RADIO-ELECTRONIC Engineering SECTION

RADIO & TELEVISION NEWS

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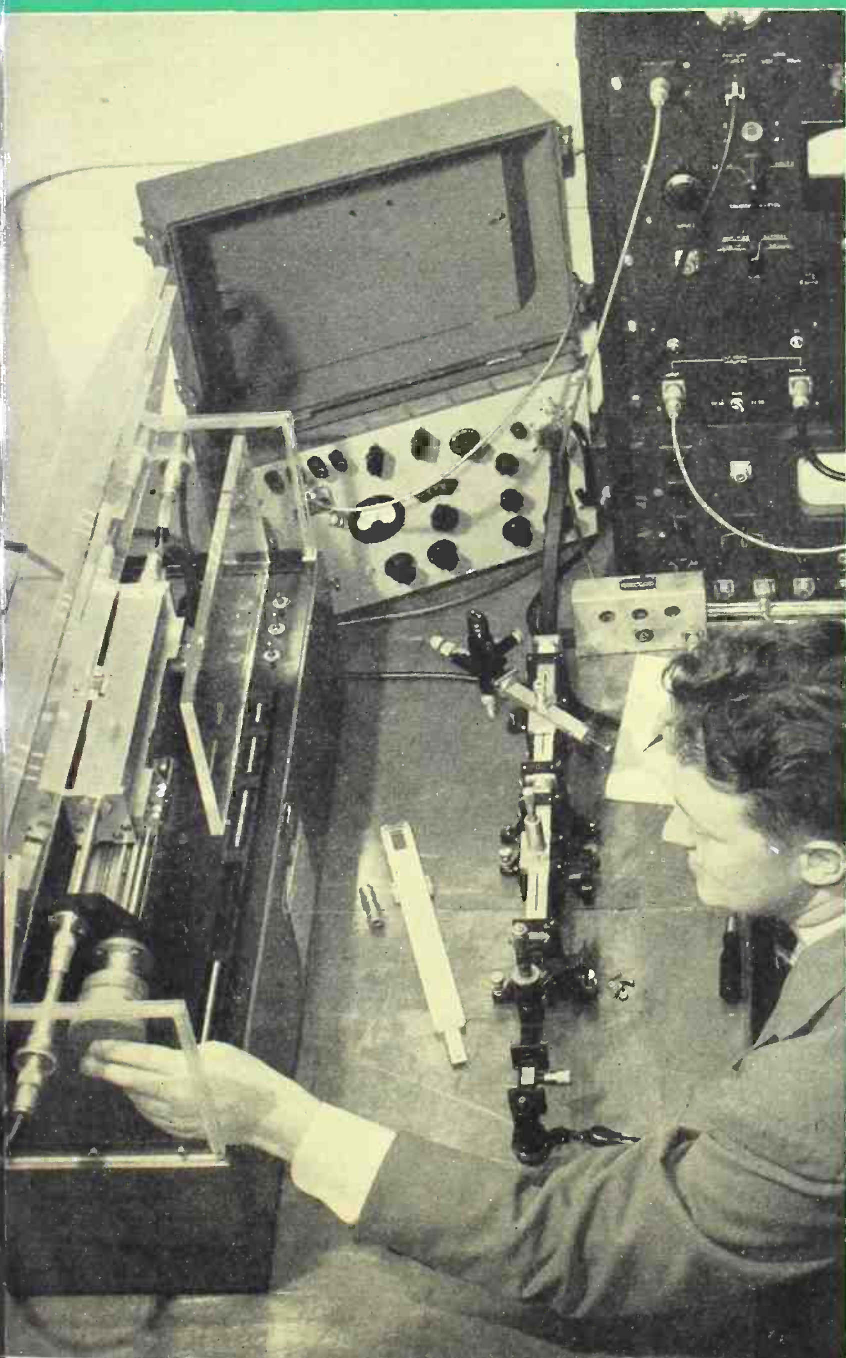

JULY, 1951

DEPARTMENTS

RADIO-ELECTRONIC ENGINEERING is published each month as a special edition in a limited number of copies of RADIO & TELEVISION NEWS, by the Ziff-Davis Publishing Company, 185 N. Wabash Avenue, Chicago 1, Illinois.

← This primary standard attenuator calibrates microwave wattmeters and attenuators for k-band radar test sets in the standards laboratory of the Sperry Gyroscope Co. The primary standard converts attenuation to physical length and uses precision gauge blocks accurate to a millionth of an inch for reference lengths.

Sylvania Tubes help keep U. N. Building free from smoke

Showing chassis of "Vericon" Picture Monitor equipped with Sylvania tubes. These monitors are finding a wide variety of uses today in industries and institutions. They were designed to the exacting requirements of the Remington Rand "Vericon" System and built by Television Utilities Corp.

The problem of smoke at New York's beautiful U. N. Area is being solved with the help of Remington Rand's "Vericon" Industrial Television System equipped with Sylvania Tubes.

In reaching a satisfactory solution, much credit goes to the Consolidated Edison Company, located near by, for their all-out cooperation. Among other preventive measures, this company installed and focused a set of Remington Rand "Vericon" TV cameras on their towering stacks.

These cameras are hooked up to five strategically located viewing monitors—(soundless TV sets)—made by Television Utilities Corp. and equipped with Sylvania picture tubes and receiving tubes.

Every day, these monitors are in operation. If at any time smoke should appear, Consolidated Edison observers on watch immediately operate special controls to clear up the situation.

Writes Mr. A. E. Siegel, President of Television Utilities: *"Our monitors have been running all day long without stop for more than three months. All are equipped with Sylvania radio and picture tubes. We are wondering how long the Sylvania tubes will continue to take this kind of abuse without talking back."*

★ ★ ★ ★

The above is another interesting record of the durability and excellent performance of Sylvania tubes. Let us tell you something about the reasons behind this quality. For full technical data about any types of Sylvania receiving, transmitting, or picture tubes write today to: Sylvania Electric Products Inc., Dept. R-1307, Emporium, Pa. Sylvania Representatives are also located in all foreign countries.

SYLVANIA ELECTRIC

SYLVANIA ELECTRIC PRODUCTS INC. 1901–1951 50th ANNIVERSARY FIVE DECADES OF PROGRESS

TELEVISION PICTURE TUBES; RADIO TUBES; ELECTRONIC PRODUCTS; ELECTRONIC TEST EQUIPMENT; FLUORESCENT TUBES, FIXTURES, SIGN TUBING, WIRING DEVICES; LIGHT BULBS; PHOTOLAMPS; TELEVISION SETS

IMPEDANCE MEASUREMENTS In The 50 to 2000 mc. RANGE

By
R. A. SODERMAN
General Radio Company

Fig. 1. Admittance meter, adjustable-length line, generator, and detector set up for measurements on a stub antenna mounted over a 2-foot square ground plane.

Description and applications of a meter for the direct reading of conductance and susceptance.

THE FREQUENCY range between 50 and 2000 mc. is characterized by the transition between the use of purely lumped-parameter circuits and purely distributed-parameter circuits. The problem of measuring impedance in this range is complicated by difficulties arising from this transition as well as by the widespread use of both balanced and unbalanced circuits and transmission lines. In the lower part of this range, conventional lumped-parameter bridges[1] can be made to operate successfully by careful design which minimizes the stray inductances and capacitances. In the upper part of the range slotted lines are widely used for impedance measurements. Recently two devices have been developed which will operate over a large part of the frequency range under consideration and which have several advantages over both slotted lines and conventional bridges. These instruments are null devices and operate similarly to conventional low-frequency bridges in that the impedance is read directly from dials after balancing the instrument to a null. One of these instruments[2] measures the magnitude of the unknown impedance and its phase angle, over the frequency range from 50 to 500 mc., while the other, the U-H-F Admittance Meter,[3] measures the conductive and susceptive component of the unknown admittance over the frequency range from below 50 mc. to above 1000 mc.

Although the U-H-F Admittance Meter was designed for the purpose of measuring the conductance and susceptance of an unknown circuit, it is very flexible and can also be used to match a load to a line by a null method, to compare directly the impedance of one circuit or component with that of another, and to measure voltage standing-wave ratios or the magnitude of the impedance of an unknown circuit by a voltage-ratio method. When it is used in conjunction with an adjustable-length coaxial line having a uniform characteristic impedance, measurements on antennas and components can be simplified as the correction for the length of line between the unknown and the instrument can be eliminated, and when used with a wide-range balun, accurate measurements on balanced circuits can be easily made over a wide frequency range.

Admittance Meter Principle

In the admittance meter, the currents flowing in three coaxial lines fed from a common source at a common junction point are sampled by three adjustable loops which couple to the magnetic field in each line as shown in Fig. 6.

The coupling of each of the loops can be varied by rotation of the loop. One of the coaxial lines is terminated in a conductance standard which is a pure resistance equal to the characteristic impedance of the line, one in a susceptance standard which is a short-circuited length of coaxial line, and one in the unknown circuit. The outputs of the three loops are combined by connecting all three loops in parallel, and when the loops are properly oriented, the combined output is zero. The device therefore balances in the same manner as a bridge.

At balance the vector sum of the voltages induced in the three loops is zero. The induced voltage in each loop is proportional to the mutual inductance, M, and to the current flowing in the corresponding line. Since all three lines are fed from a common source, the input voltage is the same for each line and the current flowing in each line is proportional to the input admittance. Therefore, at balance:

$$M_X(G_X+jB_X)+M_GG_S+jM_BB_S=0. \quad (1)$$

and on separating the real and imaginary parts:

$$G_X=-\frac{M_G}{M_X}G_S \quad (2)$$

$$B_X=-\frac{M_B}{M_X}B_S \quad (3)$$

These equations show that the conductance and susceptance of the unknown are proportional to the couplings of the respective loops to the conductance and susceptance standard arms and inversely proportional to the coupling of the loop to the unknown arm. If the susceptance standard is made adjustable to allow it to be set to the same

Fig. 2. Front view of admittance meter showing dial and indicator arms which control orientation of the loops.

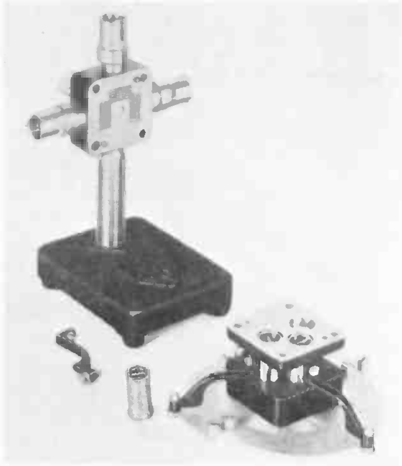

Fig. 3. Internal parts of the admittance meter. Pickup loop assembly has been removed to show coupling slots and loops.

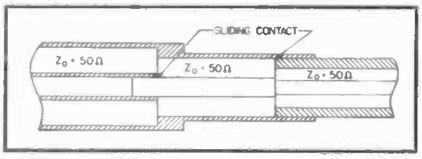

Fig. 4. Cross-section of a constant-impedance adjustable-length line.

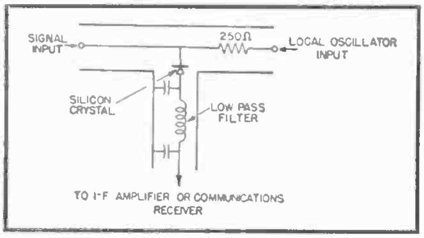

Fig. 5. Circuit of crystal mixer.

value of susceptance at any frequency, the loops can be calibrated directly in the conductance and susceptance of the unknown and in a multiplying factor applicable to both of the other scales with all calibrations independent of frequency. Since each coupling can be varied through zero, theoretically admittances from zero to infinity can be measured, but in the practical case, both extremes are limited by the resolving power of the dials. Fig. 2 shows the calibrated dial and the indicator arms attached to the loops. Fig. 3 is a view of the disassembled unit showing the barrels in which the loops are mounted and the slots in the branch lines through which the coupling is obtained.

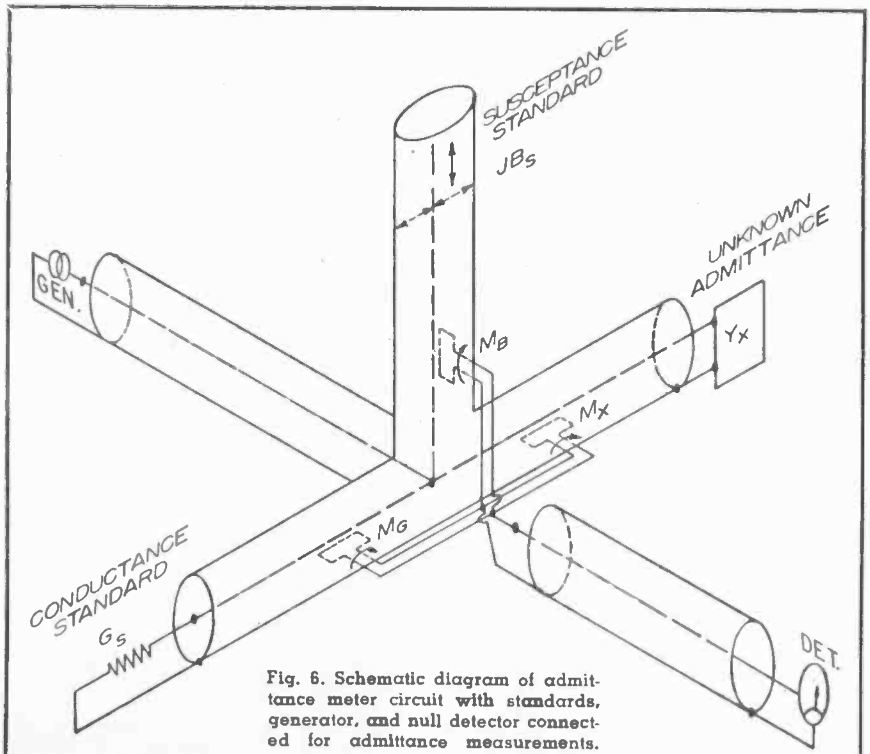

Fig. 6. Schematic diagram of admittance meter circuit with standards, generator, and null detector connected for admittance measurements.

Correction for Line Length

In most high-frequency measuring devices it is not possible to connect the unknown circuit exactly at the point at which the impedance is measured. For instance, even the addition of a coaxial connector introduces a short section of coaxial line between the actual point at which the impedance is measured and the unknown circuit. This length of transmission line transforms the unknown impedance and must be corrected for in order to obtain the true impedance of the unknown. Corrections for the length of transmission line between the point of measurement and the unknown can be made using standard transmission-line equations or a Smith chart[4] calculator.

In the admittance meter, the admittance is measured at a point directly under the center of the multiplier loop and a short length of 50-ohm coaxial line extends from this point to a coaxial connector.

In many types of measurements, for instance in antenna measurements, the unknown must be mounted some distance away from the measuring instrument. Under these conditions a length of transmission line is used to make the connection between the unknown and the instrument, and corrections for the total line length are made in the same manner as outlined for the section of line internal to the instrument. Of course corrections for both the internal and external sections of line can be made simultaneously by adding the two lengths. The total electrical length of line can be measured by short circuiting the line at the unknown and measuring the suspectance seen by the instrument. As long as the loss in the line is low, the electrical length, l, is related to the measured susceptance, B_m, and the characteristic admittance of the line, Y_o, by the expression:

$$l = \text{arc tan} \frac{-Y_o}{B_m} \text{ degrees} \quad (4)$$

It is possible to eliminate the line correction and thus simplify the measurements by the proper choice of the line length. If the total electrical length of the line between the unknown and the point of measurement is exactly a half wavelength, or any integer multiple thereof, and has a uniform characteristic impedance, the measured admittance or impedance will be the same as that of the unknown. If the total electrical length of the line is an odd integer multiple of a quarter wavelength, the measured admittance, Y_m, will be:

$$Y_m = \frac{Y_o^2}{Y_x} = Y_o^2 Z_x \quad (5)$$

where Y_o is the characteristic admittance of the line and Z_a is the impedance of the unknown. If a quarter-wave line is used with the admittance meter, the resistance and reactance of the unknown will be the respective readings of the conductance and susceptance dials, multiplied by 2.5.

The use of this aid to measurements has been restricted by the difficulty in obtaining a simple aperiodic constant-impedance adjustable-length line. Recently D. W. Peterson and W. C. Morrison thought of a simple solution to this problem. A cross-section of a line based on their idea is shown in Fig. 4. In this line the ratio of the diameters of the inner and outer conductors, and hence the characteristic impedance, is a constant at all points along the line. This is achieved by making the inner and outer conductors slide at different points as indicated. In a line constructed, which can be adjusted over a 20 cm. range, the voltage standing-wave ratio introduced in a matched line at frequencies up to 2000 mc. by the insertion of the adjustable line was less than 1.03.

The line can easily be adjusted to the desired length by placing a short circuit at the point at which the impedance is desired. The admittance meter is then set to balance at a short circuit if a half-wave line is desired or at an open circuit if a quarter-wave line is desired and the line length adjusted until a null is obtained. The short circuit is then removed and the actual impedance or admittance measured. Fig. 1 is the admittance meter, adjustable length line, generator, and detector setup for the measurement of the impedance of a stub antenna mounted on a 2-foot square ground plane. Fig. 8 shows the results of measurements made on this antenna over a wide frequency range.

The Crystal Mixer as a Detector

In measurements on radiating systems, leakage between the radiating element and the detector can be a serious problem, particularly at the higher frequencies where most available receivers are poorly shielded. One solution to this problem is to connect a well-shielded crystal mixer directly to the detector terminals and to heterodyne the unbalance signal with a signal from a second oscillator to produce a low-frequency output. The low-frequency signal is then passed through a low-pass filter and detected by a communications receiver or the i.f. amplifier section of a high-frequency receiver. The receiver then does not require good shielding as the frequency it operates at is different from the frequency of the signal radiated from the circuit under test. The low-pass filter prevents high-frequency signals

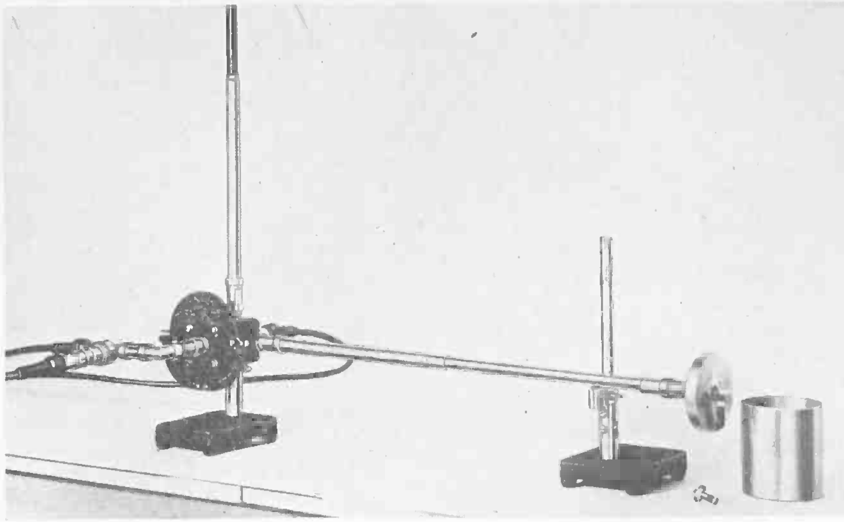

Fig. 7. Admittance meter, component holder, and adjustable line set up for measurements on resistors and capacitors.

from reaching the mixer through the receiver. The crystal also mixes well on harmonics of the local oscillator signal and hence a very wide frequency range can be covered using a local oscillator covering only a two-to-one frequency range. A circuit diagram of a crystal-mixer unit is shown in Fig. 5. The detector used in Fig. 8 is of this type and uses the 30 mc. i.f. amplifier section of an AN/APR-4 receiver as the low-frequency detector.

Components and Lumped Circuits

Over a large part of the frequency range under consideration lumped-constant circuit elements are widely used. A knowledge of the impedance of various elements is necessary in many cases, but unfortunately the measurement of the impedance of components in this frequency range can

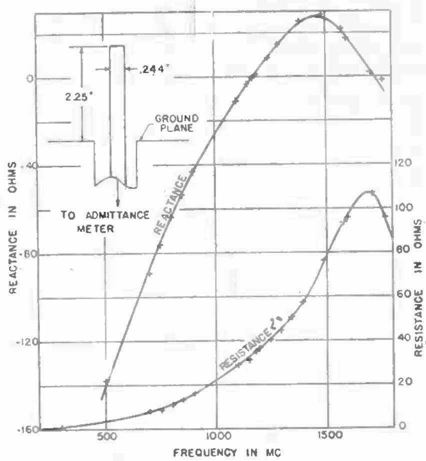

Fig. 8. Measured resistance and reactance of the stub antenna shown in Fig. 1.

