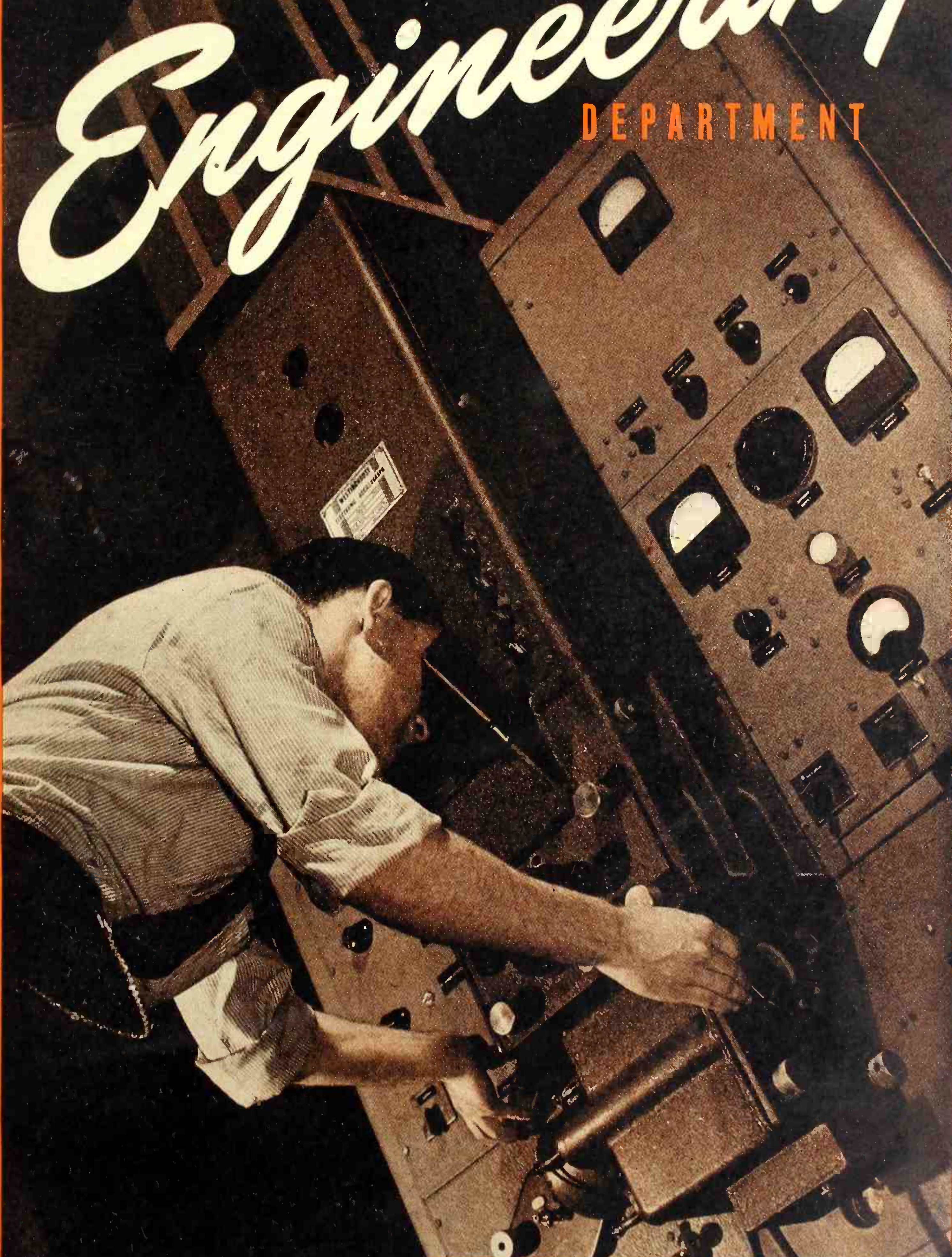
RADIO NEWS

DECEMBER 1944

RADIO-ELECTRONIC Engineering DEPARTMENT



TELEVISION ★ RADAR ★ ELECTRONICS ★ RESEARCH
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RADIO NEWS

RADIO·ELECTRONIC
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DEPARTMENT

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DEPARTMENTS

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VOLUME 3 NUMBER 6

Cover Photo—By WESTINGHOUSE

Recording the ignition action of an airplane engine by means of the new Westinghouse streamlined cathode-ray oscillograph. The stream of electrons, pencil thin, photographs the electrical sparks which pass at 5,000 mph.

PHOTOELECTRIC CONTROL of Manufacturing Operations

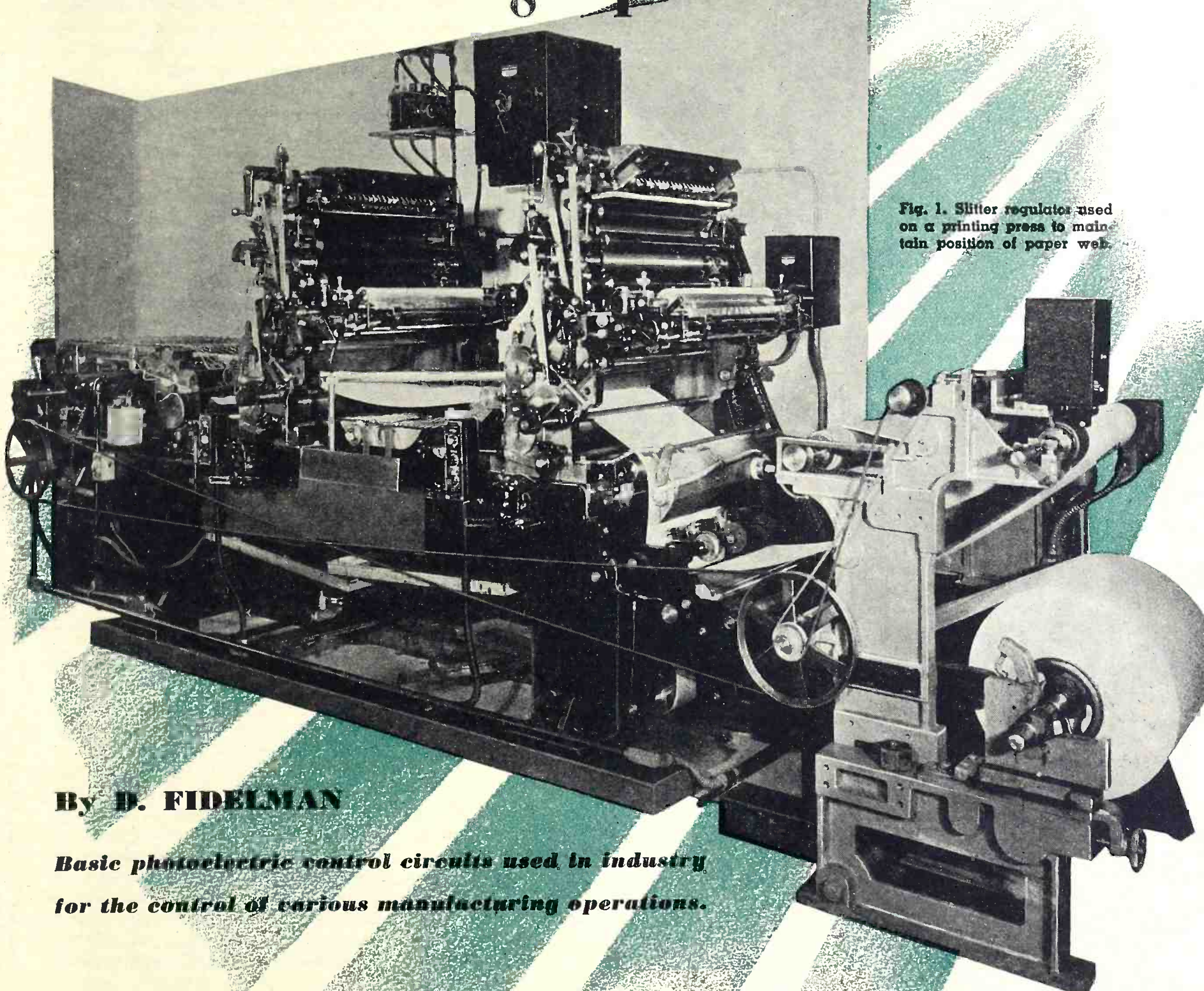


Fig. 1. Slitter regulator used on a printing press to maintain position of paper web.

By D. FIDELMAN

Basic photoelectric control circuits used in industry for the control of various manufacturing operations.

WITHIN the past few years photoelectric controls have become of increasing importance in industrial processes. Not only has their application solved many problems better and more cheaply than mechanical or other electrical means, but in many cases electronic control in conjunction with mechanical and electrical control systems has been able to accomplish many results which would otherwise be impossible.

There are a number of reasons for the success of electronics in industry. High sensitivity can be attained without the use of sensitively balanced moving parts. The absence of moving parts and the consequent absence of mechanical inertia gives electronic control equipment an extremely high speed of response. In many processes where control must be actuated by transient conditions of such short duration that mechanical or electromagnetic control devices cannot successfully be applied, high-speed electronic controls have been applied with excellent results.

In many industrial control operations it is not possible to use either mechanical or electromagnetic means to obtain the desired control function because the variation in the factor to be controlled cannot easily be converted into mechanical or electrical forces, or because the amount of energy available to initiate the control sequence is low. The photoelectric tube has proved valuable in such applications, since no power is required of an object in order to intercept a beam of light. Thus, many operations can be initiated by objects which may be too light, too fragile, too heavy, too hot, or too highly polished to permit satisfactory operation with ordinary mechanical switches.

Since electron tubes can operate an unlimited number of times without mechanical wear, a much smaller amount of maintenance is required to

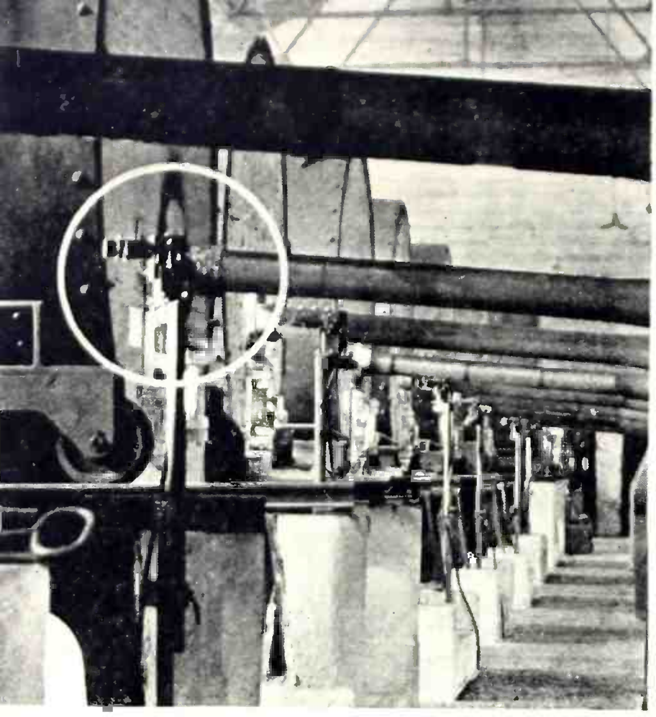


Fig. 2. Pyrometer phototube temperature control of cement kilns.

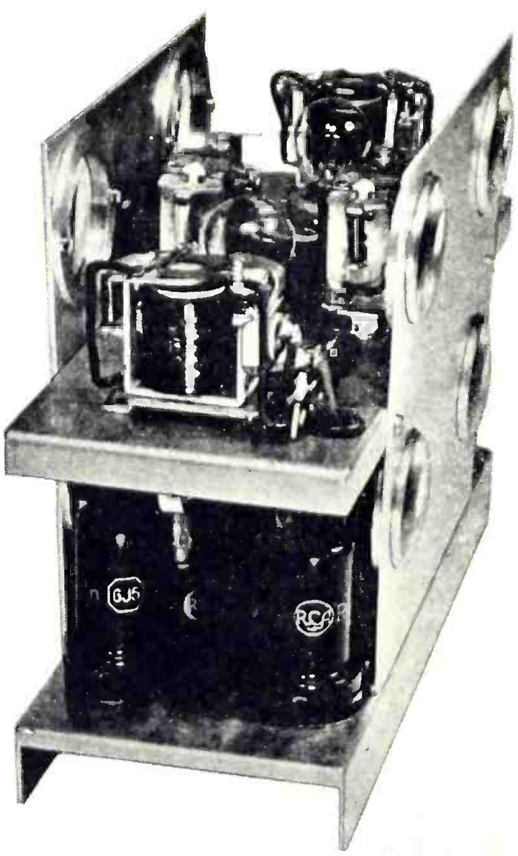


Fig. 3. Photoelectric directional counter.

keep the equipment in the proper operating condition. There are no moving parts to be oiled and adjusted for wear, and no contacts to be filed to remove the effects of arcing, as in electro-mechanical control devices. Under ordinary circumstances, the only maintenance required is the replacement of tubes. Since the operating life of electronic tubes is several thousand hours and can be extended by operation below the rated currents, this consideration does not represent a major objection to the use of electronic control equipment.

Electronic control devices may be divided into two classes. One consists of the applications which would be impossible without the use of electron tubes. The other class contains those problems which can be solved better or more cheaply by the use of electronic controls than by mechanical or other electrical means.

Photoelectric controls are used for actuating systems in response to a change of color, shade, density, shape, or position without mechanically touching the controlling object. There are several distinct types of applications of photoelectric controls:

(a) Where only a simple on-and-off relay effect is desired, for instance as limit switches to control manufacturing operations, or for the stoppage of machinery when a light beam is affected, as by a break in a printing press paper roll.

(b) Where a varying light input intensity produces a variable regulating effect, as in process regulating equipment.

(c) Where a selective effect is desired, as in sorting or grading of objects according to a particular characteristic such as color or size.

Previous to the development of photoelectric controls, industry had no practical substitute for the human eye. By careful design of the optical system so that the phototube will receive a varying amount of light which depends upon the particular characteristic which it is desired to detect, the phototube can be made to act as an electric eye.

The following brief list indicates a few specific types of manufacturing operations to which phototube controls have been applied successfully.

1. Automatic counting
2. Conveyor control
3. Fault detection (i.e., pin-holes, etc.)
4. Chemical process control
5. Register regulation
6. Colorimetric regulation
7. Temperature regulation
8. Sorting
9. Grading
10. Matching
11. Dimension gauging.

Numerous other possible applications of photoelectric controls will readily suggest themselves.

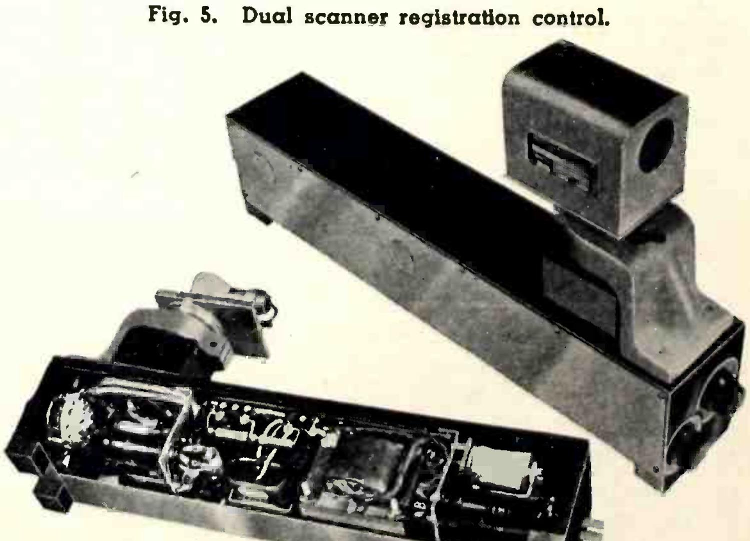
Basic Control Circuits

The photoelectric device which has found the widest application up to the present time is the alternating-current photoelectric relay. The simplest relay of this type consists of a phototube connected so as to control a grid-glow tube, as shown in Fig. 10 (A). The phototube may be connected in such a manner that the grid-glow tube will break down and energize the relay if the illumination is decreased. In the circuit of Fig. 10 (A), when no light is applied to the phototube, the grid is biased to a negative potential with respect to the cathode and the grid-glow tube passes no current.

The grid and plate voltage relations are shown in Fig. 10 (B). The grid voltage e_g consists of the direct voltage e_b on which is superimposed the alternating voltage e_{ps} in such phase that the tube will always break down at the beginning of the positive half-cycle of the anode voltage E_a. If only d.c. were applied to the grid, the point at which the grid voltage would reach the criti-

Fig. 4. Photoelectric temperature control with push button.

Fig. 5. Dual scanner registration control.



cal value e_c is at the center of the positive half-cycle. Breakdown at this point corresponding to the crest value of E_a would give only 50 per cent of the maximum average current output from the tube. Increasing the phototube illumination would advance the point of breakdown and give a gradual increase in current up to maximum value. This characteristic is undesirable for relay operation.

When the phototube is illuminated, a current flows through it and the grid resistor, R, resulting in the voltage drop e_p across R. The total grid voltage e_t is shown exactly at the point to cause breakdown, since the voltage e_t is shown equal to the critical grid voltage e_c. When the grid-glow tube breaks down, the contactor closes and the operation is completed. Interruption of the beam of light reduces e_p and causes the contactor to open. The advantage of the grid-glow tube in this type of circuit is that it can pass enough current to close a standard industrial type of contactor or solenoid without the use of interposing relays.

Another common type of photoelectric relay is that in which a phototube operates a high-vacuum amplifier which in turn operates a relay. Since the output of the high-vacuum amplifier is low, a small sensitive relay is used in the plate circuit, often in conjunction with an additional relay of greater current capacity. This type of unit may be designed with a rectified power supply for the phototube voltage and the grid and plate voltage of the amplifier. The circuit may also be adapted for use without rectification, and it then operates self-rectifying to actuate a relay intended for operation by direct current.

The above types of photoelectric relays require the light impulse to last an appreciable length of time for proper operation. However, many processes require a control which will respond to a light impulse lasting only a few microseconds. Units for performing this function make use of the lock-in characteristic of the grid-glow tube. A typical circuit of this type is shown in Fig. 11. It will be noted that in such circuits provision must always be made to open the plate circuit of the grid-glow tube to de-energize the tube, for instance by means of an auxiliary control relay as shown in the circuit of Fig. 11. When great sensitivity and speed of response are required, the output of the phototube may be applied to the grid of a high-vacuum amplifier which, in turn, is coupled to the grids of one or more grid controlled vapor discharge tubes.

Photoelectric equipment has been applied to perform a variable regulating function in a large number of industrial operations because the phototube satisfies two great needs characteristic of most regulated processes: (a) a means for quick analysis, and (b) a means for quick response control. The simplest type of photoelectric regulating equipment is the chemical process regulator shown in Fig. 12. The circuit consists of a phototube, a light source and a grid-glow tube connected to control a balancing relay. Any change in the illumination of the phototube results in a corresponding change in the current through the amplifier tube, closing one pair of contacts if the color of the material to be controlled is too light, or closing the other pair of relay contacts if the color

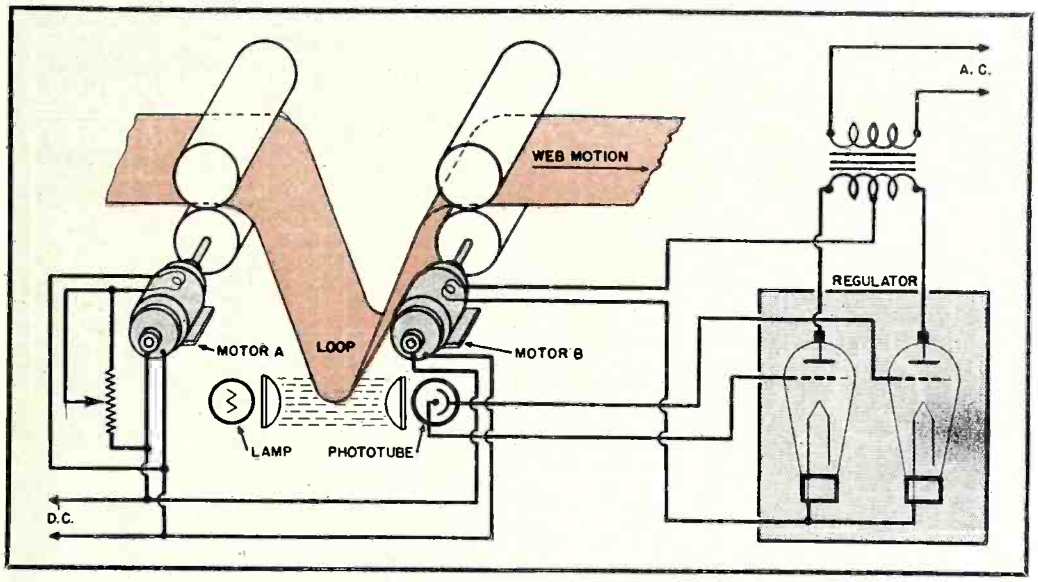


Fig. 6. Schematic arrangement of photoelectric loop regulator for matching motor speeds in roll drive.

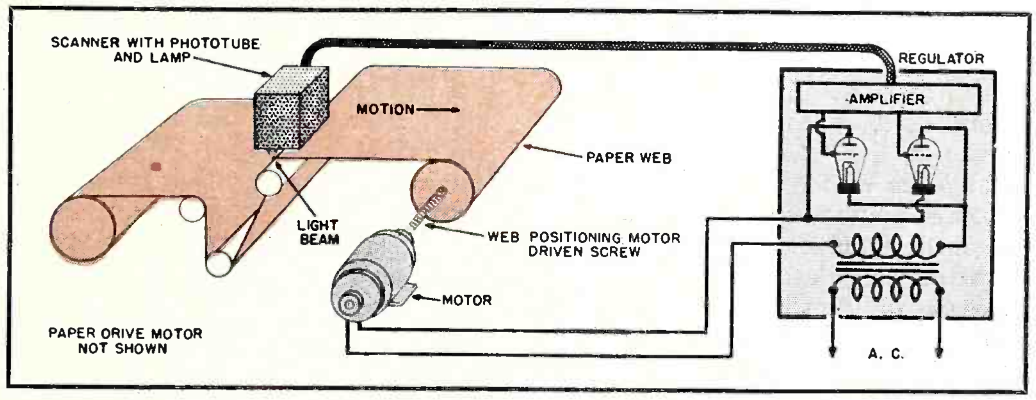
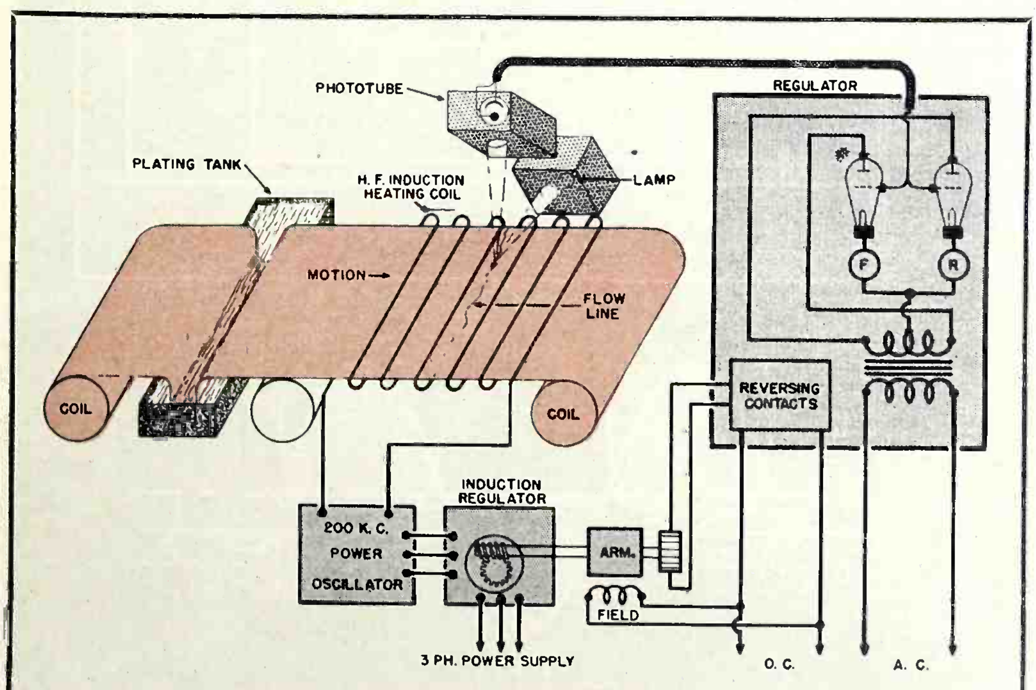


Fig. 7. Schematic arrangement of photoelectric edge line control for slitting or rewinding paper, glassine, etc.

Fig. 8. System for regulating power input in tin flowing process.



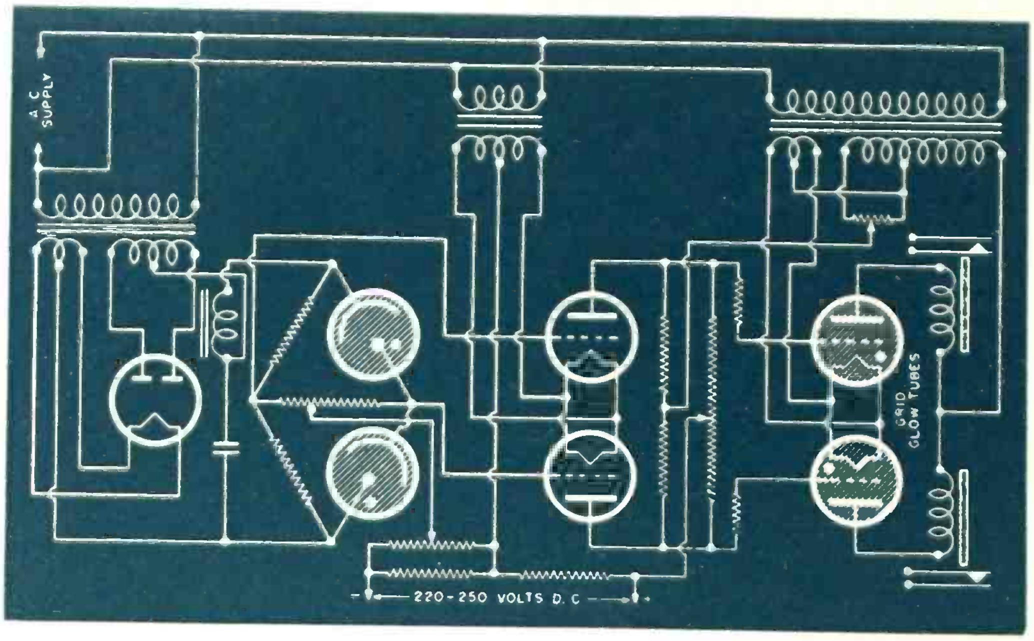


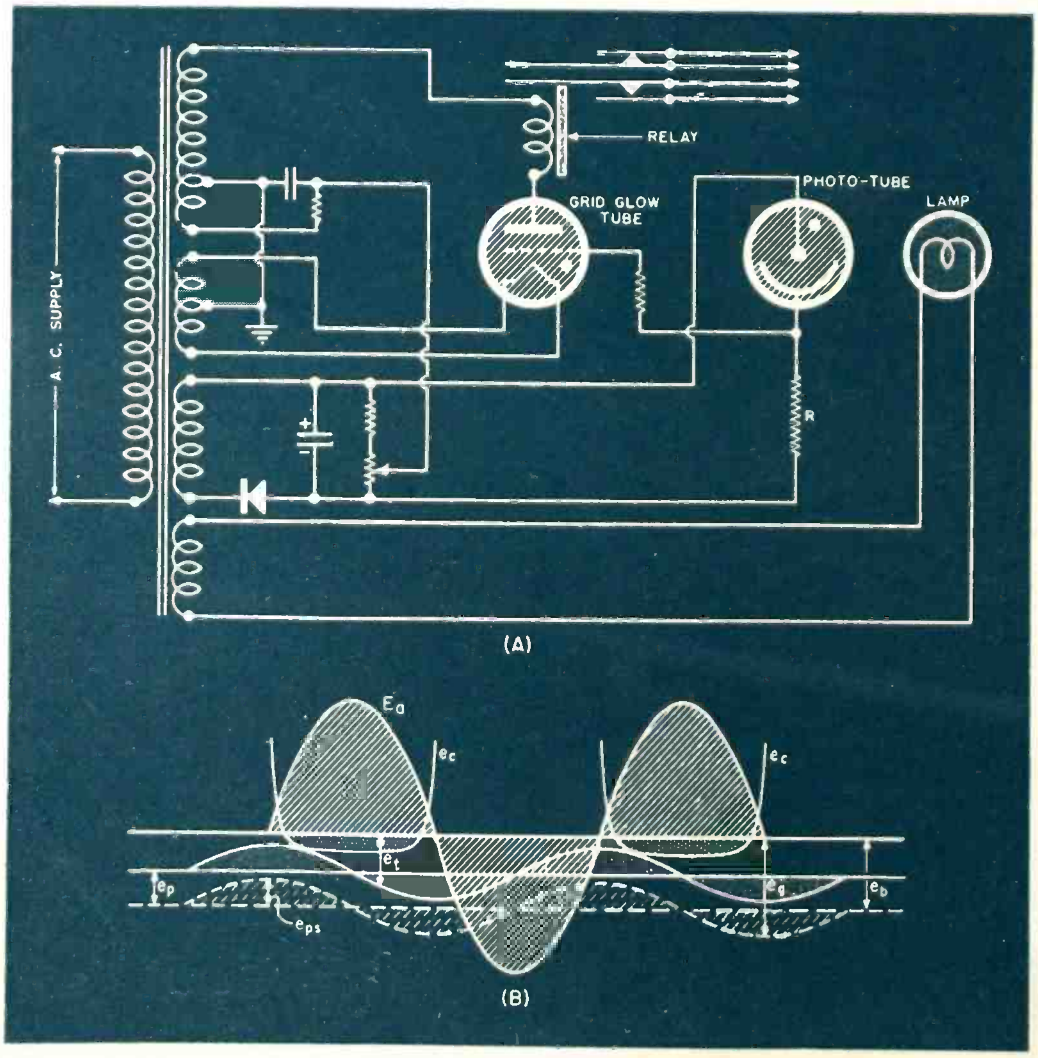
Fig. 9. Schematic diagram of balanced type process regulator.

of the material is too dark. This type of control is extremely simple, but for many processes it is not sufficiently accurate because changes in the supply voltage as well as changes in phototube and amplifier tube characteristics affect the calibration of the equipment.

In many regulator applications there is a possibility that if the regulator should lose its calibration during operation, considerable amount of material might be spoiled before the error was corrected. To eliminate this possibility, the equipment must be self-calibrating. This can be done by continuously comparing the material to be controlled with a standard sample. There are two general methods for performing such a comparison:

1. *Balanced-bridge method.* Two phototubes are connected in a Wheatstone bridge circuit and illuminated from the same light source. In front of one phototube is placed a standard sample, while the material to be controlled passes in front of the other phototube. Any unbalance causes a regulating effect upon the process which is being controlled. Although this method can be made very sensitive to unbalance, it has the disadvantage of requiring recalibration from time to time because of the possibility of discrepancies in characteristics developing with age of the tubes.
2. *Flicker method.* The light from a single source is directed by a system of mirrors and lenses through two different paths onto a single phototube in such a manner that one beam passes through a standard sample while the other beam passes through the processed material. The two beams shine alternately in rapid succession on the phototube. If there is any flicker the process is automatically modified until the flicker is zero. In this method the linearity of the phototube and amplifier does not affect the regulation.

