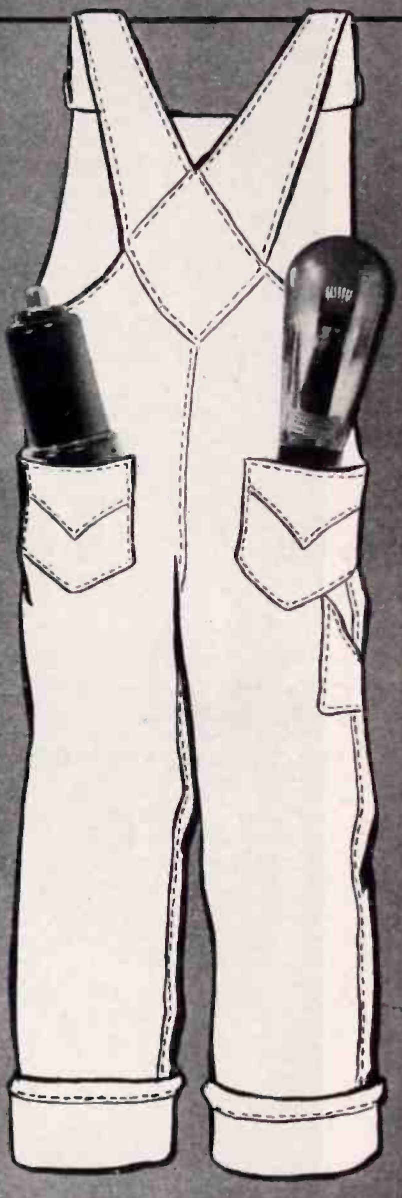
Electron
Tubes in Overalls



THE electron tube is one of the most versatile and flexible man has produced. In communication it performs duties impossible for any other mechanism. In industry it saves time, it saves in the cost of things, it protects life and property. The tube does many things better, cheaper, quicker than older devices. Many industrial jobs are performed by the tube which cannot be done in other ways. In wartime, the speed-up of production made possible by the electron tube may prove to be its greatest contribution. Tubes have gone into overalls.

It is impossible to give examples of all of the things tube can do within the confines of a single issue of ELECTRONICS. The applications described are typical, and the selection is designed to show not only the ingenuity of engineers working with tubes but the versatility and flexibility of these devices whose motivating force is the ultimate building block of the universe itself—the electron.

CONTENTS

CLASSIFICATION OF ELECTRON TUBES

INPUT		ELECTRICAL ENERGY														RADIANT ENERGY (Light)		
OUTPUT		ELECTRICAL ENERGY												RADIANT ENERGY (Light)		ELECTRICAL ENERGY		
SOURCE OF ELECTRONS		Thermionic Cathode							Pool Cathode			Cold Cathode		Thermionic Cathode		Photoelectric Cathode		Metallic Contact
METHOD OF CONTROL		None			Electrostatic		Electromagnetic		None	Electro-static	Igniter Electrode	None	Electro-static	Electro-static	Electro-magnetic	Radiant Energy (Light)		
CHARACTER OF CONTROLLED REGION OR SPACE		High Pressure Gas	Low Pressure Gas or Vapor	Vacuum	Gas or Vapor	Vacuum	Gas or Vapor	Vacuum	Vapor	Vapor	Vapor	Gas	Gas	Vacuum	Vacuum	Gas	Vacuum	Metallic
TUBE NAME		Tungar or Rectigon	Phanotron	Kenotron	Thyratron	Pliotron	Permatron	Magnetron	Pool Tube	Grid Pool Tube	Ignitron	Glow Tube	Grid Glow Tube	Cathode Ray Tube	Cathode Ray Tube	Phototube	Phototube	Barrier Layer Cell
FUNCTION	RECTIFIER OR SWITCH																	
	CONTROLLED RECTIFIER																	
	AMPLIFIER																	
	OSCILLATOR, GENERATOR OR INVERTER																	
	VOLTAGE REGULATOR																	
	WAVE FORM ANALYSIS																	
	LIGHT DETECTION AND MEASUREMENT																	

In this tabular classification of electron tubes suitable for industrial purposes the graphical symbol for the type of tube in question is used to designate the customary or possible uses to which the tube is put. Tubes having electrical energy in both input and output circuits may be regarded as impedances, while those in which the input or output is radiant energy may be regarded as energy converters

Industrial Tube Characteristics

OF all methods of controlling energy, that afforded by the e of electron tubes is one of the ost convenient and effective.

The advantages of control through e use of electron tubes may be mmarized as follows: (1) There i a wide variety of energy transrming devices whose output is cable of being associated with electon tubes. (2) The electrical power tput of an electron tube is cable of minute and complete control trough the employment of a control ement usually called a grid. (3) I coupling the appropriate energy cnverter to a tube, one form of eergy may be transformed into an ectrical voltage or current which c then be very easily and conniently modified in almost any convable manner. (4) Through use c the electron tube the expenditure o a minute amount of control power ry effect the control of a very conerable amount of power in the otput circuit because of the amplifing properties of the tube. (5) Trough the appropriate energy conrting device in the output circuit o an electron tube, the controlled ectrical energy may be reconverted io other forms of energy for the nasurement, detection, indication, o control of certain physical, chemic, or other properties. (6) The ctrol afforded through the use of a acuum tube is of a flexibility and cvenience not approached by any o er control mechanism. (7) For mny applications and in many fields o endeavor, the availability of tubes wh extremely high input impedance is a decided advantage. (8) The ailability of tubes to handle power from the smallest up to hundreds o kilowatts, enables the advantages o electron tube control equipment to e applied to the power, industrial, o communications fields with equal fility. (9) With proper design, intallation, and maintenance, electr tubes make a stable, rugged, fleible and convenient device of long usful life. (10) Certain types of tues are available in which one form of energy may be directly converted into another form. Thus, phototubes convert light into an electrical current and conversely cathode-ray tubes convert electrical current into variations of light. Through the use of such tubes, vast opportunities are opened up for the industrial uses of electron tubes. (11) Finally, the unique properties of the electron tube enable it to perform a wide variety of functions, all of which are extremely useful. For example, the tube may operate in the following manner:

(a) As an amplifier, over a wide range of frequency and power.

(b) As an oscillator or generator of voltage over a wide range of frequency, power and waveform.

(c) As a trigger or relay circuit or switch.

(d) As a modulator or demodulator to combine or to separate two or more frequencies.

(e) As a measuring instrument, indicator, or comparator.

(f) As a rectifier or inverter over a very wide range of frequencies, currents, or power.

(g) As a frequency converter to change from one frequency to another.

(h) As a visual indicator or image-forming device as in the electron microscope or the television camera or projecting tube.

All of these advantages and operations cannot be obtained in a single tube. Instead, a very great number of tube types in various classifications according to mode of operation are commercially available. Furtherfore, to make an appropriate selection from the tubes already available, and to utilize the tubes advantageously, some knowledge of the method of operation and the characteristics of the most suitable tubes is necessary.

Types of Electron Tubes

The many types of tubes available for industrial service may be classified according to: (1) the type of control stimulus which causes them to perform the industrial job to which they are assigned, (2) the phenomena occurring within the tube itself, (3) the method of operation, or (4) the number of internal elements or electrodes.

Under the first method of classification, most tubes may be regarded simply as electrical impedances in which a voltage and current are applied to the input terminals and a voltage and current are obtained from the output. Another common type of tube is that which also acts as an energy converter. The phototube, for example, converts radiant energy into electrical energy, while the cathode-ray tube converts electrical energy into light.

In the second classification, we may have vacuum tubes providing smooth instantaneous control of output, or gaseous tubes providing control of the average (but not instantaneous) value of the output power. We may have two electrode tubes or rectifiers in which the useful power output is always less than the input. We may also have control tubes or multi-element tubes, in which the useful output is greater than the input control power, the power sources connected to the tube accounting for the difference.

The classification according to method of operation is largely associated with the use of the tube and will be treated in Section II. Tubes are commonly classified according to the number of electrodes. Depending upon whether they have two, three, four, or five electrodes they are known as diodes, triodes, tetrodes or pentodes. Two element tubes may be regarded as two terminal networks. All commonly used multi-element tubes in which a varying signal is impressed on only one grid, may be thought of as equivalent to a rather special kind of four terminal T or Y network, which can be analyzed by studying the input and output current and voltage relationships.

To obtain a picture of the fundamentals of operation, it is desirable to classify tubes according to the phenomena which makes them work.

Fundamental Operations of Control Tubes

All control tubes consist of at least three elements: (1) A source of the electrons (or ions), usually produced by the cathode, which permits conduction of an electric current through the tube; (2) an electrode (plate or anode) to collect the electrons (or ions) within the evacuated space of the tube; and (3) control elements or modifying arrangements (grid) almost always located in the space between the source of electrons and the collector and whose purpose is to modify the flow of current in some manner in accordance with the voltage on this control element. The cathode (which supplies the electrons) and the control element form the input terminals whereas the cathode and the collector form the output terminals of the tube, as usually used. Two-element tubes do not have the control element.

Let us assume that we have the most common type of control vacuum tube securely locked up in a black box with a number of terminals marked on it. Beyond the markings on these three pairs of terminals, we do not care at all, for the moment, as to the nature of the contents of the box. Our primary purpose is to investigate the properties of the device in this box in terms of external conditions which we can easily measure with electrical instruments.

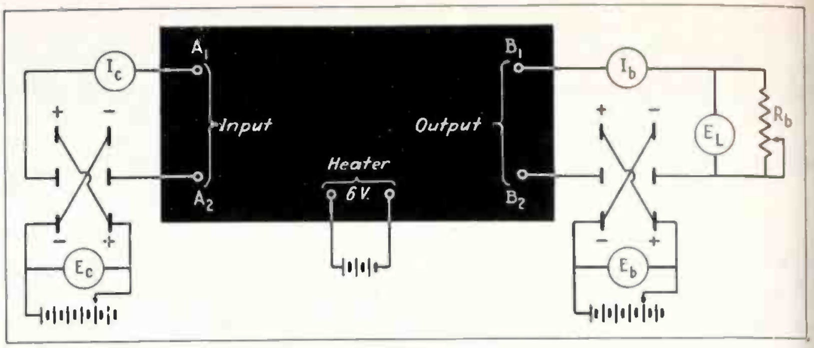


Fig. 1—Schematic wiring diagram for determining the input, output, and transfer characteristics of electron tube contained in the black box

The three sets of terminals are labelled input, output and heater. The heater terminals must be connected to a battery of proper voltage. The instruction book with the black box states that a battery must be placed in series with the output circuit and another in series with the input circuit.

If the box is connected as shown in Fig. 1 and we attach to it certain meters as indicated we are in a position to learn all we want to know about its d-c or static characteristics. All we have to do is to vary the polarity and magnitude of the voltages E_c and E_b and measure the resulting input and output currents.

We shall find that: (1) For all voltages E_c for which terminal A_1 is negative with respect to A_2, the input current (and therefore the input power) is negligible. Therefore we can state that the input impedance of the box is very high. (2) Some current flows in the output circuit if terminal B_1 is positive with respect to B_2. No current flows if this polarity is reversed. (3) For a given resistor R_b, and battery voltage E_b, the plate current, I_b, is a function of input voltage, E_c. Over a certain range, this relationship is more or less linear but in general, the relationship is not linear. (4) For a given input voltage, E_c, and load resistor R_b, the output current depends upon the voltage E_b. The voltage between B_1 and B_2 is not E_b but $E_b - I_bR_b$ since a voltage drop occurs across R_b. The plot of current, I_b, against voltage, E_b, is an S-shaped curve in the majority of cases. (5) For constant values of E_c and E_b, the current in the output, I_b, is a

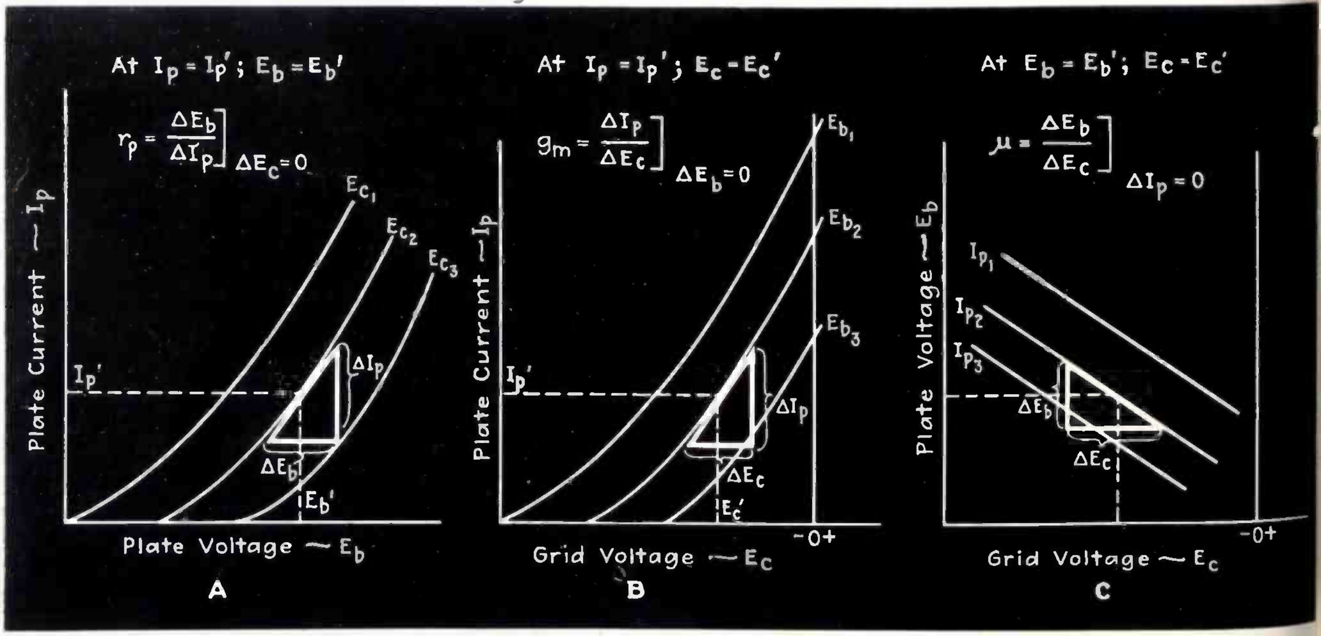


Fig. 2—Output and transfer characteristics of electron tube having characterictics of a triode. Graphical methods of determining plate resistance, r_p, transconductance, g_m, and amplification, μ, are given at A, B, and C respectively

nction of the load resistance, R_b.) Even a casual examination shows at the output current I_b, is tre-endously greater than the input rrent, and from this we infer that e box may be used as a current nplifier. (7) Voltage variations plied to the input result in a very uch larger variation in voltage in e output and measured by E_L. From is, we conclude that the tube in e box may be used as a voltage plifier. (8) From the last two statements, we conclude that the tube ay be used as a power amplifier, sice the input voltage and current minute quantities are capable of ctrolling a very much larger aount of voltage and current in te output circuit. (9) We note, wever, that the polarity of the otput voltage across the resistor is oposite from that of the polarity othe input voltages and accordingly, conclude that the tube operates a a 180 deg. phase shifting network resistive loads. (10) Electrically can regard the black box as an ipedance, but we note that we must sply sources of power to this implance for otherwise it will not fction properly. In this respect t black box differs from a transfmer in which sources of power eernal to that being transferred a not required to effect the necessy control or transformation. (11) careful examination of our data, conclude that the box is, in general, a non-linear device, but that under certain conditions of operation, the relationship between input and output may be made linear. (12) If we were to add an alternating voltage in series with the steady or d-c input voltage, we would measure alternating currents and voltages in the output circuit which are magnified replicas of their input.

If we make a graphical plot of the d-c voltages and currents in the input and output circuits, with the plate resistor short circuited, we obtain the d-c or static characteristics of the tube. The shape of these curves will depend upon the type of tube contained in the box, but the essential concepts of tube operation apply no matter what the curve shape. Typical characteristics for a triode and for a pentode are shown in Figs. 2 and 3. These static characteristics suffice to give us all the important information we need to know concerning tube operation, for from them we can obtain knowledge of: (1) the important tube parameters, amplification factor, μ, plate resistance, r_p, and transconductance, g_m, (2) the required d-c operating voltages for desired operation of the tube, (3) the mode of operation of the tube with any kind of load in its output circuit, and (4) the mode of operation of the tube with any kind of time-varying input signal applied to the grid or input.

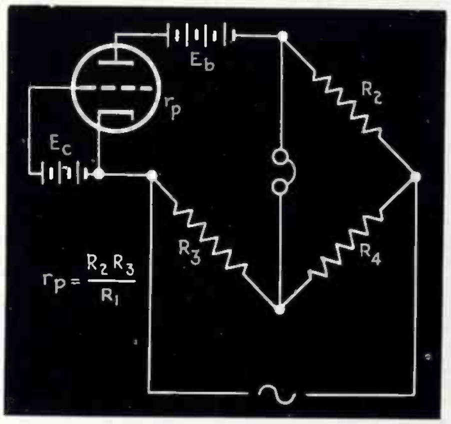
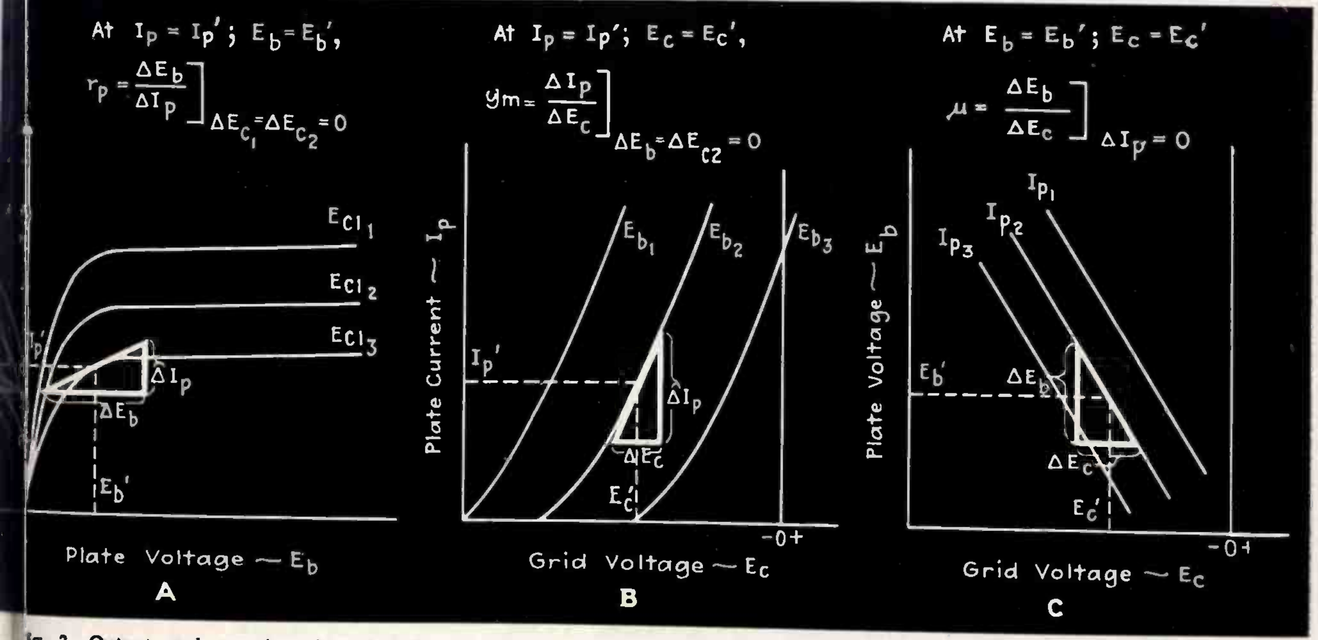


Fig. 4—Bridge circuit for measuring plate resistance for selected grid and plate operating voltages, E_c and E_b

Operating Coefficients for Vacuum Tubes

Since the plate current is a function of the plate voltage, even if the load resistance, R_b of Fig. 1, is short circuited, the plate circuit must have some internal resistance. Its d-c resistance may be determined from Ohm's law, but this value is seldom of any use to the designer and will not be found in manufacturers' literature. The resistance for small changes of plate voltage, and with the grid voltage maintained constant, is very important. It may be measured by the circuit of Fig. 4, for the operating voltages E_c and E_b, since the cathode-plate circuit takes the place of the unknown re-



ig. 3—Output and transfer characteristics of electron tube having characteristics of a pentode. Graphical methods of determining plate resistance, r_p, transconductance, g_m, and amplification factor, μ, are given at A, B, and C respectively

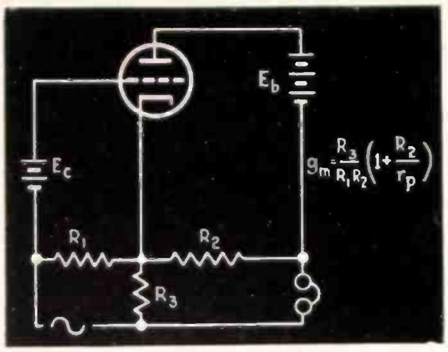


Fig. 5—Circuit for measuring transconductance for grid and plate operating voltages, E_c and E_b, respectively

sistor in one arm of the a-c Wheatstone bridge. In general, a different value of plate resistance is obtained for each new value of E_c and E_b, so these operating voltages should be specified when the plate resistance, r_p, is measured.

The plate resistance is defined as the ratio of the change in plate voltage to the corresponding change in plate current produced, all other voltages being maintained constant. The mathematical definition is given in Fig. 2A and 3A which also shows that the plate resistance at any operating point specified by the dashed lines, may be determined from the inverse slope of the E_b-I_p characteristic at this point. (This is, of course, measured in terms of voltage and current changes as measured on the graph, and not by measuring angles with a protractor.)

For a fixed value of plate voltage, the plate current is a function of the grid voltage, and it is convenient to have a tube factor, which designates the ability of the grid to control the plate current. This term, called the transconductance (formerly called mutual conductance) may be measured by the circuit of Fig. 5. It is defined as the ratio of the change in plate current to the change in grid voltage causing it, under the condition that all other electrode voltages remain constant. As shown in Figs. 2B and 3B, the transconductance is measured by the inverse slope of the E_c-I_p curve, at the point of the characteristic determined by the operating voltages (shown by the dashed lines). The unit of transconductance is the mho or reciprocal ohm, although the terms milliamperes-per-volt and micromho are also employed, since they are more convenient submultiples of the mho.

Finally, we may determine the relative effect of the grid and plate voltages upon the plate current. This is the slope of the constant-current curves of Figs. 2C and 3C, is called the amplification factor, and is designated by the Greek letter μ. The amplification factor may be measured with the circuit of Fig. 6, or it may be determined graphically, as indicated in Figs. 2C and 3C. The amplification factor is a numeric, having no dimensions; it is merely a voltage ratio.

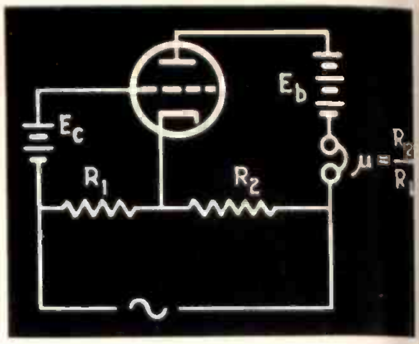


Fig. 6—Simple bridge circuit for measuring amplification factor for grid and plate operating voltages, E_c and E_b

An interesting relation connect
these three tube coefficients, for

$$\mu = g_m r_p$$
$$g_m = \mu / r_p$$
$$r_p = \mu / g_m$$

Consequently, if we know the valu
of any two at the same operatin
voltages, we can easily calculate th
value of the third at the same ope
ating conditions. Tubes may hav
values of μ from 3 to several thou
and (values of 10 for triodes an
800 for pentodes are typical); valu
of transconductance from 500
10,000 micromhos, with 1,500 m
cromhos a typical value; and valu
of plate resistance from 500 ohms
100,000 ohms for triodes and up
several megohms for pentodes. Tab
I shows operating characteristics f
a few typical vacuum tubes.

TABLE I — OPERATING CHARACTERISTICS OF TYPICAL VACUUM TUBES

Type No.	Description	Heater Voltage E_H (Volts)	Heater Current I_H (Amps)	Grid Voltage $-E_{c1}$ (Volts)	Anode Voltage E_b (Volts)	Screen Grid Voltage E_{c2} (Volts)	Anode Current I_b (Ma.)	Amplification Factor μ	Plate Resistance r_p (Ohms)	Trans-Conductance g_m (μ mhos)	Plate Dissipation P_L (Watt
	Diodes										
6H6	Full Wave Rect.	6.3	0.3	......	117*	......	4	......	......	......	......
12Z3	Half Wave Rect.	12.6	0.3	......	250	......	60	......	......	......	......
219	" " "	22.0	24.5	......	50,000	......	2,500	......	......	......	......
F103A	" " "	28.0	51.0	......	50,000	......	9,000	......	......	......	......
WL-660	" " "	10.0	10.5	......	230,000	......	30	......	......	......	......
	Triodes										
PJ10	Det. Amp. Osc.	5.0	0.25	−9.0	135	......	3	8	10,000	1,250	......
6C5	" " "	6.3	0.30	−8.0	250	......	8	20	10,000	2,000	......
6F5	" " "	6.3	0.30	−2.0	250	......	0.9	100	66,000	1,500	......
89	Amp. Osc.	6.3	0.40	−31.0	250	......	32	4.7	26,000	1,800	8
841	" "	7.5	1.25	−9.0	425	......	2.2	30	40,000	750	12
842	" "	7.5	1.25	−96.0	425	......	28	3	2,500	1,200	12
849	" "	11.0	5.0	*	2,500	......	350	19	*	*	400
848	" "	22.0	52.0	*	15,000	......	1,000	8	*	*	10,000
862	" "	30.0	325.0	*	20,000	......	1,500	10	*	*	125,000
	Tetrodes and Pentodes										
FP-54	Low Grid Cur.	2.5	0.09	*	6	......	....	1.0	....	40	......
6D6	Voltage Amp.	6.3	0.30	−3.0	250	100	8.2	1,280	800,000	1,600	1
25A6	" "	25.0	0.30	−18.0	160	120	48	100	42,000	2,375	5
6L6	" "	6.3	0.90	−18.0	350	250	54	170	33,000	5,200	19
813	Beam Tetrode Amp.	10.0	5.0	*	2,000	400	100	*	*	*	100

* Depends upon method of operation

Characteristics of Gaseous Tubes

If we proceed in the manner already outlined to study the characteristics of gas tubes, we shall obtain results which at first appear to be somewhat erratic but which are, none the less, subject to an orderly and systematic classification.

If we have a two-element tube (i.e. not a control tube) in a blue box the input terminals can be short circuited and we can obtain all of the information we desire from a study of the output voltage and current.

For low values of plate voltage E_b any current which flows at all is measured in microamperes or at most a very few milliamperes. As E_b is increased, a critical value is obtained at perhaps 10 to 25 volts beyond which the current suddenly rises to a rather high and constant value determined by the external resistance R_b and the voltage E_b, according to Ohm's law. Increasing the voltage beyond the critical value will increase the current as calculated on the basis of Ohm's law, taking account only of the resistor R_b and neglecting the tube resistance. On the basis of this operation we conclude that, after the critical voltage has been reached or exceeded, the internal resistance of the gas tube had suddenly decreased to an extremely small value from its previous value of several hundred or several thousands of ohms. The relatively large current will continue to flow in R_b until E_b is reduced to a fairly low value, when the current will suddenly decrease to a negligible value.

This operation of a two-element tube indicates that it can be used as a voltage control switch. The smooth type of voltage-current control possible with vacuum tubes has now been lost and for most practical purposes the tube can be used to conduct current on an all-or-nothing basis.

If we place a control type of gas tube in a blue box with the grid and cathode connected to the input terminals and the plate or anode and cathode connected to the output terminals, the operation becomes more complicated. Let us apply steady voltages to the input and output circuits and measure the input and output currents as these voltages are varied. Again, at a given grid voltage the tube suddenly conducts at some critical value of positive plate voltage. Likewise, for a given positive plate voltage, the tube suddenly conducts at some critical grid voltage. The breakdown now depends not only upon the magnitude of the plate voltage but also upon the magnitude of the grid or input voltage. Over a considerable range of values the critical grid voltage which initiates conduction is some fairly definite fraction of the applied plate voltage. This critical grid voltage may be either positive or negative, depending upon the type of tube within the box. It will also be observed when the plate circuit of the tube becomes conducting that there is also a relatively large input or grid current flowing, even though the grid of the device is negative. Thus, before the critical grid voltage is reached the input resistance of the tube may be fairly high but beyond the critical grid voltage it becomes relatively low. Thus, the "switch action" observed in the output circuit is also apparent in the input circuit and it will be observed that both input and output current increase simultaneously. If the tube contains mercury vapor, it will be found that the critical grid and plate voltages also depend somewhat upon the temperature at which the tube is operated.

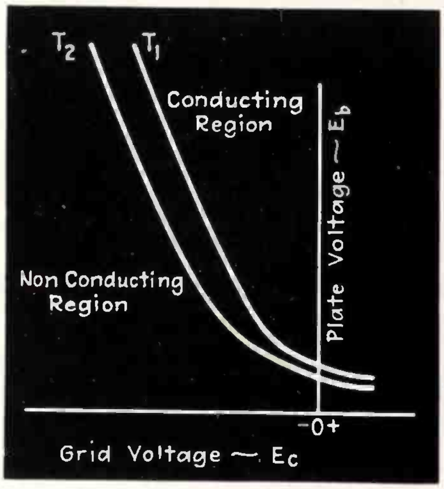


Fig. 7—Voltage control characteristics for gaseous control tube, for two different operating temperatures, T_1 and T_2

It is convenient to plot the grid and plate voltages for the condition at which the tube suddenly becomes conducting. Such a set of curves (Fig. 7), divides the tube characteristics into two essential regions. For those conditions of voltage occurring to the left of curve, the tube is nonconducting and no appreciable current will flow through it. On the other hand, if the voltages occur to the right of the curve, the tube becomes conducting and passes a current which is limited only by the external load and by the ability of the cathode to supply electrons. Thus, Fig. 7 may be regarded as a type of "trigger diagram" to indicate the conditions under which the tube conducts. Once the gas within the tube becomes conducting the grid loses control and the tube can in general, be made non-conducting only by removal of plate voltage. The region between the various curves depends upon the ambient temperature of the tube surroundings.

For an appreciable portion of the curve of Fig. 7, a linear relation exists between the grid and plate voltages which produce breakdown. For a given temperature, the ratio of the plate voltage to the grid voltage required to initiate ionization is called the control factor. It is analogous to the amplification factor in the high vacuum grid tube, and is determined in much the same way. For gaseous conduction tubes there are no significant coefficients analogous to the transconductance and plate resistance of the vacuum tube.

When the gas within the tubes becomes ionized gaseous tubes have much lower internal resistance than vacuum tubes. Consequently greater currents may be passed through them than through vacuum tubes of equivalent structure. However, for gas or vapor tubes having pressures of a fraction of a millimeter, the maximum obtainable current is equal to the current which the cathode can supply. On the other hand, tubes containing gas or vapor at a pressure of about 5 centimeters of mercury can rectify currents of larger magnitude than the cathode emission current since the pressure of the gas tends to prevent excessively rapid evaporation of particles from the cathode. Such tubes are suitable for use only in low voltage circuits such as battery chargers.

In large industrial rectifiers, a mercury pool is frequently used instead of a hot cathode, and conduction takes place by virtue of a mercury arc between the pool and the anodes, of which two are required to maintain the device in continuous operation. Such mercury vapor rectifiers are often encased in metal tanks.

TABLE II — OPERATING CHARACTERISTICS OF TYPICAL GAS TUBES

Type No.	Description	Heater Voltage Volts	Heater Current Amps	Plate Peak Volts	Max. Av. Plate Amps	Max. Peak Plate Amps
	Diodes					
866	Half Wave Rect.	2.5	5.0	7,500	0.25	1.0–2.0
869	" " "	5.0	18.0	20,000	2.50	10
870	" " "	5.0	65.0	16,000	75.0	450
WL-670	Full Wave Rect.	2.5	24.0	1,000	9.5	3 per anode
	Triodes					
885	Negative Grid	2.5	1.4	350	0.075	0.300
FG-17	" "	2.5	5.0	2,500	0.50	2.0
GL-414	" "	5.0	20.0	2,000	12.5	100
KU-634	" "	5.0	11.5	7,500	1.25	5.0
KU-610	Positive Grid	2.5	6.5	500	0.10	0.40
	Tetrodes					
FG-98A	Negative Grid	2.5	5.0	500	0.5	2.00
FG-154	" "	5.0	7.0	500	2.50	10.0
FG-95	" "	5.0	4.5	1,000	2.50	15.0
FG-172	" "	5.0	10.0	1,000	6.40	40.0

Instead of providing the source of electrons by means of a hot cathode, they may be provided by a cold cathode with electrons supplied by field emission. Two and three element tubes of this variety are available. Of course, such tubes would not require any cathode heating battery if connected to the circuit of Fig. 1.

The igniter principle, long used in mercury vapor rectifiers, has been applied to the ignitron. The ignitron is a gas discharge tube having a pool type cathode in which an ignition electrode is employed to control the starting of the unidirectional current flow in each operative cycle, the igniter electrode initiating the conducting arc. The ignitron has important applications as a rectifier for industrial uses.

All gas or vapor filled tubes are incapable of giving instantaneous control of current, but are capable of controlling the desired average current. Consequently, they are given average current ratings. Operating characteristics for several typical gas tubes are given in Table II.

Characteristics of Phototubes

Another electron tube of very great industrial use is the photoelectric tube or phototube. Let it be placed in a white box. It has no terminals marked heater nor has it any input terminals. It does have output terminals but where the input terminal should be, there is nothing but a piece of plane glass, or perhaps a magnifying glass. The interior of the box is completely dark.

We connect up the device as shown in Fig. 8, duplicating the connection of Fig. 1 so far as the output terminals are concerned. If B_2 is positive with respect to B_1 we find that a small current may flow, but if the polarity is reversed, no current flows.

A casual examination of the characteristics of the device with the terminal B_2 positive with respect to B_1 results in values of output current which, while they depend upon the value of the output voltage, E_b, at first do not appear to be constant. Instead they appear to vary more or less at random, even being subject to our proximity to the white box. A closer examination will show that these current variations are associated with the amount of light falling upon the glass or lens of the input circuit. By following out this line of reasoning, we find that the output current is a function of the light incident upon the lens. We have now a totally new type of device in which the output current depends upon (1) the plate voltage, if the light intensity is constant, or (2) the light intensity if the plate voltage is constant.

Suppose we maintain a steady beam of light on the lens of our white box and observe the current as the voltage is changed. Since the maximum current which we can obtain is in the neighborhood of 25 microamperes or so, we conclude that the output of the device is of extremely high impedance, especially since the voltage E_b may be as high as several hundred volts. In general, the characteristic we obtain is one which rises quite sharply for low values of voltage and then, for increased voltages, results in no appreciable increase in current. This is a typical saturation curve. If the tube is a vacuum device, then the current will be essentially constant for voltages above about 50 volts, but if the tube contains gas, we shall find that the current continues to rise concave upward as the voltage is increased. These characteristics are shown in Fig. 9 for both tubes.

If the voltage is maintained constant above the knee or saturation value and the light intensity is varied, it will be found that the current is directly proportional to the intensity of the light beam so long as the external plate resistance, R_b does not have too high a value. Even for a load resistance of 1 to 2 or perhaps 5 to 10 megohms there is a reasonably good linear relationship between output current and incident light, but not for higher resistances. This linear relationship holds true only for vacuum phototubes as shown in Fig. 10. If a gaseous phototube

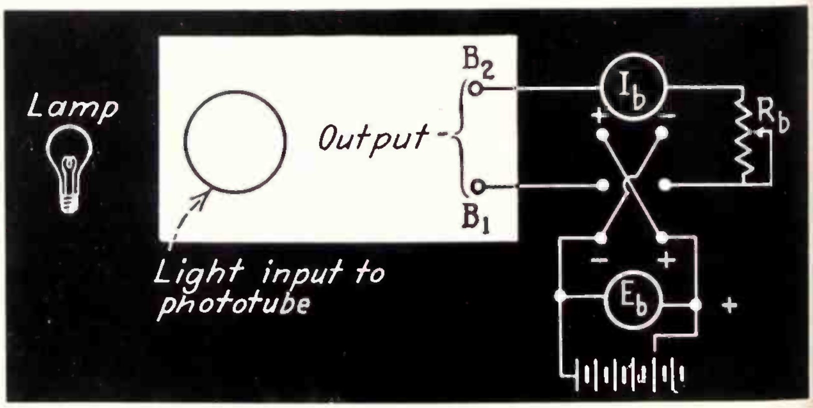


Fig. 8—Schematic diagram for determining the luminous sensitivity and electrical output characteristics of an emissive phototube. By omitting the voltage source, E_b, the same circuit could be used to determine the characteristics of barrier layer types of photoelectric cells

used, the relationship between out- t current and input light is not ear, but may increase concave up- ard as the light intensity is in- eased. This immediately suggests us that a vacuum phototube pro- des a very simple and convenient eans for determining light in- nsity by electrical means. The seous tube is not so convenient be- use the relationship between input ght and output current is not lin- r (Fig. 10).

The output current is also a func- on of the wavelength of light fall- g upon the device. Certain types phototubes are sensitive to in- ared radiation, some are sensitive roughout the visible range, whereas hers (in fact practically all of em) have an appreciable sensitiv- in the ultraviolet region. The lative sensitivity of the phototube various wavelengths will be found be a characteristic of the tube un- r consideration. Nevertheless, the t that the phototube is differen- lly sensitive to radiation of differ- t wavelengths indicates that the nposition of the light reaching the e must be maintained constant we are to use the phototube as a ecise light measuring instrument. When we consider the magnitude the current derived from the pho- ube and when we consider its re- tance, it is apparent that the ex- nal load circuit must have a very gh resistance (megohms) if max- um power is to be derived from phototube. Even then the power ailable in the external circuit is remely small. However, we may ly the output voltage developed oss the resistor R_b to the input of a vacuum tube to control power in the output circuit of the vacuum tube. In this way, we can use the phototube indirectly to control sizeable amounts of power by variation of the light beam falling upon the phototube.

As shown in Fig. 9 and Fig. 10, there are two characteristics of phototubes which are important. The first of these is called the variational resistance of the phototube and is defined as the ratio of the change in plate voltage to the corresponding change in current, for a specified incident light flux falling on the tube. The graph of Fig. 9 shows this resistance determined for the knee of the curve, but it could also be determined for any other part of any of the curve. The other tube characteristic is its luminous sensitivity which, for a specified plate voltage, may be defined as the ratio of the change in plate current to the corresponding change in luminous flux producing it. For the vacuum phototube this luminous sensitivity is constant, whereas it increases with increasing illumination for the case of a gaseous phototube. In all of these specifications for phototube factors, it is assumed that the quality of the light used in making the measurements is unchanged. The measurements are usually made with light produced by an incandescent filament operated at some specified temperature near 2,700 or 2,800 deg. F. Operating characteristics for a few typical phototubes are given in Table III.

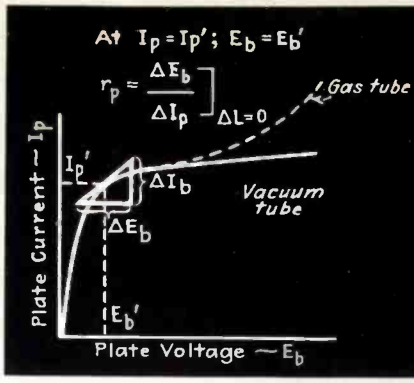


Fig. 9—Resistance or output characteristics of vacuum or gaseous phototubes may be determined from the slope of the E_b-I_p characteristics, left.

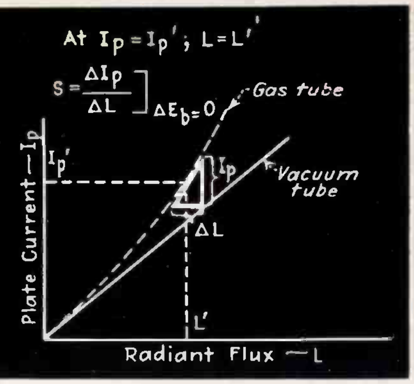


Fig. 10—The luminous sensitivity of vacuum or gaseous tubes may be determined from the slope of the current-flux characteristic, right.

Another type of photoelectric device, which incidentally can hardly be classed as an electron tube, is of importance in industrial applications of electronic devices. This is the barrier layer type of photoelectric cell which has considerable application in portable photographic exposure meters and light meters. This cell requires no external source of voltage for its operation but converts radiant energy directly into electric energy. The device is essentially a low impedance circuit element, and for this reason the output voltage, which is in the neighborhood of millivolts, cannot be conveniently amplified through the use of electron tube amplifiers. Currents of several hundred microamperes (enough to operate sensitive relays) are available from these devices, whose great virtue is that they operate without external sources of power applied to them. In many types of such devices, the spectral response is more nearly like that of the eye than is true for the emissive type of phototube already described. This type of light-sensitive device has many uses.

BLE III — OPERATING CHARACTERISTICS OF TYPICAL PHOTOTUBES

pe No.	Cathode Surface	Max. Anode Voltage Volts	Max. Anode Current μ A	Typical Sensitivity μ A/L	Window Area Sq. In.	Region of Max. Sensitivity
	Vacuum Tubes					
-22	Cs-O-Ag	200	20	5	0.9	Deep red & ultraviolet 3,000-11,000 A deep red & ultraviolet
-50	Cs-O-Ag	500	20	15	1.1	
7	Cs-O-Ag	500	30	20	0.9	
	Cs-O	90	20	30	...	
	Cs-O	180	100	20	...	
-441	Coesium	200	...	45	0.9	....
	Gas Tubes					
-23	Cs-O	90	20	50	0.9	Deep red & ultraviolet
8	Cs-O-Ag	90	5	110	0.9	3,000-11,000
	Cs-O	90	20	150	...	Deep red & ultraviolet
	Cs-O	90	10	60	...	....

Characteristics of Cathode-ray Tubes

In line with our previous investigations let us determine the characteristics of a cathode-ray tube. We shall find that the cathode-ray tube box contains a number of input voltage terminals and that in place of the output terminals we are faced with a circular glass disk (screen) having a white appearance as if the inner surface were frosted. From our study of phototubes we have already been accustomed to electron devices which convert energy from one type to another. We surmise therefore that electrical energy fed into the device may be converted into radiant energy manifested by light of various intensities on the glass screen. We note that the cathode-ray box is marked to be connected to a 110-volt a-c line and from this, as well as from the fact that the box is quite heavy, we infer that the box contains more than the tube itself. In fact, there is an internal power supply provided for the tube and the three pairs of output terminals are simply provided to enable us to control the pattern on the screen.

We begin our investigation by applying voltages to the two terminals marked control grid. If we apply a direct voltage, a spot of light appears in the center of the screen. By varying the control voltage we have a means of varying the intensity of the light on the screen. The current taken by the control grid is practically zero with one condition of polarity and fairly small with another so the impedance of this electrode is high.

Now, if we apply direct voltages to the two terminals marked *H*, we shall find that the spot of light is displaced in a horizontal direction across the screen in a manner which is proportional to the voltage applied to the *H* or horizontal terminals, the direction of the displacement depending upon the voltage polarity.

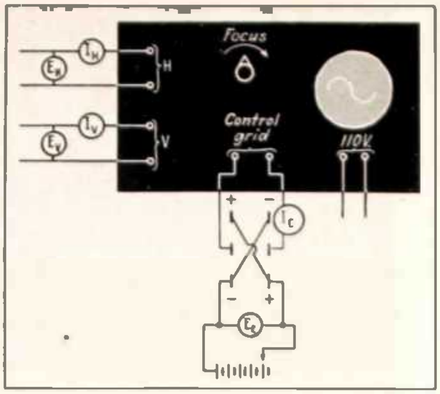


Fig. 11—Circuit arrangement for determining the intensity and deflection characteristics of a spot on the screen of a cathode-ray tube, in terms of intensity control voltage, E_c, and horizontal and deflection voltages, E_h and E_v, respectively

Likewise the vertical displacement of the spot depends upon the magnitude and polarity of the direct voltage applied to the two terminals marked *V* or vertical. The impedance of the *H* and *V* electrodes are both high as is indicated by very small currents I_H and I_V, even for voltages large enough to deflect the spot off the screen.

Now, we have three input voltages which we may control at random and independently of one another and therefore there are three possible modes of varying the spot. We can either vary the horizontal displacement of the spot or its vertical displacement and we can control its intensity. If we apply an alternating voltage to the vertical terminal and direct voltage to the horizontal terminal we shall find that the spot is lengthened out to a fine line whose length is proportional to the peak value of the voltage. If the direct voltage is applied to the vertical terminal and an alternating voltage applied to the horizontal terminal, the spot will become a thin horizontal line. If alternating voltages are applied to both the horizontal and vertical terminals, we obtain a wide variety of patterns which, if the frequencies are integrally related are known as Lissajous' figures. If apply an alternating voltage to t control grid, then it will be possib under certain values of adjustme to make a portion of the Lissajou figures disappear and to make oth portions of the figures brighter tha normal.

Using the three control voltages, is possible to obtain a wide range patterns of varying intensities the screen. The patterns thus pr duced are extremely useful to o who is accustomed to their corre analysis.

The spot of light may be green i color or white or blue or perhap some other, although less commo color. With different screen mat rials the image may not immediatel remove itself from the screen whe the control voltage is sufficientl negative. Instead, the spot tends t linger and to gradually decrease i intensity after the voltage is increased beyond its cut-off value. Suc a tube would be well suited for th photography of a phenomenon whic produces a stationary pattern on th screen, but would produce objec tional blurring if our patterns wer subject to rapid spatial changes o the screen of the tube.

For a given voltage applied to the *H* and *V* terminals, we always obtain the same spot displacement or deflection (assuming the line voltage and internal adjustments remain unchanged). It does not necessarily follow that a given voltage applied to the horizontal terminals will produce the same absolute value of displacement as when applied to the vertical terminals although usually the difference will not be more than about 20 percent. By determining the displacement of the spot for a given voltage we can specify the deflection sensitivity of the device.

In some tubes, using magnetic deflection, the deflection of the spot is controlled by current flowing through coils near the tube. In such cases the deflection depends upon the currents in the *H* and *V* coils whose impedance may be quite low. Otherwise the mode of operation is like that already described for tubes with electrostatic deflection.

The operating characteristics of a few typical cathode-ray tubes are given in Table IV.

For a list of bibliographical references relating to the material in this section, see page 69.

TABLE IV — OPERATING CHARACTERISTICS OF TYPICAL CATHODE-RAY TUBES

Type	Heater Voltage E_H (Volts)	Heater Current I_H Amps	First Anode Voltage E_1 (Volts)	Second Anode Voltage E_2 (Volts)	Approx. Sensitivity mm/volt or mm/NI	Screen Color	Screen Size
906	2.5	2.1	1,000	1,500	0.041	Green	3
1803-P4	2.5	2.1	1,900	7,000	.....	White	12
54-11-T	6.3	0.6	.....	3,000	.....	....	5

Tubes and Their Functions

HAVING discussed the characteristics of various members f the electron tube family, let us onsider the tube as part of a ciruit. All high vacuum tubes have inut impedances which are high megohms) so long as the grid is aintained negative and this is the sual way of using the tube. The utput impedances are high, of the rder of thousands of ohms to several iegohms. Both input and output npedances act like high resistances hunted by small capacitances. These apacitances may be neglected in all ut unusual industrial applications.

Gas tubes have high input impeance up to the moment of conducon, and then the tube may draw apreciable current from the input ciruit (milliamperes). The internal esistance of gaseous tubes is of the rder of 15 to 25 ohms while the tube onducts and is very high during the on-conducting condition.

A high vacuum control tube may e regarded as a one-way device for ll frequencies and applications useul to industrial processes. Very lite of the output energy gets back to ie input through the tube itself. he amplifier tube acts as a 180 deg.-hase shifting network for resisance loads. An amplifier tube oprated over the linear part of its nput-output characteristic may be oked at as a generator of voltage e_g in series with the plate resistance the tube; μ is the amplification ctor and e_g is the applied alternatg voltage.

A gaseous control tube acts as a ngle pole single throw switch. A hototube is an energy converter of igh impedance, producing electril energy from radiant energy. icroamperes of current can be seired from it; its output must be mplified for industrial purposes. he output of the vacuum type photoibe is independent of applied voltge above about 50 volts. A linear lationship exists between input engy and output current for a high icuum tube; but the relation is ot linear for a gas phototube. The photovoltaic type of light sensitive device is essentially a low impedance device with higher current output than the phototube but delivering lower output voltages. Its output may be used with a sensitive relay which acts as an amplifier, in turn operating a heavier relay.

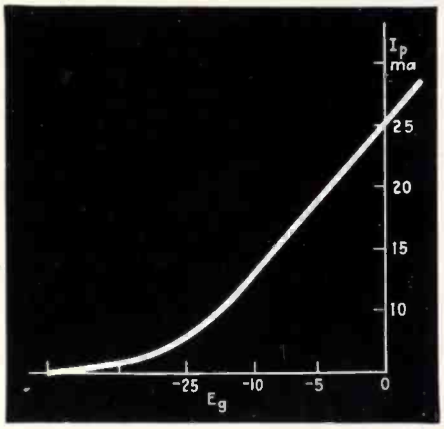


Fig. 1—Curve showing relation between input (grid) voltage, E_g, and output (plate) current, I_p, for a typical triode amplifier

How to Make the Tube Work

In industrial applications, tubes perform essentially two different types of functions. In some cases, as in rectifiers, the output of the tube is used directly, power flowing from the tube to the work to be done. In others, the tube acts merely as an accessory piece of equipment, responding to some sort of stimulus (obtained from the work to be done) and in responding releasing energy from a local source; this energy performing the desired job.

Whatever the job to be done, therefore, some means must be found for deriving from it a stimulus that can be applied to the tube, such as a voltage or illumination change. Interrupting a beam of light by an object to be counted is one method; another is to make the object to be counted change the voltage (phase, frequency or other electrical quantity) applied to the tube. Any physical quantity, such as weight, color, velocity, size; or any electrical quantity, such as voltage, phase, frequency; or any chemical quantity, such as the pH or conductivity of an electrolyte, etc., may be converted to an appropriate electrical change which will cause a tube to act.

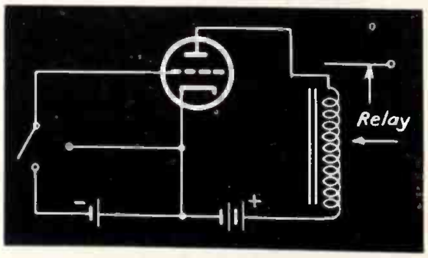


Fig. 2—Simple relay circuit using tube between a stimulus voltage and an electromagnetic relay

High Vacuum Tubes

Use of the Tube as a Relay

Consider the curve in Fig. 1, the characteristic of a typical amplifier tube. This curve expresses the relation between the voltage input and current output for a given plate voltage. Note that there is a continuous relation between current output (known as plate current or I_p and voltage input or grid voltage E_g). Thus when the grid voltage is -10 volts, the plate current is 13 milliamperes and when the grid voltage is zero the plate current has increased to 25 ma. In tubes of this type the plate current increases continuously as the grid voltage is made less negative or is made positive with respect to the cathode.

The plate circuit of the tube is the work circuit. The grid circuit is the control circuit. All that is necessary to put the tube to work as a relay tube is to change the voltage on the grid from say—10 to 0 and to use in the plate circuit an electro-mechanical relay which will remain open when 13 ma flow through it but which will close when 25 ma flow through it or vice versa. Current or power to perform the final work to be done is controlled by contacts on the relay. It is immaterial to the tube how the engineer decides to get the required input voltage change of 10 volts. For example, an extremely simple method is to have a 13 volt battery between cathode and grid with a switch which can connect the grid directly to cathode when desired. This switch could be closed by a cam arrangement, say on a cylinder of a printing press. Once in each revolution the switch connects the grid directly to the cathode, and a counter in the plate circuit rings up another newspaper off the press.

A logical question at this point is to ask why, if 10 volts are available to control the tube, this voltage change is not applied directly to the relay and thus eliminate the tube. Certainly there is no need to use a tube if we can avoid it; and industrial engineers use tubes only if they perform jobs which cannot be done in any other way, or if they are done better by tubes—i.e., either faster, cheaper, or safer.

In this case it is power that operates the relay and not current or voltage. The 10 volt change placed upon the tube input terminals may come from a source of extremely limited power; for example the output of a phototube. The phototube current change may be of the order of 10 microamperes which is not sufficient current to operate the relay. This current, however, may be caused to flow through a 1-megohm resistance. Across this resistance will appear a 10-volt change and this in turn may be applied to the control grid of the tube.

The power through the relay may be figured as follows. If it has a resistance of 500 ohms, and if a current change of 12 ma is sufficient to make it operate, the power required to make the relay operate is $72.0\text{x}10^{-3}$ watts (I^2R). Now the input power required to make the tube operate works out to be $100\text{x}10^{-6}$ watts ($10^2 \times 10^{-6}$) so that the tube produced a power amplification of some 720 times—and this is why the tube is used.

Use of the Tube as an Amplifier

The tube has an extremely important ability—to amplify voltage changes placed upon its grid circuit. Across a load in the plate circuit appear voltages which are magnified images of the voltage changes placed upon the grid circuit. These images can be almost exact replicas of the input voltages, or they can be distorted in almost any manner desired. It is this amplification ability that has made radio broadcasting possible, and it is also of very great value to industrial applications.

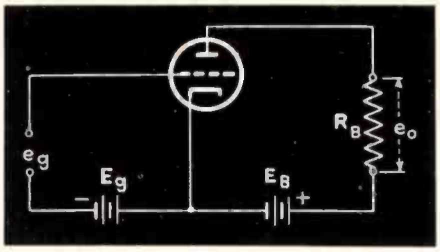


Fig. 3—Fundamental amplifier diagram. Here R_B is the load resistance across which the output alternating voltage, e_o, appears

In Fig. 3 is a simple tube amplifier circuit with a resistance load R_B. In series with the fixed grid voltage (known as a bias) is a source of alternating voltage. If the a-c terminals are shorted a steady value of plate current will flow, its value depending upon the plate voltage, upon the grid voltage, upon tube characteristics, and R_B. But if alternating voltage is applied to these terminals, the plate current will rise and fall about its former fixed value as a base. Looked at in another way, the plate circuit will have two currents in it, one a direct current and the second an alternating current.

This alternating current flowing through the plate load resistance produces a voltage drop along this resistance; and this alternating voltage will be greater than the alternating voltage placed upon the grid terminals if R_B is not too small.

Effect of Tube Resistance. The tube has an internal resistance (r_p) through which the plate current must flow. The relative value of this internal resistance and that of the load resistance govern both the magnitude of the alternating voltage developed across R_B and the power developed in R_B.

If the tube is properly biased and operated so that the plate current does not drop to zero on the negative half cycles of input alternating voltage, and the grid is always negative with respect to the cathode, the output alternating voltage, current and power are respectively

$$e_o = \frac{u e_o K_B}{r_p + R_B}\ ;\ i_p = \frac{u\ e_g}{r_p + R_B};$$

$$Po = \frac{u^2\ e_g^2\ R_B}{(r_p + R_B)^2}$$

The maximum output voltage across R_B will be secured when R_B is large compared to r_p. The maximum power in R_B will be secured when R_B is equal to r_p. Then the power output is

$$P_{o\ \max} = \frac{\mu^2 e_g^2}{4\ K_B}$$

where e_g = rms input grid voltage or

$$P_{o\ \max} = \frac{\mu^2\ e_g^2}{8\ R_B}$$

where e_o = peak input grid voltage.

Under no conditions can the amplification of voltage (e_o/e_g) be greater than the amplification factor of the tube and approaches this value only when R_o is much greater than r_p. If $R_o = 3r_p$ the amplification will be 75 percent of the amplification factor of the tube.

If the load resistance is much less than the tube resistance (as is frequently the case in using certain tubes with very high internal resistance) the voltage amplification is approximately equal to

$$e_o/e_g = g_m R_B$$

where g_m = transconductance of the tube, and here again the maximum amplification depends upon how large the load resistance is.