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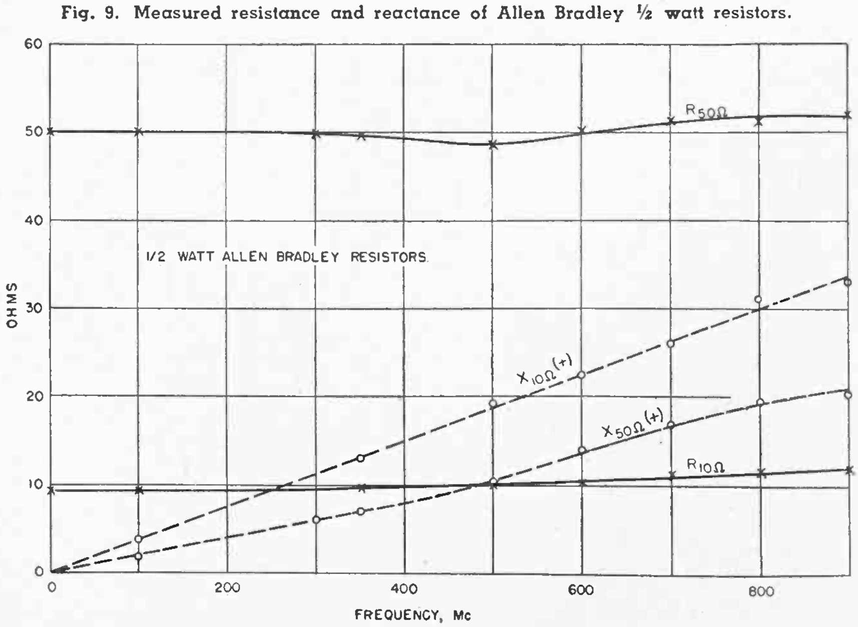
Fig. 9. Measured resistance and reactance of Allen Bradley ½ watt resistors.



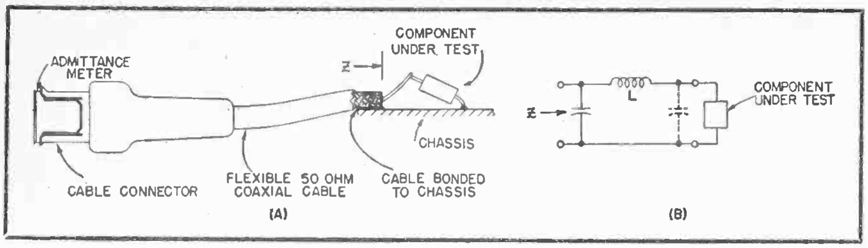


Fig. 10. Sketch of a method of measuring the impedance of a component mounted in a circuit using the admittance meter and a length of coaxial cable.

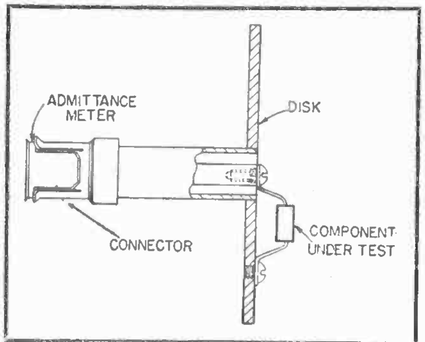


Fig. 11. Sketch of a component holder for measuring components and lumped circuits.

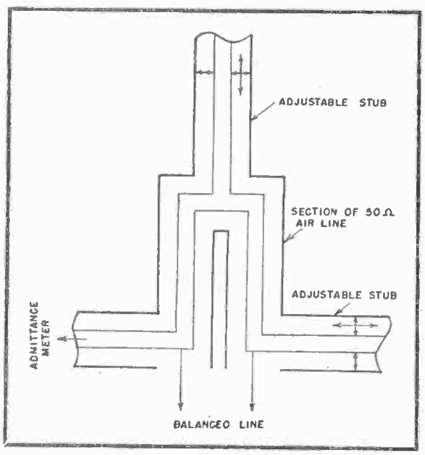


Fig. 12. Sketch of a wide-range balun.

be very complicated. For instance, in many cases the actual impedance of a component or lumped circuit is greatly modified by its physical position with respect to ground or to other circuit elements. Also it is difficult to connect a component to a measuring device without adding some lead inductance or stray capacitance. One method of measuring a component in position in a circuit is by connecting it to the measuring instrument by means of a length of flexible or rigid coaxial line as shown in Fig. 10. The inductive reactance of the lead from the end of the cable to the component under test and the stray capacitance to ground of this lead are measured as part of the unknown. However, if the leads are kept short, the distributed nature of the stray reactances can be neglected and they can be lumped into the *L* section shown in Fig. 10. The measured impedance, $R_m + jX_m$, can be corrected for these stray parameters using the following equations:

$$R_x = \frac{R_m}{(1 - X_m/X_c)^2 + (R_m/X_c)^2} \quad (6)$$

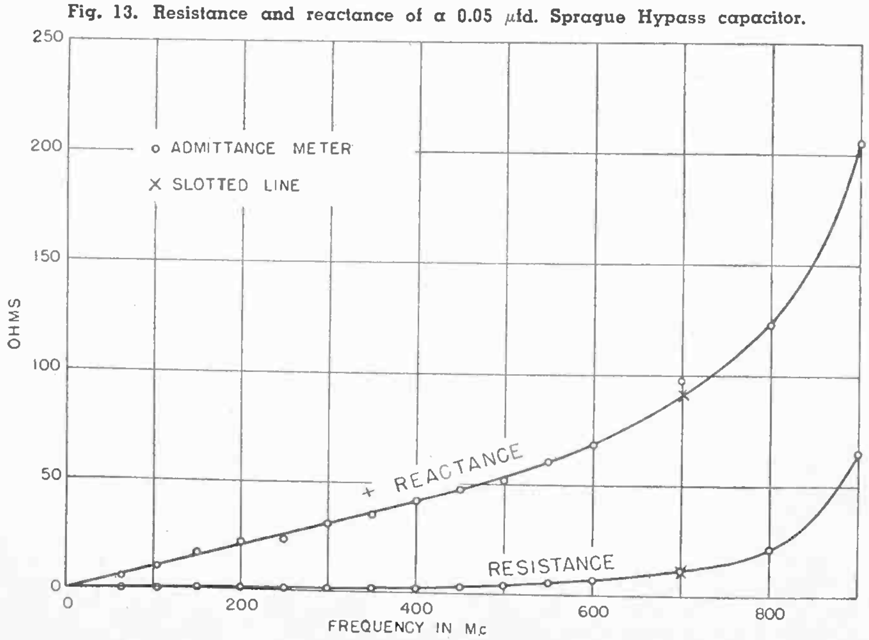
$$X_x = \frac{X_m - \dfrac{R_m^2 + X_m^2}{X_c}}{(1 - X_m/X_c)^2 + (R_m/X_c)^2} - X_L \quad (7)$$

where X_L is the series inductive reactance of the leads and X_c is the shunt capacitive reactance. Since X_c is capacitive, the quantity inserted in the equations will be negative.

The actual magnitudes of the stray reactances can be measured by disconnecting the unknown from the portion of the connecting lead that is not a part of the unknown. The stray capacitive reactance of the lead can be measured by leaving the connecting lead open-circuited and measuring the impedance appearing across the end of the line. The stray lead inductance can be measured by short circuiting the end of the connecting lead to ground without changing its position by means of a large low-inductance strap or sheet. Reasonably accurate results can be obtained using this approximate circuit as long as the capacitive reactance of the lead is at least five times its inductive reactance.

In many cases more accurate measurements can be made using the component holder shown in Fig. 11 on which the component or circuit may be mounted. The end of the center conductor of a section of air line is used as the ungrounded terminal and the outer conductor is extended in the form of a disk for a ground plane. The line can be short-circuited at the terminal by a very low-inductance disk. The component holder in conjunction with the adjustable line and the admittance meter makes a convenient means of measuring many components. Fig. 7 shows a view of such an arrangement set up for measuring *Allen Bradley* ½-watt resistors. Fig. 9 shows the results of some of the measurements. Fig. 13 shows the results of measurements made on a 0.05-μfd *Sprague* Hypass capacitor.

Fig. 13. Resistance and reactance of a 0.05 μfd. Sprague Hypass capacitor.



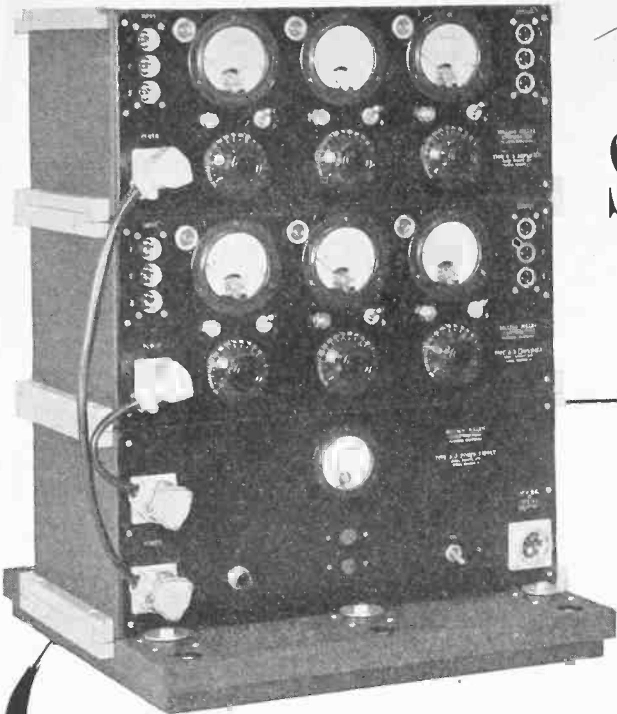
SWR Measurements

Besides being able to measure admittance by a null method, the admittance meter can also be used to measure voltage standing-wave ratio on a 50-ohm coaxial line over a wide frequency range using a voltage-ratio method. For this measurement the susceptance standard is replaced by the conductance standard and the conductance line left open-circuited. The unknown arm is set to maximum coupling, the conductance arm to zero coupling and the relative output voltage measured with the susceptance arm at maximum positive coupling and maximum negative coupling. The ratio of the smaller to the larger of these two voltages is the magnitude of the reflection coefficient. The voltage standing-wave ratio can be easily calculated from the reflection coefficient, Γ.

$$\text{VSWR} = \frac{1 + \Gamma}{1 - \Gamma} \quad (8)$$

(*Continued on page 25*)

CARRIER STRAIN GAUGE SYSTEMS



With low strains or dynamic loading, an a.c. or "carrier" power supply for the strain gauge bridge is superior to d.c.

Fig. 1. Typical commercial carrier type strain gauge amplifier.

By
ALVIN B. KAUFMAN

THERE ARE many methods of measuring the resistance value of a strain gauge. One of the earliest and still used systems is the a.c. Wheatstone bridge. Where the a.c. bridge supply frequency is high and the unbalance bridge output is rectified into d.c., it is termed a "carrier" system, as analogous with broadcast radio.

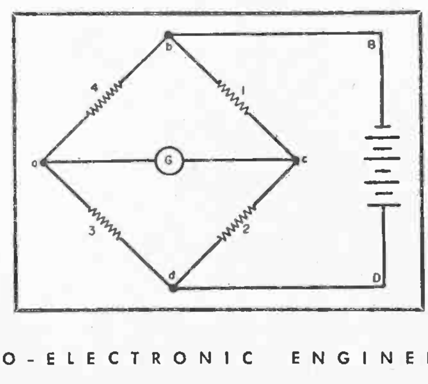
The basic circuit that all the strain gauges are hooked in is a Wheatstone bridge (Fig. 2) having one, two, or all four legs active. By means of this circuit it is possible to differentiate the small voltage changes from the principal voltage drop across the circuit. This is true whether a.c. or d.c. is used to power the bridge circuit. It does not matter what the resistance of the four legs is, just as long as the ratio of 1 to 2 is equal to that of 4 to 3 when a balanced condition is desired.

If #3 were a strain gauge, G could be calibrated to indicate either tension or compressive loads to good accuracy if there were no temperature change, but since temperature changes can cause materials to expand or contract and thus vary in resistance, it is necessary to have both legs #3 and #4 made as nearly identical as possible since the circuit will still remain balanced regardless of the magnitude of change of these two legs if they both change by the same amount.

As discussed in previous literature, the strain gauge consists of a fine resistance wire firmly cemented to a structure, strain or stress being indicated by a change of resistance in the gauge due to tension or compression on the resistance wire.

The d.c. bridge is generally quite satisfactory for the measurement of static loads. Where strain is very low or dynamic loading occurs, the d.c. bridge is not satisfactory. The use of an a.c. power supply on the Wheatstone bridge is a natural step forward, allowing easy amplification of minute strain induced potentials, and making recording of strains of various amplitudes easily possible. To facilitate galvanometer recording, etc., the amplified unbalance bridge a.c. or "carrier" is rectified into d.c. As with any carrier system, the carrier frequency must be ten or more times higher than the signal intelligence to be carried. This allows easy separation of the signal from the carrier and prevents to a large degree intermodulation products from developing. The rectified carrier may be both filtered and attenuated by a tuned filter to put out essentially smooth d.c. whose amplitude depends upon and varies directly as the strain applied to the resistive strain gauge.

Fig. 2. Wheatstone bridge circuit.



The carrier system resolves into three major components: a.c. power supply, bridge circuit (with balancing network), and the amplifier-demodulator.

The design of the bridge a.c. power supply and of the amplifier will depend greatly upon two factors. These are whether the equipment is to be airborne or not, and whether operation shall be from a d.c. or a.c. line supply.

For airborne operation, size, weight, and stability are important considerations, with generally both d.c. and 400 cycle line supplies being available. Because of weight considerations, the 400 cycle line supply is generally used.

Circuit-wise, ground and airborne units may be very similar with power transformer components being the main variation. Problems of stability in both the amplifier and bridge supply are more severe in the airborne operations, where frequent resetting or calibration is not possible.

It is desirable to hold the output of the bridge a.c. supply constant as any variation of supply is reflected into variations of bridge output, thus producing fraudulent strain indications. Likewise, the amplifier gain must remain stable over a wide range of line input voltages to avoid the same trouble.

Calibration of the over-all circuit is possible and should be performed at the

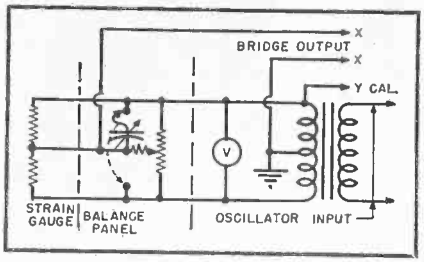


Fig. 3. Schematic diagram of a strain gauge bridge circuit with a.c. input.

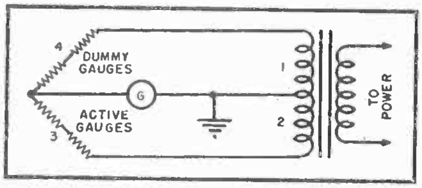


Fig. 4. Typical "half bridge" configuration showing dummy gauge installation.

start and end of taking records, but as indicated, changes of gain or supply must not give fraudulent changes in strain indication while the record is being taken.

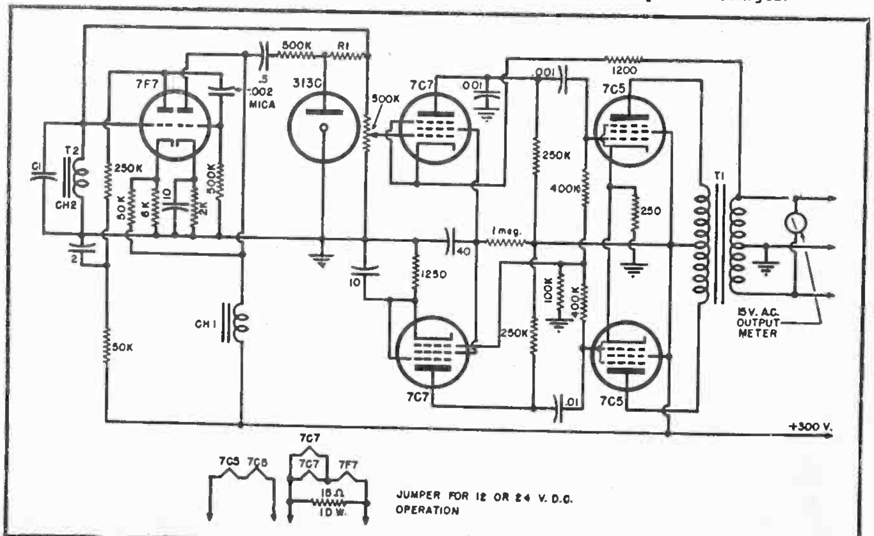
In considering the bridge a.c. supply, it is immediately apparent that neither the commercial 60 cycle nor aircraft 400 cycle line frequencies would be directly suitable for the bridge supply unless output voltage stability was obtained and the engineer would be satisfied with recording dynamic phenomena not to exceed respectively 6 and 40 cycles per second. In aircraft practice it is generally desirable to have a top recording frequency of at least 100 cycles, and so commercial and other privately constructed equipment generally produces a carrier output of 1000 to 5000 cycles. This output must be stable with fluctuating line voltage, and must be adjustable to handle various loads at a specified output voltage without producing excessive harmonic output. Loads may vary from one channel to twenty or thirty, all of which tends to make the engineering design difficult. Inverse feedback is used to help stabilize the gain and control the harmonic content with varying loads.

Frequency control of the bridge supply may be obtained by tuning fork (ground operation only), by Wien bridge, tuned transformer or other well-known devices.

The bridge supply may operate twice as many channels where half-bridge configurations are used. In this configuration, the output transformer must be center tapped, this return being used for one of the conjugate output terminals of the balanced bridge, as shown in Fig. 3.

Unlike automatic balancing potentiometer equipment used for quasi-dynamic strains, the carrier system works with an unbalanced bridge. To control this condition a 50,000 ohm potentiometer is used to adjust the bridge to a resistance balance and then by means of an adjustable trimmer condenser the system is brought to a capacity null balance. (Fig. 3). Having a balanced bridge, the resistance balance dial is turned clockwise, unbalancing it resistively to bring the meter up on scale to the desired point, the amount of adjustment depending upon the gain setting of the amplifier attenuator. To facilitate testing and to assure that a tension reading will go up scale, the resistance balance potentiometer is always rotated clockwise when bringing the meter needle on scale after obtaining the null balance. To make the system uniform, one side of the oscillator power outlet is designated as "tension power" and the other side as "compression or dummy power" with color coding as desired.

Fig. 5. Carrier strain gauge power supply. With proper selection of R_1, unit output is insensitive to variations in heater and plate voltages.



Dummy gauges are gauges that are so mounted that they pick up no mechanical strain yet are mounted in the neighborhood of the active gauge in order that temperature changes will affect both equally, including possible resistance changes in the hookup power leads. For convenience, six gauges are usually mounted on each dummy plate. More than this would result in self-heating of the plate unless it were very large.

The circuit as used commercially is such that legs 1 and 2 are actually the two halves of the secondary of the transformer furnishing the power and are low in resistance. Also the coupling between halves of the output transformer is very high, so that potentials of leg 1 and leg 2 are equal; therefore, any slight short to ground in any gauge will not unbalance the bridge too greatly. Where only tension or compression strains exist in a half-bridge configuration, it is possible to have only one leg of the bridge exposed to strain. The balancing leg is then called a "dummy".

With the a.c. bridge, resistive balancing alone is not satisfactory. Capacity unbalance may exist due to unequal capacity between hookup wires. This will also create an output signal, but this condition can be corrected with the trimmer condenser.

After all channels have been balanced, each is set to the anticipated sensitivity needed. If the trial loadings show a compressive strain to exist on the channel being adjusted, bring the output reading up-scale to the upper portion of the dial by rotating the potentiometer on the balance panel in the clockwise direction, or leave it on a low reading if the preload indicates a tension strain.