Fig. 10. (A) Basic circuit for an a.c. operated photoelectric relay. (B) Voltage relations of circuit in (A).



The circuit of a balanced type regulator is shown in Fig. 9. If the phototube bridge becomes unbalanced, the voltage on the grid of tube 2 differs from the grid voltage of tube 3. This unbalance in the amplifier tubes causes an unbalance in the grids of the grid-glow tubes, with the result that when the unbalance becomes great enough one of the tubes will break down and energize the corresponding relay to exercize a corrective effect.

In Fig. 13 is shown the circuit and optical arrangement of a flicker method regulator for chemical processes. The two beams of light are interrupted by a diaphragm containing an aperture so constructed that the sum of the areas of the light beams is always constant, one aperture varying from zero to 100 per cent while the other aperture varies from 100 per cent to zero. The output from the phototube is fed into the grid of an a.c. amplifier. When the light-transmitting qualities of the two liquids are identical, the illumination on the phototube is unchanged as the diaphragm is rotated. If the light-transmitting quality of the sample differs from that of the standard, the illumination on the phototube varies as the diaphragm is rotated and the pulsating current is amplified. The a.c. which appears in the secondary of transformer *T* is proportional in phase and magnitude to the deviation of the light-transmitting quality of the sample from that of the standard fluid. This a.c. component is rectified by a

(*Continued on page* 40)

Clipping, Blanking, and Discriminating Circuits

By M. H. SHAMOS
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New York University

Circuits for the production and utilization of various waveforms, including square and peaked waves.

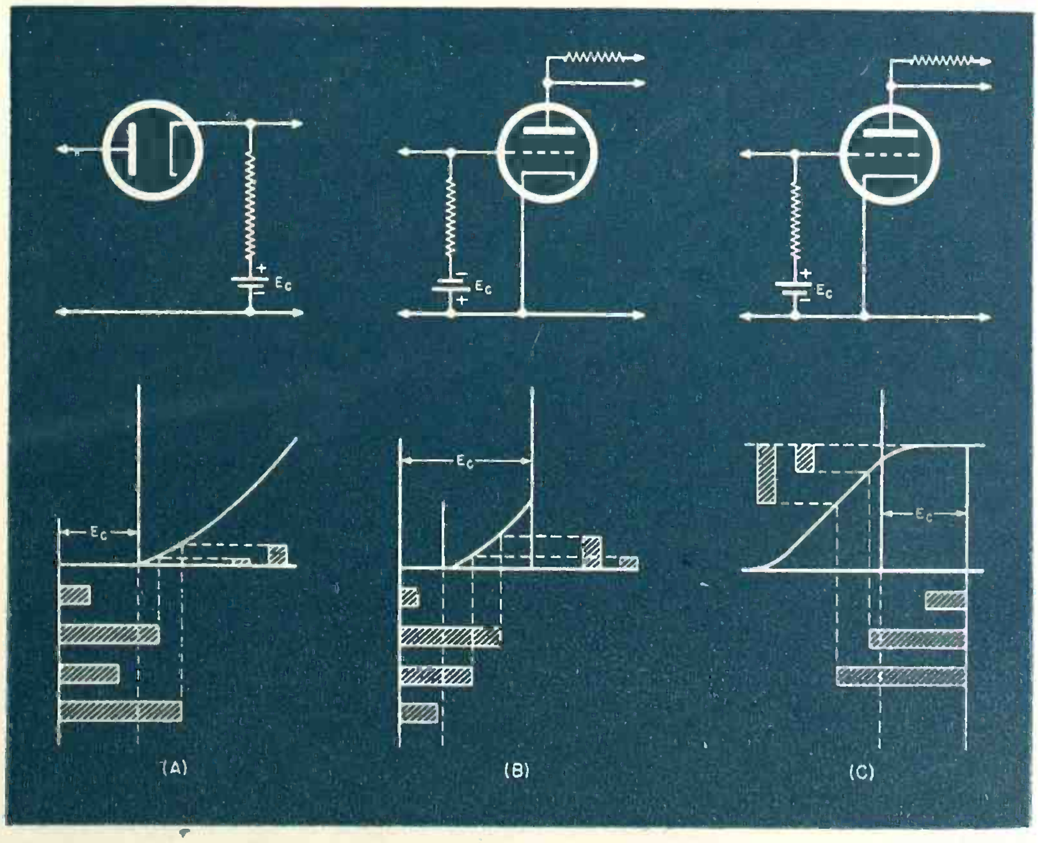
SINCE most control circuits depend upon pulses of one sort or another for their operation, it is of some importance to examine various methods of controlling these pulses. This discussion precedes that of pulse generators in general, for several of the circuits described here have application in the production of pulses as well. Essentially, these circuits are distorting amplifiers, in that they amplify only selected pulses—or selected portions of pulses. The basis for selection may be one of several: amplitude, width, pulse shape and polarity being the distinguishing characteristics of the pulses. The problem is complicated by the fact that the pulses used in control circuits are generally of random nature; hence, frequency is not among the distinguishing features and a rigorous mathematical analysis becomes extremely difficult. Despite this transient nature the information contained in the pulses is sufficient to allow for selection in most cases.

The most marked feature of a pulse, as far as selection is concerned, is, of course, its polarity. The simplest method of separating pulses according to polarity is by means of a diode. Those pulses of undesired polarity may be shunted to the ground rail, while pulses of the opposite polarity are passed on. A double diode such as the 6H6 presents a forward impedance of but a few ohms, so that the drop across the tube will be small for the undesired pulses. If the pulses are to be separated for use in further circuits, without discarding those of any particular polarity, the circuit of Fig. 8 (A) may be used. Here, the negative pulses are obtained at the plate of tube 1 and the positive pulses at the cathode of tube 2. In some applications it is desirable that the wave shape of the original pulses be retained; hence, a diode with a linear characteristic should be employed. While the 6H6 with proper load resistance is fairly good in this respect, some of the new u.h.f. diodes such as the 9004 exhibit somewhat more linear characteristics. The blocking capacitance, C, should be as large as possible to avoid distorting the wave shape, else the low forward impedance of the conducting tube will combine to make the circuit an effective high-pass filter.

Editor's Note: This is the third of a series of articles by Mr. Shamos on the subject of Electronic Control Circuits. Previous articles appeared in the October and November issues, and other articles of the series will appear in the future. In some cases, material in one article may depend on material presented previously.

The same results can be achieved through the use of any control-grid tube biased to cut-off or to saturation, depending upon the polarity of the pulses to be passed. However, the distortion is considerable in this mode of operation, due to the extreme curvature of the transfer characteristic around cut-off. The transfer characteristic of most pentodes can be straightened somewhat by maintaining the first grid slightly positive and using the screen-grid as the control grid. The optimum potential for the first grid is best determined by experiment for any particular tube type. The potential must be great enough to overcome the retarding field at the cathode due to the space charge, yet not sufficient to cause excessive grid current to flow. The first grid becomes, essentially, a virtual cathode—without the attendant retarding field due to image charges. Tubes with high grid resistance are best for this purpose, as

Fig. 1. Discriminating circuits, sometimes called "clippers" or "choppers," utilizing a biased diode or triode. Operation may be at cut-off, as in (B), or at saturation, as in (C).



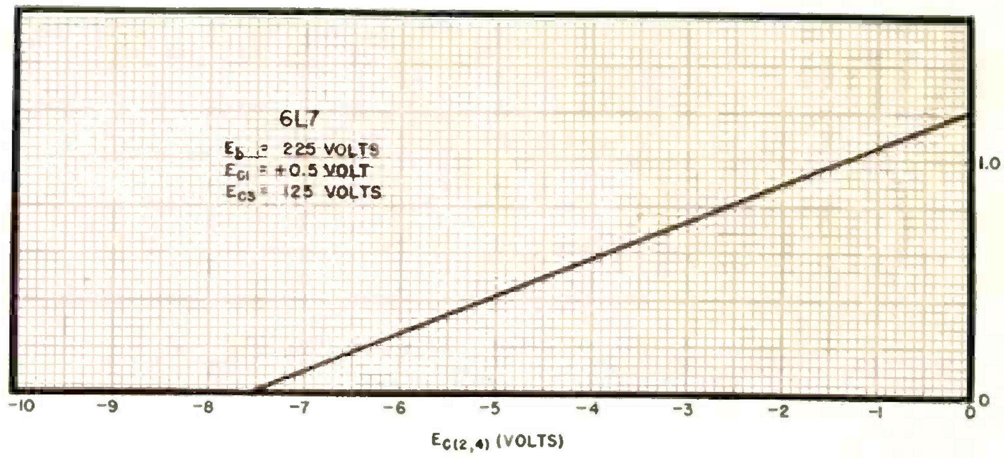


Fig. 2. Straight line transfer characteristic of 6L7 with + 0.5 volts on first grid.

the grid current is then kept low. It is important that the impedance of the source supplying the potential for the first grid be very low, else the grid current will set up a drop across the source which will cancel the effect of the positive grid. This presents a problem in itself, as the optimum potential is usually found to be smaller than that provided by a single bias cell. Thus, the resistance of the potential divider employed must be low, which means that the current drain on the cell will be high.

Several tubes have been examined in the author's laboratory with a view toward obtaining a linear transfer characteristic. In all cases, it was found that the linearity could be improved in screen-grid tubes by operating the first grid at a slight positive potential; the optimum potential varied among tube types, but was of the order of 0.5 volt. The most interesting results were obtained with the 6L7 pentagrid mixer, the first grid of which is of the remote cut-off type. As shown in Fig. 2, the transfer characteristic is, within the experimental limits, a straight line. Here, the second and fourth grids, which are tied together, are used as the control grid, the third grid as the screen, and the fifth grid as suppressor. Increasing the plate potential to 300 volts has no appreciable effect upon the curve. Of course, the transconductance is decreased in this mode of operation, being of the order of 200 micromhos. The plate characteristics, two of which are shown in Fig. 3, indicate that the tube retains the familiar pentode feature to some extent, the plate resistance being of the order of 1 megohm at a control-grid potential of —3.0 volts. When a pentode is used in this fashion the plate characteristics resemble those of a tetrode, and, while the static transfer characteristic is fairly linear, the dynamic characteristic need not be.

In driving a tube to saturation by means of a positive control grid it is desirable that saturation be reached upon the application of a very small positive pulse. Such operation is also possible by maintaining the first grid of a pentode at a small positive potential. At the same time, the control-grid resistor should be kept high for a flat characteristic. Since the screen-grid resistance is generally much higher than that of the control grid, several megohms may be placed in the screen-grid circuit. Fig. 4 shows two curves for the 6SJ7 operated in this fashion, each taken with 2 megohms in the control-grid circuit, *i.e.*, in the screen grid.

Discriminating Circuits

In the separation of signals according to their identifying characteristics the simple circuits described above, with some modification, are used to good advantage. Such circuits will be referred to as discriminators, although the terms "clipper" and "chopper" have been used in the literature. However, the former term appears to be somewhat more general, aside from its usual connotation in regard to FM receivers. A biased diode or control-grid tube serves to pass only those pulses which exceed the bias potential in the case of the diode—or the difference between the bias potential and the cut-off potential in the case of the control-grid tube. The operation of these circuits is outlined in Fig. 1 (A) and (B). The diode may be oriented in the circuit so as to operate on positive or negative (but not both) pulses. If a control-grid tube is to be used in selecting negative pulses, the tube is biased beyond saturation, Fig. 1 (C). It is usually desirable to obtain a large output pulse from the circuit of Fig. 1 (B) irrespective of the size of the input pulse, provided, of course, that the pulse is large enough to drive the grid above cut-off. Hence, a high gain screen-grid stage should be employed, resulting in a characteristic somewhat like that shown in Fig. 8 (B). Here, the

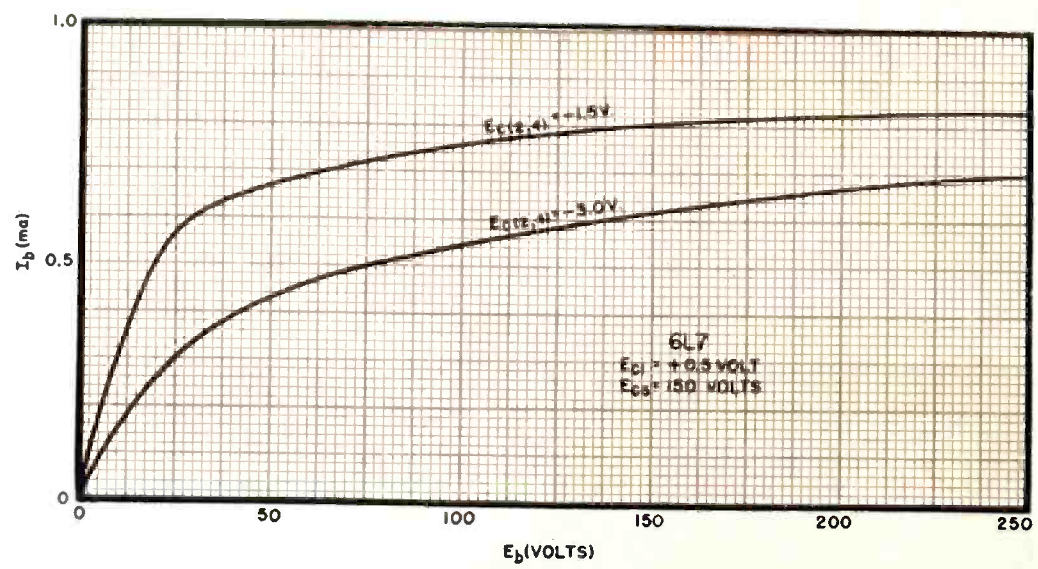
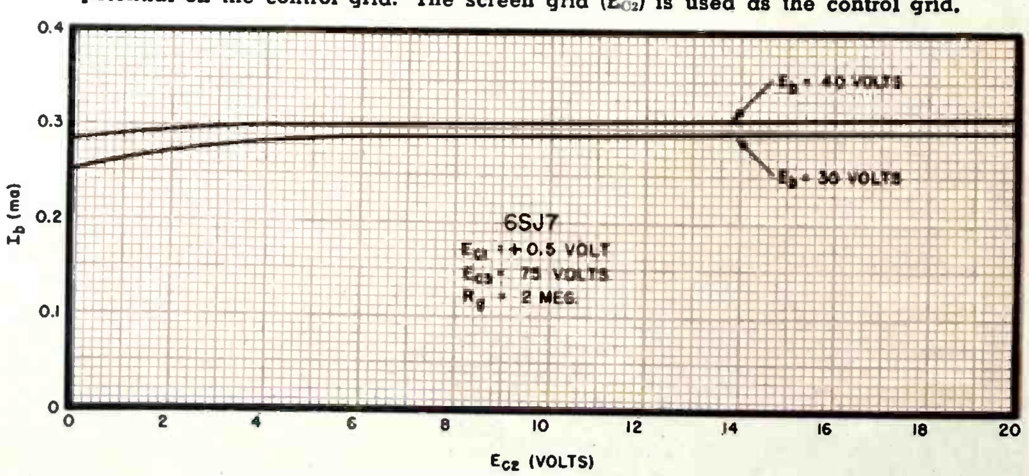


Fig. 3. Plate characteristics of 6L7 with small positive potential on first grid, showing characteristics of a pentode. $E_{c(2,4)}$ is used as the control grid.

Fig. 4. Plate characteristics of 6SJ7 driven to saturation by means of a positive potential on the control grid. The screen grid (E_{c2}) is used as the control grid.



ideal response is shown by the broken line and the actual response by the continuous curve. The use of a screen-grid tube also ensures against small sharp pulses passing to the plate by way of the interelectrode capacitance. For most reliable performance, such a stage should be direct-coupled; otherwise the charge accumulated on the coupling condenser after each pulse changes the effective cut-off bias, thus making it dependent upon the rate at which the pulses are received. Lewis[1] has described a rather reliable circuit of this type which is capable of discriminating among pulses differing by only ½ volt.

In many cases a simple thyratron "trigger" tube[2] provides satisfactory discrimination, provided the tube is of the type which can not be extinguished by a large negative pulse on the grid. Here the characteristic curve more nearly approaches the ideal curve of Fig. 8 (B), except that the striking potential may not always be regarded as constant.

All the circuits described thus far operate only on those pulses which exceed some pre-determined value. The inverse type circuit, although somewhat more complex, is nevertheless possible. It is required that such a circuit operate only on pulses of amplitude less than some pre-determined value. (The circuit is considered to "operate" when it transmits a pulse of certain polarity). The addition of a "control" tube, so biased as to become operative when the pulse height exceeds the required maximum, serves to balance out the effect of the pulse. The basic circuit is shown in Fig. 5. Tube 1 is biased just below the firing potential, while tube 2 is biased to a point determined by the maximum pulse to be transmitted. For all pulses of amplitude smaller than the desired maximum only tube 1 fires, thereby passing a pulse through the output transformer. However, when the maximum pulse height is exceeded both tubes fire, and since the potentials on both plates drop simultaneously (or with little lag), there is no appreciable output pulse. The combinations R and R_c provide bias for the thyratrons, which is varied by means of the tap on R_c. The tubes are made self-quenching by the condensers C. Since tube 1 fires a brief instant before tube 2 (depending upon the slope of the leading edge of the pulse), a sharp pulse may be transmitted to the succeeding stage. However, this can be eliminated by a filter arrangement. The circuit also serves as a differential selector, since the bias potentials are variable on both tubes. Hence, only those pulses lying between the two limits will activate the circuit. Roberts[3] has described a circuit of this type which discriminates among pulses differing in amplitude by about 0.1 volt over a considerable range. Of course, the accuracy of a circuit of this type is limited ultimately by the reliability of the firing potentials of the thyratrons; with some of the new types, such as the 2050 and 2D21, a fairly high degree of accuracy can be obtained. It will be seen that such circuits can be of considerable use in automatic tolerance inspections.

The simplest method of selecting among pulses of different base width consists in translating the variations in width to variations in amplitude and then proceeding by the methods outlined above. The pulses are first equalized in amplitude by "clipping" and then applied to the grid of a conventional amplifier stage. The pulses appearing at the plate of this stage are fed back to the grid through a phase-shifting (delay) and reversing net-

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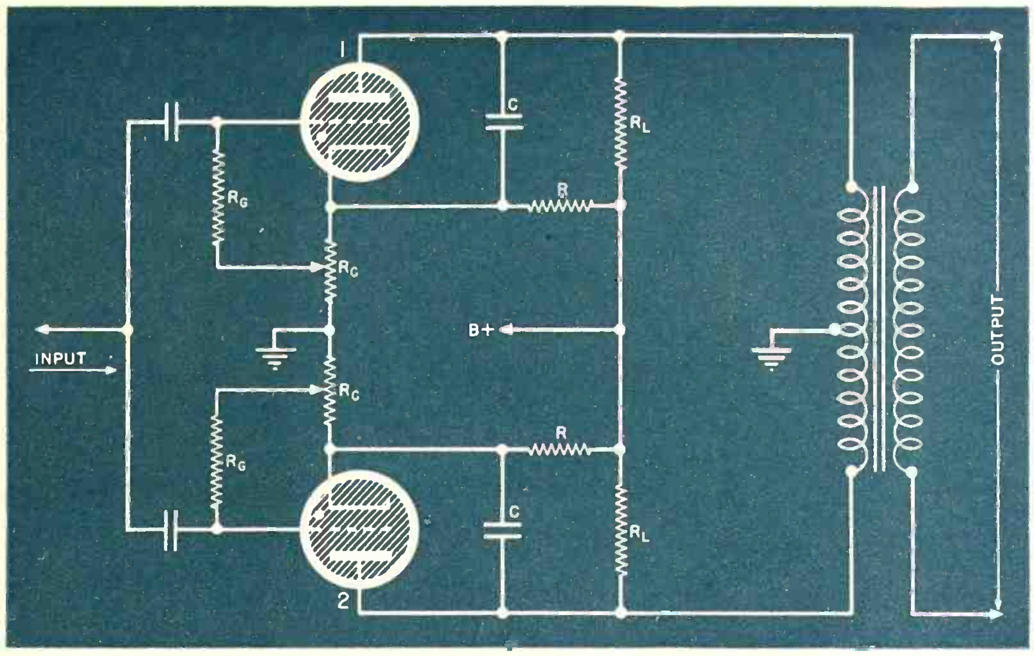


Fig. 5. Circuit which transmits a pulse when input drops below a certain predetermined value.

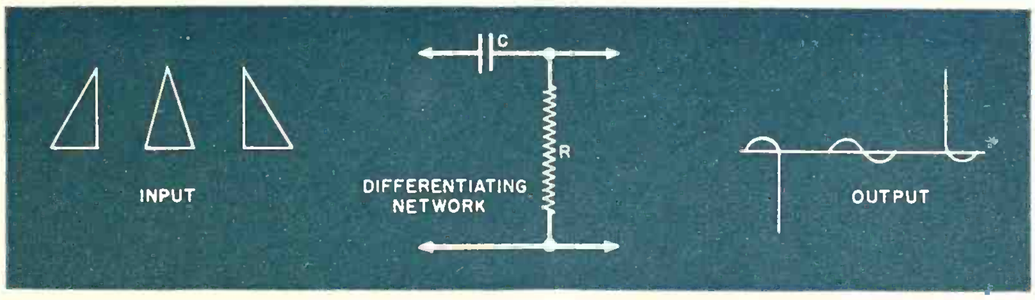
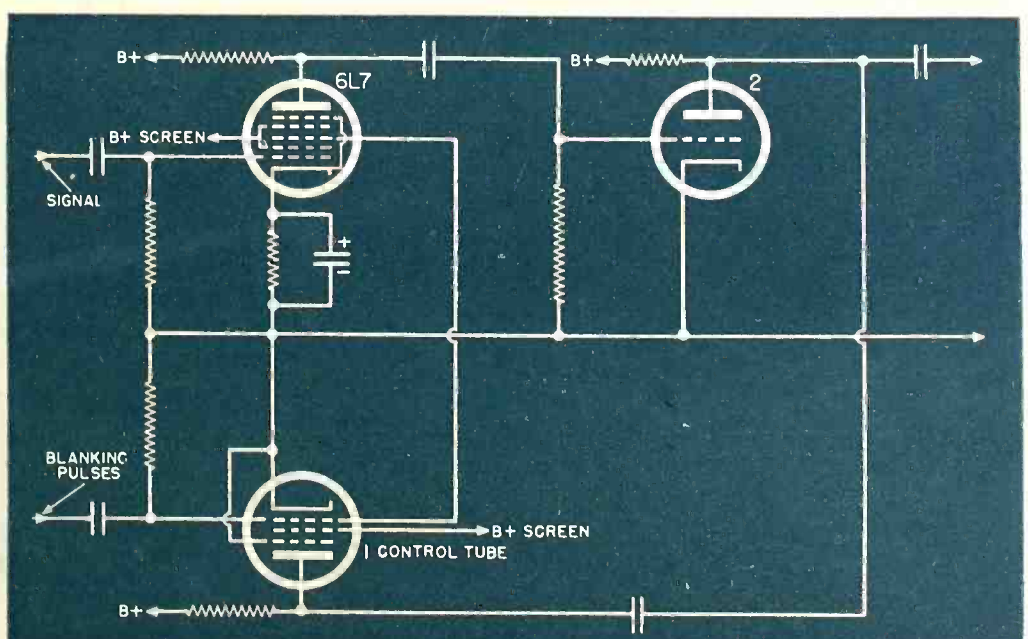


Fig. 6. Differentiating network used in discriminating among pulses having different shapes.

Fig. 7. Circuit for removing blanking pulse from signal when blanking pulse is not unidirectional. Negative pulse at tube 2 is cancelled by positive pulse from tube 1.



PHASE EQUALIZERS

By R. A. WHITEMAN
Electronic Engineer, Bell and Howell Co.

Designing and testing phase-equalizer circuits for video amplifiers.

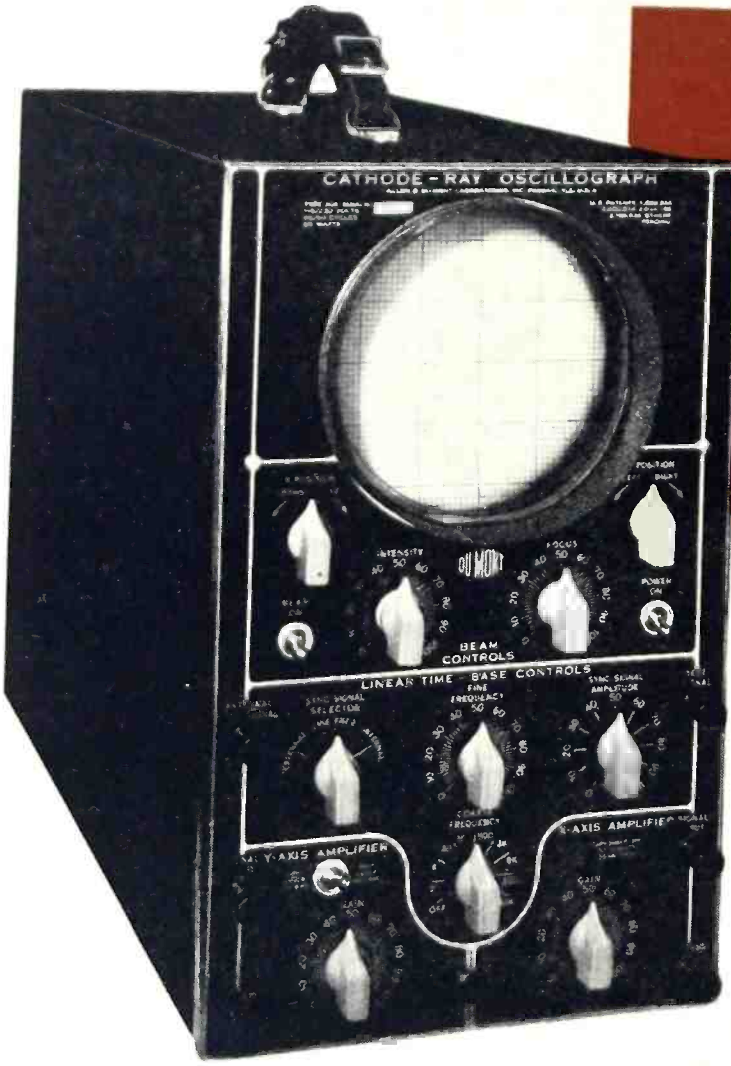
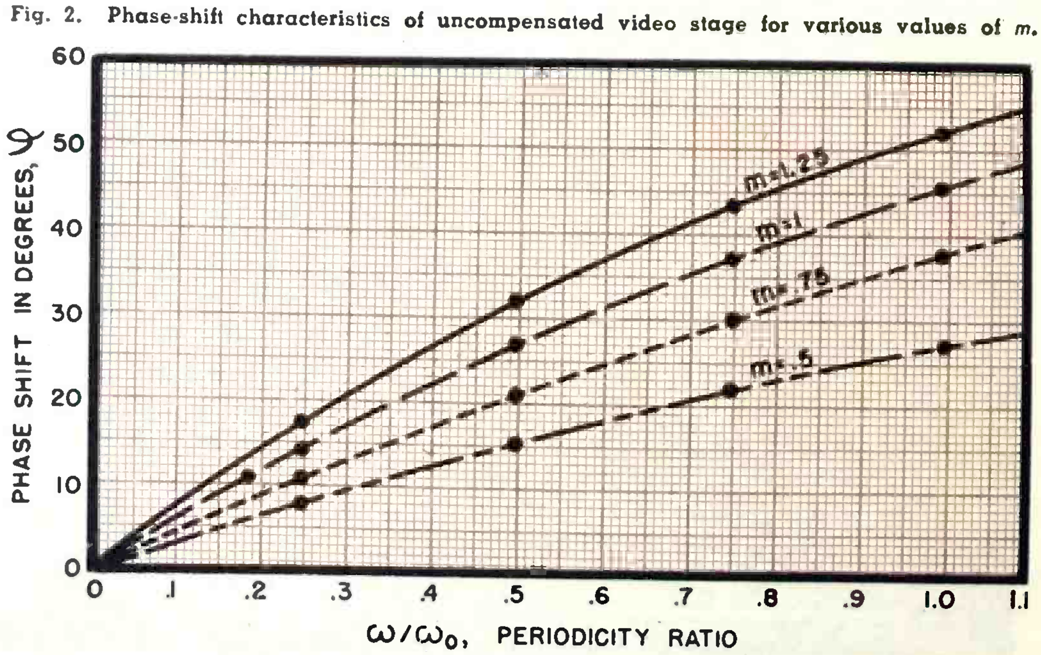


Fig. 1. Wide-band oscillograph which may be used to determine phase delay.

THE design of electronic-transmission circuits generally includes consideration of the three basic types of distortion classified as amplitude, frequency, and phase distortion. The relative importance of these distortions depends upon the particular application and the tolerances permitted in the reproduced signals. The correction of amplitude and frequency distortion by equalization has been an important consideration in audio-frequency design. Phase distortion, however, has not been considered important in audio-frequency work except in circuits involving transcontinental telephone lines and transoceanic submarine cables. Phase-equalizer networks are of considerable importance at high frequencies and in picture-transmission circuits. The video amplifier is of a class of circuits which necessitates the inclusion of phase equalization to obtain "sharp" pictures. Unfortunately, in practice, it is not possible to completely divorce the phase-shift properties of a transmission circuit from the amplifying characteristics of the circuit. This may be emphasized very simply by noting that the phase shift at a particular frequency depends upon the rapidity with which the amplification is changing. If the amplification is constant over the transmission band, the phase shift is independent of amplification and depends upon the frequency and circuit elements. To proceed with the design of circuits which will produce the desired phase shift, consider the ideal performance desired of a video amplifier.

Fig. 2. Phase-shift characteristics of uncompensated video stage for various values of *m*.



The frequency band to be amplified ranges from 30 cycles per second to approximately 4.5 megacycles per second. If the amplification of this circuit changes in the pass band, the intensity of illumination of the image will be incorrectly proportioned. If the phase shift is not the proper value, sharp lines of demarcation separating bright areas from dark areas will appear as blurred lines. This result may be readily explained by visualizing sudden changes in brightness of illumination accompanied by a corresponding change in the video signal. Such signals are composed of an extremely wide band of frequencies ranging from zero to several megacycles. Theoretically, these frequencies extend to infinity but this fact has no practical significance in the present state of video amplification. To obtain a reasonably faithful distribution of the brightness over the image, a fairly constant amplification is required over the video-frequency band. This requirement can be satisfied without imposing difficult circuit tolerances. The phase-shift problem is somewhat more difficult and requires very careful consideration.

Visualize a wide band of frequencies representing a voltage pulse due to a sudden change in the intensity of illumination. This band of frequencies is generated simultaneously at the transmitter and in order to arrive at the receiving screen at the same instant, they must travel through the video-amplifier during the same time interval.

High and low frequencies entering the video amplifier at the same instant must emerge from the amplifier output together. The time required for the group of frequencies to pass through the amplifier is defined as the *time delay.* The time delay, in seconds, and the frequency are related by the formula:

$$\varphi = 2\pi f \tau + k \quad \text{.................... (1)}$$

where:

φ = phase angle delay in radians
f = frequency in cycles per second
τ = time delay in seconds
k = a constant
$\omega = 2\pi f$

Since the ideal conditions require that τ have the same numerical value for all frequencies, the phase delay should be directly proportional to the frequency, *f,* or the periodicity, ω. This is expressed algebraically as

$$\frac{d\varphi}{d\omega} = \tau \quad \text{.......................... (2)}$$

The phase-delay graph which satisfies equation (1) is shown as curve *A* in Fig. 3, while curve *B* satisfies the condition of constant time delay plotted as a straight line.