Plate Battery Requirements. It is a disadvantage to place too high a load resistance in the plate circuit of a tube, especially when using the low resistance tubes. This arises from the fact that the plate current not only flows through the tube but through the load too, and for every milliampere of current drawn

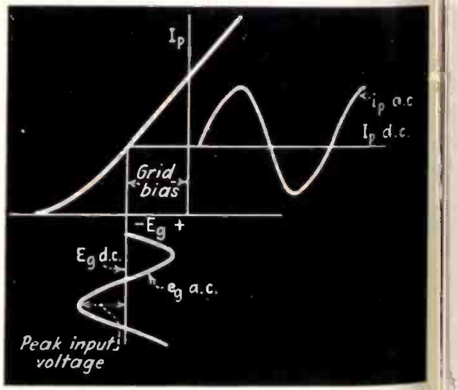
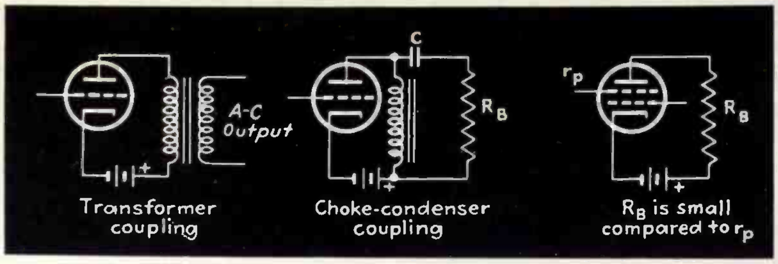


Fig. 4—Tubes usually operate with a fixed direct voltage on both plate and grid. In addition, alternating voltages may be placed upon the grid circuit. Then alternating currents will flow in the plate circuit. Here E_g and I_p are steady values of grid voltage and plate current; e_g and i_p are peak values of alternating grid voltage and plate current



ig. 5—Ways of avoiding use of high late battery voltage with resistance loads› ie resistance of the choke (center) is low, its inductance high

rough a thousand ohms of resist- ice, 1 volt is lost—it does not ap- ar across the cathode-plate path. hus if 10 ma flow through 10,000 ims, 100 volts appear across R_B. the tube requires 250 volts across e resistance of the tube and if 100 lts are lost across R_B, the plate ttery must supply 350 volts.

It is worth noting here that there but a single source of voltage in e plate circuit—the plate battery. rrent from this battery flows rough the tube and through the ad resistance. The way in which e total plate circuit voltage divides, rt appearing across the tube d part across the load, depends on the relative resistances of the be and the load but the sum of the o voltages is never greater than e plate battery voltage. When the ltage drop across the load is high e to high plate current, the volt- e across the tube is low and vice rsa.

Use of high resistance loads ich cause large voltage drops ich must be supplied by high plate battery voltages can be avoided by: (1) use of a transformer between the tube and the load so that the desired a-c power is developed in the load without the steady plate current having to flow through it; (2) use of a low-resistance inductance through which the direct current flows as in Fig. 5; (3) use of tubes of high intrinsic plate resistance with loads which have resistances lower than that of the tube. Then the tube acts more or less like a constant-current source and variations in load voltage with consequent variations in plate voltage are much less important.

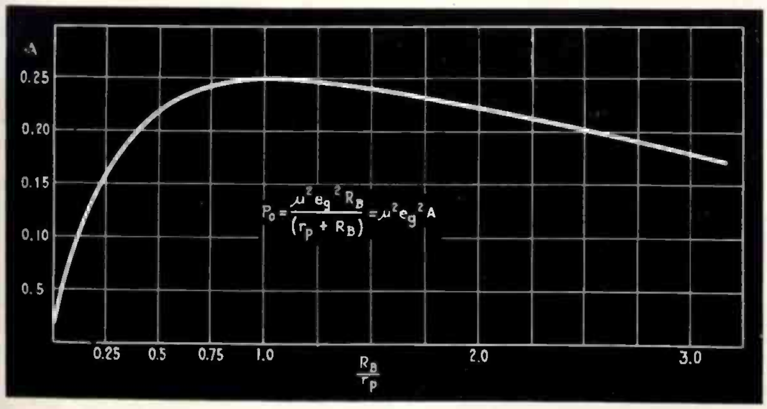
Tube Efficiency. If $R_B = r_p$, the efficiency of the plate circuit is 50 percent since half the power developed will be lost in the tube and half will be usefully developed in the load resistance. Greater efficiency can be had by raising the value of R_B, but less power will be secured thereby unless the plate voltages and currents are increased.

The amount of power that a tube can deliver depends upon how much it can safely dissipate on its own plate and its efficiency of operation. A tube that can safely dissipate 10 watts can also deliver 10 watts to a load at 50 percent efficiency; but at higher efficiencies, higher power can be developed in the load without raising the 10 watt limit in plate dissipation.

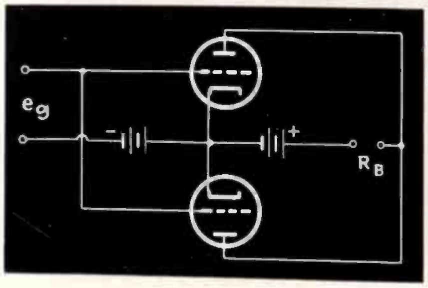
In most industrial cases, it is more important to get the maximum power into a load (such as an electro-mechanical relay) rather than to achieve efficiency and in this case the load must be adapted to the tube or vice versa. This means that the resistance of the load should approximate the resistance of the tube. The reduction in power is not very great if the load resistance is greater than that of the tube by 2 or 3 times, but considerable loss occurs if R_B is very much less than r_p.

Where maximum voltage output (contrasted with maximum power output) is desired, R_B must be high compared with r_p if possible. This is not possible with pentode tubes and here R_B should be as high as possible or convenient.

Tubes in Parallel or Push-pull. If more output is desired than a single tube will deliver, two or more of them may be operated in parallel. Under these conditions the effective internal resistance of the tube part of the circuit goes down; and if one



g. 6—Power output from an amplifier be depends upon the relative values of e internal tube resistance, r_p, and the ad resistance, R_B. Maximum power output occurs when R_B is equal to r_p



g. 7—Use of tubes in parallel to in- ease output over that obtainable from a single tube

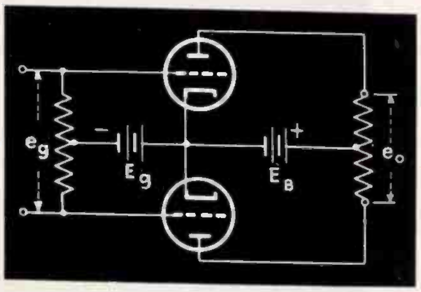


Fig. 8—Push-pull arrangement of tubes decreases harmonic content of output and increases power output over that obtainable from a single tube

tube will deliver 10 watts, two of them will deliver 20 watts—if the output circuit is appropriately changed to take account of the decreased tube resistance.

It is often more economical to use two or more tubes in parallel than using a single tube of greater output power.

Tubes may also be operated in push-pull. More power output may be secured; but the big advantage is the fact that the waveform of the output can be made to resemble more closely the waveform of the original. This is not a matter of great importance to industrial applications, except in unusual cases.

Tubes can also be connected with their grids in parallel and plates in series or with grids in series and plates in parallel.

Use of Tube as Generator. Because a tube will amplify, it will also generate alternating currents from direct currents. A voltage applied to the grid of the tube results in a larger voltage appearing in the output. If a part of this output is fed back into the input in the proper phase, this portion of the input will reappear in the output in amplified form. If the amount of energy fed back is sufficient to overcome all the losses in the input circuit, it will be found that the initial driving voltage applied to the tube from an external voltage supply may be eliminated and the tube will continue to develop power in the load. In practice no external exciting grid voltage need be applied to start oscillations since any small instability (such as mechanical, thermal or electrical change) will set the circuit into oscillation.

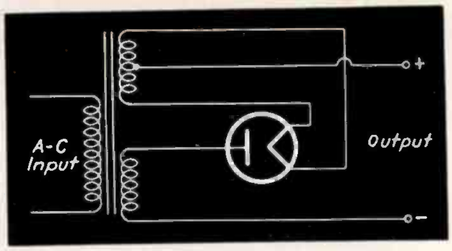


Fig. 9—Simple half-wave single-phase rectifier comprising anode and cathode only. Output load is in series with anode

The tube is now acting as a generator, the frequency of the generated power depending upon the inductance, capacitance and resistance of the circuit elements attached to the tube. The amount of power developed in the load depends upon the tube, the voltages used and the load characteristics.

Alternating currents of practically any frequency, of practically any waveform, or of any power may be produced in this manner. Direct potentials need to be applied to the tube, some sort of energy feedback from output to input must be provided, and as a result alternating currents will be produced.

Tubes can be made to generate oscillations in other ways (dynatron, Barkhausen oscillators, etc.) but these methods are not used industrially at the present time.

Tube as a Frequency Converter. Suppose a tube has two grids and that voltages of different frequencies are placed upon these grids. Now if the plate circuit can be explored with some sort of frequency discriminating detector, two (or more) frequencies will be discovered. If there exists a linear relation between each grid and the output, only the two input frequencies will be detected; but if any non-linearity exists between the input and output, or in the output E_p-I_p curve, then the detector will indicate not only the original input frequencies but others as well. Among the new frequencies found may be the sum and the difference of the two input frequencies.

This is known as frequency conversion, since we convert two originating frequencies into other frequencies with totally different values. This is the principle of the superheterodyne radio receiver; but the principle has some application to laboratory and industrial problems as well. The two voltages can differ widely in frequency or can be alike or very nearly alike in frequency. One can be variable and the other fixed so that a variable frequency, differing from either originating frequencies, can be secured from the converter.

Modulation. If a high frequency and a low frequency are "mixed" properly, the high frequency will act as a carrier for the lower frequency (as in radio or carrier telephone communication). This process is called modulation and can be performed by varying the amplitude, the phase or the frequency of the carrier by the modulating frequency.

Conversely, if two frequencies have been mixed, they can again be separated by going through an inverse process. Thus from a modulated carrier, the modulating frequency can be secured and put to whatever use is desired.

Other Tube Functions. High-vacuum control tubes can also be used as frequency multipliers or dividers to deliver to a load higher or lower frequencies which may or may not be integral multiples of the originating frequency. The number of the output frequencies is practically unlimited.

When properly associated with other circuit elements, the tube can be made to perform an extremely wide variety of useful functions. For example tube circuits can be made to count impulses occurring

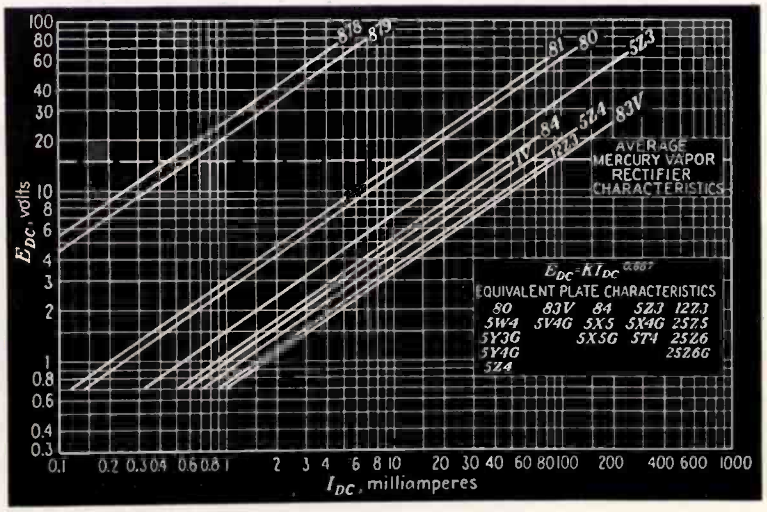


Fig. 10—Current-voltage characteristics of typical rectifier tubes. Current output is proportional to the 3/2's power of plate voltage

much too rapidly for any mechanical counter, to differentiate or integrate mathematical expressions descriptive of electrical, mechanical or other phenomena, can be used as a variable reactance and is widely used through laboratory practices as a measuring tool.

High Vacuum Tube Limitations. The high vacuum tube is a low current-high voltage device. If high currents at low voltages are desired, some other means must be used. Since the tube amplifies, and since a considerable amount of amplification can be secured with a single tube and its accompanying apparatus, care must be taken that the grid or input circuit has impressed on it only the desired voltages and that it be protected from stray fields, such as power line fields, etc. Since the output is a function of the plate voltage, the plate voltage must be steady if a steady output is necessary. If the tube is to amplify (and not to generate oscillations) care must be taken to see that none of the output voltage is allowed to get back into the input circuit in phase with the input voltage.

Rectification

Since the tube conducts current only when its plate is positive with respect to the cathode, an alternating voltage placed between a tube and a load will cause current to flow through the load on the half cycles when the plate is positive. On the half cycles of the alternating voltage when the plate is negative with respect to the cathode, no current will flow in the load. The tube acts as a one-way switch or like a check valve in a pump. This tube phenomenon is called rectification. Only two electrodes are necessary—a cathode to supply electrons and a plate to collect them.

There are two kinds of rectifier tubes, high vacuum tubes and gas tubes. Some rectifiers have control grids in them so that control over the output current is possible. These will be discussed below.

Half-wave Rectifier. In this case a single tube is used and only one half of the a-c cycle is rectified. Current flows in spurts through the load. If continuous current is desired through the load, the output of the rectifier may be put through a filter and then into the load. The filter smoothes out the spurts of current so that the load current resembles that from a d-c source.

The half-wave single-phase rectifier is simple and inexpensive. Its output is relatively difficult to filter and is seldom used.

Full-wave Rectifier. In this case two tubes are used (or a single tube with two sets of elements) and both halves of the a-c cycle are rectified, each tube conducting current when its anode is positive and remaining non-conducting while the other tube conducts. Output from this rectifier is relatively easy to filter and is widely used where currents of 1 ampere at 1000 volts or less are desired.

When a half-wave rectifier works directly into a resistance load without any intervening filter circuit, the average current passed through the load is

$$I_{av} = \frac{0.45\ (V_{rms}) - V_{drop}}{R_L}$$

where V_{rms} is the rms voltage across the power transformer secondary terminals, V_{drop} is the voltage drop across the rectifier tube, for the average current passing through the tube, and R_L is the resistance of the load. V_{drop} is obtained from Fig. 10.

When mercury vapor rectifiers are used, V_{drop} is about 15 volts and is independent of the current drawn from the tube.

In full-wave circuits, the average current is twice that given by the half-wave equation. In this case V_{rms} is the rms voltage between the center tap and one end of the transformer secondary.

$$V_{av} = I_{av} R_L \text{ volts}$$

Polyphase Rectifiers. In polyphase circuits, half- or full-wave rectifiers may be provided for each phase. Such polyphase rectifiers are of considerable industrial application where high power direct current is to be obtained. The output from polyphase rectifiers is often used without filtering, although if filtering is required, this can be carried out relatively easily because the output voltage is relatively high throughout the cycle and because the frequency components to be filtered are higher multiples of the supply frequency.

Voltage Doubler. In this circuit two rectifier units are used. The output voltage is approximately

TABLE 1 — RECTIFIER CIRCUITS

	Circuit A	Circuit B	Circuit C	Circuit D	Circuit E
Average d-c volts, E_a	$0.45\ E_{rms}$ $0.32\ E_{max}$	$0.90\ E_{rms}$ $0.64\ E_{max}$	$1.07\ E_{rms}$ $0.83\ E_{max}$	$1.07\ E_{rms}$ $0.83\ E_{max}$	$2.32\ E_{rms}$ $1.65\ E_{max}$
Peak volts across tube	$3.14\ E_a$	$1.57\ E_a$	$2.09\ E_a$	$2.09\ E_a$	$1.05\ E_a$
Secondary kva*	1.57	1.11	1.48	1.48	1.05
Primary kva*	1.11	1.11	1.21	1.05	1.05
R-m-s ripple, % of E_a	48	48	18	4	4

Note: Drop through rectifier tubes neglected.
* Per kw power delivered to load, transformer losses neglected.

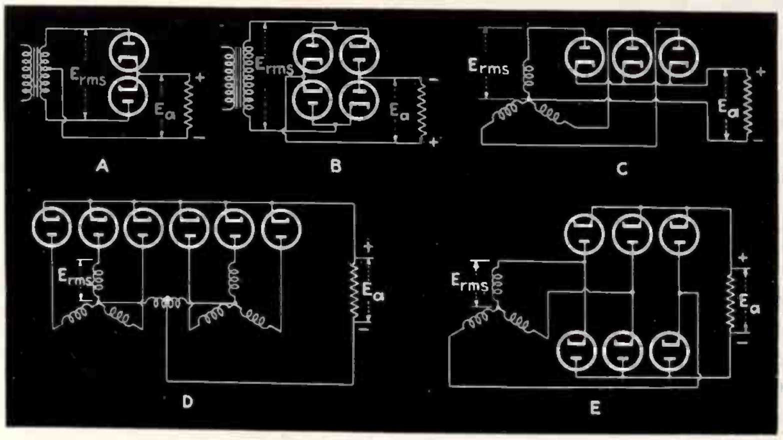


Fig. 11—Several rectifier circuits including A, full-wave single-phase circuit; B, bridge arrangement; and C, D and E, polyphase circuits

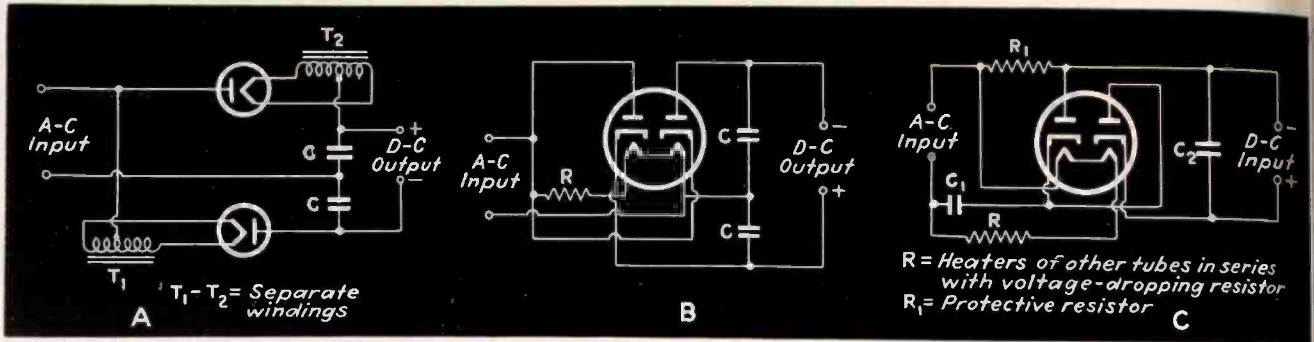


Fig. 12—Voltage doubler circuits. In *A*, separate filament transformer windings are necessary. This circuit is called a full-wave doubler because each tube conducts current to the load on each half of the a-c input cycle. In *B* and *C* both tubes are placed in a single bulb. In *B*, the d-c load cannot be grounded or connected to one side of the a-c supply line. C gets around this difficulty but is a half-wave rectifier since rectifitd current flows to the load only on alternate half cycles of the a-c input cycle

twice the alterating voltage supplied to the rectifier. This is because each condenser (Fig. 12) is charged to the full voltage delivered by the transformer but since the two condensers are in series the total voltage across them is twice that across either.

The voltage doubler is often used where voltages of about 250 are to be obtained from the 110 volt a-c line in the most economical manner. Voltage is fed to the tubes directly from the power line, no transformer being needed. Economy is the reason. This rectifier is also employed in x-ray work where a single tube cannot deliver the required direct voltage output.

Filters for Rectifiers. The smoothing circuits, known as low pass filters, consist of series inductances (or resistance when the current output is small) and shunt capacities. These series and shunt elements tend to maintain the voltage across the output and the current through the output constant, independent of the spurts of current as supplied by the tube. With sufficiently good filtering the output from the filter can be as free from ripple as desired.

Rectifier Applications. The obvious use for a rectifier is to supply direct current from an a-c source. A rectifier, however, can perform other functions than as a source of direct-current power. For example, a d-c meter in the plate circuit of a rectifier will read a current which is some function of the alternating voltage applied to the tube. Thus the tube may be calibrated as an a-c voltmeter by merely placing various known alternating voltages on the tube and noting the rectified current that passes through the meter.

Gaseous Tubes

If a gas, or a vapor such as mercury vapor, is admitted to the tube after all other gases have been pumped out, the characteristic of the tube changes radically. This change in characteristic requires certain changes in the way the tube is used, and enables the tube to perform functions not possible with vacuum tubes.

Gas tubes either conduct or they do not conduct—there is no smooth control of current from zero to the maximum value as is true with high vacuum tubes. When conducting, the voltage drop across the tube is fairly low (15 to 25 volts), fairly constant and independent of current taken from the tube. The current output is limited only by the output load and by the ability of the cathode to supply electrons. Very much higher currents may be supplied by gas tubes than by high vacuum tubes.

Proper Operating Conditions. Since the current during the conducting period is often very high, the cathode may be injured unless means are taken to prevent too great a current flow in case the load should be short circuited. Such means can be a resistance in series with the tube and the load; or an overload circuit breaker or fuse, etc. Furthermore the tube should not be allowed to pass current to the load until the cathode is at the proper temperature. A time delay relay placed between the tube and the load serves this purpose.

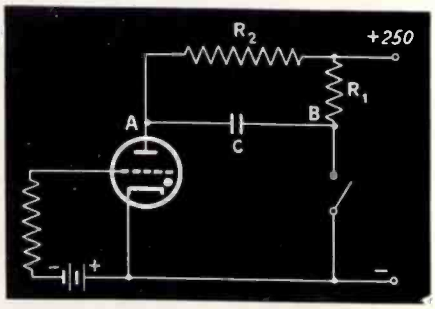


Fig. 13—Control of thyratron tube by suddenly lowering voltage of plate below point at which the tube will conduct

Gas tubes are prone to cause radio interference; small inductances in series with the anodes and physically close to them will eliminate this trouble.

Control-type Gaseous Rectifiers

D-c Operation. Two or more grids in a gaseous rectifier make it possible to control the starting of conduction but not to control the stopping of conduction. In general the only way to stop the tube from conducting is to remove the plate voltage or make it negative. Furthermore a definite time is required for the grid to re-establish control after the plate voltage has been removed. This time is required for the ions to diffuse and leave the vicinity of the grid. This time is of the order of a few micro- or milliseconds and is known as the deionization time. This brief interval between removal of the plate voltage and the establishment of control by the grid limits the frequency of operations the gas tube can control.

In Fig. 13 is shown a simple method of controlling a gas tube. If d-c power is connected to the plate and cathode terminals, and if the grid voltage is correct, anode current will flow. Removing or changing in any way the grid voltage will not have any effect upon the plate current. If, however, the switch is closed the tube will stop conducting.

When the tube conducts, the drop across it will be of the order of 15 volts. The rest of the line voltage, say 250 volts, is impressed across resistance R_2. Terminal A of the condenser is at the same voltage as the anode (15 volts) and terminal B is at line voltage (250) being charged through R_1. Now if the switch is closed, B becomes zero and terminal A will suffer an instantaneous drop in voltage equivalent to – 50 + 15 volts or to the value of minus 235 volts. The plate has now, for an instant, become negative with respect to the cathode and conduction ceases. If the time taken to recharge the condenser through R_1 is greater than the de-ionization time of the tube, the grid will regain control and conduction will not start until the grid voltage is again the proper value.

R_1 should be high enough in resistance so that closing the switch does not blow the line fuses or circuit breakers.

a glow tube (a tube with two elements in a gaseous atmosphere which conducts current only when a certain voltage is impressed across the elements) is placed across the switch terminals, the gas tube can be started and stopped intermittently. As soon as the condenser voltage becomes equal to the voltage at which the glow tube conducts, current flows through the glow tube, reducing the voltage across it sufficiently to cause the plate voltage to become negative. The gas tube goes out, de-ionization takes place, the condenser recharges and when the plate is again at a potential higher than that necessary to cause conduction (as controlled by the voltage on the grid) the tube conducts again, and the cycle is repeated. A 1-microfarad condenser and a 874 glow tube will cut off a 1-ampere current in an FG-67 tube.

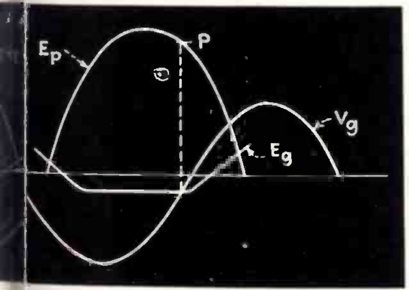


Fig. 14—Control of thyratron by alternating voltages. E_g is the voltage that must be on the grid to start current flow at the value of plate voltage immediately above it. V_g is the control voltage applied to tube. Where E_g and V_g cross, the tube will conduct or "fire"

A-c Operation. If direct voltage is placed upon the grid and alternating voltages upon the plate, conduction will take place whenever the proper relative values of grid and plate voltage occur. If the grid voltage is such that conduction occurs for any positive value of plate voltage, then current will pass through the tube on the entire half cycles which make the plate positive.

If, however, the grid is at such a potential that conduction will not occur at the highest positive voltage placed upon the plate (the peak value of the alternating voltage applied) then conduction will not occur in any part of the positive half cycle of alternating voltage.

Conduction can take place for all of the half cycle or any part of it or none of it, as desired; conduction can be prevented from taking place for all of the half cycle (180 deg.) or for 90 deg. or less than 90 deg., that is, if the tube conducts at all it will do so for 90 or more degrees of the half cycle.

Phase Control. A more elegant way to control the time in the cycle at which conduction begins, and therefore the portion of the half cycle during which conduction takes place is to use alternating voltages on both plate and grid. By adjusting the phase between these two voltages and their relative magnitudes, the average current flowing during a half cycle may be adjusted to any value from zero to the maximum corresponding to conduction for a full 180 deg.

Consider Fig. 14. Here E_p is the anode potential which can have any waveform, and E_g is the grid bias which will just prevent the tube from conducting at the value of E_p shown on the curve. V_g is a sine wave of grid voltage (other waveforms can be used). V_g may be moved along the time axis so that it can be moved into or out of phase with E_p. The tube will fire (conduct) at the earliest point in the cycle at which V_g *crosses* E_g; in the figure point P. By advancing the phase of the grid voltage with respect to the plate voltage, current can be made to pass through the tube for a longer and longer period until the entire 180 deg. is a conducting period. If the grid and plate voltages are out of phase, current does not pass at all. The average current flowing may be found from

$$I_{av} = I_{peak}\frac{(1 + \cos\phi)}{\pi}$$

where ϕ = angle at which tube starts to conduct.

A simple way in which this phase control can be effected is shown in Fig. 15.

The phase-shift method of control is the preferred method, and should be used where a continuous control of power is required. This method permits fixing the time of starting of anode current anywhere in the positive half cycle of anode voltage. The average value of the anode current may be controlled completely from zero to maximum. Some of the more usual methods of obtaining phase shift are (1) an induction phase shifter, such as a Selsyn motor on a polyphase source; (2) capacity-inductance-resistance bridge; (3) by combining two alternating voltages which are out of phase and by varying the magnitude of one of them; (4) by a saturable peaking transformer having a d-c winding and varying the amount of direct current (5) combining an alternating voltage, which is out of phase with the anode voltage, with a d-c bias voltage.

It is good practice to supply the grid with voltages considerably

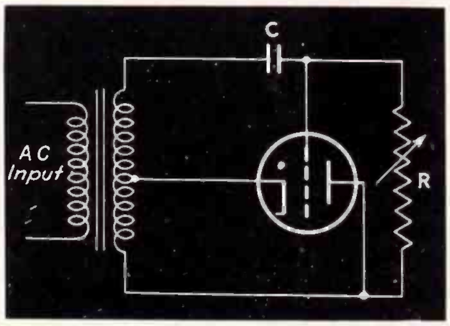


Fig. 15—Method of regulating phase between grid and plate voltages for controlling time in cycle when conduction starts

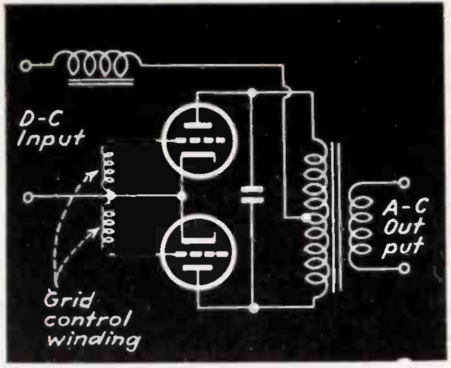


Fig. 16—Elementary circuit showing use of gas triode as an inverter—i. e., a tube which produces alternating currents from a direct voltage input. An actual inverter circuit would be more complex than this

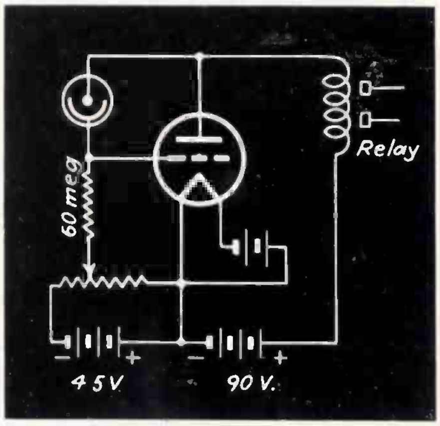


Fig. 17—Simple phototube-amplifier-relay circuit using direct voltages

greater than that just required to start conduction; this practice insures conduction when desired.

Inverter Service. Gas-filled tubes may be used also in tube inverter circuits for conversion of direct current to alternating current. As there are many types of inverter circuits, it is impossible here to do more than cover the fundamental principles.

In all such circuits direct current is applied to the anodes of the tubes and the grid is supplied with the desired frequency, either from an external exciter or by means of coupling with the output circuit. In this respect an inverter may be considered also as an amplifier or oscillator. The function of the tubes is to commutate or, in other words, to perform a switching operation. In all inverters some form of power storage is necessary to supply power during the commutation period, e.g., from static condensers, from a power system, or from rotating apparatus.

The fundamental action of inverters may be illustrated by the simplified, single-phase case of Fig. 16 although, in practice, the larger sizes are polyphase. The anodes of both tubes are positive. Let it be assumed that the grid of the upper tube is positive. Current will flow from the positive d-c source through the transformer to the negative d-c line by way of this tube. The grid of the lower tube is negative and allows no current to pass. The condenser is charged with the potential drop across the output transformer owing to the current flow in the upper half of the winding, the upper terminal of the condenser becoming negative, and the lower positive. Toward the end of the cycle the grids exchange polarity because of reversal of the exciting voltage. This action has no direct effect on the current flow through the first tube, but allows current flow through the second, which in effect connects the lower side of the condenser to the negative lead. This places a negative voltage of short duration on the upper anode, allowing the upper grid to regain control and terminate a half cycle of the a-c output. Corresponding actions in inverse order result in producing the following half cycle of a-c output.

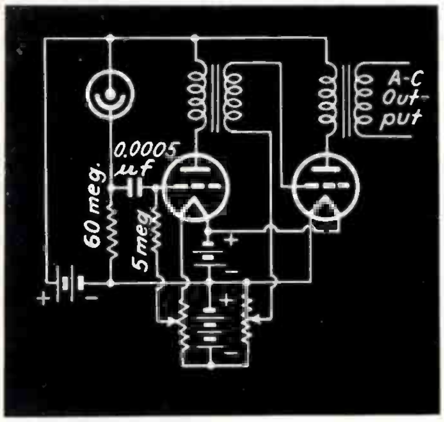


Fig. 18—Phototube circuit useful when alternating voltages secured from a modulated light beam are to be used

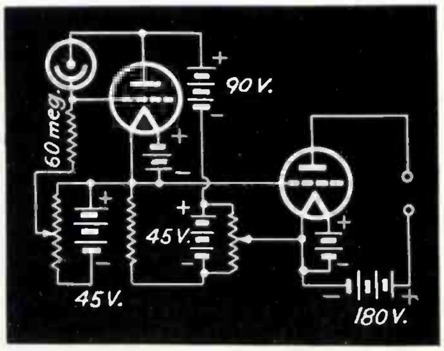


Fig. 19—Circuit useful in amplifying direct voltages. Voltage across resistor in cathode circuit of first amplifier is applied to the second amplifier

Phototube Applications

Phototubes can be used to initiat any electrical control desired b means of light impulses. If the linea relation between light intensity an current output is to be utilized (a in measurements), the tube should be operated with direct voltages but if a relay is to be operated as result of a change in illumination intensity (as for door opening, counting, etc.) alternating voltages ma be used. In Fig. 17 will be found circuit useful for d-c operation Care must be taken to see that th maximum voltage rating of gas tube is not exceeded.

In Fig. 20 is a typical a-c operated circuit. Since the output of the amplifier is pulsating direct curren (rectified current), the relay wil chatter unless a condenser is placed across its coil. The variable resistance between amplifier cathod and grid (through the phototube provides bias; the sensitivity of th circuit may be controlled by varyin the capacity of the grid condenser

If modulated light impulses are t be employed, the circuit of Fig. 1 may be used. This is a straigh transformer-coupled amplifier, th only difference being the phototub connection to the first tube. Wher direct currents are to be amplified Fig. 19 is satisfactory. Circuits amplifying direct currents are not as stable as when alternating currents are employed and are to be avoided if possible.

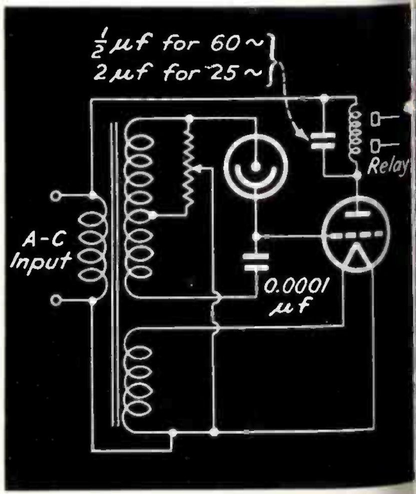


Fig. 20—Alternating current operated phototube relay. The tube rectifies the alternating voltage placed upon it; the voltage appearing across the condenser is then applied to the grid of the amplifier

ight-relay design. The amount o illumination change necessary to c se a tube to close an electro-me-c nical relay may be found from

$$L = \frac{E_c}{SR_c} \text{ lumens}$$

Were L is the increment in light fa ng upon the phototube cathode, re ired to actuate the relay, S is th luminous sensitivity of the pho-to be in microamperes per lumen, R is the coupling resistance in m ohms, and E_c is the increment in gr volts required to actuate the re y. The amplifier current in-cr ses if cathode of phototube is co ected to the amplifier grid; de-cr ses when phototube anode is con-ne ed to amplifier grid.

C thode-Ray Tubes

ecause of their ability to produce a de variety of traces over a very wi range of frequencies, cathode-ra ubes are extensively used where vis l comparisons of electrical op-r ons are to be made, or where the oltages or currents in a circuit ar o be examined. The phenomenon to studied is applied as a voltage to e set of deflecting plates, usually the vertical plates, while some con-ve nt standard of comparison, or t ing wave, is applied as a volt-a o the horizontal pair of deflect-ng lates.

fundamental circuit for the pe tion of the cathode-ray tube is hon in Fig. 21 for a tube having ec ostatic deflection. This simple r it is useful for the comparison f o voltages applied to the two ai of deflecting plates, the image n e screen depending upon the ve magnitudes, frequencies, and ha displacements of the two volt-ge nder comparison. This simple rc t is not suited for the exam-in n of a single voltage or current unction of time, since no tim-ave is provided to form the fe nce axis.

y types of sweep circuit gen-at s can be used to provide suit-ble iming axes, the charging and s rging of a condenser through ga ous tube forming a very simple d mmon method. The sweep cir-it iagram of Fig. 22 is an im-ov nent over the simple gas tube ne tors and provides a timing is hich is very convenient for the a nation of recurrent phenomena.

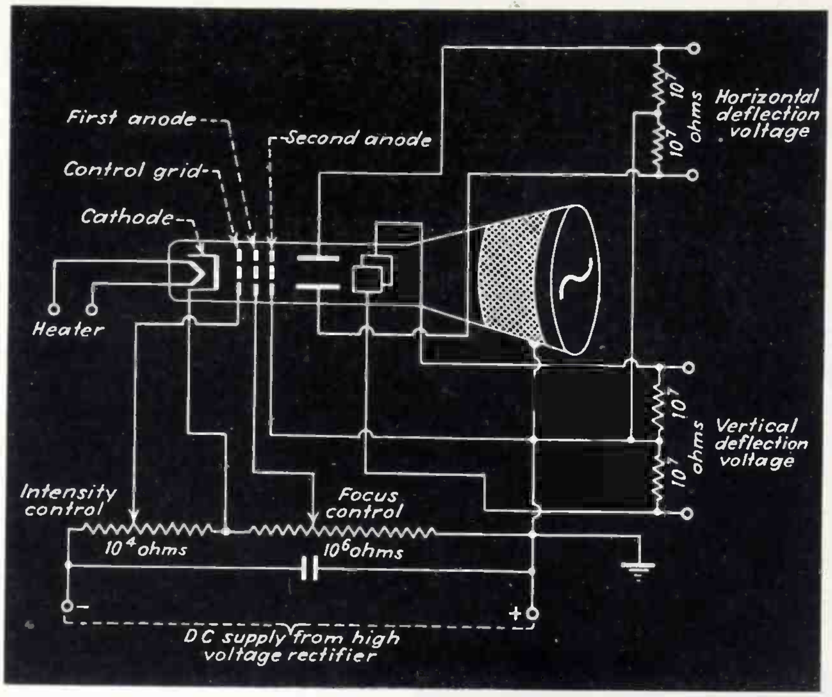


Fig. 21—Circuit arrangement of cathode-ray tube having electrostatic deflection

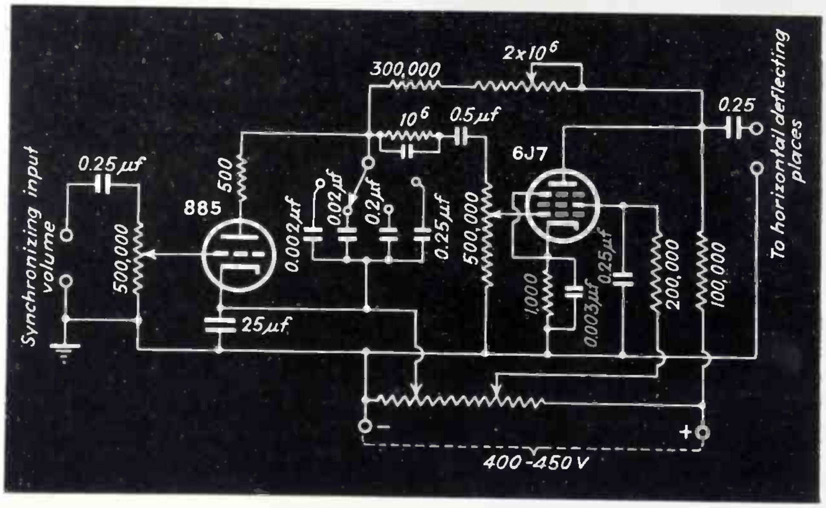


Fig. 22—Sweep circuit generator with amplifier for supplying a cathode ray tube setup with a time basis

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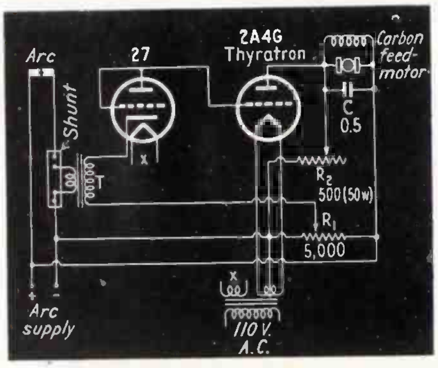
Tubes At Work

Stimulus—ELECTRICAL

Carbon Arc Electrode Feed Control

THE LENGTH OF THE gap between the electrodes of a carbon arc operated on d.c. has a direct bearing upon illumination intensity, steadiness, formation of craters at the positive electrode and the rate at which carbons are consumed. Such arcs are more critical with respect to current density than to voltage across their electrodes, hence current variations may be employed as a source of energy to automatically adjust the arc gap for optimum performance.



Carbon arc electrode feed control. Change in arc current acts to speed up or slow down the drive motor as carbons burn away and so automatically maintains the most efficient spacing

Where the source of d.c. operating the arc is pulsating in character, as from an unfiltered half-wave rectifier, the circuit shown provides suitable control. A heavy shunt having a value sufficient to produce 10 millivolts drop across the primary of transformer *T* is connected in series with the power supply feeding the arc. The secondary winding of *T* delivers 25 volts to the type 27 tube used as a diode rectifier and d-c voltage developed by this rectifier is applied as negative bias to the grid of the 2A4G thyratron.

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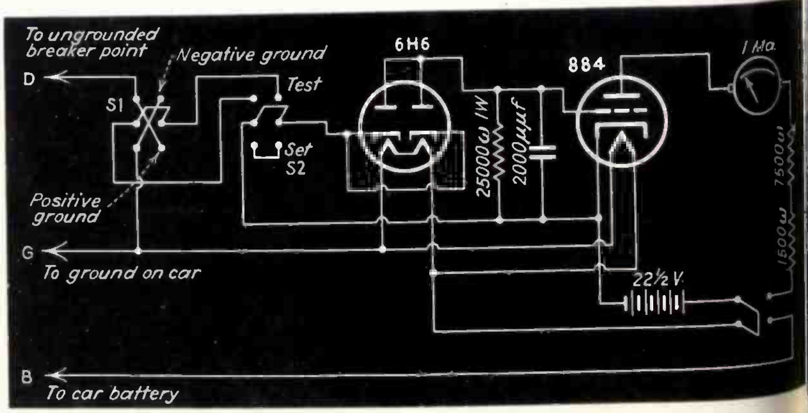

Distributor point checker. It draws only two to three ma from the ignition system to which it is connected and spark intensity is not affected by this negligible primary circuit loading

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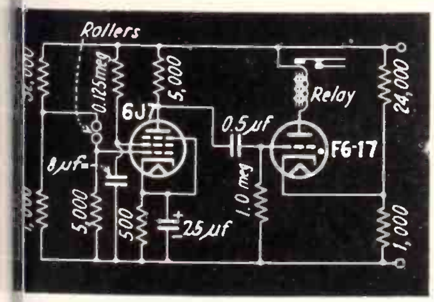
inhole Detector

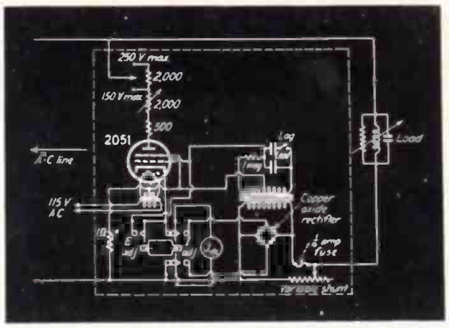
UBBERIZED CANVAS sheeting is ıssed between two rollers which e saturated with a conducting ıuid. Each roller is connected to e grid circuit of an over-biased nplifier. If there is even an ex-emely small pinhole in the canvas, e conducting liquid will penetrate and form a conducting path rough the canvas. Thus, a positive ltage, whose value is determined by the voltage divider made up of the 32,000-ohm, the 1,000-ohm, the 5,000-ohm resistors and the conducting liquid between the rollers, is applied to the grid of the pentode. This reduces the bias on the grid and permits an anode current to flow for an instant. This impulse is passed on to the grid of a gas triode which then actuates a relay. The relay operates an alarm or a marking device to locate the defect. This circuit must be operated on a.c. with one side grounded so that the grid of the gaseous triode can gain control after each operation.—*Electronic Engineering* (London), July 1941.



inhole detector circuit diagram. This in-trument will sound an alarm or mark the location of the pinhole

Power Factor Meter

THIS METHOD OF MEASURING power factor involves the use of a thyratron whose anode current is a function of the phase angle between a voltage and a current. Line voltage, or a voltage having the same phase as the line voltage, is applied to the anode and another voltage whose phase is the same as the load current is applied to the grid. The grid voltage is obtained by passing the load current through a resistor and passing the voltage across the resistor through a step-up transformer to attain the proper value. Since conduction in a gaseous tube cannot ordinarily be stopped by increasing the negative potential of the control grid, lagging power factors cannot be measured because all such factors would give the same indication on the anode current meter. To overcome this an adjustable phase-shifting network is employed in the grid circuit so that any point, preferably the midpoint, of the meter scale may be used to indicate unity power factor with lower anode currents to indicate lagging power factors and higher anode currents to indicate leading power factors. In some cases it may be desirable to have the unity power factor points at different points of the scale. This may be done by proper selection of the condensers of the grid phase shifting networks. The anode current is rectified by a copper oxide rectifier and a d-c meter is calibrated in power factor. The same meter may be used for measuring both the rectified anode current and the a-c grid voltage.—Bereskin, ELECTRONICS, October, 1941, p. 38.



Power factor meter circuit diagram. The anode voltage is in phase with the line voltage and the grid voltage is in phase with the load current. The average anode current is a measure of the phase angle between the load voltage and current

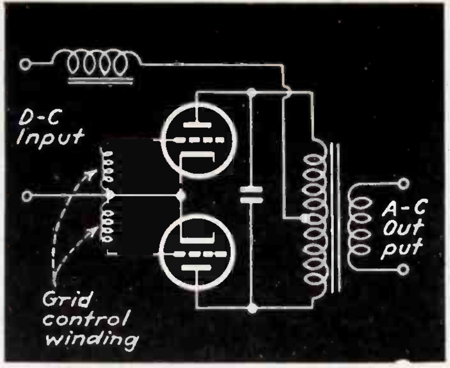


Fig. 16—Elementary circuit showing use of gas triode as an inverter—i. e., a tube which produces alternating currents from a direct voltage input. An actual inverter circuit would be more complex than this

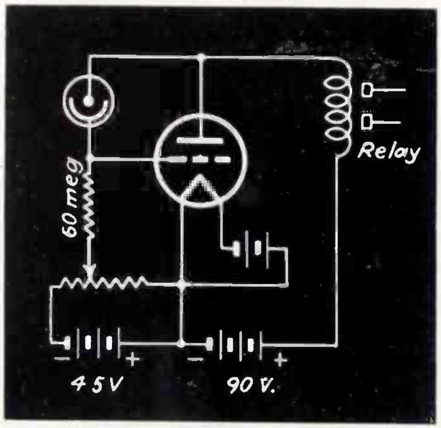


Fig. 17—Simple phototube-amplifier-relay circuit using direct voltages

greater than that just required to start conduction; this practice insures conduction when desired.

Inverter Service. Gas-filled tubes may be used also in tube inverter circuits for conversion of direct current to alternating current. As there are many types of inverter circuits, it is impossible here to do more than cover the fundamental principles.

In all such circuits direct current is applied to the anodes of the tubes and the grid is supplied with the desired frequency, either from an external exciter or by means of coupling with the output circuit. In this respect an inverter may be considered also as an amplifier or oscillator. The function of the tubes is to commutate or, in other words, to perform a switching operation. In all inverters some form of power storage is necessary to supply power during the commutation period, e.g., from static condensers, from a power system, or from rotating apparatus.

The fundamental action of inverters may be illustrated by the simplified, single-phase case of Fig. 16 although, in practice, the larger sizes are polyphase. The anodes of both tubes are positive. Let it be assumed that the grid of the upper tube is positive. Current will flow from the positive d-c source through the transformer to the negative d-c line by way of this tube. The grid of the lower tube is negative and allows no current to pass. The condenser is charged with the potential drop across the output transformer owing to the current flow in the upper half of the winding, the upper terminal of the condenser becoming negative, and the lower positive. Toward the end of the cycle the grids exchange polarity because of reversal of the exciting voltage. This action has no direct effect on the current flow through the first tube, but allows current flow through the second, which in effect connects the lower side of the condenser to the negative lead. This places a negative voltage of short duration on the upper anode, allowing the upper grid to regain control and terminate a half cycle of the a-c output. Corresponding actions in inverse order result in producing the following half cycle of a-c output.

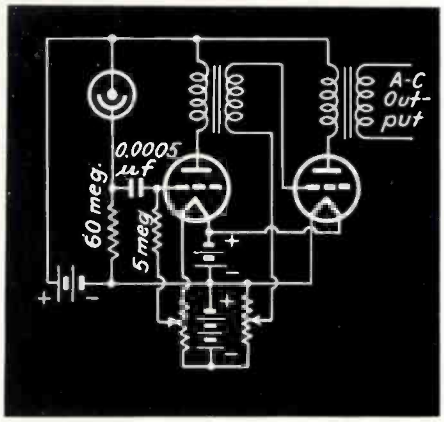


Fig. 18—Phototube circuit useful when alternating voltages secured from a modulated light beam are to be used

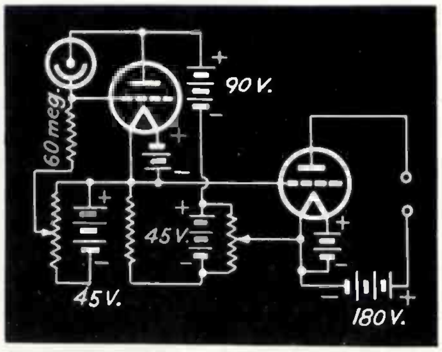


Fig. 19—Circuit useful in amplifying direct voltages. Voltage across resistor in cathode circuit of first amplifier is applied to the second amplifier

Phototube Applications

Phototubes can be used to initiate any electrical control desired by means of light impulses. If the linear relation between light intensity and current output is to be utilized (as in measurements), the tube should be operated with direct voltages; but if a relay is to be operated as a result of a change in illumination intensity (as for door opening, counting, etc.) alternating voltages may be used. In Fig. 17 will be found a circuit useful for d-c operation. Care must be taken to see that the maximum voltage rating of gas tubes is not exceeded.

In Fig. 20 is a typical a-c operated circuit. Since the output of the amplifier is pulsating direct current (rectified current), the relay will chatter unless a condenser is placed across its coil. The variable resistance between amplifier cathode and grid (through the phototube) provides bias; the sensitivity of the circuit may be controlled by varying the capacity of the grid condenser.

If modulated light impulses are to be employed, the circuit of Fig. 18 may be used. This is a straight transformer-coupled amplifier, the only difference being the phototube connection to the first tube. Where direct currents are to be amplified, Fig. 19 is satisfactory. Circuits amplifying direct currents are not as stable as when alternating currents are employed and are to be avoided if possible.

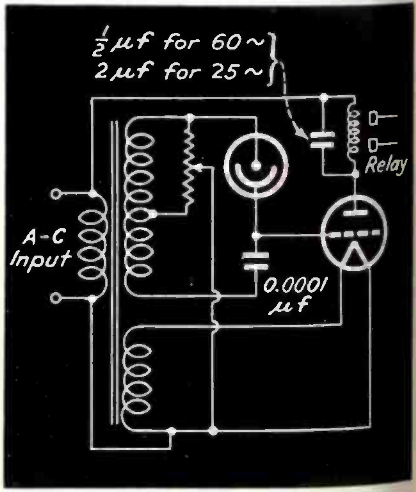


Fig. 20—Alternating current operated phototube relay. The tube rectifies the alternating voltage placed upon it; the voltage appearing across the condenser is then applied to the grid of the amplifier

Light-relay design. The amount of illumination change necessary to cause a tube to close an electro-mechanical relay may be found from

$$L = \frac{E_c}{SR_c} \text{ lumens}$$

Where L is the increment in light falling upon the phototube cathode, required to actuate the relay, S is the luminous sensitivity of the phototube in microamperes per lumen, R is the coupling resistance in megohms, and E_c is the increment in grid volts required to actuate the relay. The amplifier current increases if cathode of phototube is connected to the amplifier grid; decreases when phototube anode is connected to amplifier grid.

Cathode-Ray Tubes

Because of their ability to produce a wide variety of traces over a very wide range of frequencies, cathode-ray tubes are extensively used where visual comparisons of electrical operations are to be made, or where the voltages or currents in a circuit are to be examined. The phenomenon to be studied is applied as a voltage to one set of deflecting plates, usually the vertical plates, while some convenient standard of comparison, or a timing wave, is applied as a voltage to the horizontal pair of deflecting plates.

A fundamental circuit for the operation of the cathode-ray tube is shown in Fig. 21 for a tube having electrostatic deflection. This simple circuit is useful for the comparison of two voltages applied to the two pairs of deflecting plates, the image on the screen depending upon the relative magnitudes, frequencies, and phase displacements of the two voltages under comparison. This simple circuit is not suited for the examination of a single voltage or current as a function of time, since no timing wave is provided to form the reference axis.

Many types of sweep circuit generators can be used to provide suitable timing axes, the charging and discharging of a condenser through a gaseous tube forming a very simple and common method. The sweep circuit diagram of Fig. 22 is an improvement over the simple gas tube generators and provides a timing axis which is very convenient for the examination of recurrent phenomena.

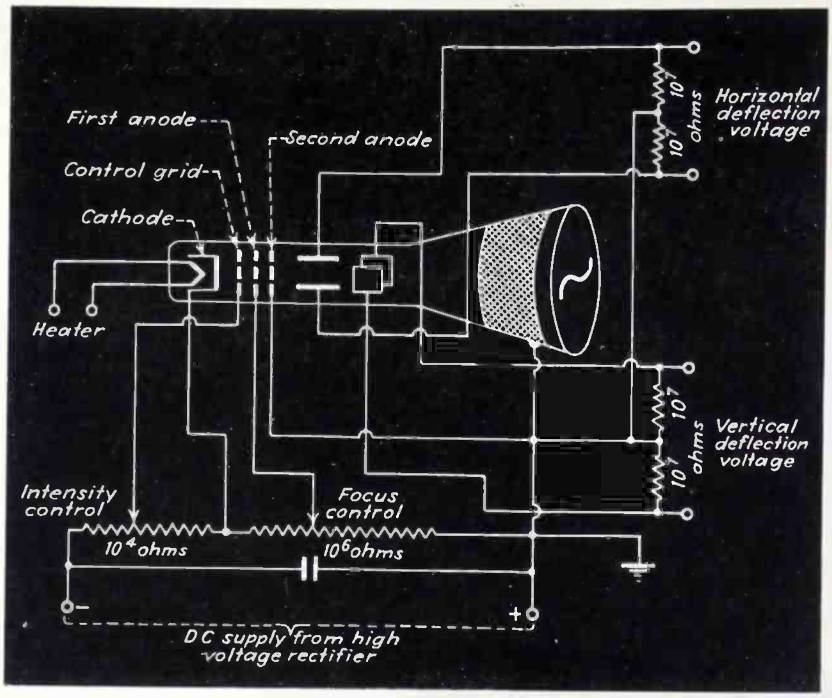


Fig. 21—Circuit arrangement of cathode-ray tube having electrostatic deflection

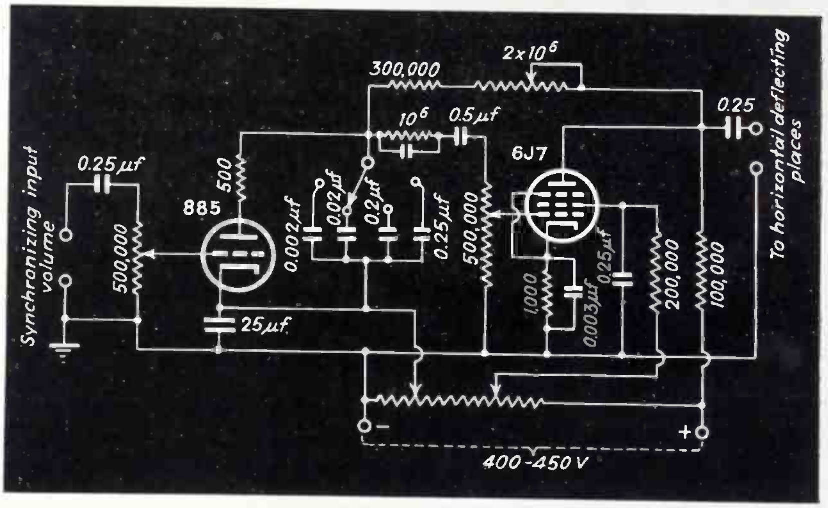


Fig. 22—Sweep circuit generator with amplifier for supplying a cathode ray tube setup with a time basis

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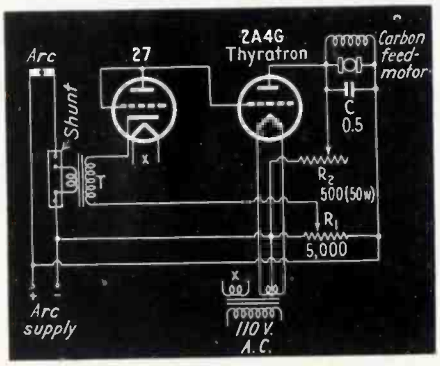
Tubes At Work

Stimulus—ELECTRICAL

Carbon Arc Electrode Feed Control

THE LENGTH OF THE gap between the electrodes of a carbon arc operated on d.c. has a direct bearing upon illumination intensity, steadiness, formation of craters at the positive electrode and the rate at which carbons are consumed. Such arcs are more critical with respect to current density than to voltage across their electrodes, hence current variations may be employed as a source of energy to automatically adjust the arc gap for optimum performance.