The a.c. carrier amplifier system plus a recording oscillograph is the best unit for recording strains when it is desired to have a continuously recorded record of simultaneous forces. The use of the modulated carrier permits the simultaneous recording of steady as well as alternating strain components of all frequencies up to the limit of the carrier or recorder. The present oscillographs for practical reasons such as recording paper emulsion speed, galvanometer driving power and galvanometer resonance characteristics are limited to several thousand cycles per second. For transient and higher frequency response the oscilloscope type of instrument is more practical since it has no inertia problems and can readily use the faster 35 mm. films. With dynamic tests where the strains being recorded may vary rapidly and vary between one another, it would be almost impossible to separate them except for the use of the calibrating switch which, besides giving sensitivity indication, sequences the channels in order. This stepping or calibrating may be performed, and is often advisable to perform, during the record. This carrier system equipment will work equally well recording vibrations, temperatures, pressures, accelerations and direct or reciprocating forces up to the limiting frequencies of the galvanometers. Built within some oscillographs is an amplifier whose frequency output is controlled by a precision tuning fork, and which drives a small synchronous motor. This is directly attached to a small slotted disc which interrupts a beam of light. The number of slots through which the light can pass is adjustable so that the light which passes through reaches the sensitized paper by means of mirrors and a condensing lens to expose parallel 1/3, 1/10, or 1/100 second lines upon it, choice depending upon paper speed. As a precaution one of the galvanometers is often connected so that it will indicate a line frequency wave, giving a double check on the timing.

When used on flight tests or where vibration is common, the equipment must be mounted on shock mounts to protect and prevent vibration from affecting and showing upon the oscillograph records. The shock mounted brackets are attached as nearly as possible to the center of gravity of the equipment.

Concluding, the discussion of the carrier system would not be proper or complete without the inclusion and discussion of typical schematics of the two major components of the system; the amplifier-demodulator (Fig. 7) and the oscillator power supply (Fig. 5).

The strain gauge amplifier is a four-stage resistance coupled unit (any number of which are built onto each rack panel) using two dual triode 6SL7GT tubes. It has an attenuator, designed to give full-scale sensitivities of the output meter of 1, 4, 10, 20, 50 and 100 x 10^{-4} inches per inch of strain, and has an 0-1 ma. output meter using a copper oxide rectifier as a demodulator.

The attenuator steps selected for this design were for aircraft use and may be modified to meet other industrial applications.

There are a number of interesting design notes incidental to this carrier amplifier. The use of copper oxide meter rectifiers over germanium or hot diodes is one point. At normal ambient temperatures of 50 to 100° F their reliability and repeatability of accurate indication has indicated their use over the possibly wider thermal range of other units which would entail a loss of accuracy in quantitative measurements at all temperatures.

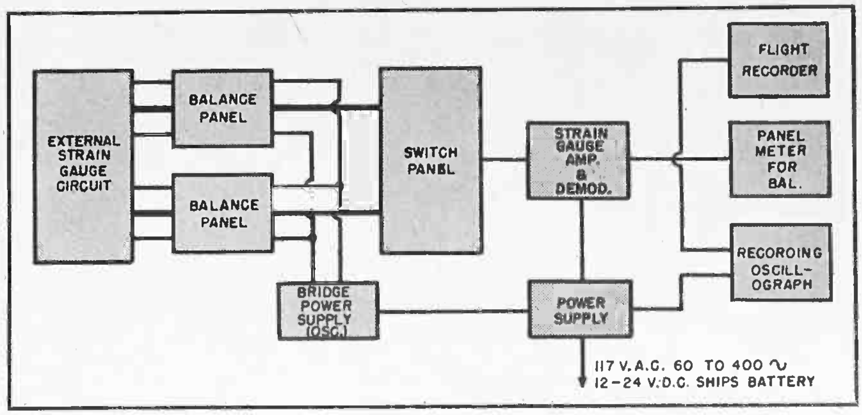


Fig. 6. Block diagram of basic carrier system strain gauge equipment.

In order to make a daily check upon the sensitivity of the amplifier, a switching arrangement has been incorporated into the amplifiers so that one by one a precision resistor is shunted across the compression or dummy side of the bridge, thus simulating a tension strain. This is shunted across the circuit to the gauge on the specimen.

The amplifier incorporates considerable inverse feedback, which is used in the first stage as the first attenuator step, and subsequently with the cascading stage's inverse feedback for stabilizing the amplifier gain against variation of power supply and tube aging.

A selective bandpass filter can be used to help lower stray pickup and hash but with the low impedance input used, this has not been necessary.

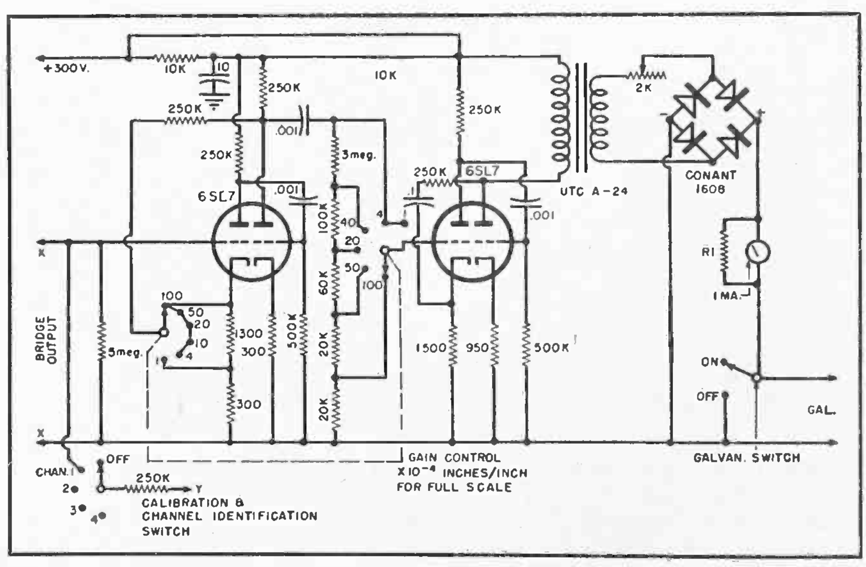
The linearity of the output meter and the calibration of step x1 is accomplished by having a high impedance output and by adjusting the series rectifier resistance to the appropriate value. Calibration of x4 is accomplished by adjusting the value of the feedback resistor in the first stage. The other calibrated attenuations depend upon the use of precision resistors in the attenuator.

It goes without saying that non-inductive resistors must be used throughout the circuit if proper operation is to be obtained in either the amplifier or oscillator unit.

The oscillator unit was designed for mobile operation where both filament and plate potentials might vary considerably. The oscillator output is stabilized by *VR* control "rectification" or peak voltage limiting of its output, while the power amplifier is stabilized by generous inverse feedback. It produces good waveform over a wide range of power supply voltages.

The design of such an oscillator power supply is quite straightforward, providing sufficient inverse feedback is used to take care of the wide range of load impedance. The output transformer is generally specially constructed, a low impedance output (about 30 ohms) carefully center tapped to give a balanced bridge condition when used with half-bridge configurations. Any small unbalance can be balanced out by the strain gauge balancing network.

Fig. 7. Strain gauge amplifier. R_1 is adjusted for proper meter range.



Improved Techniques For Tube Circuit Design

By KEATS A. PULLEN, JR.

Conductance curves provide dynamic information in a useful form for facilitating tube circuit design.

PRACTICAL use of tubes has for years been hampered by difficulty in rapid choice of preferred circuit components when handbook conditions for use could not be met. Recently, however, a method of data presentation permitting more direct design techniques has been developed. Its application to practical problems of circuit design will here be considered.

Standard Design Curves

Design curves supplied by manufacturers usually take the form of a set of plate characteristic curves. These curves show for different values of bias the variation of tube plate current as the plate voltage is varied. The curves supply only static data on tube operation. Consequently application to the small signal problem under chosen static values is difficult.

Dynamic data are made available by some of the manufacturers. These data usually consist of a single plot of transconductance, g_m, plate resistance, r_p, and amplification factor, μ, against grid bias. Since these curves apply at only one value of plate voltage, the data are of limited value.

At least one manufacturer has now recognized the need for more data. He is publishing curves of amplification factor, transconductance, and plate resistance as a function of grid bias at more than one plate voltage. This is certainly helpful. However, considerable interpolation is required even with these. A set of curves permitting direct reading of the required parameter values as needed at any value of bias and plate voltage is the step now needed.

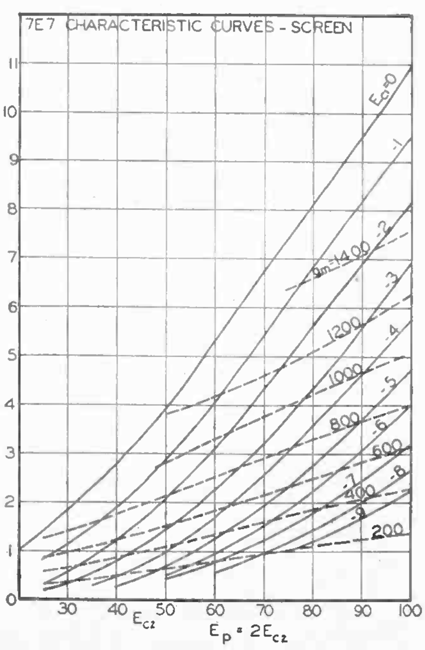
Conductance Type Curves

A form of curve set meeting this need has been presented in the literature.[1,2,3,4,5,6,7] Fig. 3 shows curves for the 6J5 tube prepared in this manner. This curve set carries the usual plate characteristic curves, and also lines along which the values of the transconductance and the plate conductance ($g_p = 1/r_p$) are constant. These additional curves, as will be shown, provide the dynamic information required in a convenient form.

The curves found useful for pentode and tetrode tubes have a slightly different form. Both differences are caused by the fact that plate current in these tubes depends almost wholly on screen voltage and grid bias. The effect of plate voltage on plate current is extremely small. For this reason the plot is here made against screen voltage (Fig. 1) rather than plate voltage.

Where correction is required for the small variations of plate and screen current and transconductance as the plate voltage varies, curves similar to Fig. 2 may be plotted. The screen characteristic curves are plotted with the plate voltage maintained at twice the screen voltage. The correction curves give the multiplying factor for determining the correct value of a given parameter for any ratio of plate to screen voltage. The significance of this will be clarified by the examples which follow.

Fig. 1. Conductance type screen characteristics for the 7E7 pentode.



Some Useful Formulas

Experience indicates that the usual form of the voltage amplification equation is not the most convenient for use with these curves.

$$\text{V.A.} = -g_m R_L/(1 + g_p R_L) \quad (1)$$

Equations in this form apply directly to both triode and pentode tube applications. In many pentode applications this reduces to:

$$\text{V.A.} = -g_m R_L \quad (2)$$

In both of these equations R_L is the load resistance in the plate circuit. Since the curves for g_m and g_p give the respective values in micromhos, the value of R_L should be taken in megohms. Then the answer will work out correctly.

The similarity of this equation to the equation of amplification for a feedback amplifier is rather striking. Comparison of Eqts. (1) and (2) shows that the $g_p R_L$ term in Eqt. (1) is in fact a feedback term. B is the feedback factor.

$$\text{Over-all amplification} = A/(1 + AB) \quad (3)$$

Two other equations, both applying exactly to triodes, of considerable use are those for the cathode follower:

$$\text{V.A.} = g_m R_k/[1 + (g_m + g_p) R_k] \quad (4)$$

and for the cathode degenerated amplifier:

$$\text{V.A.} = -g_m R_L/[1 + (g_m + g_p) R_k + g_p R_L] \quad (5)$$

For the exact form of these equations for pentodes, one should consult reference 7. Use of Eqts. (4) and (5) often is close enough for pentodes, particularly if the value of g_m used in the denominator is taken as approximately 1.3 times the value actually read from the curves. This makes allowance for the effect of screen transconductance.

Triode Applications—Resistance Coupled Amplifier

Discussion will here be limited to the resistance coupled stage. However, extension of the described techniques in the standard way makes design of other forms very flexible.

The first step in the application of the technique to triode tubes exactly parallels the initial step used in normal practice. A tentative load line is drawn. Two convenient locating points for the load line are the point for zero current in the tube, and the point for zero voltage drop across the tube. If zero current flows through the tube the plate voltage is the supply voltage. If the tube is shorted to produce zero drop, Ohm's law gives the current flowing through the resistor with full applied supply voltage. The load line is drawn through these two points.

The next step is to read the approximate values of transconductance and plate conductance at the intersections of the load line with the respective bias lines. Use of Eqt. (1) with these values then gives the actual voltage amplification at each point. Since these amplifications are not average, but actual small signal amplifications, the variation of value indicates the distortion directly. Table II shows a set of data computed for the 6J5 with a 25,000 ohm load resistor and a 250 volt supply voltage. Also included in this table are data for the same tube with an 80,000 ohm load resistor and a 400 volt supply.

One notes that the amplification change from point to point is quite large. For this reason it is often possible to select the desired operating range by inspection from these data. A quick estimate of the distortion may be obtained by use of Table I. Where the exact value of distortion is desired, Eqt. (6) should be used.

$$\% \text{ dist.} = 25\ (A_{max} - A_{min})/(A_{max} + A_{min}) \qquad (6)$$

Use of Table I is as follows. First, the range is chosen meeting the values most nearly. Then the maximum amplification column corresponding most closely to the actual amplification is found. The percentage distortion is read in the row corresponding to the minimum amplification. For an example, take a maximum amplification of 18.5 and a minimum of 13.5. The scale to twenty is chosen. The maximum value is taken as 18, and the minimum as 14. Finding the corresponding column and

A_{min}	0	2	4	6	8	10	12	14	16	18	20	A_{min}
0	—	25	25	25	25	25	25	25	25	25	25	0
5	25	0	8	10	15	17	18	19	20	20	20	2
10	25	8	0	5	8	11	13	14	15	16	17	4
15	25	13	5	0	4	6	8	10	11	13	14	6
20	25	15	8	4	0	3	6	7	8	10	11	8
25	25	17	11	6	3	0	2	4	6	7	8	10
30	25	18	13	8	5	2	0	2	4	5	6	12
40	25	20	15	11	8	6	4	0	2	3	4	14
50	25	20	17	13	11	8	6	3	0	1	3	16
60	25	21	18	15	13	10	8	5	2	0	1	18
70	25	22	19	16	14	12	10	7	4	2	0	20
A_{max}	0	5	10	15	20	25	30	40	50	60	70	

Table I. A table for giving a quick estimate of distortion in a given design.

row in the distortion table gives a value of approximately three per-cent distortion. The two ranges in the table are useful with low and high gain triode circuits and can be used with many pentode circuits. Extension to meet needs of most circuits may be made by scaling all amplifications by a factor of ten or one hundred.

Where it is desirable to optimize operating conditions, several sample load lines may be drawn and tested as indicated. Then allowance of a moderate reserve of voltage output normally yields a successful design.

As a further example of the triode application of this technique, assume that an amplifier offering a high amplification with good linearity were needed. Best linearity of operation will be obtained with the load line parallel to contours for constant g_m and g_p. This is because of the smaller changes of g_m and g_p with bias. A high value of load

Load res. Bias	25k., 250v. Amplification	80k., 400v. Amplification
0	17.6	20.7
-2	16.3	18.3
-4	15.0	17.2
-6	13.2	15.8
-8	11.7	15.3

Table II. Amplification of 6J5 for various values of bias, load res. and plate voltage.

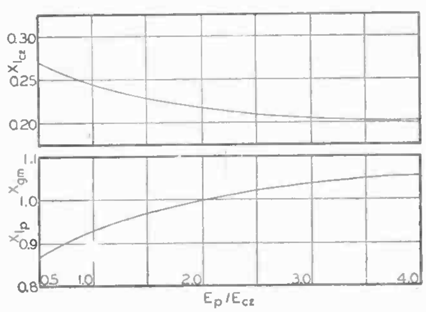
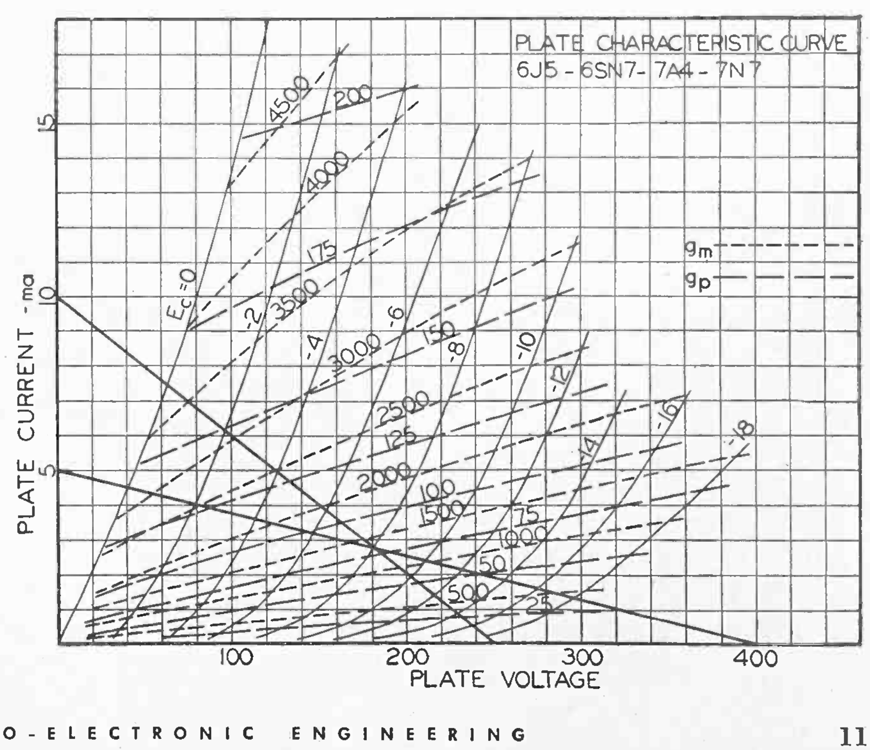


Fig. 2. Correction curves for the 7E7.

Fig. 3. Conductance type plate characteristics for the 6J5, 6SN7, 7A4 and 7N7.



Load Resistance		25,000 ohms	50,000	100,000	200,000
Bias	0	18.6	19.8	20.4	17.2
	-2	16.9	17.6	17.0	16.4
	-4	15.6	16.1	16.2	15.8
	-6	14.2	14.7	14.4	15.0
	-8	13.0	12.9	13.5	13.2
% Distortion		3	3	4	2½

Table III. Characteristic variations in gain for various loads with a plate voltage of 300 v.

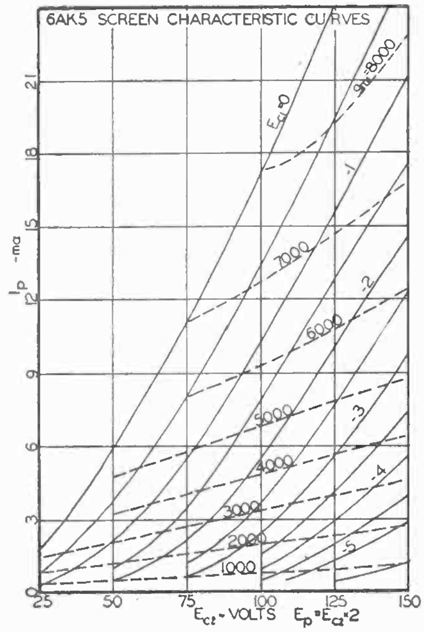


Fig. 4. Conductance type screen characteristics for the 6AK5 tube.

resistance most nearly meets the specified condition.

Characteristic variations for a series of different load resistances with a 300 volt supply are tabulated in Table III. Also included are the approximate distortion values with a signal having a peak amplitude of three volts.

Actual supply voltage requirements depend primarily on the incoming signal voltage. Although some improvement of linearity can be obtained by increasing the supply voltage, above a certain minimum the improvement is small. A series of parallel load lines representing a test load resistance value may be drawn on the chart, and the smallest supply voltage providing the desired linearity chosen. Such a set of curves is shown in Fig. 5. These curves are plotted with R_L = 100,000 ohms.

Use of the triode as a mixer requires choice of conditions offering a rapid change of amplification with bias. This condition is achieved best when $g_p R_L$ is less than or equal to one. One needs as large a change-of-transconductance times load impedance product as can be obtained. The suggested rule gives a fair approximation to best conditions.

Pentode Application

The pentode *R-C* amplifier design technique is similar in many respects to that for the triode amplifier. However, the screen voltage of the amplifier tube is available as an additional adjustable value.