The phase-equalizer network should be introduced or a modification of the existing transmission network is necessary in order to change the phase-delay characteristic from a non-linear curve, *A,* to a straight line, *B.* To determine experimentally the phase delay in the pass band, the circuit is arranged as indicated in Fig. 7. The signal generator, Fig. 5, should be connected to the input of the video amplifier and to the vertical deflection plates of a wide-band oscillograph, Fig. 1. The output of the amplifier should be connected to the horizontal deflection plates. The quantitative measurements are made by adjusting the vertical deflection so that it is equal to the horizontal deflection. This adjustment is essential in order to obtain an undistorted pattern on the screen of the oscillograph. When the vertical and horizontal deflections are produced simultaneously, the resultant pattern is a form of Lissajous figure and changes its form as the phase delay changes.

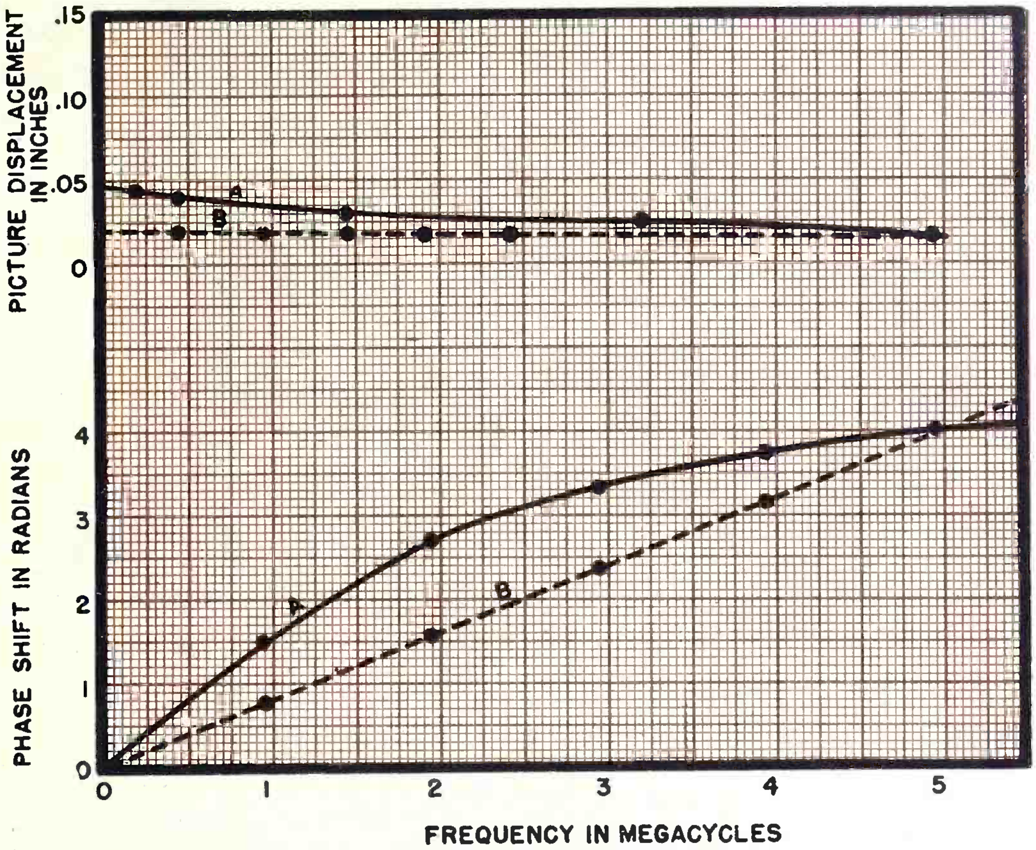


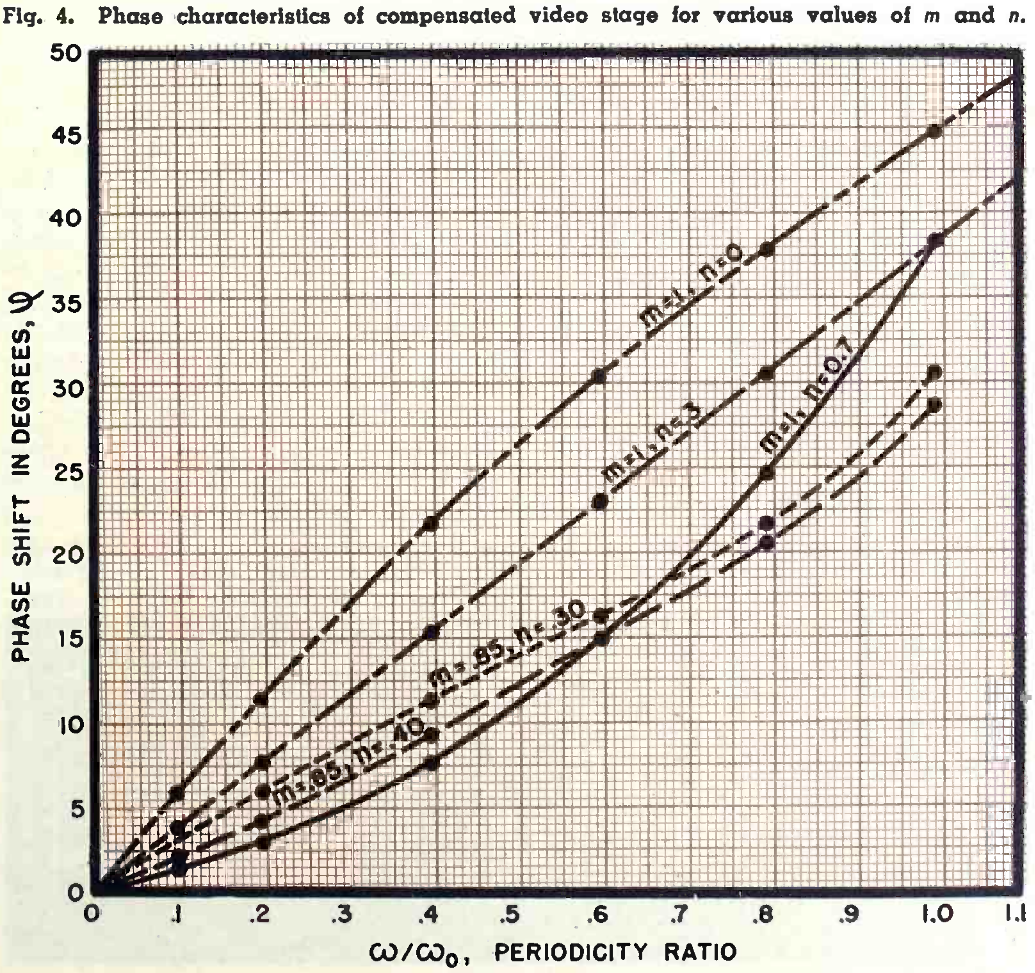
Fig. 3. Linear and non-linear phase-shift characteristics and effect on picture distortion.

For a particular frequency, f_n, the geometrical measurements necessary are indicated in Fig. 8 as A_n and B_n, measured directly from the screen pattern in centimeters or any other convenient unit of length. The electron stream should be focussed to as small a diameter as possible in order to reduce the error to a few percent. After these measurements are made, the phase-delay may be computed with the aid of the relation

$$\varphi_n = \arcsin \frac{A_n}{B_n} \quad \text{.................... (3)}$$

where φ_n is the particular phase delay at a frequency f_n. This measurement and computation should be made for approximately eight different frequen-

Fig. 4. Phase characteristics of compensated video stage for various values of *m* and *n*.



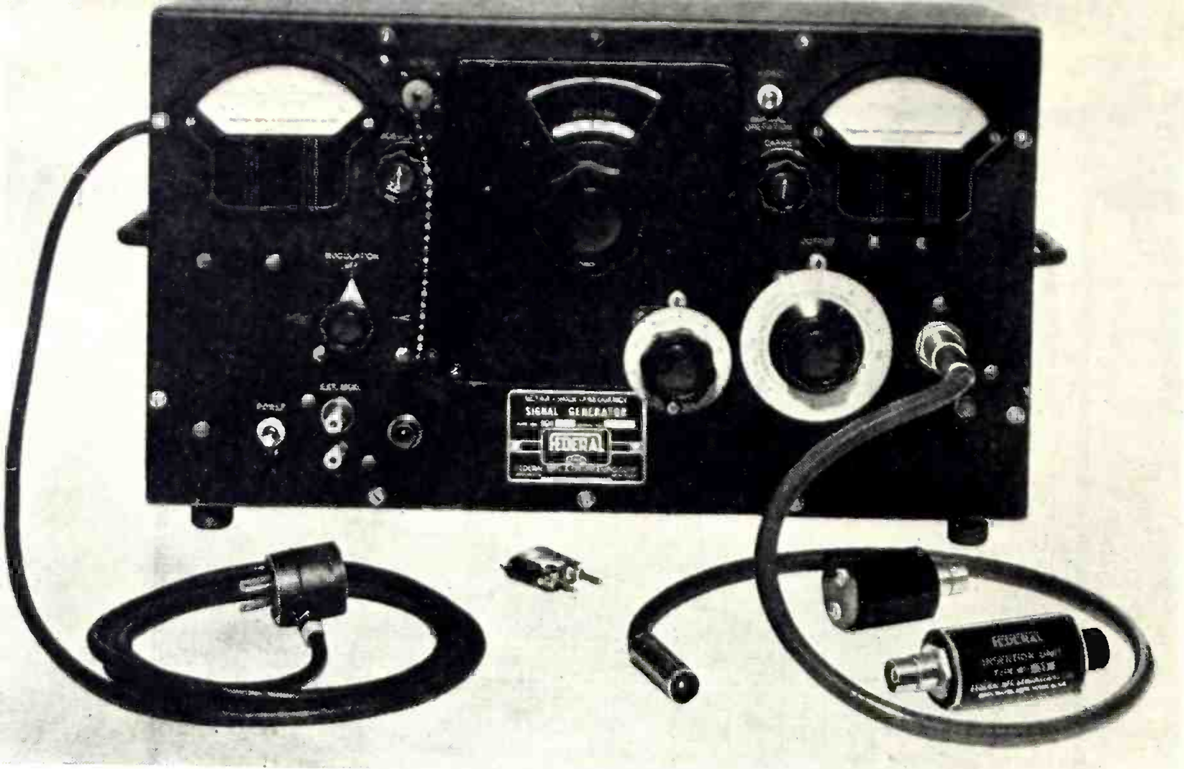


Fig. 5. R.f. signal generator which may be used in testing phase-equalizer circuits.

cies within the transmission band. A graph drawn smoothly through these eight points, plotting phase delay, φ, against the frequency, f, appears as a curve and not necessarily a straight line. Ultimately, to obtain a linear function or constant time-delay, the design of phase equalizers for video-frequency amplifiers will be introduced from the following three points of view: phase-delay correction (1) by trial and error adjustment, (2) by using filter networks, and (3) by considering the general phase-delay function.

The visual effect of a non-linear phase delay may be graphically plotted by realizing that the electron scanning beam in picture transmission moves across the cathode-ray tube screen at a speed of approximately 1.5×10^5 inches per second.

If there is a time delay of only one microsecond, the image point associated with the particular frequency will be shifted 0.15 inch. The displacement graph shown in Fig. 3 indicates the geometrical distance an image point is shifted across the screen. For the condition of no phase-delay distortion, the displacement curve should be horizontal, indicating that all image points are shifted by the same geometrical distance. The left portion of the picture would be shifted the same distance as any other part of the image and therefore local compressions in the picture would be avoided.

An analysis of one stage of a video amplifier without phase-delay correction will provide a reference and basis for improvement. The simple uncompensated stage is shown in Fig. 6 (A) as a resistive-coupled stage. The voltage gain, neglecting the 180 degree phase-shift introduced by the tube, is given by

$$G = g_m Z_L \qquad (4)$$

where

G_m = transconductance in mhos

Z_L = load impedance in ohms

The basic circuit for which equation (4) applies is shown in Fig. 6 (A). The load impedance, Z_L, includes the electrode and distributed capacitances to ground as well as the resistance, R. Since these capacitances are in parallel, they may be combined by simple addition and represented by C. The capacitive reactance of C and the resistance, R, in parallel form the video load, Z_L. The pentode tube may be considered as a constant current generator driving the signal current through Z_L, while the output voltage, E_0, is being developed across Z_L.

The phase angle between the current, I_0, through Z_L, and the voltage, E_0, is the phase-delay of the circuit. This delay may be readily computed by solving for Z_L. Let f_0 equal $\omega_0/2\pi$, the frequency at which $R = m/\omega_0 C$, then Z_L is (m being a parameter)

$$Z_L = \frac{\frac{R}{j\omega C}}{R + \frac{1}{j\omega C}} = \frac{R(1 - jRC\omega)}{R^2C^2\omega^2 + 1} \qquad (5)$$

$$Z_L = \frac{R}{\sqrt{1 + R^2C^2\omega^2}} \qquad (6)$$

$$Z_L = \frac{R}{\sqrt{1 + \frac{m^2\omega^2}{\omega_0^2}}} \qquad (7)$$

The phase-delay for this circuit is

$$\varphi = \arctan RC\omega \qquad (8)$$

$$\varphi = \arctan \frac{m\omega}{\omega_0} \qquad (9)$$

The time-delay in seconds at any frequency, f, is

$$\tau = \frac{\varphi}{2\pi f} \qquad (10)$$

which gives

$$\tau = \frac{1}{2\pi f} \arctan \frac{mf}{f_0} \qquad (11)$$

The graphs relating φ to ω/ω_0 for different values of m are plotted in Fig. 2. The effect of decreasing m serves to reduce the time delay but unfortunately the voltage gain is likewise diminished. As a result of this relation, the upper cut-off frequency of the amplifier, ω_0, is selected as that frequency at which the gain has dropped 3 db., and therefore, m must equal unity.

The phase-delay may be made more linear by introducing an inductance, L, in accordance with the schematic diagram of Fig. 6 (B). If the relation between the capacitive reactance, inductive reactance and the resistance is given by

$$R = \frac{m}{\omega_0 C} \qquad (12)$$

$$\omega_0 L = \frac{n}{\omega_0 C} \qquad (13)$$

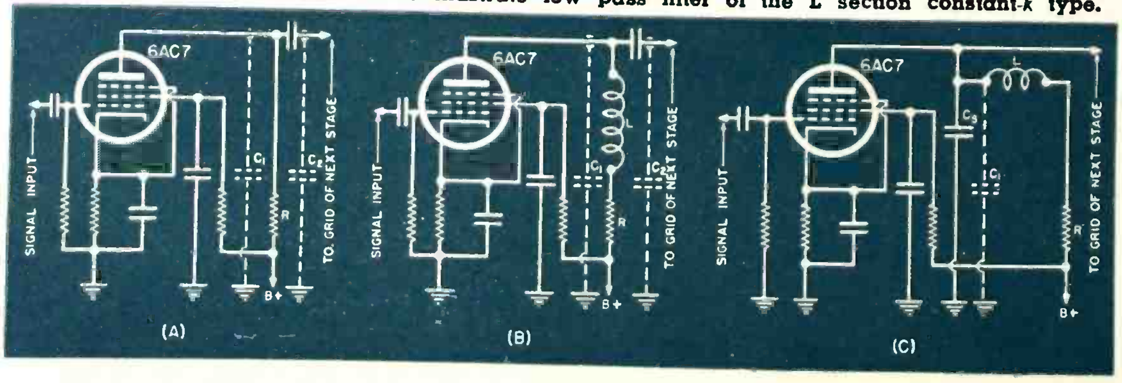
and the load impedance by

$$Z_L = \frac{(R + j\omega L)\frac{1}{j\omega C}}{R + j\left(\omega L - \frac{1}{\omega C}\right)} \qquad (14)$$

$$Z_L = \frac{R + j(\omega L - \omega^3 CL^2 - R^2\omega C)}{R^2C^2\omega^2 + (LC\omega^2 - 1)^2} \qquad (15)$$

(Continued on page 24)

Fig. 6. (A) Uncompensated video stage showing distributed capacity C_1 and C_2. (B) Stage with shunt-peaking circuit including inductance L to compensate for C_1 and C_2. (C) Shunt-peaking circuit redrawn to illustrate low pass filter of the L section constant-k type.

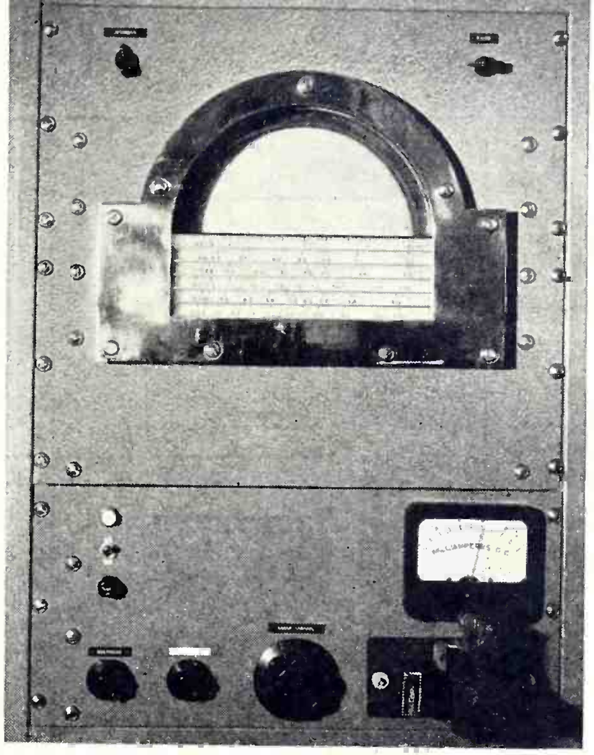


A VISUAL CRYSTAL CHANNEL SORTER

By WILLIAM MARON

Senior Radio Eng., North American Philips Co., Inc.

A device for rapidly and visually indicating the oscillating frequency of quartz crystals with a minimum of time and effort.

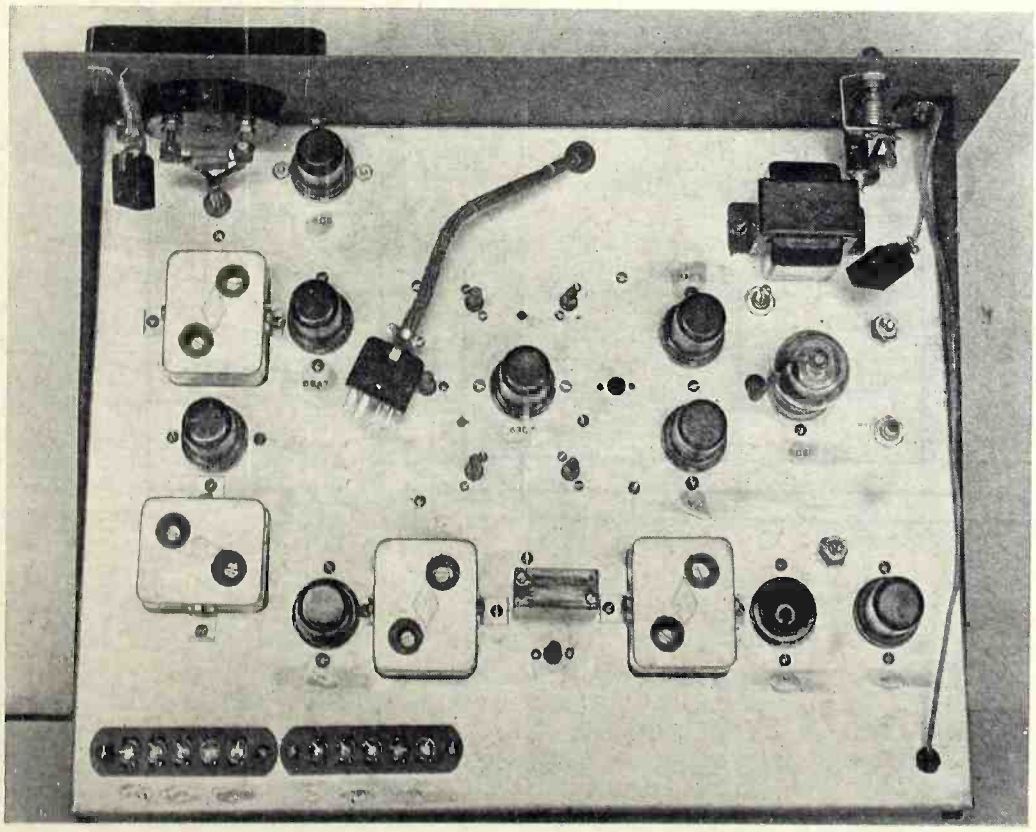


Front view of the channel sorter.

THE present development is concerned with a device for indicating directly, in a visual manner, the frequency of piezoelectric crystal blanks, so that the blanks may be quickly and positively sorted according to channels and assigned to further treatment in accordance with established manufacturing practices.

The primary object of this development is to provide a channel sorter device of novel character which makes practically no demands on the skill or experience of the operator, and dispenses with prior complex testing procedures involving a number of interrelated steps which must be properly correlated and interpreted by the operator in order to obtain correct results. Experience has demonstrated that the installations heretofore used for the purpose were complicated and difficult to handle, even by highly-trained operators. At best, sorting the blanks was an intricate procedure consuming a great deal of time; errors in sorting were frequent and practically impossible to eliminate.

The principle underlying the present device will be best understood by reference to the block diagram (Fig. 2). Essentially, a reference oscillator is provided, having a suitable crystal holder attachment connected thereto wherein the crystal under test may be conveniently inserted. The r.f. oscillations produced by the oscillator are introduced into a mixer, or first detector, together with the output of a local oscillator. The resultant of the two oscillations is an intermediate frequency which is amplified by means of an amplifier sharply tuned to a predetermined i.f. frequency, as will appear from the following discussion of the operating principles of the device.



Top view of chassis of the channel sorter, showing arrangement of parts.

Obviously, the crystal blanks under test may have widely different frequencies. Were the local oscillator of a constant frequency, the resulting frequency would be so different from that to which the i.f. transformer is tuned, that, in general, practically no signal would pass through the sharply tuned i.f. channel. Provision is made, however, to modulate the frequency of the local oscillator by means of a reactance tube within a predetermined range, corresponding to one of the frequency ranges within which the tested crystals may fall. Thus, the reactance tube may be controlled by means of a sweep oscillator tuned to a low frequency such as, for example, 30 cycles per second. Consequently, the local oscillator will have a frequency which will be continuously varied between a maximum and a minimum value, 30 times per second. Whenever the frequency of the local oscillator passes through a value such that the difference between the reference oscillator and local oscillator frequencies momentarily equals that of the i.f. amplifier, a short pulse will be passed through the i.f. amplifier and may be rectified in a second detector. In case the sweep oscillator frequency is 30 cycles per second, this condition will occur 30 times per second.

The rectified signal pulses, after sufficient low frequency amplification, are introduced into the vertical deflection

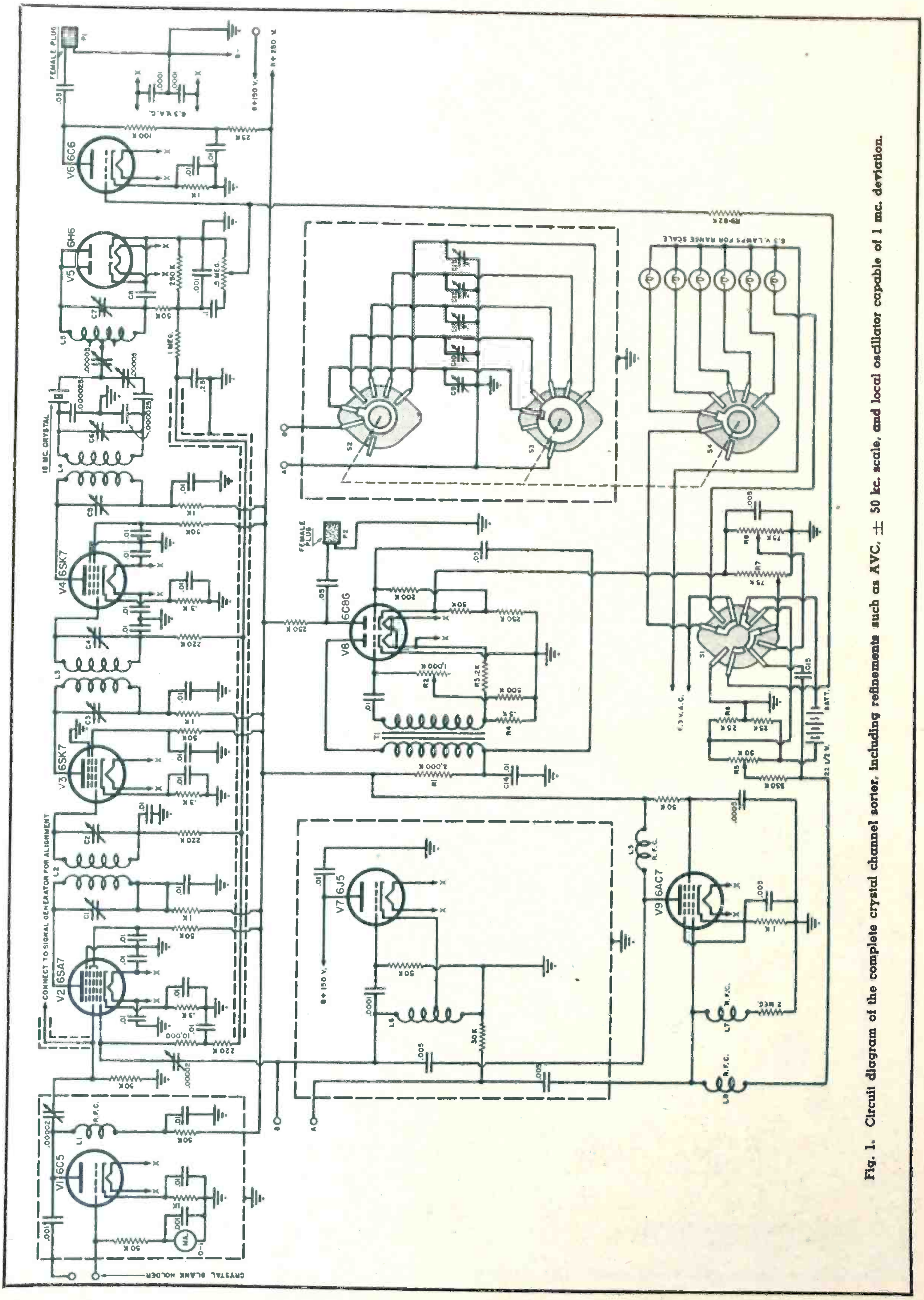


Fig. 1. Circuit diagram of the complete crystal channel sorter, including refinements such as AVC, ± 50 kc. scale, and local oscillator capable of 1 mc. deviation.

plates of a cathode-ray tube. Horizontal deflection for the cathode-ray tube is provided by the same sweep oscillator that is responsible for the frequency modulation of the local oscillator. Thus, assuming proper waveform of the sweep oscillator output, horizontal deflection of the cathode-ray tube beam will be correlated to the frequency of the local oscillator, as governed by the impedance injection caused by the reactance tube, while vertical deflection of said beam will be correlated to coincidence of the reference and local oscillator frequencies with the fixed i.f. frequency. The cathode-ray tube screen may be provided with a horizontally arranged scale which may be directly calibrated in frequency. The peak of the vertical deflection pattern permits one to read the frequency of the crystal under test directly on the calibrated scale. The operation of the device is fully automatic. All that the operator has to do is to insert the crystal to be tested into the holder and, after placing the range switch into its proper position, in which a vertical deflection will appear on the screen, the frequency of the crystal may be read on the corresponding horizontal scale.

The above discussion has outlined a unique crystal channel sorter in practice. The following will describe, in detail, how such a channel sorter was first conceived, put on paper, constructed into a rough model, and finally into a finished product.

The first practical embodiment of the *Visual Piezoelectric Crystal Channel Sorter*, was to be capable of testing crystal blanks, the frequencies of which may fall between 5 to 9 megacycles. Theoretical considerations seem to indicate that proper treatment of such possible crystal frequencies requires an i.f. amplifier frequency of at least 15 megacycles. This i.f. frequency has been found to be sufficient to satisfactorily reject image frequencies and, at the same time, to prevent the production of spurious peaks in the cathode-ray tube pattern, which otherwise might be caused by higher harmonics of the crystal.

As a range of 4 megacycles, from 5 to 9, would require a frequency modulation sweep practically impossible to obtain and, at the same time, would render accurate readings of the crystal frequency on the horizontal scale of the cathode-ray tube rather difficult, it was decided to incorporate 5 ranges of measurement. A range switch having 5 positions permits the operator to successively test the crystal blank in these ranges until vertical deflection of the cathode-ray tube beam indicates that the frequency of the crystal has been reached.

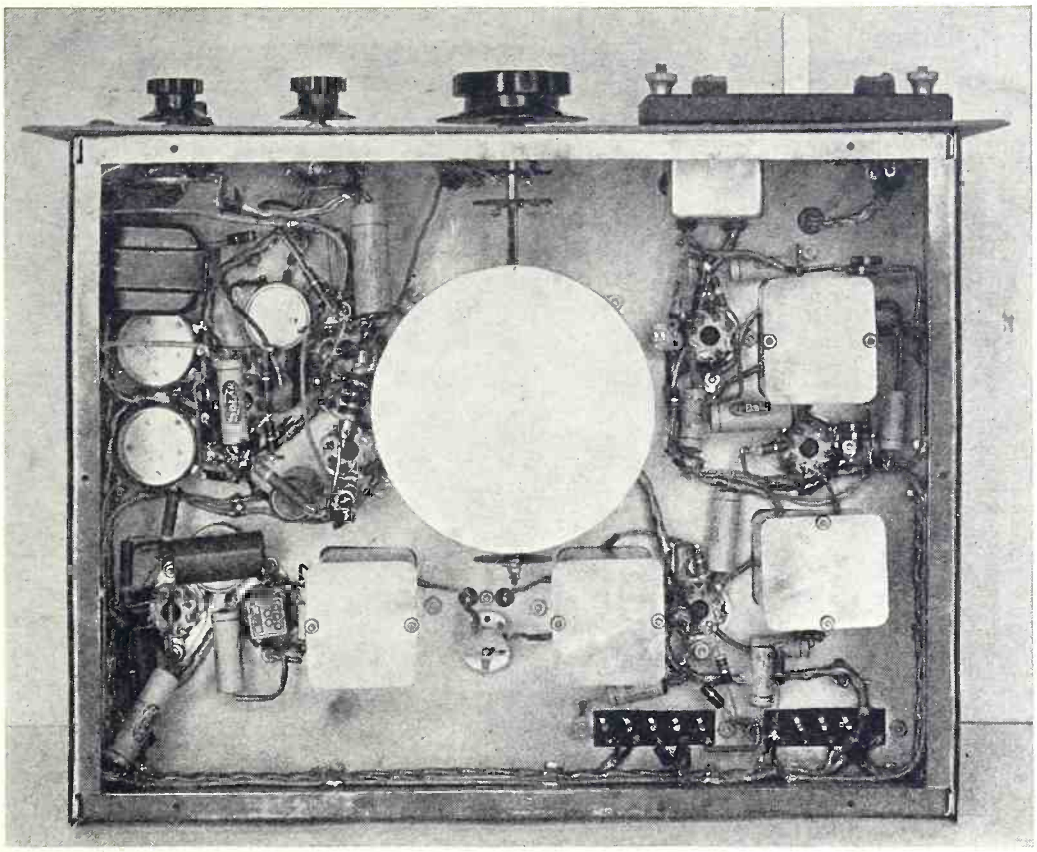
The tentatively established frequency coverage of these ranges and the corresponding frequency ranges of the local oscillator appear below.