Carbon arc electrode feed control. Change in arc current acts to speed up or slow down the drive motor as carbons burn away and so automatically maintains the most efficient spacing

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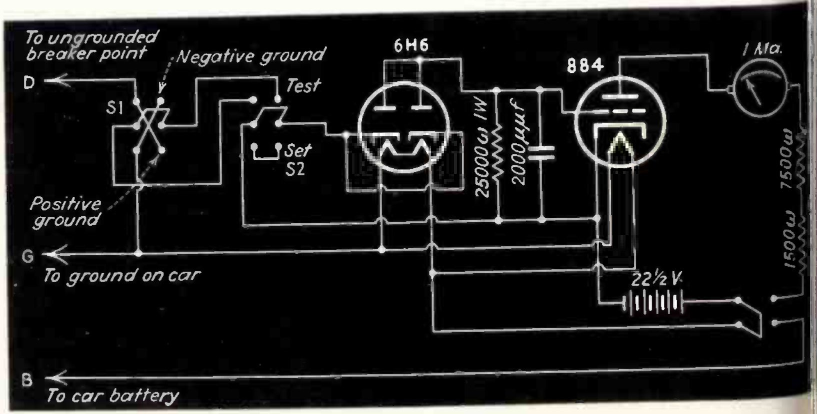

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Pinhole Detector

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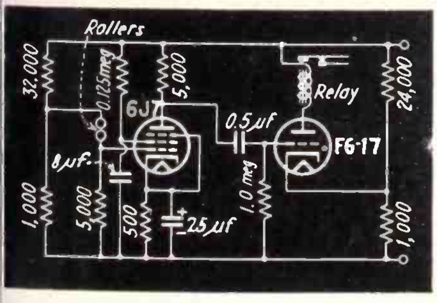

Pinhole detector circuit diagram. This instrument will sound an alarm or mark the location of the pinhole

Power Factor Meter

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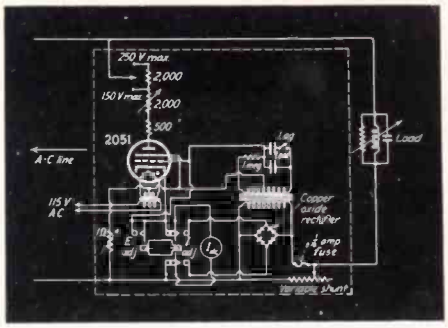
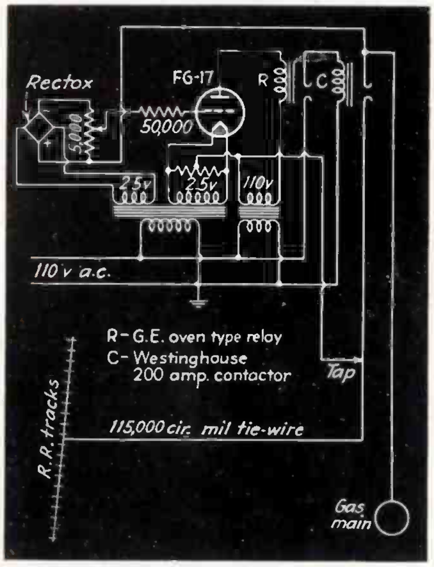


Power factor meter circuit diagram. The anode voltage is in phase with the line voltage and the grid voltage is in phase with the load current. The average anode current is a measure of the phase angle between the load voltage and current

Anti-Electrolysis Relay

WHEN A GAS MAIN IS located close to an electric railway, stray currents from the railway frequently damage the main by producing electrolytic action and corrosion. Damage is done when the main is at positive potential with respect to the rails, causing a current flow from rails to main. It may be avoided by using a directional relay circuit such as the one illustrated which employs a thyratron tube.

When the rails are positive with respect to the gas main, voltage from the tie-wire tap bucks the fixed bias supplied to the grid of the FG-17 by the Rectox unit, making the grid of the tube less negative with respect to the cathode. The tube conducts and anode current closes relay *R*, which closes contactor *C* and permits current to flow from main to rails. Reversal of external voltage polarity produces an increase in negative bias on the tube, causing it to cease conducting and opening up the tie-wire circuit between main and rails.—Davis and Wainwright, ELECTRONICS, March, 1942, p. 72.



Anti-electrolysis relay. This circuit protects a gas main by preventing current flow from electrified railway tracks to main

Electrostatic Powder Separator

CERTAIN DRY, POWDERED materials may be separated from each other by electrostatic action. In the chemical field, for example, among the materials which may be separated in this manner are sphalerite and iron pyrites, graphite and mica, biotite micas and muscovites, garnet and metal particles. These have essentially different electrical characteristics and this difference provides a means of attack.

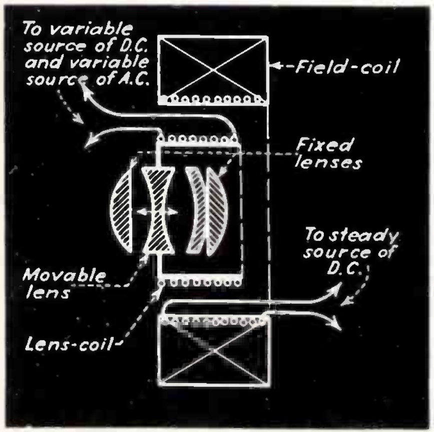
The materials electrically unlike to be separated are passed over or between electrodes charged to about 15,000 volts d.c. One material picks up and retains a charge in its passage over or between electrodes sufficient to cause it to adhere to an electrode. The other material flows unimpeded through the separator to a collecting hopper. High voltage d.c. to operate such separators is readily obtained by stepping up a-c power line voltages through suitable transformers and then rectifying electronically.—ELECTRONICS, January, 1942, p. 58.

Remote Control of Camera Focus

IF ONE OPTICAL element of a complex photographic lens system is substituted for the conventional cone of an electro-dynamic loudspeaker, focus of the lens system may be adjusted by electrical remote control.

A constant d-c potential is fed to the field-coil of the unit. A variable source of d.c. is connected to the coil carrying the movable optical element. By altering the lens-coil potential and/or polarity this coil may be caused to assume various positions with respect to the field coil, hence the movable optical element may be made to assume various positions with respect to the fixed lens elements.

If a.c. is also fed to the lens coil this coil may also be caused to oscillate back and forth about an axis, the speed of oscillation being dependent upon the frequency of the supply voltage and the distance of travel being dependent upon its amplitude. If the lens system is designed so that changes in focal length do not result in changes in image size, lens element oscillation can materially increase the depth of focus. The source of a.c., variable with respect to frequency and amplitude, may be a vacuum tube oscillator.—MacDonald, ELECTRONICS, March, 1942, p. 44.



Electronically controlled lens of a motion picture camera. The principle appears to have possibilities for use in connection with other optical devices

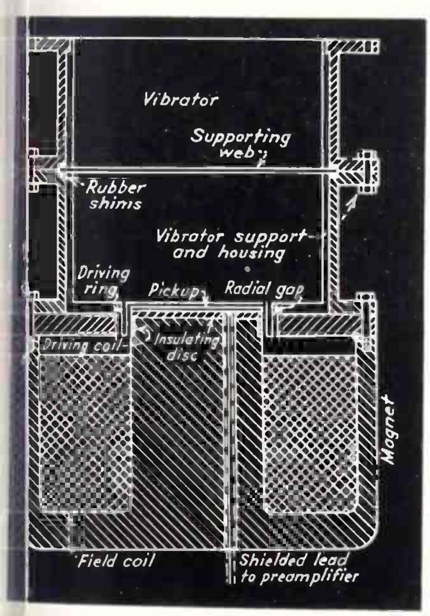
Precipitator for Matter Suspended in Gases

IT IS KNOWN THAT suspended matter in smoke, fumes or fog can be flocculated, or caused to form clouds or masses which precipitate, by high frequency sound vibrations of the order of 17,000 cps. This knowledge has distinct industrial possibilities but one stumbling-block is the design of sound generators which will develop sufficient power for the purpose.

One experimental generator comprises a solid cylinder of duralumin supported in an open-ended housing by an annular web or ring which is an integral part of the cylinder and extends out from its mid-section. A driving ring electrically equivalent to a single-turn coil, also made as an integral part of the cylinder and at its bottom end, projects into the radial gap of a pot magnet energized by a field coil. The ring is inductively excited by an adjacent driving coil. The unit thus resembles a dynamic loudspeaker in construction, the duralumin cylinder taking the place of the conventional diaphragm or cone and the "voice-coil" being driven inductively to eliminate frictional damping.

The cylindrical duralumin cylinder is designed to vibrate at one critical frequency and is an extremely efficient device for translating electrical energy into high frequency sound at this frequency. Efficiency is so critical with respect to frequency, in fact, that it is desirable to use the sound generating device itself as a frequency control element for the electronic equipment which supplies driving power. This is done by placing a small disc of metal on the top of the pot magnet and insulated rom it by a thin disc of Bakelite. his disc, in conjunction with the losely adjacent bottom end of the uralumin cylinder or vibrator, erves as a condenser microphone onnected to the input circuit of an ssociated amplifier. It will thus be een that the overall equipment operates as a mechano-electronic oscil-tor, a.c. generated by changes in pacing between the plates of the ndenser microphone energizing e amplifier at the resonant freency of the duralumin cylinder d supplying power for the operaon of the sound generator at that equency.

Amplifier power output used in cent experiments has been about 0 watts. Overall translator efficicy of the order of 30 percent or ore has been obtained.—St. Clair, *eview of Scientific Instruments*, ay, 1941, p. 250.

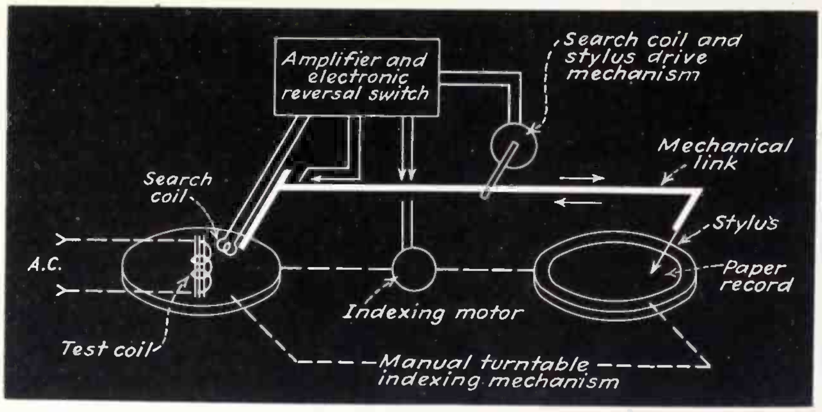


gh-frequency, high-power sound gener-r. Critically resonant, it serves as its own frequency controlling source

agnetic Field Plotter

E MAGNETIC FIELD PATTERN of s may be automatically plotted paper records by means of the ice illustrated here in elemental m.

he coil to be tested is fastened to center of the turntable shown at left and energized by a.c. Both ntables are held still and the rch coil-recording stylus drive hanism is started, causing the rch coil to approach the center of



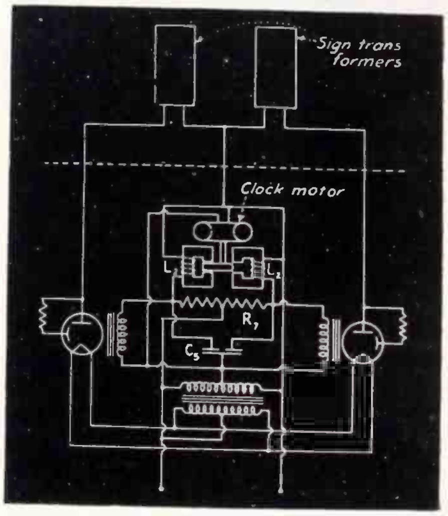
Automatic coil field plotting machine in elemental form

the test coil turntable while the recording stylus approaches the center of the recording turntable. During this period the recording stylus draws a line from the periphery of the paper disc toward its center. At a point determined by the strength of the test coil field and by the sensitivity adjustment of the amplifier sufficient voltage is induced into the search coil to trip the electronic reversal switch and the mechanical link returns both search coil and recording stylus toward the peripheries of their respective turntables. When the peripheries are reached a mechanically actuated limit switch starts a motor which turns both turntables simultaneously to the next index position, stops them and then starts search coil and stylus once more toward the centers of the turntables.

It will be seen that when this cycling process has been completed for every index position around the entire 360 degrees of turntable rotation the configuration of the test coil field may be determined by noting the shape of the pattern formed by the inner ends of the lines drawn on the paper record. In practice, the stylus of the field plotting device may be a fine metal wire and the paper record may be of high resistance metallic material. If a spark is caused to arc through the paper record at the instant the search coil reaches its innermost point of travel and no record trace is made except at this instant field configuration may be determined as before and the record may be re-used for other positions of the test coil or other test coil plots. It is also practical to energize the test coil with d.c. if the search coil is arranged so that it rotates at a constant and high rate of speed, rotation of the search coil providing the a-c impulses necessary for operation of the amplifier.—Weiller, ELECTRONICS, May, 1942, p. 52.

Fader for Neon Signs

THE BRILLIANCY OF neon signs cannot be effectively reduced by cutting down the a-c voltage applied to them by conventional means, such as tapping down on the transformer secondary or introduction of a primary circuit "losser", since ionization producing the characteristic glow will cease before the voltage has been dropped enough to produce perceptible dimming. Brilliancy may, however, be reduced by varying the time in each cycle during which voltage is applied. This amounts to reduction in effective a-c voltage but if a gaseous control tube is used in the primary of the sign transformer to accomplish it the surge voltage introduced by the sharp starting charac-



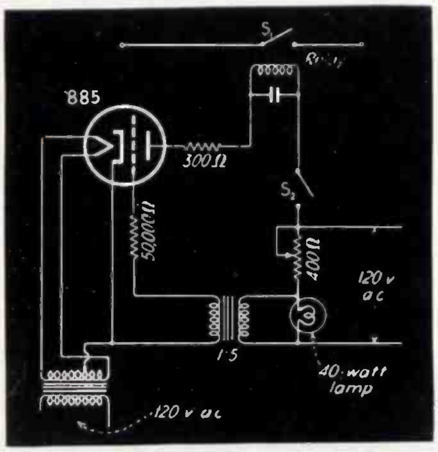
Fader circuit for neon signs, using Permatron magnetically controlled tubes teristic of the tube will be sufficient to ignite the sign even at low brilliancy levels.

The figure shows a method of fading a neon sign of one color into a neon sign of another color. Permatron tubes are magnetically controlled by a phase-shift circuit consisting of reactors L_9 and resistor R_7. The inductance of the reactors is periodically varied in opposite sequence by a synchronous motor-driven cam which moves iron in and out of the gaps in the reactor cores. The amount of inductance in the reactors at a given instant determines the amount of voltage magnetically applied to the Permatrons and therefore controls conduction.

Condenser C_5 resonates the control coils to reduce the load on the phase-shift circuits.—Overbeck, ELECTRONICS, April, 1939, p. 25.

Overvoltage Relay

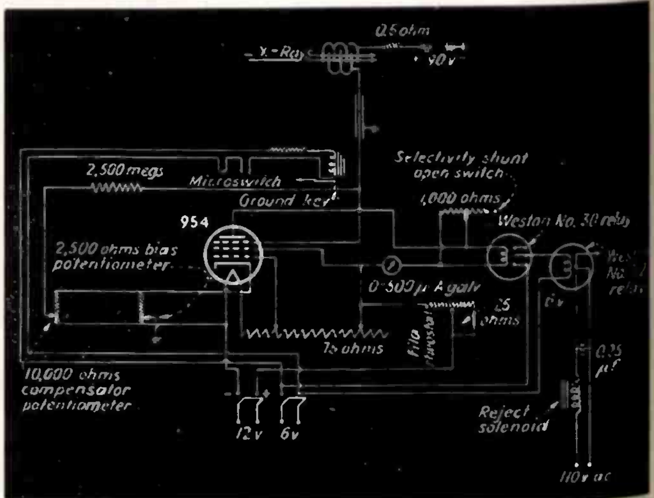
EQUIPMENT MAY BE protected against overvoltage by a relay making use of a gaseous triode. The line voltage is applied to the anode in series with an electromagnetic relay and a portion of the line voltage is reversed in phase and reduced (in a transformer) to a point near the critical grid voltage for application to the grid. The circuit is shown in the accompanying diagram. A voltage divider consisting of a 400-ohm rheostat and a 40-watt incandescent lamp is connected directly across the line and a step-down transformer is connected across the lamp. The secondary of the transformer applies voltage, its phase reversed, between the cathode and the grid. When the line voltage increases, the grid voltage increases in a negative direction and, at a point determined by the setting of the rheostat, will cause the type 885 tube to cease passing current thereby de-energizing the relay and opening the line switch. The purpose of using the lamp is to magnify the voltage increase somewhat because of the temperature-resistance characteristic of the filament.—Kretschmar, ELECTRONICS, February, 1941, p. 48.



This overvoltage relay reverses the phase of the line voltage, reduces it to a voltage close to the critical grid voltage of a type 885 gaseous triode, and applies it to the grid to control a power line relay

Checking Internal Soldered Joints

THE QUALITY OF THE internal soldered joints between the handle and the tang of a table knife is checked by the degree of absorbtion of x-rays in joint (depends upon the amount of lead present) at the factory of Oneida, Ltd. If such a joint is satisfactory, the x-rays will be almost entirely absorbed, but if the joint is imperfect, x-rays will pass through the knife and into a chamber where the air will be ionized to some degree. If a pair of oppositely charged electrodes are placed within the chamber, a very small current will flow because of the migration of ions to the electrodes. In this particular case the amplitude of the current is of the order of 10^{-9} (one billionth) ampere. To make this current useful in rejecting a defective knife, a vacuum tube amplifier of unusual design is used. A type 954 acorn tube with low voltages applied to the electrodes is used. The plate voltage is 7.7 v and the voltage on the first grid is positive. The filament, however, operates at norm voltage. The ionization current passed through a 2500-megohm r sistor and the resultant voltage applied to the suppressor grid. Th causes a larger current to pa through the tube and to operate relay in the plate circuit. A secon relay actuates the reject solenoi This device is capable of testin table knives at the rate of 1400 pe hour.—Woods and Kenna, ELECTRO ICS, April 1941, p. 29.



Circuit diagram of the amplifier used to increase the current through the ionization chamber from a value of 10^{-9} ampere to a level which is capable of operating relays and a solenoid

Resistance Welding Control

RESISTANCE WELDING may theoret cally be accomplished by connectin welding electrodes to the low-voltag high-current secondary of a weldin transformer and supplying the pri mary of the transformer with a This would be equivalent to using th upper part of the circuit shown i the accompanying figure, includin the connection indicated as a dotte line and excluding everything be neath this line. In practice, satisfac tory welds could scarcely be made i this manner due to variations in th resistance of metals to be welde Extremely low resistance, for ex ample, would permit all the curren available from the line and passe by the transformer to flow throug the work, with the result that eithe the work or the electrodes or bot would burn up. Some method of con trolling the amount of current flow ing through the work, or the tim during which current flows, or both is required.

In the basic circuit shown, one leg of the a-c supply line is broken and

(Continued on page 98)

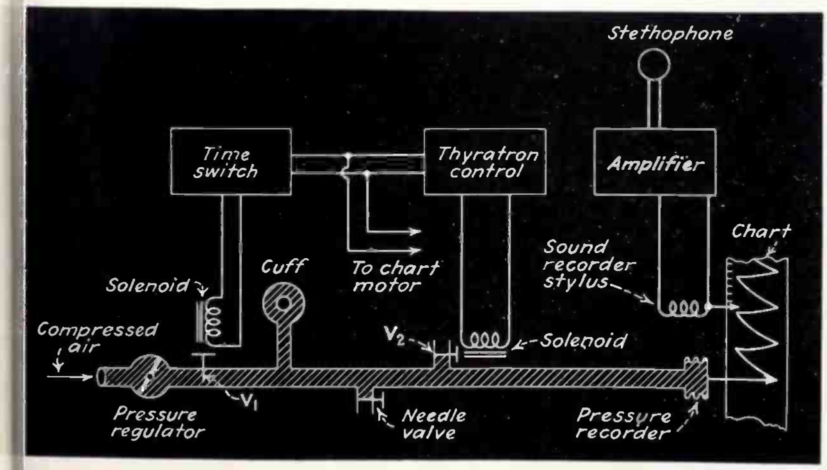
Stimulus—PHYSICAL or CHEMICAL

Blood Pressure Recorder

WHEN BLOOD PRESSURE is determined by a physician an inflatable cuff is placed around the arm of the patient and a stethoscope is applied below the cuff. The pressure in the cuff is raised above systolic pressure (heart contracted) and allowed to fall gradually. When pressure in the cuff is slightly below systolic pressure the arterial walls slap together rhythmically and produce sounds which may be heard in the stethoscope until cuff pressure falls below diastolic pressure (heart relaxed), at which time the sounds cease.

ystolic and diastolic blood pressures may be recorded automatically. An air pressure recording instrument is substituted for the gage. A contact microphone or stethophone is substituted for the stethoscope and drives an amplifier, the output of which operates a pen which makes intermittent marks on the edge of the pressure chart so long as sounds are present as outlined above. Thus the physician need not listen for blood sounds but may merely note recorded cuff pressures at points where blood sound stylus marks start and stop.

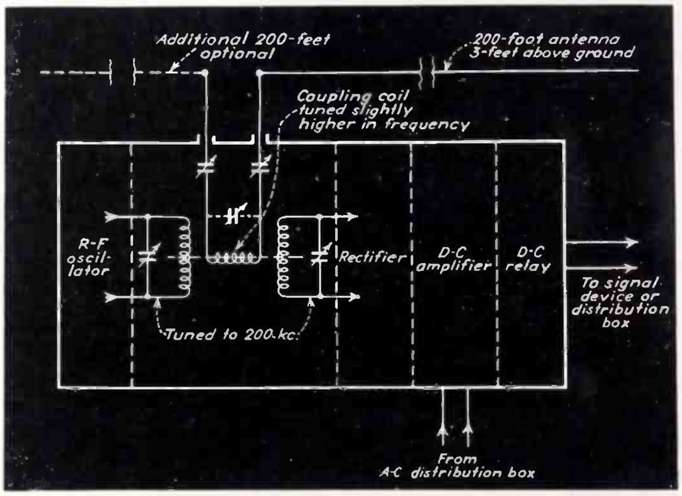
ecent refinements eliminate the necessity for manipulating the air valves and repeat measurements are made automatically at intervals of a few seconds or minutes. A motor driven switch opens and closes intake valve V_1 at required intervals. A thyratron tube circuit opens and closes outlet valve V_2, starts and stops movement of paper through the recording instrument, controls circuit timing.—Gilson, ELECTRONICS—May, 1942, p. 54.



Blood pressures are recorded using an air pressure and sound pressure actuated styli. Cycling of the device is accomplished by electronic control

Capacity Burglar Alarm

IF A WIRE OR ANTENNA is stretched out a few feet above the ground on insulated supports there will be a definite electrical capacity between that wire and the ground. Movement of a foreign body into the field of the wire will increase antenna-to-ground capacity. Weeds growing up beneath the wire, change in ground conductivity due to moisture or formation of ice on the wire will also increase capacity, producing a false alarm unless the circuit is designed to be insensitive to relatively slow capacity changes.



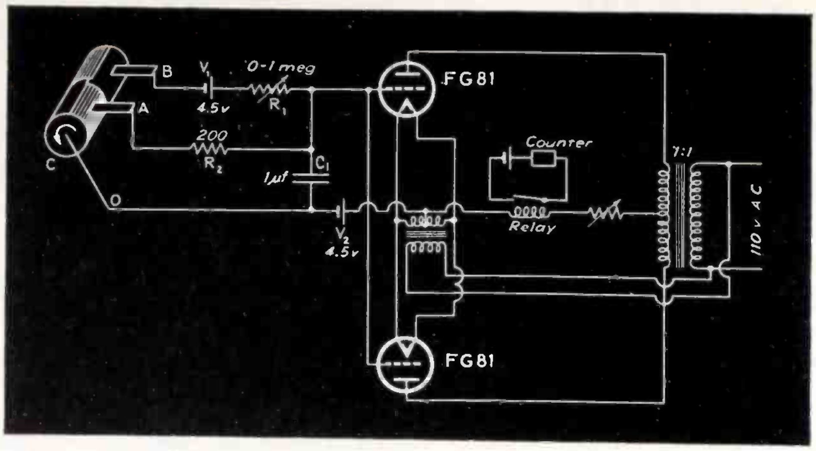
Block diagram of capacity operated alarm designed for outdoor boundary protection service. It employs a circuit minimizing effects of relatively slow changes in capacity caused to growing weeds and by rain, ice and snow

One effective method of accomplishing the above objective is illustrated in the block diagram. A radio-frequency oscillator is tuned to a given frequency and coupled through an intermediate coil to a rectifier tuned to the same frequency. The intermediate coil forms part of the antenna circuit and is tuned to a frequency slightly higher than that of the oscillator and rectifier. The d-c output of the rectifier is amplified, delivering current to the signalling relay only when it receives sharp pulses of input voltage. Slow input voltage changes leak off the coupling capacitors to ground through the amplifier grid resistors before voltage can build up sufficiently to trip the relay.

When an intruder enters the field of the antenna, increased antenna-to-ground capacity is reflected back into the antenna coil. This intermediate coupling circuit more closely approaches the resonant frequency of the oscillator and rectifier, coupling between oscillator and rectifier is increased and the d-c amplifier receives a sharp pulse of input voltage. Or, if the designer so desires, the circuit may be arranged so that when the antenna approaches the resonant frequency of the oscillator sufficient power is absorbed from the oscillator circuit to "rob" the detector of input power and produce a sharp decrease in input voltage to the d-c amplifier. Either method of coupling will actuate such an alarm.—Mac Donald, ELECTRONICS, February, 1942, p. 38.

Hydraulic Flow Indicator

MANY INDUSTRIAL PROCESSES require continuous indication of the rate of flow of a liquid. Others require only



Hydraulic flow indicator. It counts when commutator rotation speed is sub-normal

that sub-normal rates of flow be indicated. This electronic device operates a counter when liquid flow is sub-normal. The portion of time in a given period in which flow is sub-normal may be calculated.

Commutator C is rotated by the flowing liquid in any desired manner. When it is in the position shown, thyratron tube grids are biased sufficiently negative with respect to cathodes by battery V_2 to prevent flow of anode current through the counter. As the commutator rotates, brush A breaks contact with C while brush B makes contact with C. In this position battery V_1 charges capacitor C_1 through variable resistor R_1. If the voltage across C_1 reaches a value sufficient to "neutralize" the negative bias supplied by V_2 the thyratrons fire and their anode current operates the counter.

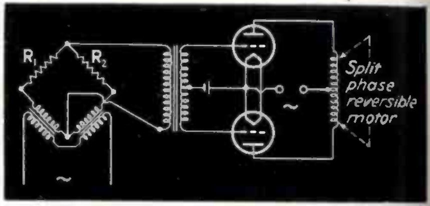
The time required to charge C_1 is dependent upon the resistance of R_1. To adjust the instrument the commutator is rotated at normal speed and the value of R_1 is set so that the thyratrons are on the verge of firing. If the commutator rotates faster than normal, brush B is in contact with C so short a time in each rotation cycle that the thyratrons cannot fire under any anode voltage condition. Should the commutator revolve slower than normal, however, C_1 charging time is increased so that the tubes fire and the counter operates once each cycle so long as sub-normal liquid flow continues.—Ware, ELECTRONICS, October, 1940, p. 36.

Liquid Level Indicator

WHERE THE LEVEL of a liquid having appreciable electrical conductivity must be continuously measured or recorded and it is desirable that the measurement equipment introduce a minimum of physical disturbance at the surface of the liquid the operating principle of the device shown will be found useful.

The resistance between a sharply pointed metal electrode and the surface of the liquid is used as the variable arm of a bridge circuit energized by a.c. The resistance of the variable arm is dependent upon the area of the metal electrode contacted by the liquid; therefore bridge output voltage is proportional to unbalance caused by rise or fall in liquid level.

Bridge output voltage is amplified and applied to the grids of two thyratron rectifier tubes whose anodes are operated from the same a-c source that drives the bridge. Thyratron grid-anode voltage phase relationship as controlled by the bridge output voltage permits only one thyratron to fire under a given set of operating conditions, the tube fired depending upon the phase of bridge output voltage. If R_1 is greater than R_2 one thyratron rectifier fires and the other remains idle while if R_2 is greater than R_1 the first thyratron cuts off and the second thyratron fires. The metal electrode of the device is geared to a split-field electric motor. One thyratron rectifier supplies d.c. to one of the motor field windings while the other thyratron supplies d.c. to the second field winding. Circuit connections are such that a falling liquid level causes the metal electrode of the device to be driven down toward the liquid surface while a rising liquid level causes the metal electrode to be raised until the bridge balances. Just the tip of the metal electrode touches the liquid surface due to follow-up action.



Fundamental circuit often used for controlling direction of rotation of a motor by means of a phase-shifting bridge

Mechanical movement of the metal electrode may be used to move a level-indicating stylus or to actuate a continuous recorder.—Ware, ELECTRONICS, March, 1940, p. 23.

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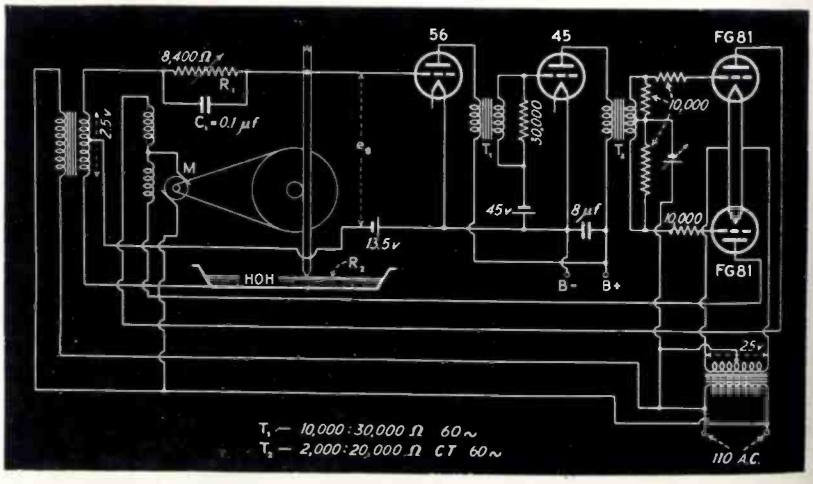


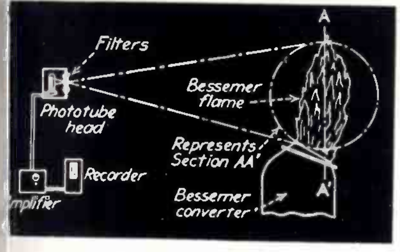
Liquid level indicator. A metal electrode touching the surface of the liquid follows the surface closely as level rises or falls

Stimulus—LIGHT

ontrol of essemer Converter

NVESTIGATION OF THE LUMINOUS nergy content of the flame of a essemer converter has shown that he quality of the steel produced ears a direct relation to the history f the flame. A record is made by hotoelectric means at the steel plant f the Jones and Laughlin Steel orp. in Pittsburgh, and this record used in controlling the operation the converter.

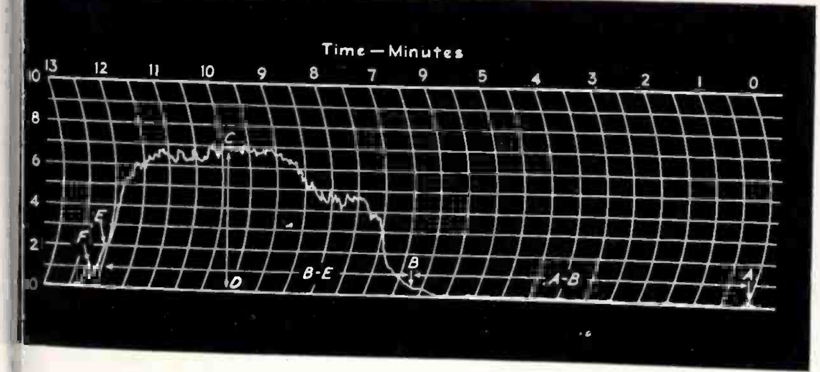
The phototube unit is located in is particular case about 60 feet om the converter and is so arnged that light from other sources not affect its operation. Suitable ters are used to emphasise the aracteristics of the flame which e most important to the charactertics of the steel being produced.



rrangement of the photoelectric equipent in relation to the flame of the Bessemer converter

I the graph point *A* is the start o the blow and the direction of ireasing time is from right to lt. *A-B* is called the silicon blow bcause a large part of the silicon ctent is burned out during this priod. The portion *B-E* is called tl carbon blow for similar reasons.

Typical record of luminous energy content of Bessemer flame produced by photo tube equipment



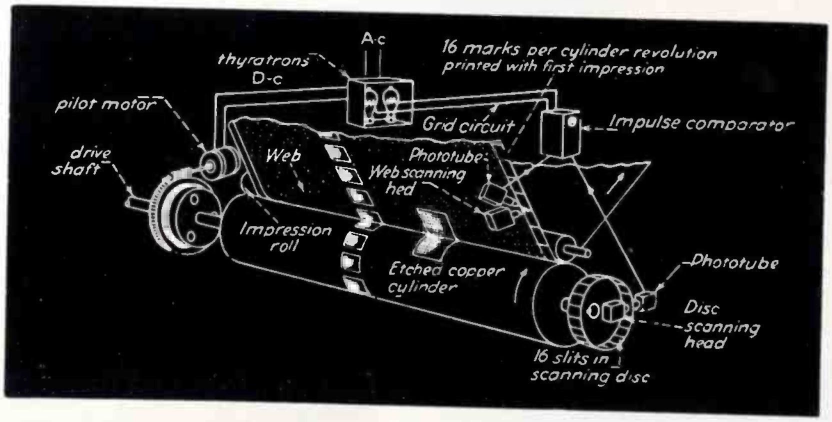
The maximum height represents the metal temperature and gives an indication of the nitrogen content of the steel. Near the end of the blow the intensity of the flame dies down and the point where this occurs is referred to as the end point because it has served to indicate when the blow should be turned down. Point *F* is generally called the flash back and is caused artificially or by the flame inpinging against the shield on the wall of the building. This is a valuable reference point for checking the after-blow and a special effort is made to select a filter combination on the phototube housing that shows this clearly.—Work, ELECTRONICS, June 1941, p. 124.

Register Control

COLOR PRINTING BY the rotogravure process requires precise control of register, i.e., successive color impressions must line up. Perfect register is difficult to achieve due to variations in the speed of motors and sag or tension in the paper. It is facilitated by electronic control, one example of which appears here.

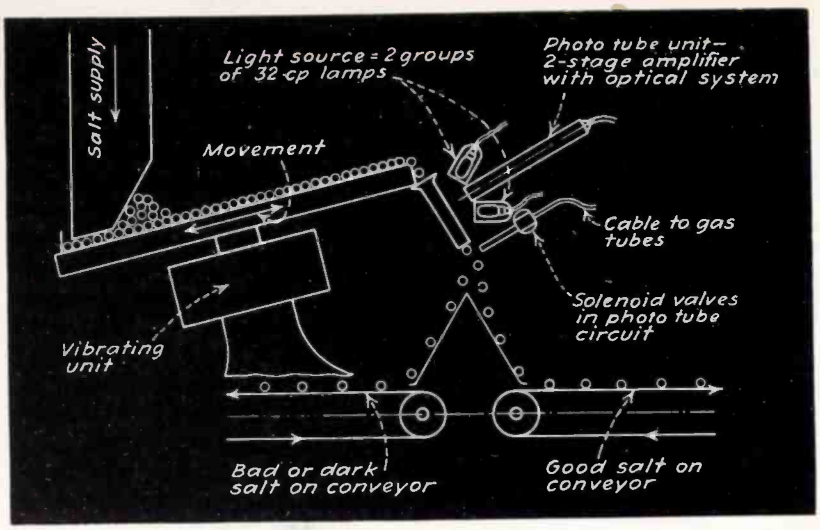
In brief, register marks are printed at regular intervals along a margin or fold of the paper web by the cylinder making the first color impression. As the web passes over the cylinder making the second color impression these marks are scanned by a light source and phototube. To one end of the cylinder making the second color impression a disc having slots comparable in number and spacing to the register marks is simultaneously scanned by another light source and phototube. The output of both scanning units is then passed to an impulse timing comparator.

When successive color rolls are operating in exact synchronism and the paper web has not sagged or tightened between cylinders impulses from the two scanning heads arrive at the comparator at the same time and, it might be said, neutralize each other. If impulses from the paper web scanner arrive too early or too late in relation to impulses from the slotted disc at the end of the cylinder a thyratron-controlled pilot motor slows down or speeds up the cylinder or moves rolls manipulating the web until synchronism is restored.



Printing register control using phototubes and thyratrons. The scheme may be applied to four-color presses

Third and fourth impression rolls may be provided with similar slotted discs and scanning heads, the register marks printed with the first color serving as the basis of comparison throughout an entire multicolor printing process.—Wright, *G. E. Review*, November, 1941. (ELECTRONICS, February, 1942, p. 72.)



Method of operation of rock salt sorting machine. The pieces of salt drop one at a time past the photoelectric unit. The dark pieces reflect less light causing a blast of air to blow them off the path of the good pieces

Rock Salt Sorting Machine

ROCK SALT MUST BE sorted to remove the dark colored pieces before it can be sold. A photoelectric method can be used by differentiating between the reflection characteristics of the desired white particles and the undesired dark particles. The particles are about ⅛ inch in diameter and can be individually examined. Here, the mechanical portion of the system was more difficult to develop than the photoelectric portion. After considerable experimentation the mechanism shown in the diagram was built. The vibrating conveyor feeds the salt in ten individual rows. The salt falls off, one crystal at a time, through the small directional chutes. Each of the ten chutes is arranged with a phototube housing in the form of a 2-inch square stick about 18 inches long. Each phototube unit contains a two-stage amplifier. The power supply and the thyratrons are located at a remote point. If a dark salt crystal appears before any one of the ten photoelectric units, a small fast-acting solenoid valve opens long enough to allow a squirt of air to move that dark crystal out of the normal path of fall. It then falls on one side of a "camel back" while the good pieces fall on the other side. The solenoid air valves must open very rapidly and they operate directly in the anode circuits of the thyratrons. The valves close automatically to eliminate the possibility of rejecting good salt. The valves were designed to open and close 20 times per second against an air pressure of 90 pounds per square inch. By adjustment of the grid bias on the amplifiers and the intensity of the light beam various grades of salt can be sorted for different degrees of purity.—Powers, ELECTRONICS, August 1941, p. 33.

Modulated Beam Photoelectric Alarm

CONVENTIONAL PHOTOELECTRIC burglar alarm systems employ a light source of constant output. Interruption by an intruder of an infrared beam projected to a distant phototube reduces the d-c output of the phototube and its associated d-c amplifier and actuates a relay controlling a signalling device. Such systems are sometimes rendered insensitive by increases in ambient light, such as those caused outdoors by the transition from darkness to daylight or indoors by the turning on of artificial illumination. Ambient light level may become so high that the relay is held open by phototube current even when the beam is interrupted.

This difficulty may be minimized by using modulated light. A motor-rotated disc with holes punched in its periphery is introduced between the light source and the projection lens. The projected light beam is chopped up at a rate dependent upon the speed of the motor and number of holes in the disc, usually between 500 and 1,500 times per second. The phototube in the distant receiving unit operates into an a-c amplifier equipped with a band-pass filter which permits amplification only when current delivered by the phototube is modulated at the prescribed

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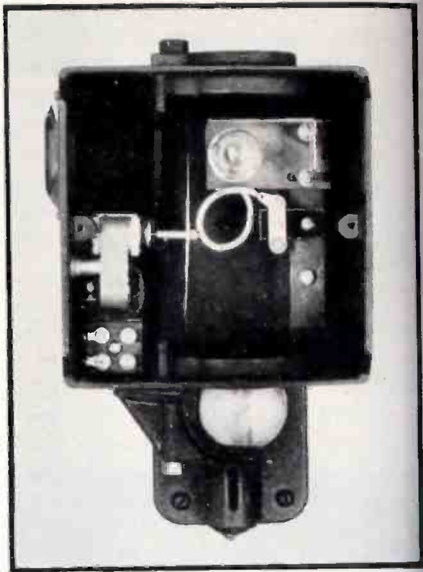
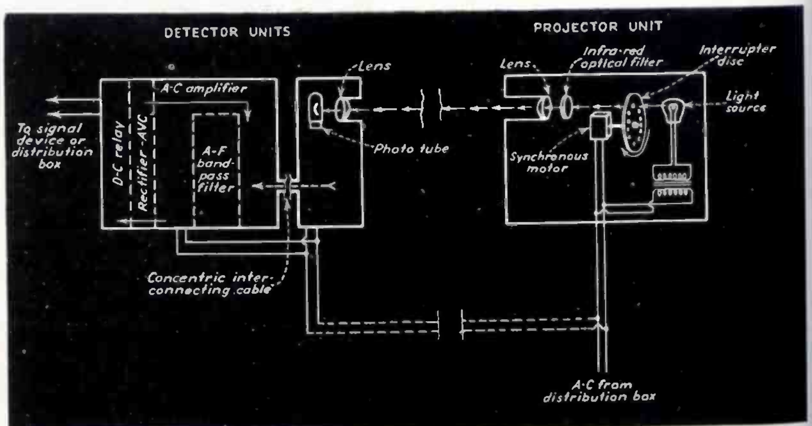


Projector unit of typical modulated-beam photoelectric system. Edge of disc which interrupts light appears as a vertical white line just to the left of center



Block-diagram of typical modulated-beam photoelectric alarm system. Beam-throw distances of 1.000 feet or more are proving practical with such systems

A QUICK-SELECTION CHART OF ELECTRONIC TUBES FOR INDUSTRY

THERE'S A G-E TUBE FOR EVERY ELECTRONIC DEVICE

KENOTRON—A high-vacuum thermionic tube in which no means is provided for controlling the unidirectional current flow.

THYRATRON—A hot-cathode, gas-discharge tube in which one or more electrodes are employed to control electrostatically the starting of the unidirectional current flow.

IGNITRON—A gas-discharge tube with a pool-type cathode (liquid or solid) in which an ignition electrode is used to control the starting of the unidirectional current flow in each operative cycle.

GLOW TUBE—A cold-cathode, gas-discharge ube in which no means is provided for controlling he unidirectional current flow.

PHANOTRON—A hot-cathode, gas-discharge tube in which no means is provided for controlling the unidirectional current flow.

BALLAST TUBE—A resistor-type tube used to maintain a constant average current—resistance varies with temperature so rapidly that, as the voltage across the tube varies, the current remains practically constant.

PLIOTRON—A high-vacuum tube in which one or more electrodes are used to control the unidirectional current flow.

PHOTOTUBE—A light-sensitive vacuum tube in which electron emission is produced directly by radiation falling upon an electrode.

KEEP THIS TIME-SAVING CHART FOR READY REFERENCE

ON the following two pages, we give you the *first* comprehensive list of electronic tubes for industrial use. This makes it almost as easy to choose a tube for your electronic device or application as it is to select an ordinary light bulb. The streamlined technical data on each tube, in easy-to-get tabular form, makes it a simple procedure to select the tube to fit your particular requirement.

● You'll notice bulletin numbers for each tube listed in the column farthest right on each page. These and other bulletins, described briefly on the fourth page, contain valuable installation, operating, and technical data. Get them on every G-E tube type you are now using or plan to use. You'll find them invaluable when designing electronic devices or discovering new ways of solving production problems electronically.

● If you have a special design problem, call on G-E engineers.

GENERAL ELECTRIC

Prices effective May 18, 1942

PHANOTRONS — gaseous-discharge-rectifier tubes

Type No.	Price	No. of Electrodes	CATHODE		PLATE		Avg Amp	Temp Range Condensed Mercury, C	Shipping Weight in Lb	Ask for This Bulletin
			Volts	Amp	Peak Volts	Peak Amp				
GL-866A/866	$1.50	2	2.5	5	10000	1	0.25	40— ±5	3	GET-966
FG-190	18.75	3	2.5	12	175	5	1.25	−20— +60*	6	GET-969
GL-872	9.00	2	5.0	10	7500	5	1.25	40— ±5	3	GET-917
GL-872A	11.00	2	5.0	6.75	10000	5	1.25	40— ±5	3	GET-745
GL-512	33.00	2	5.0	10	15000	6	1.5	15—50§	3	GET-993
FG-32	11.00	2	5.0	4.5	1000	15	2.5	30—80	6	GET-969
GL-869B	125.00	2	5.0	18	20000 15000‡	15	2.5 5.0‡	35— ±5	6	GET-964
FG-280	35.00	2	5.0	10	1000	40	6.4	40—80	3	
FG-104	27.50	2	5.0	10	3000	40	6.4	40—80	9	GET-733
GL-510	240.00	2	5.0	30	22000	40	5.0 10.0‡	30—40	9½	GET-993
FG-166	98.00	2	2.5	100	1500	75	20	20—60	9	GET-735

‡Quadrature operation. § Ambient temperature range.

THYRATRONS — grid-controlled gaseous-discharge-rectifier tubes

Type No	Price	No. of Electrodes	CATHODE		PLATE		Avg Amp	Starting Grid Voltage	Temp Range Condensed Mercury, C	Shipping Weight in Lb	Ask for This Bulletin
			Volts	Amp	Peak Volts	Peak Amp					
GL-2051	$2.50	4	6.3	0.6	700	0.375	0.075	Neg		3	GET-984
GL-2050	3.00	4	6.3	0.6	1300	0.500	0.100	Neg		3	GET-984
FG-178-A	14.00	3	2.5	2.25	500	0.500	0.125	Neg	−20— +50*	3	GET-618
FG-81-A	11.00	3	2.5	5.0	500	2.0	0.5	Neg	−20— +50*	3	GET-465
FG-98-A	15.50	4	2.5	5.0	500	2.0	0.5	Neg	−20— +50*	3	GET-743
FG-97	15.50	4	2.5	5.0	1000	2.0	0.5	Var	40—80	3	GET-743
FG-17	9.50	3	2.5	5.0	2500	2.0	0.5	Neg	40—80	3	GET-428
FG-154	23.00	4	5.0	7.0	500	10.0	2.5	Neg	−20— +50*	6	GET-743
FG-27-A	17.00	3	5.0	4.5	1000	10.0	2.5	Neg	40—80	6	GET-428
FG-33	16.25	3	5.0	4.5	1000	15.0	2.5	Pos	35—80	6	GET-435
FG-57	15.00	3	5.0	4.5	1000	15.0	2.5	Neg	40—80	6	GET-428
FG-67	15.75	3	5.0	4.5	1000	15.0	2.5	Var	40—80	6	GET-438
FG-95	19.00	4	5.0 †5.5	4.5 5.0	1000 1000	15.0 40.0	2.5 0.5	Var Var	40—80 40—80	6	GET-743
GL-429	47.50	4	5.0	10.0	1000	40.0	3.0	Var	50—70	9	GET-962
FG-105	38.00	4	5.0	10 0	1000	40.0	6.4	Var	40—80	9	GET-743
FG-172	35.00	4	5.0	10.0	1000	40.0	6.4	Var	40—80	9	GET-619
FG-41	92.00	3	5.0	20.0	10000	75.0	12.5	Neg	40—65	9	GET-436
GL-414	92.00	4	5.0	20.0	2000	100.0	12.5	Neg	40—80	9	

* These tubes are inert-gas-filled, and the temperature ratings are expressed in terms of the ambient temperature range over which the tubes will operate.
† These ratings apply only when the tube is used for ignitor firing.

PLIOTRONS — grid-controlled high-vacuum tubes

Control Types	Price	No. of Electrodes	CATHODE		PLATE		Max Dis Watts	Mu	Shipping Wt Lb	Ask for This Bulletin
			Volts	Amp	Max Volts	Max Amp				
PJ-21	$6.25	3	4.5	1.1	350		7.5	3	3	GET-496
PJ-7	6.25	3	4.5	1.1	350	0.040	10	30	3	GET-492
PJ-8	6.25	3	4.5	1.1	350	0.040	10	8.5	3	GET-493
Special Purpose										
FP-54	$56.00	4	2.5	0.09	6	0.0060	Low grid-current measurement tube		9	GET-484
FP-62	27.00	3	4.5	1.48	112.5	0.010	For gas-pressure measurements		9	GET-485

Therapy Types							Max Input	Max Dis Watts	Mu	Shipping Wt Lb	Ask for This Bulletin
FP-285	$15.00	3	10	3.25	1350	0.200	270	100	12	6	GET-738
FP-252A	25.00	3	10	3.85	2000	0.200	400	150	18	6	GET-750
FP-265	23.75	3	10	5.20	1500	0.200	300	160	75	6	

Power Triodes	for high-frequency heating.						Max Dissip. Watts	Mu	Type of Cooling	Shipping Weight in Lb	Ask for This Bulletin
GL-483	$160.00	3	11	15.5	2500	1.00	750	20.5	......	9	GET-989
GL-8002	200.00	3	16	39.0	3500	1.00	1200	20.5	Water		GET-960
GL-8002R	325.00 ★	3	16	39.0	3500	1.00	1200	20.5	Air	15	GET-961
GL-891R	410.00 ★	3	22	60:0	10000	2.00	4000	8	Air	90	GET-914
GL-509	275.00	3	11	125.0	8500	2.00	5000	21	Water	9	GET-992
GL-509R	425.00 ★	3	11	125.0	8500	2.00	5000	21	Air	52	GET-992
GL-891	285.00	3	22	60.0	12000	2.00	6000	8	Water	9	GET-913
GL-207	275.00	3	22	52.0	15000	2.00	10000	20	Water	9	GET-763
GL-452	285.00	3	22	60.0	15000	2.00	10000	50	Water	9	GET-975
GL-893	750.00	3	20	183.0	20000	4.00	20000	36	Water	27	GET-766
GL-893R	1150.00 ★	3	20	183.0	20000	4.00	20000	36	Air	290	GET-959
GL-862	1650.00	3	33	207.0	20000	10.00	100000	45	Water	175	GET-919
GL-898	1650.00	3	33	207.0	20000	10.00	100000	45	Water	175	GET-767

★Lower prices apply when new tube is purchased, and radiator in good condition is returned prepaid.

KENOTRONS — high-vacuum rectifier tubes

Type No.	Price	No. of Electrodes	CATHODE		PLATE		Shipping Weight in Lb	Ask for This Bulletin
			Volts	Amp	Peak Volts	Peak Amp		
FP-400	$14.00	2	4.0	2.25	100	0.025	6	GET-746
FP-92	155.00	2	10	14.5	150000	0.3	9	GET-734
GL-411	130.00	2	10	14.5	100000	0.3	9	GET-734
KC-4	140.00	2	20	24.5	150000	1.0	9	GET-734

GNITRONS — high-peak-current, pool-cathode tubes

Welding Control Types*	Price	MAXIMUM RATINGS				Type of Cooling	Shipping Weight in Lb	Ask for This Bulletin
		Kva Demand	Corresponding Average Anode Current Amperes	Maximum Average Anode Current Amperes	Corresponding Kva Demand			
GL-415	$33.00	300	12.1	22.4	100	Water	6	GET-968
FG-271	55.00	600	30.2	56.0	200	Water	12	GET-967
FG-235-A	110.00	1200	75.6	140	400	Water	16	GET-967
FG-258-A	250.00	2400	192.0	355	800	Water	45	GET-967

* Ratings are for voltages of 600 volts rms and below. Ignitor requirements for all welding-control types are 200 volts and 40 amperes.

Power Rectifier Types†	Price	D-c Volts	MAXIMUM CURRENT			Type of Cooling	Shipping Weight in Lb	Ask for This Bulletin
			Peak Amp	Average Amp	Average Amp 1 Minute			
GL-427	$55.00	125	30	5	.....	......	3	
FG-238-B	355.00	300 600	1800 1200	300 225	400 300	Water	35	GEA-3565
FG-259-B	200.00	300 600	900 600	150 100	200 133	Water	22	GEA-3565

† Typical ignitor requirements for power-rectifier ignitrons are 75–125 volts, 15–20 amperes. Maximum requirements are 150 volts, 40 amperes.

HOTOTUBES — light-sensitive tubes

Type No.	Price	Gas or Vacuum	Cathode Surface Material	Anode Volts	Sensitivity in Microamperes per Lumen	Window Area Sq In.	Max Amb Temp, C	Shipping Weight in Lb	Ask for This Bulletin
PJ-22	$2.60	Vacuum	Caesium	200	14	0.9	50	3	GET-742
PJ-23	2.60	Gas	Caesium	90	50	0.9	50	3	GET-742
FJ-401	6.75	Gas	Rubidium	90		0.9	50	3	GET-742
FJ-405	44.00	Vacuum	Sodium	200		0.75	50	6	GET-742
GL-441	7.50	Vacuum	Caesium	200	45	0.9	100	3	GET-742
GL-917	4.75	Vacuum	Caesium	500	20	0.9	50	3	
GL-919	4.75	Vacuum	Caesium	500	20	0.9	50	3	
GL-921	2.00	Gas	Caesium	90	100	0.38	50	3	
GL-922	2.00	Vacuum	Caesium	500	20	0.38	50	3	
GL-923	2.60	Gas	Caesium	90	100	0.43	50	3	GET-983
GL-927	3.70	Gas	Caesium	90	75	0.4	50	3	
GL-929	3.00	Vacuum	Caesium	250	45	0.6	100	3	GET-983
GL-930	2.00	Gas	Caesium	90	100	0.6	100	3	GET-983
GL-931	12.00	Vacuum	Caesium	1250	2.3×10^6	0.25	50	3	

ALLAST TUBES — resistor-type tubes used to maintain a constant average current

Type No.	Price	VOLTS		AMPERES		Shipping Wt Lb	Ask for This Bulletin
		Min	Max	Min	Max		
FB-50	$4.50	5	8	0.225	0.275	3	GEH-1000
B-25	3.00	7	16	1.07	1.16	3	GEH-1000
B-47	3.75	8	18	2.05	2.35	3	GEH-1000
B-46	4.25	8	18	2.70	3.25	3	GEH-1000
B-6	4.50	15	21	0.95	1.01	3	GEH-1000
B-4	25.50	105	125	1.24	1.36	3	GEH-1000

LOW TUBES — cold-cathode tubes for use as voltage regulators

Type No.	Price	Starting Supply Voltage, D-c, Min	Operating Voltage Maintained, D-c, Approx	OPERATING CURRENT, MILLIAMPERES		Shipping Wt Lb	Ask for This Bulletin
				Min	Max		
GL-75-30	$1.25	105	75	5	30	3	GET-985
GL-874	1.50	125	90	10	50	3	GET-985
GL-105-30	1.25	137	105	5	30	3	GET-985
GL-150-30	1.25	180	150	5	30	3	GET-985

ACUUM SWITCHES

ype No.	Description	Price	A-c	D-c	Amp	Shipping Wt Lb	Ask for This Bulletin
FA-6	Single-pole double-throw	$8.75	440	500	10	3	GET-609
FA-15	Single-pole double-throw	6.25	3000	3000	8	3	GET-729

ACUUM GAGES—to measure gas pressure

Type No.	Price	Volts	Range in Microns	Shipping Wt Lb	Ask for This Bulletin
FA-13	$14.00	6	0–600	3	GEI-8695
FA-14	11.00	6	‡	3	GEI-8695

‡ Used with FA-13 to compensate for temperature and voltage changes.