The basic set of curves on the screen characteristic sets present the variation of the plate current with the screen voltage for different values of control grid bias. The auxiliary curves indicate contours of constant transconductance as a function of plate current and screen voltage. Plate conductance contours could be added as in the triode curves if desired. Inclusion of the transconductance contours measured to the screen current conveys more useful information. These curves are needed primarily under conditions of a sort not often met by the average user.

The first step in the design of the pentode amplifier is the determination of the range of screen voltage permissible. The minimum screen voltage is limited by the available signal voltage and the desired distortion. The maximum is determined either by the required frequency response or the need for as great an amplification as possible. Freedom from distortion requires that the plate voltage at minimum bias not drop appreciably below the screen voltage.

As an example, assume that an amplifier using a 7E7 were to be built. The signal input voltage was two volts peak, and the stage distortion was limited to ten per-cent maximum. From Fig. 1, transconductance values and expected distortion values can be obtained.

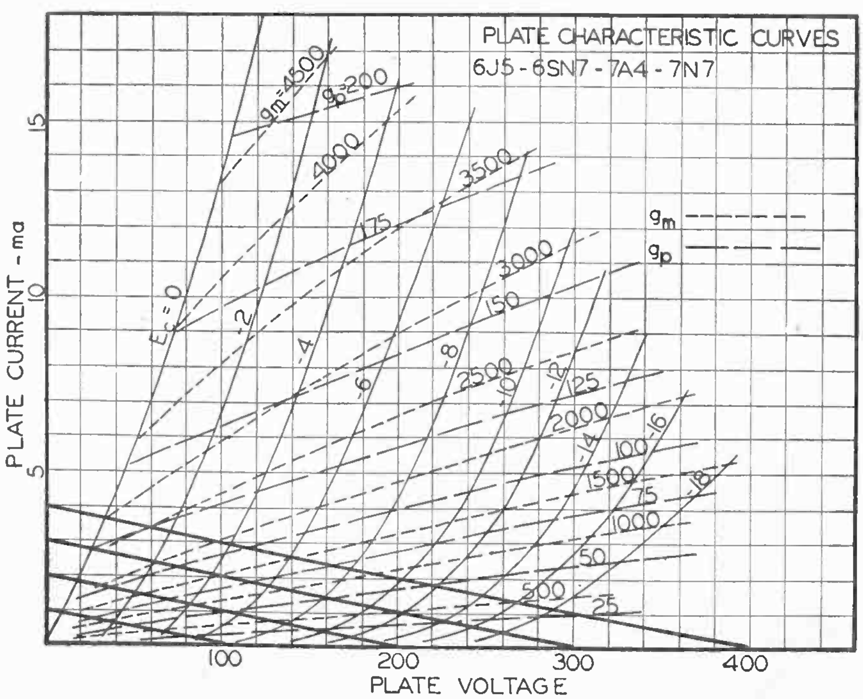
The minimum acceptable screen voltage under these conditions is 62.5 volts. Any value in excess of this up to the tube damage limits would meet distortion requirements.

If the frequency response characteristics limited the load resistance to a tenth megohm and the supply voltage were 250 volts, a design giving maximum voltage amplification can be found. A trial calculation at minimum screen voltage indicates that the maximum load resistance must be less than a tenth megohm. Reading the plate current at zero bias, the required supply voltage for a tenth megohm is $E_b = E_s + I_p R_L = 62.5 + 600 = 662$ volts. Voltage amplification would be 100. In the actual case, 188 volts are available for the load resistance loss. This limits the load resistance to 33,000 ohms. Amplification would be 33.

If the screen voltage were taken as 75 volts, the maximum load resistance determined in the same way is 22,000 ohms. The average voltage amplification is approximately 25.3. With higher screen voltages the amplification available is even less. Consequently the screen voltage should be chosen as small

(*Continued on page* 27)

Fig. 5. Effect of variation of the supply voltage for the type 6J5 and similar tubes.



A SUBMINIATURE L. F. RECEIVER

The new subminiature receiver (left) is the functional equivalent of the World War II airborne unit (right).

This NBS receiver indicates some steps that can be taken to reduce the size of electronic equipment.

A 12-TUBE subminiature radio receiver for aircraft use, continuously tunable from 190 to 550 kilocycles and utilizing a 135-kilocycle intermediate-frequency amplifier, has been developed by Gustave Shapiro and associates of the National Bureau of Standards. This assembly is the functional equivalent of a World War II unit more than five times as large.

With the use of more and more electronic equipment within the limited space of military planes and tanks, reduction of size has become increasingly important. The Bureau of Aeronautics of the Department of the Navy has therefore initiated at the National Bureau of Standards a broad program for subminiaturization of airborne equipment. Designed and constructed as part of this program, the new low-frequency receiver, in conjunction with a previous high-frequency project (a 60-megacycle, 11-tube intermediate-frequency amplifier assembly), effectively brackets the communication spectrum.

The new equipment, a "radio range" receiver used to keep aircraft on course, occupies about 55 cubic inches, whereas the volume of the original version was approximately 300 cubic inches. Characteristics of the receiver include continuous tuning from 190 to 550 kilocycles, intermediate frequency of 135 kilocycles, a sensitivity of 5 microvolts for 6 decibels signal-to-noise ratio, and a power output of 100 milliwatts. The 12 tubes provide two tuned radio-frequency amplifier stages, a mixer, a local oscillator, two 135-kilocycle intermediate-frequency amplifier stages with a bandwidth of about 2 kilocycles, a diode detector, an a.v.c. diode, a beat-frequency oscillator, an audio amplifier stage, and a push-pull-parallel power output stage. All stages operate with 26 volts direct current on heaters, screens, and plates. Under these conditions of operation, four subminiature audio power output tubes are required for adequate power output.

Unusual design problems were presented by the need for hermetic sealing and the high operating temperatures resulting from the very compact construction. Some of the noteworthy features of the equipment are outlined below.

To facilitate mass production, seven detachable subassemblies, each of which can be built independently, are employed in the receiver. This also permits somewhat easier servicing. The subassemblies are fastened to one another and to the front panel, which takes the place of a chassis.

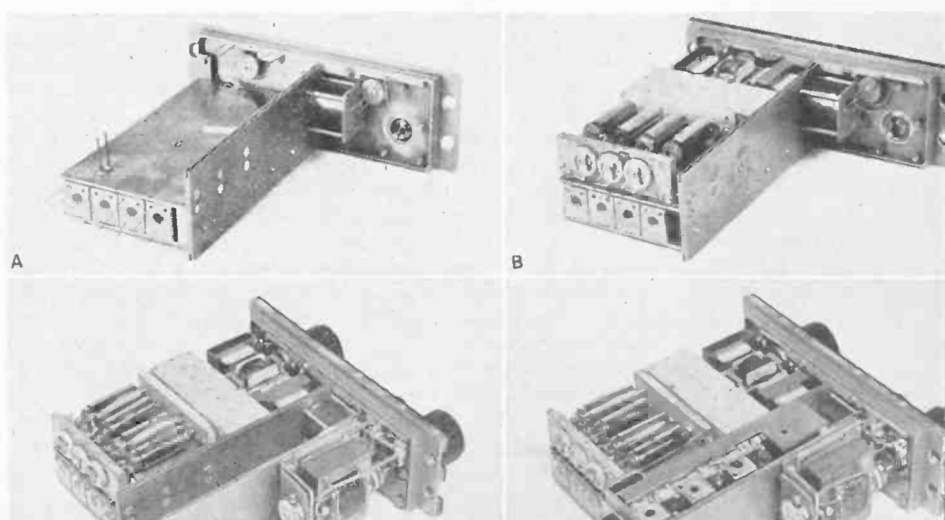
Printed circuits are used to a considerable extent. They are of value both in conserving space and for economical mass production. The wiring is "printed" on steatite or silicone-impregnated fiber-glass.

Hermetic sealing of the entire unit affords protection against moisture and contamination. It also permits elimination of protective coatings for the individual components, which saves space. A soldered copper band seals the housing to the front panel; this band can be removed for repair purposes with a key of the type used for opening coffee cans. The air in the unit was replaced with nitrogen before sealing to prevent any possibility of oxidation.

The bushings of the two shafts projecting from the front panel for control purposes also had to be hermetically sealed, and this presented a serious problem. The solution finally devised

(*Continued on page 27*)

The new receiver is made up of a number of subassemblies. (A) Mechanical tuning assembly and r.f. inductors in place. (B) R.f. amplifier and power-filter assemblies have been added. (C) Output transformer, potentiometer switch and associated hardware in place. (D) Unit is ready for hermetic sealing in nitrogen.



TEST GENERATOR for Pulse Coded Systems

By
DE WITT H. PICKENS and ALBERT A. GERLACH

Armour Research Foundation

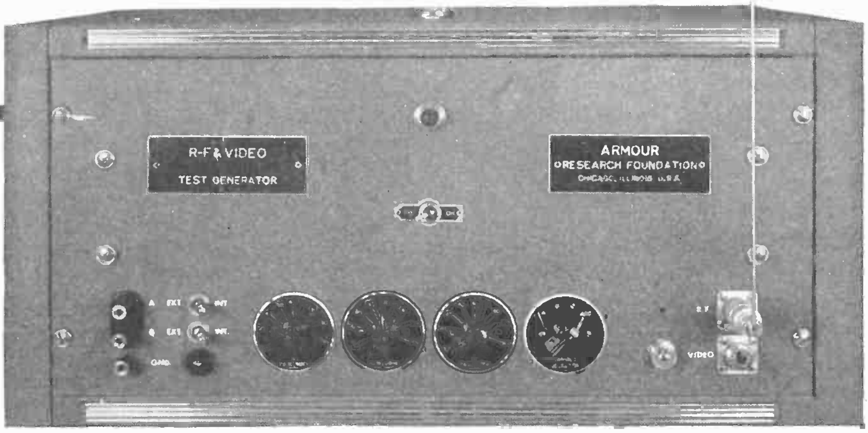


Fig. 1. Front panel view of the test generator.

Details of an instrument for use with pulse coded telemetry or with work involving pulse techniques.

IN RECENT years the advance of electronic instrumentation and measurements into media heretofore unexplored by mankind has established radio-link telemetering as one of the most useful tools of the scientific world. Research is no longer confined to the small bit of stellar space we inhabit but instead it extends out beyond the natural boundary of distance until at last man may feel that he is perhaps a step closer in solving some of the mysteries of this universe. If credit for such expansion could be assigned to any one field it would undoubtedly be attributed to the long arm of modern research—radio-link telemetering.

Hosts of telemetering systems have been used but perhaps the most versatile is the pulse coded system. This system of telemetering is used where a continuous record of intelligence is not required. One of the most familiar systems of this type is the one which is used to transmit intelligence emanating from count-rate phenomena. The use of pulse coding enables the sensing elements to transmit a maximum number of intelligence channels with a minimum of electronic equipment. A common example of this type of system is one which utilizes pulse-width coding wherein all channels of intelligence are transmitted by the same transmitter but are coded by having each separate channel of intelligence transmitted in pulsed form at different pulse widths. In such a coding system the recovery of the intelligence from the transmitted signal is accomplished by means of pulse width discriminators in the decoding equipment.[1]

It is the purpose of this paper to describe a test generator which is used to align and test decoding equipment for pulse width coded systems. The test unit simulates the sensing elements and transmitter and provides a signal which may be used in testing the receiving and decoding equipments.

The test generator to be described in this paper is a modified and extended version of one which was designed and constructed by the Naval Research Laboratories. A photograph of the test generator is shown in Fig. 1. The test generator has three independently adjustable pulse-producing channels which provide either a video pulse output or bursts of r.f. energy equal to the pulse widths. Each of the three channels is provided with a pulse-width control conveniently located on the front panel. These controls may be used to vary the output pulse widths over a range of twenty to one hundred microseconds. An output selector is provided wherein an output consisting of either of the three channels singly or all of them combined may be obtained. Provisions are made to internally initiate all three channels from the sixty cycle power source, each channel being displaced from the others by one hundred and twenty electrical degrees. However, two of the three channels may be initiated from an external source at the desired repetition rate by means of external triggering terminals.

The r.f. section is tunable over a range of from three hundred and seventy five to four hundred and eighty megacycles by an easily accessible tuning control. An output indicator consisting of a neon bulb is provided for visual indication of the output.

Operation Of Electronic Circuits

Fig. 2 is a functional block diagram of the test generator and Fig. 3 is a circuit diagram of the test generator. Basically all three channels of the unit are composed of identical circuitry, hence it is necessary to explain only the operation of a single channel.

The network formed by R_{13} and R_{12} serves as a phase-shift network when the generator is triggered internally from the sixty cycle power source. The network formed by R_1, R_2, and R_3 (see Fig. 3) is a pulse shaping network which provides an exceptionally steep wave front for triggering the pulse generator. This permits the use of low frequency sinusoids as external triggering sources. V_{1A} serves to square up the triggering pulse. This pulse is then differentiated by C_1 and R_4 and the positive spike from the leading edge is used to trigger a monostable multivibrator comprised of both sections of V_2. The width of the output pulse of the multivibrator is varied by varying the time constant of the grid-circuit network by means of R_7. A small variable condenser is provided to allow a minor adjustment in this time constant to bring the range of adjustment to the desired value. The outputs of all multivibrators are mixed in V_{1B}, V_{3B}, and V_{5B} according to the dictates of the output-selector switch S_4. The video output is taken from the cathodes of these mixing tubes.

The output of the mixer tubes is also used to provide plate voltage to the r.f. section which provides bursts of r.f. energy for each video output pulse. This r.f. section is composed of a line type ultraudion oscillator whose quiescent plate voltage is too low to sustain oscillation. The pulses from the mixer tubes supply plate voltage to the oscillator as a plate modulator. An r.f. output is provided by loop coupling to the oscillator plate line.

In radio-link telemetering systems some difficulty is generally encountered in simulating the transmitting section in order to align and test the receiving and decoding equipments. This paper has described a test generator which will serve this purpose. While the test generator described herein was designed and constructed for a particular system, the versatility of the unit allows unlimited extension to include broader systems. The range of pulse width variation may be increased to allow for many more channels of intelligence than the three provided by this unit. The number of channels that may be built into the unit is limited only by the pulse-width and guard-band spectrum of the entire system. This feature may be expanded further by the addition of more than one r.f. section, thus providing a multicarrier system.

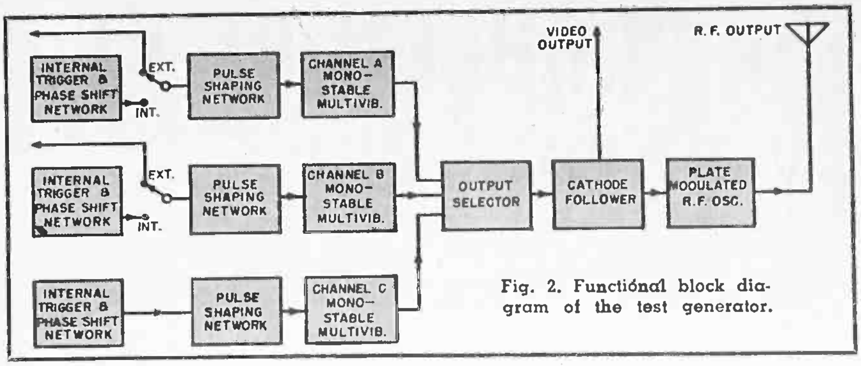


Fig. 2. Functional block diagram of the test generator.

All of these extensions may be easily incorporated into the test generator since they involve no new design but only an increase in the number or range of the component circuits already found in the unit.

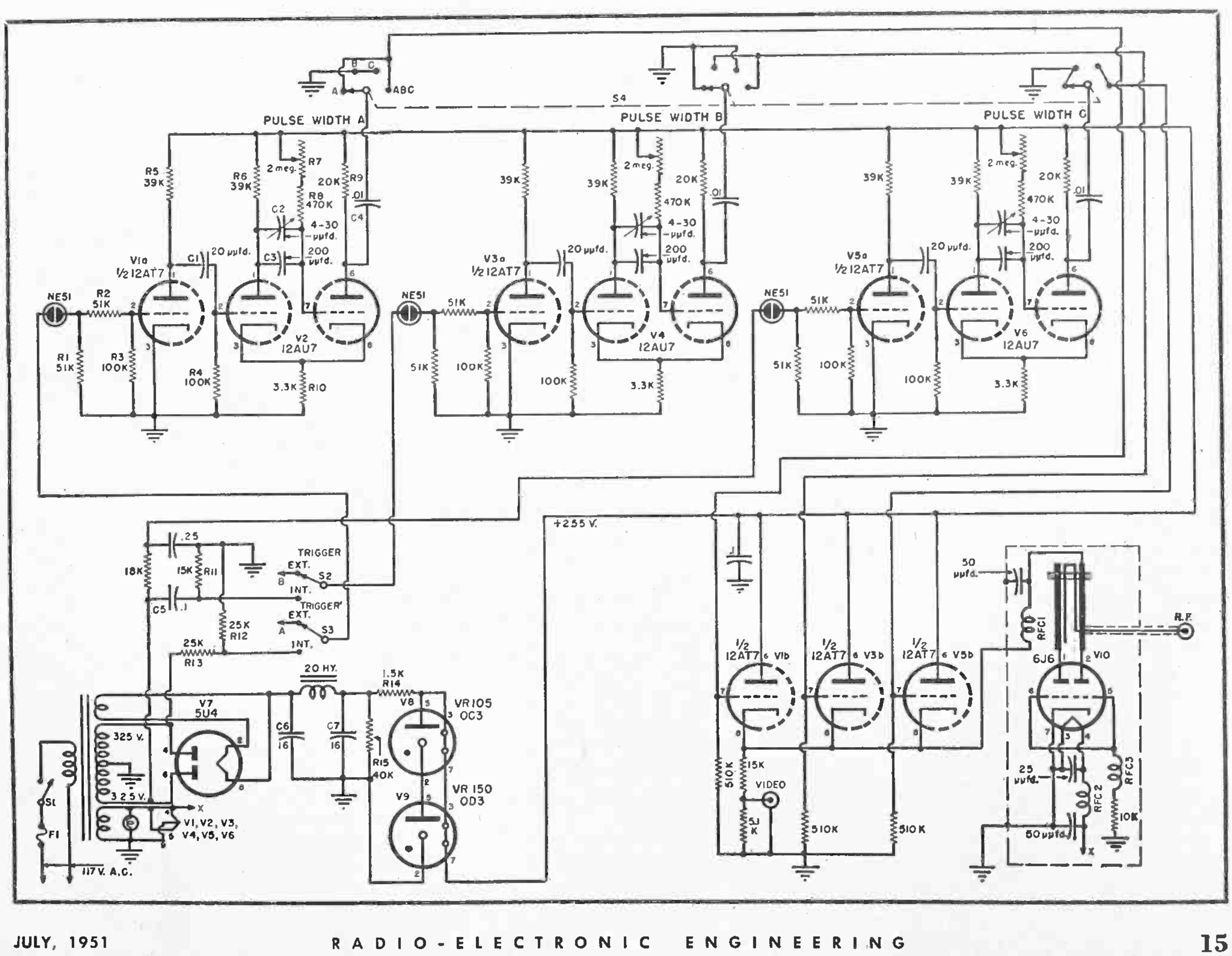
The authors have found that versatility of this test generator and the fact that it is so easily extended makes it a very useful laboratory instrument in work dealing with pulse-coded telemetering systems.

This test generator was developed and constructed under contract with the United States Department of the Air Force.

REFERENCE

1. *Gerlach, A. A., and Schover, D. S., "A Versatile Pulse Width Discriminator," Electronics, Vol. 24, No. 3, March 1951.*

Fig. 3. Circuit diagram and component values for the complete test generator.