Range	Crystal Freq. in mc.	Local Osc. Freq. in mc.
1	5.0-5.8	20.0-20.8
2	5.8-6.6	20.8-21.6
3	6.6-7.4	21.6-22.4
4	7.4-8.2	22.4-23.2
5	8.2-9.0	23.2-24.0

However, in actually making the unit, it was found to be almost impossible to adhere to the above-mentioned channels without spending a great deal of time in pruning coils, making changes in condensers, and in eliminating every bit of stray capacity. Actually, the channels are divided as follows:

Crystal Freq. in Megacycles
5.0 -6.05
6.05-6.9
6.9 -7.75
7.75-8.5
8.5 -9.2

The next important step was frequency modulating the local oscillator. Frequency modulation broadcast transmitters, as known today, have a deviation of ±75 kilocycles; a loud sound without the proper limiting device may even swing the frequency ±100 kilocycles. It should be borne in mind, however, that this swing is the result of frequency multiplication, perhaps nine times that of the oscillator frequency. In this device, it was essential to deviate the local oscillator *directly* approximately 1 megacycle. Without deviating the local oscillator about a megacycle, it would be necessary to incorporate many more ranges which would, of course, make the device inaccurate, as the lowest range, physically speaking, would be farthest from the image on the cathode-ray tube.

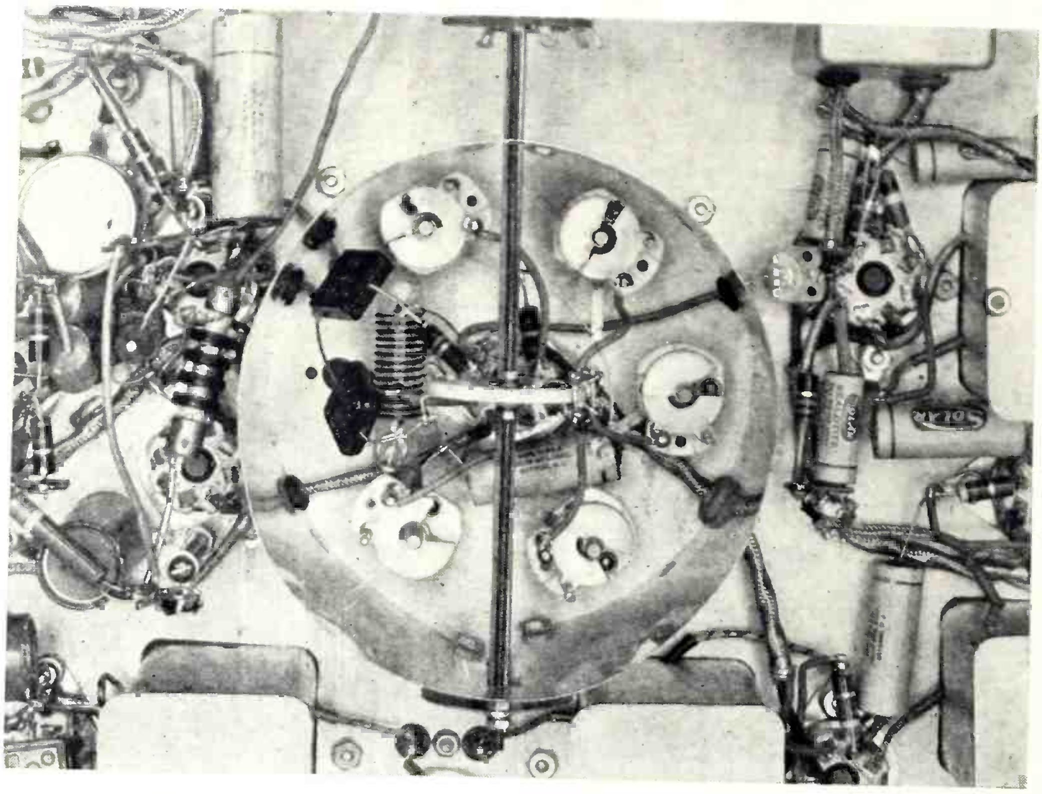


Bottom view of chassis with shield over tuning condensers in place.

Numerous reactance tube-oscillator combinations were tried with no avail, amongst which was Fig. 3—a common circuit found in most textbooks. One very interesting thing was discovered, however; to secure a large deviation, it was necessary to remove all tuning capacity from the oscillatory circuit. Without a tank condenser, a deviation of 1½ megacycles is easily attained. However, putting a condenser of only 10 micro-microfarads across the coil made the deviation decrease over 90%.

Another important consideration is the excitation tap on the tank coil. One turn one way or the other from the optimum point results in an immediate cessation of frequency modulation. It is, therefore, apparent that the circuit is of very little value for this purpose.

The circuit in Fig. 4 was finally evolved. Having solved the most difficult step in the entire unit, the i.f. amplifier problem was then thoroughly scrutinized. The selectivity of the i.f. amplifier determines the steepness of the vertical deflection pattern, the peak of which is referred to the horizontal scale to visually indicate the crystal frequency. The greater the selectivity, the sharper will be the frequency definition, in view of the fact that the device actually exhibits resonance curves. While extremely high selectivity could be obtained, for example, by the incorporation of a crystal filter, it was believed that high selectivity beyond a certain limit would defeat its purpose, as it would cut



Shield removed from tuning condensers to show placement of parts.

down the time in which the transient heterodyne frequency could pass through the i.f. channel to such a low value as to interfere with clear visibility of the cathode-ray tube pattern.

Later experience proved otherwise. It was necessary to install a crystal filter in the i.f. amplifier in order to make the image sharp for accurate reading. The crystal utilized in the unit was a 15 megacycle, fundamental crystal in a standard holder. It soon became apparent that the standard holder had sufficient capacity to bypass the crystal and to allow signals to reach the second detector without any filtering action whatsoever. By cutting down the crystal holder capacity to about 10 micro-microfarads, another phenomena became apparent. The device was so *sensitive* that multiple responses of the filter crystal appeared.

While listening on a receiver, this multiple response sounded like one frequency but, on the cathode-ray tube, as previously mentioned, numerous frequencies were visible and each was sufficiently strong to make it impossible to select one by proper phasing. Additional filter crystals were ground and a crystal filter was obtained which exhibited one strong, dominant frequency. By phasing, it was possible to reduce the amplitude of all the unwanted frequencies to a point where they did not interfere with the use of the device.

Having practically completed the design, an additional refinement was needed—to be able to expand the range on any channel to ±50 kilocycles at will. The purpose for that can be explained as follows. An order is received for a number of crystals at 7410 kilocycles. Now 7410 falls on the range that is between 6.9 and 7.75 megacycles, and it is desired to know which stock blanks are 50 kc. below the required frequency. On this range, which is almost a megacycle wide, it will be extremely difficult to see a small change of 50 kc. Therefore, the object was to expand that particular portion of the range so that 100 kc. (±50 kilocycles) would fill the entire screen. Also, it was desirable to be able to shift this expanded range, of any particular frequency, to any position on the screen.

That, in itself, not counting the frequency modulated oscillator problem, more than doubled the difficulties in the final design. To expand the range, it was necessary to cut down the injection voltage into the reactance tube by a certain definite amount. To move any desired frequency to any particular spot on the screen at will was a feature that required lengthy experimentation.

Fig. 5 illustrates how this was accomplished. By swinging a fixed bias on the control grid of the reactance tube plus or minus, it is possible to shift any desired frequency to any particular point on the screen. At first, a well-filtered power supply (negative and positive), ungrounded but with a midpoint grounded, was used to supply this bias. The reactance tube was so sensitive that a sufficient amount of 120 cycle ripple got onto the grid to produce a double image on the cathode-ray screen. The simplest solution was to use a battery. As there is practically no drain on it, its life may be compared to shelf life.

An activity meter is also included in the reference oscillator circuit so that the operator may tell, at a glance, whether or not the crystal is oscillating, and if its activity is below a certain required minimum.

The above gives a theoretical idea for a *Visual Crystal Channel Sorter;* the actual construction of the device will now be discussed. The device has 9 stages, as follows: 6C5 reference oscillator, 6SA7 mixer, 2 6SK7 i.f. amplifiers, 6H6 second detector, 6C5 low frequency amplifier, 6J5 local oscillator, 6AC7 reactance tube, and 6C8G sweep generator.

It may be well to describe the operation of the sweep generator. Referring to Fig. 1, V_8 is the sweep generator and operates as follows: C_{14} slowly charges through R_1, producing the forward slope of the saw-tooth wave. R_3 and R_4 form a voltage divider network across the 6.3 volt filament supply. A small portion of this voltage is fed into the cap grid of V_8 and, on positive cycles, triggers the tube which causes C_{14} to discharge rapidly. This corresponds to the return sweep of the cathode-ray beam. R_2 is used for synchronizing V_8 with the line frequency. The other half of V_8 acts as an amplifier for this sweep voltage.

The operation of the 6J5 local oscillator and 6AC7 reactance tube (V_1-V_2, Fig. 4) are as follows: V_2 with L_1 C_1 forms the oscillatory circuit. V_1 is the reactance tube and operates as follows: The current through C_1 leads the current through L_1. Inserting a low value non-inductive resistor between the rotor of C and ground forms the voltage divider network. This voltage is placed on the control grid of V_1. From the plate of V_1, a connection is made to the grid side of the coil on V_2. This makes V_1 appear as a reactance across L_1. By varying the voltage on the control grid of V_1, the G_m is varied and the resulting change in reactance changes the frequency of the LC combination.

A word about this particular circuit: While stray capacities should be watched and kept down for satisfactory operation of the oscillator, the amount of deviation is not influenced, to any great extent, by additional capacity in the circuit.

The operation of the device, stage by stage, is as follows: A crystal of unknown frequency, between 5 and 9 megacycles, is plugged into the crystal blank holder. If it is a live crystal, it will oscillate and also produce a reading on the milliameter. The output of the crystal oscillator is fed into the signal grid of V_2. Simultaneously, the frequency modulated signal from the local oscillator is fed into grid 5 of V_2. As the frequency modulated local oscillator varies within 1 megacycle, at a moment when the resultant of the two frequencies equals 15 megacycles, a signal will be passed into the i.f. amplifier. In the i.f. amplifier, V_3 amplifies the signal, passes it into V_4, which further amplifies it, and then into the crystal filter. Only signals of exact crystal frequency pass through and are fed into V_5, where the signal is detected or rectified. V_6 amplifies the low frequency output of V_5 which is then fed into the vertical amplifier of the oscilloscope. From the plate of V_8, a signal is taken and fed into the horizontal amplifier of the scope. This produces a synchronized time base with the local oscillator and so shows visually on the calibrated scale the frequency of the crystal blank which was previously unknown.

Explaining the operation of the expanding feature, it will be noticed from the position of switch S_1 in Fig. 1 that, in the position shown, sweep voltage is taken from R_7, passed through C_{15}, and fed into the grid of V_9. This position is for the normal, full channel operation. By rotating switch S_1 clockwise, the following changes in the circuit take place:

1. The battery circuit is closed.
2. The voltage for the bulbs on any scale is removed and is fed to the bulbs illuminating the expanded scale.
3. Injection voltage to V_9 is now taken from R_8. R_8 had been adjusted to give less voltage to V_9, *expanding the range*.
4. R_9 is connected to ground to form a bleeder circuit for the grid input of V_9. This is necessary because a signal of greater amplitude results when the local oscillator sweep is reduced.

The wiring is shielded, and the shield is soldered to chassis every few inches. V_7 is placed directly over the condensers and coil to form the local oscillator circuit. A shield is provided which entirely encloses these condensers and coil to prevent r.f. from leaking into the various stages.

The power supply used for this device is of standard design. High voltage is 300, and a 150 volt tap regulated with a VR150-30 is incorporated to keep the plate voltage on V_7 constant.

The i.f. transformers are National air-tuned 175 kc. originals, re-wound to 15 megacycles. These transformers are half submerged into the chassis to make the leads as short as possible; the bottoms of the i.f. cans are covered with brass plates. Any oscilloscope may be used with the device—providing it has an external horizontal amplifier connection, as the horizontal sweep built into the scope is not used.

It is well worth repeating that the crystal holder for the filter must have as little capacity as possible and still allow the crystal to oscillate. The crystal must be ground as precisely as possible in order to avoid a plurality of peaks which will, naturally, show up on the screen. The range switch should be well constructed and preferably have ceramic insulation.

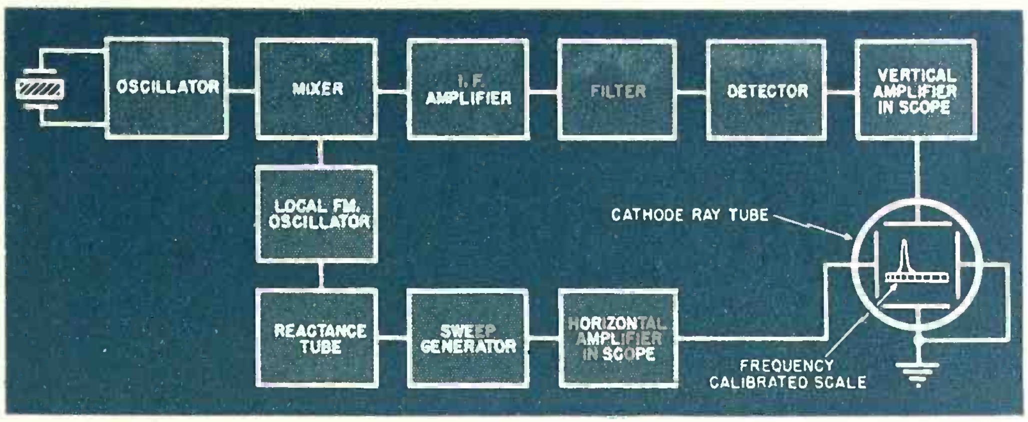


Fig. 2. Block diagram of channel sorter, with essential parts indicated.

Initial Alignment

Putting the device into operation for the first time requires carefully worked-out procedures to be followed in order. The entire device should be turned on and allowed to warm up for an hour. An accurate signal generator should also be allowed to warm up in order to stabilize its output frequency. The signal generator should be connected to the point shown in Fig. 1, and set to 15 megacycles. The same oscilloscope which will be used with the device may be connected to the output of V_6. Then, applying audio modulation, i.f. transformers L_2, L_3, L_4, and L_5 should be tuned to secure the greatest amplitude on the screen. As the various transformers are tuned to resonance, it will be necessary to reduce the output of the signal generator in order to keep the image from going off the screen. Then, using standard procedure, the crystal filter should be made operative by aligning the i.f.'s to exact crystal frequency—even if it is slightly above or below 15 megacycles. Having completed this step, an oscilloscope should be connected to the plug marked P_2, which goes to the horizontal amplifier, and R_2 adjusted until a well-shaped, synchronized, saw-tooth wave is seen on the screen. This adjustment is rather non-critical.

The 'scope is removed and the output of V_8 connected to the horizontal amplifier, and the output of V_6 to the vertical amplifier in the 'scope to be used with the device.

It is now necessary to calibrate the channels. This may be done by listening to a receiver tuned to the local oscillator frequency, which, for channel 1, starting at 5 megacycles, will be 20 megacycles, and adjusting R_7 until the deviation is about 1 megacycle.

R_7 may be adjusted in a slightly different manner. The audio modulation is removed from the signal generator,

(*Continued on page* 34)

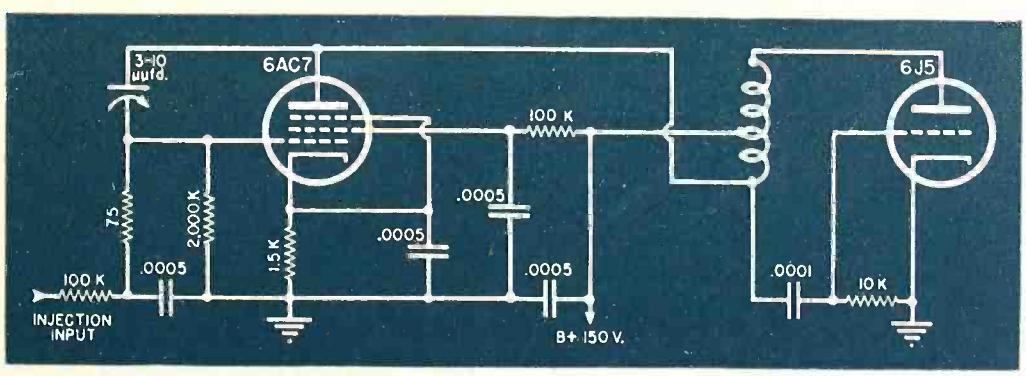
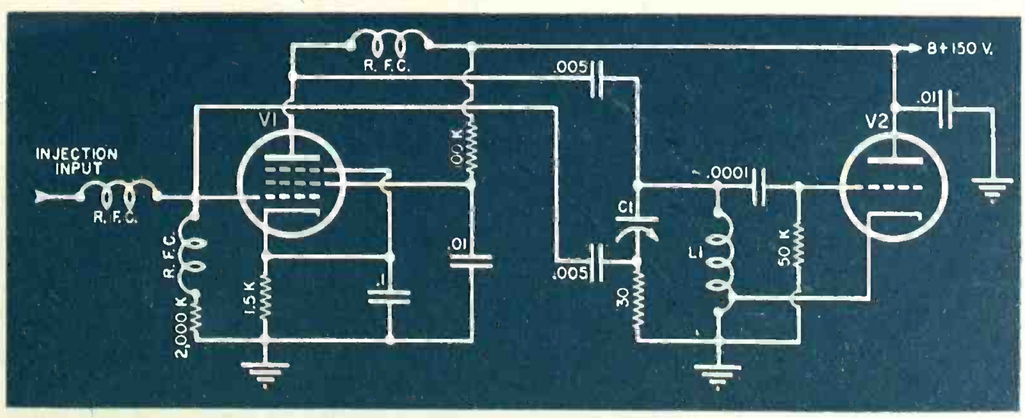


Fig. 3. Circuit diagram of a typical reactance-tube modulated oscillator.

Fig. 4. Reactance-tube modulated oscillator used in the channel sorter.



Systematic Classification of RADIO KNOWLEDGE

By MONROE A. MALLER

Use of the Dewey Decimal System in properly classifying books and articles pertaining to radio and allied fields.

INTELLIGENT research demands intelligent use of the tools of research, and certainly the modern library is one of the most useful of these "tools." For this reason it is desirable to become familiar with the modern research library and its *modus operandi*.

Systems of Classification

There are two principal systems of classifying knowledge employed by most libraries in this country; namely, the Dewey Decimal System and the Library of Congress System. There are other systems but their use is restricted to particular, specialized libraries. Each of the two principal systems has groups advocating its particular use; however, the relative merits of each system need not be discussed at this time. Suffice to say that both systems are widely used.

The present discussion will be confined to the application of the Dewey Decimal System to the subject of radio since classifications based on this system are almost universally accepted in that subject.

The Dewey Decimal System was originated by and named after the famous American librarian, Melvin Dewey[1]. According to Dewey, all knowledge is divided into nine main classes with a tenth class for miscellaneous items such as general encyclopedias, periodicals, etc. The ten classes are as follows:

000-099	General Works
100-199	Philosophy
200-299	Religion
300-399	Sociology
400-499	Languages
500-599	Science
600-699	Useful Arts
700-799	Fine Arts
800-899	Literature
900-999	History and Travel

Of particular interest to those in the technical fields are the subjects falling in the 500 and 600 series. The series 500-599 can be broken down as follows:

510-519	Mathematics
520-529	Astronomy
530-539	Physics
540-549	Chemistry
550-559	Geology
560-569	Paleontology
570-579	Biology and Ethnology
580-589	Botany
590-599	Zoology

The 600-699 series may be broken down into:

610-619	Medicine
620-629	Engineering
630-639	Agriculture
640-649	Domestic Economy
650-659	Communications, Business
660-669	Chemical Technology
670-679	Manufactures
680-689	Mechanical Trades
690-699	Building

In the original Dewey System, the whole subject of radio is found under the number 621.384. Just how this number is secured is indicated by the following breakdown:

Series 600	Useful Arts
20	Engineering
1	Mechanical
.300	Electrical
.080	Communication
.004	Radio

From a utility standpoint, the number 621.384 is somewhat bulky to handle and it is quite convenient to replace it with the letter R. Thus R130, for instance, is understood to represent the classification for vacuum tubes and corresponds to the number 621.384.130. This notation has been adopted in the radio field and is particularly useful in small specialized libraries.

It is obvious that the classification 621.384 or R is quite inadequate to describe the complete subject of radio. The National Bureau of Standards was the first to realize the need for an extended classification of the subject and in 1923 published their first expansion of Dewey Decimal System based on Dewey's original paper[1]. In 1930 the Bureau revised its classification and expanded it further, thus bringing it up to date. It was issued as Circular 385[2], and also appeared in the proceedings of the Institute of Radio Engineers, Vol. 18, pp. 1435-1456. Reference 2 presents two breakdowns of the subject of radio, which differ only in degree of expansion.

The more compact form is reproduced in Table I and is suitable for small private libraries and card files. The classification R800, representing non-radio subjects, is fully expanded in the extended classification, and is presented here as Table II. Those numbers marked with an asterisk are not to be found in the regular Dewey System, but were added by the Bureau of Standards for convenience.

In the Bureau's paper[2], the extended classification is accompanied by a large alphabetical index to assist in assigning the proper numbers to new papers. While this alphabetical index is useful when working with the extended classification, it is not necessary when applying Table I. Two examples, using articles appearing in a recent issue of RADIO NEWS, will serve to show how the system is applied.

Consider the article entitled "Direct-Reading Capacity Meter" by Rufus P. Turner, which appeared in the September issue of RADIO NEWS. Here is a paper having direct bearing on two subjects, namely, capacitance and instruments. In that case two cards will have to be made out and some method used to indicate that the subject has been cross-indexed. Capacitance falls under the heading R220 in Table I while instruments is given by R380. One card is then indexed as R220 x R380 while the other is indexed under R380 x R220.

As another example, consider the article entitled "The Sound Scriber" by Stanley Kempner which also appeared

(*Continued on page 39*)

TABLE I

Contracted Form of the Bureau of Standards Classification Table

R000	Radio—General in nature and pertaining to the field of radio as a whole.
R100	Radio Principles—Material on underlying theory.
R110	Radio Waves
R120	Antennas
R130	Vacuum Tubes
R140	Circuit Theory and Effects
R150	Transmitting Apparatus
R160	Receiving Apparatus
R170	Interference
R190	Other Radio Principles
R200	Radio Measurements and Standardization
R210	Frequency
R220	Capacity
R230	Inductance
R240	Resistance; Current; Voltage
R250	Transmitting Apparatus
R260	Receiving Apparatus
R270	Intensity
R280	Properties of Materials
R290	Other Radio Measurements
R300	Radio Apparatus and Equipment
R320	Antennas
R330	Vacuum Tubes
R350	Transmitting Apparatus
R360	Receiving Apparatus
R380	Parts; Instruments
R390	Other Radio Equipment and Apparatus
R400	Radio Communication Systems
R410	Modulated-Wave Systems
R420	Continuous-Wave Systems
R430	Interference Elimination
R440	Remote Control (by wire)
R450	Connection of Radio Systems to Wire Systems
R460	Duplex and Multiplex Systems
R470	Radio-Frequency Carrier Wave Systems
R480	Radio Relay Systems
R490	Other Systems
R500	Application of Radio
R510	Marine Applications
R520	Aeronautic Applications
R530	Commercial and Special Services
R540	Private
R550	Broadcasting
R560	Military
R570	Remote Control by Radio
R580	Picture Transmission; Television
R590	Other Applications
R600	Radio Stations
R610	Equipment
R620	Operation and Management
R700	Radio Manufacturing
R710	Factories
R720	Processes
R740	Sales
R800	Non-Radio Subjects (see Table II)
R900	Miscellaneous Radio

TABLE II

Non-Radio Subjects Closely Associated with the Field

347.7	Patent Practice
353.821*	Bureau of Standards
383	Postal Service, Air Mail Service
510	Mathematics
520	Astronomy
526	Geodesy
526.8	Map Projections
530	Physics
531	Mechanics
532	Hydrostatics
533	Pneumatics
533.85	Vacuum Apparatus
534	Sound
534.3	Tuning Forks
534.83	Signals in Navigation
535	Light
535.3	Photoelectric Phenomena
535.38*	Photoelectric Tubes
536	Heat
536.33	Radiation; General Theory
536.83	Heating by Induction
537	Electricity
537.1	Theory of Electricity
537.23	Electrostatic Generators
537.26*	Corona Discharge
537.4	Lightning
537.6	Electrodynamics
537.65*	Piezo-electric Phenomena (see R191, R214 & R355.65)
537.67*	Experimental Plotting of Electrical Fields
537.7	Wave Form Analysis
537.87	Physiological Electrical Phenomena
538	Magnetism
538.11*	Magnetstriction
539	Molecular Physics; Atomic Physics
539.7	Radioactivity
540	Chemistry
541.3	Physical Chemistry
550	Geology
551.5	Weather; Meteorology
621	Mechanical Engineering
621.3	Electrical Engineering
621.313	Electrical Generators; Electric Motors
621.313.2	Direct Current Machinery
621.313.23	Direct Current Generators
621.313.24	Direct Current Motors
621.313.25	Motor Generators
621.313.26	Dynamotors
621.313.3	Alternating Current Machinery
621.313.7	Rectifiers
621.314.3	Transformers
621.314.6	Choke Coils
621.314.7	Induction Coils
621.317	Switchboards
621.317.3	Switches
621.317.4	Rheostats
621.319.2	Transmission Lines
621.325	Incandescent Arcs
621.326	Incandescent Filament Lamps
621.327.4	Mercury Vapor Tubes (lamps)
621.327.7	X-Ray Tubes
621.353	Batteries, Primary
621.354	Batteries, Secondary (storage)
621.354.7	Battery Charging Devices
621.374.2	Wheatstone Bridges
621.374.3	Voltmeters
621.374.33*	Electrometers
621.374.41*	Ammeters
621.374.45*	Galvonometers
621.374.6	Wattmeters
621.374.63*	Electrodynamometers
621.374.7	Oscillographs
621.375.1*	Vacuum Tubes, Special Application Other Than Radio
621.38	Electric Communication
621.382	Telegraphy
621.382.4	High Speed Telegraphy
621.382.7	Picture Transmission, Facsimile (by wide) (see R581)
621.382.8	Submarine Cable
621.382.92*	Ground Telegraphy
621.382.94	Induction Signalling
621.383.21	Relays
621.385	Telephony
621.385.91*	Program Distributions
621.385.95*	Condenser Transmitters
621.385.96*	Talking Motion Pictures
621.385.97*	Electro-Acoustic Devices (see R265 & 365)
621.385.971*	Electric Phonograph
621.388	Television (by wire) (see R583)
621.39	Other Applications of Electricity
623.731	Light Signals
623.8	Steamships
629.13	Aeronautics (see R520)
629.145	Aerial Navigation
629.18	Airplane Construction
658	Business Methods

Graphical Treatment of HIGH FREQUENCY LINES

By R. G. MIDDLETON
Engineer, Templetone Radio Corporation

Designing single and double matching stubs for use with transmission lines by means of circle diagrams.

OPEN wire or coaxial transmission lines may be assumed to have no losses at higher radio frequencies. While not strictly true, especially in the case of open wire lines which may have appreciable radiation losses, calculations based upon this assumption are within engineering limits of accuracy.[1] Graphical treatment of lines and stubs is easy and practical for the lossless case.

Graphical treatment of lines requires an electrical picture of the lines for any points in which the engineer is interested. The elements of the picture are input impedance, characteristic impedance, terminating impedance, distance from the line terminus, and match points, to list the more important.

Without going into the rather abstruse mathematics of the line,[2] it is necessary to describe the general properties of the line at the outset.

A line differs uniquely from an LCR circuit in that its inductance, capacitance and resistance are smoothly distributed along the line instead of being lumped. This is indicated in Fig. 1 (A). It has not been possible to show the parameters actually smooth; the reader must imagine an infinity of infinitesimal parameters.

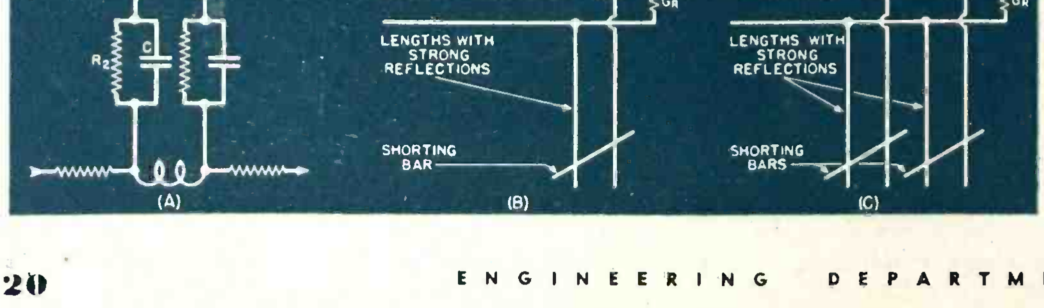
Mathematical analysis of the line shows that the line has negligible attenuation at higher radio frequencies, since the series reactance becomes much larger than the series resistance and the shunt reactance becomes much smaller than the shunt resistance.

Author's Note: No new material on graphical matching of lines is presented, but this article serves as an introduction to the subject for the reader who may not be familiar with graphical matching systems.

Analysis likewise shows that the lossless line has a very important property called its characteristic resistance; a lossless line infinitely long has a characteristic resistance which is the ratio of input voltage to input current. This is a real quantity whose magnitude is determined by the line spacing, etc. The line looks exactly like a resistor to the generator. It is interesting to note that for lower frequencies where the series and shunt resistance of the line are of relative importance, this characteristic resistance adds to itself a reactive component and it is then spoken of as the characteristic impedance of the line. It is apparent that for the general line, characteristic impedance is a function of frequency; for the lossless line, the characteristic resistance is independent of frequency; and depends on the physical properties of the line such as spacing and diameter of the conductors.

Another very important property of the finite line is that if terminated in its characteristic resistance, it looks like an infinite line to the generator. That is, it looks like a pure fixed resistance. The line is then said to be matched.

Fig. 1. (A) Section of transmission line showing distributed constants. (B) Line matched with one shorted stub. (C) Line matched with two shorted stubs.



If the line is not terminated in its characteristic resistance, reflections take place; these reflections then travel back to the source, and if the source is not matched to the line, the reflections re-echo. When reflections take place, the voltage and current on the line are not uniformly distributed. Instead, voltage maxima and minima occur as may be seen by moving a neon tube along such a line.

Moreover, the improperly terminated line has a reactive component to the input for most lengths; the line terminated in its characteristic resistance has a purely resistive input for any length.

A dipole has an input resistance of approximately 72 ohms.[3] If this antenna is fed with a 600 ohm line (characteristic resistance of 600 ohms), the line is improperly terminated. Inefficient performance is the result, with many losses appearing which need not be enumerated here. The problem is to terminate such lines properly, usually by means of single or double stubs.