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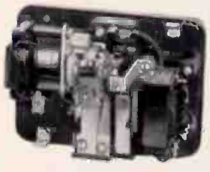

TIME-DELAY RELAYS
Bulletin GEA-1540B

PYRANOL CAPACITORS
Bulletin GEA-2621

Prices and other data are subject to change without notice.

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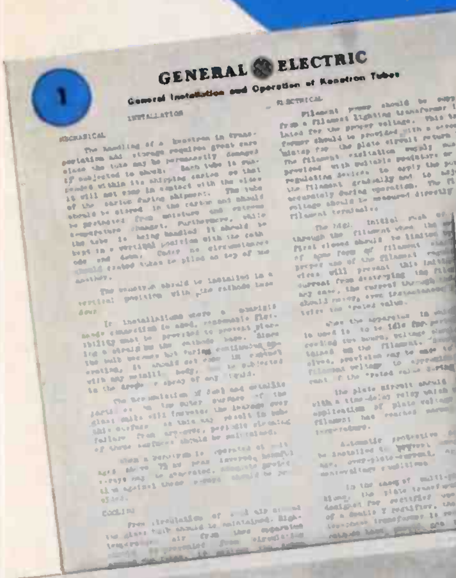
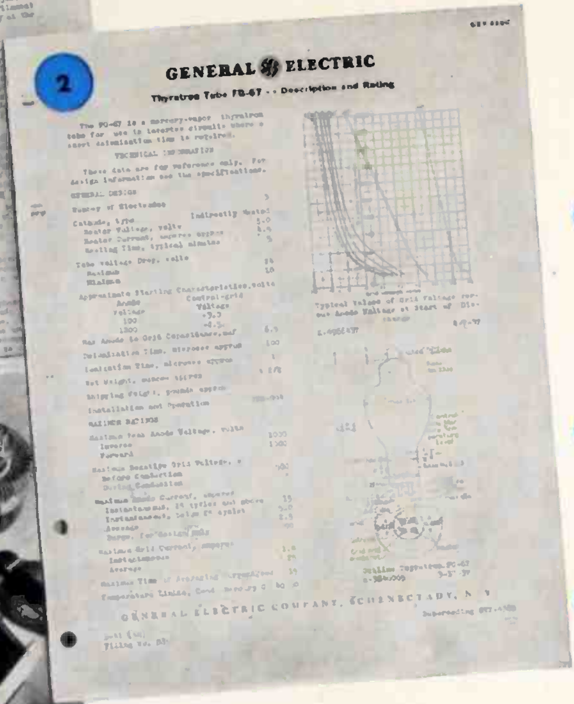
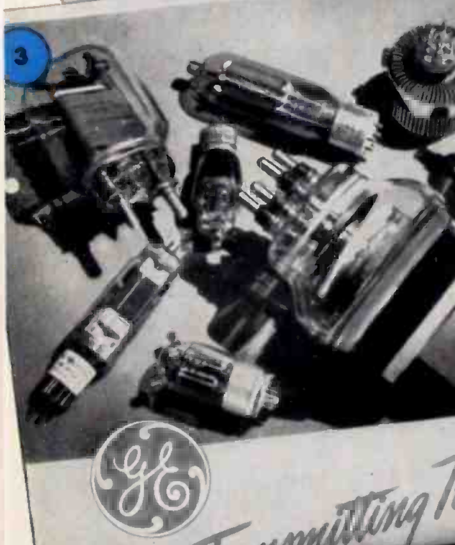
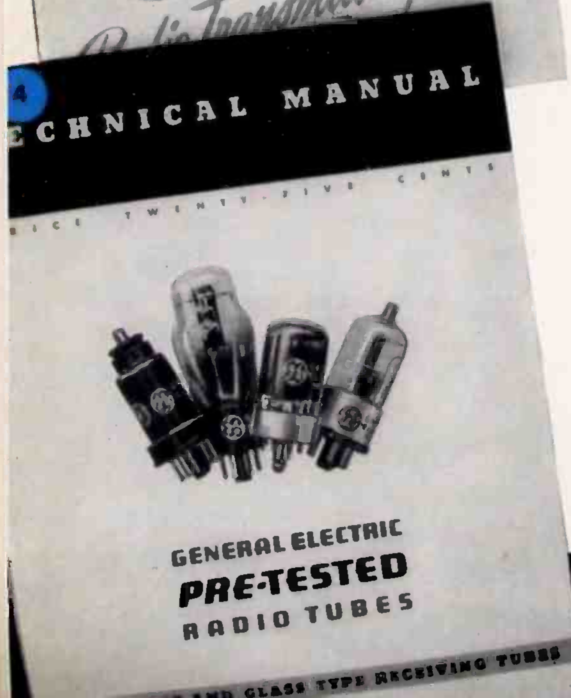


GENERAL ELECTRIC
General Installation and Operation of Kenotron Tubes



GENERAL ELECTRIC
Thyratron Tube FG-67 -- Description and Rating





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GENERAL ELECTRIC

(*Continued from page* 78)

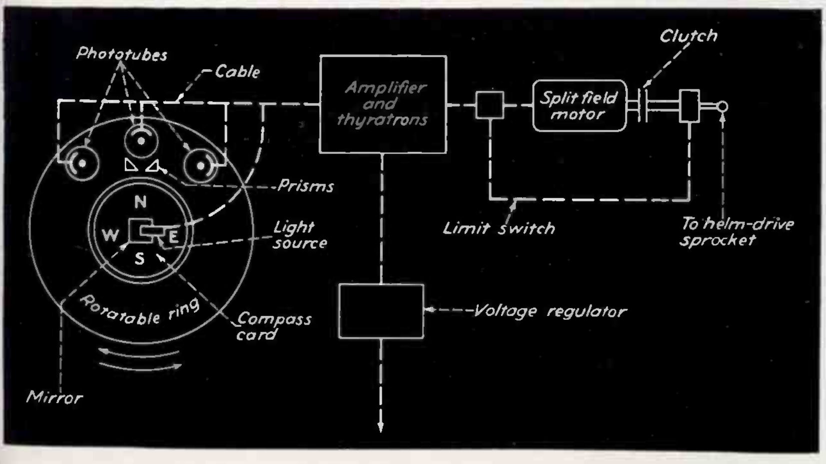
rate. The output of the amplifier is rectified and the resultant d.c. keeps the warning device relay open in the usual manner until the light beam is broken.

The warning device relay is held open only when the receiving unit phototube receives light modulated at the prescribed frequency. Light which is unmodulated or light that is modulated at other than the prescribed frequency, such as that from amps powered by 60 cycle lines, does not paralyze such systems as they are not affected by reasonable variations in light intensity.—MacDonald, ELECTRONICS, February, 1942, p. 38.

Automatic Ship-Steering Device

NO MATTER HOW perfectly designed, ship set upon a given compass urse will not exactly hold that ourse with the tiller lashed down or he steering wheel locked. The helmsman must continuously correct off-ourse variations caused by the ction of sea or wind upon hull and udder if the desired course is to be made good. Continuous correction may be accomplished automatically, ne device designed for this purpose canning the ship's compass card hotoelectrically and using off-course movement of the card to initiate movement of the rudder in a compensating direction.

The compass card carries a mirror which reflects a beam of light rom a source directly above it to a ystem of prisms and phototubes. When the ship is on her set course he middle phototube is illuminated and this phototube's output current renders automatic steering mechanisms inoperative. A deviation in course throws the light into one of the phototubes to the side of center and the output current of the phototube so illuminated actuates an electronic amplifier which trips a thyratron that operates a split-field motor in the direction necessary to move the rudder so that the ship is brought back on course. When the light shines on the middle phototube, denoting return to the desired course, the automatic mechanism is rendered inoperative until the ship yaws again. —Chance, ELECTRONICS, June, 1939, p. 41.



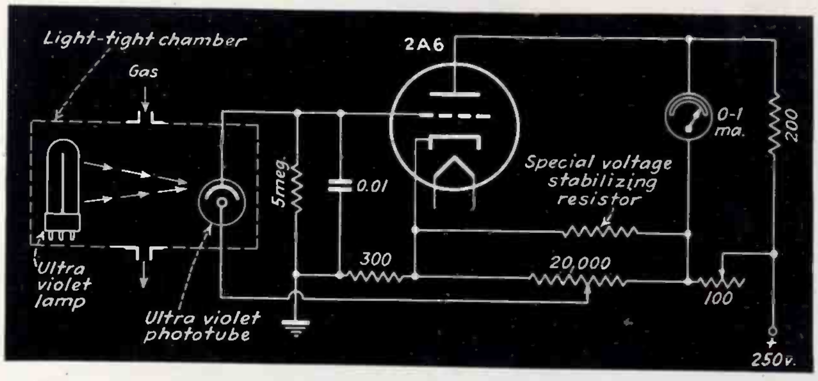
Automatic ship-steering device. When the ship yaws off a set course the light beam illuminates one of the side phototubes, causing the split-field motor to move the rudder in a compensating direction

Mercury Vapor Detector

THE PRESENCE OF SMALL quantities of mercury vapor in air or other gasses may be detected photoelectrically. If, for example, a phototube sensitive to ultraviolet light is exposed to light from an ultraviolet lamp the presence of mercury vapor in the space intervening between phototube and lamp will decrease phototube output because of scattering of the light. This measurement principal is industrially useful since it permits mercury vapor boilers and mercury vapor turbines to be adjusted so that a minimum of expensive mercury goes up the flue.

The device uses a Wheatstone bridge circuit, the 2A6 amplifier tube constituting one arm of the bridge. It is adjusted for operation by balancing the meter to zero through variation of the 100 ohm resistor with the lamp operating and the air intervening between lamp and phototube clear of Hg and then, with the lamp turned off, varying the 20,000 ohm resistor until the meter reads full scale.

In operation after such adjustment, Hg vapor between lamp and phototube causes a reduction of transmitted ultraviolet light, a reduction of phototube current, less negative bias on the grid of the 2A6, more plate current and a meter reading comparable with the quantity of mercury vapor in the air or gas.—Woodson, *Review of Scientific Instruments*, October, 1939, p. 308.



The uv lamp and uv phototube in this mercury vapor detector are placed at opposite ends of a chamber excluding external light. Gas to be checked is introduced into the chamber

Dew-Point of Gas Measured by Photoelectric Method

THE INTENSITY OF A light beam after it passes through a film of moisture condensate on the surface of a glass window or mirror is considerably less than if the moisture is not present. This principal is used in the design of a dew-point recorder used by the Colorado Interstate Gas Co., at the Denver metering plant where natural gas arrives from Texas. The purpose of this instrument is to determine the amount of moisture present in the gas and to remove some of it by

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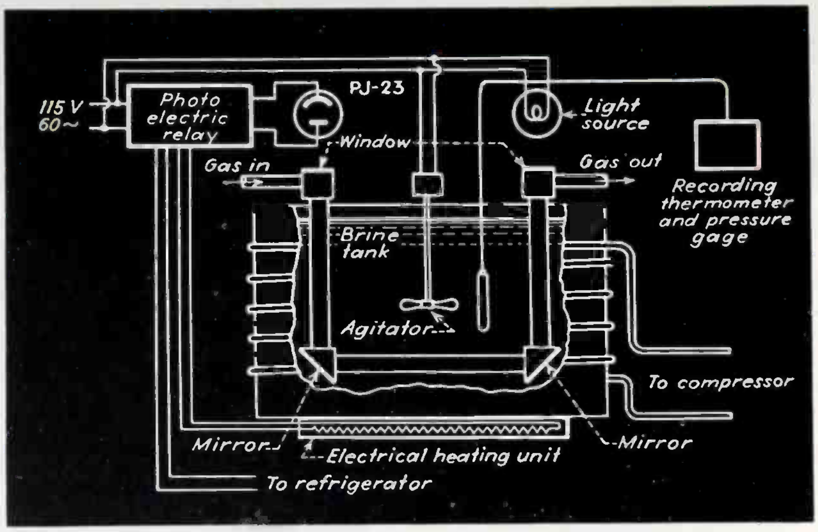


The gas in the U-shaped tube is alternately cooled just below and heated just above the dew-point by cooling coils and an electric heater controlled by a phototube relay which is operated by a light beam whose intensity is decreased by the presence of condensed moisture

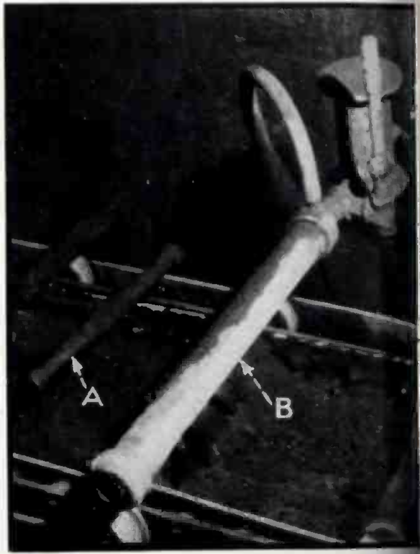
dehydration if there is any danger of the moisture condensing and freezing.

A continuous flow from a bypass valve in the main line passes through a U-shaped tube which has a plate glass window at the top of each side of the U, glass mirrors at the square corners of the U as shown. The interior of the tube is gold plated and highly polished. A light source is located above one window and a phototube (type PJ-23) is located above the other window. If a film of moisture can be made to condense upon the glass and gold-plated surfaces, the intensity of the light beam reaching the phototube will be reduced. This can be done by immersing the U-tube in a brine bath cooled by cooling coils connected to a refrigerating compressor. When the moisture film appears, the cooling coils are cut off and a heating unit is turned on to heat the gas and evaporate the moisture at which time the heater is turned off and the cycle repeated. Measurements on a recording thermometer whose element is located in the brine bath will indicate that the temperature changes approximately according to a sine wave. In this installation the temperature difference between the tops and bottoms of the curves is about 2 to 3 degrees. The cycle of operation is about 10 to 15 minutes. The pressure of the gas is also recorded and the dew-point can be calculated from the records of temperature and pressure.—Setter, ELECTRONICS, November 1941, p. 72.

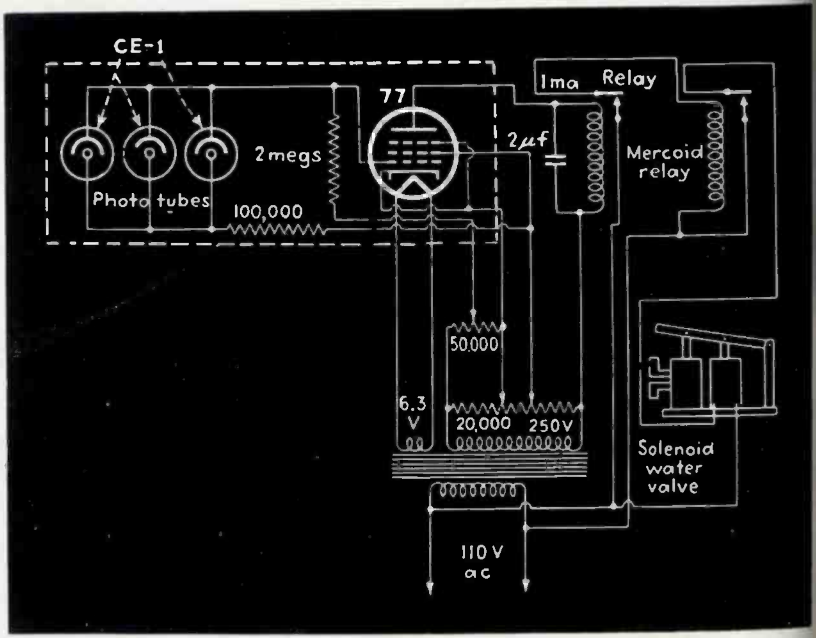
Photoelectric Cooling Control

AT THE TVA FERTILIZER WORKS phosphate ore is heated to a high temperature and crushed to sizes varying from fine dust to two inches in diameter. The phosphate must be cooled by a water spray on a moving conveyor before further processing, but if a continuous spray of water of sufficient capacity to cool the larger pieces is used, the finer and cooler material is flooded, making a mud that clogs the equipment.

The problem is to provide cooling water when it is necessary to cool large, hot pieces and to shut it of when the relatively cool smalle pieces are passing by on the conveyor. The solution is to use a phototube relay using tubes which ar sensitive to infrared heat rays to operate a solenoid water valve. Thre type CE-1 phototubes are mounte a few inches above the ore in the conveyer and a few inches ahead of th water nozzles to allow for the tim delay in the relay and valve circuit Because of the heat involved, th phototubes are mounted in a Pyre glass cylinder and a current of ai



The actual setup showing the conveyor which moves from right to left. The water spray *(A)* is mounted away from the phototubes *(B)* to permit the ore to reach it before water flows



Circuit diagram of the infrared sensitive phototube relay. The three phototubes connected in parallel are mounted within a Pyrex cylinder for protection from heat

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Inorporating requisite mechanical ruggedness with sm ll size, these RCA miniature and acorn-type tubes ha e been specifically designed for Transmitter and ot er applications where good high-frequency perfo ance must be combined with extreme portability. A ough catalogued here for the first time, the tubes have been thoroughly tested and proved, and are now being supplied for war equipment use on suitable priorities.

Complete descriptions and operating characteristics for each of the seven tubes are given in the following tabulations of technical data.

RCA-9004

U-H-F DIODE

Acorn Type (Tentative Data)

9004 is a heater-cathode type of Acorn diode suitable e as a detector, mixer, or measuring device in u-h-f circuits. resonant frequency of the 9004 is approximately 850 cycles.

ER VOLTAGE (A.C. or D.C.)	6.3	Volts
ER CURRENT	0.15	Ampere
T INTERELECTRODE CAPACITANCES:*		
te to Cathode	1.3	μμf
te to Heater	0.3 approx.	μμf
eater to Cathode	2.2 zpprox.	μμf
ALL LENGTH	$1\frac{7}{32}$" ± $\frac{5}{32}$"	
ALL DIAMETER	$1\frac{3}{32}$" ± $\frac{1}{16}$"	
	T-4½	
OCKET	Stock No. 9925	
TING POSITION	Any	

no external shield.

RECTIFIER

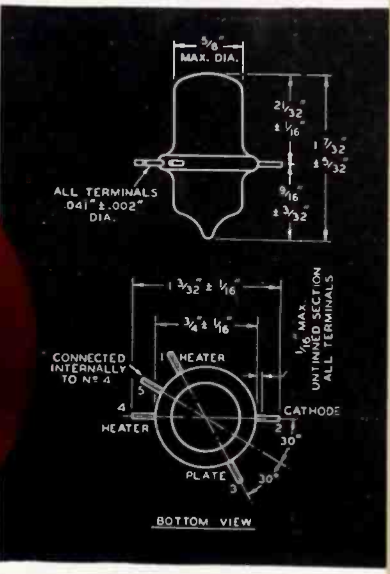
um Ratings Are Based on a Line-Voltage Design Center of 117 Volts

LATE VOLTAGE (RMS)	117 max.	Volts
UTPUT CURRENT	5 max.	Milliamperes

RCA-9005

U-H-F DIODE

Acorn Type (Tentative Data)



The 9005 is a heater-cathode type of Acorn diode suitable for use as a detector, mixer, or measuring device in u-h-f circuits. The resonant frequency of the 9005 is approximately 1500 megacycles.

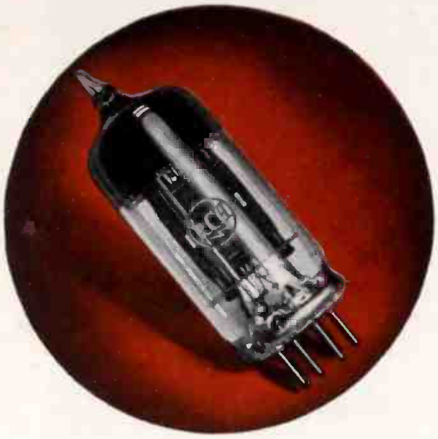
HEATER VOLTAGE (A.C. or D.C.)	3.6	Volts
HEATER CURRENT	0.165	Ampere
DIRECT INTERELECTRODE CAPACITANCES:*		
Plate to Cathode	0.8	μμf
Plate to Heater	0.2 approx.	μμf
Heater to Cathode	1.1 approx.	μμf
OVERALL LENGTH	$1\frac{7}{32}$" ± $\frac{5}{32}$"	
OVERALL DIAMETER	$1\frac{3}{32}$" ± $\frac{1}{16}$"	
BULB	T-4½	
RCA SOCKET	Stock No. 9925	
MOUNTING POSITION	Any	

* With no external shield.

RECTIFIER

Maximum Ratings Are Based on a Line-Voltage Design Center of 117 Volts

A-C PLATE VOLTAGE (RMS)	117 max.	Volts
D-C OUTPUT CURRENT	1.0 max.	Milliamperes



RCA 6C4

H-F POWER TRIODE

Miniature Type (Tentative Data)

The 6C4 is a heater-cathode type of Miniature tube intended for use as class C amplifier and oscillator in compact, light-weight, portable equipment, but it is useful in other applications where a medium-mu miniature triode with high transconductance is desired. In class C service, the 6C4 will deliver a power output of about 5.5 watts at moderate frequencies, and 2.5 watts at 150 megacycles. The heater is designed to operate at 6.3 volts, 0.15 ampere.

HEATER VOLTAGE (A.C. or D.C.)†	6.3	Volts
HEATER CURRENT	0.15	Amp.
DIRECT INTERELECTRODE CAPACITANCES:*		
Grid to Plate (Cgp)	1.6	μμf
Grid to Cathode [Cg (h + k)]	1.8	μμf
Plate to Cathode [Cp (h + k)]	1.3	μμf
MAXIMUM OVERALL LENGTH		2⅛"
MAXIMUM SEATED HEIGHT		1⅞"
MAXIMUM DIAMETER		¾"
BULB		T-5½
BASE		Miniature Button 7-Pin♦
MOUNTING POSITION		Any

* With no external shield.

A-F AMPLIFIER

PLATE VOLTAGE	300 max.	Volts
PLATE DISSIPATION	3.5 max.	Watts

Characteristics—Class A_1 Amplifier:

Plate Voltage	100	250	Volts
Grid Voltage**	0	—8.5	Volts
Amplification Factor	19.5	17	
Plate Resistance (Approx.)	6250	7700	Ohms
Transconductance	3100	2200	μmhos
Plate Current	11.8	10.5	Ma.

** The type of input coupling used should not introduce too much resistance in the grid circuit. Transformer- or impedance-coupling devices are recommended. Under maximum rated conditions, the resistance in the grid circuit should not exceed 0.25 megohm with fixed bias, or 1.0 megohm with cathode bias.

R-F POWER AMPLIFIER & OSCILLATOR—
CLASS C TELEGRAPHY

D-C PLATE VOLTAGE	300 max.	Volts
D-C GRID VOLTAGE	—50 max.	Volts
D-C PLATE CURRENT	25 max.	Ma.
D-C GRID CURRENT	8 max.	Ma.
PLATE DISSIPATION	5 max.	Watts

Typical Operation‡

D-C Plate Voltage	300	Volts
D-C Grid Voltage	—27	Volts
D-C Plate Current	25	Ma.
D-C Grid Current (Approx.)	7	Ma.
Driving Power (Approx.)	0.35	Watt
Power Output (Approx.)	5.5	Watts

‡ Approximately 2.5 watts can be obtained when the 6C4 is used at 150 Mc as an oscillator with grid resistor of 10,000 ohms and maximum rated input.

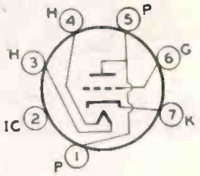
† In circuits where the cathode is not directly connected to the heater, the potential difference between heater and cathode should be kept as low as possible.

Ratings are to be interpreted according to RMA Standard M8-210 (Jan. 8, 1940 Rev. 11-40).

♦ The center hole in sockets designed for this base provides for the possibility that this tube type may be manufactured with the exhaust-tube tip at the base end. For this reason, it is recommended that in equipment employing this tube type, no material be permitted to obstruct the socket hole.

BOTTOM VIEW OF SOCKET CONNECTIONS

- Pin 1—Plate
- Pin 2—Internal Connection
- Pin 3—Heater
- Pin 4—Heater
- Pin 5—Plate
- Pin 6—Grid
- Pin 7—Cathode



RCA 1L4

R-F AMPLIFIER PENTODE

Miniature Type (Tentative Data)

The 1L4 is an r-f pentode of the Miniature type with a sharp cut-off characteristic. It is recommended for use wherever a sharp cut-off pentode is required in compact, light-weight, portable receivers. The tube is, therefore, of interest in FM receivers and other circuits not requiring avc. The 1L4 features internal shielding which eliminates the need for an external bulb shield, but a socket with shielding is essential if minimum grid-plate capacitance is to be obtained.

FILAMENT VOLTAGE (D.C.)	1.4	Volts
FILAMENT CURRENT	0.05	Amp.
DIRECT INTERELECTRODE CAPACITANCES:*		
Grid to Plate [C_{g_1p}]	0.008 max.	μμf
Input [C_{g_1} (f & g_3 & internal shield + g_2)]	3.6	μμf
Output [Cp (f & g_3 & internal shield + g_2)]	7.5	μμf
MAXIMUM OVERALL LENGTH		2⅛"
MAXIMUM SEATED HEIGHT		1⅞"
MAXIMUM DIAMETER		¾"
BULB		T-5½
BASE		Miniature Button 7-Pin♦
MOUNTING POSITION		Any

* With no external shield.

AMPLIFIER

PLATE VOLTAGE	110 max.	Volts
SCREEN VOLTAGE (Grid No. 2)	90 max.	Volts
SCREEN SUPPLY VOLTAGE	110 max.	Volts
GRID VOLTAGE (Grid No. 1)	0 min.	Volts
TOTAL CATHODE CURRENT	6.5 max.	Ma.

Typical Operating Conditions and Characteristics —Class A_1 Amplifier:

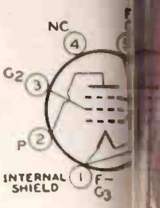
Plate Voltage	90	90	Volts
Screen Voltage	67.5	90	Volts
Grid Voltage	0	0	Volts
Plate Resistance	0.6	0.35	Meg.
Transconductance	925	1025	μmhos
Grid Bias for Plate Current =10μamp.	—6	—8
Plate Current	2.9	4.5
Screen Current	1.2	2.0

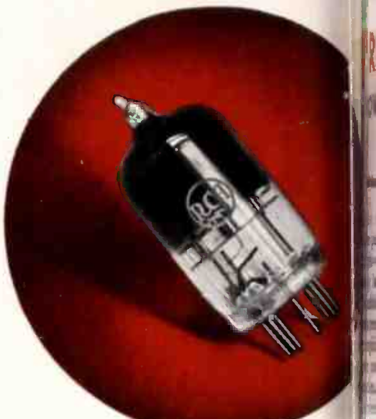
Ratings are to be interpreted according
Standard M8-210 (Jan. 8, 1940 Rev. 11-40

♦ See RCA 6C4

BOTTOM VIEW OF SOCKET CONNEC

- Pin 1—Filament (—), Grid No. 3, Internal Shield
- Pin 2—Plate
- Pin 3—Screen
- Pin 4—No Connection
- Pin 5—Filament (—), Grid No. 3, Internal Shield
- Pin 6—Grid
- Pin 7—Filament (+)





RCA 1A3

H-F DIODE

Midget Type (Tentative Data)

The 1A3 is a heater-cathode type of
diode particularly useful as a discri
tube in portable FM receivers, and
able high-frequency measuring equ
Its interelectrode capacitances are v
being in the order of 0.5 micro-micr
The resonant frequency of the
approximately 1000 megacycles. T
button base provides short leads
lead inductance.

HEATER VOLTAGE (A.C. or D.C.)	
HEATER CURRENT	0.
DIRECT INTERELECTRODE CAPACIT (Approx.):*	
Plate to Cathode (Cpk)	
Plate to Heater (Cph)	
Heater to Cathode (Chk)	
MAXIMUM OVERALL LENGTH	
MAXIMUM SEATED HEIGHT	
MAXIMUM DIAMETER	
BULB	
BASE	Miniature Butt
MOUNTING POSITION	

* With no external shield.

RECTIFIER

A-C PLATE VOLTAGE (RMS)	117 m
D-C OUTPUT CURRENT	0.5 m

Ratings are to be interpreted accordin
Standard M8-210 (Jan. 8, 1940 Rev. 11-4

♦ See RCA 6C4

BOTTOM VIEW OF SOCKET CONNE

- Pin 1—Heater
- Pin 2—Plate
- Pin 3—Cathode
- Pin 4—No Connection
- Pin 5—No Connection
- Pin 6—Plate
- Pin 7—Heater

RCA 3A4

POWER AMPLIFIER PENTODE

iature Type (Tentative Data)

is a Miniature type of power pentode designed for use in com- -weight, portable equipment. The large filament employed in the ebles it to supply the high peak nt required in r-f power applications. plifier service, the 3A4 will deliver output of about 1.2 watts at 10 cyes. The filament of the 3A4 can ted either with series connection lts or parallel connection on 1.4

	Series Filament Arrange-ment*	Parallel Filament Arrange-ment**	
VOLTAGE (D.C.)	2.8	1.4	Volts
CURRENT	0.1	0.2	Amp.
TERELECTRODE CAPACITANCES:†			
e (C_{g_1p})		0.2 max.	µµf
f & g_1 + g_2)]		4.8	µµf
(f & g_1 + g_2)]		4.2	µµf
OVERALL LENGTH			2⅛"
SEATED HEIGHT			1⅞"
DIAMETER			¾"
			T-5½
			Miniature Button 7-Pin♦
G POSITION			Any

external shield.

A-F POWER AMPLIFIER

LTAGE	150 max.	Volts
OLTAGE	90 max.	Volts
SIPATION	2 max.	Watts
SSIPATION	0.4 max.	Watt
RO-SIGNAL HOE CURRENT††	18 max.	Ma.

perating Conditions and Characteristics —Class A_1 Amplifier‡

	Parallel Filament Arrangement**		
olte	135	150	Volts
age (Grid No. 2)	90	90	Volts
e (Grid No. 1)	−7.5	−8.4	Volts
rid Voltage	7.5	8.4	Volts
Plate Current	14.8	13.3	Ma.
Plate Current	14.9	14.1	Ma.
Screen Current	2.6	2.2	Ma.
Screen Current	3.5	3.5	Ma.
esance	90,000	100,000	Ohms
ctance	1900	1900	µmhos
esance	8000	8000	Ohms
onic Distortion	5	6	%
Power Output	0.6	0.7	Watt

R-F POWER AMPLIFIER

VOLTAGE	150 max.	Volts
N VOLT. (Grid No. 2)	135 max.	Volts
VOLT. (Grid. No. 1)	−30 max.	Volts
CURRENT	20 max.	Ma.
CURRENT	0.25 max.	Ma.
CATH. CURRENT††	25 max.	Ma.
UT	3 max.	Watts
PUT	0.9 max.	Watt
SIPATION	2 max.	Watts

Typical Operation‡

	Parallel Filament Arrangement**	
D-C Plate Voltage	150	Volts
D-C Screen Voltage	135	Volts
Grid Resistor	0.2	Meg.
D-C Plate Current	18.3	Ma.
D-C Screen Current	6.5	Ma.
D-C Grid Current	0.13	Ma.
Power Output (Approx.)	1.2	Watts

* Filament voltage applied across the two sections in series between pins No. 1 and No. 7. Grid voltage is referred to pin No. 1.

** Filament voltage applied across the two sections in parallel between pin No. 5 and pins No. 1 and No. 7 connected together. Grid voltage is referred to pin No. 5.

†† For series-filament operation, a shunting resistor must be connected across the section between pins No. 1 and No. 5 to by-pass excess cathode current in this section. The value of the shunting resistor should be adjusted to make the voltage across the shunted section equal to the voltage across the section between pins No. 5 and No. 7. When other tubes in series-filament arrangement contribute to the filament current of the 3A4, an additional shunting resistor may be required between pins No. 1 and No. 7.

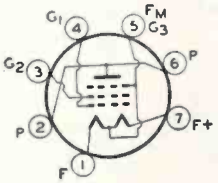
‡ Typical operating values for the 3A4 with filament sections in series will be approximately the same as those shown for parallel-filament operation.

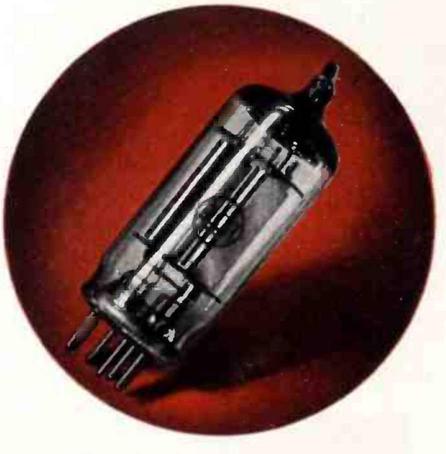
Ratings are to be interpreted according to RMA Standard M8-210 (Jan. 8, 1940 Rev. 11-40).

♦ See RCA 6C4

BOTTOM VIEW OF SOCKET CONNECTIONS

Pin 1—Filament (— for series operation)
Pin 2—Plate
Pin 3—Screen
Pin 4—Grid
Pin 5—Filament Mid-Tap (— for parallel operation), Grid No. 3
Pin 6—Plate
Pin 7—Filament (+)





RCA 3A5

H-F TWIN TRIODE

Miniature Type (Tentative Data)

The 3A5 is a twin triode of the Miniature type intended for use in high-frequency applications. The relatively large filament employed in the 3A5 enables it to supply the high peak currents required in r-f power applications. In class C service, a 3A5 with its units in push-pull will deliver a power output of approximately 2 watts at 40 megacycles. It may be used at still higher frequencies with reduced efficiency. Each triode may be used independently of the other. The filament of the 3A5 can be operated either with series connection on 2.8 volts or parallel connection on 1.4 volts.

	Series Filament Arrange-ment*	Parallel Filament Arrange-ment**	
FILAMENT VOLTAGE (D.C.)	2.8	1.4	Volts
FILAMENT CURRENT	0.11	0.22	Amp.
DIRECT INTERELECTRODE CAPACITANCES:†			
	Triode Unit T_1	Triode Unit T_2	
Grid to Plate (Cgp)	3.2	3.2	µµf
Grid to Filament (Cgf)	0.9	0.9	µµf
Plate to Filament (Cpf)	1.0	1.0	µµf
Plate to Plate ($C_{pt_1pt_2}$)	0.32		µµf
MAXIMUM OVERALL LENGTH			2⅛"
MAXIMUM SEATED HEIGHT			1⅞"
MAXIMUM DIAMETER			¾"
BULB			T-5½
BASE			Miniature Button 7-Pin♦
MOUNTING POSITION			Any

† With no external shield.

A-F AMPLIFIER—Each Unit

PLATE VOLTAGE	135 max.	Volts
PLATE CURRENT	5 max.	Ma.
PLATE DISSIPATION	0.5 max.	Watt

Characteristics—Class A_1 Amplifier

Plate Voltage	90	Volts
Grid Voltage	−2.5	Volts
Amplification Factor	15	
Plate Resistance	8300	Ohms
Transconductance	1800	µmhos
Plate Current	3.7	Ma.

R-F POWER AMPLIFIER & OSCILLATOR— CLASS C TELEGRAPHY

D-C PLATE VOLTAGE	135 max.	Volts
D-C GRID VOLTAGE	−30 max.	Volts
D-C PLATE CURRENT (per unit)	15 max.	Ma.
D-C GRID CURRENT (per unit)	2.5 max.	Ma.
PLATE INPUT (per unit)	2.0 max.	Watts
PLATE DISSIPATION (per unit)	1.0 max.	Watt

Typical Operation at 40 Mc with Both Units:
Push-Pull Power Amplifier & Oscillator
(Key-down conditions per tube without modulation)

D-C Plate Voltage	135	Volts
D-C Grid Voltage		
From a fixed supply of	−20	Volts
From a grid resistor of	4000	Ohms
From a cathode resistor of	570	Ohms
Peak R-F Grid-to-Grid Voltage	90	Volts
D-C Plate Current	30	Ma.
D-C Grid Current (Approx.)	5	Ma.
Driving Power (Approx.)	0.2	Watt
Power Output (Approx.)	2	Watts

* Filament voltage applied across the two sections in series between pins No. 1 and No. 7. Grid voltage is referred to pin No. 1. For series-filament operation, a shunting resistor must be connected across the section between pins No. 1 and No. 4 to by-pass excess cathode current in this section. The value of the shunting resistor should be adjusted to make the voltage across the shunted section equal to the voltage across the section between pins No. 4 and No. 7. When other tubes in series-filament arrangement contribute to the filament current of the 3A5, an additional shunting resistor may be required between pins No. 1 and No. 7.

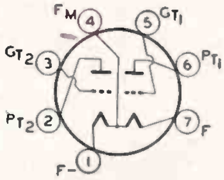
** Filament voltage applied across the two sections in parallel between pin No. 4 and pins No. 1 and No. 7 connected together. Grid voltage is referred to pins No. 1 and No. 7 tied together.

Ratings are to be interpreted according to RMA Standard M8-210 (Jan. 8, 1940 Rev. 11-40).

♦ See RCA 6C4

BOTTOM VIEW OF SOCKET CONNECTIONS

Pin 1—Filament (—)
Pin 2—Plate (Triode T_2)
Pin 3—Grid (Triode T_2)
Pin 4—Filament Mid-Tap (+ for parallel operation)
Pin 5—Grid (Triode T_1)
Pin 6—Plate (Triode T_1)
Pin 7—Filament (+ for series operation)



RCA MANUFACTURING CO., INC.
CAMDEN, NEW JERSEY

(NOTE: For additional copies of literature on these tubes, address RCA, Commercial Engineering Section, Harrison, N. J.)


SPECIAL PURPOSE TUBE DATA

is blown past them. Because of the dust conditions prevalent at ore treating plants, the relay is placed in a dust-proof glass container.

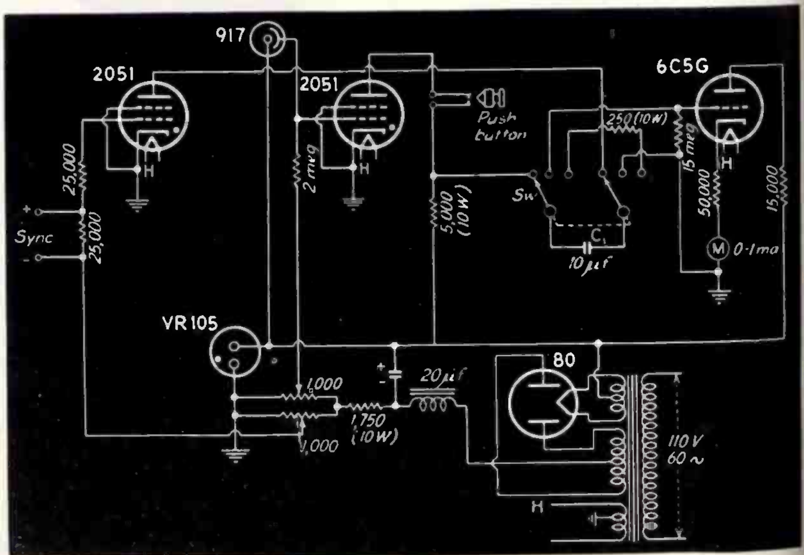
The sensitive relay has a drop-out current which is about 80 percent of its take-up current. The circuit may be adjusted to operate at any desired radiant heat by adjustment of the amplifier grid bias control (50,000-ohm potentiometer).—Ewald, ELECTRONICS, November, 1941, p. 55.

Photoflash Synchronizer Tester

TYPICAL FLASHLAMPS used in photography reach peak brilliancy 20 milliseconds after filament voltage is applied. Synchronizing devices must open the camera shutter in that short space of time if maximum illumination and film exposure are to coincide. A convenient instrument for determining the time required for a shutter to open measures it in terms of voltage attained by a condenser charging from a steady source of potential during that period.

A beam of light from a steady external source is directed into the type 917 phototube. The camera shutter to be actuated by the synchronizer is interposed in this beam of light. The input terminals of the testing device are substituted for the flashlamp, which is not used, in such a manner that when the synchronizer switch is closed the battery within the synchronizer is connected to the input terminals.

When the synchronizer switch is closed the negative bias applied to the control grid of the first type 2051 thyratron is reduced, causing this tube to conduct. Anode circuit capacitor C_1 starts to charge and continues to charge until the camera shutter blocking off the light beam opens. When the shutter opens the output of the phototube trips the second 2051, which reduces the voltage applied to the anode of the first thyratron by an amount equal to the drop in resistor R_1 sufficient to stop conduction in the first 2051. The capacitor is left with a definite charge, which may then be measured by means of the 6C5G tube connected as a vacuum tube voltmeter calibrated in milliseconds. — Marsal, ELECTRONICS, January, 1942, p. 34.

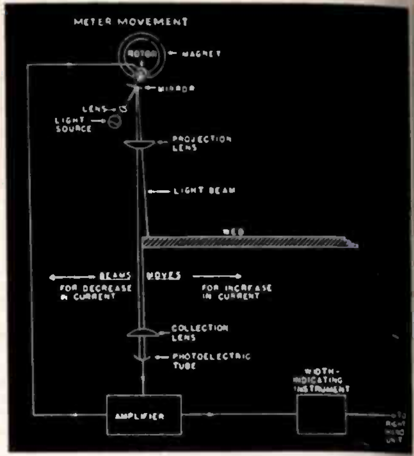


Photoflash synchronizer tester designed to measure the elapsed time between closing of the switch and opening of the camera shutter

Width Gage for Moving Webs

THE WIDTH OF A continuously moving sheet or web of material may be measured during manufacture or processing even where the web shifts slightly from side to side while passing through the fabricating or finishing machine. One measurement system involves photoelectric scanning of each edge of the material, with mechanical movement of the web itself controlling the quantity of light transmitted and causing the beams to follow the material edges as they shift.

Considering one of the two scanning units involved, a light source is focussed upon a mirror fastened to the moving coil of a meter. The light is reflected by the mirror past the edge of the material into a phototube, the initial adjustment permitting the edge of the material to partially cut off the beam. The output of the phototube is fed into an amplifier and the output of the amplifier drives the meter carrying the mirror. Reduction in transmitted light by movement of the web deeper into the light beam changes the mirror angle and causes the beam to move away from the edge of the web until the initial condition of balance is restored. Movement of the web away from the light beam, conversely, increases the light received by the phototube and the meter moves the mirror in such a manner that the beam follows the edge.



Width gage for moving webs. Two scanning devices are needed, one at each edge. Their outputs are combined in an electronic totalizer and indicator

The output of the scanning devices at either edge of the sheet or web is combined in an electronic totalizing and indicating device. The indicating device may be calibrated in terms of width despite lateral shifts in the web as, with constant web width, the output of one amplifier declines while that of the other amplifier rises and vice versa, depending upon which way the web shifts. If the width of the measured web remains constant, in other words, shifts from side to side simply add current to the detector on one side and subtract a like amount from the other side, with the net result that there is no change in the position of the indicator. Increasing current indicates increased web width while decreasing current indicates decreasing web width as, under these conditions, amplifier output is additive or subtractive.—Alexander, ELECTRONICS, January, 1942, p. 66.

* Cinch tube holders maintain tubes rigidly, an effective guard against shocks that distort reception. The added protection of the tube holder is a precaution when "*every* signal must be caught". Made of high quality spring steel, Cinch tube holders as illustrated are inexpensive and simple units for locking tubes in their sockets. "They're the Clincher".

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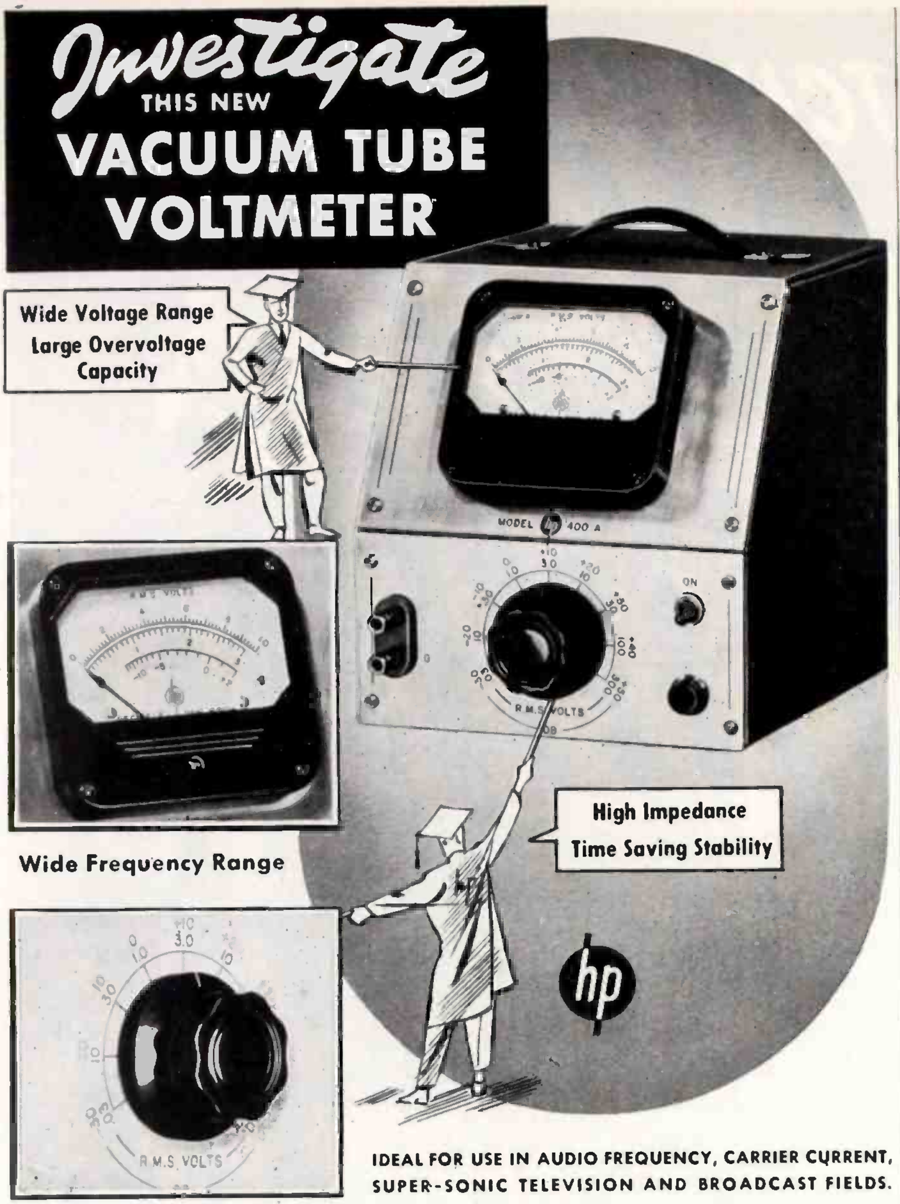
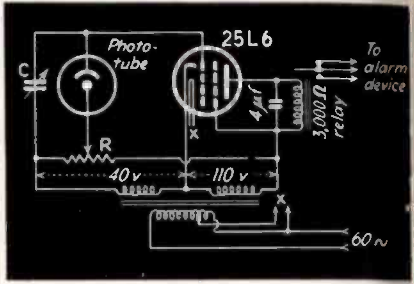


Static Beam Photoelectric Alarm

THE FIGURE SHOWS the schematic of a simple static beam photoelectric alarm device. Light from a distant source is directed across the area to be protected into the phototube. D-c output of the phototube is amplified by the 25L6 and holds a signalling device relay closed so long as the light is uninterrupted by an intruder.



Simple static beamelectric alarm circuit. The 25L6 amplifier phototube self-rectifies its own operating potentials

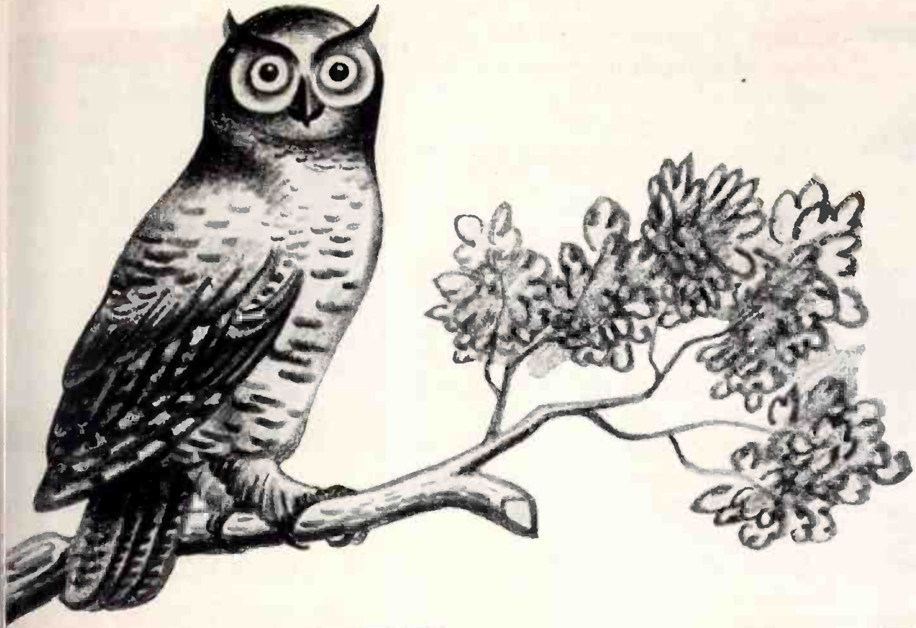
Capacitor *C* provides a timing adjustment, the length of time required to discharge this capacitor when the beam is interrupted determining the speed with which the device operates. Resistor *R* is a sensitivity adjustment, permitting the bias on the 25L6 to be varied to suit the amount of light impinging upon the phototube.

In this elemental example d-c potentials required for the operation of the amplifier are obtained through self-rectification of applied a.c. by the 25L6 itself. A majority of static beam alarm devices now being made have d-c powerpacks supplying required operating potentials to the amplifier tube or tubes.—MacDonald, ELECTRONICS, February, 1942, p. 38.

Optical Filter Tester

LIGHT LOST IN TRANSMISSION through an optical filter may be measured by the following method:

A light source of constant intensity is focused upon a phototube. The phototube operates into an a-c amplifier driving a cathode-ray oscilloscope provided with a 60-cps sinusoidal sweep. An opaque disc or wheel in which there are two apertures directly opposite each other, one aperture containing the filter and the other left open, is placed in the path of the light beam



"KNOW-HOW"

Just as important to many customers as the quality of IRC fixed and variable resistors itself is the "Know-How" of resistor usage that IRC specialized experience makes available.

This "Know-How" is designed into IRC products. It is a big part of IRC customer service. It avoids mistakes in resistor specifications and orders. It simplifies matters of inspection and priorities. It clarifies many special technical problems. Above all, it means invaluable help in selecting the right resistor for the job—chosen without bias as to type from a line sufficiently broad to cover practically every requirement.

For the solution of a large number of the problems confronting the designing engineer, IRC has prepared the Resistor Chart which is yours for the asking. However, many special problems frequently arise requiring the "Know-How" of a trained staff of resistor engineers, which IRC has available.

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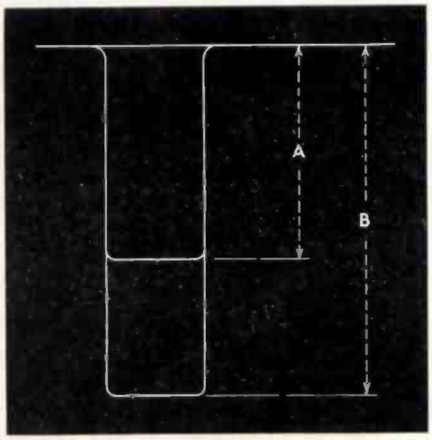
in such a manner that the light shines alternately through the two apertures when the disc is rotated by a motor running at 1800 r.p.m.

Since such a disc revolves at 30 rps and there are two openings in the disc light will reach the phototube once each 60th second. A pattern similar to the one shown will be observed on the oscilloscope screen, the distance *B* indicating the amount of light reaching the phototube directly and the distance *A* indicating the amount of light reaching the phototube through the filter. Thus the ratio *A*/*B* represents the percentage light passing through the filter.

If the wavelength of maximum transmission is desired, this may be determined by passing the light from the source through a prism before passing it through the disc apertures. Angular movement of the prism will permit the wavelength of the light transmitted to the phototube to be varied.—Seeley and Anderson, *Review of Scientific Instruments*, August, 1941, p. 392.



Cathode-ray oscilloscope pattern showing the relationship between light passed directly to a phototube and light passed to the phototube through an optical filter. *B* represent light transmitted directly and *A* light transmitted through the filter

Oil Hole Inspector

AUTOMATICALLY INSPECTING one shackle bolt per second, a photoelectric machine determines that oil holes drilled longitudinally through the bolts exactly meet other oil holes drilled into the bolt centers from the sides.

A beam of light is reflected from a mirror into the longitudinal hole while a bolt is revolved one complet turn by a rubber-tired driving wheel If the quantity of light at which th device is calibrated fails to reach phototube mounted adjacent to th side hole during some portion of thi cycle, indicating imperfect alignment or a block, the bolt is automatically rejected by an electromechanical mechanism. — Power ELECTRONICS, September, 1939, p. 54

Photoelectric oil-hole inspector

Articulated Weighing Scale

WEIGHING SCALES FREQUENTLY used to indicate one specific weight may be made to actuate an audible or visible signal when that weight i reached.

A small hole is drilled through th face of the scale at a position corresponding to the weight to be indicated. A light source is mounte in front of the hole and a phototub is placed back of the hole in such manner that the beam of light i interrupted by the pointer or by flag attached to the pointer whe this weight is reached. The outpu of the phototube is amplified and when interrupted, operates a rela which energizes the selected signa device.

The advantage of the electroni method of control in this instance is the fact that no error-producing load is introduced in the mechanism of the scale by the articulating device.

Editor's note — This hole-in-the scale device is widely used with phototubes for controlling mechanical or electrical quantities.—Kro Scale Co., ELECTRONICS, January 1942, p. 60.


Hytron's newly acquired "Sunshine Plant" at Newburyport, Massachusetts

HYTRON now has QUADRUPLED space for war production

Hytron REMEMBERS PEARL HARBOR—Wake Island—Bataan—Corregidor. As its contribution to the swelling tide of production which will equip the nation with an overwhelming flood of war materials to avenge these temporary defeats, Hytron is developing at top speed the productive capacity of its new plant at nearby Newburyport. The new factory is so large that it could easily accommodate on one floor the entire Salem plant. In this appropriately-named radio war, Hytron's quadrupled facilities will play an important part in the production of vital electronic tubes to be used in making the enemy remember with regret his mistake in attacking the United States.

