type speaker system, using four low-frequency units and high-frequency multicell horn with a dividing network system.

Index of Advertisers

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TWO PARTS PER MILLION

The Type 815 Precision Fork is calibrated in terms of the G-R Primary Standard of Frequency. A harmonic of the frequency standard drives a 1,000-cycle motor to which is affixed a paper stroboscopic disc. The output of the fork is amplified and flashes a G-R STROBOTAC, used to illuminate the stroboscopic disc. By counting the number of spots on the paper disc passing a given index per unit of time, the frequency of the fork can be measured to within a few parts per million.

A TYPICAL ILLUSTRATION of the care used in manufacturing and testing G-R equipment is the Type 815 Precision Fork, widely used as a low-frequency standard, in geophysical exploration, general laboratory testing, and in rating clocks and watches. These forks are supplied for frequencies of 50, 60 or 100 cycles. They are calibrated to an accuracy of two parts per million.

The material from which the forks are made is low-temperature-coefficient stainless steel, received from the supplier in the form of bars. As the temperature coefficient of different lots of steel varies, a sample fork is made from each new lot and the coefficient is obtained after a protracted temperature run.

From previously determined mechanical tolerances, the forks are then machined in our shop. The average fork as received from the shop is about two cycles below its nominal frequency. The initial frequency is measured to within one millicycle. From data previously obtained, the amount of material to be milled from the ends of the tines is determined and the fork is returned to the shop for the first rough adjustment. A second check to within one millicycle is then made and if necessary the fork is returned to the shop again for further adjustment. Occasionally a third rough check and adjustment are required.

The fork is then ready for final adjustment and calibration. A hole is drilled and tapped in the end of each tine to receive two adjustable loading screws. The frequency is measured to within one millicycle with both tine holes empty, with an inner tine screw in each hole and then with an outer tine screw set up tightly against the first screw. From these measurements the approximate amount of material to be cut from the tine screws to bring the frequency very close to its nominal value is ascertained.

The fork is then allowed to run for a half-hour at a controlled temperature of 77 degrees F., after which the final frequency measurement is made. Appropriate adjustments of the tine screws set the frequency to within 0.001% of the nominal value. The voltage coefficient of frequency is now obtained. This is approximately 0.005% per volt. The output voltage and harmonic content are then measured.

The forks are then placed in stock. When orders are received the forks are returned to the laboratory and the frequency is measured at a driving voltage of exactly four volts. A calibration certificate showing the exact frequency to within 0.002% at a stated temperature between 70 and 80 degrees F., and showing the temperature and voltage coefficients of frequency is supplied with each fork.

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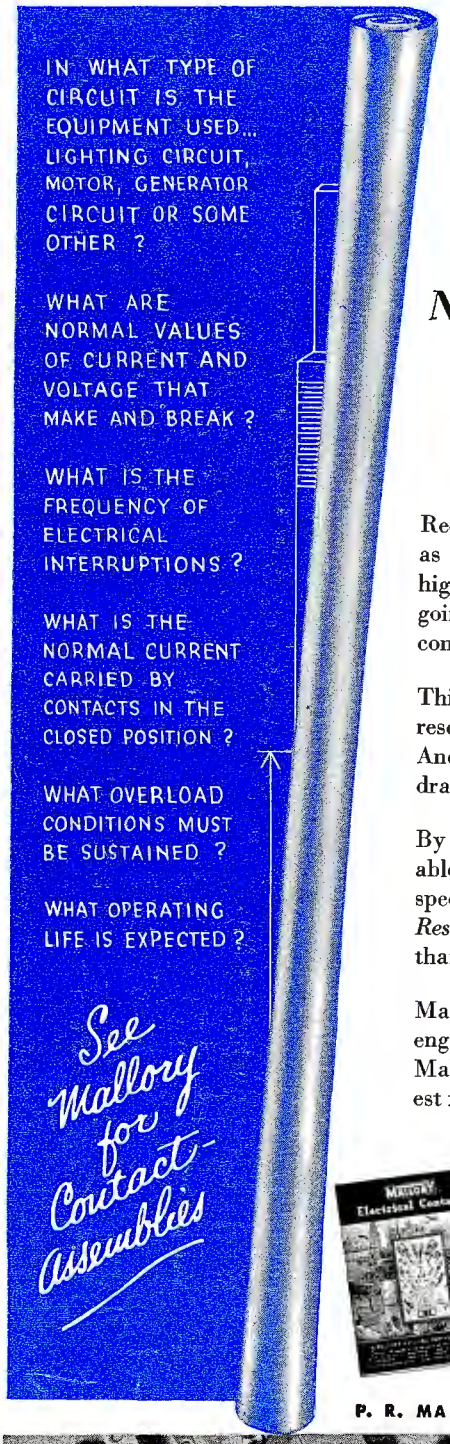

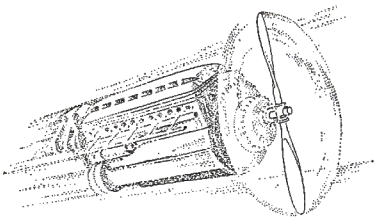

New Aviation Products on Your Schedule?

Write Mallory Complete Contact Assemblies into Your Blueprints

Recently, a company that had used a Mallory-developed alloy, Elkonite, as the contact material for a Diesel engine starting relay . . . carrying a high initial current . . . came to Mallory with a new problem. "We're going into production on aircraft relays—what about some help with contacts and contact assemblies?"

This request was right up our alley. Mallory engineers have been doing research on aviation and other industrial contact problems for many years. And Mallory is delighted to get in on planning when designs are still on the drafting board . . . it usually saves time, money and effort for all concerned.

By working closely with the relay manufacturer, Mallory engineers were able to suggest silver Elkonite for the main contact and Mallosil . . . our special dense, hard silver surfacing . . . for several points in the relay. *Result:* A relay with lower contact resistance and better performance than anyone expected.

Mallory isn't satisfied with just suggesting the right electrical contact. Our engineers know that the contact member may be equally important. So a Mallory Complete Contact Assembly is often the complete answer for highest functional efficiency, electrical *and* mechanical . . . and faster production.

Why not call us in . . . to blend Mallory experience with your blueprints? Your Mallory representative will gladly supply you with full details.

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Complete information on every phase of electrical contact selection, design and service. You need it for your technical library. Write today. No obligation.

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