A stub is a piece of short-circuited line (less frequently a piece of open-circuited line) and of course has pronounced electrical echoes or reflections along its extent; thus the input to the stub is *reactive*. A stub may be used as a transformer, or even as an insulator. A short-circuited quarter wave stub looks like an infinite reactance at radio frequencies.

Fig. 1 (B) and (C) shows two matching schemes. The line is electrically smooth up to the stub, but between the stub and the load there are strong reflections as well as on the stub itself; these reflections cancel at the point where the stub meets the line, making this point look like the characteristic resistance to the portion of line between it and the source. It is evidently advantageous to locate the stub at the *first* possible match point, to cut down the length of line on which reflections exist.

The solution of the situations shown in Figs. 1 (B) and (C) may be computed with considerable labor, or performed graphically.

Fig. 3 (B) shows the elements of the matching chart which is basically a plot of certain hyperbolic functions, the significance of which was first recognized by Kennelly.[4,5] It is both rectangular and polar in character; the axis of abscissas is graduated in units of r or g, defined as Z_r/Z_0 or Y_r/Y_0 for the lossless line. Reactive components are read from the axis of ordinates. On the graph, Z_0 = characteristic impedance Y_0 = characteristic admittance Z_r = receiving impedance Y_r = receiving admittance. It will be found easier to work some problems in admittances, while others will be easier in impedances.

As the vector rotates clockwise, it travels from the load (receiving terminus) in electrical degrees. One wavelength is 360 electrical degrees, and when given the frequency the wavelength may be computed since $c = f\lambda$, where c is the velocity of light. A wavelength of line may be considered equal to a wavelength in space.

Stub travel is not on the circle, but up or down the axis of ordinates. Travel on the circle is travel along the line.[6] The *M*'s are points on the line where matching may be accomplished with a single stub. Traveling clockwise, the first match point will be selected for reasons discussed above.

Another important property of the chart is that when the vector has rotated through 360 geometrical degrees, it has rotated through 180 electrical degrees. The angular increments are likewise non-uniform. When the circle is completely traversed, the line has been covered one-half wavelength from the load, and the input impedance of the line is exactly the terminating impedance.

Fig. 4 shows a conventional matching chart, carrying a family of circles similar to the one shown in Fig. 3 (B). A second family of circles are added, which are graduated in degrees and which form a coordinate system. If a certain circle is selected, travel around its circumference constitutes travel along the line, and the number of electrical degrees of travel is determined by the second family of circles.

An illustrative case is helpful. Suppose a high radio-frequency line of characteristic impedance 600 ohms is terminated in a 2400 ohm resistor. Then $Z_r/Z_0 = 4$, and the line may be traversed as far as desired by traveling around the circle which passes through $\rho = 1/4$, $\rho = 4$. To start from the load, the chart is entered at (4, 0) and the corresponding circle traveled clockwise as earlier explained. Thus, the line rapidly becomes reactive, and the first match point occurs 27° back from the load. The second match point occurs 153 degrees back from the load.

The stub used to match the line to the load is in shunt with the line; for this reason stub problems are usually

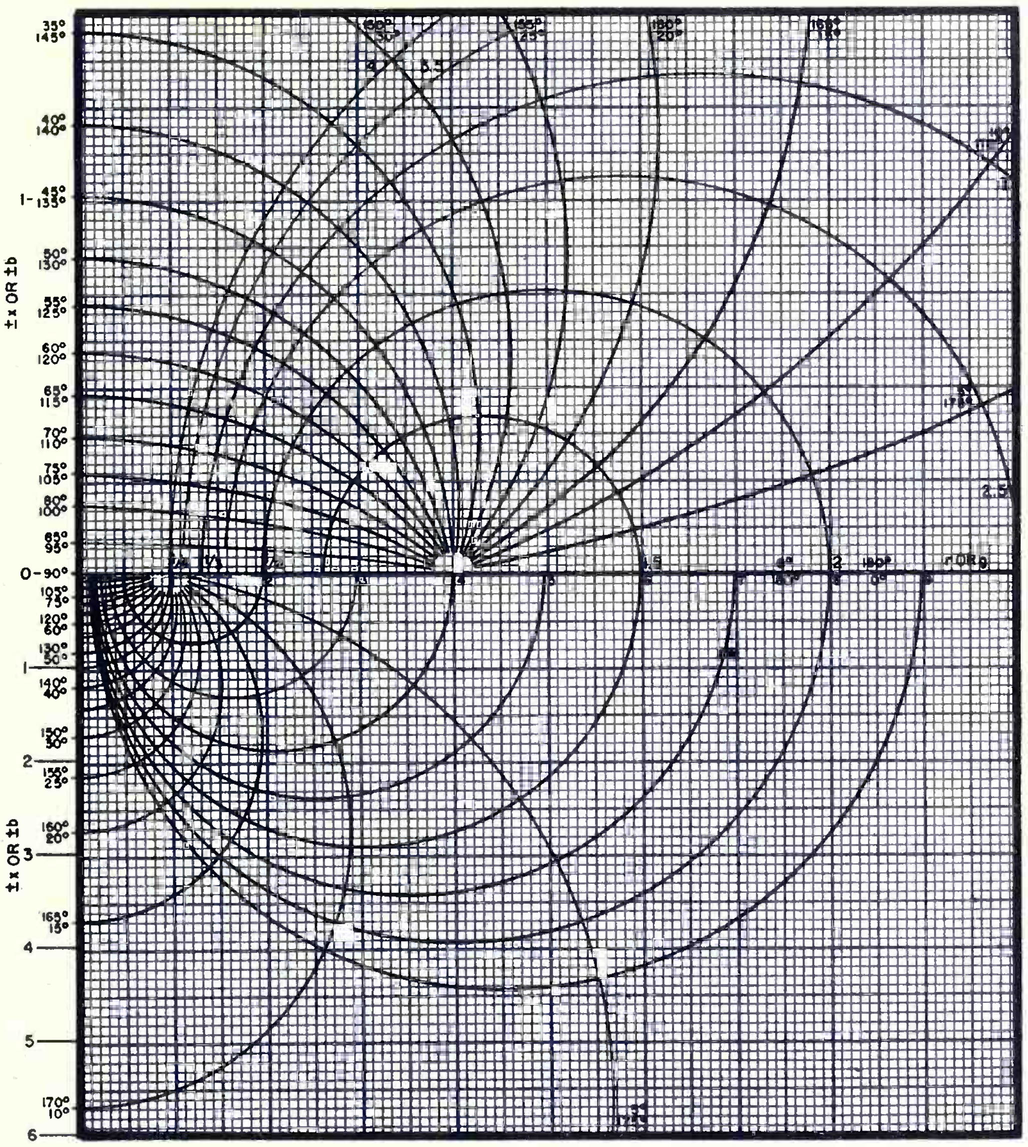
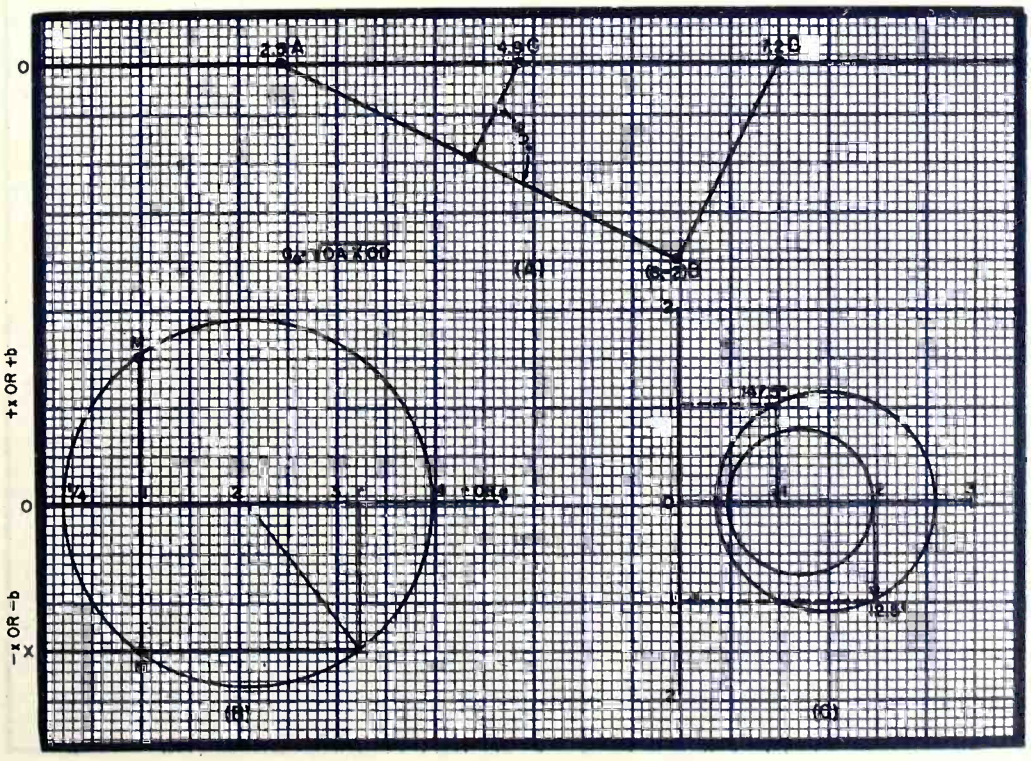


Fig. 2. Matching chart for computing matching stubs. Scale for top half expanded 4 to 1.

Fig. 3. (A) Using rectangular properties of chart for determining geometric mean. (B) Basic elements of matching chart. (C) Finding correct interpolated circle in two-stub matching problems.



discussed in terms of admittances rather than impedances.

It was seen that the input impedance may be reactive, resistive, or reactive and resistive. If the load is resistive, which will be the case if the line drives a resonant circuit at its resonant frequency, a line less than a quarter wavelength will show:

a) Inductive reactance at the input when Z_r is less than Z_o
b) Capacitive reactance when the termination is greater than Z_o

If the line is between 90° and 180° long, with a resistive load, the input will show:

a) Capacitive reactance when Z_r is less than Z_o
b) Inductive reactance when Z_r is larger than Z_o

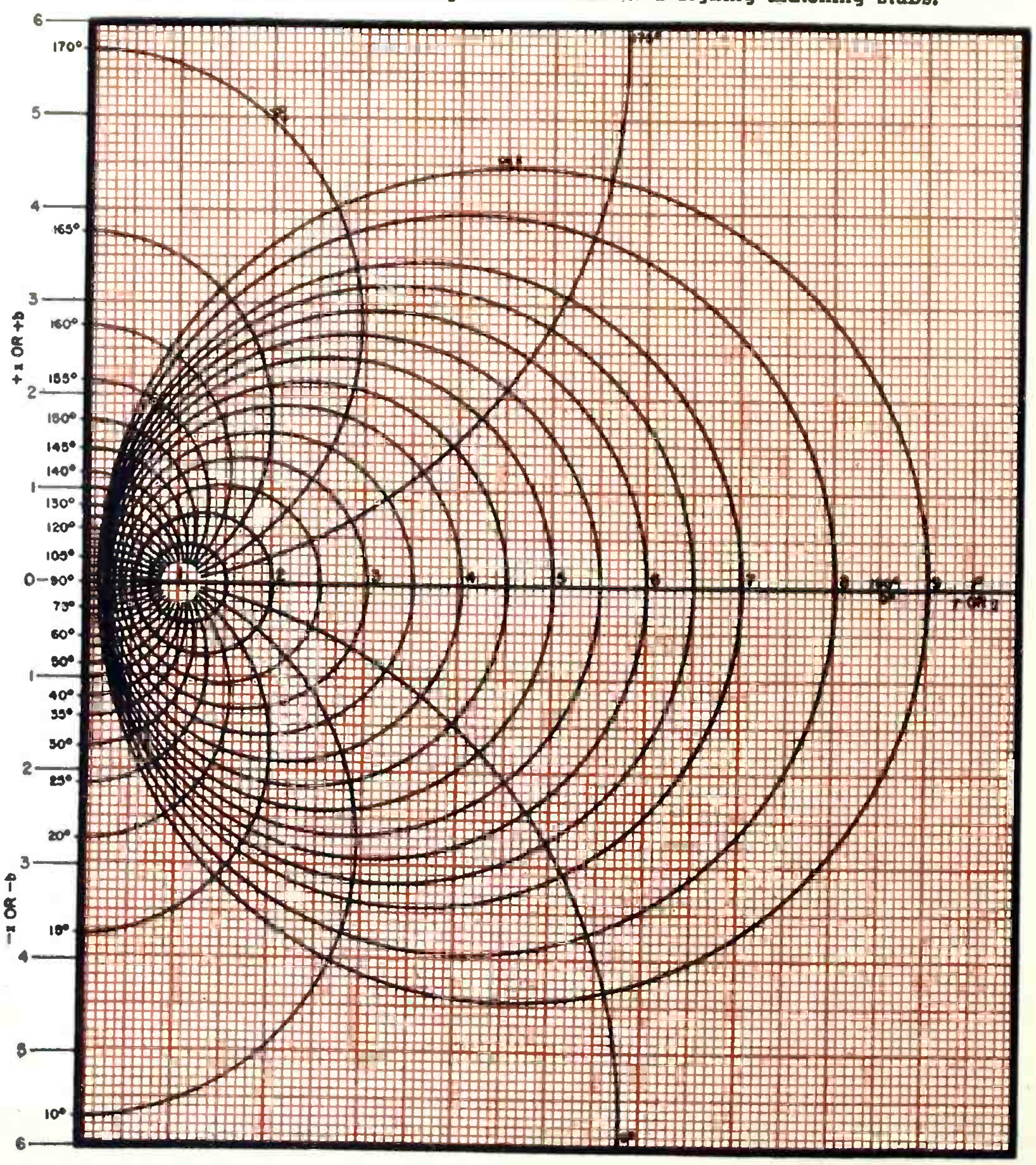
Since a stub is purely reactive when short-circuited (or open-circuited) it cannot change the *resistive* property of the line. Therefore, the stub must be located at the first point on the line, traveling back from the load, where the characteristic admittance of the line $= G_{in}$.[7] Now, it will be seen from the chart, or will be understood from the general discussion, that at the match point the susceptance of the line is not zero; it will have a reactive component depending on $Z_r—Z_o$ and the electrical length of line, as pointed out above. Thus, the stub is cut to a length which shows a reactance equal and opposite to the reactance of the line at the match point. Reactance from match point to source is cancelled out; the line is smooth, or *matched* to the load network.

An important guidepost to keep in mind is that:[8]

a) A shorted stub is inductive from 0° to 90°
b) It is capacitive from 90° to 180°
c) At exactly 180° it is resistive

Now that all necessary data is available, a line of $Z_o = 800$ ohms ($Y_o = 1/800$ mhos) can be matched to a load with $Z_r = 200$ ohms ($Y_r = 1/200$ mhos). The stub may also be assumed to have a characteristic admittance of 1/800 mhos. $Y_r/Y_o = 4$, making the ratio purely conductive, and the chart is entered at (4, 0). The match point is found by traveling the circle clockwise 27° to its intersection with the match line, $\rho = 1$. The susceptance is negative, the line is inductive at the match point, and the stub must have positive susceptance or be capacitive. The length of stub required from the axis of ordinates reads about 147°.

Fig. 4. Conventional matching chart for use in designing matching stubs.



Rules for computing stubs are:

a) In admittance problems the shorted stub is computed from (0,∞), since the termination of a short-circuited stub has infinite admittance.

b) In impedance problems the shorted stub is computed from (0, 90°), since the termination of a shorted line has zero impedance.

c) Stubs are always traveled on the axis of ordinates (x & b) axis.

It is not possible to use the chart effectively until the above rules are memorized. It is necessary to know whether the line is inductive or capacitive at match point, and whether the stub is inductive or capacitive, and from what point the end of the stub is computed.

Fig. 2 is essentially the same chart as Fig. 4, with symmetrical halves superimposed, and one-half magnified to allow closer reading near the origin. It is instructive to work out the foregoing stub problem on both charts.

As another illustration, let a line of $Z_o = 600$ ohms be matched to a load of 200 ohms with a stub of $Z_o = 600$ ohms. $Y_o = 1/600$ and $Y_r = 1/200$; $Y_r/Y_o = 3$. The chart is entered at (3, 0), and the circle found there is traversed clockwise to the match point 30° or 0.0833 wavelength down the line from the load. Since Z_r is less than Z_o, and the line less than 90°, the match point is inductive. A capacitive stub is required with equal absolute value of reactance. The stub is read from the reactance axis of the chart as 139°, since the end of the shorted stub is at (0, ∞) and is capacitive between 90° and 180°.

While open stubs are capacitive between 0° and 90°, they radiate strongly, especially at higher frequencies, and they are not as rigid mechanically. The shorted stub is preferred.[9]

The characteristic impedance of the stub does not have to be the same as that of the line. A line with $Z_o = 400$ ohms terminated by $Z_r = 150 + j50$ ohms may be matched by a stub of some other characteristic impedance. Converting these parameters to admittances, $Y_r = 1/Z_r$ or $Y_r = 1/(R + jX) = 0.006—j0.002$ and $Y_o = G_o = 0.0025$ mho.

Disregarding the polar properties of the chart, the rectangular system may be used as a convenient device for the determination of a geometric mean: Fig. 3 (A) shows how, by letting 1 = 0.001, it is possible to find (0.0025, 0) and (0.006, —j0.002) on the chart as (2.5, 0) and (6, —j2). This determines the line *AB* whose perpendicular bisector determines point *C* at (4.9, 0). The geometric mean is then $\sqrt{OC \cdot OD}$ = 0.00596 mho, or the stub Z_o is 168 ohms.

(*Continued on page 38*)

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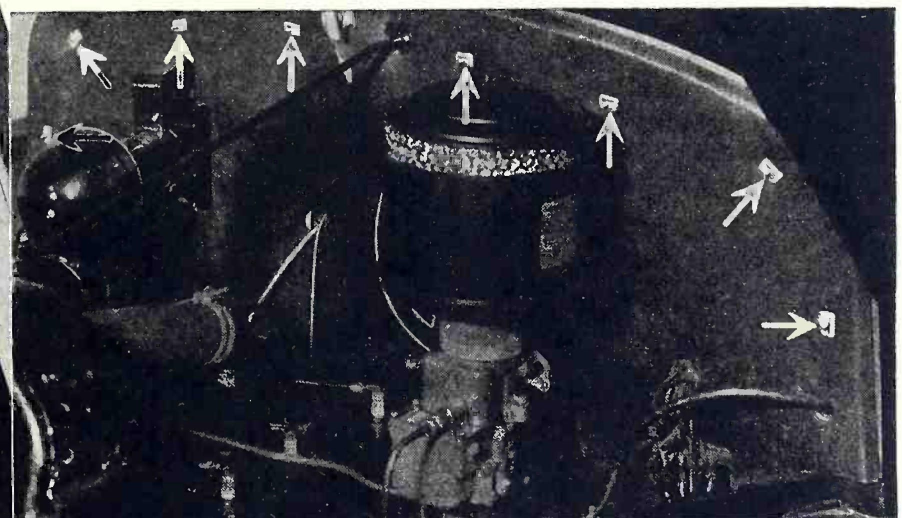

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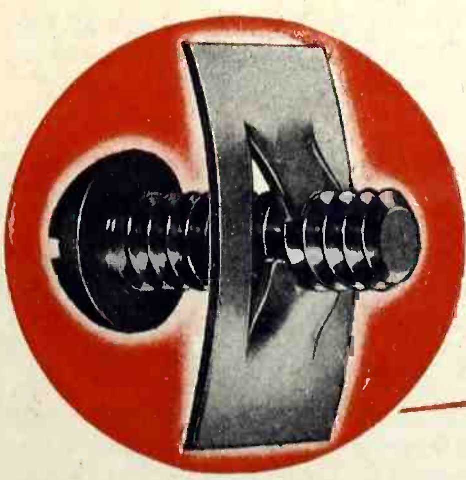

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Personals

J. H. JEWELL has been appointed to the post of manager of Westinghouse's Industry Departments according to the announcement made recently by R. A. Neal, vice-president of the company. Mr. Jewell joined Westinghouse in 1920 upon his graduation from Pratt Institute and since that time has held various positions in the industry division and the communications and public works sections of the organization.

EDMUND A. LAPORT who is widely known for his installation of transmitters both here and abroad has been appointed staff engineer for international communications systems and special apparatus of the RCA Victor Division. His headquarters will be at the Camden, New Jersey plant of the company. He will be responsible for all of the engineering in connection with RCA's international sales and installations of radio transmitters.

RUSSELL H. LASCHE has been appointed director of engineering and research for the Fairchild Camera and Instrument Corporation of New York. The company manufactures radio compasses, electrically operated gunfire control instruments and other electronic devices. Mr. Lasche, who is a graduate of the University of Wisconsin, has been with Fairchild for 15 years. Recently he has been in charge of company sales to the War Dept.

JOHN H. MILLER of the Weston Electrical Instrument Corporation has been promoted to the post of chief electrical engineer. Mr. Miller started his business career as an apprentice in the Westinghouse student program upon graduation from the University of Illinois in 1915. During the first World War, Mr. Miller served in the Signal Corps, devoting his time to special radio developments. He is one of the founders of the Chicago I.R.E.

GERRARD MOUNTJOY who was the winner of the National Association of Manufacturers "Modern Pioneer Award" while working as head of the RCA Licensee Consulting Section, has been appointed head of Lear, Incorporated Radio Laboratories. Mr. Mountjoy will have supervision over all radio research and development at Lear and will make his headquarters at the company laboratories in New York.

ALEXANDER G. HELLER, chief engineer and treasurer of Insuline Corporation of America passed away after an extended illness. Born 47 years ago, Mr. Heller came to this country as a boy. He was well known for his work in experimental television and video transmitter design. His video transmitter was introduced in 1930.

Phase Equalizers

(Continued from page 12)

$$Z_L = \frac{R\left[1 - j\left\{\frac{n^2\omega^3}{m\omega_0^3} + \frac{\omega}{\omega_0}\left(m - \frac{n}{m}\right)\right\}\right]}{m^2\left(\frac{\omega}{\omega_0}\right)^2 + \left(n\frac{\omega^2}{\omega_0^2} - 1\right)^2} \quad (16)$$

then, the phase delay is

$$\varphi = \arctan\left[\frac{n^2}{m}\left(\frac{\omega}{\omega_0}\right)^3 + \left(m - \frac{m}{m}\right)\frac{\omega}{\omega_0}\right] \quad (17)$$

This equation will be shown to be the first step toward the general phase-delay equation and must necessarily be more linear for certain numerical values of n and m. By assigning a few values to the parameters n and m and plotting graphs of the phase-delay as a function of ω/ω_0, the interesting curves of Fig. 4 are obtained.

This set of curves shows that the most linear relation is obtained when m and n are approximately equal to 1 and 0.3 respectively.

The methods of determining m and n to obtain φ directly proportional to ω have been empirical with little correlation to a general procedure. The first step in the direction of attempting to generalize a phase-correction method was made by Wheeler.[1] The point of view which he introduced visualized the load impedance, Z_L, as the input impedance of a low-pass filter circuit with the upper cut-off frequency in the neighborhood of 4.5 megacycles per second. Fig. 6 (B) can be redrawn to illustrate that the circuit is nothing more than an L-section of a low-pass constant-k filter. This change of configuration is indicated in Fig. 6 (C) with the additional shunting capacitance, C_s, introduced in order to provide a more linear phase characteristic. Of course, a matched load or termination must be provided to obtain satisfactory results. To provide a better termination than a simple resistance, R, across the L-filter network, the resistance may be replaced by a constant-k section or an m-derived L-section.

Considering the video-stage of Fig. 6 (C) properly terminated, then the input impedance across C_1 is given by

$$Z_\pi = \frac{R}{\sqrt{1 - \left(\frac{f}{f_c}\right)^2}} \quad (18)$$

where:

R = coupling resistance

f = a frequency within the pass-band

f_c = cut-off frequency = $1/\pi\sqrt{LC}$

The obvious disadvantage of having the input impedance given by (18) is very non-linear attenuation and phase characteristic. To overcome these difficulties an additional capacitance, C_s,

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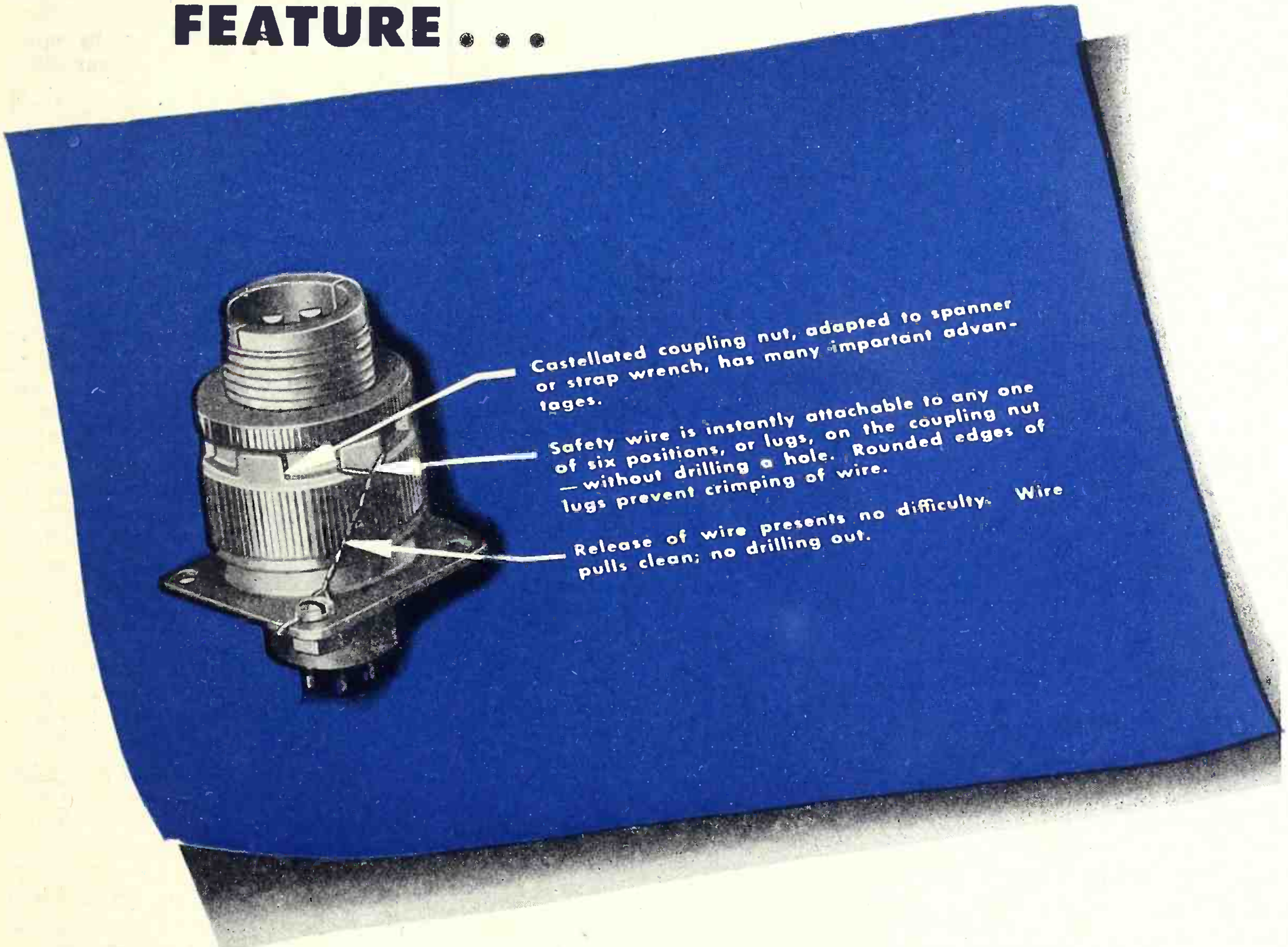

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from anode to ground is introduced. The input impedance of the plate load circuit then becomes the impedance of $Z\pi$ and $1/j\omega C_s$ in parallel. This is

$$Z_i = \frac{Z_\pi\left(\frac{1}{j\omega C_s}\right)}{Z_\pi + \frac{1}{j\omega C_s}} \qquad (19)$$

By substituting equation (18) in (19) and simplifying, the following relations are obtained for the input impedance

$$Z_i = \frac{R}{\sqrt{1-\left(\frac{f}{f_c}\right)^2} + j\omega C_s R} \qquad (20)$$

and for the phase angle

$$\varphi = \arctan \frac{\omega C_s R}{\sqrt{1-\left(\frac{f}{f_c}\right)^2}} \qquad (21)$$

If the relation between the resistance, R, and the added shunt capacitance at the upper frequency limit is similar to (12) such as

$$R = \frac{m}{\omega_c C_s} \qquad (22)$$

Then the simplified expression for φ is

$$\varphi = \arctan \frac{m\left(\frac{f}{f_c}\right)}{\sqrt{1-\left(\frac{f}{f_c}\right)^2}} \qquad (23)$$

with φ becoming a fairly linear function of f/f_c when m is 2. Thus the coupling network for the stage may, with limited advantages, be considered as a low-pass filter network.

To correlate the basic principles of the various methods of designing phase-equalizer networks, consider the general expression for the impedance of the coupling circuit. The expression is conveniently written as

$$Z_L = \frac{a_0+a_1(j\omega)+a_2(j\omega)^2+a_3(j\omega)^3+\ldots}{b_0+b_1(j\omega)+b_2(j\omega)^2+b_3(j\omega)^3+\ldots} \qquad (24)$$

Equation (24) is a ratio of two polynomials with the exponent of the frequency in the denominator within ±1 of that in the numerator. In order to make the phase angle of Z_L linear with respect to the frequency, certain restrictions will have to be applied to the *a's* and *b's* which in turn depend upon the numerical value of the circuit constants. This is very well exemplified by the ladder network made up of series inductances and shunt capacitances and finally terminated by a resistance, R. The greater the number of meshes in the ladder network, the greater the number of terms in the numerator and denominator of (24) and the more linear the phase function. In order to obtain the equation for the phase function, (24) is first rationalized and then the ratio of the reactive component to the resistive component is the tangent of the phase angle. Algebraically, this may be expressed as

$$\tan\varphi = \frac{\alpha_1\omega+\alpha_3\omega^3+\alpha_5\omega^5+\ldots}{\alpha_0+\alpha_2\omega^2+\alpha_4\omega^4+\ldots} \qquad (25)$$

where the α's depend upon the numerical values of the circuit constants. It is interesting to observe that the odd numbered exponents are always in the numerator and the even numbered exponents in the denominator.

Another way of writing (25) to facilitate calculations is

$$\varphi = \arctan \frac{\alpha_1\omega+\alpha_3\omega^3+\alpha_5\omega+^5\ldots}{\alpha_0+\alpha_2\omega^2+\alpha_4\omega^4+\ldots} \qquad (26)$$

The generality of this expression is immediately noticed when compared with (8), (17) and (23). The values of the constants in these equations were determined empirically by a considerable amount of trial and error. A straightforward method which may be applied proceeds by contracting the expression (26) to

$$\varphi = \arctan F(\omega) \qquad (27)$$

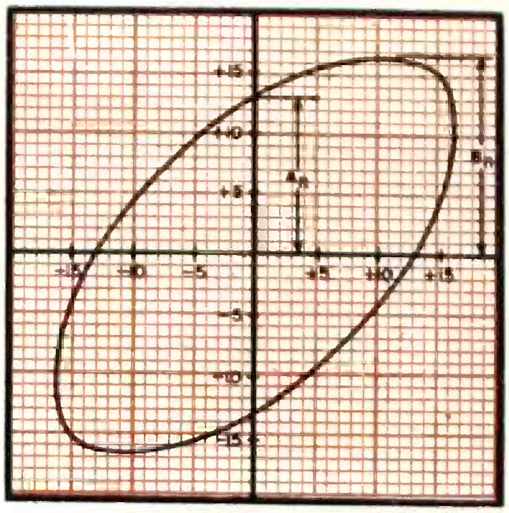


Fig. 7. Elliptical pattern on oscillograph screen indicating 38° phase shift.

and setting the condition that $d\varphi/d\omega$ be a constant, the relation becomes

$$\frac{d\varphi}{d\omega} = \frac{1}{1+F^2}\frac{dF}{d\omega} \qquad (28)$$

The right hand side of (28) should be arranged as a ratio of two polynomials with ascending powers of ω. If the coefficients of ω in the numerator are equated to the corresponding coefficients in the denominator the entire expression for $d\varphi/d\omega$ will become independent of frequency. This is precisely the condition required by equation (2) in order to have a linear phase function.