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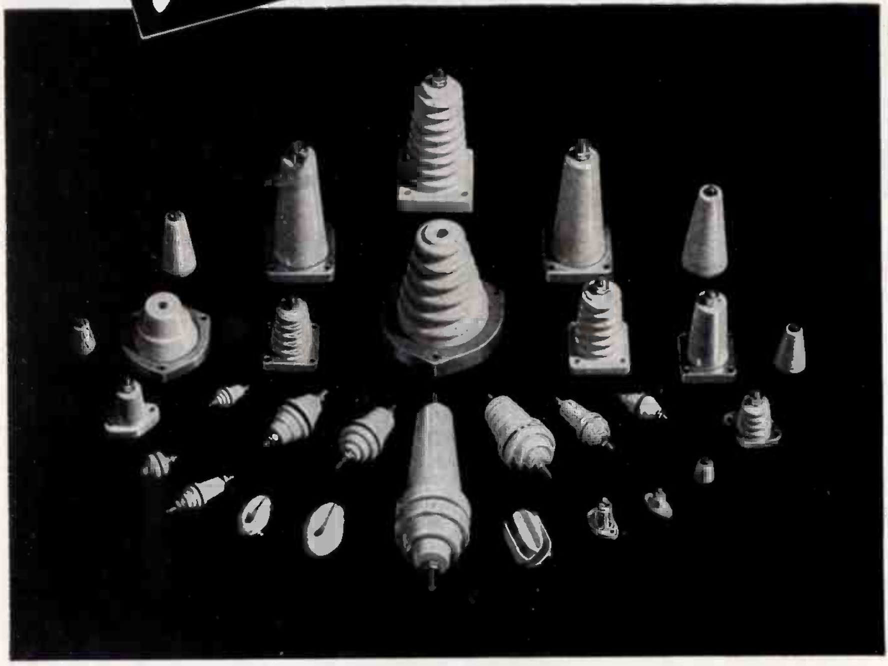
Hytron's Plant at Salem



Measurement of Turbidity in Liquids

THE TURBIDITY OF ALMOST clear sol tions can be measured by the exte to which a light beam is disperse by the suspended particles. By th use of proper filters, colored sol tions can also be measured. T method is to pass a collimated lig beam through two grids consistin of alternate bars and open spac with the sample and a lens syste between them. The grids must b machined very accurately so that th two units are of the same dimensio and so that the bars and the ope spaces are of the same size. Aft the light beam passes through th first grid it consists of several bean which are rectangular in cross se tion. A pair of 4-inch objective lens is mounted in a slide for focussin

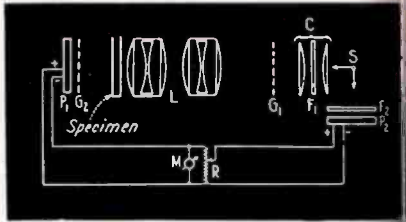


Diagram of the circuit and optical syste of the photoelectric turbidimeter

The lens system is adjusted so tha the light beam has unity magnific tion on the second grid. The secon grid is positioned so that the re tangular portions of the light bea fall on the bars. Thus, no light ge past the second grid, except tha which results from imperfect m chining of the grids. Beyond the se ond grid is a barrier type photoc to detect any light. Another phot cell is located near the light sour as shown in the diagram and co nected to a potentiometer acros which are connected the first phot cell and a microammeter. This is fo the purpose of balancing out an light getting past the second grid.

When a liquid sample is placed be tween the two grids as shown, an suspended particles cause a dispers of the light and permits it to pas through the openings of the secon grid to the photocell where it is co verted into electrical energy fo measurement.—Silverman, *Revie of Scientific Instruments*, Februar 1941 (ELECTRONICS, April, 1941, p 100).

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Daylight Measurement of Cloud Heights

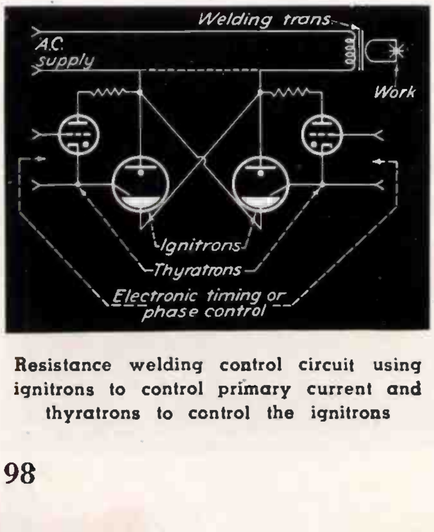
THE HEIGHT OF CLOUDS above ground level is of utmost importance to aircraft operators and can be measured in daylight by means of a modulated light beam pointed vertically at the cloud, and a photoelectric detector unit and amplifier. The light source is an a-c operated high intensity mercury vapor lamp operated on 60-cps power. The modulation of the beam is about 95 percent and has a frequency of 120 cps. The detector system includes a lens system designed to pick up a cloud area no larger than that illuminated by the light beam to reduce the background light to a minimum. A type 929 phototube is used and its current is amplified by a five stage resistance-capacitance amplifier tuned to 120 cps. In practice, the base of the cloud is scanned by the detector until the output meter indicates that the light signal is being received. The computation of cloud height is a simple trigonometric problem making use of a known base line and one angle of a right triangle to determine the vertical leg, or height of the cloud.—*Electrical Engineering*, May 1941.

Stimulus—Electrical

(*Continued from page 74*)

electronic control equipment is inserted in series with this lead. The control comprises two ignitron tubes connected in such a manner that primary current flows through one tube on one half cycle and through the other tube on the other half cycle. When the ignitrons are conducting, circuit operation is precisely the same as outlined above. It will be obvious, however, that welding current may be started and stopped by starting and stopping ignitron conduction, using the ignitrons as an "electronic switch." It will also be apparent that the ignitrons may be used as an "electronic rheostat" if some means of causing them to fire at controllable points along each half cycle of a.c. is employed.

One method of controlling the ignitrons and thus controlling welding time or welding current or both is to connect thyratron tubes between ignitron anodes and igniters as shown. The thyratrons may be controlled by means of any conventional electronic timing circuit or by phase-shift methods described elsewhere in this issue and will, in turn, control the points along each half cycle at which associated ignitrons fire. No special provision for stopping ignitron current flow is required in this circuit as the tubes automatically cease conduction on half cycles of a.c. during which their anodes are negative with respect to their cathodes.—GENERAL ELECTRIC COMPANY, Instruction Manual.



Resistance welding control circuit using ignitrons to control primary current and thyratrons to control the ignitrons

Motor Reversal and Speed Control

THE DIRECTION OF rotation and the speed of d-c motors may be controlled by means of the circuit shown. The motor field is operated from any suitable d-c source. Alternating current is applied to the motor field in series with two thyratron rectifiers connected "back to back." The thyratrons employed here are cut off unless their grids are made positive with respect to their cathodes. Throwing the control switch to the left makes the grid of thyratron *A* positive and that tube conducts. Half waves of current pass through the motor armature in one direction and the motor operates. Throwing the control switch to the right causes tube *B* to fire and the motor direction reverses.

If a variable inductance is included in the center arm of the control switch, as drawn, it will be possible to control motor speed as well as the direction of motor rotation. Varying the inductance shifts the phase of voltage applied to the thy-

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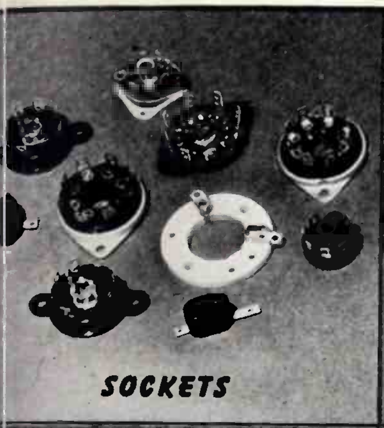
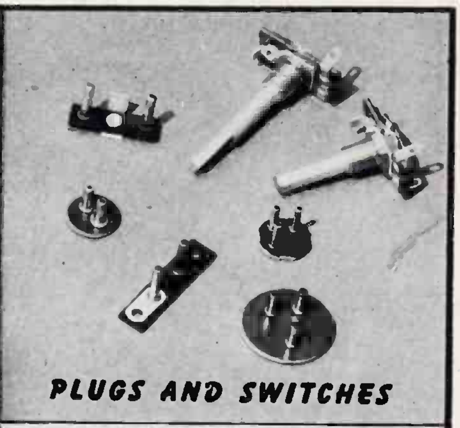
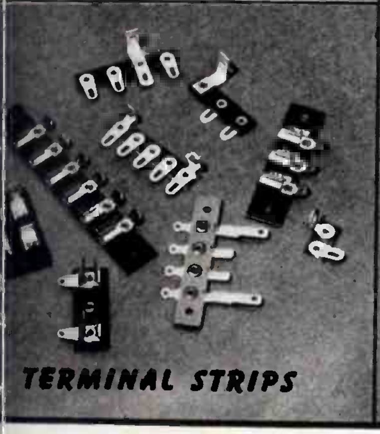


SOCKETS

METAL STAMPINGS



PLUGS AND SWITCHES



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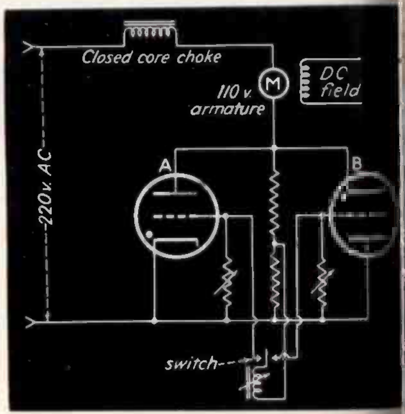
ratron grids so that the conductin tube rectifies during part rather tha all of a half cycle. Latitude of spee control is increased if the thyratro grid resistors are made variable.

Rapid motor braking may b achieved by using a control switc whose center arm normally contact both grid return circuits. In thi case both thyratrons fire alternatel with the result that full wave a.c. applied to the motor field. Inertia the armature rotor will be sufficier to stop "hunting" by the motor the polarity of voltage applied to th field changes. The closed core chok in series with the a-c supply is i cluded to reduce current flowi through the armature when the m tor is held at a standstill, saturati of the core of the choke reducing i inductance and avoiding serious vol age drop when the motor is operat The fact that current flows in th



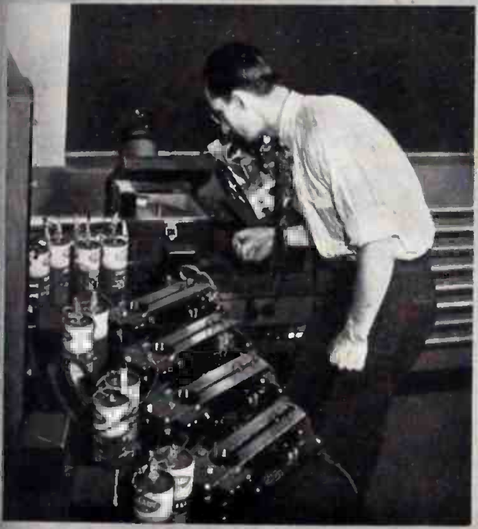
Direct-current motor control circuit. permits the direction of rotation to be re versed, provides variable speed adjus ment and lends itself to rapid moto braking

motor armature only on half cyc requires that the a-c supply have a proximately twice the voltage r quired by the armature to compe sate the voltage drop in the recti ing system.—Ryder, ELECTRONI December 1938, p. 20.

High Speed Stroboscop Light Source

A COOPER-HEWITT mercury vap lamp may be used as a source of hig speed stroboscopic light for the o servance or photographing of recu rent or transient phenomena. Th circuit shown in simplified form pr vides control of timing and brillian

TWO PARTS PER MILLION



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

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

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

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

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

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

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

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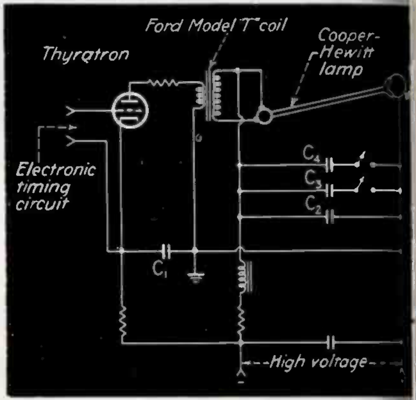
The thyratron tube is triggered a the rate required to "stop" motio of the observed subject by an electronic voltage pulse generator suc as a relaxation oscillator. When th grid of the thyratron goes positiv with respect to its cathode the tub fires and capacitor C_1 discharge through the transformer primary producing an extremely high voltag in the transformer secondary. Thi voltage appears as an electrostati potential between the mercury an shield of the lamp and ionizes mercury vapor in one corner of the lamp



A Cooper-Hewitt mercury vapor lamp connected in the circuit shown makes a good high speed stroboscopic light source. A lamp that has been retired from regul illuminating service because of starting difficulty will fire satisfactorily in thi circuit

The high voltage power supply connected across the ends of the lam causes further ionization and capacitor C_2 discharges through the Cooper-Hewitt. Additional brilliancy may b obtained by closing one or bot switches, connecting C_3 and C_4 i parallel with C_2. The associated electronic timing circuit regains contr of the thyratron by swinging th thyratron grid sharply negative soo after C_1 discharges, at which tim the anode voltage is at a minimum —Street, ELECTRONICS, April, 1940 p. 36.

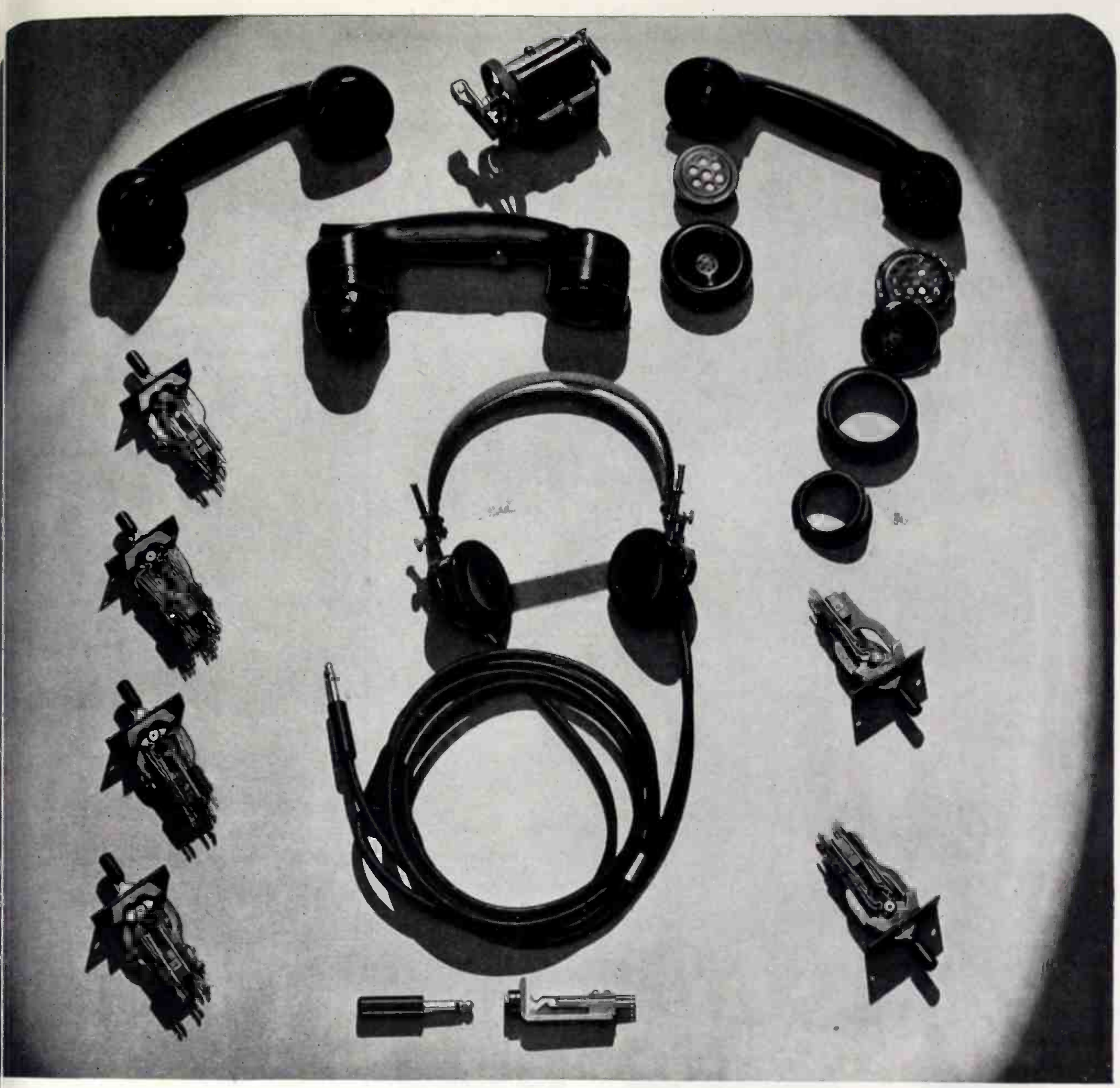
Stimulus-Physical or Chemical

(*Continued from page 76*)

Motor Speed Checker

THE SPEED OF SMALL motors may b determined under conditions approximating no-load by the method shown in the diagram.

A small metal fitting, *A*, is fastened



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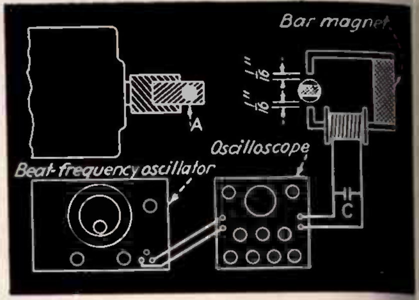


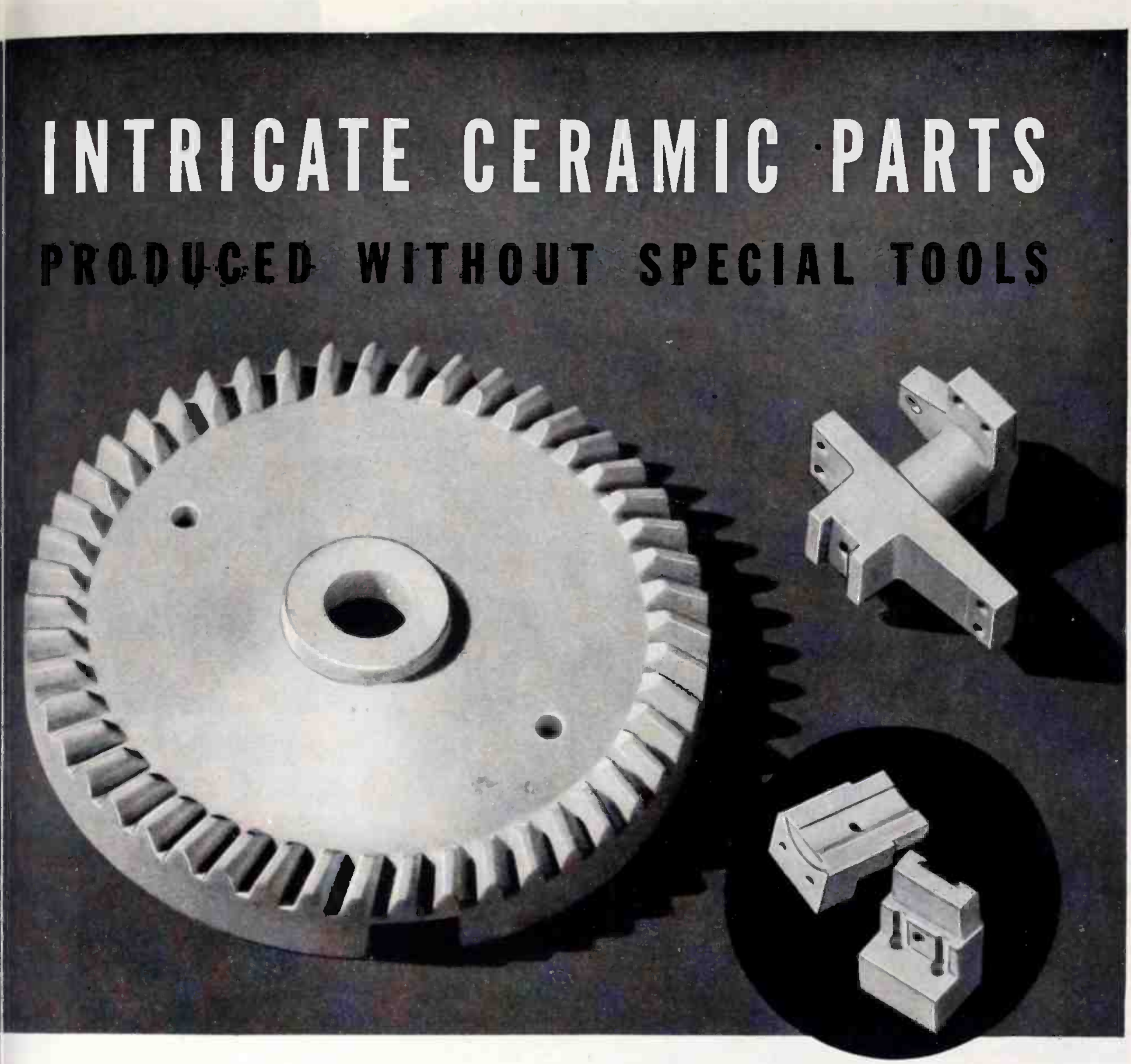
Set-up for measuring the speed of small motors without introducing a load in the measurement process

to the motor shaft and acts as the rotor element of an a-c generator. The frequency of the a.c. generated in the coil surrounding the magnet of the generator is directly proportional to the speed of the motor and can be used as the basis of a comparison measurement. The output of the coil is connected to the vertical deflection plates of a cathode-ray oscilloscope, while the horizontal plates lead to a beat-frequency oscillator whose frequency calibration may be marked directly in rpm. The beat frequency is adjusted until the pattern formed on the oscilloscope is a simple ellipse, which is the Lissajous figure indicating that the two oscilloscope input frequencies are the same.

The a-c generator does not produce a true sine-wave but the harmonics introduced may be attenuated by the capacitance *C*, connected across the generator output.—Clough Brengle, ELECTRONICS, October, 1939, p. 47.

Temperature Control

A CONTROL FOR maintaining the temperature of any enclosed chamber within a few thousandths of a degree has been developed in the laboratories of the Shell Development Co. It uses a resistance thermometer controlling a thyratron tube through a phase-shifting network. The resistance changes with temperature and therefore is useful for converting a temperature change into a voltage change the thermometer is located in the chamber and is connected in a Wheatstone bridge circuit to which is applied a 60-cps voltage. When the bridge is balanced the temperature is at the desired point and nothing happens. If, however, the temperature falls below the



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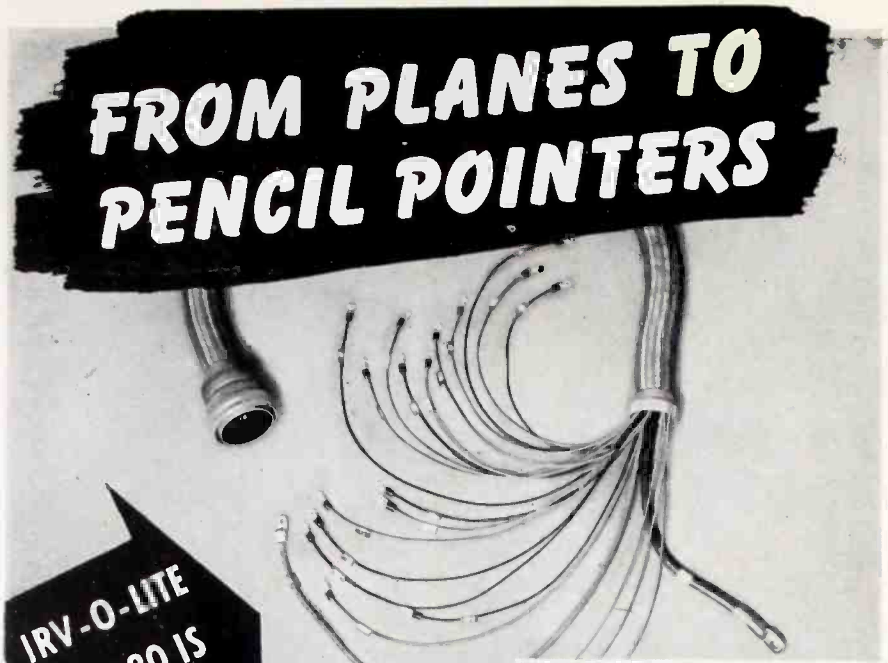

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XTE-30 Tubing used in wiring systems on prominent planes.

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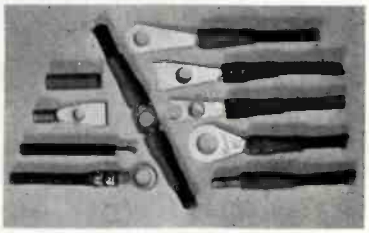

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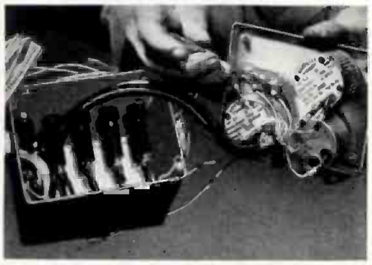

IRV-O-LITE XTE-30 is used as insulation on parts for famous planes.

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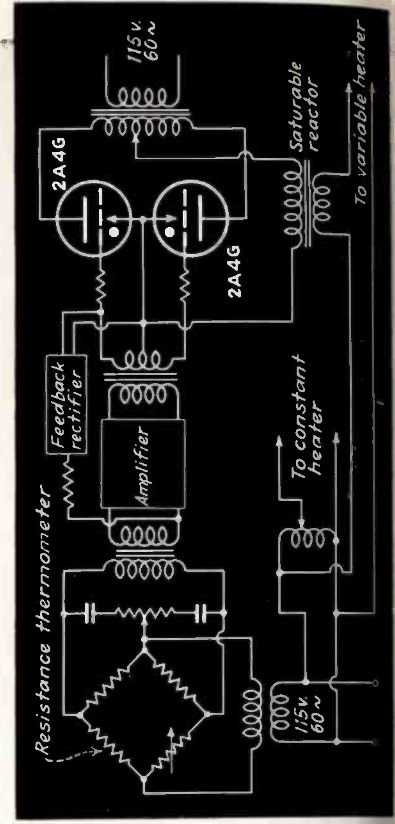

Simplified circuit diagram to show the prin- ciple of operation of the temperature con- troller. A voltage appears across the out- put of the Wheatstone bridge when un- balance occurs, its phase is shifted, it is amplified to fire two thyratrons (2A4G), and control the heating element through a saturable reacter

desired point, the resistance thermometer changes in resistance by a very small amount and the balance of the Wheatstone bridge is upset. There is then a voltage across the output of the bridge and this is fed into the phase shifting network and the primary of a transformer. The voltage developed across the secondary of the transformer is now out of phase with the line voltage by an amount depending on the phase shifting network and it is fed through a two-stage amplifier. The output of the amplifier, even with temperature changes of a few thousandths of a degree in the chamber, is sufficient to operate the two 2A4G thyratrons. The amplified out-of-phase voltage is applied to the grids of the thyratrons and a voltage 180 degrees out of phase with line voltage (a step-up transformer is used) is applied to the anodes. The thyratron pass anode current whenever a very slight decrease in temperature in the chamber occurs. The anode current must be made to control the application of heat to the chamber. In this case, the anode current is

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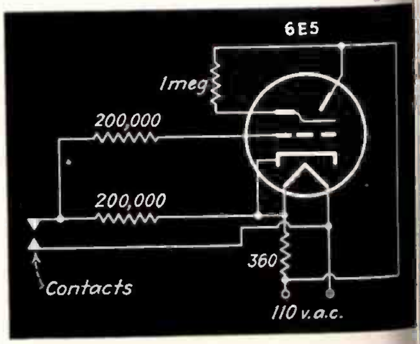
passed through a saturable reactor, one winding of which is in series with the power line and an electric heater. When zero current passes through the saturable reactor, the heater winding acts as a current-limiting reactor and no voltage is applied to the heater. However, when current does flow through it, it becomes saturated and the inductance drops to a very low value. Voltage is applied to the heating element whenever thyratron current flows. When the temperature reaches the desired level, the bridge is again balanced, thyratron anode current flows and application of heat ceases.

To avoid overloading the circuit when a relatively great drop in temperature occurs, automatic gain control is used on the amplifier. This is obtained by the application of automatic bias control derived from part of the output transformer.—Penther and Pompeo, ELECTRONICS, April 1941, p. 20.

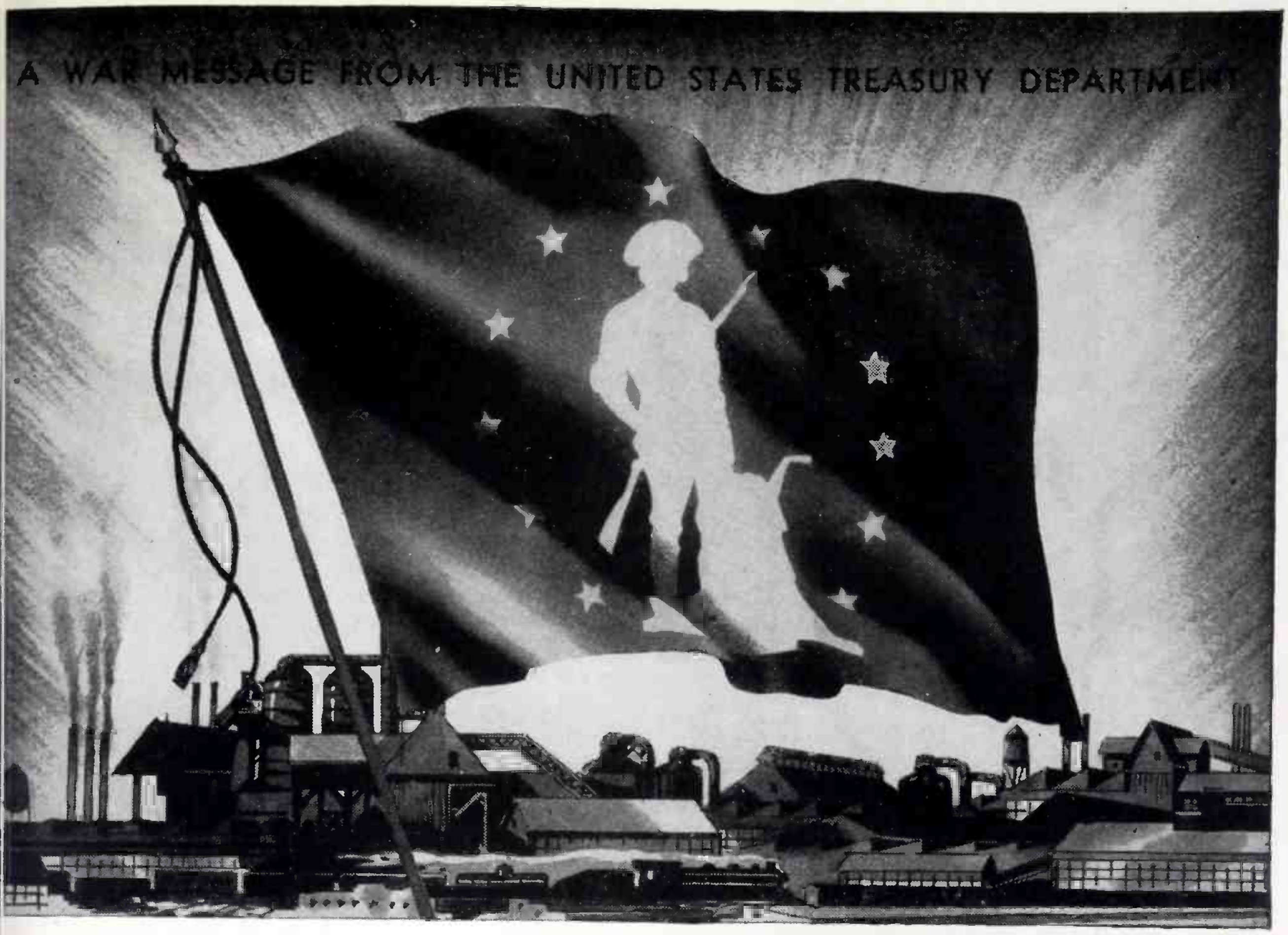
Sensitive Contact Indicator

A SO-CALLED "MAGIC-EYE" cathode-ray tube (used as tuning indicators in radio receivers) may be used as a simple and inexpensive indicator of the precise moment at which two metallic bodies touch. Used in connection with an interferometer type strain-gage calibrator, for example, it has been found that the relative position of two polished steel surfaces at the instant of contact will be indicated with a maximum variation of four millionths of an inch on successive tests.

Referring to the figure, the grid of the 6E5 is biased sufficiently nega-



Sensitive contact indicator. The target of the tube is illuminated when the contacts touch, a useful indication method for use in connection with micrometers, interferometers and other measuring instruments



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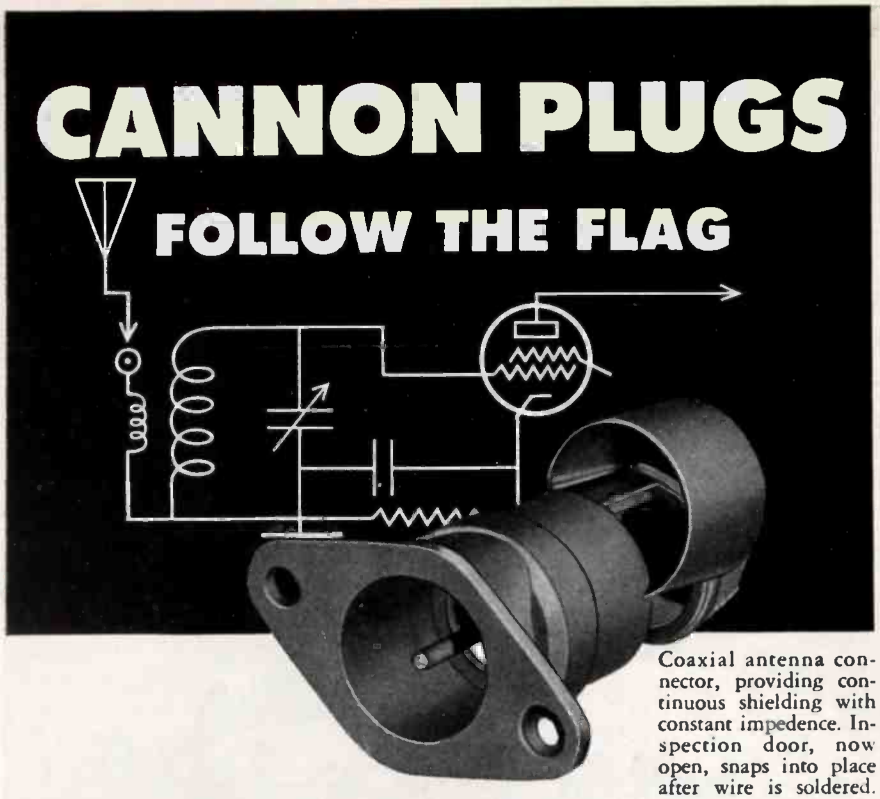
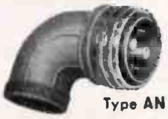




tive with respect to the cathode t cut off anode current and the targe fluoresces all around. When the contacts touch, the grid of the tube i made positive with respect to th anode and target, anode curren flows and a shadow appears on th target.—Mills, *Review of Scientifi Instruments*, February, 1941, p 105.

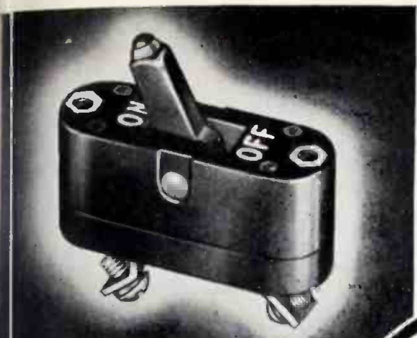
Casting Tester

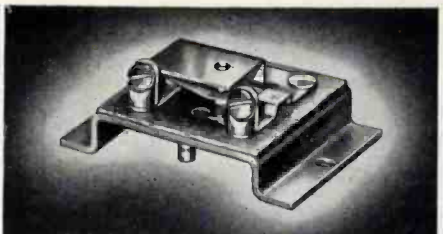
CERTAIN METAL CASTINGS may b tested for cracks or other imperfections by striking them with a hammer and comparing the "ring" witl that of a similar casting known to b perfect. The value of such a test depends to a large extent upon identica suspension or mounting of sampl and standard castings, striking o both with the same force at the sam relative point and the accuracy wit which differences in sound pitc can be distinguished.

Suspension of samples and tes castings may be made uniform b any one of a number of mechanic means which need not be mentioned here. Uniformity of striking poin and power may be solved by usin rigidly positioned and mechanicall or electrically driven hammers Sound output at a given standard pitch may be measured by feeding the "ring' into a microphone mounted a fixed distance from the hammer amplifying the microphone output by an a-c amplifier equipped with a band-pass filter designed to accept the standard frequency only and, finally, operating an output meter giving a visual peak reading. Electronic Control Corp., ELECTRONICS—February, 1939, p. 25.

Vibration Burglar Alarm

THE VIBRATION ACCOMPANYING an attempt to cut or break through a property boundary fence, or vibration induced in a fence from th ground by attempts to tunnel beneath or jump over a fence, or vibration of a fence by sound waves produced in the vicinity of the fence, can be transmitted along the rails or other inter-connecting members of the fence for a considerable distance. Such vibration may be used to actuate an electronic alarm circuit, a vibration unit converting me-


Type C-6363 Switch Circuit Breaker


Type C4351 Series, Used for Tube Warming Tube Cooling, and High Limit Controls


Type PM (NAF-1131) Circuit Breaker

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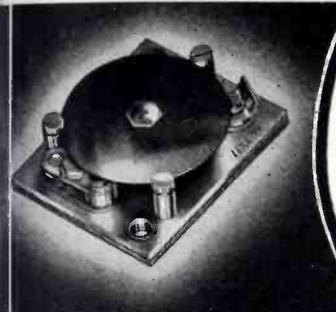
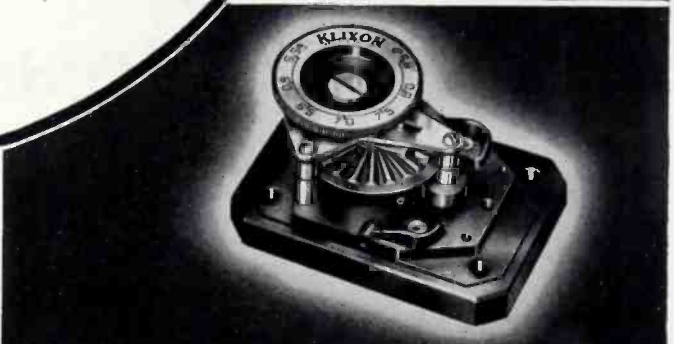

Type B3120 Crystal Dew Point Control


Type C2851 Series, Used as Roughing Controls on Outer Crystal Ovens


Type ER Series Ambient Compensated Time Delay Relays


Type RT Adjustable Crystal Temp. Oven Control

for Positive, Snap-Acting Control

Klixon Controls have a wide range of applications. They are used for motor and transformer overheat protection, electrical circuit overload protection, temperature control, as well as many uses in radio equipment. All the big performance advantages that you get with these controls are due to the snap-acting Spencer Disc, which is the heart of Klixon Controls. This disc not only insures more accurate, positive action but also eliminates many of the troubles common to more complicated and more fussy controls.

Because of the scientifically calibrated Spencer Disc, Klixon Controls are unaffected by motion, altitude, or position of mounting and they are highly immune to shock and vibration. Moreover, Klixon Controls are small and compact, simple, yet rugged in construction, light in weight, low cost, and capable of handling heavy duty electrical loads with ease.

It is very probable that many of the standard types of Klixon Controls are suitable for your requirements. If not, Spencer Thermostat Company's engineering department will gladly co-operate with you on your problems and in the development of special disc-operated controls for your needs.

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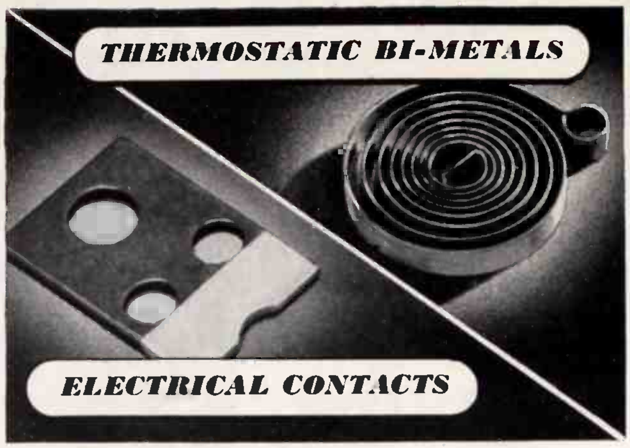
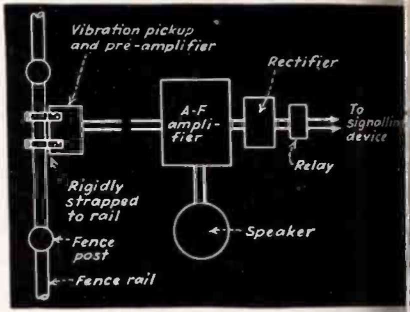


chanical energy into electrical energy.

To operate such a unit there mus be a variation in the relative positio of the actuating needle or drivin lever and its crystal or coil. One element must move while the othe element remains motionless, or on element must move more than th other. The latter principle permit the entire unit to be connected t the fence alone, rather than to th fence and a more rigid support, a one element may be driven b direct connection to the case of th device contacting the fence while th other is damped in some manne One method of accomplishing this i to weight one element and suspen it from a spring, using the inerti of the weighted spring to provid damping.



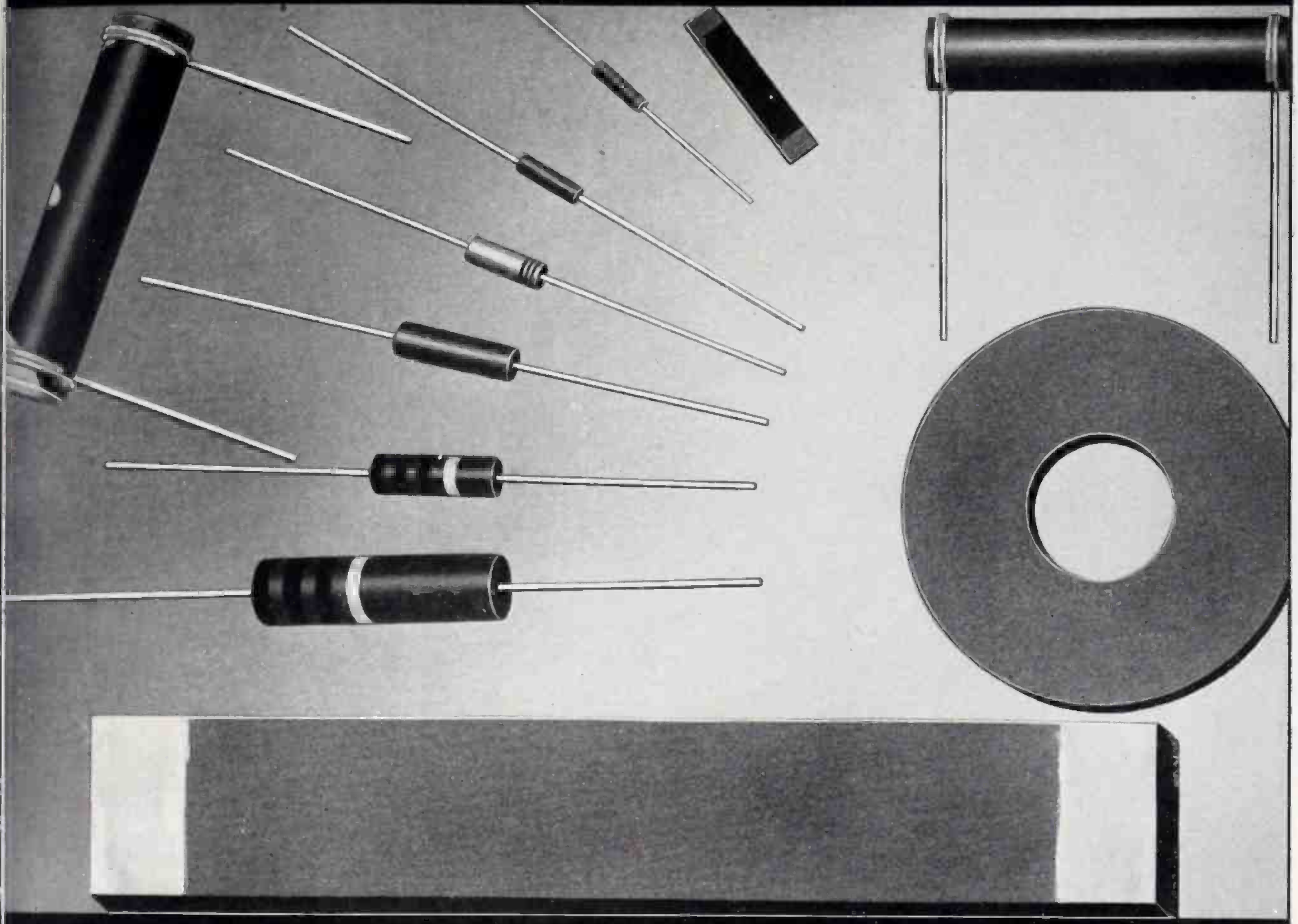
Vibration unit connected to transmit a alarm when a property boundary fence i disturbed

The output of the unit is use to drive an audio-frequency amplifier. The a-f output of the amplifie is rectified and the resultant d.c operates a sensitive relay which controls any desired variety of signal such as a light, bell, or horn. Connection of a loudspeaker to the output of the a-f amplifier will permit sounds transmitted to be heard. Depending upon the character of th fence and the character of the unit it may be possible to identify sounds and to understand speech originating in the vicinity of the unit.

Acoustically Actuated Alarms

ACOUSTICALLY OPERATED alarm devices today commonly installed in vaults are generally designed to turn in an alarm when physical attack upon walls, floor or ceiling occurs rather than to give an alarm on rela-

COMPENSATE FOR HEAT EFFECTS ON METAL CONDUCTORS



SPEER NEGATIVE TEMPERATURE-COEFFICIENT RESISTORS

gative change in resistance obtainable from 10 ohms t 10 megohms — with degree of change varied to meet customer's requirements.

A typical application is a SPEER Negative Temperare-Coefficient Resistor connected i series with a coil in such a man- that the resultant ampere turns main constant. Resistors for such svice generally range from 20 to) ohms, change approximately 0% per degree C. change of temrature, and range from 1 to 12 tts. For heavy wattages, these istors can be furnished in flat cs or other shapes to fit housings.

2572

SPEER NT-C Resistors, available in any size illustrated, insulated or non-insulated, are particularly useful in voltage regulator and time delay equipment applications.

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RESISTOR
CORPORATION
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Characterized by unique advantages due to molding shell and core in one operation. Result:

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Catalog E mailed promptly on request

tively low-level sounds produced by intruders moving around within vaults. Pickup devices range from sound-pressure actuated non-electronic "switches" to crystal and other type microphones having inherently low noise levels. Where microphones are used their output is amplified and then rectified and the resultant d.c. actuates a signal relay.

Sensitivity required of vault alarms depends upon whether or not vaults are reverberant or non-reverberant, a non-reverberant vault being normally defined as one in which the average coefficient of sound absorption of exposed interior surfaces exceeds 0.5, or is variable because of merchandise in storage. In reverberant vaults it is customary to adjust alarms to transmit a signal at sound levels of the order of 80 to 90 db for a sound of impact origin. In non-reverberant vaults the alarm systems should transmit a signal at a sound level 15 db above the normal ambient. Required amplifier frequency response varies with the type of vault and its contents, most frequently encountered conditions requiring a range readily obtainable through conventional a-f amplifier design.—MacDonald, ELECTRONICS, February, 1942, p. 38.

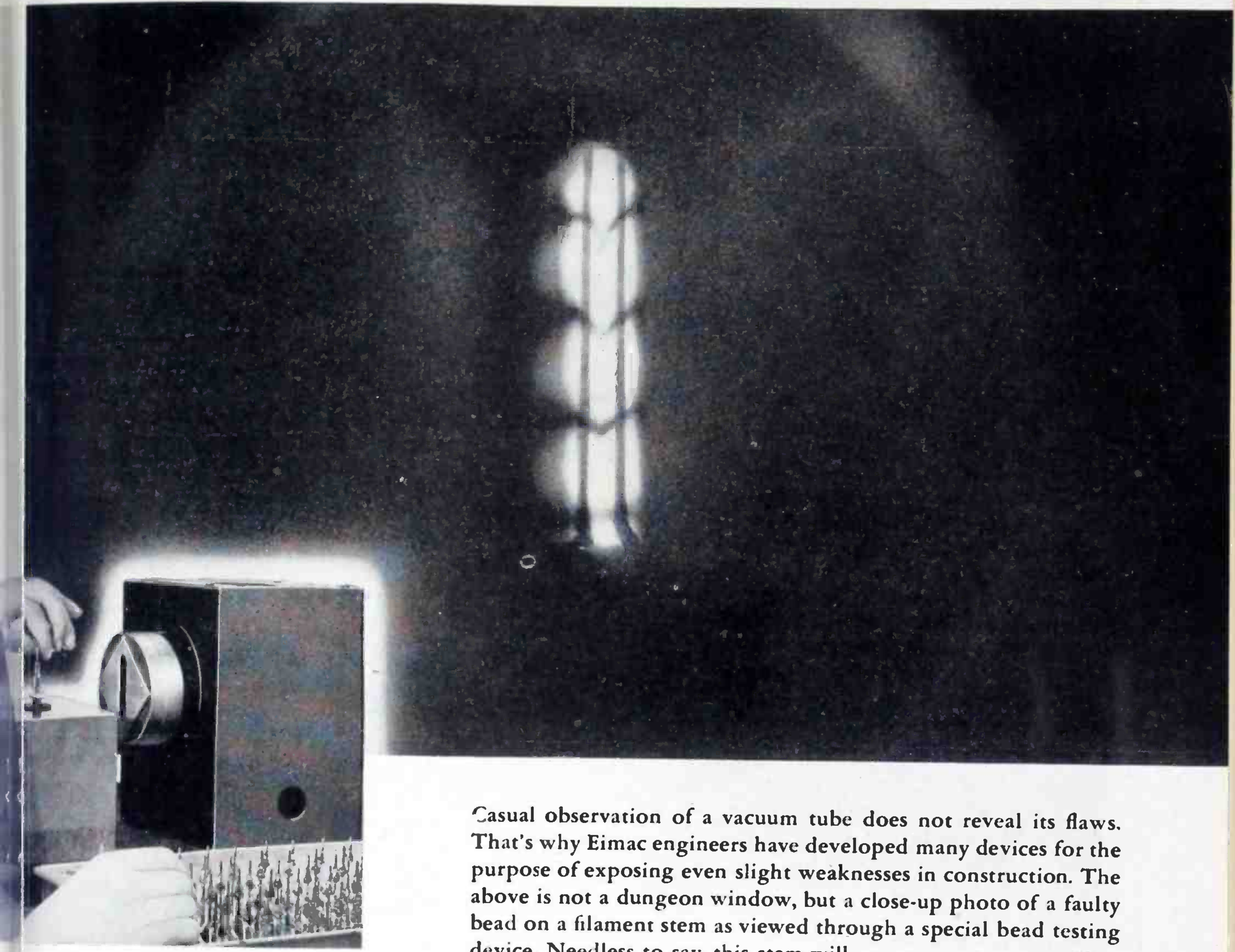
Engine Cylinder Pressure Indicators

MECHANICAL INDICATORS were used for many years to study the pressure variations inside the cylinders of internal combustion engines. Electronic indicators having less moving-part inertia are now generally used, the usual method of measurement involving conversion of pressure variations into electrical variations and the reading of the electrical variations on the screen of a cathode-ray oscilloscope.

One method of conversion involves the insertion of a small, flexible and highly polished metal diaphragm in the wall of the cylinder under test. A light beam is directed at the diaphragm and is reflected to a phototube. As cylinder pressure variations flex the diaphragm, light reflected from it diverges and a lesser amount, proportional to cylinder pressure, reaches the phototube. Phototube output is thus proportional to cylinder pressure.

Other energy conversion devices

DEATH *before* DISHONOR!

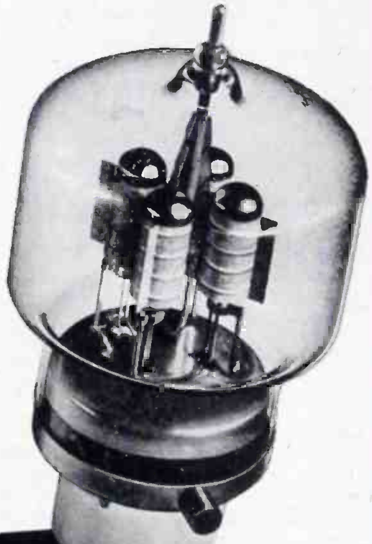


on of the stress points on glass bead d vacuum tube leads is made with . Close-up photo above shows the ac- of a faulty lead. Note the change in l light creating distorted shadows up stress and strain in beads. Such etimes occurs where metal and glass together.

the entire glass bulb with the help of light. This device shows up stress on the glass which might be created shaping operations.

Casual observation of a vacuum tube does not reveal its flaws. That's why Eimac engineers have developed many devices for the purpose of exposing even slight weaknesses in construction. The above is not a dungeon window, but a close-up photo of a faulty bead on a filament stem as viewed through a special bead testing device. Needless to say, this stem will never reach final assembly . . . better "death before dishonor" to the Eimac tradition of dependability.

Such care in production plus constant research into the phenomenon of the electron tube assures you of the utmost in performance from every Eimac tube . . . provides the answer to why Eimac tubes are first choice by most of the leading engineers throughout the world.



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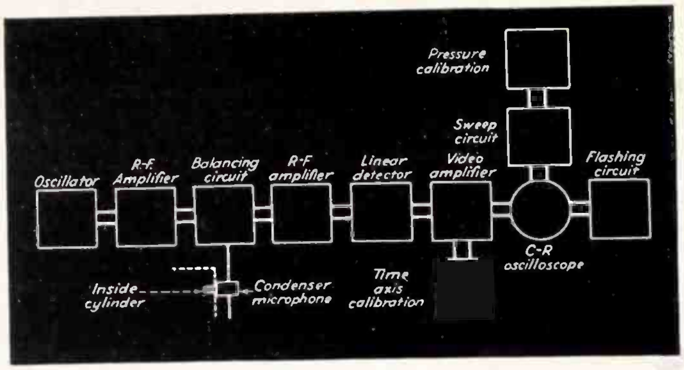


Block diagram of the apparatus necessary for the measurement of cylinder pressures by the use of a condenser microphone and a cathode-ray oscilloscope

used to transform pressure into electrical impulses include carbon stacks (variable resistance), quartz crystals (piezoelectric effect), moving coils or variable reluctance (electromagnetic conversion) and condenser microphones (variable capacity). Numerous refinements have been made in connection with such systems of measurement. For example, measurement of engine pressure variations by means of a condenser microphone polarized with high d-c potential and driving a high-gain d-c amplifier has several disadvantages. Inasmuch as a condenser microphone used in this manner operates as a high impedance device the microphone circuit has a tendency to pick up and indicate undesired voltages induced from nearby ignition systems. Variation in microphone-cable-to-ground capacity due to vibration affects measurements since the high impedance cable capacity is essentially in parallel with the capacity of the microphone. Instability is frequently serious due to changes in microphone insulation and changes in the input resistance of the initial d-c amplifier tube. In the circuit shown in block form the difficulties outlined above are resolved by energizing the microphone with high frequency voltage of the order of several Mc, employing it to modulate an r-f amplifier rather than to operate a d-c amplifier. A linear detector removes the r-f component of the modulated signal and delivers voltages comparable to the output of the microphone to the video amplifier of the associated cathode-ray oscilloscope.—Robertson, *Review of Scientific Instruments*, June, 1940, p. 142; Penther and Pompeo, ELECTRONICS, May, 1941, p. 43.

Temperature Control

ONE JUNCTION OF A thermocouple is placed within the chamber whose temperature is to be controlled and the other junction at some reference point. A milliammeter is connected in series with the thermocouple and a calibrating resistance. As the temperature within the chamber increases, the thermocouple current passes through the meter and deflects its pointer. A small and light metallic vane mounted on the pointer passes between two coils mounted close to the plane of pointer travel. The pointer may be free to move along the pointer path for operation at various temperature levels. The two coils, L_1 and L_2, are part of the grid and plate circuits, respectively, of a vacuum tube oscillator. In normal operation, when the vane is not between the two coils and the temperature is below the desired value, the circuit is not oscillating because of the degenerative action of L_2 on L_1 and the plate current has an average value of about 10 ma. This is sufficient to energize the relay M_1 which controls the operation of the fuel injection apparatus or the damper system of the furnace thereby permitting the continued application of heat to chamber.