The PROBLEM OF RECORDING TV FREQUENCIES

By
JOHN D. GOODELL
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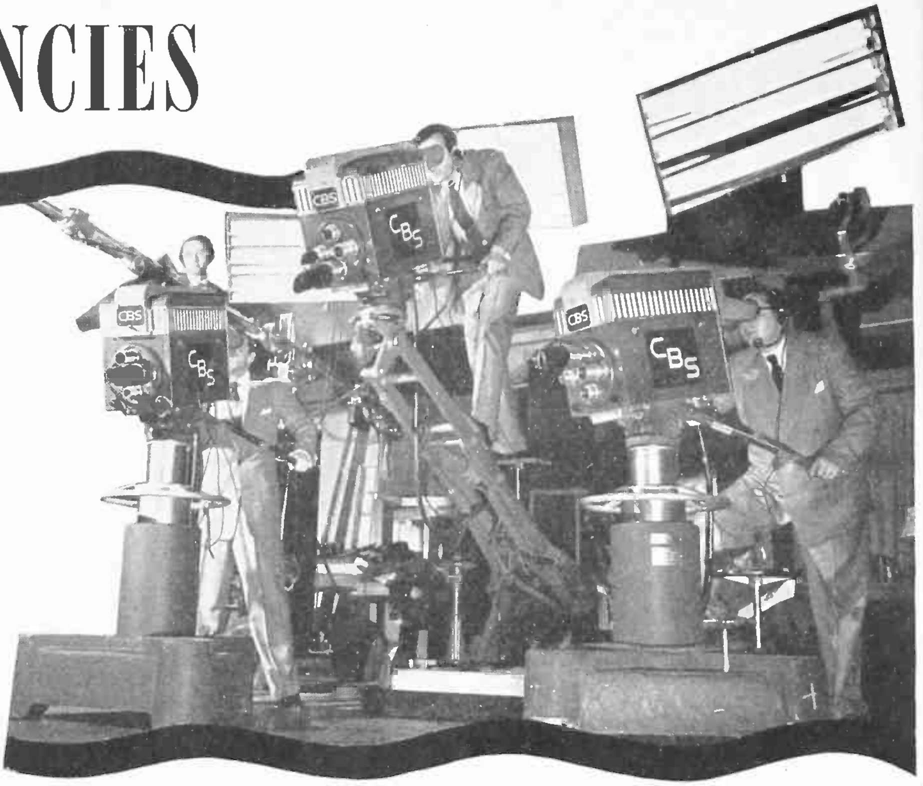


A bank of television cameras in operation at a CBS studio.

The recording of TV picture information for playback on conventional TV receivers presents a challenge.

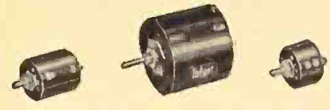
EVERY engineer dreams, at one time or another, of finding the solution to an important problem in a manner that is unique, reasonably simple, and readily marketable. In this era there are many such problems to be solved. A particularly interesting group involves finding methods for the recording and reproduction of the intelligence contained in extremely high frequency signals. The most obvious application is the recording of television programs. There are a number of reasons why this project should have importance, not the least of which is the fact that various people competent to do so have conservatively estimated that a really satisfactory development along these lines should be worth, say, fifty million dollars. This is a large enough financial goal to be interesting not only to individuals but to very large corporations, and undoubtedly a great deal of work along these lines is going on in many laboratories. To date no one has announced a complete solution.

The initial reaction to this may be that motion picture film is a very satisfactory and obvious method, and why look further? Another is that home movies never became particularly popular and there is no reason to believe that recorded television entertainment would be any more successful.

An answer to the first question is that motion picture film is expensive, and it is certainly a requirement of any new process that it be low in cost. One reason that motion picture film is so costly is that it cannot be used more than once. A medium such as magnetic tape would greatly reduce costs because of the fact that it can be erased and re-used indefinitely. Ideal as motion picture film might seem, it is certainly true that current practice as dictated in part by economics does not yield a satisfactory result. Anyone who has made the comparison recognizes immediately the difference between a live show and a film show. This is not simply a matter of the fact that many movies shown are old and would not be good under any circumstances. It is intimately tied up with the techniques currently used for the recording and reproduction of television shows using this medium. It is involved with the differences in frame repetition rates, with the information that is lost in the scanning process between horizontal lines, and many other factors.

The answer to the second objection is that even if recorded television shows never become popular in the home, the networks would provide a market of very substantial dimensions. It has been estimated that if anticipated growth of television networks is realized, in a matter of a few years the total current output of the film manufacturers would be inadequate to supply sufficient material. Many people were stopped from purchasing 16 millimeter home movie equipment by the inadequacy of available program material, the nuisance involved in setting it up and many other factors that do not apply to television. If there had been as many movie projectors in homes as there are television sets today, the market would have warranted a greater range and higher quality of program material and it would undoubtedly have been supplied. This could, in fact, be the best answer to the motion picture producer's problem. One-shot television shows can hardly support the cost of feature motion pictures, and the need for condensation, provision of intervals for suitable commercial breaks and other factors make it most unlikely that television will ever provide the same kind of entertainment now offered by the movies. No one will question that developments in the radio field, the availability of radio equipment in millions of homes and associated factors provided the foundation for the phonograph record industry as it exists today. The parallel is quite sound. At the beginning of radio broadcasting the record industry began to fail. In a short time the improved facilities widely available for music reproduction brought it back to climb far beyond its previous peaks. There are probably as many television set owners who would purchase added facilities and rent or buy recorded high quality shows as there are radio set owners who have

In this panel are illustrated standard models of HELIPOT multi-turn and single-turn precision potentiometers—available in a wide range of resistances and accuracies to fulfill the needs of nearly any potentiometer application. The Beckman DUODIAL is furnished in two designs and four turns-ratios, to add to the usefulness of the HELIPOT by permitting easy and rapid reading or adjustment.

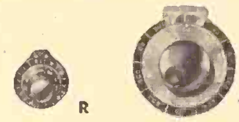


MODELS A, B, & C HELIPOTS
A—10 turns, 46″ coil, 1-13/16″ dia., 5 watts—resistances from 10 to 300,000 ohms.
B—15 turns, 140″ coil, 3-5/16″ dia., 10 watts—resistances from 50 to 500,000 ohms.
C—3 turns, 13-1/2″ coil, 1-13/16″ dia., 3 watts—resistances from 5 to 50,000 ohms.

MODELS D AND E HELIPOTS
Provide extreme accuracy of control and adjustment, with 9,000 and 14,400 degrees of shaft rotation.
D—25 turns, 234″ coil, 3-5/16″ dia., 15 watts—resistances from 100 to 750,000 ohms.
E—40 turns, 373″ coil, 3-5/16″ dia., 20 watts—resistances from 200 ohms to one megohm.

MODELS F, G AND J PRECISION SINGLE-TURN POTENTIOMETERS
Feature both continuous and limited mechanical rotation, with maximum effective electrical rotation. Versatility of designs permit a wide variety of special features.
F—3-5/16″ dia., 5 watts, electrical rotation 359°—resistances 10 to 100,000 ohms.
G—1-5/16″ dia., 2 watts, electrical rotation 356°—resistances 5 to 20,000 ohms.
J—2″ dia., 5 watts, electrical rotation 357°—resistances 50 to 50,000 ohms.

LABORATORY MODEL HELIPOT
The ideal resistance unit for use in laboratory and experimental applications. Also helpful in calibrating and checking test equipment. Combines high accuracy and wide range of 10-turn HELIPOT with precision adjustability of DUODIAL. Available in eight stock resistance values from 100 to 100,000 ohms, and other values on special order.



MODELS R AND W DUODIALS
Each model available in standard turns-ratios of 10, 15, 25 and 40 to 1. Inner scale indicates angular position of HELIPOT sliding contact, and outer scale the helical turn on which it is located. Can be driven from knob or shaft end.
R—2″ diameter, exclusive of index.
W—4-3/4″ diameter, exclusive of index. Features finger hole in knob to speed rotation.

FOR PRECISION POTENTIOMETERS come to Helipot

...world's largest manufacturer of such equipment!

For many years The HELIPOT Corporation has been a leader in the development of advanced types of potentiometers. It pioneered the *helical* potentiometer—the potentiometer now so widely used in computer circuits, radar equipment, aviation devices and other military and industrial applications. It pioneered the DUODIAL*—the turns-indicating dial that greatly simplifies the control of multiple-turn potentiometers and other similar devices. And it has also pioneered in the development of many other unique potentiometric advancements where highest skill coupled with ability to mass-produce to close tolerances have been imperative.

In order to meet rigid government specifications on these developments—and at the same time produce them economically—HELIPOT* has perfected unique manufacturing facilities, including high speed machines capable of winding extreme lengths of resistance elements employing wire even less than .001″ diameter. These winding machines are further supplemented by special testing facilities and potentiometer "know-how" unsurpassed in the industry.

So if you have a problem requiring precision potentiometers your best bet is to bring it to The HELIPOT Corporation, world's largest manufacturer of such equipment. A call or letter outlining your problem will receive immediate attention!

**Trade Marks Registered*

The versatility of the potentiometer designs illustrated above permit a wide variety of modifications and features, including double shaft extensions, ganged assemblies, the addition of a multiplicity of taps, variation of both electrical and mechanical rotation, special shafts and mounting bushings, high and low temperature operation, and close tolerances on both resistance and linearity. Examples of potentiometers modified for unusual applications are pictured at right.

3-GANGED MODEL A HELIPOT AND DOUBLE SHAFT MODEL C HELIPOT
All HELIPOTS, and the Model F Potentiometer, can be furnished with shaft extensions and mounting bushings at each end to facilitate coupling to other equipment.
The Model F, and the A, B, and C HELIPOTS are available in multiple assemblies, ganged at the factory on common shafts, for the control of associated circuits.

MULTITAPPED MODEL B HELIPOT AND 6-GANGED TAPPED MODEL F
This Model B Helipot contains 40 taps, placed as required at specified points on coil. The Six-Gang Model F Potentiometer contains 19 additional taps on the middle two sections. Such taps permit use of padding resistors to create desired non-linear potentiometer functions, with advantage of flexibility, in that curves can be altered as required.

THE Helipot CORPORATION, SOUTH PASADENA 4, CALIFORNIA

Field Offices: Boston, New York, Philadelphia, Rochester, Cleveland, Detroit, Chicago, St. Louis, Los Angeles and Fort Myers, Florida. Export Agents: Fratham Co., New York 18, N.Y.

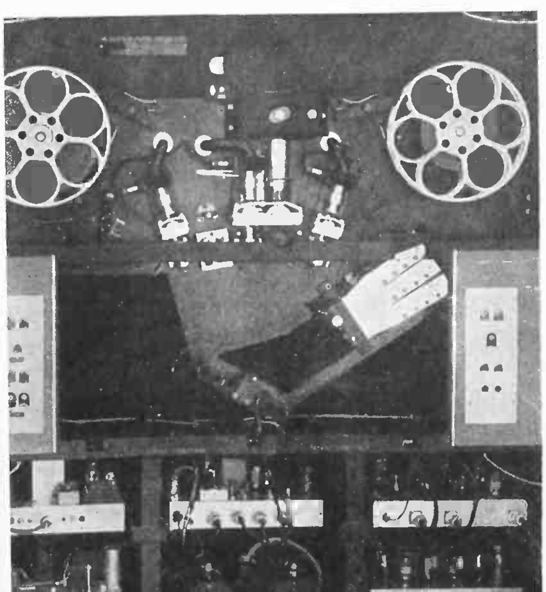
Some form of magnetic recording may solve the problem of recording TV frequencies. Here is some Ampex tape recording and reproducing equipment in use.

phonograph facilities and collect records. It is not a small potential market.

Television recording provides only one of the important applications for some means of recording and reproducing the intelligence contained in very high frequency signals. There is little doubt that the design and development of various types of computers will play an increasingly important part in the growth of all industry and all scientific progress. The principal function of computers is to handle data so rapidly that complex problems may be solved in extremely short periods of time. This applies not only to the handling of statistical studies and mathematical analyses but equally to control functions. It is the speed with which a computer may take dynamic variables into account that makes it superior and important as a control device.

The speed with which data may be manipulated is directly related to the compactness with which it may be recorded. Temporary storage is necessary in many types of problems, and permanent memory of reference tables and experience is essential for many applications. Even the dynamic handling of information is related to the compactness of its representation.

Interior view of the Rapid Selector used by the U. S. Department of Agriculture library.



The accumulated information of mankind is stored principally in books and in libraries of considerable physical size. The cost of details involved in absorbing a book into a large library, with suitable reference and index operations, is measured today in dollars. The physical problem of locating all the references on a single subject places a burden on library staffs that makes satisfactory service to their clients impossible. A partial solution is found in microfilm techniques and devices for rapidly collating microfilmed material for reproduction by photographic methods. This is not necessarily the best solution nor the most convenient and compact means for storing such material.

The same difficulties arise in connection with the files of any large organization. Punched card coding of information is one of the present solutions. Again, it is not necessarily the best nor the least expensive. There are, of course, many potential military uses for these developments that will be readily identified by informed engineers.

Medical case histories, legal decisions, chemical abstracts—the list of applications for compact, readily available storage of information is endless. Printing, photographic, xerographic, magnetic, electrostatic, luminescent, and countless other techniques are currently in use or under investigation. The specific desirable features and apparent limitations of some of these have already been discussed.

It is of some interest to attempt to conceive of the limiting case, and at least a reasonable approximation is found in statistics regarding memory in the human central nervous system. It may be that temporary storage systems, regenerative feedback structures as suggested by Weiner, exist for the handling of data important only in the consideration of a current problem. Most authorities in the field believe that at least all of the total perceptions of the outside world are permanently stored in human memory. It has been determined that the time required for the human system to observe and record a total impression of the world available to the senses at any instant is approximately a tenth of a second. Each of these impressions may include simultaneous informational recording from each of the five senses. If it is true that this information is permanently stored (even though it cannot always be recalled) and if a man's life is considered to be seventy years, the total capacity in numbers of intelligence units that can be recorded is a staggering figure. It is somewhat more than 10^{11}—a hundred billion!

A simple but important concept in connection with the recording, reproduction and observation of intelligence units is the matter of series versus parallel orientation. The units of picture information in television programs are transmitted in series, presented and observed in parallel. The eye observes each static picture of the world with the individual units of information in parallel while dynamic changes are observed in series. This means that if each picture of the world as observed by the eye is considered in terms of the total number of information units contained, the figure mentioned above must be multiplied by a large factor.

In accordance with present practice the horizontal and vertical resolution of television pictures is approximately equal and amounts to about 360 lines along each axis. This takes into account the various losses involved in scanning techniques, the bandwidth limitations and other factors. The number of theoretical units of information possible in each complete picture is then 360 squared, or approximately 130,000. With 16 millimeter movie film this figure is in an order of 150,000 units of information per frame, and with 35 millimeter film about 250,000 to 300,000. There are many factors affecting picture quality that are in no way represented by these figures, and they are totally inadequate as expressions of merit for making comparisons. In some respects television presentation has theoretical advantages over motion pictures with regard to picture quality. It is widely believed that without change in existing basic standards, television may be so improved as to produce pictures with total effective quality equal or superior to 35 millimeter film.

The point under consideration here is the matter of determining the frequencies that must be recorded in order to provide storage for television images of contemporary quality. Since the number of units of picture information now provided corresponds to an upper limit of four million per second, this would appear to be the bandwidth necessary provided the information is to be recorded in series. A square wave signal would be desirable, of course, but would require a bandwidth of around 50 megacycles. The present goal is not to produce recordings superior to existing standards but to be capable of results comparable to those obtained with the top frequency of four megacycles in the form of a sine wave.

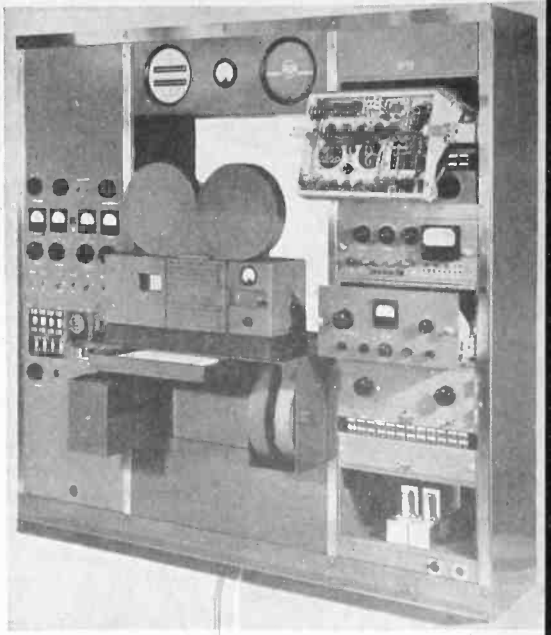
There has been considerable discussion in the literature about dividing the signal up into several bands for purposes of recording. This, in effect, is a matter of partially shifting the signals into a parallel orientation in order to reduce the frequency response required from each channel. This appears very attractive and it may well be that a suitable method will be developed, but it isn't quite as easy as it sounds. The method requires a considerable change in the orientation of television procedures, or it requires systems for changing from series to parallel to series arrangements. Phase shift in this process is an extremely important consideration and seriously limits the methods that may be used. No means suggested to date in the literature appears to be inherently capable of meeting the theoretical minimum phase shift requirements.

It is not too difficult to conceive of methods for recording information at high frequencies. Most engineers familiar with magnetic tape research are aware of several possible methods. It is quite a different problem to reproduce the signals properly. One reason is that many of the methods by which the signals may be closely packed do not lend themselves to the playback characteristics of conventional head designs, or conceivable head designs. Another, perhaps more limiting, factor is involved with the maintenance of registration if a number of channels are to be used. Slight skewing of the tape as it passes over the reproducers is very difficult to avoid, and synchronization between channels is indeed complex. Problems involving tape stability with respect to temperature and humidity that are a nuisance in audio recording become a major barrier at frequencies in the ultrasonic range, and would appear almost insoluble at anything approaching television frequencies. This does not mean that they are insoluble.

There is at least one other approach to this problem, and to all of these problems, that is worthy of careful consideration. Almost all transmission of intelligence is in terms of abstract codes, or codes that are at least partially abstract. This applies to verbalisms, printed words, two-dimensional pictures, etc. Two classes of code information may be considered. In the one class a symbol is completely arbitrary and is in no way representative of the intelligence it conveys except by common agreement. In the other case the code is actually indicative of the meaning attached to it but still lacks complete information. Most verbalisms are in the first category although there are a few words that "sound" like their meanings. In the latter class are the perspective lines seen in a two-dimensional picture that indicate the third dimension and for which the eye has considerable tolerance. Also in this class is the music that comes out of most loudspeakers. It suggests the original music with sufficient accuracy so that the trained observer is able to fill in the gaps from his experience in listening to live programs.

All of these codes represent a condensation of the information units necessary to convey intelligence. To describe a refrigerator to a man from Mars would very possibly involve several thousand words, even assuming that he had some understanding of the

(*Continued on page 24*)

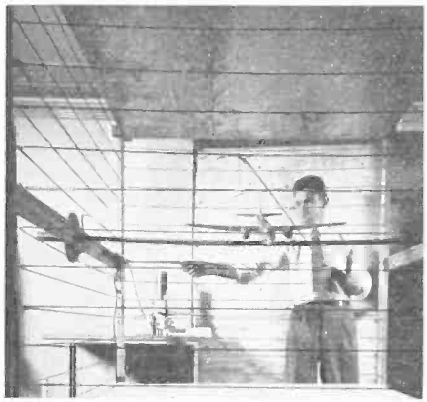


At present, extensive use is made of kinescope recordings. This picture shows some recently developed RCA film recording equipment.

NEWS BRIEFS

STANFORD RESEARCH REPORT

The imperative role organized research plays in a defense economy is cited in the 1950 Annual Report of



Stanford Research Institute, recently released. During 1950 the technical staff worked on 154 projects. Eighty-seven projects established last year were carried on for business and industrial sponsors. Twenty-two new research studies were initiated for government and military agencies.

Extension to lower frequencies of the model technique for aircraft antenna studies is made possible by the staff-developed facility shown, in which electrostatic fields simulate low radio-frequency fields. In the industrial field, SRI has designed an electronic computer, applied a new continuous ion-exchange process to the purification of industrial liquors, and worked on a new principle for color television. Research on the Poulter Seismic Method of geophysical exploration for oil, sponsored by the Institute of Inventive Research, developed a new split-spread technique allowing the use of smaller explosive charges, higher operating speed and lighter equipment.

Four new companies are named in the report as having joined the Institute's Associate Plan, through which funds are subscribed to support development of research facilities and the Institute-sponsored research program.

AUTOMATIC WEATHER STATION

A self-contained automatic weather station which transmits weather data by radio and which can be parachuted from aircraft onto inaccessible territory has been developed by Percival D. Lowell and William Hakkarinen of the National Bureau of Standards.

Named the "Grasshopper", the device was developed during World War II. Designed in the shape of a bomb, and packing its own parachute, the weather station will automatically set itself up and periodically make and transmit weather observations. When the unit is released over a desired location, the parachute is automatically opened by a line rigged from the aircraft. Simultaneously, an electric clock, which controls subsequent operations of the station, is turned on. The impact of landing sets off a small explosive charge which disengages the parachute and prevents the station from being pulled along the ground. A second explosive charge causes the station to rise to an upright operating position and a third explosive charge extends a telescopic

vertical antenna to a height of some 20 feet. The station is then ready for automatic transmission at intervals predetermined by the built-in timing mechanism.