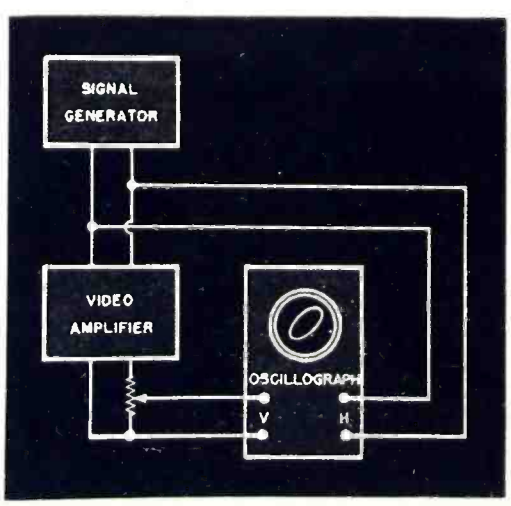
By applying this method to equations (8), (17) and (23), it is evident that true linear functions cannot be obtained but only approximated. Equation (23) serves as a satisfactory example by realizing that ω/ω_0 is generally less than unity and therefore this ratio raised to the fourth power may be neglected as a first approximation. This calculation yields $m = 2$ and provides a fairly linear phase function.

A practical consideration which is not generally emphasized sufficiently in the literature deals with the effects of distributed capacity between turns and layers in each inductance. This effect may be introduced into the equation for Z_L by assuming the inter-winding capacity shunting the inductance and thereby obtaining a more correct relation for φ as well as a more satisfactory first degree approximation when evaluating circuit parameters.

The method discussed for applying the phase-characteristic equation (25) may be supplemented by other methods more or less accurate than that presented in this article. As an example, a more accurate method of applying (25) to the design of equalizers would require as many points on the phase-angle vs. frequency curve as there are α's to determine. That is, three points must be assigned, if the numerical values of three α's are required. Such a procedure would provide three simultaneous equations similar to (25) with the α's as unknown quantities. Solving for the α's, would then determine a phase-angle delay curve which would pass through the assigned points and approach linearity.

By considering equation (25) and the methods of applying it, a general procedure for analyzing existing circuits and for designing new ones is available and preferred when compared to the trial and error procedure.

Fig. 8. Hookup for determining phase shift.



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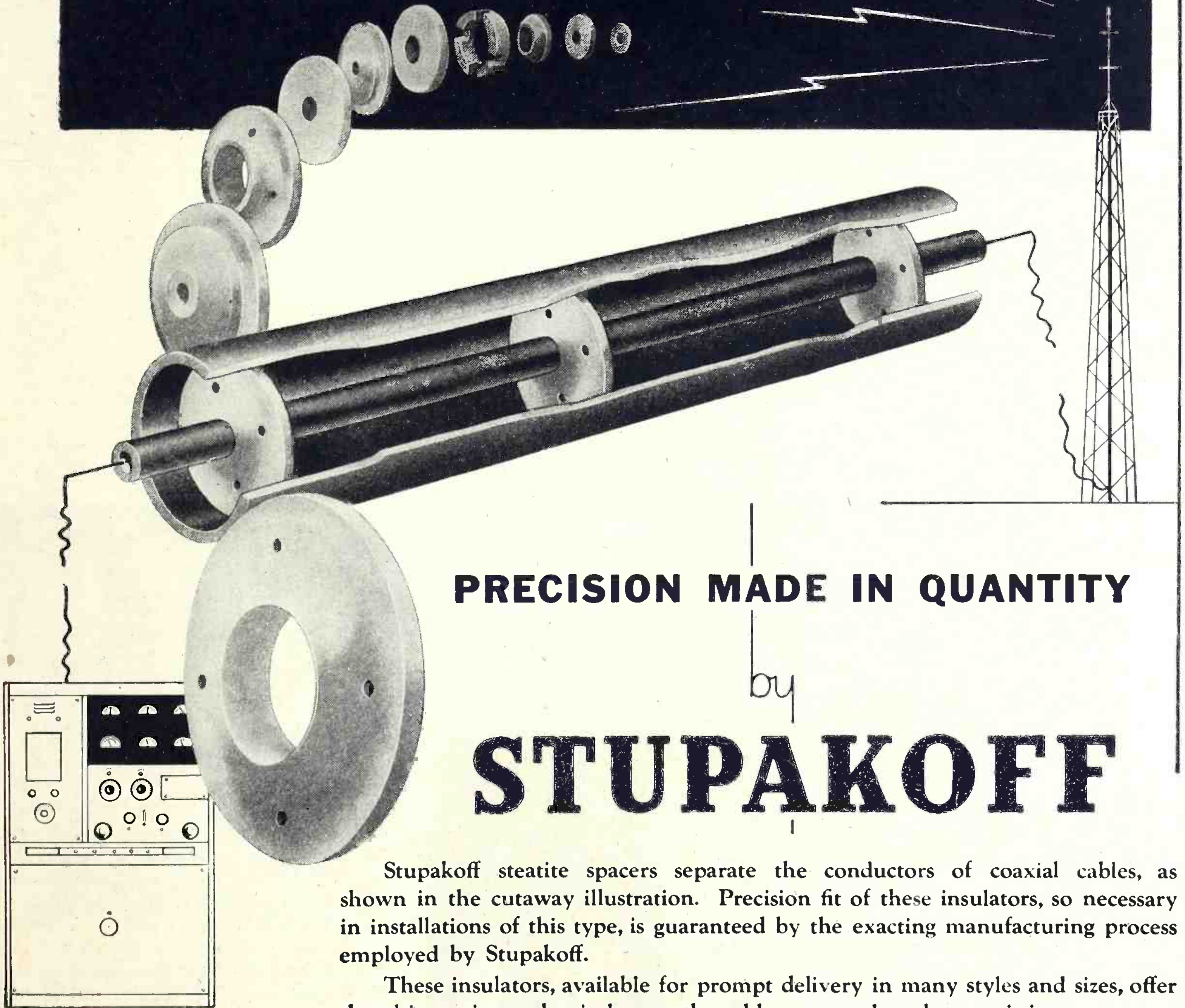
Steatite Insulators for
COAXIAL TRANSMISSION LINES



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STUPAKOFF

Stupakoff steatite spacers separate the conductors of coaxial cables, as shown in the cutaway illustration. Precision fit of these insulators, so necessary in installations of this type, is guaranteed by the exacting manufacturing process employed by Stupakoff.

These insulators, available for prompt delivery in many styles and sizes, offer the ultimate in mechanical strength and low power loss characteristics.

Stupakoff, backed by two generations of engineering and manufacturing experience, produces a complete line of ceramic insulators made of steatite and other materials.

Write today for dependable assistance in developing correct insulation for your electronic apparatus. Problems involving insulators—whether specialized or standard—will be given prompt attention by our Technical Staff.

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Ceramics for the World of Electronics

Industrial Review

R. F. Rubber Processing

THE *B. F. Goodrich* plant at Wilkes-Barre, Pennsylvania, the largest cord tire mill in the United States, is using electronic heating in the processing of textile cords according to a

joint announcement by Goodrich and RCA.

Early experience with synthetic rubber indicated the need for rayon cord, as this product generates less heat in the tire and gives greater strength per unit of weight.

However, the cord used in tire fabric had to be treated to balance the "twist" thus eliminating its tendency to curl and kink in the process of manufacture.

The solution to this problem was found in electronic heating, by means of which it is possible to raise the temperature uniformly and simultaneously in all parts of the product. The cord is wound on large spools or cones and is placed in a high-frequency electrical field, and the cord heated in 10 minutes. The moisture content is controlled by wrapping each cone in moisture-proof paper before processing. In effect, each spool is "steamed" within its individual paper wrapper and the twist is set.

The units being used for this work have a capacity of 15 kw. at frequencies from 2 to 10 megacycles.

* * *

Wire Stripping

A NEW method of clean-stripping Formex coating from fine size wire (Numbers 36-44) has been announced by *Fairchild Camera and Instrument Corporation* of New York.

The method is safe and simple, involving only two chemicals. Heat is used as an accelerating factor, with all operations carried out at temperatures under 500 degrees F. Tests have shown that this process is in no way harmful to the operator.

The usual methods of removing Formex from the smaller sized wires resulted in either weakened wires, burned insulation or melting of the wire. By means of the new process, the wires are dipped first into material A to the depth that the Formex is to be removed and then into material B. Following these operations, the Formex may be removed from the wire by hand through gentle pressure of the thumb and forefinger.

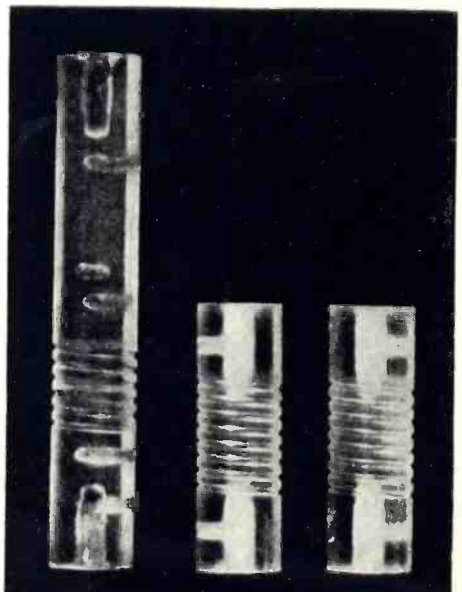
The company has estimated a 50% saving in normal man-hours by means of this new process. The method, which was developed by two members of the engineering staff, is being patented by the company, but details of the process will be forwarded to executives and engineers of other plants using either Formex or Formvar in the manufacture of electronic products.

* * *

Plastic Processing

THE increased use of plastics, such as polystyrene, acrylics, Lucite and Plexiglas, in the manufacture of radio and electronic equipment has brought new problems to the companies making plastic parts.

Laboratory tests were made on production lots of certain insulators made


BEFORE CLEANSING AFTER CLEANSING

from these plastics and the results showed that they did not have the essential qualities of electrical resistance that could be expected from these materials. A test of the raw material before fabrication proved that the original material was perfect in every respect. This difficulty was traced to surface contamination of the machined parts, caused by handing and the oils that were used as coolants during the manufacturing process.

Ordinary washing methods were not satisfactory as the chemical reaction of the solvents affected the plastics adversely.

Printloid, Inc., of New York has evolved a method of washing various insulating parts by means of successive baths in a special degreasing solution which does not affect the plastic, with a final wash in water. The parts are then dried and packed with gloved hands immediately thereafter.

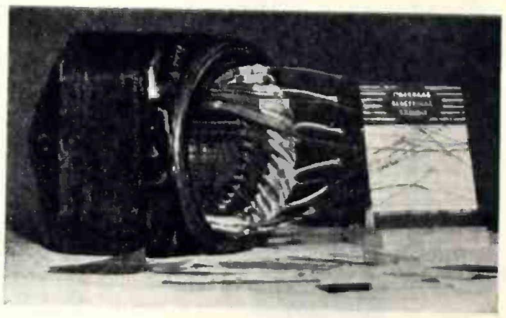
As a result of this advancement, all electronic parts produced by the company are now subject to this treatment.

* * *

Fiberglas Exhibit

THE performance of Fiberglas is being demonstrated to industrial and design engineers by means of a special traveling exhibit sponsored by *Owens-Corning Fiberglas Corporation.*

Units included in the exhibit were selected to demonstrate proved appli-



cations of Fiberglas insulation and to show how use has been made of these materials to enable motors, generators, transformers and other equipment to stand up under conditions of high overload, high temperatures, high humidity and the presence of corrosive fumes.

Severe service requirements for electrical equipment have resulted in a greatly increased and broadened use of Fiberglas electrical insulation during the past several years. The exhibit is aimed at familiarizing users, designers and manufacturers with this recent development by presenting a comprehensive picture of current proved applications.

* * *

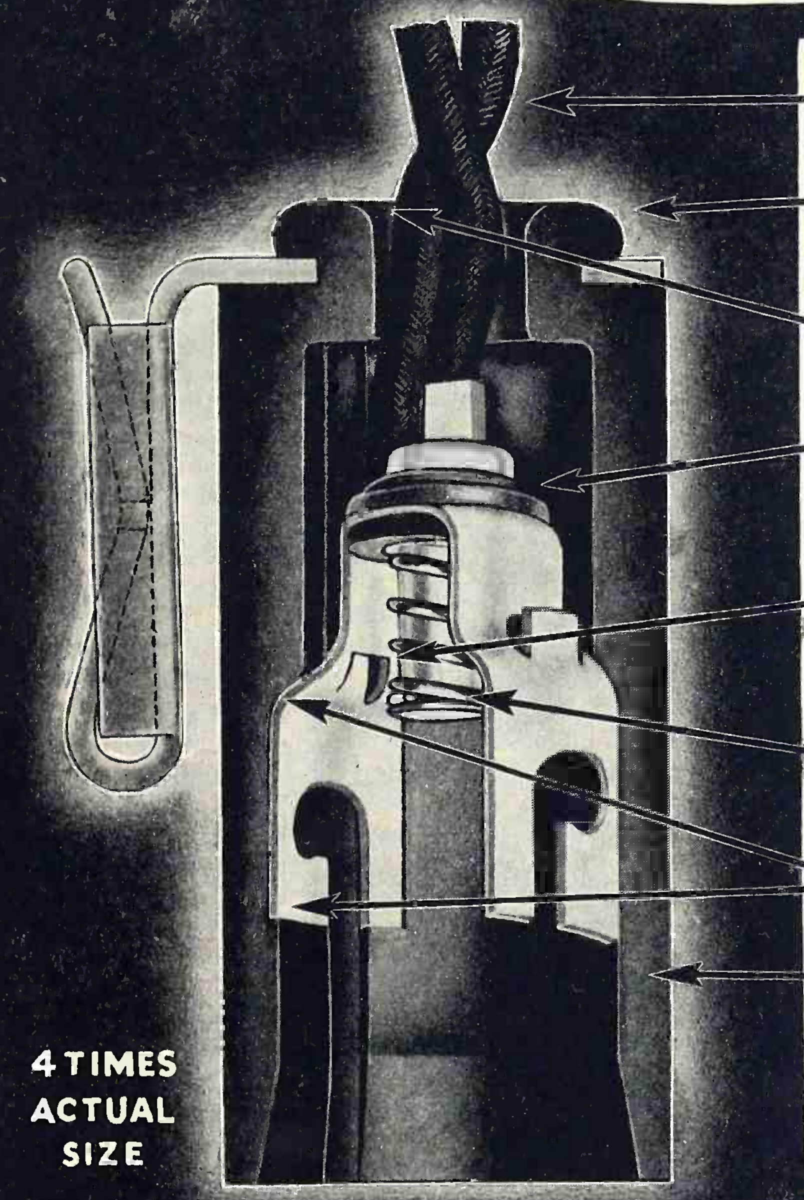
Electronic Drives

THE elimination of overhead drives has been accomplished in the plant of the Axelson Manufacturing Company of Los Angeles through the installation of *Westinghouse* electronic drives.

Faced with increased production and inability to secure new machine tools,

(*Continued on page* 43)

a New and Superior DIAL LIGHT SOCKET



Tensile strength of leads and connections far in excess of requirements.

Tough, plastic shell molded around bracket providing a secure bond with mechanical strength far beyond any normal requirement.

Rounded edge will not cut or fray wire insulation.

Voltage Breakdown between contacts—1200 Volts. Voltage Breakdown to ground —5000 Volts.

Lug on contact fits in groove in shell so that contact cannot be turned or twisted when inserting lamp.

Center contact mounted so that it cannot protrude from shell and short on chassis when lamp is removed.

Plastic shell is recessed for contacts, which cannot be pushed or pulled out of position.

Stronger, tougher, heavy walled plastic shell.

A variety of different mounting bracket styles available, suitable for practically any mounting.

For Your Present and Post-War Production

40TH ANNIVERSARY
1904-1944

This year Lenz celebrates its 40th year of service to the communications industry.

Lenz Dial Light Sockets have always been known for their superior mechanical qualities and electrical characteristics.

Now these sockets are still further improved, with even greater mechanical strength. A stronger, tougher plastic shell is attached to the bracket with a new type of construction that provides a virtually unbreakable bond between shell and bracket. Its excellent electrical characteristics are maintained.

Consider these Lenz Dial Sockets for your present and post war production. Write for sample today.

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ELECTRIC CORDS, WIRES AND CABLES

Clipping Circuits

(Continued from page 9)

work, thus appearing at the grid with same polarity but delayed by some known amount. The mode of operation is illustrated in Fig. 9. The output then consists of double pulses if the pulse duration is shorter than the amount of delay applied, or "peaked" pulses if the duration is such that the delayed pulse appears at the grid before the original pulse has died down. These peaked pulses are then selected by a stage biased somewhat beyond the clipped level.

The phase-shifting circuit may be one of two general types: if the required delay is small, an integrating net followed by a wave shaping circuit is employed.[4] For long delays (of the order of 0.01 sec and upward) a timing circuit[5] which supplies a pulse some time after receipt of the initiating signal is more satisfactory.

Pulse Shape Discrimination

In discriminating among pulses having different shapes, several factors must be considered. In general, the problem resolves itself into an examination of the harmonic content or "degree" of distortion of the pulses. A rough examination of this type is performed by a differentiating network, which is essentially a high-pass filter, the output of which is proportional to the number and relative prominence of the harmonics. When it is simply a matter of selecting among comparatively few types of pulses, this method may be used to advantage. In Fig. 6 are shown three different pulses, all having the same amplitude and duration; also shown is the approximate output obtained from a simple R-C net of time constant small compared to the width of the pulses. The character of the output is such that selection can be performed very readily by amplitude discrimination. Notice that there are marked differences in the slopes of the leading and/or trailing edges of these pulses—a requirement for accurate discrimination.

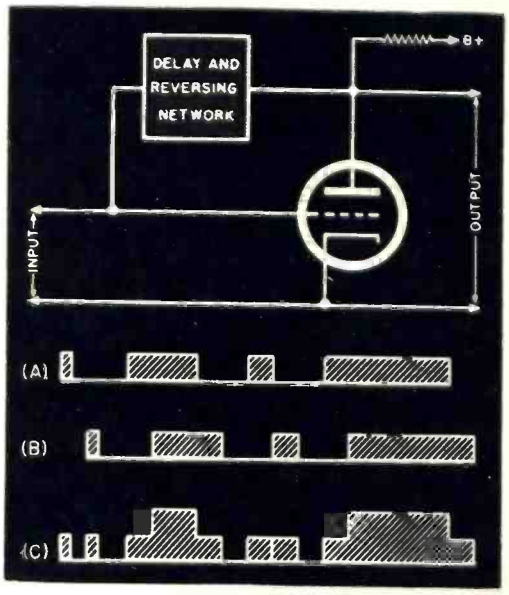
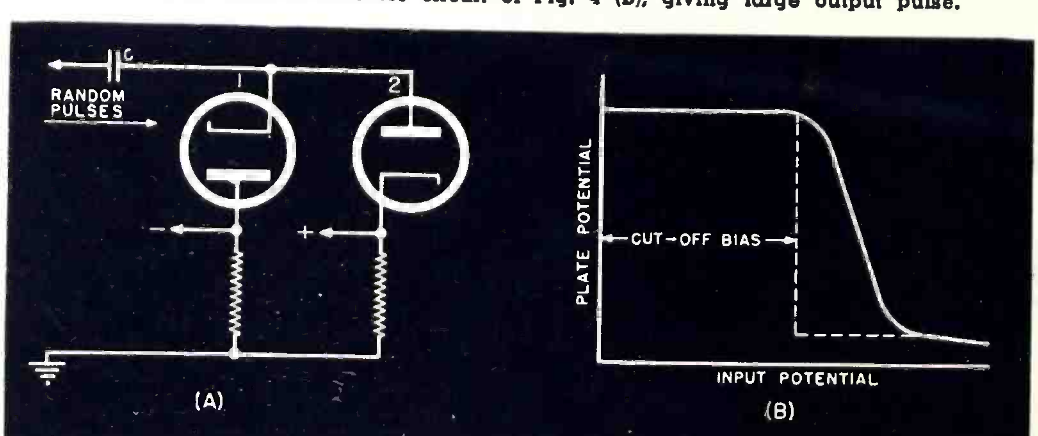


Fig. 9. (A) Clipped input, (B) feedback from delay and reversing net, (C) resulting output.

Clipping Circuits

Distorting amplifiers which amplify only selected portions of pulses are known variously as "clippers," "choppers," "limiters" and "pulse equalizers." Since the above-mentioned terms have been used in widely divergent senses in the literature, it seems best to adopt a standard terminology for the two basic type circuits involved. "Clippers" or "choppers" are below-cut-off amplifiers to which are fed positive pulses, resulting in amplification of only those portions of the pulses which carry the grid above cut-off. "Limiters" or "pulse equalizers" are amplifiers biased slightly above cut-off, and to which are fed negative pulses of sufficient amplitude to drive the grid to cut-off, resulting in output pulses of equal amplitude. Both types of operation may also be carried out at saturation, the former by applying negative pulses to a tube biased beyond saturation, and the latter by applying positive pulses to a tube biased near saturation. The choice of operation will depend, of course, upon the polarity of the pulses.

Fig. 8. (A) Circuit for separating pulses of opposite polarity. (B) High gain screen grid characteristic for circuit of Fig. 4 (B), giving large output pulse.



Blanking circuits, so-called because they serve to render an amplifier inoperative upon the receipt of a signal, have wide application in control problems. The simplest method of blanking an amplifier is by driving one stage below cut-off for the duration of the blanking signal. This may be accomplished in screen-grid tubes by applying the blanking pulse to the screen; however, a dual-control tube such as the 6L7, in which the two control grids are shielded from one another, affords better control, as there is no interaction between the signals on the two grids.

The pulse produced in biasing the blanking stage to cut-off may be removed in several ways. First, if the pulses applied to the blanking stage are unidirectional and positive, the input to the following stage is negative. On the other hand, the blanking pulse, being negative, gives rise to a positive pulse at the following stage. Hence, if this stage is biased to saturation, the blanking pulses produce no effect other than rendering the amplifier inoperative. In the event the signals are not unidirectional a somewhat more elaborate circuit is required, as shown in **Fig. 7. Here, the signal is applied to the first grid of the 6L7, which is R-C coupled to the following stage. The blanking pulse is applied both to the second control grid of the 6L7 and to the grid of tube 1. As a consequence of the negative blanking pulse a negative pulse appears at the plate of tube 2, and is there cancelled by the positive pulse arriving from the plate of tube 1.**

Although the circuits described here are not ordinarily identified with control circuits, they are indispensable in the generation and control of pulses of various types, and have been of considerable aid in television work.

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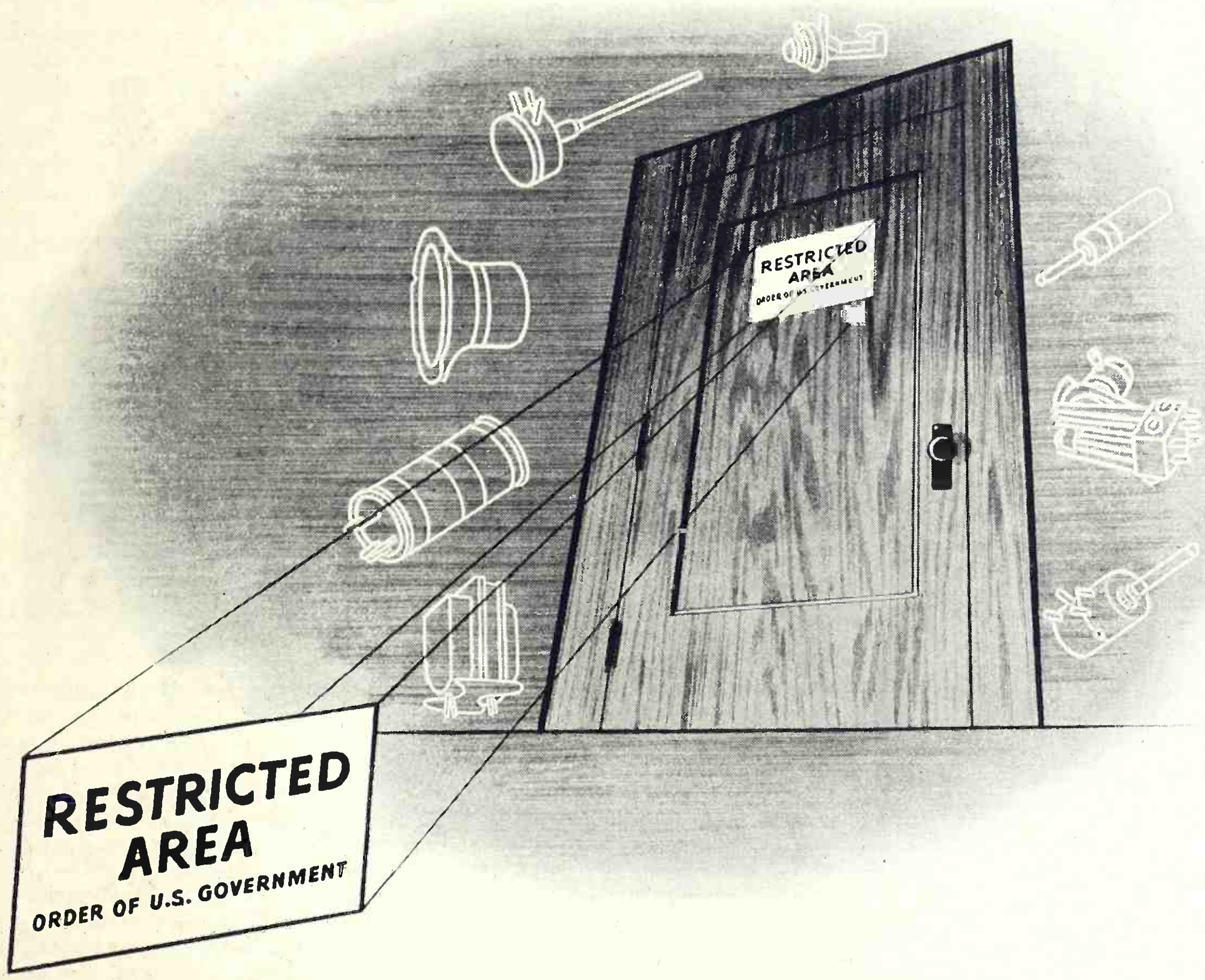

locked door . . .

● Forbidden to all but top government officials and Utah technicians . . . this room has been the birthplace of many miracles in radio, electronics and electricity. Behind this locked door, Utah has developed vital equipment . . . earmarked for military needs. Inevitably, the wartime secrets of this forbidden room will be adapted to commercial and consumer needs . . . assume a prominent role in the pursuits of peace.

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ARMY E NAVY

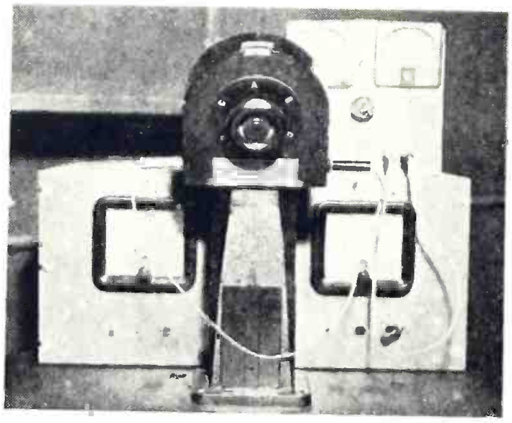
Utah Radio Products Company, 863 Orleans Street, Chicago 10, Ill.

NEW PRODUCTS

QUARTZ ADJUSTMENT

Special X-ray apparatus for the precise adjustment of the frequency of quartz oscillator plates has been announced by the engineers of North American Philips Company, Inc.

The unit employs a new high-capacity water-cooled tube of maximum efficiency. The operator is protected from X-ray exposure by means of a rotary fixture that exposes one crystal to the beam while another crystal is being loaded into a second holder.



Depending on the original characteristics of the quartz plate, the frequency may be lowered in the X-ray unit at a rate of 30 to 50 cycles per second. The crystal holder will accommodate all crystal sizes from .4" x .4" up to .75" x .75".

Further information regarding this unit may be obtained by writing direct to *North American Philips Company, Inc.*, 100 East 42nd Street, New York 17, N. Y.

FUNGUS RESISTANT

A new fungus-resistant coating for phenolic parts of communications equipment to be used in tropical climates has been developed by Maas and Waldstein Company.

This coating is designed for application on phenolic insulators, terminal blocks, junction blocks and the fixed windings of motors, generators and dynamotors.

This product is marketed under the trade name, Durad Fungus Resistant Coating No. 524. It is a varnish which may be applied by spray, dip or brush methods. It has been successfully tested for dielectric strength, hardness, flexibility and resistance to salt spray and thermal shock.

Complete details on this coating may be obtained from *Maas and Waldstein Company,* 438 Riverside Avenue, Newark 4, New Jersey.

UHF CABLES

New sizes and types of solid-dielectric coaxial cables used in u.h.f. radio and radar equipment for the armed services have been added to the line of cables manufactured by the Intelin Products Division of Federal Telephone and Radio Corporation.

Federal cables are manufactured in five basic types; coaxial, dual-coaxial, twin-conductor, coaxial air-spaced and spiral delay. Designed, generally, for 50 to 70 ohms impedance, the cable selected is predicated upon power requirements or power loss limitations.

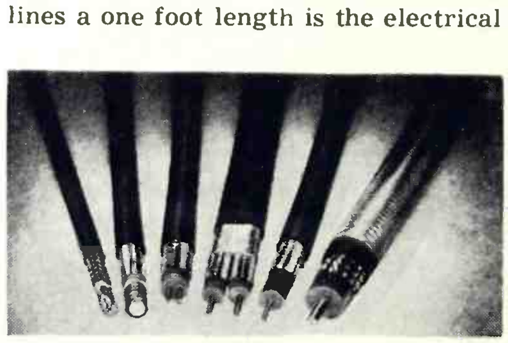
The coaxial lines include sizes from 3/16" o.d. up to and including cables over 1" o.d. Standard designs include single and double-braided cable.

The dual-coaxial lines have been developed to fill the need for parallel circuits having a high degree of balance.

Twin-conductor lines, also known as "Twinax", are balanced shielded pairs, usually somewhat smaller than dual-coaxial lines and provide nearly as good electrical balance.

For low capacitance requirements, a line of coaxial air-spaced cables which can be made in any required length and which have capacitances as low as 8μμfd. per foot, has been developed.

Spiral delay lines have been developed for special test sets requiring lines with an appreciable delay or very high impedances. In some of these lines a one foot length is the electrical equivalent of 15 feet of coaxial cable.