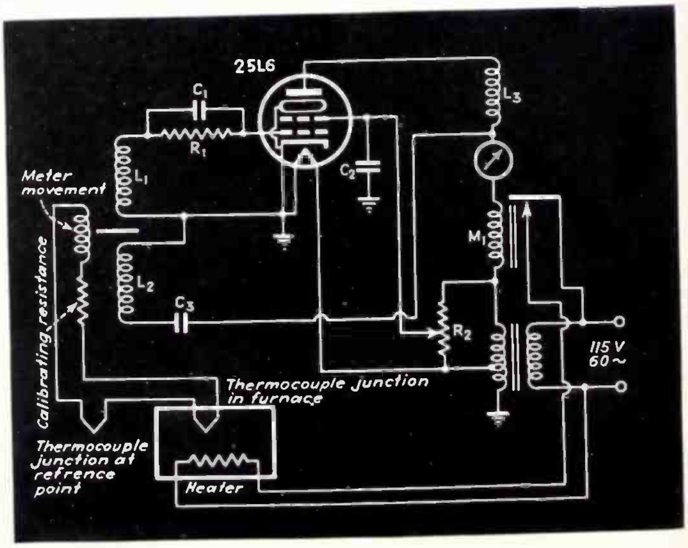
When the temperature rises to desired value, the vane passes tween the two coils and acts as shield to isolate them from ea other electromagnetically and p vent the degenerative action of L_2, thereby allowing the circuit oscillate. When the circuit oscilla the control grid draws current an voltage drop appears across the g leak resistor R_1 and condenser This drives the grid to a more ne tive potential and reduces the pl current to an average value of ab 5 ma. The drop-out current of relay M_1 is somewhat greater th 5 ma and it therefore opens circuit to the fuel injection appa tus and cuts off the supply of he —McLaren, ELECTRONICS, Nove ber, 1941, p. 50.

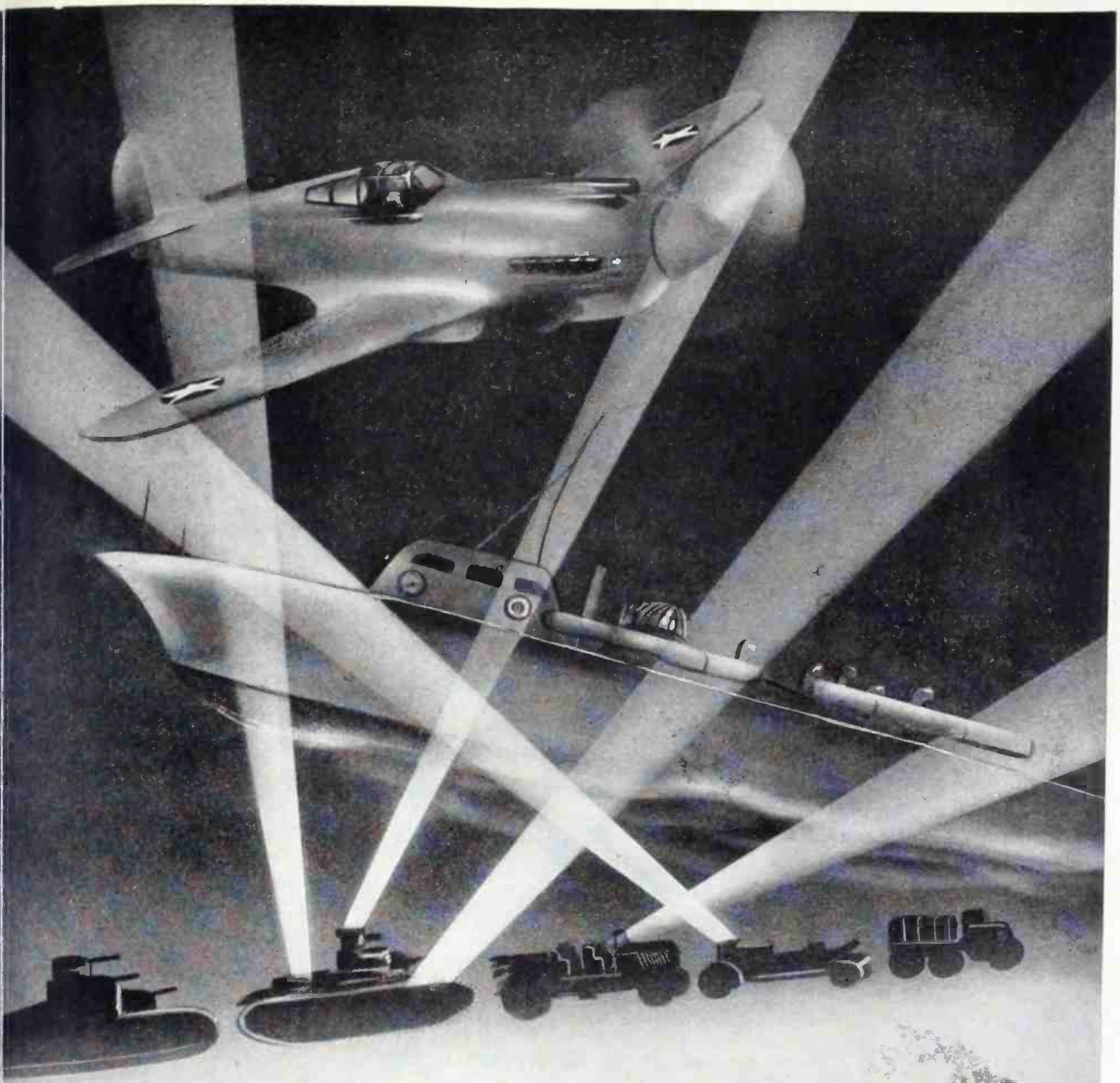
Mechanical Conveyor Synchronize

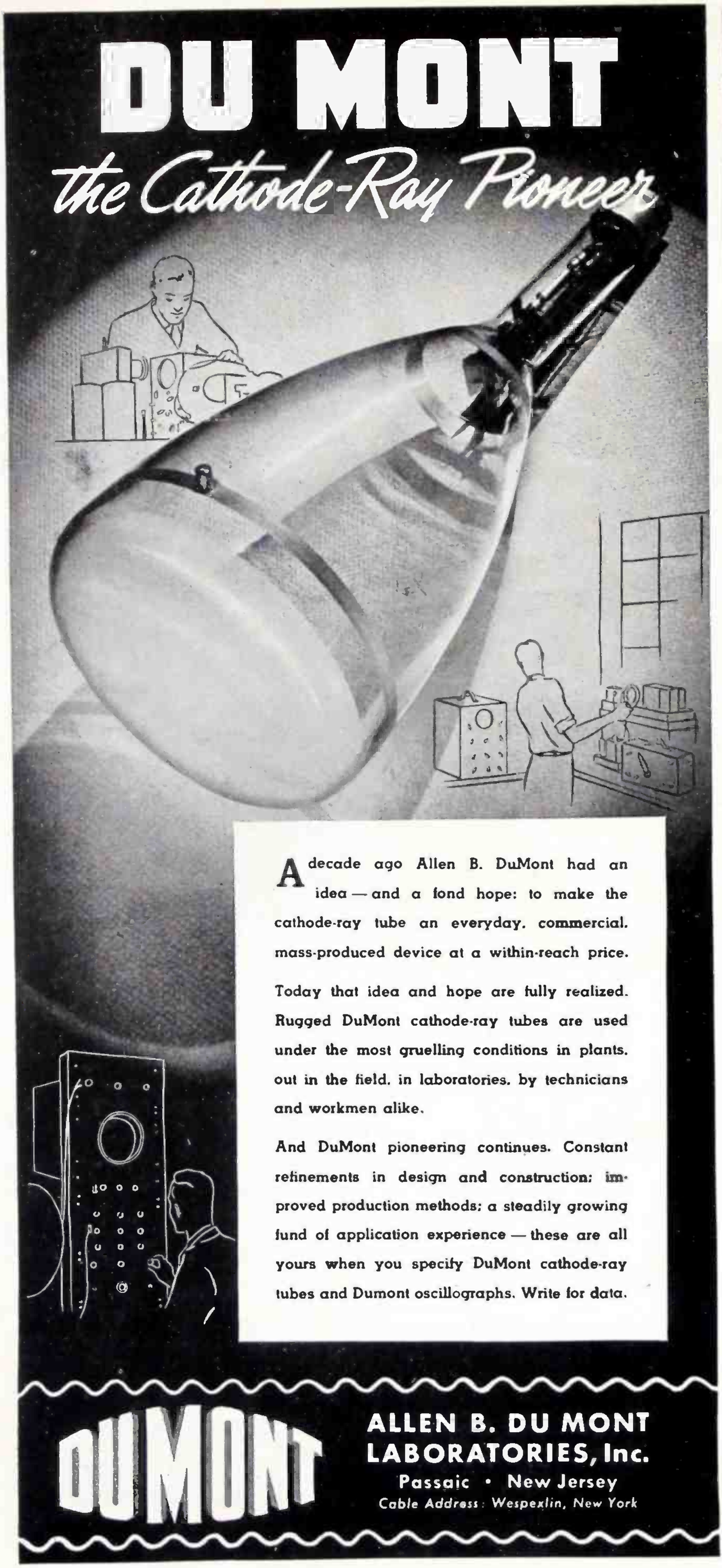
WHERE A CONVEYOR belt travels independently driven wheels sprockets the straightening or in the belt which occurs betw units when motors get out of may be used as a source of power force them back into synchroni tion.

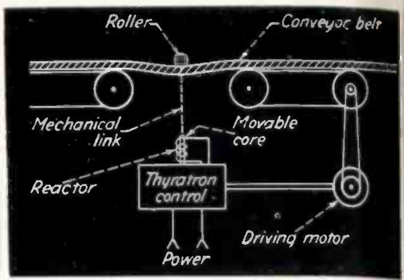
A roller rides the conveyor between driving units and is chanically linked to the movable of a reactor. Up or down movem of the roller varies the inductance the reactor and this variation in ductance controls the firing of

Circuit diagram of the thermocouple and meter movement temperature controller. Although a type 25L6 tube is used here, other similar tubes may be used. Note that a-c power is used









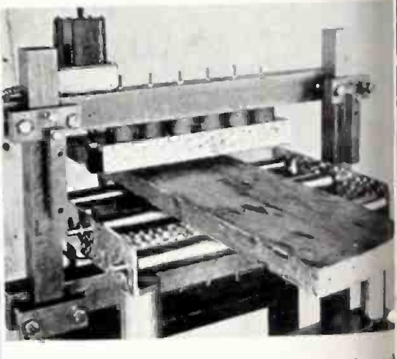
Conveyor synchronizer using thyratro control, shown in elemental form

ratron tubes by the phase-shi method. The belt-driving motor i connected to the power line throug the thyratrons in such a manner tha when the belt sags the motor speed up while straightening of the be causes the motor to slow down.

Many variations and refinemen of this synchronizing scheme a possible.—Henney, ELECTRON TUB IN INDUSTRY.

Nail Detector

THE PRESENCE OF NAILS in lumbe moving through a machine at th rate of 100 feet per minute produc an alarm or, if desired, causes th lumber to be marked at the locati of the nails.



Nail detector. If lumber passing throug the jaws contain nails an alarm is op erated or the board is marked at the lo cation of the nails

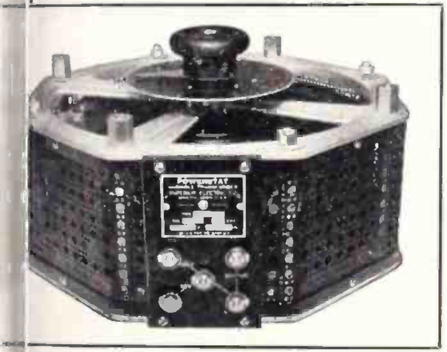
Lumber to be examined passe through an air gap in a magneti circuit. Passage of iron through th gap changes the reluctance and consequently, the flux of the ma netic circuit. Changing flux induc a voltage in a pickup coil and thi voltage is amplified sufficiently t operate an alarm or actuate a sol noid type hammer which punches mark on the lumber.—Andrews an Perillo, ELECTRONICS, January, 194 p. 72.

POWERSTAT

VARIABLE TRANSFORMERS

And Seco Automatic Voltage Regulators

Type 1126 Powerstat



Type 1256 Powerstat

Three-Phase Powerstat

Powerstat — the Variable transformer that accurately controls power for all electronic and radio purposes solves such power problems as Tube Filament Voltage Control, Transmitter Bias Power Supply Voltage Control, and Transmitter Plate Supply Control.

Type 1126 Powerstat

Input: 115 volts 50/60 cycles
Output: 2.0 KVA
Max. Rated Output Current: 15 amp. available over entire range of output voltages
Output Voltage Range: 0 to 135 volts
No-load Power Loss: 16 watts
Over-all Dimensions: 8 x 8 x 7⅝ inches
Net weight: 20 lbs.

◆

Type 1256 Powerstat

Input: 230/115 volts 50/60 cycles
Output: 7.5 KVA on 230 volt line
Max. Rated Output Current: 28 amp. available over entire range of output voltages
Output Voltage Range: 0 to 270 volts
No-load Power Loss: 40 watts
Over-all Dimensions: 14¾ x 14¾ x 8 inches
Net Weight: 66 lbs.

◆

Typical Three-Phase Powerstat Type 1256-2

Input: 230/115 volts 3 phase 50/60 cycles
Output: 13.1 KVA on 230 volt line
Max. Rated Output Current: 28 amp. available over entire range of output voltages
Output Voltage Range: 0 to 270 volts
Connection: See figure 7 of Bulletin 149

Oil Mounted Powerstat in Stainless Steel Tank

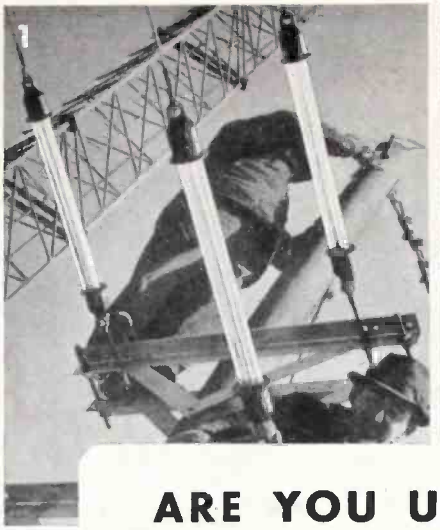
Seco Automatic Voltage Regulator

is used for radio transmitters and many types of electronic devices requiring reasonably close tolerances of line voltages. Important for radio transmitters located at the ends of long feeder lines where regulation is poor and voltage fluctuation wide (Send for Bulletin 163 LE).

Send for Powerstat Bulletin 149LE

Superior Electric Co.

36 HARRISON ST. **BRISTOL, CONN.**



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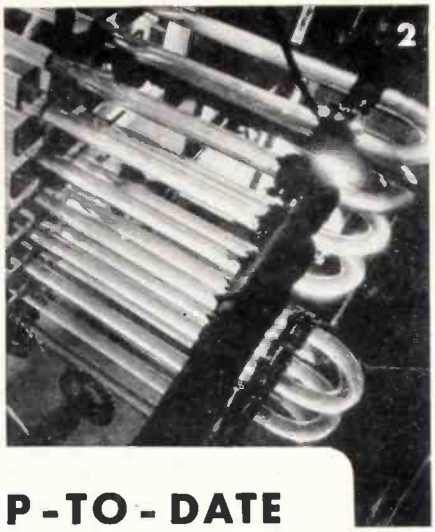
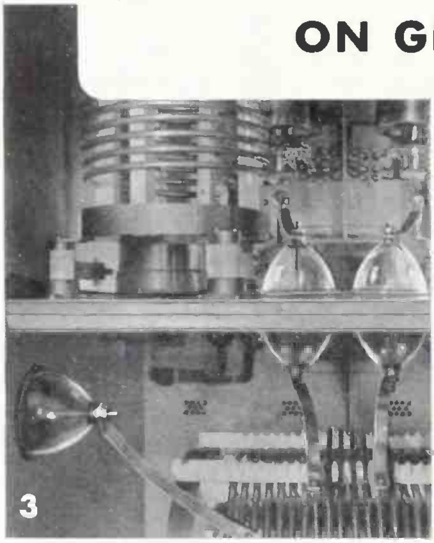


2

ARE YOU UP-TO-DATE ON GLASS?



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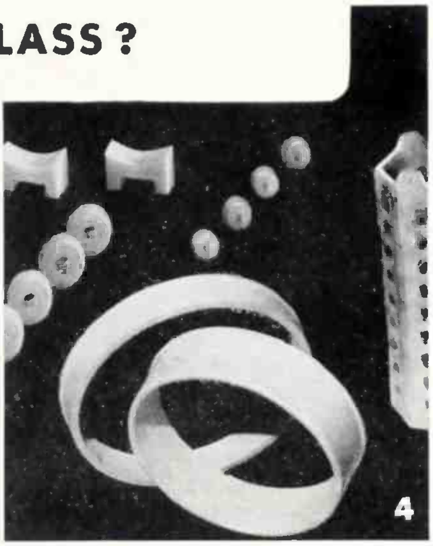


4

COUNT the outstanding insulating properties of borosilicate glass! High electrical resistance. Low power loss. Low surface conductivity. Great resistance to corrosion. High strength-to-weight ratio. All are good reasons why you'll find Pyrex brand insulators at work wherever superior performance is demanded: i.e. at famous Station KDKA (Fig. 1); at Station WLW (Fig. 2); in the new Westinghouse 50-H.G. broadcast transmitter (Fig. 3).

But that's not all! In addition to standard antenna, strain, entering and stand-off insulators, advanced manufacturing techniques now make it possible to produce insulators of more intricate shape, in wider ranges of size and type, and to more precise dimensions than ever before. For example, coil mounting blocks, insulation bushings, line spacers, coil forms and anode bushing rings (all Fig. 4) are just a few.

If you're worried about a continued material supply, check into glass now! Send your problem to Insulation Division, Corning Glass Works, Corning, N. Y., and write for free booklet "The Dielectric Strength of Glass."

DO YOU KNOW HOW HIGH GLASS RATES AS AN INSULATING MATERIAL?

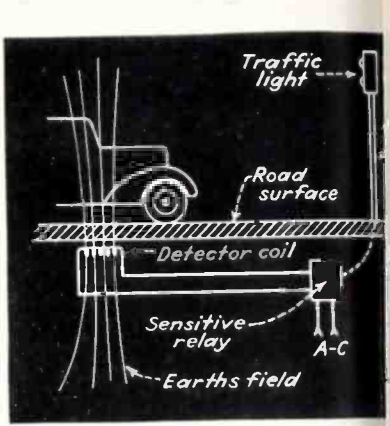
PROPERTY	BOROSILICATE GLASS	LOW-LOSS STEATITE	PORCELAIN	CELLULOSE ACETATE	PHENOLIC RESINOID
High scratch hardness	6	5	3	1	2
Low thermal expansion	6	4	5	1	2
High dielectric strength	5	2	1	3	4
Low dielectric constant	6	3	5	4	1
High volume resistivity	5	4	3	2	1
Total point score	28	18	17	11	10

Pyrex Insulators
BRAND

"PYREX" is a registered trade-mark and indicates manufacture by Corning Glass Works.

Vehicle-Operated Traffic Light

TRAFFIC LIGHTS MAY be caused to erate at the approach of a car by method shown. An induction or tector coil is installed beneath road surface over which cars proaching the light must pass. C rent is induced in the coil by earth's magnetic field and the ser tive relay connected to the coil is justed to remain inoperative wh this normal current is present. Wh



Distortion of the earth's magnetic fi by an approaching car may be made alter current flowing in a coil sufficient to actuate a relay

a car passes over the road surf beneath which the coil has been stalled the earth's magnetic field distorted sufficiently to alter amount of current flowing in coil, tripping the relay and supp ing power to the light.—La ELECTRONICS, December, 1940, p.

Lumber Moisture Content Checker

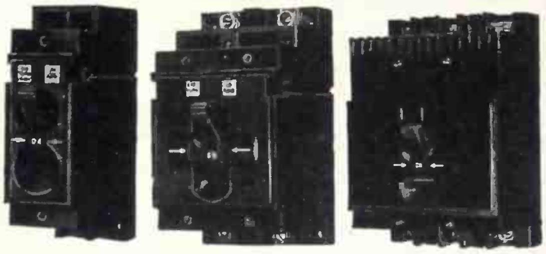
THE CONVENTIONAL electric meth of checking the moisture content lumber is to use a sensitive o meter, inserting test needles dee into the wood some standard dista apart and comparing the d-c re tance reading with that of lum known to be dry. An instrum made by the Moisture Register Co pany of Los Angeles dispenses w the test needles by utilizing the hi frequency field of a 12 Mc oscilla as shown in the drawing on page

An electrode forming part of oscillator circuit is brought into i mate contact with the lumber t tested. Power absorbed from the cillator by the lumber cause

3 HEINEMANN "Re-Cirk-it" CIRCUIT BREAKERS

Fully Electro-Magnetic

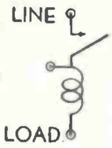
Single Pole Two Pole Three Pole

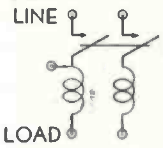


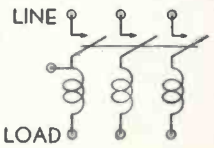
And

Here is what they do!

with **CALIBRATING TAP**

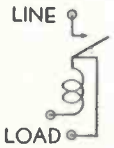


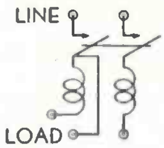


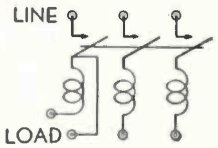


These "Re-Cirk-It" circuit breakers are assembled with an extra terminal attached to e load side of the interrupting mechanism which is the line side of the trip coil. ils additional terminal can be used for an extra circuit not to have any effect on the p coil; or it may be to provide means of connecting a rheostat or resistor in rallel with the trip coil to gain different fixed ratings; or an adjustable variation the rating giving a much wider range in calibration of the tripping point.

with **SHUNT TRIP**

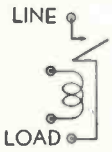


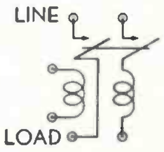


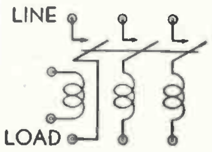


These "Re-Cirk-It" circuit breakers are assembled with the trip coil connected be- een an extra terminal and the load side of the interrupting means. The circuit nnection from the line terminal through the contacts to the load terminal is solid thout an overload coil, one end of the coil being connected to the load side of the ntacts (interrupting means), the other end of the coil to the extra terminal. The use this breaker is for remote control tripping so that a circuit of very low capacity at same voltage may control the opening of the breaker.

with **RELAY TRIP**



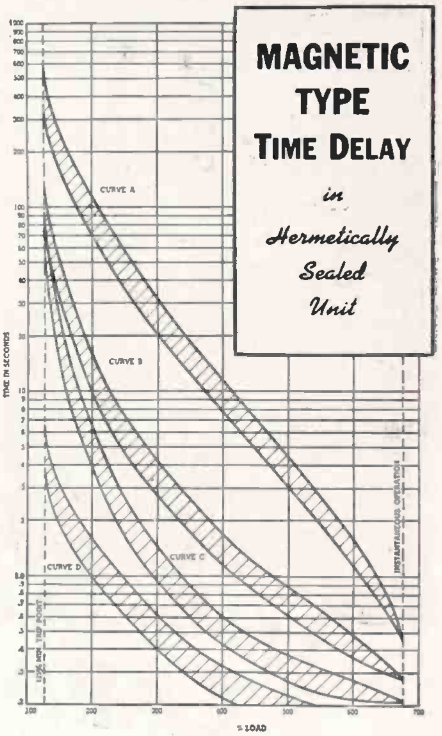




hese "Re-Cirk-It" circuit breakers are assembled with the leads of the trip coil ached to separate terminals so that the interrupting mechanism (circuit opening ams or contacts) may be in one circuit which is connected to the load and line minals while the trip coil is connected to separate terminals and may be energized a separate control circuit or may be used with the interrupting mechanism in the nary of a transformer and the coil in the secondary circuit. The trip coil can be anged for as low as a few volts and up to several thousand.

Send for Catalog 40 with complete data.

TIME OVERLOAD CURVES



MAGNETIC TYPE TIME DELAY

in

Hermetically Sealed Unit

The time curves shown illustrate the wide range of adaptability of these breakers to various conditions. In other words, they can be assembled to meet specific requirements as to the time delay feature, since they are not dependent upon movement of thermostatic metal nor the heating of soft metal.

Curve "A" illustrates the standard time delay curve to which a standard time delay breaker will adhere. However, if so ordered, they may be had with other time curves. Curve "D," for instance, is the time curve of a breaker that would protect a load derived from gas filled lamps, and other circuits with similar characteristics, where the current returns to normal after about one cycle.

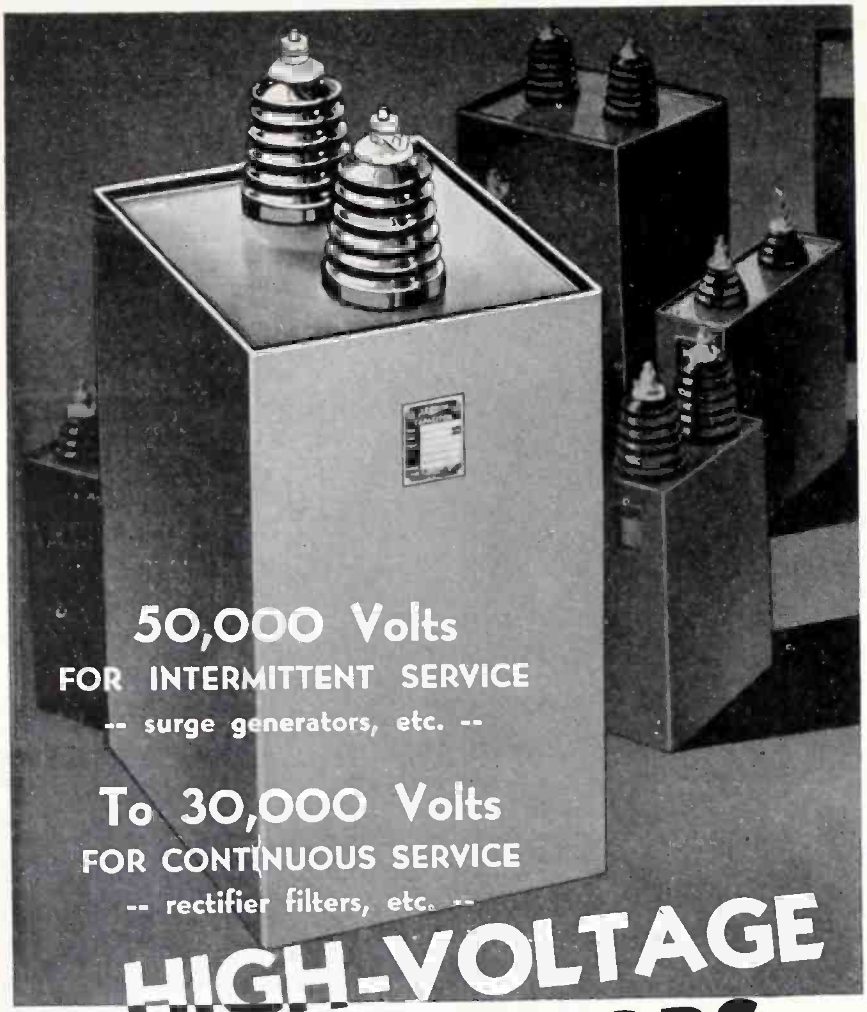
Curves "D" and "C" are also the ideal protection for small transformers since the breaker takes care of the relatively fast and high inrush of current during the first cycle when connected to the line.

If no time delay is desired, breakers can be had in instantaneous trip types. They will trip as soon as current rises to breaker rating.

HEINEMANN CIRCUIT BREAKER CO.

SUBSIDIARY OF HEINMANN ELECTRIC CO.

97 PLUM ST. Est. 1888 TRENTON, N. J.



50,000 Volts
FOR INTERMITTENT SERVICE
-- surge generators, etc. --

To 30,000 Volts
FOR CONTINUOUS SERVICE
-- rectifier filters, etc. --

HIGH-VOLTAGE
CAPACITORS

Type 6020 — 6000 v. D.C.W. 2.0 mfd. to 10.0 mfd.
Type 7520 — 7500 v. D.C.W. 0.5 mfd. to 6.0 mfd.
Type 10020—10,000 v. D.C.W. 1.0 mfd. to 5.0 mfd.
Type 12520 — 12,500 v. D.C.W. 0.5 mfd. to 5.0 mfd.
Type 15020 — 15,000 v. D.C.W. 0.25 mfd. to 3.0 mfd.
Type 20020 — 20,000 v. D.C.W. 0.25 mfd. to 4.0 mfd.
Type 25020 — 25,000 v. D.C.W. 0.2 mfd. to 1.0 mfd.
Type 37520 — 37,500 v. D.C.W. 0.1 mfd. to 1.0 mfd.
Type 50020 — 50,000 v. D.C.W. 0.1 mfd. to 0.5 mfd.
Also 25,000 v. Output (12,500—12,500 v.) for Voltage-Doubling.

● To meet recent radio and electronic developments, Aerovox engineers have evolved these Hyvol Type '20 oil-filled capacitors in ratings from 6000 to 50,000 volts D.C.W.

Likewise production means to make them. Giant Aerovox-designed and built winding machines handle up to several dozen "papers". Batteries of giant tanks permit long pumping cycles for thorough vacuum treatment followed by oil impregnation and filling. Multi-laminated kraft tissue and hi-purity foil sections are uniformly and accurately wound, compressed, impregnated, encased.

Hermetically-sealed sturdy welded-steel containers. Rust-proof lacquer finish. Cork-gasketed pressure-sealed glazed porcelain high-tension pillar terminals. Truly capacitor dreadnoughts.

Submit that Problem . . .

Whether it be for giant high-voltage capacitors or low-voltage by-pass electrolytics, regardless, send it along for our engineering collaboration, recommendations, quotations. Engineering data on request.

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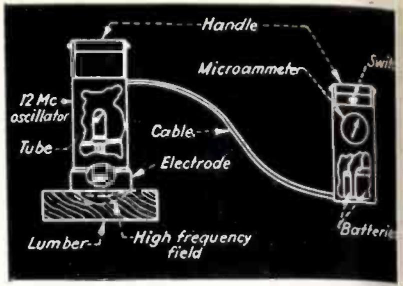


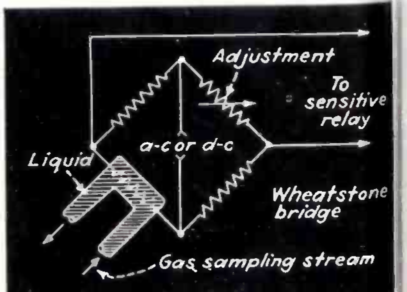
Lumber moisture checker. A high-fr quency field is substituted for the conve tional test needles and d-c ohmmeter

change in the anode current of t oscillator and this change is ind rectly measured by means of a micr ammeter installed in a second un along with operating batteries f convenience in handling. A ch furnished with the instrument te what the microammeter readi should be when woods of vario varieties are normally dry. Oth microammeter readings indicate r ative moisture content. Directly ca brated microammeter dials are ava able for certain frequently handl woods.

Gas Sampling Circuit

CERTAIN NOXIOUS gases such as ca bon monoxide have appreciable el trical conductivity even when prese in minute quantities. The presen of such gases in air is commonly d tected by means of the Wheatsto bridge circuit.

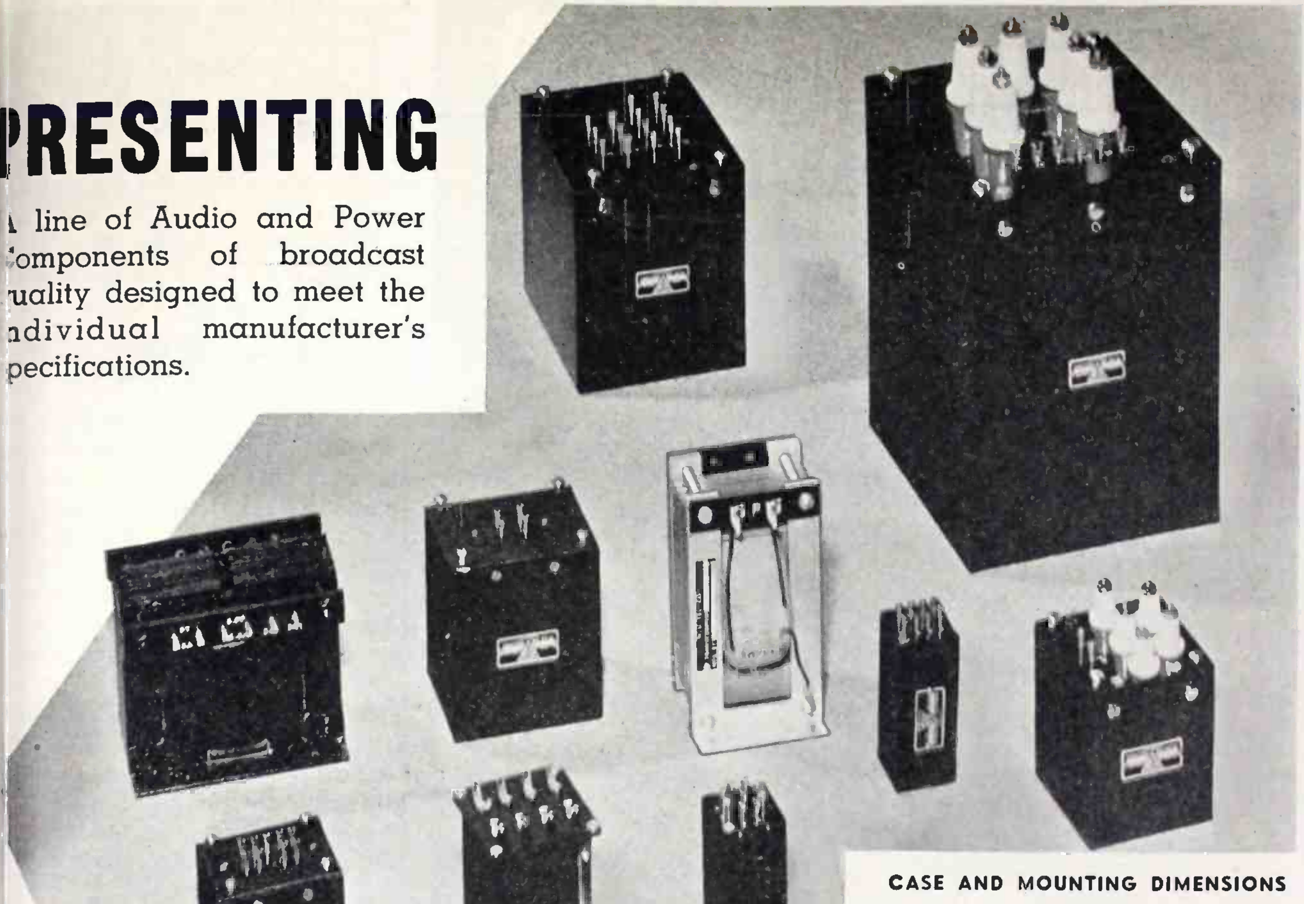
Air known to be free of the no ious gas is mixed with liquid known resistance in a sampli chamber. The sampling chamber connected to serve as one leg of t bridge and the bridge is balanc No current flows to the sensitive lay. Air suspected of contain noxious and conductive gas is th



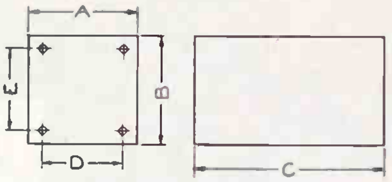
Wheatstone bridge method of sampli noxious gasses dissolved in liquid a used as one arm of the bridge

PRESENTING

line of Audio and Power omponents of broadcast uality designed to meet the ndividual manufacturer's pecifications.



CASE AND MOUNTING DIMENSIONS



CASE NUMBER	APPLICATIONS			
	AMPLIFIER UNITS	POWER UNITS	Filter Reactors	MISCELLANEOUS
20	Input, Interstage, and Output Transformers (Low Level)	2 V.A. 60cps 4 V.A. 400cps	LI²=.0015	High Q Inductors For Filter And Tuned Circuits. Q=10 to 18
30	Dual Units Same As Above	Contains two transformers each rated same as shown above.		
40	Audio Transformers of Medium Rating	4 V.A. 60cps 8 V.A. 400cps	LI²=.02	
50	Output Transformers Up to 10 Watts	5 V.A. 60cps 15 V.A. 400cps	LI²=.03	
70	Output Transformers Of Slightly Lower Rating Than V.A. Rating of Power Transformers (Assuming No Unbalanced D.C. In Primary or Secondary)	10 V.A. 60cps 20 V.A. 400cps	LI²=.05	High Q Inductors For Q=20 to 35
90		30 V.A. 60cps 50 V.A. 400cps	LI²=.20	Audio Filters (One, Two, or Three Sec.)
110		45 V.A. 60cps 65 V.A. 400cps	LI²=.40	
140		85 V.A. 60cps 125 V.A. 400cps	LI²=.80	
160	Other Audio Transformers For Higher Level Operation	110 V.A. 60cps 150 V.A. 400cps	LI²=1.0	High Voltage Plate And Filament Transformers
180		250 V.A. 60cps 500 V.A. 400cps	LI²=3.0	

APPROXIMATE RATINGS FOR STANDARD CASES

1. Data assumes low voltage units (500 volts or less) with average number of terminals.
2. The use of a case in any given application should be verified with the N. Y. Transformer Co. before making a final design.

CASE NUMBER	CASE DIMENSIONS			MOUNTING DIMENSIONS		SIZE OF HOLES**
	A	B	C	D	E	
20	1.313	1.313	1.625	.9375*	.9375*	4-40
30	1.313	1.313	2.875	.9375*	.9375*	4-40
40	2.063	1.938	2.313	1.375	1.250	8-32
50	2.438	2.000	2.500	1.875	1.531	6-32
70	2.563	2.188	3.250	2.000	1.625	6-32
90	3.188	2.688	2.875	2.563	2.125	8-32
110	4.000	3.375	3.750	3.250	2.750	8-32
140	4.500	4.000	5.125	3.750	3.250	10-32
160	5.125	4.188	5.063	4.375	3.250	10-32
180	7.500	6.500	6.500	6.500	5.750	¼-20

STANDARD CASES

Two Diagonally Opposite Mounting Holes Are Omitted.
** *All Mounting Holes Are Tapped.*

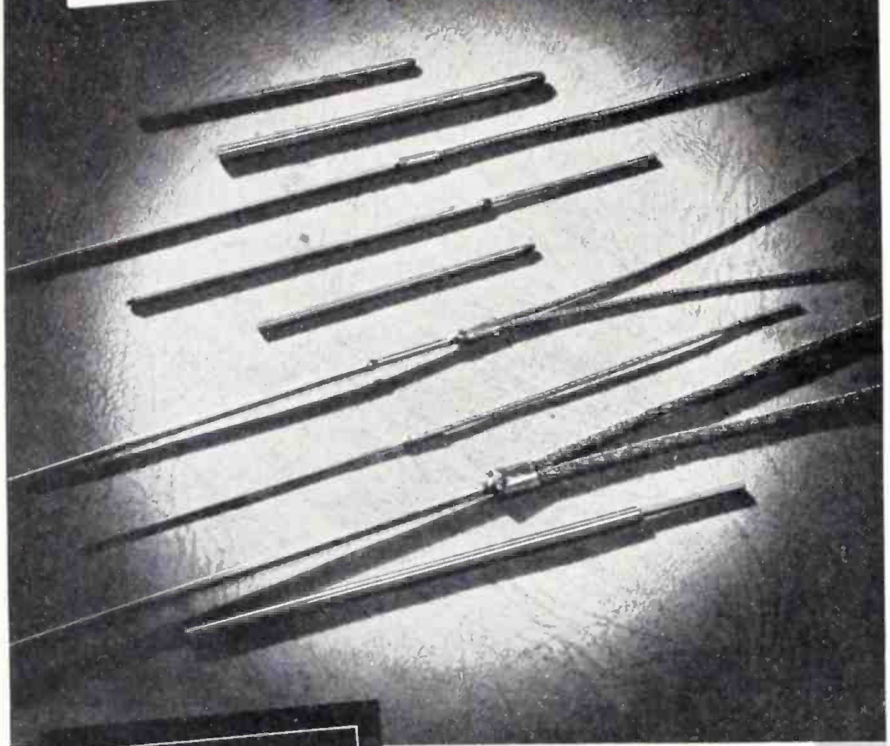
The above data refers only to cases carried in stock and available for quick delivery. Special cases will be supplied whenever the standard line does not meet the necessary requirements.

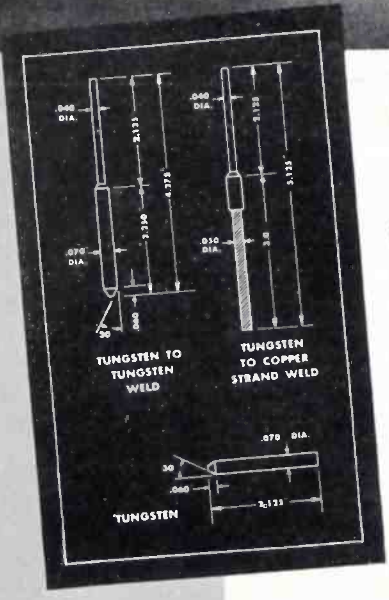
Suppliers to manufacturers demanding highest quality

NYT

NEW YORK TRANSFORMER CO.
51 WEST 3rd ST., NEW YORK, N. Y.

Send for latest folder.

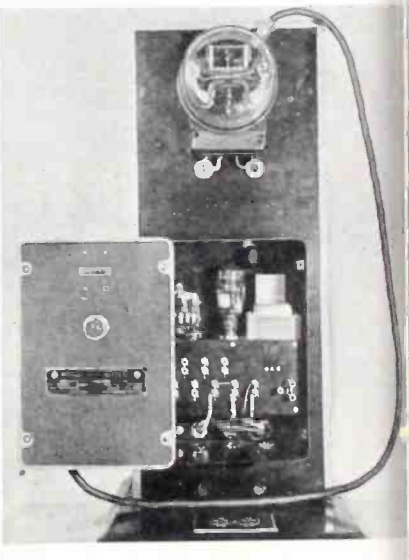




mixed with the liquid in the sampling chamber. Any increase i sampling chamber conductivity du to the presence of such gas upset the balance of the bridge and curren proportional to the unbalance flow in the sensitive relay circuit, actuating an alarm.—Lamb, ELECTRONICS, December, 1940, p. 35.

Watt-Hour Meter Tester

THE DIRECT CURRENT in the anode circuit of a vacuum tube oscillator ma be caused to change by introducing metallic vane or shield between tub output and load circuits thereby altering the coupling between the two or by introducing a metallic vane b tween an oscillator input and feed back coils, or into an oscillator fiel in such a manner that the frequenc of oscillation is altered. The van may be made of non-magnetic material and may be small and light, tw factors which provide the basis fo electronic control where magnetic o mechanical loading of the controlle device must be held to a minimum



Electronic watt-hour meter tester. It counts the number of revolutions made by the meter disc or compares the speed of a test meter with that of a standard mete

The watt-hour meter tester pictured here and designed by Wheel Instrument Co., uses the oscillat frequency-change principle. A sma aluminum vane is mounted on th revolving disc of the meter to b tested. The vane passes betwee turns of wire in a pickup coil couple to the tuned circuit of a remote oscillator through a flexible co-axial ca

LUMARITH

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plastics are available in many forms and formulae for *Insulation*

For a fast-growing range of applications LUMARITH helps speed production and generally improves product performance. The properties listed below illustrate a *few* of the reasons. LUMARITH is available in sheets, rods, tubes, molding powders, transparent film from .0005″, and dopes.

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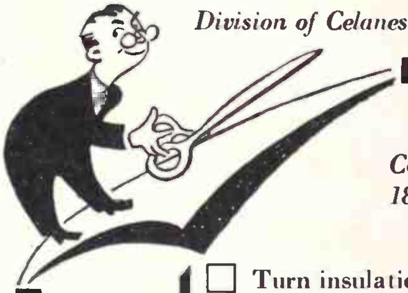
Division of Celanese Corporation of America



I am interested in the applications checked...

Give me more information on the factors checked...

A LARGE COUPON FOR A LARGE SUBJECT

Celanese Celluloid Corporation,
180 Madison Ave., New York City

- ☐ Turn insulation on wire.
- ☐ Layer insulation.
- ☐ Slot insulation.
- ☐ Molded parts.
- ☐ Laminated parts.

LUMARITH *Plastics have these properties:*

- ☐ Dielectric strength 2,000 to 2,500 volts per mil.
- ☐ Low moisture absorption—resistant to humidity. Does not dry out with age.
- ☐ Impervious to water—provide effective water barrier.
- ☐ Resistant to salt water.
- ☐ Unaffected by mineral oils and ordinary varnish solvents such as naphtha, toluol, alcohol. Resist weak acids.
- ☐ Slow burning — comparatively non-inflammable.
- ☐ High resistance to mechanical abrasion.
- ☐ Stable at temperatures up to 257° F. (125° C.) when protected from air.
- ☐ Absolutely non-corrosive to copper.
- ☐ Germproof.
- ☐ Cement easily, firmly (actually a weld).

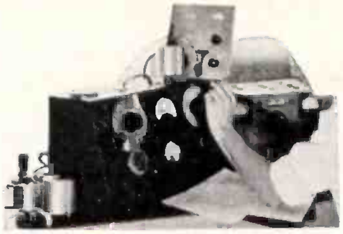
*Name*________________________ *Company*____________

*Address*____________________________________

Precision ... MEASURING INSTRUMENTS

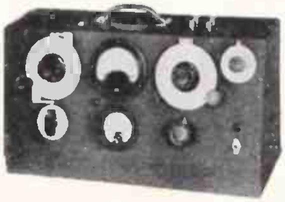
For the

RESEARCH WORKER
RECEIVER DESIGNER
PRODUCTION ENGINEER



Boonton Radio Engineers have devoted the past seven years to the development of precision measuring instruments for the research worker, the equipment designer, and the production engineer, with the result that these devices are universally recognized as standard equipment throughout the radio and allied industries.

The well-known Q-Meter was the first of a series of pioneering instruments and has proved of great value for the rapid determination of the ratio of reactance to resistance of coils or condensers used in circuit design. It was followed by instruments such as the Noise Meter, the Wide Range Beat Frequency Generator, and the Frequency Modulated Signal Generator. Boonton Radio Corporation is constantly furthering its research activities so that essential measuring instruments of the latest design are available to the industry. The principal products are briefly described below. More detailed information is contained in Catalog B, a copy of which will be sent upon request.

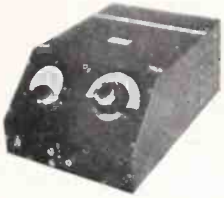


← Q-METER, TYPE 160-A

Frequency Range: 50 kc. to 75 mc. with internal oscillator and 1 kc. to 50 kc. with external oscillator.
Range of Q Measurements, Coils: 50 to 625.
Accuracy: In general ±5%.
Range of Q Tuning Condenser: 30-450 mmf, also Vernier Condenser: ±3 mmf.

Q-METER, TYPE 170-A →

Frequency Range: 30 mc. to 200 mc.
Range of Q Measurements, Coils: 100-1200.
Accuracy: In general ±10%.
Range of Q Tuning Condenser: 10-60 mmf.

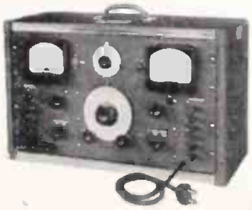


← QX CHECKER, TYPE 110-A

The factory counterpart of the Q-Meter. Compares fundamental characteristics of inductance or capacitance and Q under production line conditions with a high degree of accuracy, yet quickly and simply. Insures uniform parts held within close tolerances. Frequency range 100 kc. to 25 mc.

BEAT FREQUENCY GENERATOR, TYPE 140-A →

A single compact instrument which provides wide frequency and voltage coverage of generated signals.
Frequency Range: 20 cycles to 5 mc. in two frequency ranges.
Output Voltage Range: 1 millivolt to 32 volts.
Accuracy: ±3%.
Output Power: One watt into external load.



← FREQUENCY MODULATED SIGNAL GENERATOR, TYPE 150-A

Developed specifically for use in design of F. M. equipment. Frequency and Amplitude Modulation available separately or simultaneously. Direct reading controls. Frequency range: 41 mc. to 50 mc. and 1 mc. to 10 mc. Output voltage 1 microvolt to 1 volt.

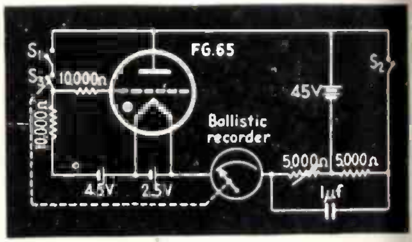
Other instruments in this series are the Type 151-A, range 30 mc. to 40 mc., Type 152-A, range 20 mc. to 28 mc.

BOONTON RADIO CORPORATION
BOONTON, NEW JERSEY U.S.A.

ble. Passage of the vane through the pickup coil field indirectly alters the frequency of the oscillator, changing its anode current. Anode current changes operate a sensitive d-c relay which operates a magnetic counter. The number of revolutions of the meter disc in a given time with a given load is counted electronically. —ELECTRONICS, April, 1942 p. 82.

Ballistic Speedmeter

THE TIME REQUIRED for an object, such as an automobile, to pass between two fixed points may be used to operate a circuit containing a recording ballistic galvanometer to determine the speed of that object in any arbitrary units, miles per hour, feet per second, etc. Either phototube relays or mechanical switches may be located at the fixed points to operate the circuit. A thyratron is caused to conduct current when the object passes the first fixed point (S_1 closes momentarily) and to cease flowing when the object reaches the second point (S_2 closes momentarily). The mass of the moving element in the galvanometer is such that one-quarter of its natural period exceeded the longest time to be measured. With a moving mass of about 4 ounces and a spring tension such that the period was two seconds, the graph of time intervals versus deflection for a constant current corresponding to an automobile speed over a distance of 15 feet of 20 miles per hour is approximately 0.61 second. S_1 with S_3 is actuated by the moving element of the galvanometer to prevent acceptance of another indication until the stylus of the recorder is at rest. The record is made by a heated recording stylus moving over waxed paper.—Reich and Toomim, *Review of Scientific Instruments*, February 1941, p. 96.



Ballistic speed meter circuit. Current flows through the ballistic galvanometer between the momentary closings of S_1 and S_2

Ears of the Signal Corps!

Serving the cause of Victory

For training—for action—the U. S. Army Signal Corps demands sensitive, *reliable* Radio Phones.

Precision - built Murdock Radio Phones are important aids to communication wherever the Army goes. In peace—in war—since 1904, Murdock has furnished 'scientific ears' for the Signal Corps.

Murdock

RADIO PHONES

URDOCK MANUFACTURING COMPANY—Chelsea, Mass.

TUBES

INDEX

Cathode-Ray Tubes

Type	Diameter of Screen	Issue	Pa
2501A3	3 inches	Jan 42	9
2501C3	3 inches	Jan 42	9
2503A3	3 inches	Feb 42	8
2503C3	3 inches	Feb 42	8
2505A5	5 inches	Feb 42	8
2505C5	5 inches	Feb 42	8
2507A5	5 inches	Feb 42	8
2507B5	5 inches	Jan 42	
2507C5	5 inches	Jan 42	9
2509A5	5 inches	Jan 42	9
2509C5	5 inches	Jan 42	9
2511A5	5 inches	Jan 42	9
2511B5	5 inches	Feb 42	8
2511C5	5 inches	Feb 42	8
2511D5	5 inches	Feb 42	9
2512A9	9 inches	Feb 42	9
2512B9	9 inches	Feb 42	9
2512C9	9 inches	Feb 42	9
2514A9	9 inches	Mar 42	9
2514B9	9 inches	Mar 42	9
2514C9	9 inches	Mar 42	9
2514D9	9 inches	Apr 42	11
2519A14	14 inches	Apr 42	11
2519B14	14 inches	Apr 42	11
2519C14	14 inches	Mar 42	10
2519D14	14 inches	Apr 42	11
2520A20	20 inches	Mar 42	10
2520B20	20 inches	Mar 42	10
2520C20	20 inches	Apr 42	11
2520D20	20 inches	Mar 42	10
2529A5	5 inches	Apr 42	11
2529B5	5 inches	Apr 42	11
2529C5	5 inches	Apr 42	11
2529D5	5 inches	Apr 42	11
2530A9	9 inches	Apr 42	11
2530B9	9 inches	Apr 42	11
2530C9	9 inches	Apr 42	11
2530D9	9 inches	May 42	9
2532A20	20 inches	Mar 42	10
2532B20	20 inches	Mar 42	10
2532C20	20 inches	Mar 42	10
2532D20	20 inches	Mar 42	10
2533A5	5 inches	May 42	9
2533B5	5 inches	May 42	9
2533C5	5 inches	May 42	9
2533D5	5 inches	May 42	9

Receiving Tubes

Type	Function	Issue	Pag
6AH5G	Beam power amplifier, $P_o = 10.8$	Mar 42	99
6C5GT/G	Triode, $\mu = 20$	Jan 42	94
6F6GT/G	Pentode power amplifier, $P_o = 3.2$	Jan 42	96
6J5GT/G	Triode, $\mu = 20$	Jan 42	94
6SC7GT	Double triode, $\mu = 70$	Mar 42	98
6ST7 (M)	Double diode, triode, $\mu = 16$	Feb 42	88
6Y3G	Half-wave rectifier, $E_p = 5000$	Mar 42	98
7S7 (GL)	Triode-heptode converter, $g_c = 600$	Jan 42	95
7T7 (GL)	Pentode voltage amplifier, $g_m = 4900$	May 42	94
7W7 (GL)	Pentode voltage amplifier, $g_m = 5800$	Jan 42	94
14S7 (GL)	Triode-heptode converter, $g_c = 525$	Jan 42	94
14W7 (GL)	Pentode voltage amplifier, $g_m = 5800$	Jan 42	94

Injection Molded Mycalex

DESIGN CONSIDERATIONS

The General Electric Plastics Department's development of a technique for the injection molding of G-E mycalex has greatly expanded applications for this material. A mixture of ground mica and specially prepared glass, G-E mycalex is particularly valuable in parts for radio and electronics equipment. The following design features indicate the increased scope possible with the injection molding method.

RELATIVELY INTRICATE SHAPES

Injection molding permits greater latitude in shape and dimension without sacrificing physical properties. Machining is not required on most parts.

HOLES AND INSERTS

Metallic inserts are readily molded and are firmly anchored in part. Use of inserts often simplifies assembly of finished parts and provides excellent terminals or contacts. Molded holes eliminate drilling, and tolerances on holes or part dimensions may be held close.

FABRICATION

G-E mycalex parts may be machined, filed or polished. Thin sheets may be punched.

THERMAL CONDUCTIVITY

Parts may be designed for use at high temperatures, as mycalex conducts heat away from points of incipient failure.