The developmental model had an output of the order of 5 watts. Operating on a frequency in the neighborhood of 5 megacycles, it performed reliably over land at ranges of more than 100 miles. The dry batteries used provided power for transmission of weather reports at 3-hour intervals for more than 15 days.

EDISON MEDAL PRESENTED

Otto B. Blackwell, retired Assistant Vice-President of the *American Telephone and Telegraph Company*, has been awarded the Edison Medal of the

American Institute of Electrical Engineers for "pioneer contributions to the art of telephone transmission".

Presenting the award to Mr. Blackwell (left) is Titus G. LeClair of Chi-

cago, President of the AIEE, with Dr. Harold S. Osborne, Chief Engineer of *A.T. & T.* Mr. Blackwell is the 40th engineer to receive the medal since it was established in 1904.

TV ANTENNA

During the recent IRE Convention in New York, a 14-foot scale model of the new Empire State Multiple TV antenna was unveiled before FCC commissioners and heads of broadcast stations that will use the new antenna.

On hand to witness the unveiling were (from left to right): George Sterling, FCC Commissioner; Comdr. M. W. Loewi, director of the *DuMont* TV network; Frieda Hennock, FCC Commissioner; Lt. Gen. Hugh Drum,

president, Empire State Building, Inc.; Brig. Gen. David Sarnoff, Chairman of the Board, *RCA*; P. B. Stephens, business manager, N. Y. Daily News; E. M. Webster, FCC Commissioner; Kay Burke, "Miss Empire State;" E. J. Noble, chairman of the Board, *ABC*.

PACIFIC ELECTRONIC EXHIBIT

The 7th Annual Pacific Electronic Exhibit to be held Aug. 22-24 at the San Francisco Civic Auditorium will be both a jobbers show and an engineering exhibit, according to latest reports from Al Fry, committee chairman. The Preliminary Program and Exhibitors Directory are now available and the Official Directory will be off the press early in August.

Heckert Parker, Exhibit Manager, expects that manufacturers will be

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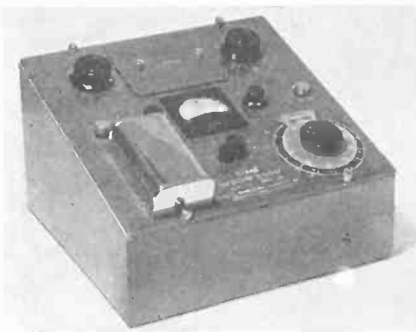
NEW PRODUCTS

MEGOHM BRIDGE

A Wheatstone bridge on which resistances of ten megohms (10^7 ohms) to



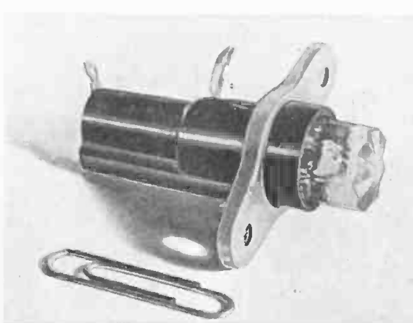
one hundred million megohms (10^{14} ohms) may be read directly is announced by *Special Instruments Laboratory, Inc.*, 1003 Highland Avenue, Knoxville, Tenn.

Measurements with the Model 144 Megohm Bridge may be made with a precision of one tenth of one per-cent over most of the range. Absolute accuracies of considerably better than one per-cent are made possible by a unique circuit which permits the instrument to be checked and calibrated against a set of standard resistors calibrated by the National Bureau of Standards.

The Spinlab Megohm Bridge operates from batteries from which shelf life is obtained and is designed to permit either vertical or horizontal use.

FUSEHOLDER

A miniaturized indicating fuseholder that instantly spots blown fuses and is an ultra compact unit that takes very little mounting space on or behind the panel is now being offered by *Alden*



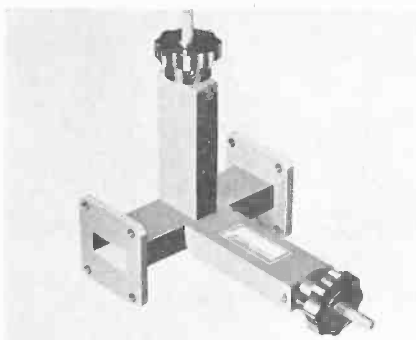
Products Company, 117 North Main St., Brockton, Mass.

The 440-3FH has a neon bulb and double contacts molded as an integral part of the crystal clear lens. The neon bulb glows when fuse blows and can be seen from any angle. Ideally suited to mass production assembly techniques, this fuseholder has generous, easily accessible solder tabs which facilitate wiring and assembly to other circuit elements.

Complete details are obtainable from Norman Curtis of *Alden Products Company*.

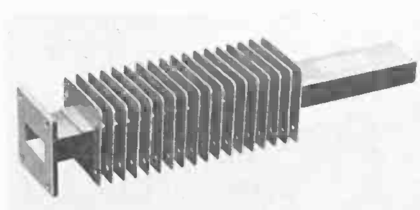
MICROWAVE INSTRUMENTS

The *Hewlett-Packard Co.*, 395 Page Mill Road, Palo Alto, California, has added two precision microwave instru-



ments to its line of wave guide equipment.

The 880A E-H Tuner consists of hybrid wave guide "tee" with movable

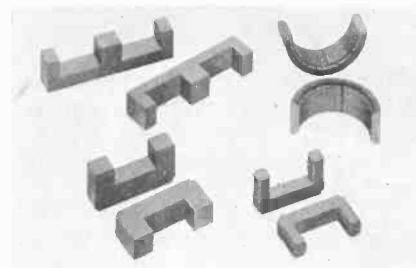


contacting shorts placed in both shunt and series arms. The equipment permits the reduction of VSWR's as high as 20:1 to values of less than 1.02, and is designed for use in tuning out residual VSWR of loads, antennas, bolometer and crystal mounts. This tuner is offered in six wave guide sizes: 3" x 1½", 2" x 1", 1½" x ¾", 1¼" x ⅝", 1" x ½", .702" x .391".

Also offered is the 912A High-Power Termination designed for use as a dummy load for high-power transmitters, in testing vacuum tube characteristics, transmitter output, etc. It consists of a rectangular wave guide section containing a high loss material carefully tapered for low VSWR. The 912A, maximum VSWR 1.1, is offered in sizes 3" x 1½" and 1" x ½". 910A terminations, maximum VSWR 1.06, are offered in six sizes, 3" x 1½", 2" x 1", 1½" x ¾", 1¼" x ⅝", 1" x ½", and .702" x .391".

HIGH PERMEABILITY CERAMIC

A compound of a complex crystalline structure formed by special treatment of selected metallic oxides featuring



high permeability and low electrical losses is now being produced by the *D. M. Steward Manufacturing Co.*, Chattanooga, Tennessee.

The manufacturer recommends the use of this compound, Lavite Ferrites, in television circuits (horizontal output transformer cores, permeability tuning cores, and deflection yokes), antenna cores for radio receivers, toroidal coil cores, electronic computers, high frequency ferrites with printed circuits, 1-200 mc., and high saturation ferrites—5000 gauss.

Additional information on Lavite Ferrites can be obtained upon request from Mr. D. G. Wilson, Director of Sales.

CAPACITANCE METER

A low-range r.f. capacitance meter which enables capacitances from a few hundredths of a micromicrofarad to 100 micromicrofarads to be easily and quickly measured has been announced by *General Radio Company*, 275 Massachusetts Ave., Cambridge 39, Mass.

Type 1612-AL Capacitance Meter has two ranges, 0 to 10 μμfd. and 0 to 100 μμfd., and are switched automatically

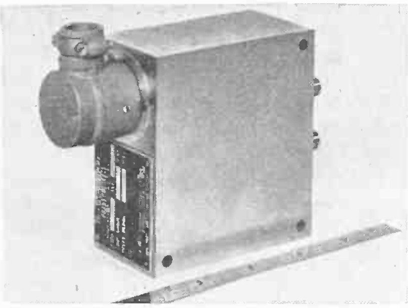
by rotating the main capacitance dial. The instrument has a self-contained 1 megacycle oscillator and resonance indicator. The measurement of tube-socket capacitances as covered by the recent RTMA Standard TR-111 is accurately and conveniently carried out by means of socket adaptors which are available.

This instrument is not limited to measurements on sockets but is useful for measuring ceramic, molded mica, or variable air capacitors of all types. A companion instrument, the Type 1612-A, with ranges ten times those in the Type 1612-AL, can be used to extend the range of measurements up to 1000 micromicrofarads.

PRESSURE CELLS

Baldwin-Lima-Hamilton Corporation, Philadelphia, Pa., has added to its line of standard products differential pressure cells based on SR-4 resistance wire strain gauge measurement.

These cells, identified as Type FMB, are available in two pressure ranges: ±10 and ±20 lb. per sq. in. Maximum permissible line pressures are 50 and 100 lb. per sq. in. respectively. Designed for the standard 120 ohm circuit



and for 300 ohm circuits, recommended input voltages are 6 volts and 12 volts respectively with maximums of 8 and 16 volts respectively. Output at rated differential pressure is 2.000± .005 millivolts per volt input. Cells are temperature compensated for zero and span. Calibration accuracy is within ¼% of full scale anywhere within the rated range.

In addition to differential measurements of fluid and gas pressures, the cells may be used for measurement of flow, liquid level, and other purposes such as determination of airfoil pressure distribution in wind tunnel tests. They may be used with standard *Baldwin* and other indicating, recording, and controlling instruments.

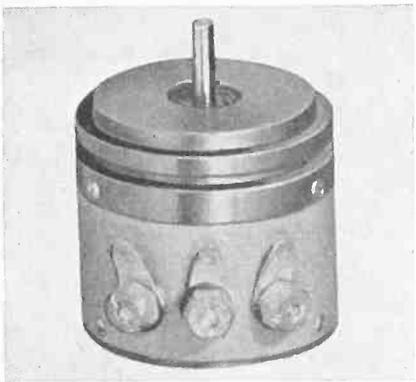
WARNING LABEL

A specially printed pressure-sensitive tape with the radioactivity symbol and the word "Radioactivity" printed in magenta on yellow background (approved radiation warning colors) has been announced by *Nuclear Instrument & Chemical Corporation,* 229 West Erie St., Chicago 10, Ill.

A convenient means of labeling radioactive hazards, chemicals, and containers, this tape is arranged for small pieces to be easily torn off and put onto any surface. Each complete design is 1½ inches long. The roll is 215 feet long, one inch wide, and can be used on a standard holder.

MINIATURE POTENTIOMETER

The *Helipot Corporation* of South Pasadena, California is now in production on a miniature potentiometer of ultra low torque design, with an average starting torque of .005 ounce inches at room temperature.



The unit measures only ⅞ inches in

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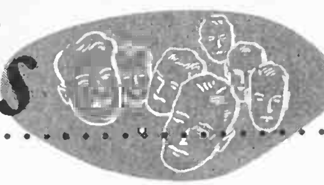
Personals



DR. ROBERT F. BACHER, formerly a member of the Atomic Energy Commission, has been named chairman of the Committee on Atomic Energy in the Department of Defense Research and Development Board. Dr. Bacher is head of the Physics Department at the California Institute of Technology. Co-author of Atomic Energy States, 1932, Dr. Bacher is a member of the National Academy of Sciences, the American Philosophical Society, and Sigma Xi.

GILBERT BRYAN DEVEY has been named Navy Department representative and consultant to the Physical Security Equipment Agency. Mr. Devey was Antenna System Engineering Supervisor at the U. S. Navy Underwater Sound Laboratory and has served as Staff Electronics Engineer to the Undersea Warfare Branch of ONR since 1949. Mr. Devey received his B.S. degree from MIT and studied engineering electronics at Annapolis.

DR. MERVIN J. KELLY, Executive Vice President of *Bell Telephone Laboratories*, has been elected President and will succeed Dr. Oliver E. Buckley who has been appointed Chairman of the Science Advisory Committee of the Office of Defense Mobilization. During World War II, Dr. Kelly supervised the research and development of electronic material and equipment designed for the Army and Navy and received the Presidential Certificate of Merit.

ROBERT F. LAMB has been appointed sales and service engineer for *Esterline-Angus Company, Inc.* Mr. Lamb has been a Sales Engineer in the factory office for several years and was formerly associated with *Electronic Laboratories* as chief draftsman, as a designer for *Whittington Pump Co.*, and as sales agent in industrial chemicals for *The Diversey Corporation.* He studied Electrical Engineering at the University of Minnesota.

F. K. McCUNE, assistant general manager of *General Electric Company's* Nucleonics Department, has been appointed manager of engineering of the company's Large Apparatus Division in Schenectady, N. Y. An electrical engineering graduate of the University of California, Mr. McCune joined *GE* in 1928 and subsequently held positions in the *International General Electric Company* commercial department and in the *GE* West Lynn, Mass. Works.

RUSSELL A. WHITEMAN, formerly with *Tuttle and Kift, Inc.*, has joined the engineering staff of Eugene Mittelmann, Consulting Engineer, Chicago, where he will head research and development in the applied electronics field. Author of numerous technical articles, Mr. Whiteman obtained his E. E. degree from Columbia University. He was formerly associated with *The Bell Telephone Labs., RCA, Bell and Howell Co.,* and *Illinois Tool Works.*

Recording TV

(*Continued from page* 19)

language. To the man familiar with the code the single word is adequate. All information stored in books is stored in coded form. Shorthand is a superior code in the sense that it is more compact than conventional writing but is fully capable of conveying the same intelligence.

Machines may be designed to understand and interpret coded information. Thus, the possibility of recording intelligence that is now represented by a four megacycle sine wave by means of suitable coding of the information units becomes apparent as a possible means of television program storage.

Consider one limiting case where the information involves only the two sequences black-white and white-black. It is not difficult to conceive of a system where the variable amplitude of a single pulse would selectively trigger one of two mechanisms to provide the correct sequence. The other limiting case is defined by the fact that the possible number of pictures that may be presented with 150,000 units of information, each with ten possible shades in the range from black to white, is a finite number. Given a sufficient storage in the receiving device and a sufficiently wide range of variation in some parameter of the individual waveforms in the signal, television programs could be recorded and played back at the frame repetition rate of 30 cycles per second. Somewhere between these two is the practical possibility of reducing the number of symbols that must be recorded and reproduced per second to a figure that is within the limitations of available methods.

There is another aspect of this problem that suggests a solution not dissimilar to the coding system mentioned above. Large sections of picture information are repetitive. Only in sections

The art of disc recording has advanced rapidly, but with present techniques, frequencies are limited to the audio range or somewhat higher. A technician is shown checking the quality of a transcription being made on an RCA professional type recorder, Type 73-B.

of the picture where the detail is fine and where there are abrupt changes in pattern is the upper limit of four megacycles actually required. Large sections of the picture consist of identical repetitive information units. This points out the possibility of somehow providing a mechanism in the receiver that will need only a single triggering pulse at the beginning of each repetitive series. This would leave substantial units of time during intervals where the signal is self maintaining for storage of the information required to produce detail in relatively small areas.

Impedance Meas.

(*Continued from page* 6)

Since the susceptance arm is terminated in the characteristic admittance of the line and the voltage induced in each loop is proportional to the admittance of each line, the output voltage with the susceptance loop set to maximum positive coupling is $K|Y_x + Y_o|$ and with the susceptance loop set to maximum negative coupling, it is $K|Y_x - Y_o|$. The ratio of these two voltages is $|Y_x - Y_o| \ / \ |Y_x + Y_o|$, which is the reflection coefficient.

In high-frequency work it is often necessary to match a load to a line. This can be a very tedious procedure using a slotted line, as the standing-wave ratio must be measured after each adjustment of one of the transformer elements in order to determine whether the match is being approached.

The procedure can be greatly simplified by the use of an Admittance Meter. For this application, the conductance arm is set to 20, the susceptance arm to zero, and the multiplier arm to unity. The matching transformer is then adjusted until a null is obtained. The adjustments can be made rapidly and simply as a continuous indication of the deviation from a match is obtained.

In production testing and also in many laboratory applications it is often necessary to adjust two elements or networks to the same impedance. This can be carried out very simply using the Admittance Meter by setting the controls as outlined for matching applications, but with the standard to which the other elements are to be adjusted substituted for the conductance standard. When a null is obtained the two circuits have the same impedance.

Balanced Circuits

In many devices, such as television receiving antennas and high-frequency aircraft antennas, balanced transmission-line circuits are extensively used. Instruments for measuring balanced impedances are not readily available and at high frequencies it is usually impractical to make three terminal measurements[5] of balanced circuits using instruments which have unbalanced terminals as three measurements are required. Measurements with unbalanced instruments can be made by a single measurement if a balanced-to-unbalanced transformer, called a balun, of the proper type is connected between the balanced line and unbalanced terminals of the instrument. One simple type of balun is a section of coaxial cable a half-wavelength long which is connected between one of the balanced-line conductors and the ground terminal on the instrument. This type of balun has the limitations that each length of line can be used only over a narrow frequency band, and usually the balanced terminals are not symmetrical. Another type of balun[6] which overcomes the difficulties associated with a fixed length of cable is shown in Fig. 12. This balun is a semi-artificial half-wave line made up of short sections of air line and adjustable stub lines or capacitors. The stub adjustments required to make the line exactly equivalent to a half-wave line are simple to make and the unit can be used over a very wide frequency range. In Fig. 14 the admittance meter and balun transformer are shown set up for making measurements on balanced lines at frequencies in the vicinity of 400 mc. Satisfactory operation has been obtained at frequencies between 50 and 550 mc. Operation at frequencies above 550 mc. has not been explored as yet. As can be seen from the figures, the balanced terminals are completely symmetrical. The adjustment procedure is very simple. The balanced terminal farthest from the measuring instrument is short-circuited to ground and the stub or capacitor at the center of the artificial line adjusted until a short circuit appears at the other balanced terminal. The short circuit is then removed and the other stub adjusted until an open circuit appears at the other balanced terminal. If the Admittance Meter controls are set to appropriate positions for each of these measurements, the proper adjustments of the stubs are indicated by null readings.

The admittance seen looking into the balun from the unbalanced terminals is 4 times the admittance seen looking into the balanced line, or the input impedance to the balun is one fourth the impedance seen across the balanced terminals. The actual voltages from both balanced terminals to ground are the same, and the two are 180° out of phase, independent of the impedance of the balanced line. This balun is very useful for driving a balanced line as well as for measuring through.

Very accurate measurements of balanced impedances can be made using this balun. Fig. 15 shows the results of

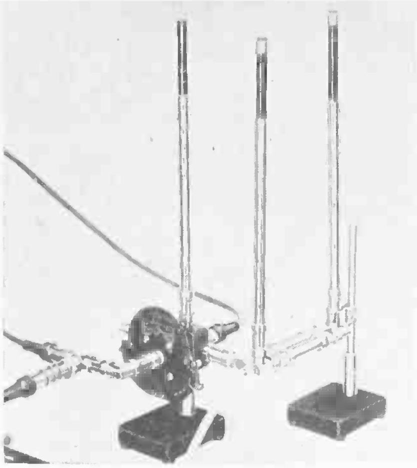


Fig. 14. Admittance meter and balun set up for measurements on balanced lines in the 400 mc. range.

measurements made on various short-circuited lengths of 300-ohm balanced line at 400 mc. The measured susceptances were plotted as a function of length, and the velocity of propagation calculated from the physical lengths corresponding to electrical lengths of ¼ and ¾ wavelength. The susceptances of the various lengths of line were calculated from the characteristic admittance and the relative velocity of propagation and the measured values plotted as a function of the calculated values.

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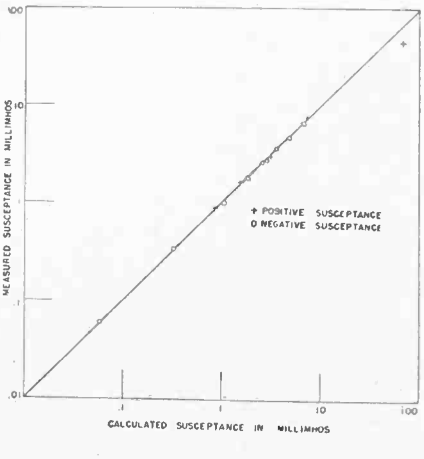
Fig. 15. Results of measurements on various short-circuited lengths of 300-ohm balanced line at 400 mc.