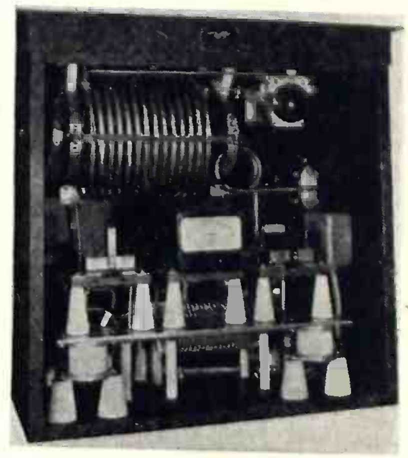
Descriptive literature about these cables will be forwarded upon request to the *Federal Telephone and Radio Corporation, Intelin Products Division,* 28 Halsey Street, Newark 1, N. J.

ANTENNA TUNING UNIT

A new type of antenna tuning unit for coupling a vertical tower antenna to a coaxial transmission line has been introduced by Andrew Company.

This unit, known as the Type 48, uses an L network with variable elements in order to permit adjustment for optimum performance.

Among the unique features of this unit are the built-in isolation filter which permits the connection of the coaxial transmission line to u.h.f. antenna; the weatherproof steel cabinet; a built-in tower lighting filter to facilitate feeding aircraft tower warning lights on the top of the tower; steatite insulation throughout; plug-in meter positions; and a convenient outlet box for soldering irons and extension lights.



Full details will be forwarded by the *Andrew Company,* 363 East 75th Street, Chicago 19, to those requesting them.

GYROSYN COMPASS

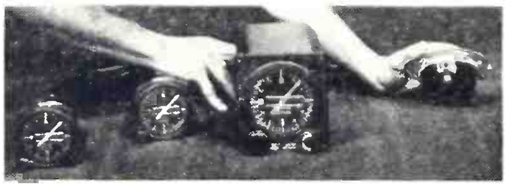
A new flight instrument, the Gyrosyn Compass, has been developed by the *Sperry Gyroscope Company.* This compass is a directional gyro synchronized with the magnetic field of the earth.

In the Gyrosyn, the functions of a directional gyro and a magnetic compass are combined and the resulting instrument provides greater accuracy in navigation and simplifies the duties of the pilot. The compass allows for deadbeat indication and accurate magnetic headings without northerly turning error or the necessity for resetting. In military aircraft, the usefulness of the standard magnetic compass in the cockpit is diminished because of disturbances in the earth's magnetic field due to the proximity of the electrical apparatus and armor plate. The new compass avoids the effect of these disturbances.

The Gyrosyn is an electrically driven directional gyro precisely controlled by a flux valve. The latter replaces the magnetic compass in the detection of the direction of the earth's magnetic field. Small, hermetically sealed and

with no rotating parts, the flux valve may be rigidly mounted in a wing tip safely removed from the disturbing influences of the cockpit.

The compass is installed on the pi-



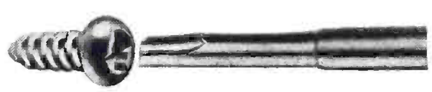
lot's instrument panel or at the navigator's station. Up to six repeaters for remote indications may be used with this compass. The Gyrosyn with two repeaters weighs less than twelve pounds.

The employment of a split arrow course setting device makes the faces of both the Gyrosyn Compass and the repeaters easy to read.

CLUTCH HEAD SCREWS

The United Screw and Bolt Corporation of Chicago is offering a free assortment of their Clutch Head Screws and a sample of their Type "A" bit to engineers, purchasing agents and executives in order that comparison tests of their product may be made on the assembly line.

Among the exclusive features of this type of screw are; operation with an



ordinary type screwdriver or any flat blade of correct width, a lock-on feature which unites the screw and bit for one-handed reaching to inaccessible places, safe withdrawal of the screws, undamaged and saved for re-use in field service, straight walled engagement which eliminates any "ride-out" tendency and the need for forward pressure on the drive home, simultaneously cancelling the fatigue factor and the hazard of slippage.

The assortment may be secured by writing the company at 2513 West Cullerton Street, Chicago 8, Illinois, Dept. RE-12.

TIME DELAY RELAYS

Several new time delay relays have been announced by the R. W. Cramer Company, Inc.

The model TD6 was designed for the protection of transmitter and electronic tubes. This relay has a cam

(*Continued on page* 42)

Crystal Sorter

(*Continued from page* 17)

the output frequency adjusted to 5 megacycles, and connected to point marked "Signal Generator" (Fig. 1). Then, C_9 is rotated until the image is seen at the left side of the screen. The signal generator is tuned until an output of about 6 megacycles has been reached. If the image is not entirely to the right of the screen, R_7 should be adjusted until it is. Once this step has been accomplished, the range switch should be turned to the next channel and C_{10} rotated until the image appears on the left side of the screen, without having changed the output frequency of the signal generator. The signal generator output frequency is then changed until the image is again on the right side of the screen. The range switch is then turned to the next position, C_{11} is rotated until the image appears at the left side of the screen, the signal generator frequency is changed until the image is at the right side again, and the remaining channels are then set up in the same manner.

To calibrate the expanded range, the following steps are to be observed: First, switch S_1 is turned in a clockwise direction. Then, a voltmeter is connected from the arm of R_5 to the midpoint of R_6. The arm of R_5 is then rotated until the voltmeter reads zero.

Incidentally, any channel may be used for calibration of the expanded range. If Channel 1 is chosen, the signal generator is tuned until the image is in the center of the screen and, for sake of illustration, the frequency will be assumed to be 5500 kc. Next, the signal generator is tuned to 5450 kc. The image may go off the screen entirely at the left. If so, R_8 is adjusted until the image can be seen at the left side of the screen. This adjustment is rather critical and requires extreme patience. With the adjustment of R_8 left as it is, the signal generator is tuned to 5550 kc. If the image has gone all the way to the right, the expanded range has been calibrated to read ±50 kc. from center. It can be set for practically any kind of expansion by adjustment of R_8. Also, from the right side of the screen to the left side is arbitrarily—100 kc., and from the left to the right, +100 kc.

To use this expanded range, a pilot crystal is first plugged in, S_1 is turned clockwise, potentiometer R_5 is adjusted to bring the pilot frequency image to the center of the screen, the pilot crystal is then removed, and any crystals plugged in will be seen as + or — up to 50 kc. from the frequency of the pilot crystal.

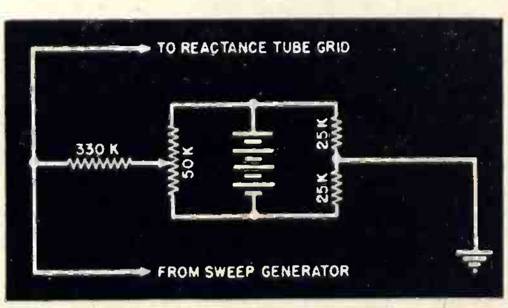
In Fig. 1, a 22½ volt battery is shown. This furnishes entirely too much voltage and it should be tapped down, a battery with taps being used, so that the rotation of R_5 does not cause the image to move too rapidly across the screen. As the battery ages, the next highest voltage tap will, naturally, be used and, when the 22½ volt tap does not cause sufficient movement of the image, a new battery will have to be installed.

The scale covering the lower half of the cathode-ray tube is made of plexiglass and sanded to make it translucent. Between each channel are metal strips to confine the light from the bulbs to the particular band in which operation is being conducted at the moment. As will be seen in front view shown on page 13, the entire scale has been calibrated and engraved. It will be safe to say that no two channel sorters made will have identical scale calibration.

Operation of the device places very little burden and responsibility on the operator. The range control knob has been made large in order to make it less tiring on the hand, when operating the device over a long period of time. Only the channel which is in use at the moment is illuminated, making it almost impossible to make an error in determining frequencies of the crystal by looking at the wrong scale. This device lends itself admirably to rapid sorting of crystal channels for large scale production. With it, crystals can be checked as rapidly as the blank can be inserted into the jig, the range switch turned until the image appears on the screen, and the frequency of the crystal noted.

Routine operation is extremely simple. If the operator has been given a number of rough blanks, the frequencies of which are unknown, all that has to be done is to insert one in the crystal holder provided on the front of the device, and the activity meter noted. If the activity meter does not indicate, it means that the crystal is not oscillating and, providing it is not caused by foreign matter, should be discarded. If the meter does read, and no image appears on the screen, the range control is then turned from one band to another until the image appears. When it does, the illuminated band will immediately indicate in which channel

Fig. 5. Frequency range expanding circuit.



and what the frequency of the crystal happens to be.

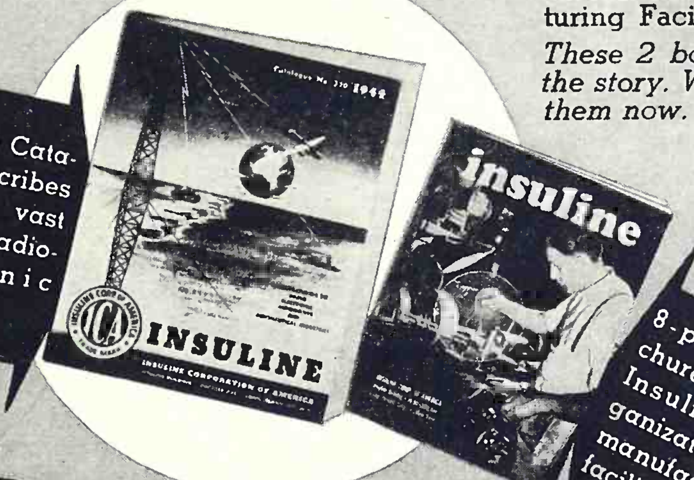
The use of the expanded range will be briefly described by taking the order previously mentioned for crystals of 7410 kc. A pilot crystal is made to the exact frequency. That crystal is plugged in, the range control is turned until the 6.9 to 7.75 megacycle channel is illuminated, then the 1 mc. 100 kc. switch is turned to 100 kc. The centering control is then rotated left or right until the image is exactly over the zero point. The pilot crystal is removed, and rough blanks are then sorted. If they are not visible on the screen, and the activity meter shows oscillation, then the operator knows it was either above or below 50 kc. from the center point, and these crystals are discarded for the moment. A crystal which is above the zero point is, of course, also useless for filling this order. Crystals from zero to —50 kc. are kept for further processing.

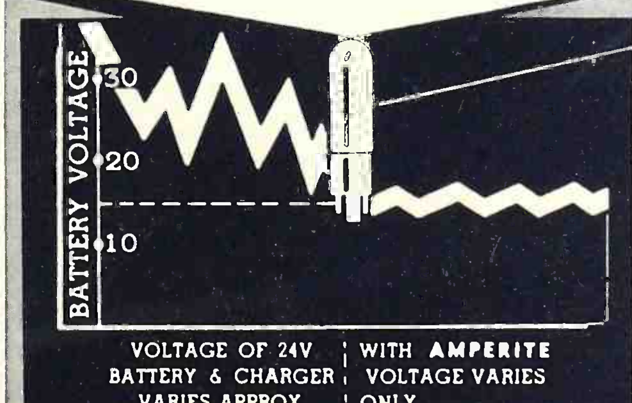
Thus, operation of this device does not depend on the skill of the operator, and it is clear that the *Visual Piezoelectric Crystal Channel Sorter* provides a device which is relatively simple in character and which is positive and fool-proof in operation. The device can be safely and satisfactorily operated by any person of average intelligence without lengthy training.

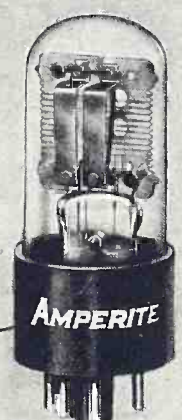
No doubt this device will find many other uses. Only the imagination of engineers using it will determine to what additional uses it can be adapted. The design can also be refined. For example, the entire half of the screen need not be visible; only an inch of screen is sufficient. A hood over the front of the tube would permit operation in a brightly lighted room.

Its practically fool-proof construction, ease of operation, reliability, accuracy, and speed will enable crystal manufacturers to reduce costs of crystals and accelerate production.

After the channel sorter was put into operation, unsatisfactory operation was reported at first due to nonuniformity of crystal activity—this resulted in too great changes of the vertical pip. In other words, after the device was adjusted so that the output of a crystal with low activity was visible on the screen, a crystal with relatively strong activity forced the pattern off the screen. A vice-versa adjustment results in being unable to see crystals of lower activity. The only solution was to incorporate AVC. The output from the reference oscillator was adjusted to give a minimum input of .5 volts to the mixer grid, and vertical gain was adjusted to match. Any larger input voltage does not cause a change of vertical amplitude.







NEWS BRIEFS

FM SELECTIVITY

George L. Beers of RCA described the new frequency-dividing locked-in oscillator FM system to engineers meeting at the National Electronics Conference in Chicago.

According to Mr. Beers a substantial improvement in selectivity has been obtained by means of this new system by designing the oscillator to lock-in only with frequency variations occurring within the desired channel.

Another improvement is the increased stability of the receiver from the standpoint of over-all feedback. This results from the fact that the locked-in oscillator arrangement provides a substantial voltage gain at a different and lower frequency than the intermediate frequency employed in the receiver. High sensitivity is required in an FM receiver in order to obtain maximum performance. If this sensitivity is obtained at a single intermediate frequency, it is difficult to prevent over-all feedback and provide satisfactory receiver stability, according to Mr. Beers.

NAME CHANGE

For the purpose of simplification, the Electro-Voice Manufacturing Company has announced a change in the corporate name to Electro-Voice Corporation.

The company, which developed and manufactures the T-45 lip microphone, the 600-D mobile communications microphone and the new 205-S hand-held noise-cancellation microphone, will continue to operate under the same management and personnel as formerly.

WHITE'S SPEECH

In his address to the luncheon meeting of the National Electronics Conference, William C. White, head of the Electronics Section of the General Electric Research Laboratory, urged engineers to design electronic devices for industry which are not "gadgets" attached to some piece of equipment but are rather a closely knit part of the whole.

He stressed the importance of the engineers knowing fields beyond those closely allied to the electronics field in order to be able to design for improved performance and over-all usefulness.

The successful use of electronic devices, according to Mr. White, is based upon giving better results than other methods, or because the engineering problem involved cannot be solved in any other way. He feels that the glamor of electronics is responsible for putting electronic devices to work in applications where the possibility of failure is a foregone conclusion.

In Mr. White's opinion the largest single kind of industrial electronic equipment to contribute to the war effort is resistance control welding. The high quality of welds are obtainable only with the precision timing and heat control offered by electronics.

NATIONAL UNION APPOINTS

Dr. A. M. Skellett, formerly of the Bell Telephone Laboratories, has been appointed chief engineer in charge of research for the National Union Radio Corporation, manufacturers of radio-electronic tubes.

Dr. Skellett has specialized in electronic tube research and is the inventor of the secondary emission trigger tube and the radial beam tube.

He will make his headquarters in the Research Laboratories of National Union Radio Corporation in Newark, New Jersey.

RECTIFIER BULLETIN

A new engineering data bulletin on selenium rectifiers has been issued by the *Benwood-Linze Company* of St. Louis, Missouri.

The company has made every effort to provide pertinent facts and figures covering the characteristics and applications of their line of selenium rectifiers.

Included in the booklet are two inquiry sheets for engineers who desire specific data for certain applications of the rectifiers. The bulletin, Number R-41, will be forwarded upon request to the company at 1811 Locust Street, St. Louis 3, Mo.

REPRESENTATIVES ELECT

At the annual meeting of The Representatives held recently, forty delegates representing thirteen chapters of the organization elected new officers.

The men so honored include, Irvin I. Aaron, President; Royal A. Stemm, Vice-President; and David Sonkin, Secretary-Treasurer.

This group, which is now in its ninth year, is affiliated with the Radio Parts Manufacturers, Inc. Membership has grown from 38 to 230 in the nine-year period.

A new chapter in the Seattle, Washington, district was admitted to membership during the annual meeting.

WESTINGHOUSE ANNIVERSARY

The work-study plan of Westinghouse Electric and Manufacturing Company has begun its 18th year in Pittsburgh.

The program, which aids employed college and university graduates attain advanced degrees, has a present enrollment of 250 employees. This night school offers, through the University of Pittsburgh, courses leading to the degrees of Master of Science or Doctor of Philosophy in either electrical engineering or business administration.

Since the inception of this plan in 1927, 108 students have received their Master's degrees and seven have been awarded their Doctorates.

INDUSTRIAL ELECTRONICS

The *De Forest's Training, Inc.*, is currently offering a course in Industrial Electronics at the New Hamilton Hotel in Chicago.

This course covers such subjects as electronic measuring instruments, electronic control of welding operations, X-rays and industrial applications and high frequency heating. The lectures are augmented by a series of mimeograph notes, circuit diagrams and data charts.

Full details of the courses offered may be obtained by writing to the school at 2533 North Ashland Avenue, Chicago 14, Ill.

NEW DEJUR PLANT

A completely new plant has been opened in Long Island City by the DeJur-Amsco Corporation, manufacturers of photographic and electronic components.

This plant contains separate manufacturing divisions for both electronic equipment and photographic assembly. Located on Northern Boulevard, it covers 75,000 square feet which provides the largest manufacturing space the company has ever had.

The building is of daylight construction and is equipped with employees' restaurant and recreation room. The entire plant is air conditioned. An adjoining athletic field provides recreational facilities for the employees.

DECEMBER

11-12—**National Television Broadcasters Association Conference,** New York City. Mr. O. B. Hanson, Chairman, Hotel Commodore, New York.

* * * *

JANUARY

22-26—**American Institute of Electrical Engineers,** Technical Meeting, New York, N. Y.

* * * *

APRIL

22—**National Electrical Wholesalers Association,** 37th Annual Convention at The Stevens, Chicago, Illinois.

* * * *

MONTHLY MEETINGS

Association of Electronic Parts & Equipment Mfrs. J. Arthur Kealy, Secretary pro tem, 77 W. Washington St., Chicago, Illinois.

2nd Thursday each month at the Electric Club of Chicago.

* * * *

The Representatives. R. Edward Stemm, Secy., 21 E. Van Buren Street, Webster 4840. Chicagoland Chapter, Chicago, Illinois.

Luncheon meeting 1st Monday each month.

* * * *

Sales Managers Club, Hotel New Yorker, New York. Walter Jablon, Secy., Hammarlund Mfg. Co.

Lunch meeting on the 4th Wednesday each month.

* * * *

I. R. E., Chicago Section. Alois W. Graf, Secy., 135 So. LaSalle St., Chicago, Illinois. Central 4060.

Meeting December 15, 1944, Central Y.M.C.A. Symposium on "Factors Influencing Fidelity in Home Radio and Record Reproduction." Ralph P. Glover, Symposium Chairman.

Meeting January 19, 1945, Central Y.M.C.A., 19 So. LaSalle Street, Chicago, Illinois. Dudley E. Foster, Majestic Radio and Television Corporation, will present a paper on "Television Development." A second paper on "Television Distribution Systems" has also been scheduled.

Television

New Video Council

A NATIONAL Television Council was formed recently in Chicago for the purpose of keeping the public informed on the newest developments in the video art, and to serve as a clearing house for information among manufacturers.

Richard H. Hooper, the regional manager of advertising and promotion for the RCA Victor Division was elected president of the council. Permanent headquarters have been set up in the LaSalle Hotel in Chicago and regular meetings will be held.

Requests for speakers on the subject of television will be cleared through the council to assure adequate coverage of the subject for interested audiences.

Members of the council include Commander William Eddy, representing the technical interests of television; Ross Metzger, advertising agencies; Don McNeil representing radio broadcasting; Burr Tillstrom representing the television actors, Charles Lyons for the announcers, F. K. Starbird representing the advertisers.

* * *

Editorial Comment

THE *American Magazine,* through its publisher Mr. Arthur H. Motley, has entered the controversy regarding the use of prewar standards for first postwar television sets.

Mr. Motley feels that the television industry should decide and should inform the public that its postwar development will take full advantage of wartime scientific discoveries, rather than freeze operations on present standards.

"The public is entitled to the best practicable system which wartime research has made possible" according to Mr. Motley. "Of course, some manufacturers and set owners will take a loss, but that is the only way progress ever comes. Fewer than 8,000 television sets are in the hands of the public today, and these are designed to receive only television pictures of the prewar quality."

Mr. Motley is an advocate of color television and he believes that color will add new life and new dimensions to television in the same manner that the use of color in magazines aided the sale and public acceptance of this medium.

Because of Mr. Motley's interest in television, the *American Magazine* was the first publication to be televised.

* * *

Managers Visit WRGB

STATION WRGB, the General Electric television station in Schenectady, played host to a group of department store executives recently.

The transmitting facilities of the station were explained and exhibited to the group by James D. McLean, General Electric Sales Engineer.

The executives, representing 22 of the largest stores from coast-to-coast visited Schenectady to learn how television might be used for internal interdepartment display of merchandise.

* * *

New DuMont Studio

A NEW television studio was recently opened by station WABD, the DuMont outlet in New York. In addition to the original studio on the 42nd floor at 515 Madison Avenue, the station now occupies the second floor for its new large studio, two reviewing rooms, a theatre with projected screen images, general offices, dressing and prop rooms and other accommodations. A sales department for television equipment occupies the third floor.

DuMont reports vastly improved facilities now available. New lighting for providing higher illumination level permits smaller lens apertures which provides greater depth of focus and sharper over-all television images.

(*Continued on page* 46)

Graphical Treatment

(*Continued from page* 22)

It is noted that if any shorted stub matches a line to a load, an equivalent open stub could be used in its place, and its length is (180°—shorted stub length). This is true whether the matching stub has the same characteristic impedance as the line or not.

When reactive termination is used, the input impedance is calculated by entering the chart at a suitable point. For example, an r.f. line with $Z_o = 50$ ohms is terminated by $Z_r = 30 + j40$ complex ohms.[10] The length of the line is ⅛ wavelength. $Z_r/Z_o = 0.6 + j0.8$, and the chart is entered at $(0.6, + j0.8)$, a circle found passing through the point, and this circle traveled clockwise ⅛ wavelength or 45° to the ρ axis since (180°—135°) = 45°. Thus, $Z_{in}/Z_o = 3$, or Z_{in} has been determined as 150 ohms and is a pure resistance at this distance from the load.

It will immediately occur to the reader how to match any load to any source by merely choosing a suitable length of line. While this is possible, it is not desirable, since the line operates with voltage maxima and current maxima which is less efficient and more expensive than a matched line and load.

The stub necessary to match a reactive load to a line may be computed as follows: Suppose $Y_r/Y_o = 2 + j1.5$. The chart is entered at (2, 1.5) and the corresponding circle traveled clockwise to (1, —1.27), showing a travel from the load of 44°, and a capacitive stub of 143°. It is observed that the axis on the circle diagram has been crossed or a doubling back has taken place on the semi-circle diagram.

Frequently it is not feasible to break into a line, particularly of the coaxial cable type, at an arbitrary point;[11] however, the line may perhaps be opened at two fixed points. In such a case, double stub matching may be employed. For example, suppose a line with $Z_o = 50$ ohms and $Z_r = 25$ ohms may be entered 1.5 wavelengths from the load, and again ⅜ wavelength further back. Two stubs may be used to match.

$Y_r/Y_o = 2$, and the chart is entered at (2, 0). After negotiating the corresponding circle 1.5 wavelengths (three complete revolutions), the starting point is again reached. A stub is added by dropping vertically [see Fig. 3(C)] a trial distance to a circle which is negotiated ⅜ wavelength or 135° to end on the match line $\rho = 1$. Now, if it is *not* possible to thus find a circle on the chart, advanced methods of matching must be used which are beyond the scope of this article.

In this particular case, it is possible

to drop to the 12.5° circle, finding an interpolated Y_r/Y_0 circle which may be traveled 135° to the 147.5° circle, thence to drop down the match line to (1, 0).

The first drop corresponds to a shorted stub of 49.5°, while the second stub will be 47.5° long. It is observed that the second stub is computed exactly as for a single stub problem.

In case of a reactive load, the procedure is the same as in the case of the first stub above except that the susceptance of the load must be subtracted from the apparent stub length; thus if $Y_r/Y_0 = 1.5 + j1$, the chart is entered at $g = 1.5$, $b = j1$, and a suitable vertical distance dropped as dictated by the conditions of the problem. However, this drop will correspond to a stub whose length is the total chart drop minus 1, the susceptance of the load. The second stub is computed exactly as in a single stub matching problem.

Chart Construction

For purposes of chart construction (circle or semicircle diagrams), the following relations are of interest:

Each αx semicircle or circle intersects the ρ axis (axis of abscissas) at r_1 and $1/r_1$.

The center of each αx semicircle or circle is:

$$1/r_1 + \frac{r_1 - (1/r_1)}{2}$$

or, the center of the circle may be found by striking arcs from its points of intersection with the rho axis.

Each βx semicircle has a center on the axis of ordinates (reactance axis), and this center is at a distance from the origin equal to cotangent $2\beta x$. All βx semicircles pass through (1, 0).

Summary of Chart Properties

The axis of abscissas gives the dimensionless resistance or conductance defined as R_r/R_0 or G_r/G_0.

The axis of ordinates is calibrated in equal intervals giving the dimensionless reactance or susceptance defined as the imaginary part of Z_r/Z_0 or Y_r/Y_0.

Traversing a circle or semicircle in the direction of increasing electrical degrees constitutes travel down the line from the load. Travel in the opposite direction takes the observer toward the load from the source.

The βx circles are a coordinate system on the chart which calibrates the αx circles in electrical degrees of line. They also calibrate the axis of ordinates in electrical degrees of stub.

In impedance computations the shorted end of a stub is at (0, 90°); in admittance problems the shorted end of the stub is at (0,∞).

Summarizing, a shorted stub is inductive from 0° to 90° and capacitive from 90° to 180°, an open stub capacitive from 0° to 90° and inductive from 90° to 180°. Lines are lossless and have resistive characteristic impedance at radio frequencies.

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Classification

(*Continued from page* 18)

in the September issue of RADIO NEWS. The actual subject is sound recording which falls under the heading of Applications of Radio (R500). Noting that there is no particular place for that subject in the series, it is classified under R590, "Other Applications." Since this does not completely classify the subject, it can be cross-indexed under 621.385.97, "Electro-Acoustic Devices" (from Table II).

Thus, it can be seen that the system is quite flexible and can be modified to suit the needs of the individual. It is hoped that the foregoing discussion will indicate the manifold advantages to be realized from an understanding of how radio knowledge can be effectively classified. After the war, a vast amount of literature now restricted by the military will become available for general distribution. When this happens, proper dissemination and maximum benefit can be achieved only through systematic classification. It should be realized that it is much easier to refer to a convenient card file for the location of a certain piece of information than it is to thumb through countless pages of literature, on the slim chance that a page or paragraph will appear familiar.

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1. Dewey, Melvil: "Decimal Classification and Relative Index for Libraries, Clipping Notes, etc.," copyrighted by the Lake Placid Club Foundation, Lake Placid, N. Y.
2. National Bureau of Standards Circular 385: "Classification of Radio Subjects—An Extension of the Dewey Decimal System," 1930.

Photoelectric Control

(*Continued from page 6*)

mechanically-driven commutator mounted on the shaft of the motor which drives the diaphragm, resulting in a direct current which is proportional in polarity and magnitude to the deviation in light-transmitting quality. Relay 3 is then set to pick up at a definite value of current of one polarity, and relay 4 is set to pick up at the same value of current of opposite polarity.

In both of the above circuits, it is apparent that any variation in light intensity or amplifier gain due to varying line voltage will have no effect on the balance. When a correction in the process has been made by the regulator, it is essential to prevent a second correction from being made until the effect of the first has been recorded by the phototube; for this reason, a time delay relay is provided which is so connected in the circuit that during the delay period no further regulating action can take place.

Vacuum tubes have certain characteristics which may prove undesirable when they are used with apparatus for the industrial field. Therefore, in designing photoelectric control circuits it is necessary to choose the circuit carefully to minimize these effects. Whenever possible, only one tube should be used as the controlling element. A comparison circuit in which the result is compared to the cause should, in general, be used whenever the tube circuit is to regulate power flow to some device.

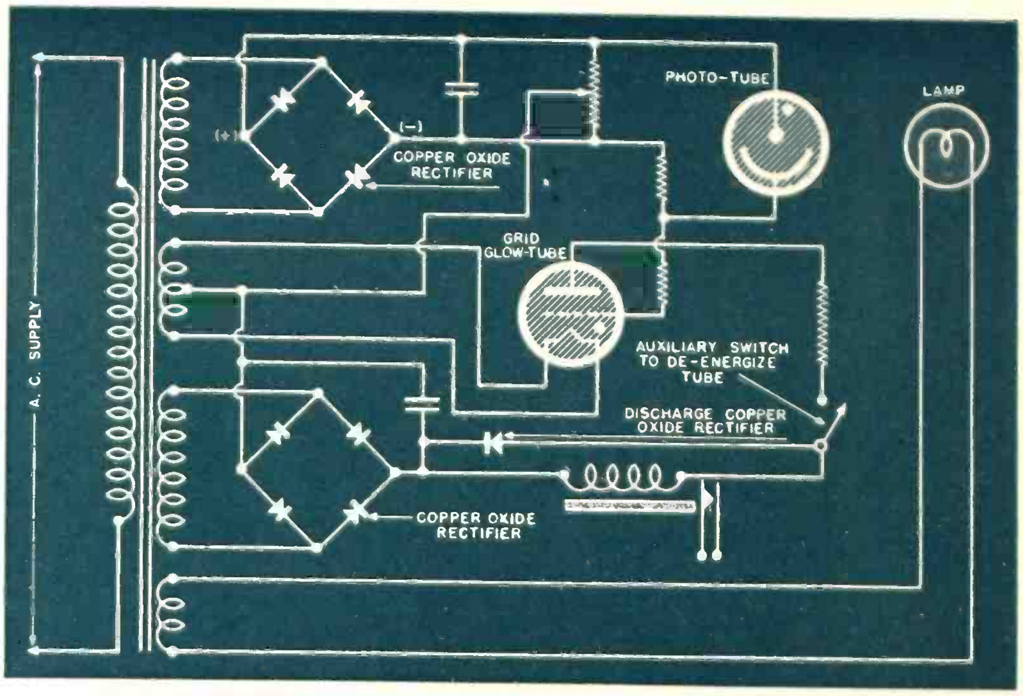


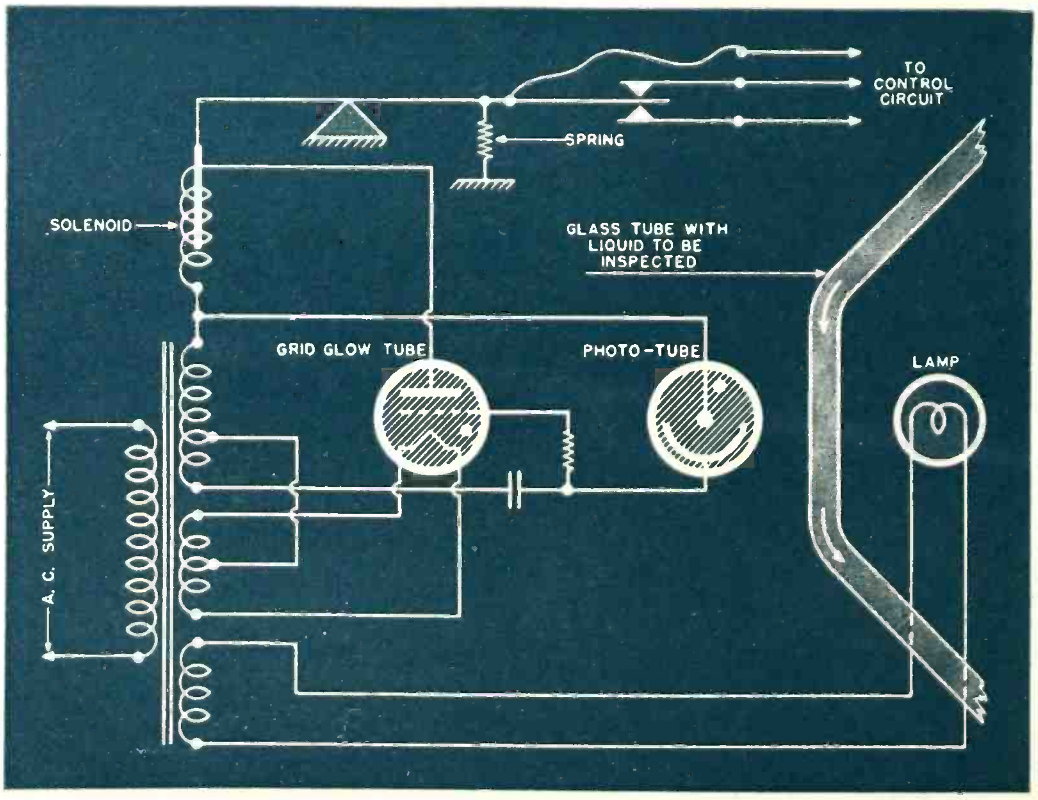
Fig. 11. Schematic diagram of lock-in type of photoelectric relay.