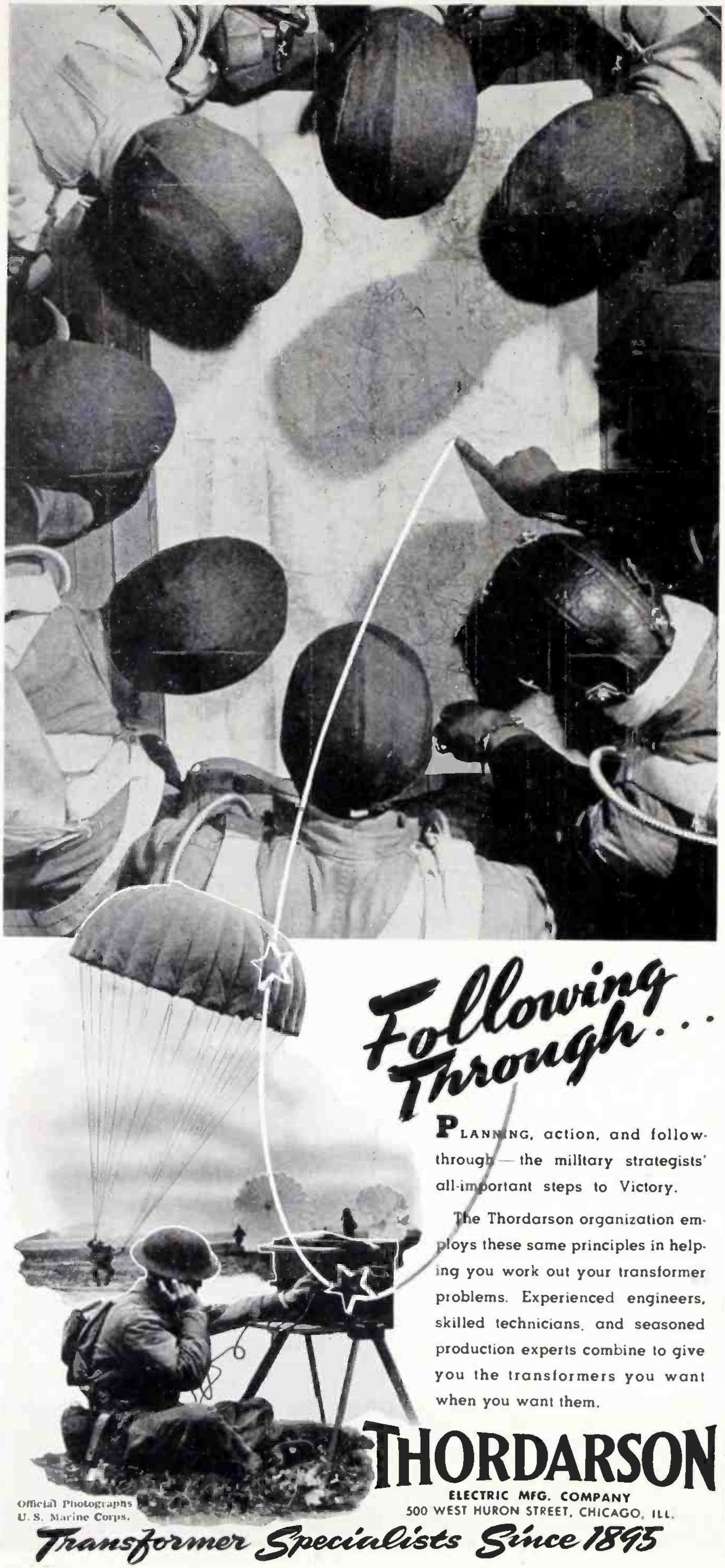
Injection molded mycalex has many other physical and chemical features which influence design of parts. G-E Plastics Department engineers are familiar, through experience and actual production, with problems of design and manufacture. Their services and suggestions may aid in the improvement of your product.

For information and descriptive booklet write Section H-5, Plastics Department, General Electric Co., **ONE PLASTICS AVENUE,** *Pittsfield, Mass.*

PLASTICS DEPARTMENT

GENERAL ELECTRIC

PD-50



INDEX CONTINUED

Industrial Tubes

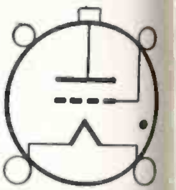
Industrial Tubes

Type FG-17

General Electric

THYRATRON; grid-controlled gaseous-discharge rectifier; glass envelope; overall height $6\frac{5}{8}$ inches (max); diameter $2\frac{7}{16}$ inches (max); 4-pin base.

E_f = 2.5 v
I_f = 5.0 amp
Peak Plate Voltage = 2500 v
Peak Anode Current = 2.0 amp
Avg Anode Current = 0.5 amp
Grid Voltage for Starting—Negative
Temp Range, Condensed Mercury = 40—80° C

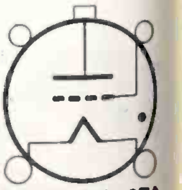

FG-17 FG-27A
FG-57 FG-81A

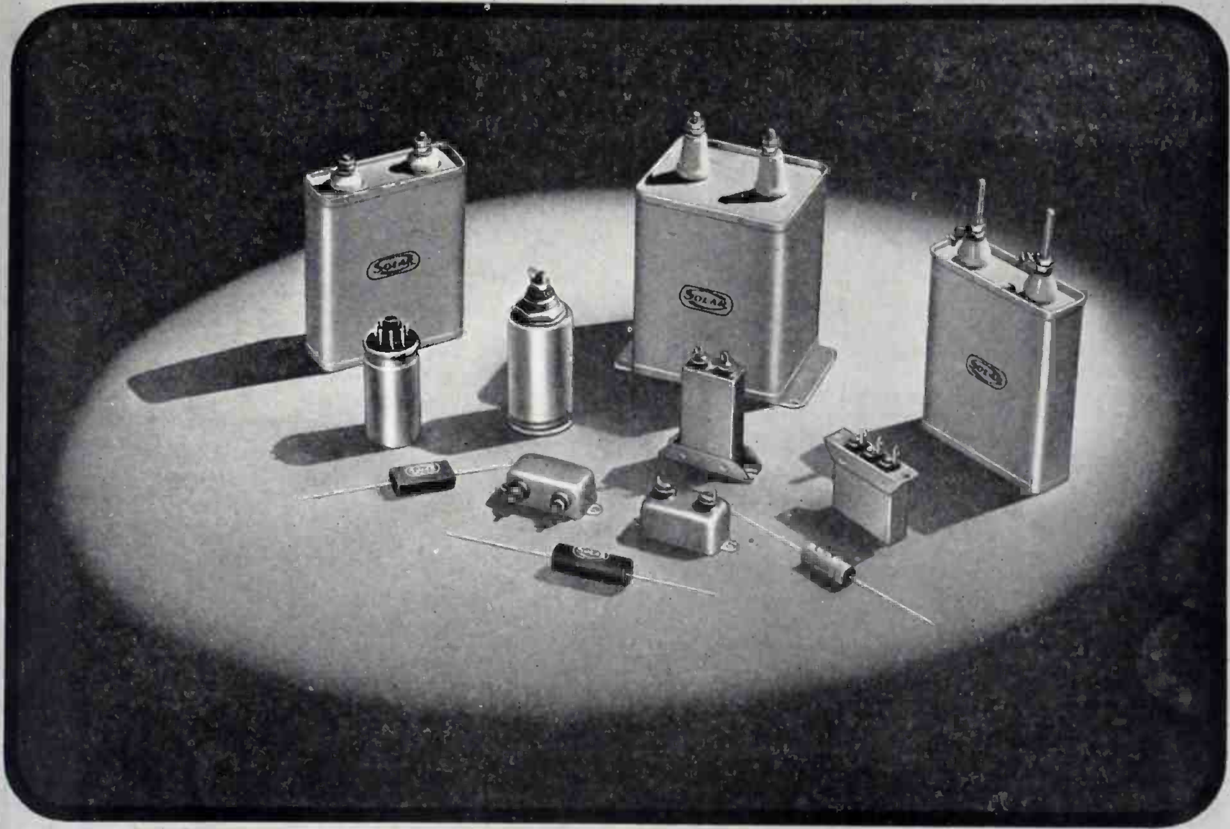
Type FG-27-A

General Electric

THYRATRON; grid-controlled gaseous-discharge rectifier; glass envelope; overall height 7.25 inches (max); diameter 3 inches (max); 4-pin base.

E_f = 5.0 v
I_f = 4.5 amp
Peak Anode Voltage = 1000 v
Peak Anode Current = 10.0 amp
Avg Anode Current = 2.5 amp
Grid Voltage for Starting—Negative
Temp Range, Condensed Mercury = 40—80° C


FG-17 FG-27A
FG-57 FG-81A



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Solar experience plays a vital part in the production of completely dependable paper capacitors for the Armed Service Branches of our Government.

Consult Solar for prompt solution
of your paper capacitor problems

SOLAR MFG. CORP. . . . . . BAYONNE, N. J.

SOLAR

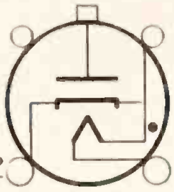
"QUALITY ABOVE ALL" CAPACITORS

Type FG-32

General Electric

PHANOTRON; mercury-vapor, half-wave rectifier; glass envelope; overall height $6\frac{3}{4}$ inches; diameter 3 inches (max); 4-pin bayonet base.

E_f = 5.0 v
I_f = 4.5 amp
Tube Voltage Drop
= 24 v (max)
= 5 v (min)
Peak Plate Voltage = 1000 v
Peak Plate Current = 15 amp
Avg Plate Current = 2.5 amp
Temp Range, Condensed Mercury = 30—80° C



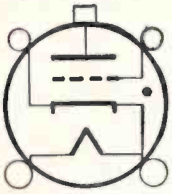
FG-32

Type FG-33

General Electric

THYRATRON; grid-controlled gaseous-discharge rectifier; glass envelope; overall height $7\frac{1}{2}$ inches (max); diameter 3 inches (max); 4-pin base.

E_f = 5.0 v
I_f = 4.5 amp
Peak Anode Voltage = 1000 v
Avg Anode Current = 2.5 amp
Grid Voltage for Starting—Positive
Peak Anode Current = 15 amp
Temp Range, Condensed Mercury = 35—80° C



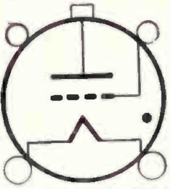
FG-33
FG-67

Type FG-57

General Electric

THYRATRON; grid-controlled gaseous-discharge rectifier; glass envelope; overall height $7\frac{1}{4}$ inches (max); diameter 3 inches (max); 4-pin base.

E_f = 5.0 v
I_f = 4.5 amp
Peak Anode Voltage = 1000 v
Peak Anode Current = 15 amp
Avg Anode Current = 2.5 amp
Grid Voltage for Starting—Negative
Temp Range, Condensed Mercury = 40—80° C



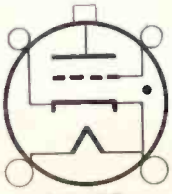
FG-17 FG-27A
FG-57 FG-81A

Type FG-67

General Electric

THYRATRON; grid-controlled gaseous-discharge rectifier; glass envelope; overall height 7 inches (max); diameter 3 inches (max); 4-pin base.

E_f = 5.0 v
I_f = 4.5 amp
Peak Anode Voltage = 1000 v
Peak Anode Current = 15 amp
Avg Anode Current = 2.5 amp
Grid Voltage for Starting—Variable
Temp Range, Condensed Mercury = 40—80° C



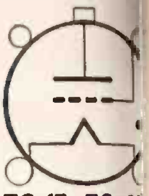
FG-33
FG-67

Type FG-81-A

General Electric

THYRATRON; grid-controlled gaseou discharge rectifier; inert-gas fille glass envelope; overall height $6\frac{5}{8}$ inch (max); diameter $2\frac{7}{16}$ inches (max); pin base.

E_f = 2.5 v
I_f = 5.0 amp
Peak Anode Voltage = 500 v
Peak Anode Current = 2.0 amp
Avg Anode Current = 0.5 amp
Grid Voltage for Starting—Negative
Temp Range, Ambient = − 20—+50° C



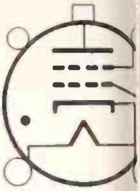
FG-17 FG-2
FG-57 FG-81

Type FG-95

General Electric

THYRATRON; grid-controlled gaseo discharge rectifier; glass envelo overall height $5\frac{13}{16}$ inches (max); dia eter 3 inches (max) plus one-half in for grid cap on side of envelope; 4- base.

E_f = 5.0 v
I_f = 4.5 amp
Peak Anode Voltage = 1000 v
Peak Anode Current = 15 amp
Avg Anode Current = 2.5 amp
Grid Voltage for Starting—Variable
Temp Range, Condensed Mercury = 40—80° C



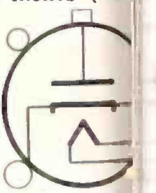
FG-95

Type FG-104

General Electric

PHANOTRON; mercury-vapor, half-w rectifier; glass envelope overall hei 11 inches; diameter $3\frac{13}{16}$ inches (ma 4-pin bayonet base.

E_f = 5.0 v
I_f = 10.0 amp
Peak Plate Voltage = 3000 v
Peak Plate Current = 40 amp
Avg Plate Current = 6.4 amp
Tube Voltage Drop
= 24 v (max)
= 5 v (min)
Temp Range, Condensed Mercury 40—80° C



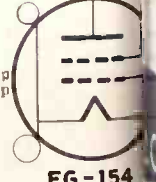
FG-104

Type FG-154

General Electric

THYRATRON; grid-controlled gase discharge rectifier; inert-gas fill glass envelope; overall height inches; diameter 3 inches (max) p one-half inch for grid cap on side envelope; 4-pin base.

E_f = 5.0 v
I_f = 7.0 amp
Peak Anode Voltage = 500 v
Peak Anode Current = 10.0 amp
Avg Anode Current = 2.5 amp
Grid Voltage for Starting—Negative
Temp Range, Ambient = −20— +50°C



FG-154

When Designing Electronic Control Equipment

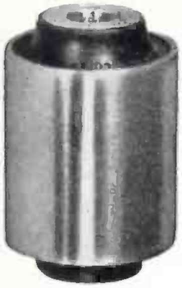
Include Vibration Control with

LORD

BONDED RUBBER

MOUNTINGS

PLATE FORM



TUBE FORM

VERTICAL SNUBBING (V.S.) PLATE FORM

VERTICAL SNUBBING (V.S.) TUBE FORM

FLEXIBLE COUPLING

These efficient shear-type bonded rubber mountings will isolate vibration and reduce operating fatigue to a minimum. Their effectiveness is based on the use of shear-stressed rubber (synthetic rubber, if desired) which deflects more readily than rubber under compression or tension and yet provides sufficient stability.

Lord Plate Form Mountings are made with square, round or diamond outer plates or in stamped holders. They can be used singly or in series for supporting loads from ½ to 300 pounds.

Lord Tube Form Mountings consist of two metal tubes bonded in position to rubber. Loads are carried and vibration is absorbed axially. Tube Form Mountings are used for equipment when exceptional radial stability is required. They are designed to carry loads from a few pounds up to 1500 pounds.

Lord Vertical Snubbing Mountings are made in both plate and tube forms for installations where heavy shock loads as well as vibratory forces are encountered. The "V-S" design effectively snubs shock loads without impairing vibration isolation characteristics.

Lord Flexible Couplings are one piece bonded rubber units that accommodate parallel and angular misalignment without inducing high bearing loads. Shear-stressed rubber provides effective absorption of torsional vibration and prevents transmission of sound through the shaft. Made in seven sizes up to and including 1 H.P. to fit all shaft sizes.

Other Lord Bonded Rubber Products include aircraft engine suspensions, joints for radial loading, torsion joints, diaphragms and instrument mountings. Special bonded rubber products can be designed and manufactured to meet individual requirements.

Lord's research facilities and wide knowledge of vibration engineering are available to every industry for the solution of problems in their field.

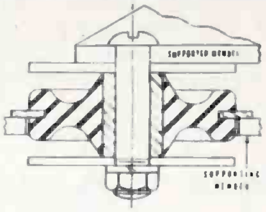
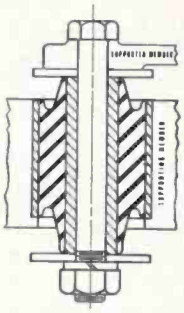
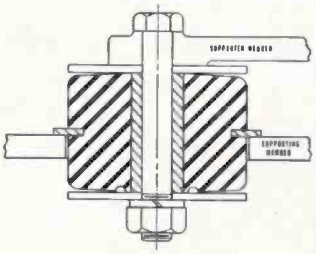


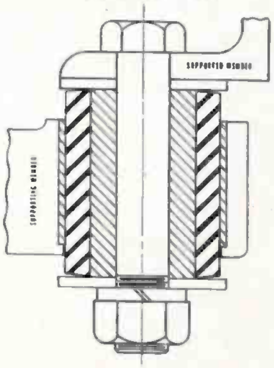
PLATE FORM



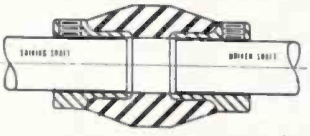
TUBE FORM



VERTICAL SNUBBING (V.S.) PLATE FORM



VERTICAL SNUBBING (V.S.) TUBE FORM



FLEXIBLE COUPLING

It takes rubber in shear to absorb vibration

ORD MANUFACTURING COMPANY ERIE, PA.

Research workers on war problems may find the answer in the following list

Ceramics:

- Binder for ceramic insulation
- Protective coating against mechanical abuse
- Binder for vitreous enamels
- Binder for abrasive wheels
- Binder for porcelain enamel frit

Pharmaceuticals and Foods:

- Edible emulsifying agent
- Non-staining ointments
- Edible fixative oil for candies
- Binder for yeast tablets
- Enteric coating
- Polish for tablets and pills

Adhesives:

- "Cellophane" and cellulose acetate adhesive
- Tissue paper to aluminum adhesive
- Adhesive for rubber to cloth
- Thermosetting cement

Paints, Varnishes, Colors and Pigments:

- Pulp color and pigment dispersing agent
- Flattening agent for paints and varnishes
- Emulsion paints
- Lacquer and varnish plasticizer
- Soft grinding of lake colors
- Increased length of pigment lakes
- Non-mar enamels
- Water and ink resistant lacquers

Rubber and Synthetic Rubber:

- Gasoline resistant finish
- Rubber gasket lubricant
- Rubber to cloth adhesion
- Polishing of hard rubber
- Plasticizing synthetic rubber

Metals:

- Aluminum castings corrosion protection
- Foundry cores
- Joint seals for pipes
- Aluminum drawing lubricant
- Tin stamping lubricant
- Nickel alloy stamping rust prevention
- Metal surface protection
- Drawing and stamping of nickel alloys
- Sintered bearing lubricant

Paper:

- Transparent coating
- Waterproofing liquid
- Flameproofing agent
- Translucent paper
- Wax coating

Textiles:

- Transparent coating
- Olive oil substitute
- Waterproofing liquid
- Textile lubricant
- Flameproofing agent
- Flexibilizer for cotton braid
- Dye solvent
- Textile emulsions
- "Nylon" and "Vinyon" lubricant
- Worsted and spun rayon lubricant

Cork:

- Cork preservative

Cements:

- Waterproofing agent

Wood:

- Warpage prevention
- Flameproofing

Leather:

- Sulphonated oil substitute

Plastics:

- Plasticizer and lubricant
- Polishing
- Lubricant for molding

●

Our laboratories have developed solutions to these unique problems. The answers to these and many other problems are given in a 112 page manual of chemical formulation for numerous industries. A copy of the manual "Chemicals by Glyco" is yours for the asking. Send for it today. You may find the answer to your war-time problems. GLYCO PRODUCTS CO., INC., 230 King Street, Dept. 54, Brooklyn, N. Y.

Type FG-166

General Electric

PHANOTRON; mercury-vapor, half-w rectifier; quick heating cathode; me envelope; overall length 19½ inc (max); diameter 5 inches (ma flexible leads.

E_f = 2.5 v
I_f = 100 amp
Tube Voltage Drop
= 20 v (max)
= 5 v (min)
Peak Plate Voltage = 1500 v
Peak Plate Current = 150 amp
Avg Plate Current = 30 amp
Temp Range, Condensed Mercury = 20—70° C

Type FG-190

General Electric

PHANOTRON; inert-gas-filled, full-w rectifier; metal envelope; overall hei 4⅜ inches (max); diameter 1$\frac{13}{16}$ i (max); supplied with lead wires.

E_f = 2.5 v
I_f = 12 amp
Tube Voltage Drop
= 13 v (max)
= 5 v (min)
Peak Plate Voltage = 175 v
Peak Plate Current = 5.0 amp
Avg Plate Current = 1.25 amp
Temp Range = − 20—+60° C

Type FG-235-A

General Electric

IGNITRON; high-peak-current, pool-c ode tube; water cooled; for wel service; metal envelope; height inches (max); diameter 4¼ in (max).

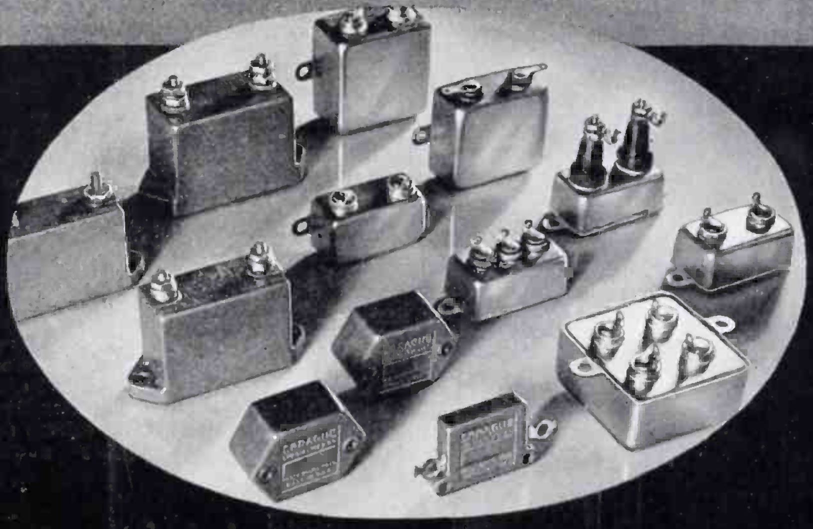
Supply Voltage (rms)
= 250—600 v
Demand = 1200 kva
Corresponding Avg Anode Current = 75.6 amp
Max Avg Anode Current
= 140 amp
Corresponding Demand
= 400 kva
Ignitor Voltage = 200 v
Ignitor Current = 40 amp

Type FG-258-A

General Electric

IGNITRON; high-peak-current, pool-c ode tube; water cooled; for wel service; metal envelope; height inches; diameter 5⅜ inches (max

Supply Voltage = 250—600 v
Demand = 2400 kva
Corresponding Avg Anode Current = 192.0 amp
Max Avg Anode Current
= 355 amp
Corresponding Demand
= 800 kva
Ignitor Voltage = 200 v
Ignitor Current = 40 amp



Let CLAROSTAT Solve YOUR RESISTANCE PROBLEM

★ Yes indeed, it pays to follow the example of leading equipment builders, instrument makers, communication companies, broadcasters and other critical users of components: Let Clarostat solve your resistance problem!

Because Clarostat has a wider choice of resistors, controls and resistance devices, due to a wide range of fabrication facilities, you can usually take care of your requirements more critically when you depend on Clarostat. For instance:

Controls . . .

Clarostat composition-element controls are the last word in high-resistance potentiometers. Accurate resistance values, first and last. 1000 ohms to 5 megohms. Ad-A-Switch feature. Choice of tapers and taps. ★ Clarostat wire-wound controls or potentiometers, 1 to 100,000 ohms, choice of tapers and taps. Single or multiple units. ★ Clarostat power rheostats, 25 and 50 watt ratings, built for hardest kind of service. ★ Also faders, padders, mixers, attenuators, etc.

Resistors . . .

Greenohms—those green-colored cement coated power resistors found in quality transmitters, oscillographs, fine instruments and dependable electronic assemblies—are positively the toughest power resistors made. 4 to 200 watts. Fixed and adjustable. Round and flat. Any mounting or terminals. ★ Also choice of voltage divider strips, voltage-dropping power cords, etc.

Ballasts . . .

Tube-type plug-in resistors, line-voltage reducers, automatic line-voltage regulators, etc.

Submit that Problem . . .

No matter what your control or resistance problem may be, send it to us for engineering collaboration, recommendations, specifications, quotations. Engineering loose-leaf data on request.

CLAROSTAT Manufacturing Co. Inc.
285-287 NORTH SIXTH STREET
BROOKLYN, NEW YORK, U.S.A.
• OFFICES IN PRINCIPAL CITIES •

Type FG-271

General Electric

IGNITRON; high-peak-current, pool-cathode tube; water cooled; for weldir service; metal envelope; height inches (max); diameter 2¾ inch (max).

Supply Voltage (rms) = 250—600 v
Demand = 600 kva (max)
Corresponding Avg Anode Current = 30.2 amp
Maximum Avg Anode Current = 56.0 amp
Corresponding Demand = 200 kva
Ignitor Voltage = 200 v
Ignitor Current = 40 amp

Type FP-85

General Electric

KENOTRON; high-vacuum, half-wa rectifier; glass envelope; air coole overall height 6⅝ inches (max); ameter 2 7/16 inches (max); 4-pin ba

E_f = 10.0 v
I_f = 5.0 amp
Peak Inverse Anode Voltage = 20,000 v (max)
Peak Anode Current = 0.1 amp (max)

FP-85

Type FP-92

General Electric

KENOTRON; high-vacuum, half-wa rectifier; glass envelope; air cool overall height 25¼ inches (max); ameter 6⅛ inches (max).

E_f = 10 v
I_f = 14.5 amp
Peak Inverse Anode Voltage = 150,000 v (max)
Peak Anode Current = 0.3 amp (max)

Type GL-411

General Electric

KENOTRON; high-vacuum, half-w rectifier; glass envelope; air cool overall height 18⅛ inches (max); ameter 5⅛ inches.

E_f = 10 v
I_f = 14.5 amp
Peak Inverse Anode Voltage = 100,000 v (max)
Peak Anode Current = 0.3 amp

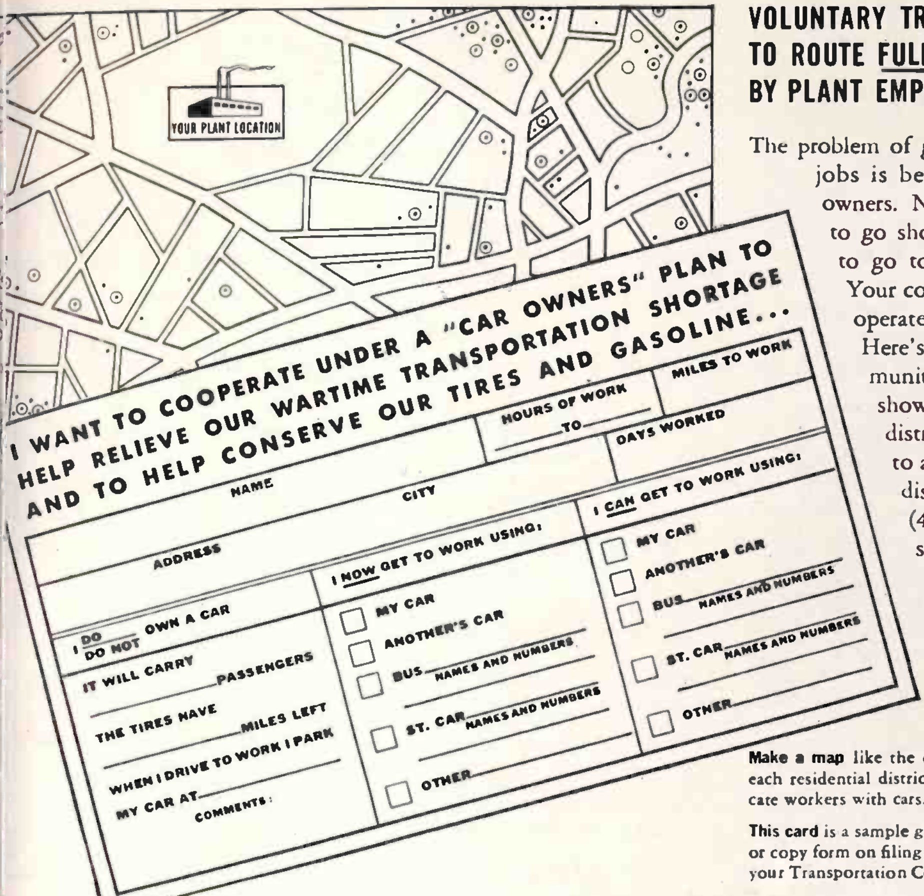
Type GL-415

General Electric

IGNITRON; high-peak-current, pool-ca ode tube; water cooled; for weld service; metal envelope; overall hei 5¼ inches; diameter 2¾ inches (max)

Supply Voltage (rms) = 250—600 v
Demand = 300 kva
Corresponding Avg Anode Current = 12.1 amp
Maximum Peak Anode Current = 22.4 amp
Ignitor Voltage = 200 v
Ignitor Current = 40 amp

ANY LARGE COMPANIES ARE NOW TAKING A CENSUS
F EMPLOYEES' CARS AS PART OF NATION'S PROGRAM
O GET 40,000,000 WORKERS TO THEIR JOBS ON TIME



I WANT TO COOPERATE UNDER A "CAR OWNERS" PLAN TO HELP RELIEVE OUR WARTIME TRANSPORTATION SHORTAGE AND TO HELP CONSERVE OUR TIRES AND GASOLINE...

NAME

HOURS OF WORK ______ TO ______

MILES TO WORK

ADDRESS

CITY

DAYS WORKED

I DO / DO NOT OWN A CAR

IT WILL CARRY ______ PASSENGERS

THE TIRES HAVE ______ MILES LEFT

WHEN I DRIVE TO WORK I PARK MY CAR AT ______

COMMENTS:

I NOW GET TO WORK USING:
- ☐ MY CAR
- ☐ ANOTHER'S CAR
- ☐ BUS ______ NAMES AND NUMBERS
- ☐ ST. CAR ______ NAMES AND NUMBERS
- ☐ OTHER ______

I CAN GET TO WORK USING:
- ☐ MY CAR
- ☐ ANOTHER'S CAR
- ☐ BUS ______ NAMES AND NUMBERS
- ☐ ST. CAR ______ NAMES AND NUMBERS
- ☐ OTHER ______

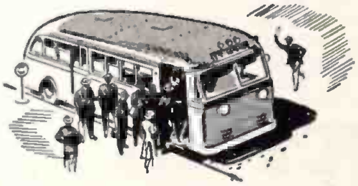
VOLUNTARY TRANSPORTATION COMMITTEES TO ROUTE FULL CARS TO WORK ARE SET UP BY PLANT EMPLOYEES IN EACH COMMUNITY

The problem of getting 40,000,000 workers to their jobs is being taken over by America's car owners. Neighbors are already doubling up to go shopping, to take children to school, to go to work . . . *but not enough of them!* Your company and your employees can co-operate by taking a census of workers' cars. Here's how you can do it in your community: (1) Fill out cards, like the one shown here, (2) Sort cards by residential districts, (3) Select sectional committees to act as traffic control groups for each district to assure equitable use of cars, (4) Route *full* cars to work on every shift. Details can be worked out quickly by you . . . your workers . . . your community. The important thing is to start today to get every last mile of use from our cars, our gas, our tires!

Make a map like the one above, on which to chart the routes for each residential district. Dots indicate workers' homes; circles indicate workers with cars.

This card is a sample guide. Make changes to suit your needs. Reprint or copy form on filing cards for each worker to fill out and turn in to your Transportation Committee.

Trolleys can't do it ALONE. Even with staggered work hours to level off transportation peaks there aren't enough trolleys to take America's millions to work.

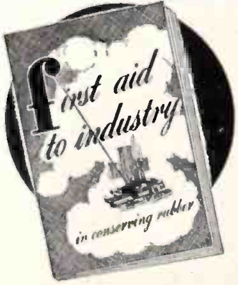


Buses can't do it ALONE. They're already taxed to their full seating capacity. And enough vital steel and rubber can't be spared to build enough new buses.

Trains can't do it ALONE. Although every railroad is cooperating 100%, many of America's mighty war production plants can't be serviced by trains or subways.

TO CONSERVE MECHANICAL RUBBER GOODS

48-page book is for managers, engineers
plant operating men. It shows how you
onserve rubber through proper handling,
lation and care of rubber conveyor, ele-
and transmission belts; all types of in-
ial hose; packings; linings; rolls; mount-
and other mechanical rubber goods; and
ical wires, cables, and tapes. For free
s, write directly to Mechanical Goods
ion, United States Rubber Company.



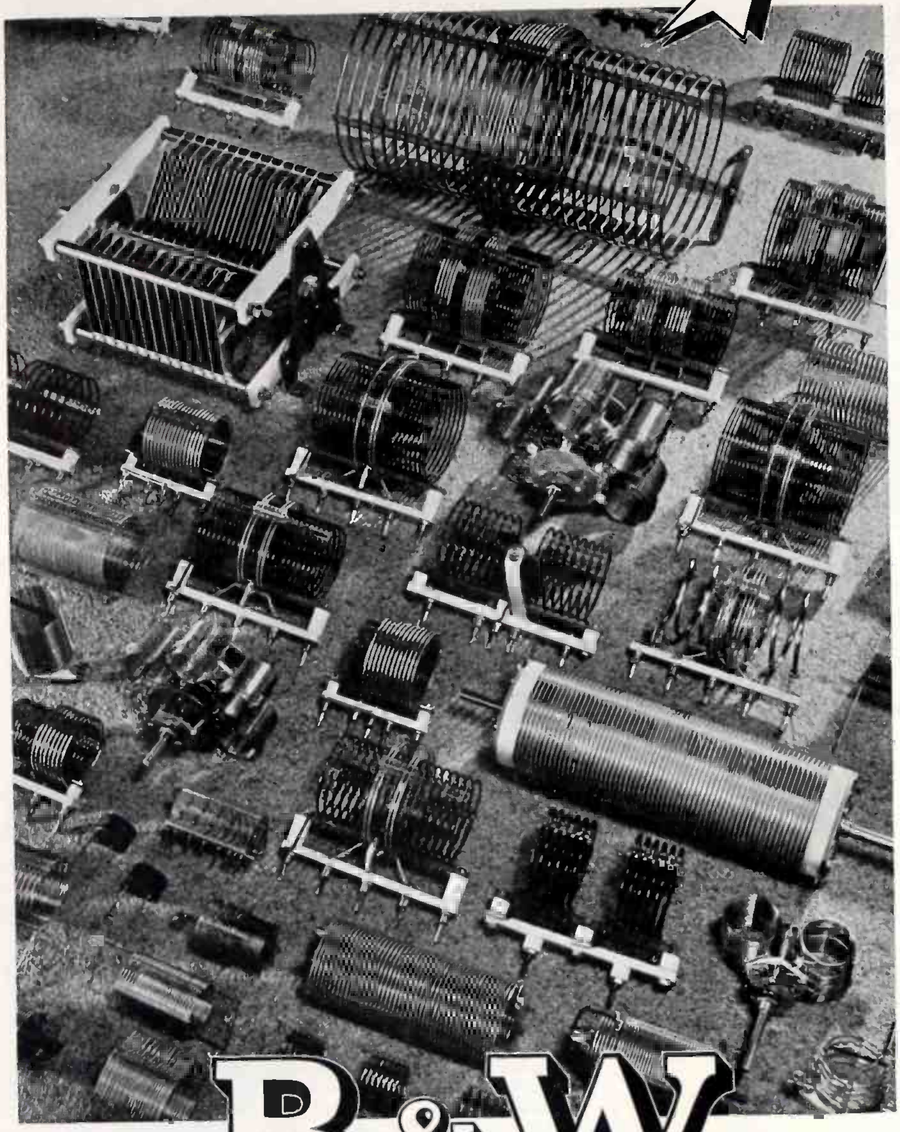
GET FREE MILEAGE BUDGET CHARTS

and copies of this free 32-page book on tire care from your local U. S. Tire Dealer or write direct to the United States Rubber Company. Hundreds of thousands of these charts and books are already in the hands of American car owners — helping to save tires, gas and oil.

IN AMERICA'S FIGHT FOR LIFE, EVERY TIRE-MILE MUST BE SAVED FOR ESSENTIAL DRIVING

NITED STATES RUBBER COMPANY

1230 Sixth Avenue • Rockefeller Center • New York



Type KC-4

General Electric

KENOTRON; high-vacuum, half-w rectifier; glass envelope; air cool overall height $25\frac{1}{2}$ inches (max); ameter $6\frac{3}{8}$ inches (max).

E_f = 20 v
I_f = 24.5 amp
Peak Inverse Anode Voltage = 150,000 v (max)
Peak Anode Current = 1.0 amp

Type KU-610

Westinghouse

THYRATRON; grid-controlled gase discharge rectifier; inert-gas fill glass envelope; overall height $6\frac{1}{2}$ in (max); diameter $2\frac{7}{16}$ inches (ma 4-pin base.

E_f = 2.5 v
I_f = 6.5 amp
Peak Anode Voltage = 500 v
Peak Anode Current = 0.4 amp
Avg Anode Current = 0.1 amp
Grid Voltage for Starting—Positive
Temp Range, Ambient = − 20— +70° C

KU-610

Type KU-618

Westinghouse

GRID GLOW tube; cold cathode; in gas filled; glass envelope; overall hei $5\frac{3}{4}$ inches (max); diameter $2\frac{3}{16}$ in (max); 4-pin base.

Peak Anode Voltage = 800 v
Peak Anode Current = 0.10 amp
Avg Anode Current = 0.015 amp
Grid Voltage for Starting—Positive
Temp Range, Ambient = − 20— + 70° C
Tube Voltage Drop
= 225 v (max)
= 180 v (avg)
= 125 v (min)

KU-618

Type KU-627

Westinghouse

THYRATRON; grid-controlled gase discharge rectifier; glass envel overall height 7 inches (max); di eter $2\frac{7}{16}$ inches (max); 4-pin base.

E_f = 2.5 v
I_f = 6.0 amp
Peak Anode Voltage = 2500 v
Peak Anode Current = 2.5 amp
Avg Anode Current = 0.64 amp
Grid Voltage for Starting—Negative
Temp Range, Condensed Mercury = 25 − 70° C

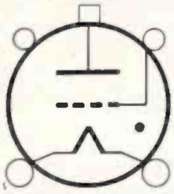
KU-627 KU
KU-634 KU
KU-67

ye KU-628

e inghouse

ATRON; grid-controlled gaseous-
rge rectifier; glass envelope;
ll height 9¾ inches (max); diam-
r inches (max); 4-pin base.

0 v
1.5 amp
ode Voltage = 2500 v
ode Current = 8.0 amp
ode Current = 2.0 amp
tage for St arting—
tive
tange, Condensed Mer-
= 25—70° C



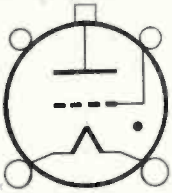
KU-627 KU-628
KU-634 KU-636
KU-676

e KU-634

inghouse

ATRON; grid-controlled gaseous-
rge rectifier; glass envelope;
l height 9 inches (max); diam-
r inches (max); 4-pin base.

0 v
1.5 amp
ode Voltage = 7500 v
ode Current = 5.0 amp
de Current = 1.25 amp
ltage for Starting—
ive
ange, Condensed Mer-
= 25—50° C



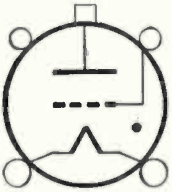
KU-627 KU-628
KU-634 KU-636
KU-676

e KU-636

nghouse

TRON; grid-controlled gaseous-
rge rectifier; inert-gas filled;
envelope; overall height 7 inches
; diameter 2$\frac{7}{16}$ inches (max);
base.

v
amp
ode Voltage = 350 v
ode Current = 0.4 amp
de Current = 0.1 amp
tage for Starting—
ive
ange, Ambient
20— +70° C



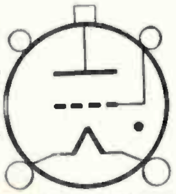
KU-627 KU-628
KU-634 KU-636
KU-676

e KU-676

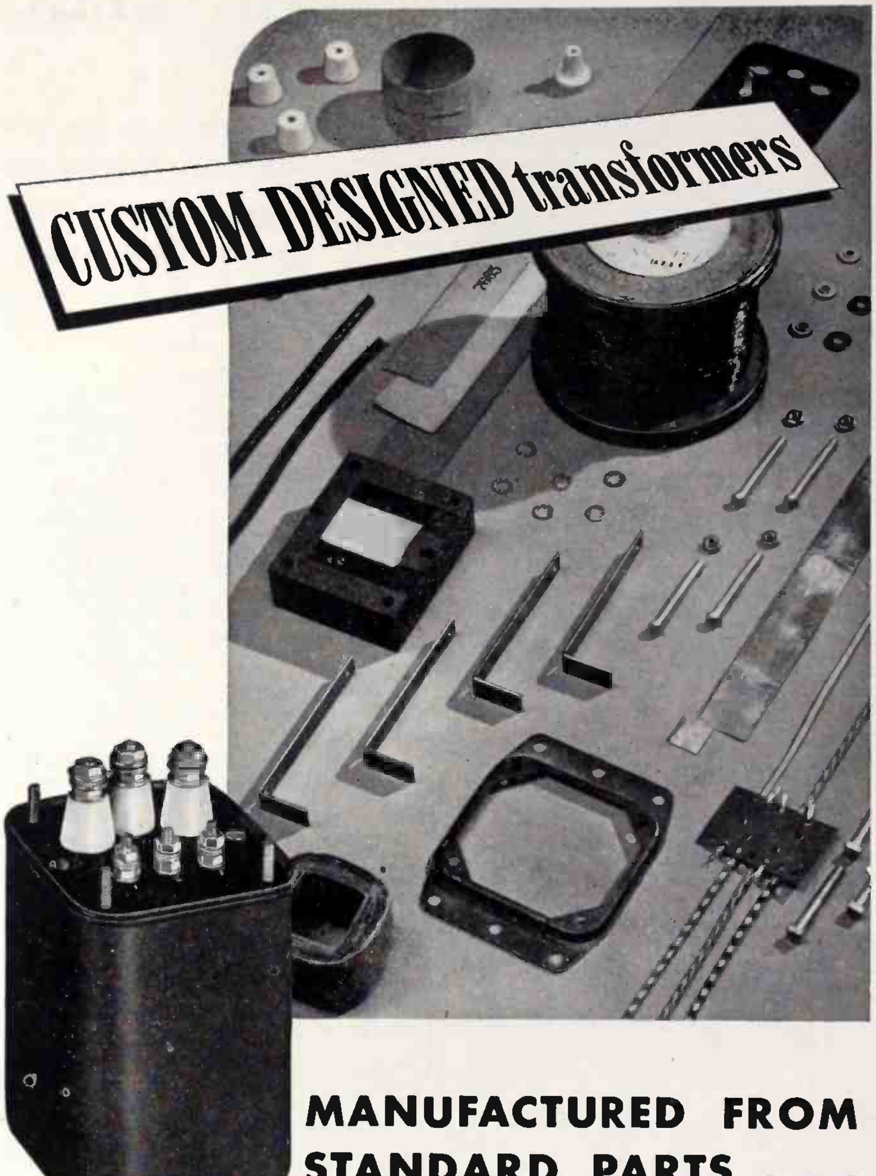
nghouse

TRON; grid-controlled gaseous-
ge rectifier; glass envelope;
l height 11⅞ inches (max); diam-
inches (max); 4-pin base.

v
amp
de Voltage = 1000 v
de Current = 40.0 amp
de Current = 6.4 amp
tage for Starting—
ive
ange, Condensed Mer-
= 25—70° C



KU-627 KU-628
KU-634 KU-636
KU-676



THE ELECTRON ART

Optimum Response Scanning Slit-Image

By George Logan

Sound Department
M-G-M Studios
Culver City, Cal.

In sound reproduction from film, a mechanism moves the sound track at uniform speed past a scanning beam. The track acts as a light modulator, and the modulated light transmitted through the film falls upon a phototube. A pulsating direct current is set up in the phototube circuit, and the amplified alternating component of that current operates the horns.

The scanning light is the image of a physical slit; the slit-image is created by an optical system such as is depicted in Fig. 1. Appearance of the slit-image is further illustrated in Fig. 2.

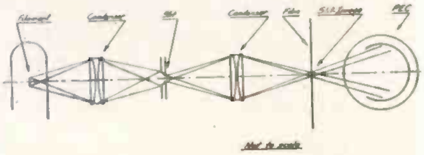


Fig. 1—Schematic arrangement of optical system of typical reproducer

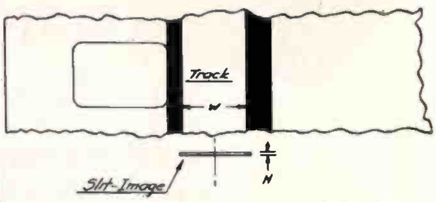


Fig. 2—Slit image and sound track

As is usual in most signal amplifying systems, it is desirable to secure an overall flat response up to some chosen cut-off frequency. To achieve this aim, the point of lowest level response must be determined, and equalization attenuation inserted to lower other regions of a response curve to that level. Yet, it is desirable to keep the amount of equalization attenuation inserted to a minimum. Such attenuation represents loss, and must be compensated for by increased amplifier capacity.

It has been well known that with a necessarily finite slit-image height, H, the relative response falls off with increasing frequency as shown by the curves of Fig. 5. It is logical, then, to determine the slit-image height which will present maximum relative response at the cut-off frequency. Once t optimum slit-image height is found, will follow that the equalization tenuation chargeable to H will be minimum. Hence the purpose of t investigation is to derive the form for optimum H in terms of the cut frequency.

The symbols used in the derivat are:

T = track transmission, the ratio: (tr mitted light)/(incident light),
y_m = maximum change in transmission fr mean transmission,
λ = wavelength of cycle on track: 1800
θ = angular distance from cycle's origi
ϕ = angular distance of slit-image ce line from cycle's origin,
x = linear distance from cycle's origin,
Q_1 = incident light quantity,
Q_2 = transmitted light quantity,
H = slit-image height,
β = radians of cycle covered by ½ H
w = track width,
L = slit-image illumination intensity,
i = instantaneous value a-c and,
f = frequency, cycles per second.

Units employed are the radian angles, the second for time, and the (0.001 inch) for linear distances.

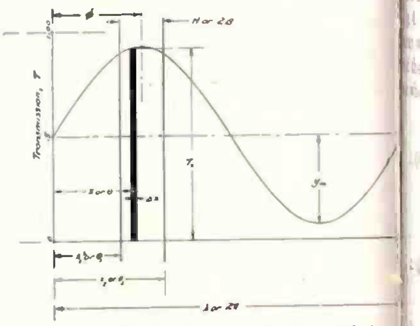


Fig. 3—Transmission of sinusoidal re corded cycle

Referring to Fig. 3, if a sine w signal has been recorded, the li transmission along a cycle on the tr is represented by a sine curve. For ample, the transmission at x is T_x,

$$T_x = \frac{\Delta Q_2}{\Delta Q_1}$$

$$\therefore \Delta Q_2 = (T_x)(\Delta Q_1)$$

$$= (y_m + y_m \sin\theta)(L w \Delta x)$$

Total quantity of light passed thro the film is:

$$Q_2 = \sum_{x_1}^{x_2} \Delta Q_2$$

$$= \int_{x_1}^{x_2} (y_m + y_m \sin\theta) L w$$

'o integrate, it is necessary to express dx in terms of $d\theta$.

$$\frac{x}{\theta} = \frac{\lambda}{2\pi}$$

$$dx = \frac{18000}{2\pi f} d\theta$$

ubstituting above and integrating:

$$Q_2 = \frac{18000\ L\ w\ \beta\ y_m}{\pi f} + \frac{18000\ L\ w\ y_m}{\pi f} \sin \phi \sin \beta \qquad (1)$$

he incident light quantity presented he film is:

$$Q_1 = L\ H\ w$$

out $H = \frac{18000\ \beta}{\pi f}$

$$\therefore Q_1 = \frac{18000\ L\ w\ \beta}{\pi f} \qquad (2)$$

is a constant for any given optical em, which of course includes a fixed e for H. Substituting Eq. (2) into (1), we obtain:

$$Q_2 = Q_1\ y_m \left(1 + \frac{\sin \phi \sin \beta}{\beta}\right)$$

$$Q_2 = Q_1\ y_m \left(1 + \frac{\sin \phi \sin \frac{\pi f H}{18000}}{\frac{\pi f H}{18000}}\right) \qquad (3)$$

'or any particular frequency we ht choose to investigate, and for particular value of H, the quotient

$$\frac{\frac{\pi f H}{000}}{\frac{f H}{000}}$$

is a constant. From Eq. therefore, it is apparent that scan- a recorded sine wave cycle will Q_2 to vary sinusoidally about an which is placed a distance $Q_1\ y_m$ e the $Q_2 = 0$ line, as illustrated in 4. The maximum value of Q_2 must r when $\sin \Phi = 1$, or at $\Phi = \pi/2$; the minimum value of Q_2 must oc- when $\sin \Phi = —1$, or at $\Phi = 3\pi/2$.

$$\therefore Q_{2\ max} = Q_1\ y_m \left(1 + \frac{\frac{\sin \pi f H}{18000}}{\frac{\pi f H}{18000}}\right)$$

$$\therefore Q_{2\ min} = Q_1\ y_m \left(1 - \frac{\frac{\sin \pi f H}{18000}}{\frac{\pi f H}{18000}}\right)$$

we are working the linear range of cell, which is assumed, the instan- ous current output of the cell is ctly proportional to the amount of t falling on the cell.

$$i = k\ Q_2$$

urther, the signal output level of cell depends upon the current g; that is, upon the difference be- en i_{max} and i_{min}. We can express difference in terms of y_m, Q, f, and t is seen. Our intention is to in- igate the effect on response of H es, at different frequencies, so we me y_m constant. Now if we arbi- ily select a reference set of condi- s with, say, $H = 0.75$ mil and $f =$) cps, we can write:

$$\text{tive Response,} = 20 \log (A/B) \text{ decibels} \qquad (4)$$

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where A is current swing, for any combinati of H and f and B is current swing, for $H = 0.$ and $f = 1000$

Expressing current swing as in cated and simplifying:

$$R = 20 \log \left[\frac{7660 \sin \frac{\pi f H}{18000}}{f} \right]$$

To determine the H value which w give maximum response at some fr quency, $\frac{d\,(R)}{d\,H}$ is equated to zero.

$$\frac{d\,(R)}{d\,H} = \frac{\pi f \log \epsilon}{900} \cot \frac{\pi f H}{18000} = 0$$

$$\therefore H = \frac{9000}{f}$$

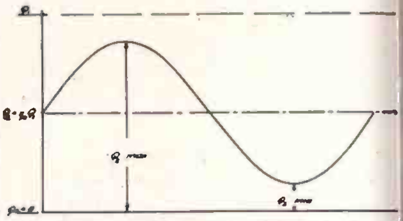


Fig. 4—Sinusoidal variation of transmitt light

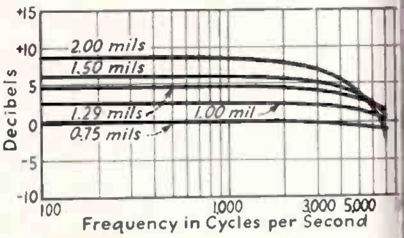


Fig. 5—Relative response of slit-image plotted against frequency

This Eq. (5) is the formula desir Let us presume that the upper f quency to which we intend to equal for flat response is 7000 cps. Then optimum slit-image height is:

$$H = \frac{9000}{7000} = 1.29 \text{ mils}$$

Each curve in Fig. 5 was obtained selecting an H value, and solving (4) with various frequencies sub tuted therein. These curves show t only the 1.29 mil slit-image dimens will give maximum response at 7 cps. Other values of H, whether lar or smaller, produce less response that cut-off frequency, verifying efficacy of Eq. (5).

• • •

Heating by High-Frequency Induction

THE PROBLEMS OF WARTIME product have accelerated the development heating by high frequency induct This method has the advantage in t heat can be induced into metals points where it is wanted with n exacting control. Four pertinent ticles on induction heating have peared in the February 1942 issue tinghouse Engineer. The first is 'Heating by High Frequency Induc-" by Frank T. Chestnut; the second "External Surface Hardening by iction Heating" by W. E. Benning- and H. B. Osborn Jr.; the third "Internal Surface Hardening by ction Heating" by Howard E. es; and the fourth on "Electrical ipment for Induction Heating" by . Levy and L. J. Lunas.

he problems encountered in high uency heating are much more in- ed than those of melting. If a ge is to be heated throughout to a orm temperature, a low frequency ld be selected for high depth of etration and the power should be enough to allow the interior of the ge to be heated by conduction from surface nearly as fast as the sur- itself is heated. On the other hand, charge is to be surface heated only, frequency and high power are ired.

ntrolled temperatures up to 3600 C have been attained in induction aces. Time cycles of only a few nds may be obtained by automatic lation of power and quenching in- als, thus assuring exact duplica- of parts. Microscopically, the cture of an induction hardened has a distinct appearance. The l needle-like crystals resulting from ace hardening are absent and in- d we find a more homogeneous cture with finer nodular crystals.

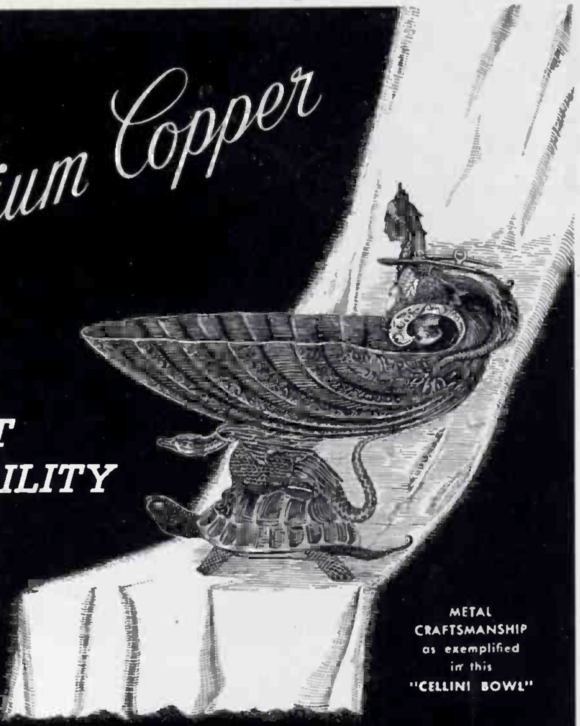
igh frequency hardening equipment ists of a high frequency generator, ctor, quenching auxiliaries, suit- transformers and capacitors, and matic timing controls. Frequencies rom 60 cps to more than 100 kc been used. A variety of generat- equipment and of instruments is sary to meet all requirements. ting equipment has been designed bly for 500, 960, 1920, 3000, 9600 11,520 cps. Frequencies above 100 are best obtained from electronic lators. They have the advantage eing non-rotating and are readily table to changes in frequency. ll units up to 20 kilowatts are with water-cooled tubes and when capacity is required, several os- tors are connected in multiple.

ecause an oscillator has no moving s, and because its output frequency riable, there have been attempts to ace motor-generator sets in the 500 2,000 cps field by electronic oscil- rs. However, the cost of the va- n tube oscillator rises as the fre- cy is reduced and at present no omical low-frequency oscillators available.

• • •

tronic Differentiation

APPLICATIONS OF vacuum tube cir- to electronic differentiation are erous: displacements can be con- ed into velocity, velocity into ac- ation, quantity of electricity can hanged to current and sine wave



voltages shifted 90 electrical degre Simplified electronic differentiati circuits are described by Otto Schmitt and Walter E. Tolles in article entitled "Electronic Different tion" in the March 1942 issue of *T Review of Scientific Instruments.*

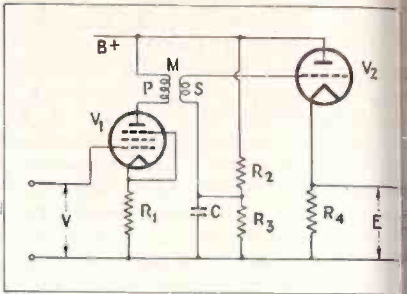


Fig. 1—Mutual inductance differentiat

Two general methods have been e ployed. The first uses a coupled circ as shown in Fig. 1. The voltage duced in the secondary of a pure n tual inductance varies in direct p portion to the time rate of change current in the primary.

$$V_s = M \frac{dI_p}{dt},$$

where V_s is the secondary indu e.m.f., M is the mutual inductance a I_p is the primary current.

The second uses a series circuit o condenser and resistor, as shown Fig. 2. The current through the c denser varies directly with the ti rate of change of potential across condenser.

$$I = \frac{dq}{dt} = C \frac{dv}{dt}$$

where I is the current through condenser, q is the charge on the c denser, V is the potential differe across the condenser plates and C the capacitance of the condenser.

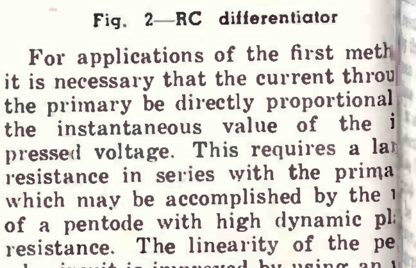
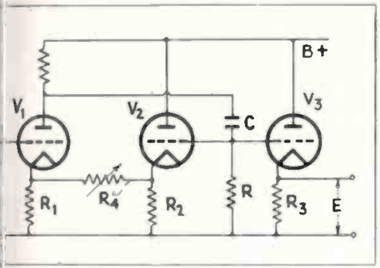


Fig. 2—RC differentiator

For applications of the first meth it is necessary that the current throu the primary be directly proportional the instantaneous value of the i pressed voltage. This requires a la resistance in series with the prima which may be accomplished by the of a pentode with high dynamic pl resistance. The linearity of the pe ode circuit is improved by using an bypassed biasing resistor R_1.