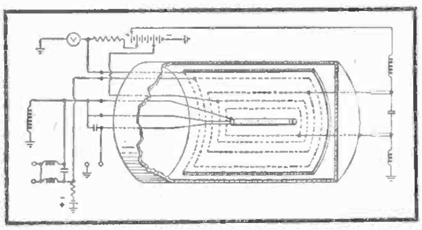


PATENT REVIEW

Printed copies of these or any other patents may be obtained from the U. S. Patent Office for 25c each. Address the Commissioner of Patents, Washington 25, D. C.

MODULATABLE OSCILLATOR

This device consists of a newly-designed microwave oscillator tube which may be made to oscillate over a very



wide band of frequencies, and which may be very easily frequency-modulated by using only a very small amount of modulating power. The device exhibits excellent linearity.

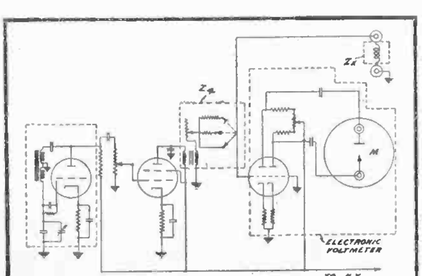
The tube utilizes a series of concentric grids. Frequency variation is produced by varying electron transit time by means of a voltage impressed on one of the grids. This particular grid is biased negatively, so no power is drawn from the modulating source. Several possible variations in tube construction are described.

Patent No. 2,533,406 was issued Dec. 12, 1950, in the name of A. M. Skellett.

ELECTRONIC IMPEDANCE METER

This invention describes a novel direct-reading electronic impedance meter for measuring impedances of the inductive or resistive types.

A source of alternating current is fed through a transformer, through a multiplier impedance, and through the

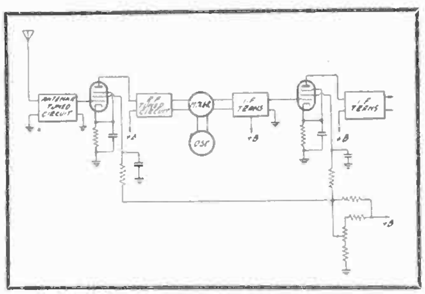


unknown impedance to ground. An a.c. vacuum tube voltmeter is connected to indicate the voltage across the unknown. If there is nothing connected to the unknown terminals, the meter will read full scale; if the unknown terminals are shorted, the meter will read zero. Thus the meter can be calibrated directly in terms of impedance for the various multiplying impedances. Potentiometers are provided to adjust the meter exactly to zero and full-scale before measurements are made.

Patent No. 2,535,608 was issued Dec. 26, 1950 in the name of Rex E. Smith.

GAIN CONTROL CIRCUIT

This invention provides a manually-operated gain control for r.f. and i.f. stages by means of varying the screen grid voltage. It is claimed to be superior to other systems because of the reduced current flowing through the control potentiometer, thus reducing size and cost, and to provide a circuit



whose operation will cause a minimum variation of current flowing through the control circuit.

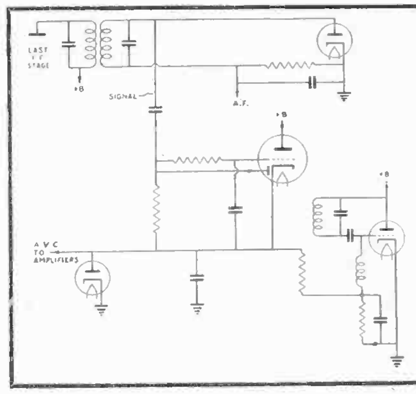
As can be seen from the circuit diagram, the control circuit includes a resistor connected between the positive terminal of the voltage source and the potentiometer and a further resistor is connected between the positive voltage source and the variable tap. Thus, the current flowing through the potentiometer is decreased. Furthermore, the two extra resistors in combination with the decoupling resistor and the bypass capacitor of the control circuit form an a.f. filter which will prevent hum modulation of the amplifier. A set of typical values for the components is included in the patent.

Patent No. 2,536,886 was issued Jan. 2, 1951 in the name of Wen Yuan Pan.

AUTOMATIC VOLUME CONTROL

This patent describes a circuit for providing the advantage of amplified a.v.c. without the use of additional i.f. amplifiers or d.c. amplifiers, and provides a minimum of loading to the system being controlled.

The a.v.c. bus is connected to a source of high-impedance negative po-



tential adequate to permit the highest-intensity signals to pass through the system without distortion. The cathode of a diode-triode is also connected to this bus. The audio signal is coupled to the diode, and the voltage developed across the load resistor is connected to the grid of the triode section, thus controlling the current through the triode. The voltage developed at the cathode bucks out the original negative a.v.c. voltage in such a manner that the smaller the audio voltage, the greater is the bucking action and the larger the gain.

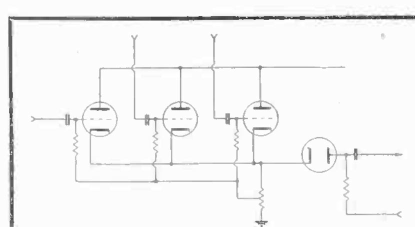
Also described is a system for delayed a.v.c., whereby no controlling action takes place until the input signal has reached a certain minimum value.

Patent No. 2,535,325 was issued Dec. 26, 1950 in the name of Raymond F. Smeltzer.

COINCIDENCE CIRCUIT

A multiple coincidence circuit having improved high-frequency response and providing a mixing circuit responsive only to pulses from various sources coincident in time is described in this patent.

The various input circuits (three are shown in the diagram) are coupled to the grids of cathode followers, the



cathodes of which are all connected in parallel and then through the cathode load resistor. The use of cathode followers gives a better high-frequency response and higher input impedance for the input pulses. Input pulses which are not coincident will produce only a very small output, not sufficient to cause the diode to conduct. The reason for this is that any change in current through one or more of the triggered tubes is almost exactly counteracted by an opposite change through the untriggered tube. However, if all are triggered at once, a large output signal is obtained, sufficient to cause the output diode to conduct.

This system is said to operate reliably over a wide range of magnitude of the input pulses.

Patent No. 2,535,377 was issued Dec. 26, 1950 in the name of Ernest William Titterton.

L. F. Receiver

(*Continued from page* 13)

made use of commercially available rotary seals of the "wobbling-bellows" type. As these were too large to be enclosed in the unit, they were housed in the control knobs, which must be of conventional size for easy manipulation, particularly with gloves.

The tuning of the receiver over its wide operating frequency range was a difficult engineering problem. A straight-line tuning characteristic (frequency proportional to control angle) was required, and this could best be attained in the limited space allowable by the use of a variable-pitch screw to drive the slugs in and out of the radio-frequency coils. These screws were readily produced on a standard lathe fitted with a special linear cam attachment designed by Robert O. Stone of the NBS staff. The tuning slugs are made of the newly developed ferrite base materials, more stable at high temperatures than powdered-iron cores. It was expected that production control of these new materials might present a difficulty; mechanical means were therefore provided in the tuner to compensate for possible nonuniformity of core material.

The intermediate-frequency transformers have an over-all size of ½ by ½ by 1⅜ inches. They are double-tuned and use permeability-tuned inductors of about 2.8 millihenries which have Q's of 70 at 135 kilocycles.

High-temperature capacitors of the tantalum electrolytic type are used for the large-capacity applications. Glass dielectric bypass capacitors are also employed. Both steatite and silicone-impregnated fibre glass serve as insulating materials. The audio-frequency transformers (two are needed) and chokes (two line-hash filter-chokes are required) employ high-temperature insulating materials and ceramic-insulated wire, and are impregnated with silicone varnish.

Panel controls involved a design problem: the small size of the panel (5¾ by 1⅞ inches) and the need for hermetic seals made it undesirable to have more than two external controls. Since one of these was required for tuning, the other had to fill the three distinct functions of gain control, power on-off switch, and beat-frequency-oscillator on-off switch.

The specially designed miniature gain control uses a high-temperature adhesive-tape resistor, also developed by the National Bureau of Standards. The tape is applied around a small glass cylinder, 3/16 inch in length and ½ inch in diameter, on which 120 axial lines of silver paint have been deposited to form commutator segments. A precious-metal brush makes contact with the projecting ends of these silver lines.

Aside from its inherent usefulness as an ultra compact piece of airborne communication equipment, the new range receiver has also served as the focal point for the development of several novel components and fabrication techniques. These components, engineered to meet the rigorous size and temperature requirements of subminiature equipment, may well afford superior permanence and reliability when used in equipment of more conventional and less compact design.

Improved Techniques

(*Continued from page* 12)

as possible when frequency response requirements are not limiting the design. Increase of the plate supply voltage value increases the available voltage amplification.

The technique of design for video amplifiers is slightly different. Here the usable load resistance is limited by the desired frequency response. Using the same 7E7 tube, assume the frequency requirements limited the load resistance to 10,000 ohms. In this case, best amplification results when the plate voltage drops to approximately the screen voltage at the minimum bias value reached with the applied signal. With 90 volts on the screen, the computed minimum plate voltage would be 150 volts for the 10,000 ohm load resistor. Optimum operation would call for exceeding the rated maximum 100 volt screen voltage by about fifteen volts. Whether this would be harmful to the tube through overload depends primarily on the mean operating conditions. The screen current should average less than two and a half milliamperes to stay within dissipation ratings. Stage gain would be about fifteen for the best design. The importance of high screen dissipation capacities and high transconductance values results from the limit on the load resistance.

A set of curves similar to Fig. 1 for the 6AK5 tube is shown in Fig. 4. These curves are used in the same manner. The 6AK5 is sometimes used as a mixer. This condition, as noted, calls for a rapid change of transconductance with bias and plate current. Often it is convenient to pick the minimum screen voltage which will produce the desired change of transconductance with the available grid input signal.

As an example, assume a local oscillator signal having a maximum amplitude of one volt peak were available. The change in grid voltage would then be from zero volts to minus two volts. Examining the 6AK5 curves at a screen voltage of 75 volts, it is seen that the transconductance changes from 6500 to 2000 for a bias change from zero to minus two volts. The average plate current is about six milliamperes. At a screen voltage of fifty volts, however, the transconductance change is from 5100 to 800. Here the average plate current is just under two milliamperes. As a consequence, the fifty volt screen condition is better, giving almost exactly the same transconductance change with a lower plate current. At lower screen voltages the tube approaches cut-off, limiting the available change. Approximate conversion transconductance may be found by taking half the change in transconductance occurring between minimum and maximum bias voltages. At 75 volts on the screen, the conversion transconductance is 2250. At 50 volts, it is 2150, and at 25 it is 850.

Mixer designs to suit the available local oscillator voltage are readily obtained. For example, if the available oscillator voltage were one and a half volts peak, a seventy-five volt screen voltage would yield a conversion transconductance of approximately 3000 micromhos.

For mixer stage design where separate injection grids are used, a somewhat different form of curve is convenient. The maximum attainable conversion transconductance in mixers is of prime importance. For this reason, a useful form of plot would be based on the minimum recommended signal grid bias. Signal grid transconductance and plate current would then be plotted as a function of bias on the local oscillator grid and the screen voltage. A set of curves for the 6SA7 is shown in Fig. 6.

Conversion gain in the stage may be found if the tuned impedance at the output frequency is known. For example, if this impedance were 10,000 ohms, the 6AK5 stage with a fifty volt screen condition would show a conversion gain of 21.5.

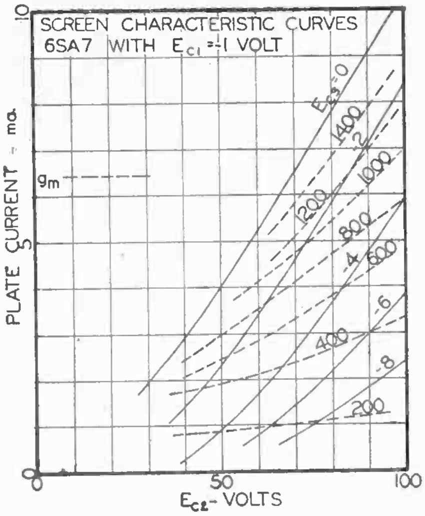


Fig. 6. Converter conductance type screen characteristics for the 6SA7 tube.

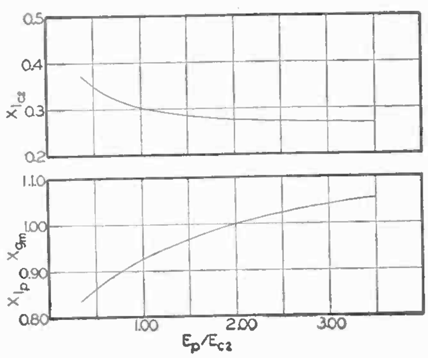


Fig. 7. Correction curves for the 6AK5.

The tuned impedance of a circuit may readily be found in most cases. Measurement of the inductance and the Q of the inductor part of the circuit is one method. Then the impedance is found by multiplying the product of the inductance and Q by two pi times the operating frequency.

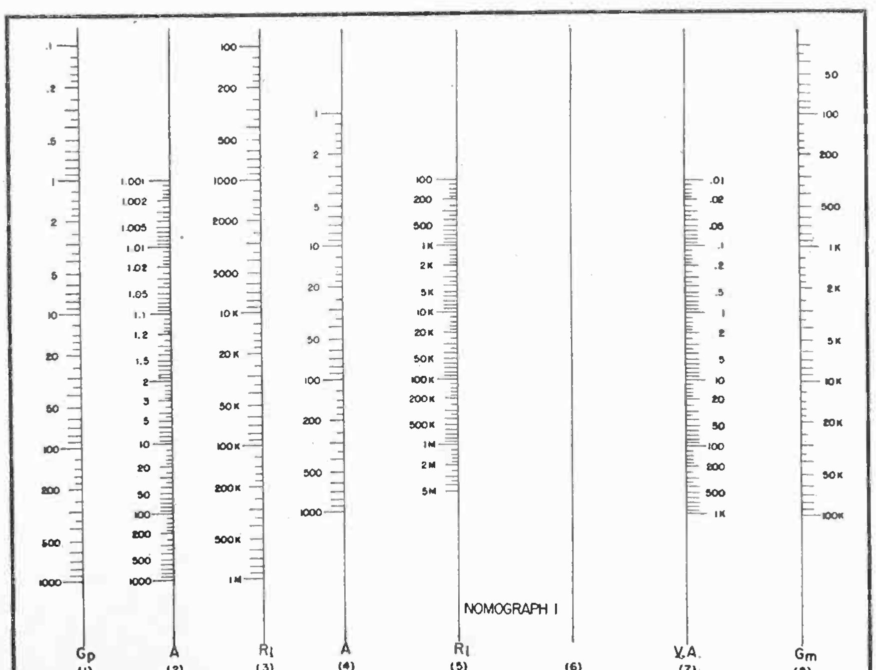
The second, approximate, method is to load the tuned circuit with carbon resistors until one is found which reduces the amplification to half the unloaded value. Then the tuned impedance is approximately equal to the paralleling resistance. The gain of the stage should be kept low enough to prevent instability. If the gain appears to be excessive, choice of a tuned circuit having a higher capacitance is desirable. As in the pentode tube, the converter plate voltage should be greater than its screen voltage for best operation.

For frequency multiplication choice of the non-linear characteristic area is required. Where considerable multiplication is required, reduction of the plate voltage below the screen voltage improves conversion. Designs that at zero bias drop the plate voltage to about a fifth the screen voltage take advantage of this effect.

Correction Curves

Correction curves for adjusting for changes as the plate voltage varies are shown in Fig. 2 for the 7E7 and Fig. 7 for the 6AK5. Use of these curves is as follows. First the approximate plate current and the approximate transconductance are read for each bias value. The voltage across the plate load is determined from the plate current and the load resistance. The net plate voltage value is found by subtraction of the load voltage drop from the supply voltage. This plate voltage value is then divided by the screen voltage. This number is E_p/E_{c2}. The correction factors for the plate current, X_{Ib}, and the transconductance, X_{gm}, are read from the curves. The product of the plate current read from the curves by X_{Ib} gives the actual plate current. Likewise, the product of the transconductance read from the curves by X_{gm} gives the actual transconductance. This correction, although seldom needed, can be made where it is necessary to operate at reduced plate supply voltages.

Fig. 8. Nomograph for the calculation of amplification (see text).



Calculations

Fig. 8 shows a very useful chart to aid determination of voltage amplifications by direct solution of Eqt. 1. First a line joining g_p on line one to R_L on line three is drawn. The value of the denominator of Eqt. 1 is then read at the intersection of this connecting line and line two. The value read on line two is found on line four. Another connecting line is drawn through this point and the value of R_L on line five. The intersection of the second connecting line with line six is noted. The third connecting line is drawn through the point noted on line six and the transconductance value which is located on line eight. The intersection point of the third connecting line and line seven determines the voltage amplification.

Conclusion

As can be seen, there is no need for mystery in the choice of preferred tube circuit parameters. These parameters actually may be determined by standard techniques. The non-linearity of tubes should be recognized explicitly and data expressing this non-linearity be provided in convenient form. When this is done, design of any type of tube circuit becomes routine.

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TECHNICAL BOOKS

"HIGH-FREQUENCY MEASUREMENTS" by August Hund. Published by the *McGraw-Hill Book Company*, 330 West 42nd St., New York 18, N. Y. 676 pages. $10.00.

This completely revised second edition is a thorough discussion of high-frequency phenomena applied to measurement. Methods are described which cover the entire useful radio-frequency band of present-day application; methods which are useful at low, medium, high, very high, ultra high, and super high radio frequencies.

Among the recent advances and revised items are: measurements and instrumentation in connection with short waves, line and antenna measurements, measurements for AM, PM, and FM, signal-to-noise measurements, modern high-frequency bridge procedures, and field intensity determinations, based on field comparators. Valuable reference material on ferromagnetic measurements, measurements of lines and aerial systems, and the determinations on wave propagation is included.

A guidebook to better understanding of high-frequency measurements, this volume supplies answers to specific questions and problems ranging from fundamental relations and circuit properties to miscellaneous measurements.

"SHORT WAVE WIRELESS COMMUNICATION" by A. W. Ladner and C. R. Stoner. Published by *John Wiley & Sons, Inc.*, 440 Fourth Ave., New York 16, N. Y. 717 pages. $8.00.

The fifth edition of this thorough study of the principles of short and ultra-short waves, written by two of England's leading authorities on the subject, has been completely revised and enlarged. Many of the chapters have been enlarged and brought up-to-date, and in some cases, material has been deleted and replaced by new subjects.

Designed to satisfy the needs of both professionals and amateurs interested in short-wave communication, the text begins with communication system requirements and the theory of high-frequency modulation. Propagation is covered, using a largely non-mathematical treatment and chapters on aerials and feeders include material on useful methods of measurement.

Power amplifiers, oscillators, velocity modulation systems, the klystron, and similar modern developments and commercial equipment are thoroughly described. Some seventy-five new diagrams are also included.

News Briefs

(Continued from page 21)

able to present even more exhibits than last year. Educational exhibits will include displays from government agencies, colleges, and universities. Also included will be material of interest to nuclear and atomic scientists, chemical and geophysical researchers, industrial production and design technicians, airplane, bus, and truck transportation companies.

The western IRE convention, 7th region, will be held in the auditorium during the same dates and will collaborate in the exhibit.

PRESSURE TANK

General Electric's picture tube plant at Syracuse, N. Y. is using what is

called an "Iron Lung" for cathode-ray tubes. It is a pressure tank used to spot-check metal television picture tubes to determine their strength. A pressure of several atmospheres is exerted on each tube.

POWER LINE SYNCHRONIZATION IN TV

A paper presented by William L. Hughes of Iowa State College at the AIEE Great Lakes District in Madison, Wisconsin, May 17-19, contained some interesting comments concerning hum and stability problems of power line synchronization in television. The paper concluded with the following remarks:

"Power line synchronization of sweep circuits has no great distadvantages when the power system is stable, and the receiver and the camera operate from the same power system. Whenever the receiver and the camera operate from different power sources, a more complex problem arises. If there is hum getting into the camera from its power source, stationary disturbances will be produced at the receiver. If there is hum getting into the receiver from its power source, the disturbances will move up or down. If the transmitter power source is unstable, the received picture may waver or move in receivers employing high inertia scanning.