A number of examples will be given of the application of some of these basic photoelectric control circuits to specific manufacturing processes.

The simplest applications of photoelectric control are those in which a photoelectric relay is used as a light-sensitive limit switch. Manufacturing operations which fall into this category are automatic counting, conveyor control, and numerous others. The basic circuit of Fig. 10 (A) can be used for many of these functions; many other circuits and modifications are available depending upon the desired sensitivity and functions to be performed.

In many processes some means of detecting faults in sheet materials is necessary. The detection of holes in sheet steel that is being processed in steel mills is a typical application of this type. The detection of these pin-holes is particularly desirable in steel which will be used for the canning industry. Prior to the use of photoelectric pin-hole detectors, effective visual inspection was difficult and food spoilage resulted. By using pin-hole detection equipment, it is possible to inspect steel strip moving at speeds up to 1500 feet per minute and detect holes with a diameter of 1/64 inch or smaller. The detector operates a marker which places a visible mark on the strip at the location of the hole so that it can readily be located after the operation is completed. In many installations, the detector also operates a classifier to reject defective sheets automatically after they have gone through the shearing operation which usually follows the pin-hole detector.

Fig. 12. Schematic diagram of a typical chemical process regulator.



Process Regulation

Many of the most important applications of photoelectric controls may be classed as process regulators. In order to keep certain processes functioning within proper limits it has been necessary, before the development of suitable automatic control, to resort to close supervision by trained inspectors. However, this was expensive, slow and inaccurate. The accuracy in the best of cases would vary with the health and fatigue of the inspector, with the conditions of illumination, and with the pressure of the work. Furthermore, the inspector must change the speeds of pumps, conveyors, compressors, etc., and either hope that the correction is sufficient or waste valuable time waiting for the correction to take effect before a further check can be obtained. The application of automatic photoelectric control has resulted in considerable savings in cost, speed, and accuracy of control in many of these processes.

In paper or steel mills, loop regulators watch the loop position and control the speed of one of the sections of the mill to maintain a constant loop. A simplified diagram of such an arrangement is shown in Fig. 6. The web is driven by motor *A* into the loop and taken out of it by motor *B*. The speed of motor *A* is adjusted as desired and the regulator then keeps the speed of motor *B* at the proper value to maintain a constant loop between the two sections. An increase of loop length reduces the amount of light reaching the phototube from the light source and modifies the field excitation of motor *B*, adjusting its speed and bringing the loop back to the proper position.

In many operations involving strip material it is necessary to regulate the sideways position of the web. This may be necessary for smooth roll windup when rewinding mill rolls, or when slitting strip materials to insure cutting at the proper point relative to a trademark or printed design on the material. The regulator shown in Fig. 7 scans the edge of the web or a line in the printed design; the proper web position is obtained by moving the roll of material to the position called for by the phototube in the scanning device. Fig. 1 shows equipment of this type installed as a slitter regulator on a printing press to maintain the correct position of the paper web.

Photoelectric regulators have also been used to great advantage in conjunction with high-frequency heating processes to permit a thinner coating of tin on strip steel for cans. This process was brought about by the wartime shortage of tin. The steel strip is coated by an electrolytic tinning process which leaves the tin surface with a silvery appearance and somewhat porous structure. It is then necessary to heat the strip enough to melt and flow the tin to obtain a more perfect coating. The amount of power furnished to the high frequency unit must be controlled to prevent the tin from flowing too early in the heating coil. The heating and regulating system for this process is shown in Fig. 8. The flow line is readily distinguished because the tin coming directly from the plating tank has a diffusing surface, whereas the tin which has been flowed has a mirror surface; the scanner detects the exact line at which this change of condition occurs. If the position of the tinning line changes, the power input is then modified accordingly.

Register Regulation

When bags or wrappers are made or packages labeled from preprinted stock, a regulator must be used to maintain the proper relationship between the position of the printing and the cut. Although the machine feeds paper at a rate to match the speed of the rotating knife, the cut will never remain registered perfectly, due to the effects of changes of paper slippage, stretch and speed relative to the cutter speed.

A register regulator of the basic lock-in type shown in Fig. 11 may be used to maintain the paper in the proper position with respect to the cutter by controlling the speed of the paper feed mechanism. The position of the printed material is indicated by a small register mark in the design or margin (or a slight transparency, such as a watermark) which has been printed for this purpose. The position of the mark with respect to the cutter is checked by a phototube which scans the margin and modifies the feed if necessary.

Temperature Regulation

Photoelectric temperature controls are of two fundamentally different types. One type is based on the pyrometric principle; the other uses auxiliary means to change the illumination on the phototube and in this manner controls the temperature, for instance the light reflected from the mirror of a galvanometer connected to a thermocouple. The fundamental photoelectric circuit is essentially the same as that shown in Fig. 10, with the contactors connected to operate the heater control equipment.

A typical installation of a pyrometric-type photoelectric temperature control is shown in Fig. 2. The phototube utilizes the radiation from the high-temperature clinker zone to determine the temperature. Ten cement kilns under phototube temperature control can be seen in the photograph.

Sorting, Grading and Matching

The use of photoelectric equipment for sorting, grading and matching is more difficult than any of the other applications which have been mentioned. The phototube, although it responds to changes in the incident light, does not possess intelligence and therefore cannot duplicate the performance of the human eye for the great majority of sorting problems. The only way in which a phototube can be made to appear to have intelligence is to design

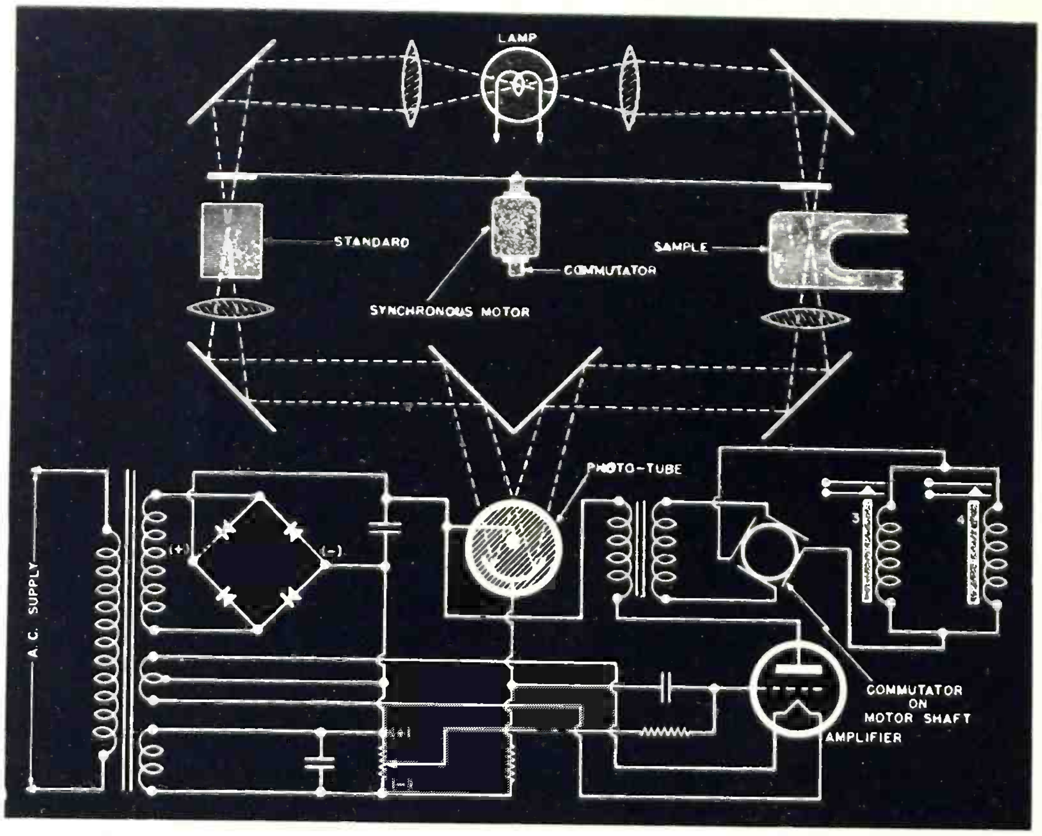


Fig. 13. Schematic diagram of a typical flicker method process regulator.

the optical systems so that the phototube receives a varying amount of light, which depends upon the particular characteristic of the material which it is desired to detect. The most difficult sorting application is that of selecting only one feature of the product when the optical characteristics of the material are affected appreciably by other factors, for instance factors of a mechanical or optical nature inherent in the process of manufacture.

The most difficult problems to handle in high-speed production are those of grading and matching. Grading, which is the division of a product into many arbitrary classes, is merely an extension and complication of the problem of sorting. If color is involved, the problem becomes still more difficult since grading for color necessitates a separate measurement for each of the three primary colors.

The application of phototubes to such problems is usually very expensive and difficult to work out because of the considerable development which is required for each individual application.

New Products

(*Continued from page 34*)

operated switch mechanism which is mounted in a dust and moistureproof bakelite case for panel mounting. It has a visible index showing open and closed position by means of a graduated indicating dial. Four screw type terminals are provided for motor and switch circuits. A totally enclosed switch unit is used. This switch has definite snap action and positive lock in both operating positions.

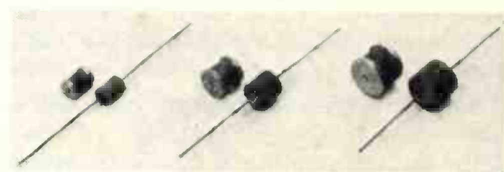
The models TD8 and TD9 are accumulative time delay relays especially designed to add the time interval of the momentary overload surges occurring in quick succession in the order of 10 to 1. Their purpose is to open the main control circuit if the additive overload periods exceed a predetermined time interval.

Full details on any of the types of relays mentioned will be furnished on request to *R. W. Cramer Company, Inc.*, Centerbrook, Conn.

HIGH VOLTAGE CAPACITORS

Three new types of capacitors are now in production at Centralab and are available for general sale. These capacitors are particularly useful in high frequency power circuits requiring a small capacitance of low loss and stable retrack characteristics.

All units have the general double-cup design that simplifies positive attachment of the terminal and gives maximum flash-over distance between the terminals. Plates are of pure silver fixed to the ceramic. Standard terminals are silver-plated brass or bronze. NPO units have zero temperature coefficient and maintain a constant capacitance with temperature change. The dielectric of this ceramic body is approximately 40.



Capacitance is determined by the area and thickness of the ceramic center partition or bottom of the cups and by the dielectric constant of the ceramic.

The new capacitors have been numbered CRL 855,854, and 853 and are available with axial screw style and axial lead terminals.

Literature on these capacitors is not ready for distribution at the present time, but application to *Centralab* for their Bulletin 814 will place your name on the advance list. Address the company at Milwaukee, Wisconsin.

NEW TUBES

RCA has recently released information on three new tubes which are available to equipment manufacturers against WPB rated orders.

6F4 Oscillator Triode

The 6F4 is an acorn triode of the heater type intended for use primarily as an oscillator at frequencies up to about 1200 megacycles. Operation at this ultra-high frequency is made possible by a close spaced electrode structure and the use of a radial 7-pin base which provides two connections each for plate and grid. Because of the close spacing, the 6F4 has high perveance, and because of the double grid and plate leads, it has reduced lead inductance, features essential to high-frequency operation.

At moderate frequencies, a single 6F4 operated in class C oscillator service with 150 volts on plate is capable of giving a power output of approximately 1.8 watts. At 1200 megacycles, and with 100 volts on plate, approximately 45 milliwatts can be obtained.

6AL5 Twin Diode

The 6AL5 is a miniature twin diode featuring high perveance. Because of this feature, the 6AL5 is particularly suitable for use as a detector in circuits utilizing wide-band amplifiers. In such circuits, the low internal resistance of the 6AL5 makes it possible to obtain increased signal voltage from a low-resistance diode load. Each diode unit has its own plate and cathode base-pin connections and can, therefore, be used independently of the other or combined in parallel or full-wave arrangement. The 6AL5 is an Army-Navy preferred type.

3B25 Half-Wave Gas Rectifier

The 3B25 is a xenon-filled, half-wave rectifier tube employing a rugged construction which permits operation under conditions of severe vibration. Because of the xenon gas, the 3B25 can be operated under conditions where ambient temperatures in the order of −75° to +90° Centigrade are likely to be encountered. The 3B25 is capable of withstanding a peak inverse anode voltage of 4000 volts and of delivering an average anode current of 0.5 ampere.

* * *

Eimac has announced the addition of two new tubes to their line.

25T and 3C24/24G

Both of these tubes are medium-mu triodes and are smaller brothers of the Eimac 35T and 35TG, respectively. Both may be used as modulators, oscillators or power amplifiers. Radio frequency outputs of as much as 100 watts per tube, with a plate dissipation of 25 watts, may be obtained.

Prompt deliveries of small quantities of these tubes can be made on a priority rating of AA-2X or better.

* * *

Hytron has recently announced that three types have been added to its line of miniature tubes.

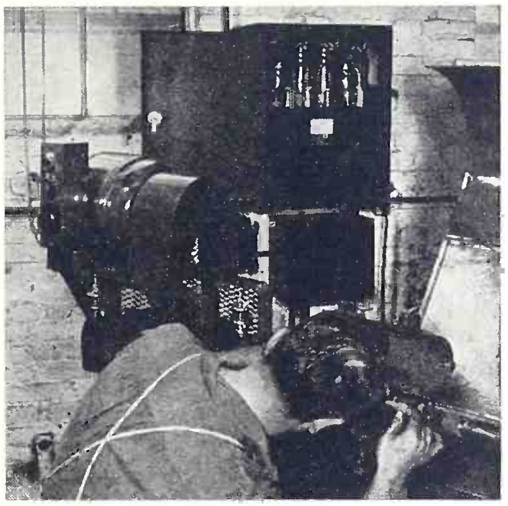
6AK5, a sharp-cutoff r.f. pentode.
6AL5, a v.h.f. twin diode.
6AQ6, a double diode triode.

These tubes are being manufactured in accordance with WPB authorized production schedules.

Industrial Review

(*Continued from page* 28)

the Axelson Company converted three 30-year-old Heald grinders. This conversion resulted in improved quality of precision finishing, vibration-free, stepless speed control over a 20-1 speed range, and better working conditions.



The equipment used was the Westinghouse "Mot-O-Trol" electronic drive consisting of an electronic rectifier and a d.c. driving motor whose stepless speed is controlled by a potentiometer in the pushbutton station.

The electronic drive consists of four

essential units, a shunt wound d.c. motor, a grid controlled thyratron rectifier, a separately mounted transformer and a pushbutton control station with speed control rheostats.

* * *

Oscillograph Use

THE *Westinghouse* cathode-ray oscillograph is now being used to check the ignition systems of aircraft. The stream of electrons, driven in a pencil-thin beam photographs electrical sparks that flash in front of the stream at more than 5,000 miles an hour.

By stopping the spark flashes at one-tenth of a millionth of a second, the electronic beam is recording airplane engine ignition actions to help solve the problems encountered in producing faster and more powerful airplane engines.

The beam of electrons is created by a high voltage rectifier. These electrons are guided into their narrow path by magnetic fields and a series of plates which channel them downward. To prevent the beam from registering on the film before the ignition study is made, the device incorporates a beam trap that deflects the electrons out of the photographic channel.

The electrical impulses which are to be studied are shot across the path of the electron beam just above the film rack. The impulses force the electronic beam out of its straight path and cause it to register a record of the voltage on a strip of photographic film. Simultaneously, the electron beam records the time involved in order to give engineers a graphic record of electrical events that occur in periods as short as one hundred-millionth of a second.

* * *

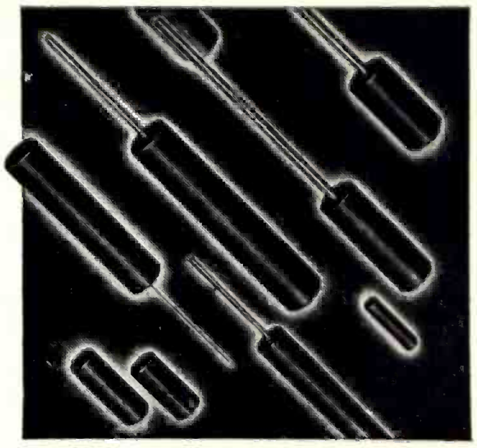
Side Molded Cores

A NEW molding method whereby pressure is applied from the sides rather than from the ends of the iron core has been introduced by the Stackpole Carbon Company.

This method has proved to have outstanding advantages for permeability tuning applications at broadcast band frequencies. Similar side-molded cores are now available for short wave frequencies including television and FM.

Conventional cores molded by applying pressure to the ends, result in a dense grouping of iron particles at these points, thus interfering with uniform permeability. In side-molded cores, however, any density resulting from molding pressure extends evenly over the entire length of the core, thus assuring uniform permeability with respect to length.

The Company has issued a catalogue, RC6, listing various components



of their manufacture. This catalogue and further data about the side-molded cores will be sent on request to the *Stackpole Carbon Company*, St. Marys, Pa.

* * *

Coil Mandrels

APPROXIMATELY 750 different types of mandrels in various sizes and shapes are being offered to the manufacturer who winds his own coils.

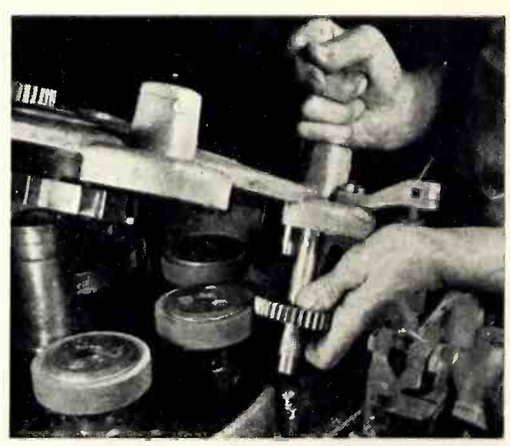
A new extended list of mandrels is available to radio manufacturers. Address *Precision Paper Tube Company,* 2023 West Charleston Street, Chicago.

* * *

Vinyl Rings

IN ORDER to replace the rubber rings originally developed to prevent gear breakage on revolving turret machinery, the *Resistoflex Corporation* of Belleville, New Jersey, has developed a new ring made of compar, a vinyl resin derivative.

The original rubber rings were used by one large radio manufacturer who now reports that the compar rings out-



last those made of natural rubber in a ratio of 5 to 1.

This long-lived ring is molded of the same basic material used as the core of the Resistoflex oil- and gasoline-proof hose assemblies. The material is compounded to give flexibility, elasticity and abrasion resistance.

★ ★ ★ ★ TECHNICAL BOOKS ★ ★ ★ ★

"ULTRA - HIGH - FREQUENCY RADIO ENGINEERING" by W. L. Emery. Published by the Macmillan Company, New York, New York. 281 pages. Price $3.25.

This text was written in response to the demand for an elementary book in ultra-high-frequency techniques. The text was written for senior electrical engineering students and a general background in elementary communications and electronics is assumed.

In the introductory chapter, the historical background of u.h.f. development is outlined along with a brief analysis of the application of the ultra-high-frequencies to communication and navigation.

In the second chapter various types of voltage regulated power supplies are discussed and suitable experimental work is outlined for the student. Electronic switching, cathode-ray tubes, amplifiers, square-wave testing and transient response, circuit elements, oscillators and wave guides are all covered in this text.

A list of references is given at the end of each chapter so that the student may read further on the subject covered. Both texts and periodicals are listed in order that up-to-date material be available.

While the author has designed this book primarily as a text book for college level, much of the material contained will be of value and interest to practicing engineers in order to provide information on new developments.

"INTERNATIONAL TELECOMMUNICATIONS" by Brig.-Gen. Sir Osborne Mance, published by *Oxford University Press,* New York. Price $1.00. 86 pages.

This book, in light of the present FCC allocation hearings, should be in the hands of every engineer whether in the broadcasting, television or industrial fields.

General Mance has presented herewith the background material of the various International Telecommunications Conferences, along with an explanation of the more pertinent points of agreement or disagreement. It has become obvious in the light of modern technical advances that communications must play an important part in making and maintaining the peace. Thus, the engineer who serves in an advisory capacity, or as the designer of equipment should be vitally concerned with the regulations involving the application of international regulatory rulings to his particular services.

Heretofore, the Americas, both North and South, have not taken a decisive part in the conferences inasmuch as it was thought that such regulation applied principally to the Old World.

This book, written by an Englishman, points out in no uncertain terms that the United States, has, at various times, "thrown the monkey-wrench" into the machinery by refusing to be a signer to certain of the articles adopted by the Conference. While Mr. Mance's viewpoint is entirely British and the book was not intended for an American audience, nevertheless, many of his points are extremely well taken in matters of allocation and cooperation for various radio services in the postwar period.

"RADIO DIRECTION FINDERS," by Donald S. Bond. Published by *McGraw-Hill Book Company,* New York. 274 pages. Price $3.00.

The increased demand on the electronics engineer for new and better radio-direction devices has inspired the writing of this text.

The newer applications of this equipment in the field of aeronautics, marine and fixed station operation has proceeded so rapidly that many engineers who are confronted with design problems involving such equipment have not been able to keep up on the latest developments.

Mr. Bond has drawn on his experience with RCA in the preparation of this book. Having taught several graduate level courses on direction finders, Mr. Bond was in the unique position of knowing just what information was needed by the average engineer to bring his knowledge up to design performance level.

The book includes discussions of wave propagation, directive antenna systems, aural null direction finders, performance characteristics of loop input circuits, as well as data on radio navigation aids.

Four appendices carry the mathematical derivations for computing radiation due to an infinitesimal dipole, calculation of field strengths, extended dipole antenna and phase relations in coupled circuits.

This is a specialized book for a limited audience but of real value to the design engineer who must have data concerning this equipment in convenient and easy-to-read form.

Television

(*Continued from page* 38)

The control room is raised three feet above the studio floor thus permitting the control operators and director an unobstructed view of the studio. The new quarters are ventilated and cooled by forced air. Equipment in the control room is similarly cooled during operation.

* * *

TBA Conference

PLANS are going forward rapidly for the Television Broadcasters Association's first annual conference which will be held in New York December 11 and 12 at the Hotel Commodore.

Chairman O. B. Hanson has announced the appointment of several committees who will handle conference details. The reception committee is in charge of Robert L. Gibson and L. S. Shugg. Allen B. DuMont will act as chairman of the speaker's committee while Worthington Miner, Ralph Austrian and William Morris are in charge of the program. The panel sessions are in charge of Dorman D. Israel.

* * *

Edison Telecasts

STATION WBKB, Chicago, has inaugurated a series of electric cooking demonstrations in cooperation with the Commonwealth Edison Company.

The series is the first of this type to be telecast to middle western audiences and is serving as a proving ground for similar programs to come. The "school" is presented in the form of informal skits, complete with kitchen demonstrations. The "instructor" is Lillian Curtis, Commonwealth Edison home economist.

Miss Helen Carson, program director of WBKB is planning additional programs of the product-demonstration type. Station WBKB, owned by Balaban and Katz theater chain, is operated, with one exception, by women who perform all of the jobs in the studio and control room.

* * *

Panel 6 Reports

PANEL number 6 of the RTPB covering television made its first formal report before the FCC hearings in Washington through its chairman D. B. Smith.

The recommendations of the panel included adequate coverage for the entire country by means of 26 channels, each six megacycles wide, that these channels should be located in the spectrum on frequencies under 250 megacycles and that adequate facilities in the higher frequency spectrum be allocated for television relaying. The committee further requests adequate allocation for continued experimentation in the higher frequencies.

PHOTO CREDITS

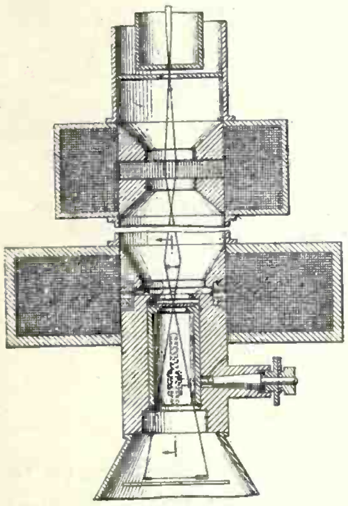
Pages
3 . . . . Westinghouse
4 (Upper Left) . . . . General Electric
4 . . . . United Cinephone Corp.
10 . . . Allen B. DuMont Laboratories
12 . . . . Federal Mfg. & Eng. Corp.

INDEX OF ADVERTISERS

PATENTS

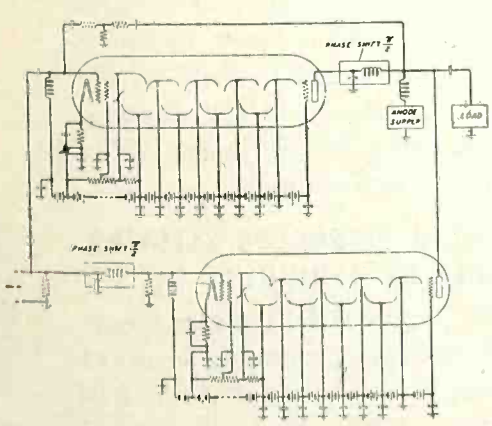
ELECTRONIC LENS

In an electronic microscope, an objective lens, an objective diaphragm located on the image side of said lens, and means for adjusting said diaphragm along the axis of the electron beam to position the diaphragm at the focus of the lens. Ernst Ruska, Germany, vested in the Alien Property Custodian. Filed July 10, 1941, issued August 22, 1944. No. 2,356,535.



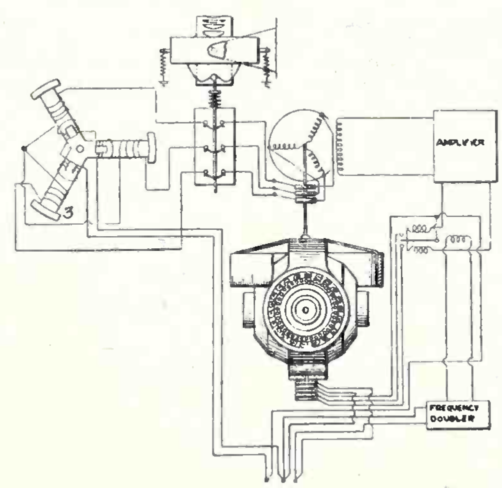
AMPLIFYING SYSTEM

In a high efficiency high gain amplifying system for amplitude-modulated oscillations, a first multistage electron multiplier, a second multistage electron multiplier, a source of modulated oscillations of varying amplitude, means causing each of said multipliers to transmit impulses of duration short compared with the fundamental period of said oscillations, under control of said multipliers to operate with an oscillating voltage of variable amplitude at its output terminals, and means including a quarter wave-length network cooperating with said one multiplier for causing the other of said multipliers to operate, during at least a portion of the modulation cycle, at a substantially constant oscillatory output voltage while supplying varying current oscillatory energy to said load. James W. McRae, assigned to Bell Telephone Laboratories. Filed October 10, 1941, issued August 22, 1944. No. 2,356,331.



MAGNETIC COMPASS

A navigational instrument comprising a flux valve adapted to provide a signal output varying with azimuthal position of said valve, a directional gyro movable in azimuth relative to said valve, means for precessing said gyro about its azimuth axis, electrical means controlled by said flux valve for controlling said precessing means and including signal-responsive means for receiving the output from said flux valve and means for compensating for any change in the received output from said valve, when azimuthal rotation only of said valve occurs, whereby a departure of said gyro from a predetermined azimuthal position will cause precession thereof. Orland E. Esval and Carl A. Frische, assigned to Sperry Gyroscope Company, Inc. Filed November 20, 1940, issued September 5, 1944. No. 2,357,319.



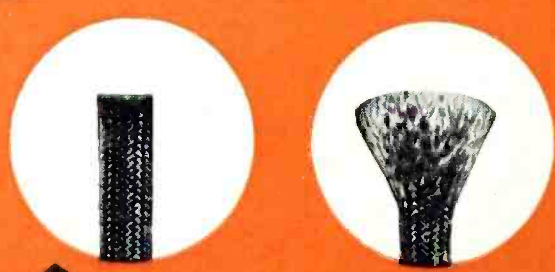
ELECTRONIC VOLTMETER

A bridge comprising two vacuum tubes connected in series, each tube having an anode, a grid and a cathode, a resistance between the cathode of one of said tubes and the plate of the other one, a resistance in the cathode circuit of said other tube and a meter adjustably connected between a point on said first named resistance and ground. John Richard Banker, assigned to Allen B. DuMont Laboratories, Inc. Filed April 24, 1943, issued August 29, 1944. No. 2,356,733.

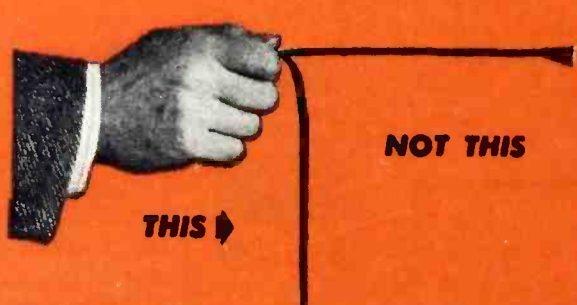
BH NON-FRAYING FIBERGLAS SLEEVING

BH EXTRA FLEXIBLE FIBERGLAS SLEEVING

2 WAYS BETTER



NON-FRAYING



NON-STIFFENING

ASSEMBLERS and electricians don't have to be contortionists when working with non-fraying BH *Extra Flexible* Fiberglas Sleeving. Remarkably resistant to stiffening, this always supple insulation won't crack or rot with age. Whether in tough, active service or dead storage, it remains "fresh" and easy to work, retaining its full insulating efficiency *indefinitely*.

This special-processed sleeving won't burn and is non-crystallizing at low temperature. It offers all the natural advantages of Fiberglas—high dielectric and tensile strength—chemical and moisture resistance—and many more—in addition to its own unusual properties.

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