"As long as the pulse generation equipment at the camera is stable, an independent sweep frequency source of good stability will present a good stable picture in all types of receivers. The instability of the power sources cannot produce waver or movement of the received picture. If hum is getting into the video circuits from the camera power source, then a moving disturbance will be produced at the receiver. If hum is getting into the receiver video circuits, a moving disturbance will again be produced. If the camera and receiver are operating on independent power sources and the hum has been removed at the camera, there is nothing to be gained by line synchronization. Receivers with hum will still have the same difficulties whether the camera is power line synchronized or not."

CONFERENCE ON STRAIN GAUGES

The first of an extended series of regional conferences for cooperative study of present and potential uses of bonded resistance wire strain gauge devices was held recently at the University of Pennsylvania, Philadelphia.

The Philadelphia conference, held in three sessions and attended by more than 400, was sponsored by eleven colleges and universities and by *Baldwin-Lima-Hamilton Corporation*, Philadelphia. Representatives of the former served as a discussion panel. Frank W. Tatnall, dean of the *Baldwin* Testing Equipment Department and who was to a large degree responsible for the development of SR-4 strain gauges as commercial products, was the principal speaker.

Among the SR-4 devices presented were extensometers, high temperature strain gauges, a feeler gauge for exploring thickness variations, a commercial engine indicator, and many other devices. Dates and locations of several future conferences, to be held from coast to coast, are yet open to arrangement.

FAX NETWORK

Major E. H. Armstrong, Professor of Electrical Engineering at Columbia University, and John V. L. Hogan, President of *Hogan Laboratories, Inc.*, recently described an unusual series of cooperative experiments which have successfully demonstrated a new FM service.

For this series of experiments, Major Armstrong used the facilities of his experimental FM transmitter KE2XCC at Alpine, New Jersey and the *Hogan* Laboratories loaned a "Multiplexer" unit, which was installed at Alpine. At Alpine the received signals were passed through the "Multiplexer" and applied to the Alpine transmitter. The

FM waves, carrying both FM sound signals and facsimile signals, were picked up by Station WQAN-FM in Scranton, Pennsylvania, which repeated them by means of another "Multiplexer" unit over its regular FM transmitter. The facsimile newspaper could thus be printed by any facsimile receiver tuned either to the Alpine station or to the Scranton station.

FM signals, carrying the multiplexed programs, were picked up from Scranton by a receiver located at Station WHCU-FM and broadcast in Ithaca, New York. The Ithaca station was the final transmitter again to rebroadcast the combined programs, and its signals have been successfully recorded by means of multiplexed facsimile receivers located in and around Ithaca and Syracuse.

NEW LITERATURE

Apparatus Noise Measurement

A standard for establishing uniform methods of conducting and recording sound-level tests on apparatus has been published by the American Standards Association. The American Standard Test Code for Apparatus Noise Measurement, Z24.7-1950 is intended as a guide for those who use sound-level meters that meet the requirements of the American Standard Sound-Level Meters for Measurement of Noise and Other Sounds, Z24.3-1944.

The standard includes procedures for factory tests of equipment, field investigations, and sound-level specifications. The section devoted to factory tests contains methods for measurement of direct air-borne noise; reflected sound; ambient sound; apparatus mounting; location of microphone, including tentative distances from the microphone for specific types of equipment; standing waves; record of measurements; and noise measurements.

Copies of this standard may be obtained from the American Standards Association, 70 East 45 St., New York 17, N. Y. at 50c a copy.

Bulletin on Measurements Lab.

A 16-page, two-color brochure describing the varied facilities of, and the work conducted in, the new $2,000,000 Measurements Laboratory of the *General Electric* Meter and Instrument Divisions at Lynn, Mass., has just been released by the company.

This booklet, GED-1406, shows pictorially how the laboratory's corps of specialists conducts research into new ways to measure; develops new materials and devices; tests them for reliability and accuracy; evaluates manufacturing processes; maintains accuracy standards; and checks products off the production lines. The booklet also covers the wide range of mechanical and electrical services and test facilities available to engineers and technicians working in the laboratory.

Bulletin GED-1406 may be obtained by writing the *General Electric Co.*, Schenectady 5, N. Y.

Electronic Equipment Construction

A 300-page illustrated report covering the description and evaluation of new components, a discussion of new construction techniques, and a survey of research at sixty-two of the nation's leading electronics development firms and laboratories is now available from the Office of Technical Services of the U. S. Department of Commerce.

Prepared by Stanford Research Institute under contract to the Office of Naval research, the report also carries a special section in which the current research and development needs of the electronics field are summarized by the authors. Special appendices include tables on the properties and characteristics of resistors, capacitors, liquid dielectrics, embedment compounds and printed circuits, etc.

PB 101 745, Electronic Equipment Construction—New Objectives, New Techniques, New Components, is available at $7 per copy from the Office of Technical Services, U. S. Department of Commerce, Washington 25, D. C. Check or money order should be made payable to the Treasurer of the United States.

Price List of American Standards

Ninety-nine new and revised American Standards are listed for the first time in the latest edition of the Price List of American Standards. This list contains more than 1180 standard specifications, methods of test, and symbols and abbreviations in civil engineering and construction, mechanical engineering, electrical engineering, safety codes, ferrous and nonferrous materials and metallurgy, rubber, textiles, mining, pulp and paper, photography, motion pictures, and gas burning appliances.

The new list offers a complete set of all American Standards at $280.00 and a complete set of all American Safety Standards at $40.00. The 26-page list of American Standards (May 1951) can be obtained from the American Standards Association, 70 East 45 Street, New York 17, N. Y. without charge.

Potentiometer Chart

A quick reference technical data chart that provides all pertinent data on the various types of *Helipot* potentiometers is now available.

The electrical and mechanical characteristics, physical dimensions with accompanying sketches, power rating, accuracies and similar engineering data is included to furnish users of potentiometer-rheostats with a handy guide to available stock units in single-turn and multi-turn designs.

Copies of the data chart in the form of a file folder for ready reference are available without charge from *Helipot Corp.*, 912 Meridian St., South Pasadena, California.

Radio-Frequency Gear

Detailed operational information on the Inductall, a radio-frequency gear-hardening machine, is presented in a booklet released by *Westinghouse Electric Corporation.*

This booklet illustrates the Inductall's simple mechanical drive system, and diagrams power and water requirements for an installation of two or more machines. Detailed technical information is provided by an outline of specifications.

A copy of booklet B-5259 is obtainable from *Westinghouse Electric Corporation*, Box 2099, Pittsburgh 30, Pa.

Laminated Plastics Catalog

A 62-page catalog covering vulcanized fibre, phenol fibre and special laminates, design and machining hints, and engineering and research facilities has been released by the *Taylor Fibre Company*.

This catalog covers basic engineering data on *Taylor* products so that the user, whether a design engineer, production engineer or buyer of these versatile products, can readily find the best material suited to his specific application. Charts and tables on engineering data are included.

Copies of the *Taylor* Laminated Plastics catalog are available upon request from *Taylor Fibre Co.*, Norristown, Pa.

CALENDAR of Coming Events

JUNE 25-29—1951 Summer General Meeting of AIEE, Royal York Hotel, Toronto, Canada.

AUG. 20-23—Pacific General Meeting of AIEE, Portland, Oregon.

AUG. 22-24—7th Annual Pacific Electronic Exhibit, San Francisco Civic Auditorium, San Francisco, Calif.

SEPT. 10-13 — NEDA Second Annual Electronic Parts Distributor Show, Cleveland, Ohio.

OCT. 22-24—7th Annual National Electronics Conference, Edgewater Beach Hotel, Chicago.

OCT. 22-26 — Fall General Meeting, AIEE, Cleveland, Ohio.

OCT. 29-31—Radio Fall Meeting, King Edward Hotel, Toronto, Ont., Canada.

New Products

(*Continued from page* 23)

diameter, exclusive of the terminals; only 25/32nds of an inch over-all back-of-panel length; and has a net weight of 0.56 ounces. Available in resistances from 1000 to 100,000 ohms in single section and ganged assemblies with single or double shaft extension, the Tinytorque potentiometer has active electrical rotation of 355 degrees and continuous mechanical rotation without stops. Power rating is one-half watt.

TRANSMITTING AND POWER TUBE

An air-cooled transmitting and power tube, Type AX-9906R/6078, with a plate dissipation of 45 kw. and a weight of only 66 lbs. has been announced by

Amperex Electronic Corporation, 25 Washington St., Brooklyn 1, N. Y.

Designed for high power transmitter and industrial applications, the triode produces an output of 108 kw. at 15 megacycles and is intended for operation up to a maximum frequency of 30 megacycles. Maximum plate voltage is 13,500 volts and maximum plate current is 12 amperes. Type AX-9906/6077 is the water-cooled version of this tube, with an available plate dissipation of 100 kw.

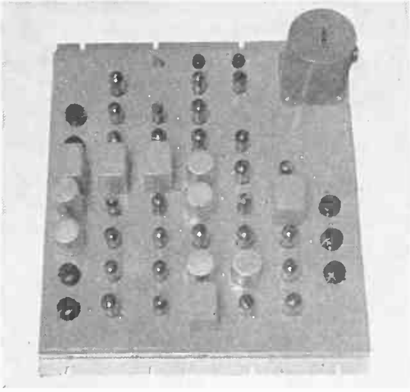
Complete information, including all technical data, is available upon request from *Amperex.*

TV MONTAGE AMPLIFIER

The *General Electric* Commercial Equipment Division at Syracuse, N. Y., has announced a television montage amplifier which permits vertical, horizontal and wedge wipes, and preset superpositions.

The montage amplifier, Type TV-35-B, and its control panel, Type TC-34-A, allow two-signal self-keyed or three-signal keyed insertions of sponsors' products or advertising material. To assure proper positioning and picture composition, a locating signal may be fed to the studio camera viewfinder. Horizontal, vertical and wedge wipe action may be stopped at any point.

Further information on this mon-



tage amplifier may be obtained from Dept. N-1, *General Electric* Advertising Div., Electronics Park, Syracuse, N. Y.

ELECTRONIC COUNTER

Berkeley Scientific Corporation of Richmond, California has announced a high speed electronic counter combined with an accurate time base to provide an instrument that will automatically count and display the number of events that occur during a precise time interval. These events may be any mechanical, electrical or optical occurrences that can be converted into changing voltages.

The *Berkeley* Events-Per-Unit-Time Meter will count events occurring either regularly or with random distribution at rates of from 20 to 100,000 events per second. Results are presented directly in digital form and no interpolation is necessary. The meter switches automatically from counting to display and recycles continuously. Display time is adjustable and provision is made for single readings to be taken manually or by remote control.

MAGNETIC CERAMIC

An improved nickel-free magnetic ceramic, designated as Croloy C-4, has been developed by the *Henry L. Crowley Company* of West Orange, New Jersey.

This material can be used in place of ferrite type ceramics in television flyback circuits, horizontal linearity, and width control circuits. Croloy C-4 has been found to provide excellent results in current production TV models and based on the average receiver design, the use of this magnetic material would save approximately ¼ lb of nickel per receiver without any curtailment of performance.

Crowley technicians will gladly collaborate in developing and applying powdered-iron cores to TV requirements and readers are invited to send them their particular problem.

Croloy C-4 may be fabricated in any of the common shapes currently utilized in TV receiver design.

DIELECTRIC HEATING GENERATOR

A 20 kw. radio-frequency generator for dielectrically heating a wide range of nonmetallic materials in the textile, rubber, wood, food, and other industries is now available from *Westinghouse Electric Corporation,* 306 Fourth Ave., Pittsburgh 30, Pa.

Designed in accordance with NEMA standards, the generator is readily adaptable to batch or continuous production methods, delivering rated power at a 100 per-cent duty cycle. Equip-

ment operating controls are held to a minimum and all adjustments necessary for operation of the equipment are made from the front panel. Built-in load coupling and tuning elements permit maximum transfer of power into a wide range of loads by front panel control.

Push-button control, stepless adjustment of output power, and a complete complement of protective devices put operation of this equipment on a semi-skilled basis.

The enclosure is designed to minimize radio-frequency radiation, and the complete generator is certified to comply with FCC regulations.

Further information may be obtained by writing Box 2099 at *Westinghouse Electric Corporation,* Pittsburgh 30, Pa.

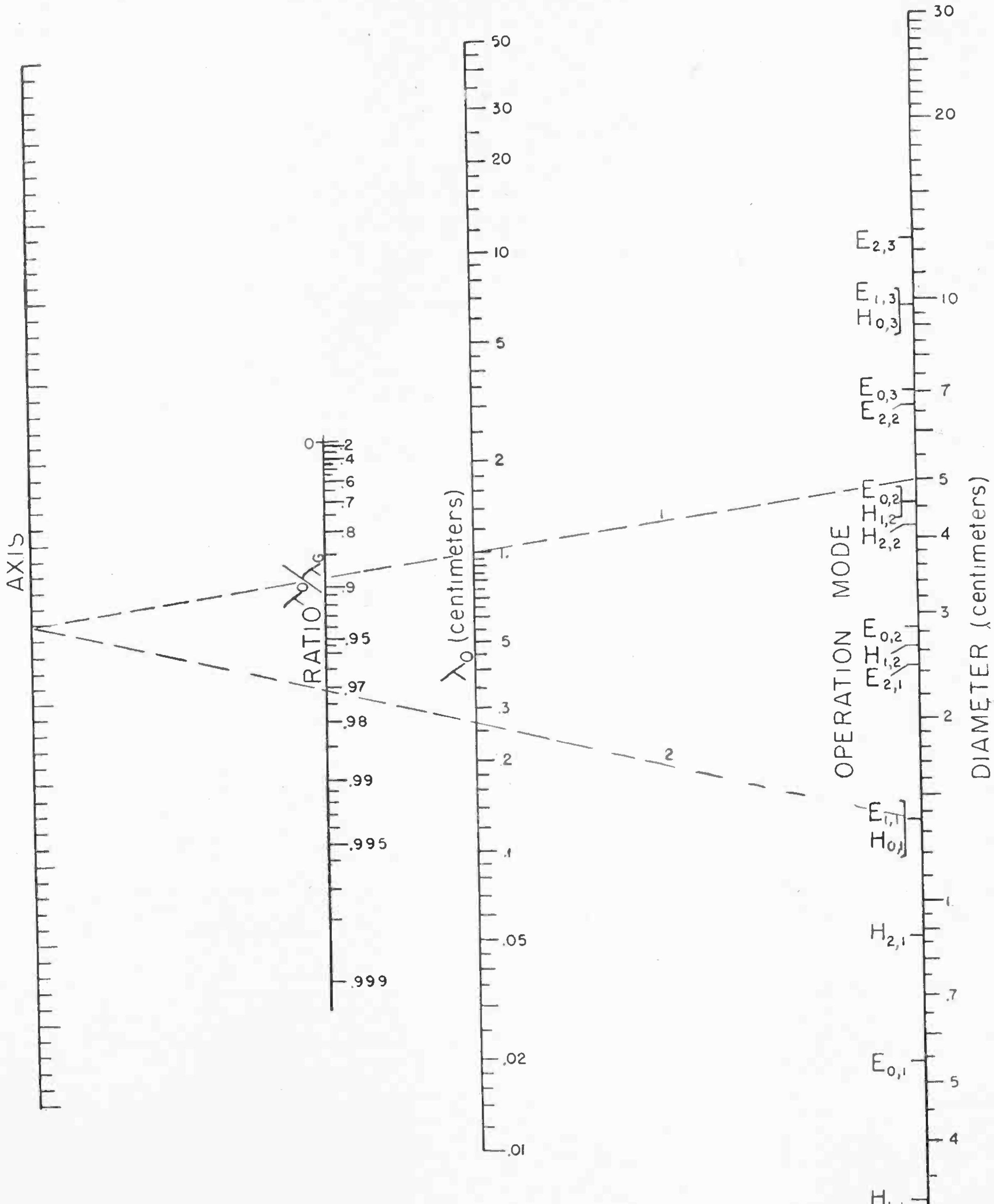
PHOTO CREDITS

3, 4, 5, 25	General Radio Co.
7	William Miller Corp.
13	Nat. Bureau of Standards
14	Armour Research Foundation
16	Columbia Broadcasting System
18 (top)	Ampex Electric Corp.
18 (bottom)	U. S. Dept. of Agri.
19, 24	Radio Corp. of America

CYLINDRICAL WAVE GUIDES

Nomograph for determining ratio of guide wavelength to free space wavelength in cylindrical wave guides.

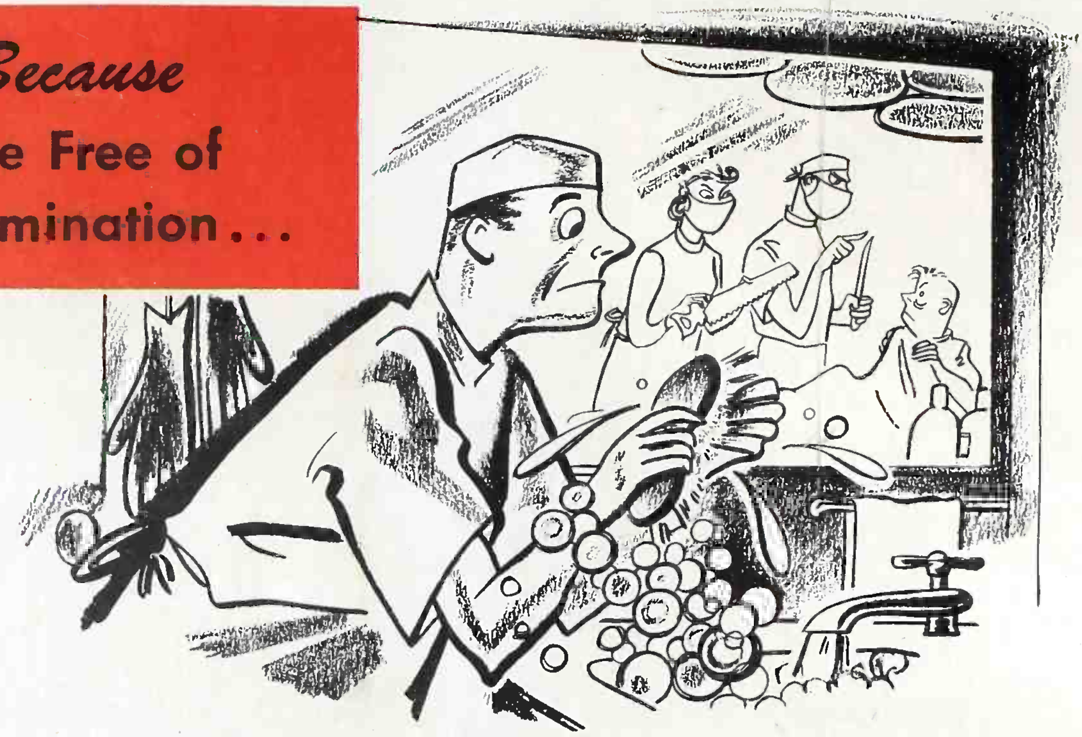
IN order to obtain the ratio of λ_o to λ_g, first draw a line (1) from the correct point on the "Diameter" scale to the desired point on the λ_o scale and obtain an intersect on the "Axis" scale. This point is then connected (2) with the correct point on the "Operation Mode" scale and the answer will be found on the "Ratio λ_o/λ_g" scale.



Courtesy of Federal Telephone and Radio Corp.

Because

They're Free of Contamination . . .



MALLORY CAPACITORS

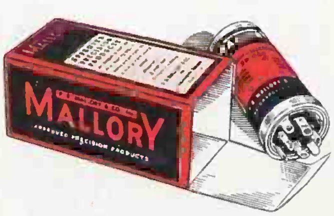
Give Long, Continuous Service!

One reason why Mallory Capacitors deliver full rated capacity throughout their long life is the unusual care taken in production to prevent contamination, which is the source of corrosion and shortens the life of capacitors.

Even at high temperatures, Mallory Capacitors operate perfectly over extremely long periods of time. Tests consistently show dependable performance for more than 2000 hours at temperatures up to 185°F (85°C). Special design and meticulous production methods make such records possible.

Mallory Capacitors have set new long-life standards for the industry, yet cost no more. You will find it pays to rely on the complete Mallory Capacitor line . . . electrolytic, plastic tubular, paper, mica and ceramic.

See your Distributor for Mallory Precision Quality Parts at Regular Prices.



P. R. MALLORY & CO Inc

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