The second, or condenser method, the simpler of the two, and is appli ble where a large but not extreme ra of frequencies has to be handled by circuit. The form of differentia els upon a condenser C to provide a ent proportional to the time rate hange of signal voltage V. The ntial drop across R, connected in s with the condenser, is proportional to the current and hence proional to the time derivative of the t voltage. The above statements made with the assumption that the essed potential is unaffected by differentiator circuit. This requires the input circuit have a low inal impedance as compared to that and C. They further assume that resistance is much less than the citive reactance at all working encies. The first condition can et by supplying the differentiator a circuit of reasonably low imnce, such as a low resistance radio plate circuit; the second, by choosuitable values of R and C. The au recommend a value of R equal to dynamic plate resistance of the um tube and a value of C such that voltage drop across R shall never d 1/30 of the impressed voltage.



ig. 3. Feedback type differentiator

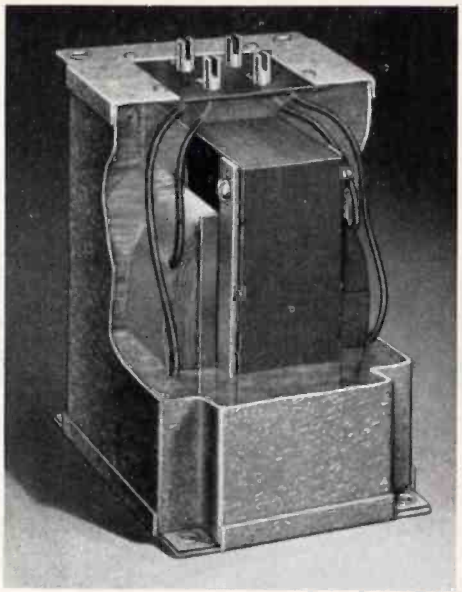
e largest error, which is due to cting the voltage drop across the rentiating resistor, can be elimine if a voltage equal to it, but in e opposition is fed back into the entiator circuit. This feed-back be accomplished with a circuit n in Fig. 3.

• • •

Relaxation Amplifier

WELL KNOWN CIRCUIT of the relax- oscillator is incorporated in the of a pulse relay called a relaxaamplifier. It is described in an by Dr. Martin Wald in *The less Engineer* of December, 1941. the addition of a diode rectifier to wo tube relaxation oscillator of ham and Block, an interesting cir- esults, called a relaxation ampliy the author. The diode is inserted en the output and input, (see Fig. us the feedback current can pass in one direction and no oscillation ccur. Should any small voltage se be impressed on the input with rid positive, relaxation oscillation be produced. These oscillations, er, will be interrupted as soon as urrent through the diode rectifier to change its direction, that is a half cycle.

maximum sensitivity and stable tion, the feed-back through the capacity is neutralized by means e condenser C_N. The operating



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point of the amplifier is determine the setting of the negative bias age E_B.

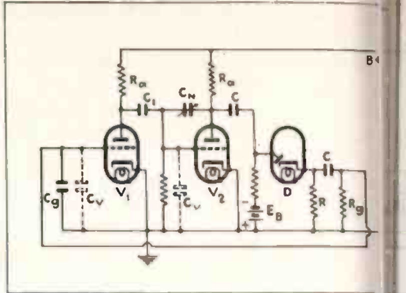

Fig. 1. Circuit of relaxation amplif

If a sine wave with a frequ greater than that of the relaxation cillations is impressed on the inpu this amplifier, the output freque will then be independent of the pressed frequency. Thus an unm lated radio frequency signal on the put would be directly converted to audio frequency. The author cla that the circuit operates well as a s plified telegraphic receiver, with strong a.v.c. effect. As long as the put signal is smaller than the op tion threshold of the relaxation am fier, no sound frequency will be he

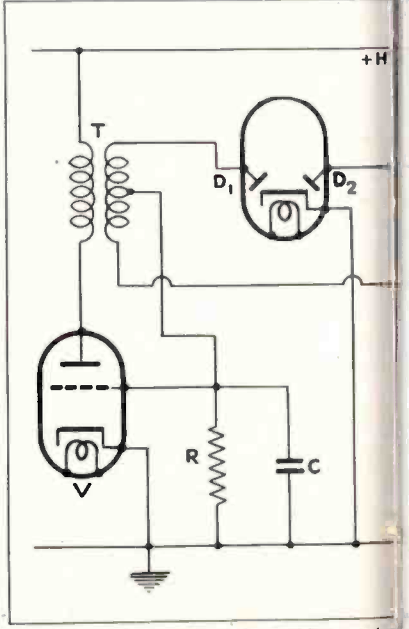

Fig. 2. Relaxation amplifier with transfor

For any signal amplitude exceeding threshold value, the relaxation osci tion will produce an audio signal.

Another possible type of relaxa amplifier is shown in Fig. 2. Here phase inversion is accomplished means of the transformer *T*. The ends of the secondary are connecte the duo-diode, and the mid-tap to grid. Any negative impulse impres on the grid will start a relaxation o lation of large amplitude, increas the negative grid potential until tube blocks. After the condenser discharges through the resistance the system remains in balance unt new impulse occurs.

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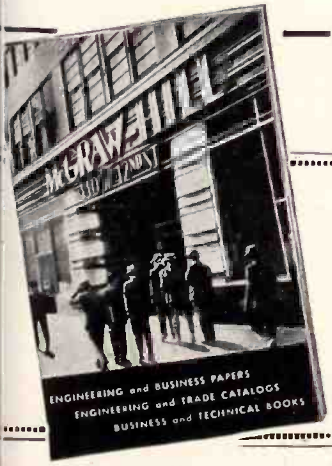

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Almost every year for many years this useful compendium of information had been revised, added to, and in general brought up to date with new research. This edition is no exception. Considerably more than half of the pages in the book have been added or completely revised and reset. These changes include such data as Physical Constants of Inorganic, Organic and Industrial Organic Compounds, Melting and Boiling Points of Organic Compounds, Description of the Elements, Properties of Commercial Plastics, X-Ray Crystallographic Data, Gravimetric Factors and their Logarithms, Definitions of Chemical Terms, Composition and Value of Foods, and many other important tables.

The format of the book also has been changed, making it longer and wider and, as a result, more convenient to use. —K.H.

Introduction to Modern Physics

By F. K. Richtmyer and E. H. Kennard *(Third Edition. 723 pages. McGraw-Hill Book Co. Price $5. 1942.)*

This well-known volume was originally based on a course of summer lectures given at Cornell University by the late Professor Richtmyer. The first two editions of this book have enjoyed considerable popularity among upper class or graduate students in physics and engineering. After the sudden death of Professor Richtmyer, preparation of the third edition was undertaken by Professor Kennard, whose text on "Kinetic Theory of Gases", which has been reviewed in these columns, is a fitting companion for the present work.

The delightful introduction of the first two editions has been retained in the present edition in the historical sketch which outlines the advancement of physics from the earliest times to the development of the theory of electro-magnetism by Maxwell, Lorentz, Hertz and others. In the reviewer's opinion, the historical sketch given in the first chapter would be well worth reading by anyone having even a cursory interest in the physical sciences.

Once the 50 pages of Chapter I are behind the reader, it is evident that the volume is no mere high school textbook. The second chapter deals with elec magnetic waves and moving char and rapidly brings the reader to the ferential expression for Maxwe equations. Subsequent chapters d with the following subjects: The p toelectric and thermionic effe theory of relativity, origin of a qu tum theory, the nuclear atom and ori of spectral line, wave mechan atomic structures and optical spec the quantum theory of specific he x-rays, the nucleus, and cosmic r All of the topics will be of interest the physicist or engineer with cath interests.

To readers of Electronics, Chap III dealing with the photoelectric thermionic effects is likely to be of most immediate and practical inter The section dealing with the discov of the photoelectric effects and the covery of the electron, an apprecia amount of historical material is in spersed with the necessary scient implications of the discovery. Ag in describing the Zeeman effect on p 87, the historical experimental searches of Faraday are mentioned the reasons for his failure are given are also the reasons for Zeeman's cess. The subject of photoelectricit treated briefly and succinctly under following topics: Photoelectrons, r tion between photoelectric current intensity of illumination of the cath energy distribution of photoelect relation between velocity of photo trons and frequency of the light, pr erties of photoelectric emission, sou of the photoelectric energy, and photoelectric section and the corpu lar theory of light. The modern p of view is apparent in the treatm of thermionic emission under the top

The "Radio" Handbook

Published by Editors and Engineers, Ltd., 1300 Kenwood Road, Santa Barbara, Calif. 640 pages. Price, $1.75 in clothbound edition.

The Radio Handbook gives a general compilation of information on the practical aspects of radio. The contents is divided into three classifications: (1) principles of electricity, radio, vacuum tubes and antennas, (2) constructional information on the building of high frequency transmitters and receivers and (3) tube characteristic tables, reference charts and graphs, and a collection of formulas useful to the practical radio man.

The fundamentals of radio are given in a descriptive manner with little use of mathematics. The treatment is such as to be suitable for high school students, although the constructional material contains important information to any who may desire an introduction into high frequency technique and methods. Throughout emphasis has been placed on the practical aspects of the communication problem.—B.D.

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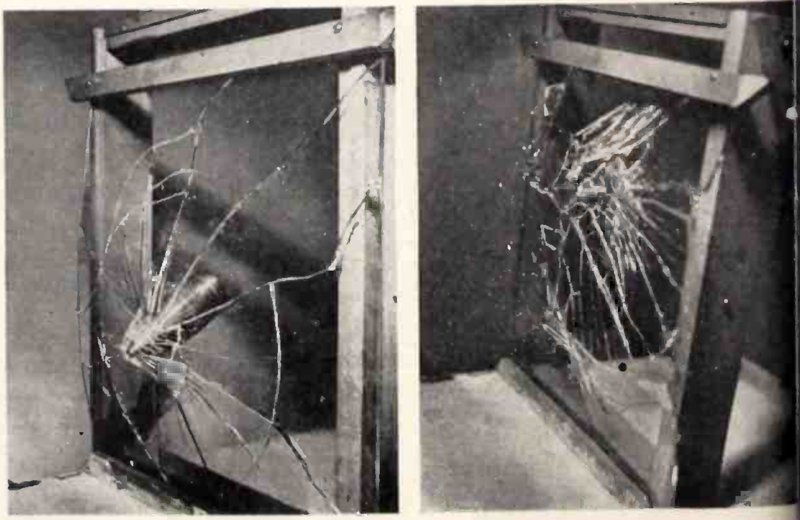

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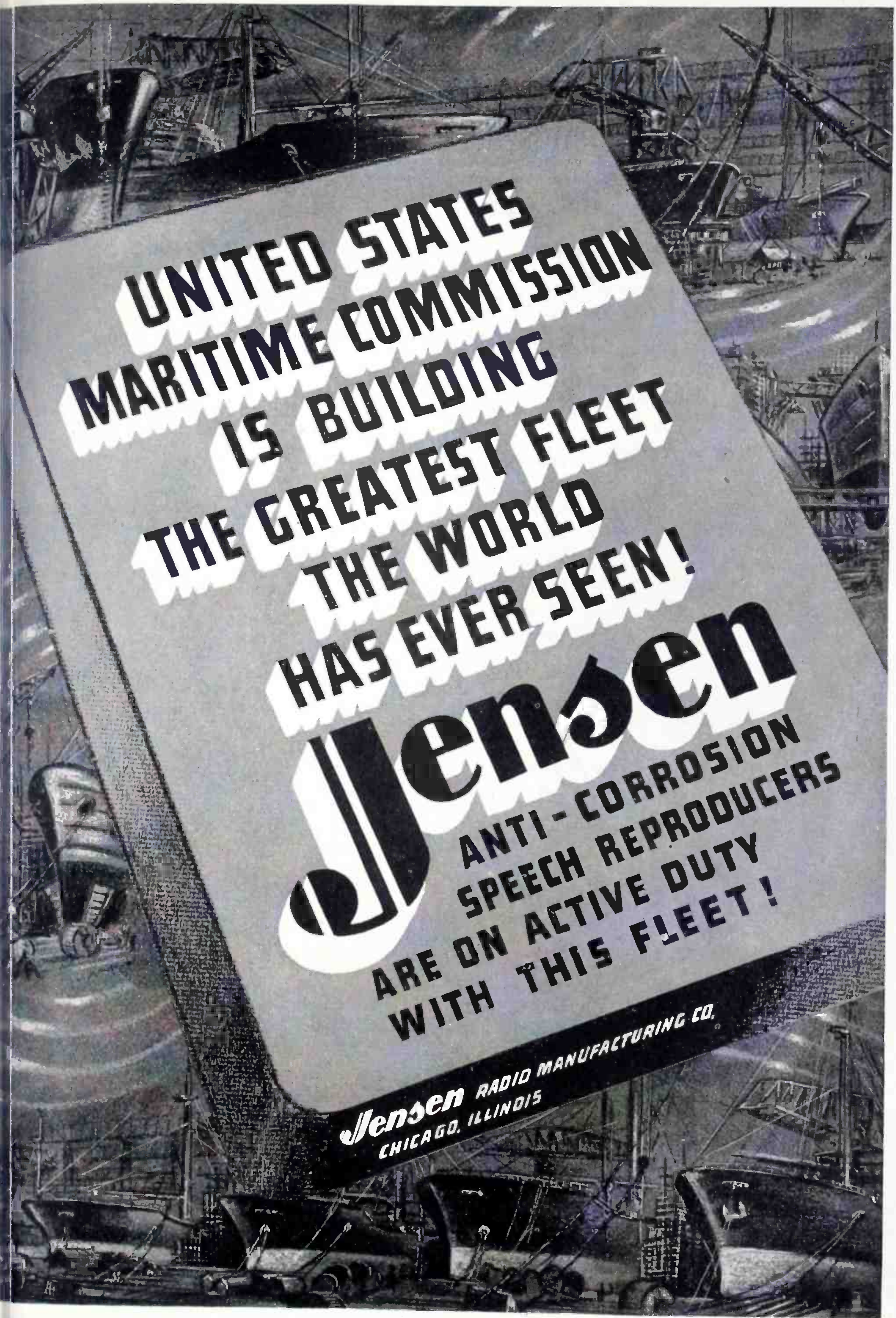
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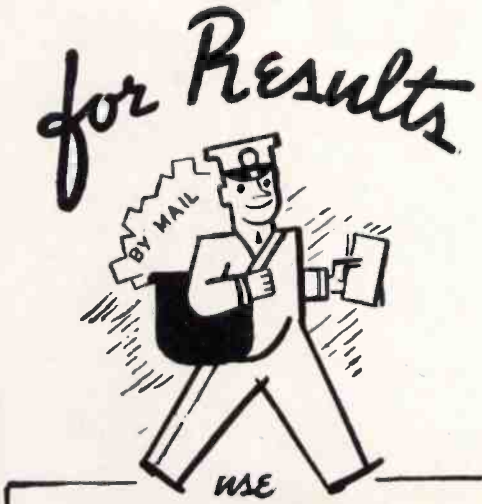

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th mionic emission, relation between th mionic and photoelectric constants, ve city of emission of thermions, th ry of electron metals, origin of ph oelectrons and thermions. While th classical work of O. W. Richardson is lequately recorded, there is no men- fi of Richardson's original derivation of the emission equation based on a th ry of gases, although the reader is re rred to Richardson's subsequent p ication for the derivation of the en ssion equation.—B.D.

e Radio Amateurs' ndbook

lished by American Radio Relay gue, West Hartford, Conn. Price $10. 288 pages.

"E SPECIAL DEFENSE EDITION" of the w known Radio Amateur's Handbook is ntended for use in radio training co ses. It differs from the usual hand- b reviewed in the February issue, m nly in that those chapters dealing w the discussion of amateur equip- m t and the operation of amateur sta- t s has been omitted, while new chap- te have been added on mathematics, m suring equipment and learning the co.

he text is suitable for high school st lents or graduates, is largely de- sc ptive rather than mathematical and is written from the practical rather th the theoretical point of view. .D.

ementary Mathematics f Engineers

AMBROSE FLEMING. *Chemical Pub- ing Co., Brooklyn, N. Y., First erican Edition 1941. 110 pages. ce $2.00*

F MING'S LITTLE BOOK (originally pub- li ed in England) has as its object to lude in one small and portable book j t the practical information on vari- to branches of mathematics which are o importance in engineering." It is n a book of mathematics for mathe- m tics' sake, but of the use of math as a ool.

hapter headings are algebra, plane tr onometry, plane co-ordinate geom- ety, vector algebra, differential cal- c us, integral calculus, differential e ations, harmonic analysis and hy- p bolic trigonometry. Fortunately the l guage of mathematics is fairly uni- v sal so that this English book does n suffer the fault of many others of u ng terminology unfamiliar to an erican reader.

Often these condensed versions of m thematics (or of any other subject) so condensed that reading pre- s ts some difficulties but in general it a useful book doing just what was p nned.—K.H.

Electrical Illumination

By JOHN O. KRAEHENBUEHL, *Professor of Electrical Engineering, University of Illinois, (441 pages. Illustrated. Price, $3.75. John Wiley & Sons.)*

ACCORDING TO THE AUTHOR, this book is intended to expound "the principles underlying specifications and design of electrical light for commercial and industrial buildings." Attention is given to the physiological and psychological aspects of lighting and illumination as well as the objective and subjective specifications of illumination. A chapter of 20 pages on color and shadow deals largely with the subjective aspects of lighting. Distribution curves and point-by-point methods of determining illumination are discussed in the fifth chapter. In the chapter dealing with incandescent and gaseous light sources, approximately 13 pages are devoted to incandescent lamps and 16 pages to gaseous conduction lamps, thereby reflecting the recent rapid advancement which has been made in electrical illumination by methods other than incandescent.

By far the largest part of this volume deals with the reflection, transmission and absorption of materials used for the control of lighting and illumination. Likewise, a considerable amount of space is given to various types of luminaires, and methods of installations which will be particularly of interest to the architect. The book is studded with line diagrams which provide helpful hints to the architect or designer by showing methods of utilizing illuminating systems. It is largely nonmathematical and is written for the level of college sophomores in both engineering and fine and applied arts divisions.—B.D.

Vacuum Tube Voltmeters

By JOHN F. RIDER, *Published by John F. Rider Publisher, Inc., 404 Fourth Ave., New York, 1941, 180 pages. Price $1.50.*

The Meter at Work

By JOHN F. RIDER, *New York, 1940, 152 pages. Price $1.25.*

THESE TWO SMALL VOLUMES are useful additions to any practicing engineer's reference library. They are well written, and the subjects are covered in a practical rather than theoretical manner. The information is specifically designed to be useful to engineers, students, and servicemen.

As the title implies, "Vacuum Tube Voltmeters" deals with potential measuring devices that employ vacuum tubes. The fundamental ideas of the subject are explained, and then how they are used in diode, triode, slide-back, rectifier-amplifier, tuned, audio-frequency, and logarithmic types of vacuum tube voltmeters. There is a section on v-t voltmeters for measur-

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ing d-c voltage, current, and resistance. The design, construction, calibration, testing, and applications of v-t voltmeters is also discussed. A valuable bibliography on the subject appears at the end of the book.

"The Meter at Work" covers measuring instruments in general. Such topics as moving-iron meters, moving-coil meters, electrodynamometer and electrostatic meters, and thermal meters are treated in some detail with an eye to principles of operation and construction. The components, characteristics, and applications of these instruments are discussed. A chapter on the characteristics of rectifiers and thermocouples is also included.

An interesting feature of this latter book is its unusual construction. The publisher has separated the text from the illustrations and diagrams so that the reader is able to thumb through the text and have the diagram referred to before him all the time. This is accomplished by binding the diagrams and illustrations in the upper portion of the book, and the text in the lower portion with a small space separating the two sections. Thus in effect you have two small books bound in the same cover. In this manner repetition of diagrams is avoided and the reader is able to cover all phases of the subject he is interested in without having to turn back pages to refer to a particular diagram. The idea is good except that in turning the pages of the lower section you tend to have

• • •

WATER LOCATOR

This apparatus which is installed in a truck is driven to the location and small portable seismographs are set up on the ground. A small blast of dynamite is then discharged and the photographic recorders make a photo record of the rebound and passage of waves through the earth. The speed of these waves indicates the glacial deposits, formation of bed rock, kind of rock, amount of water under the ground and the distance down to the water. Rev. Daniel J. Linehan, S. J. is shown working on a group of the small seismographs which are used under water to pick up the waves of a blast

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the pages of the upper section turn als. This difficulty might be solved by binding the book with a spiral type of binding which would permit the diagrams in the upper section to lie flat as the pages of the text section were turned.—E.E.G.

Geophysics in War

HEILAND, *Professor of Geophysics, Colorado School of Mines. 85 pages, Vo 37, No. 1 January 1942, Colorado School of Mines Quarterly. Price $1.00. Photographs, diagrams and charts.*

A TIMELY PUBLICATION discussing the application of the principles of geophysics to military operations and the application of the same principles to the location of mineral resources including water supply. Under military applications, the principles of geophysics may be applied to the location of the enemy's position, to remote control demolition, foundation tests of fortifications, location of wrecks and practice weapons, weather forecasting, location, etc. Each of these applications is described, and the differences in use for under land or under water, or the air are pointed out. Thus such dangers as submarine or aircraft detection and location are described.

The second portion of the book is devoted to the more prosaic uses of geophysics in the location of water sources, prospecting for oil and for strategic and critical materials. Finally there is a brief summary of what geophysics has to offer for the post war period.—

• • •

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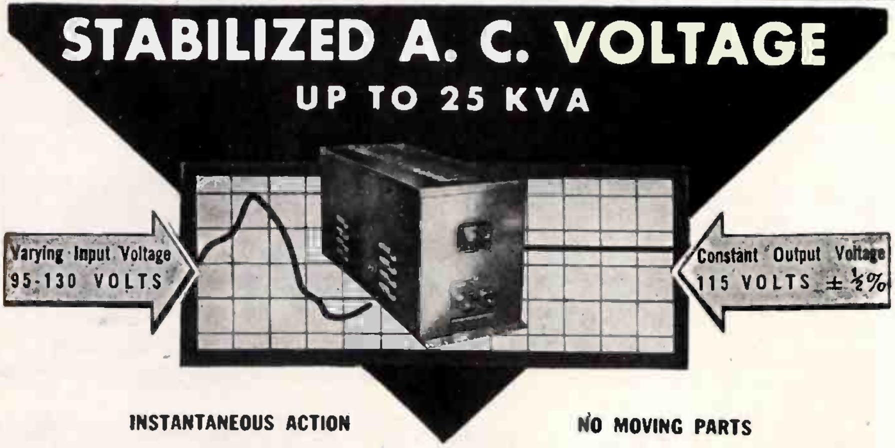

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June 29, 30, and July 1
Statler Hotel
Cleveland, O.

MONDAY, JUNE 29

10:30 A. M.—1:00 P. M.

Addresses of welcome by A. F. Van Dy P. L. Hoover, and Carl E. Smith.

"Recording Standards" by I. P. Rod Columbia Recording Corp.

"A New Approach to the Problem of Pho graph Reproduction" by G. L. Beers a C. M. Sinnett, RCA Mfg. Co.

"Measuring Transcription Turntable Var tions" by H. E. Roys, RCA Mfg. Co.

"A New Type of Practical Distortion Mete by J. E. Hayes, Canadian Broadcast Corp.

"Frequency Modulation Distortion in Lo Speakers" by G. L. Beers and H. Bel RCA Mfg. Co.

2:30 P. M.—5:00 P. M.

"Radio Frequency Oscillator Apparatus a Its Application to Industrial Process-Co trol, Equipment" by T. A. Cohen, Whee Instrument Co.

"The Scanning Microscope" by V. K. Zwo kin, J. Hillier, and R. Snyder, RCA M Co.

"Spectroscopic Analysis in the Manufactu of Radio Tubes" by S. L. Parsons, H grade Sylvania Corp.

"Minimizing Aberrations of Electron Lenses by H. Poritzky, General Electric Co.

• • •

LETTER ON A RECORD

At the USO club for servicemen in Norfolk, Va., service men record their letters o this recording-reproducing machine and mail the records home to the folks. These machines are being installed in USO club operated by the NCCS

TUESDAY, JUNE 30

10:00 A. M.—1:00 P. M.

"Maintenance of Broadcasting Operations During Wartime" by J. A. Ouiment, Canadian Broadcasting Corp.

"High Power Television Transmitter" by H. B. Fanchet, General Electric Co.

"F-M Transmitter-Receiver for ST Relay" by W. F. Goetter, General Electric Co.

"Effect of Solar Activity on Radio Communication" by H. W. Wells, Carnegie Institution of Washington.

2:30 P. M.—4:30 P. M.

"Television Video Relay Systems" by J. B. Keister, General Electric Co.

"Mercury Lighting for Television Studios" by C. A. Breeding, General Electric Co.

"The Focusing View Finder in Television Cameras" by G. L. Beers, RCA Mfg. Co.

"Automatic Frequency and Phase Control of Synchronization in Television Receivers" by K. R. Wendt and H. L. Fredenhall, RCA Mfg. Co.

WEDNESDAY, JULY 1

10:00 A. M.—1:00 P. M.

"Radio Strain Insulators for High Voltage and Low Capacitance" by A. O. Austin, A. O. Austin Co.

"Improved Insulators for Self-Supporting or Sectionalized Towers" by A. O. Austin, A. O. Austin Co.

"Brief Discussion of the Design of a 900 Foot Uniform Cross Section Guyed Radio Tower" by A. C. Waller, Truscon Steel Co.

"Circular Antenna" by M. W. Scheldorf, General Electric Co.

"Stub Feeder Calculations" by H. A. Brown and W. J. Trijitzinsky, University of Illinois.

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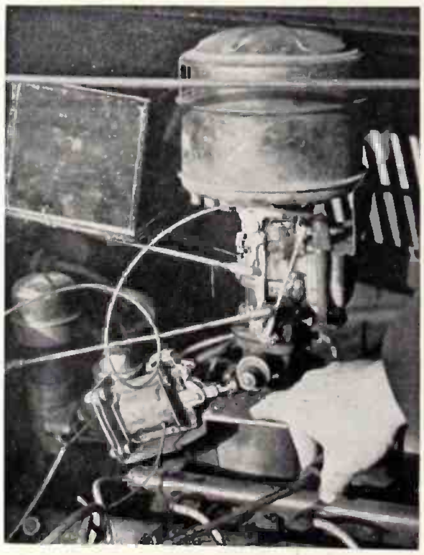
SPEED CONTROL FOR AUTOS



This radio-receiver device is attached to the motor of the automobile. Regardless of the pressure on the accelerator, it is so designed as to cut down the speed of autos approaching intersections

NEWS OF THE INDUSTRY

Supply of shellac for phonograph records sharply reduced. New demands for technical people continue to be made; even young women of scientific interest have opportunity to serve Signal Corps

News

ON APRIL 14, War Production Board limited the amount of shellac available to phonograph and transcription record manufacturers to 30 percent of 1941 consumption. The effect of this restriction upon production of records depends upon the ability of the manufacturers to use other less strategic materials or to use less shellac per record. Already, May 7, in New York records were moving out of dealers hands much faster than they were moving in.

April ruling by WPB that no new projects costing more than $5000 and requiring use of critical materials could be started without permission means that new broadcasting stations are practically impossible.

Emerson Radio and Phonograph Corp., New York City, has announced a complete line of quality replacement parts for servicing all makes of radio sets on the market. Tubes, ballast tubes, radio pilot lights, flashlight bulbs, condensers of all types, resistors, resistance line cords, shielded i-f transformers, varied phonograph equipment, speakers, transformers, volume controls, drive belts, etc. form the Emerson replac ment line.


A. E. Bailey, Jr., sales manager of new G-E electronic control section. Mr. Bailey has long been associated with the applications of electron tubes to industrial purposes, one of his major contributions being the light control system of the Chicago Civic Opera House, 1929

Armour Research Foundation, 35 We 33rd Street, Chicago, has undertak to operate a national registry of ra chemicals. It does not buy or sell, store chemicals, but maintains an i dexed file of their sources thus aidi those who do not know where to go find sources of supply.

American Standards Association h announced a new American standa for dry cells and batteries for heari aids, flashlights, telephones, igniti and portable radios, which will repr sent the best practice for many types cells and batteries and will serve starting point for new developme after the war.

Audio Productions Sold

SALE OF AUDIO Productions, Inc., Frank K. Speidell, president, acti for himself and certain associates t gether with interests representing ou side capital, by the Western Electr Company has taken place. For t past nine years, Audio Productions h been one of the leading producers the fields of industrial, advertising a training films.

Mr. Speidell will continue as pres dent of Audio with Herman Roessl vice-president, and P. J. Mooney, se retary.

Audio is now actively engaged government film contracts and is e panding its technical facilities a staff to provide an even larger produ tion set-up for training motion pictur now urgently needed in many gover ment departments and in defense i dustries.

Audio's new production headquarte and general offices are in the Fil Center Building at 630 Ninth Ave., Ne York.

Moves

CINAUDAGRAPH SPEAKERS, INC., h moved all office, machinery and equi ment to a new factory at 3911–39 South Michigan Ave., Chicago. Ad tional floor space was thereby secure

Lord Manufacturing Company's sal and engineering force has moved 520 North Michigan Ave., Chicago. T entire building at 844 North Rush S their former location has been pu chased by the Government.

Jbs

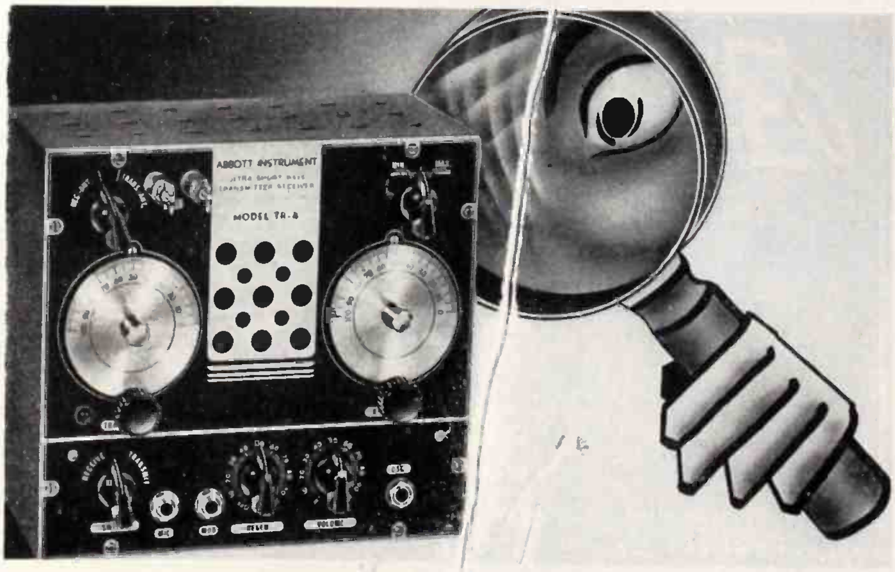
FEDERAL TELEGRAPH Co., 200 Mt. Pleasant Ave., Newark, N. J. wants men who by experience in the radio service field, have acquired a suitable background to become rapidly familiar with the inspection and testing of radio equipment for the armed services. A number of jobs are also available in marine installation work for men with commercial licenses and with ship experience. Engineering positions are also open for men who, by study have acquired the knowledge equivalent to that required for an engineering degree. No 1-A draft classification men will be considered.

Women skilled in amateur radio engineering or any part of the electronics field are having an opportunity to enter the civilian ranks of the Army Signal Corps. So great is the need for radio and telephone personnel in this branch of the armed forces that a recruiting mission is touring the country interviewing people who are interested.

Appointments as commissioned officers of the United States Marine Corps Reserve, for assignments to special aircraft warning duties, are now being offered to men holding B.S. degrees in electrical, communication or radio engineering. College graduates with special training in physics or mathematics are also eligible. Experienced radio operators, technicians and repairmen are also wanted by the Marine Corps. Appointments with initial rank of staff sergeant are open to qualified men between the ages of 17 and 35 with the assurance that they will be assigned aircraft duties. Write to Commandant, Headquarters, United States Marine Corps, Washington, D. C.

an American Airways-Africa, Ltd.

W. D. Cockrell, engineer of the new G-E electronic control division. Mr. Cockrell has 27 patents on electronic control and in 1941 received a Charles A. Coffin Foundation award for the development of phototube control of large machines and presses



will train, at its own expense, a lim number of amateur radio operators duty at its Africa stations.

In addition to free tuition the stuc will receive a salary of $100 month until successful completion this course, at which time he will part for African duty at a salary $250.00 per month plus all living transportation expenses.

The Melville Aeronautical R School, 45 West 45th St., New Y City, has been commissioned to tr operators for Pan American Airw Africa, Ltd.

Men between the ages of 18 and with previous radio experience or tr ing of any kind, in good health free to travel are desired.

Opportunity for young women, h school graduates with a bent tow mathematics and science, is offered the Signal Corps which wants hund of such women to train as enginee aids. They will be trained for 6 months and then will be assigned inspectors of communication equipm destined for the armed forces. during training is $120 per month starting with actual inspection the salary is boosted to $135. T women are being registered and sele by the Third District of the U. S. Service Commission, Philadelphia.

Marine Radio

ORDERS NOW ON hand by Radioma Corporation of America will bring total vessels equipped with radio this company to over 1000. Recentl received orders for radiotelegraph paratus for 381 new Victory ships also has orders for 400 direction fin for vessels of this and other types.

Acoustics

TO MEET DEMANDS for acoustical perts in several government lab tories as well as the technical off needs of the Army and Navy, four ters of instruction in acoustics will o advanced training during the sum of 1942. The courses start June 1 Case School of Applied Science, Cl land; Brown University, Provide University of California at Los geles; and the State University Iowa, Iowa City. The courses are o to advanced undergraduates and graduates in physics and enginee who will be available for employm upon completion of the course. Du the time these subjects are offe these schools will have other cou running and opportunity will thu offered for men to round out their cational program.

People

WILLIAM M. BAILEY and Paul McKn Deeley have been elected vice-preside of the Cornell-Dubilier Electric C poration, South Plainfield, N. J. B of these men have been actively as ciated with the company since its mation. Mr. Bailey as chief engineer in charge of the Industrial and Transmitter Capacitor Divisions, and Mr. Deeley in charge of the Chemical Laboratories, the Electrolytic Capacitor Division and the Export Division.

Wallace K. Brown has been appointed vice-president in charge of procurement for the Crocker Wheeler Electric Manufacturing Company. He will coordinate and expedite all the related functions of the procurement and purchasing departments.

Jack DeWitt, chief engineer of WSM has left for the duration to work on equipment for the armed forces at the Bell Laboratories in Whippany. His successor is to be George Reynolds, veteran WSM engineer. Another loss at WSM is that of Walter E. Bearden of the engineering staff. He is going with the Columbia University Branch of the National Research Council to be stationed at Lakehurst, N. J.

Walter C. Evans, general manager of radio, x-ray and broadcasting divisions of the Westinghouse Electric and Manufacturing Company has been made a vice-president of the company.

E. H. Fritz has been appointed plant manager of Stupakoff Ceramic and Manufacturing Company, Latrobe, Penna. Mr. Fritz is president of the Institute of Ceramic Engineers. Stupakoff is completing a large extension to its facilities for the production of Steatite insulators for radio and other communications services.

Dr. Joseph B. Engl, pioneer in sound film technique, died in New Jersey in April. Dr. Engl devoted practically his entire professional career to motion picture photography, and his patents issued in the very early days were the subject of continuous reference in litigation after sound pictures became the mode.

Another loss to the scientific world is that of Siegmund Strauss, an Austrian inventor who made notable contributions to the fields of radio and to the applications of electricity to medicine. Mr. Strauss first used a selenium cell in connection with a triode amplifier (1911); with von Lieben and Reisz made very early contributions to the electronic tube. Of recent years his contributions lay in the medical field. During 1910 to 1917 his papers appeared frequently in *ETZ* and in the London *Electrician*. He came to this country, a refugee, in 1940.

Aircraft Locaters

On April 23 newspapers carried stories regarding a press conference with Secretary of War Stimson that day giving some details of the aircraft warning systems now being located along the coast lines. According to this report, aircraft or ships at sea can be picked up more than 100 miles away. Mr. Stimson looked through one of the new warning instruments on a recent visit of inspection and "saw the electrical indication of a plane which I believe was sixty miles away."

NEW PRODUCTS

Month after month, manufacturers develop new materials, new components, new measuring equipment; issue new technical bulletins, new catalogs. Each month descriptions of these new items will be found here

Photoelectric Relay

A NEW PHOTOELECTRIC CONTROL, designated as "Light Watchman" turns off show-window lights, illuminated signs, or protective lighting during blackouts. The control is a photoelectric relay which is actuated by the nearest street light. When the street light goes out at the start of a blackout, the photoelectric relay turns off the lights in the show window, sign, or protective lighting system. When the street light goes on again the controlled lights are again energized. The unit is highly directional, and is subject only to the control of the street light at which it is aimed. A short time delay prevents false operation of the relay by momentary flickering of street lights. If either of the two tubes in the relay fails, or if the sensitive relay coil is open-circuited, the relay is de-energized and the lights are turned off. The operation of this device will not affect the normal functioning of a time switch, if one is used to turn on the lights at dusk and turn them off at a preselected time.

The "Light Watchman" is available in indoor or outdoor types, from General Electric Co., Schenectady, N. Y.

Radio and Telegraph Key

THE "GARCEAU ELECTROPLEX" KEY is an electronically operated semi-automatic or bug-key which is hand operated with the side-to-side motion of a paddle. Pressing the paddle to the right produces dots and to the left dashes. The speed of sending is continuously adjustable (even during the course of transmission) by a single control knob on the panel. At all speeds the mathematically correct proportion between dots, spaces and dashes is preserved, resulting in good sending regardless of the idiosyncrasies of the operator. The transmission may be adjusted from less than 8 to over 80 words per minute. Power consumption is 17 watts at 115 volts either alternating or direct current. Key contacts will break loads up to 1/10th amp. A supplementary toggle switch is provided to hold a telegraph line closed when the key is not operating. Overall dimensions of the instrument are 4 x 10½ x 3½ inches. The cabinet is mounted on three rubber feet to prevent creeping. Net weight is 4 lbs.

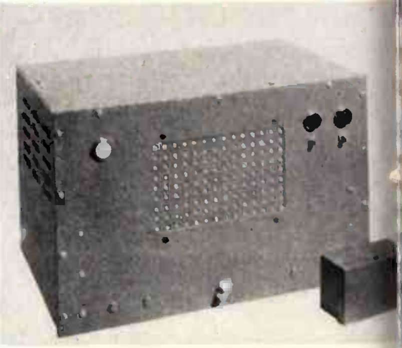
Electro-Medical Laboratory Inc., Holliston, Mass.

Automatic Alarm Systems

THESE SYSTEMS ARE FOR use in conjunction with fences which have been built around property to protect it from saboteurs and intruders, and are especially useful during blackouts, fogs, or other adverse conditions. Each system includes two parts, the detector and the indicator. The system works on the principle of detection and amplification of vibration or sound. The detector (which is sealed in a small inconspicuous box) is of rugged and moisture-proof construction, and is an inertia type vibration instrument which is mounted on the guard fence at predetermined intervals. The indicator, which is located in an office or guard headquarters, is connected with the tector unit and supplies both audi and visible warning of any attempt prowlers to scale, cut through or tun under a fence protected by the au matic alarm systems. The indicator erates on 110–120 volts, 60 cps (spec voltages and frequencies are availal if required) and conforms with gove ment requirements of uninterrupted eration at temperatures varying fr –40° F. to 130° F. The systems can be turned off or disconnected by oth than an authorized individual.

If the protecting fence is construct with a top rail or pipe, there is availal Model 10 Automatic Alarm which ut izes this rail as a conduit for lir connected to detector units operati through the alarm indicator. Audil and visual signals of any desired tensity may be obtained from the tectors, and tampering with the fen in any way (even touching the fen signals the presence of an intruder, a operates controls which will contin alarm signals until reset by the ope ator. This system consists of one au matic alarm indicator enclosed in sealed steel cabinet, and three detect units sufficient for approximately 22 feet of fence. Six such detector un can be used if necessary.

Where the segregation of two s tions of fence for separate alarms advisable, Model No. 11, illustrat below, is used. This system consists one dual channel indicator and six tector units, three for each channel section of fence. With this particul system it is possible to identify t particular section of fence from whi the alarm originates, or on a dou alarm to know that the danger lies b tween the two sections patrolled. T unit can be made to utilize twelve d tectors.



Model No. 30, besides patrolling t fence line, will also signal the failu of the alarm system that may be due an open or short circuit in the dete tors, detector lines or the indicator i self, whether caused by accident tampering. The unit consists of o indicator and three detectors.

Model No. 31 combines all of t characteristics of individual mode described above and is identical Model No. 30 except that it utilizes t dual channel arrangement in one uni

Automatic Alarms Inc., Youngstow Ohio.

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and Canadian prices 25c per volume higher.

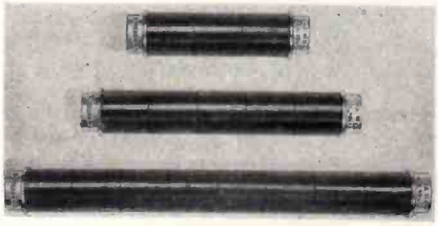
Recording Discs

New recording discs known as "Black Seal Glass Base Recording Discs" may be described as all glass discs in either a thin, flexible weight, or medium weight in 10, 12 or 16 inch sizes; both weights are available with either two or four holes; there are no fibre or other foreign material inserts; there are no metal grommets around the holes; and, finally, the holes of the discs are precision machined directly in the glass.

These discs are available from The Gould-Moody Co., 395 Broadway, New York, N. Y.

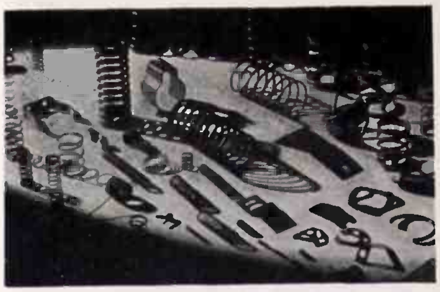
Sectional Resistors

For use in radio circuits, power rectifiers and laboratories for measuring any high voltage a-c or d-c circuit of 250 to 30,000 volts, a new sectional resistor is available. The unit is designed to replace, in certain cases, the old box type resistor which had a high power consumption and was inconvenient to install or replace. Made up of individual, hermetically sealed units wire wound around a ceramic resistor spool, the resistor units have values of from 0.25 to one megohm and a rated current of 1 ma. Dimensions are 1⅜x1¼ inches in diameter per section. The ceramic resistor spool is sectionalized, and adjacent sections are wound in opposite directions to obtain a non-inductive resistance.



Resistance is held within close tolerances permitting interchargeability of units having the same voltage rating. When a number of sections are mounted on one shaft, permanent taps may be taken off between any two sec-

MICRO-PROCESSED
BERYLLIUM COPPER
COIL OR FLAT
SPRINGS



Eliminate-Drift Set-Fatigue

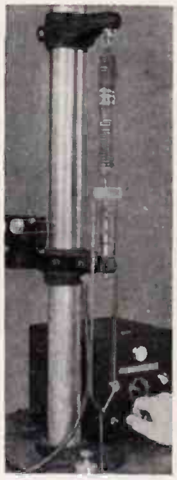
I-S beryllium copper coil springs are definitely superior—the result of micro-processing, a radically different technique, for making beryllium copper springs, perfected by Instrument Specialties Company after eight years of metallurgical research. Micro-Processing makes the difference.

First—I-S springs are made with special machines and tools of our own design. Economical for short or long runs.

Second — Special heat-treatment — laboratory controlled for each production lot—assures the desired physical properties for each shipment of I-S springs.

Third—With the Carson Electronic Spring Tester, our laboratory predicts controls and tests to closer tolerances.*

Fourth—Micro-Processed beryllium copper has higher strength and conductivity, better endurance, stability, and heat resistance than stainless steel or bronze. Better corrosion resistance and less drift than steel.



*COIL SPRING STANDARD PRODUCTION TOLERANCES
Inside diameter, up to ½ in. (any wire diameter) :003
Load test at working length. 5%

FLAT SPRING STANDARD TOLERANCES
Angles—within ½° in bends.
Flatness—within .001 to .003 in. per inch of length.

Spring measurement has been revolutionized by the Carson Electronic Spring Tester—an exclusive I-S development. Measuring to ten-millionths of an inch without pressure, this superior precision instrument enables I-S to control and test within closer limits. Extensive spring research is constantly in progress in the I-S laboratory.

Write today for Bulletin #4 for further details on micro-processed beryllium copper springs. There is a difference. InSist on I-S.

"MICRO-PROCESSED"
I-S
BERYLLIUM COPPER SPRINGS

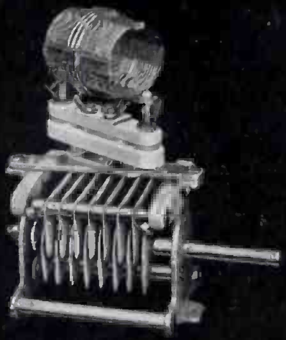
INSTRUMENT SPECIALTIES CO., INC.
DEPT. S, LITTLE FALLS, NEW JERSEY

TO BUILD SPECIAL UNITS MORE EASILY

A DIAL DESIGNED FOR INDIVIDUAL CALIBRATION

TYPE ACN DIAL

- Dial bezel acts as drilling template.
- Blank scales for direct calibration.
- Index holes in pointer for pricking calibration points.
- Scale removable without dismounting mechanism.
- Employs Velvet Vernier Drive Unit.



A UNIT COMBINATION OF COIL AND CONDENSER

TYPE AR-16 COIL & TMK CONDENSER

- Plug-in coils fit swivel mount.
- Air-spaced coils or plain coil forms available.
- Low loss construction throughout.
- Rigid condenser frame for permanent calibration.
- Condenser mounts on panel, chassis or standoff insulators.
- Condenser capacities to 250 mmf.

AN INSULATED COUPLING THAT WORKS AROUND CORNERS

TYPE TX-12

- Isolantite insulation.
- High quality flexible shafting.
- Fits ¼" shafts.

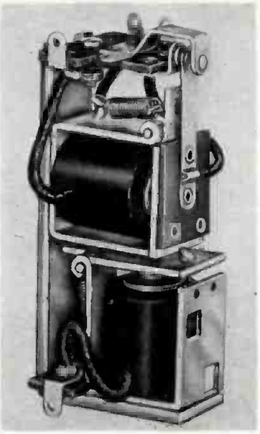
NATIONAL COMPANY, INC.
MALDEN NC MASS.

tions, permitting a multiplicity of resistance combinations on one complete unit. For switchboard mounting, insulators are available in 7.5, 15 and 30-kv sizes.

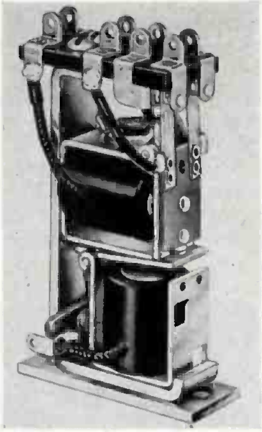
Westinghouse Meter Div., Newark, N. J.

Relays

TWO TYPES OF LOCKING relays with electrical release are available for operation on any nominal voltage under 125 volts alternating or direct current.



These are Type A.R.L. (top photo) which is a single pole double throw relay, and measures 1$\frac{5}{16}$x2$\frac{3}{4}$x1 inches; and Type A.J.L. (bottom photo) which is a double pole double throw relay and measures 3$\frac{1}{8}$x1$\frac{3}{4}$x1 inches. Features of these relays are: minimum mounting



base area, small size and weight, ability to withstand vibrations. They have coils for momentary and continuous duty. The contact rating for Type A.J.L. is 5 amps non-inductive on 110 volts a.c., or 24 volts d.c. Standard operating voltages for both types are 6, 12 to 24 on d.c., and 6, 24 to 110 on a.c.

Allied Control Co., Inc., 227 Fulton St., New York, N. Y.

New Carter
AIRCRAFT TYPE
GENEMOTORS

● SENSATIONAL!! That's the word for the new Carter Multi-Output Dynamotor. Since its introduction a year ago, Police Departments, Government Agencies, and manufacturers of Tank Radio Equipment have found it has no equal for small size, high efficiency, and extra light weight. It's the coming thing for all Transmitter and Receiver installations

● Write today for descriptive literature on Carter Dynamotors—D.C. to A.C. Converters—Magmotors—Heavy Duty Permanent Magnet Hand Generators—Special Motors—High Frequency Converters—Extra Small A.C. Generators—Permanent Magnet Dynamotors and Generators.

Carter Motor Co.
CHICAGO ILLINOIS

1606 Milwaukee Ave. Cable: Genemot
Carter, a well known name in radio since 19

PLASTICS
VINYLITE - CELLULOID - ACETATE
★
FABRICATED PARTS
Printed - Laminated
INJECTION MOLDING

DIALS, SCALES, WINDOWS, KNOBS AND SPECIAL PARTS for RADIOS, INSTRUMENTS,
—and—
COMMUNICATIONS and ELECTRICAL EQUIPMENT
★
PRINTING, DIE STAMPING, FORMING, MOLDING, ETC.
★
Bids cheerfully submitted

THE EMELOID CO., INC.
Plastic Fabricators Since 1919
ARLINGTON, N. J.

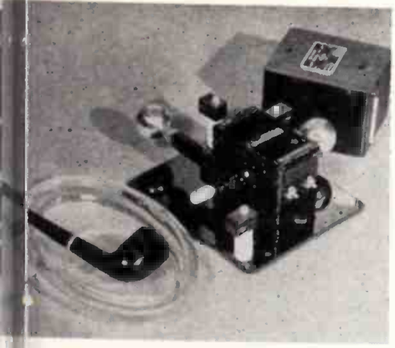
A rn Tube Socket

TH CERAMIC OF THIS new socket is of re G Steatite, glazed on top and sid and impregnated in Cerese AA wa to prevent moisture absorption. It ha very low losses at ultrahigh frequcies. Contacts are of grade C tenered phosphor bronze heavily silverplated to withstand 100 hours salt sp test, and are designed to hold the tub with a minimum of insertion pr ure under severe vibration tests. Co act jaws effect a scissor-hold on tub pin, and assure electrical contact. An her tube socket is of the lock-in typ and utilizes a molded shell of mit-filled low-loss phenolic material or se at high frequencies.

W. Franklin Mfg. Corp., 175 Var t., New York, N. Y.

auum Relay

TH PRINCIPAL OF ENCLOSING CONTACTS ubct to arcing in a vacuum is used small, light weight antenna switchng unit. The unit can handle an r-f otntial of 20,000 volts at 30,000 feet lti de and provides instantaneous re -in for keying operations. The vacuum prevents transfer of enng between the open contacts. The consists of a single pole double switch enclosed in a highly evacu- glass envelope. The armature when otted by an external electromaget ransfers the circuit from receiver



t nsmitter. As the space between pen contacts is approximately 01 inches and because of the small of the armature, the transfer is nough for instantaneous break-in. peed enables keying at 40 words inute.

maintenance is eliminated due to nently fixed contacts which are ed in the glass envelope. This nakes the unit entirely independ f climatic conditions, altitude dirt dation. Coils, which are capable inuous operation, can be supplied y of the common voltages. The veighs 24 ounces, including case, easures 2⅝x5⅝x6$\frac{7}{16}$ inches overall. dix Aviation, Ltd., Burbank, Cal.

ALLIED
GLASS
BASE
RECORDING
DISCS

FOR six years, Allied has manufactured top quality, professional recording discs for an increasing number of critical users. Our change-over from aluminum to glass base discs was successfully accomplished more than a year ago. Control in manufacture, close inspection, and constant care in every manufacturing, packing and shipping detail—results a one quality, first quality line—guaranteed to be uniform whether you order one or a thousand discs. Our regular customers continue to send us repeat orders—indicating satisfaction. If you are not using Allied Glass Base Discs, a trial will convince you of their merits and superior quality. Your inquiry will receive our prompt and courteous attention.

RECOATING SERVICE for your old aluminum discs. Delivery in one week. Details on request.

It is *economical* and saves you money to buy direct from the manufacturer. PROMPT DELIVERY to any part of the United States, Canada, South America and some foreign countries.

ALLIED RECORDING PRODUCTS CO.
21-09 43rd Ave., Long Island City, N. Y.
Phone: STillwell 4-2318 • Cable: Allrecord New York

A MESSAGE TO ELECTRICAL DESIGN ENGINEERS.......

of radio, communication, electrical, aircraft, automotive and electronic equipment

B & C Insulation materials include: Varnished Tubing, Saturated Sleeving, Varnished Cambric, Varnished Paper, and Extruded Plastic Tubing—all of the highest quality—manufactured to A.S.T.M. standards.

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We will welcome the opportunity to work with you on your insulation problems. Send us your specifications. Samples and prices will be submitted promptly. Our accelerated manufacturing schedule is now in operation.

- *Free sample display board #442 of tubing sent upon letterhead request.*

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22 WEST 21st STREET, NEW YORK, N. Y.
CHICAGO OFFICE : 831 NO. WABASH AVE.
Sales representatives in principal cities

Low-Frequency Linear-Tin Base Generator

THIS PORTABLE GENERATOR (Type is for use where oscillographic stu require sweep frequencies as low as cycle every few seconds. It may be in conjunction with an oscillograph vided with a long-persistence cath ray tube, or with photographic recor methods. Vibrations studies, stress strain measurements, low-freque electrical observation, electrocard raphy and electroencephalography, also be studied. The frequency ra of the instrument corresponds to tating speeds of 12 to 7500 rpm. T sient observation is provided for b single-stroke sweep circuit. The erator provides a sweep freque range of 0.2 to 125 cps. The maxim undistorted output signal is appr mately 450 volts peak-to-peak, bala to ground. The single sweep is initi either manually or by an observed nal. Linearity is assured by a com sating circuit. It measures 14¼x8 inches, and is rated at 115 or 230 alternating current, 40–60 cps. Po consumption is 50 watts and fuse tection is 1 amp. The primary vol is selected by a switch in the insi ment.

Allen B. DuMont Labs., Inc., Pass N. J.

Thin Slot Insulations

TO PROVIDE NON-BULKING SLOT insu tion for use in confined or limited sp a new thin type of insulation, ca "Irv-o-slot" is available in seven ferent thicknesses, dielectric streng and advantages. "Irv-o-slot" insulat consists of fish or Spauldo papers co with resin, or bonded by means o plastic insulator, to cambric, silk Fiberglass. These insulations poss strength and toughness as protect against mechanical stresses, and high dielectric strength. The duple "Irv-o-slot" and Spauldo paper good heat resistance. The bonded in ations have high moisture resista The insulation is flexible and eas form. It is available in sheets and tape form ready to be cut into strips.

Irvington Varnish & Insulator Irvington, N. J.

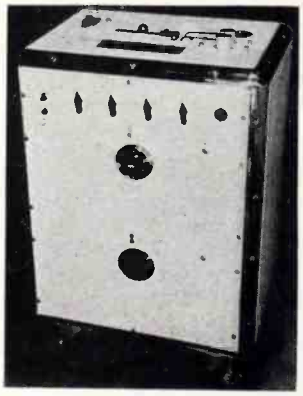
Low-loss H-f Coaxial Cable

FOR RADIO, TELEVISION, CONTROL and test equipment is a new type of co-axial cable which meets the requirements of military specifications for h-f low-loss cables. The central conductor is insulated to a suitable diameter with a recently developed low-loss dielectric, then covered with a copper braid which serves as a concentric outer conductor. The entire assembly is protected by a jacket, or sheath, made of a synthetic plastic called Simplex-Plastex. The cable itself is flexible, easy to install, and can be used on the highest radio frequencies. Moisture is eliminated and there is no internal condensation.

Simplex Wire & Cable Co., Cambridge, Mass.

Garceau Electroencephalograph

THIS IS AN ELECTRONIC DIAGNOSTIC instrument which was recently redesigned from a cumbersome and unwieldy cabinet to a compact Lindsay Structure all-steel housing. In changing the housing, the manufacturer also transformed the instrument from a complicated apparatus which could be used only by a specialized laboratory, into practical piece of medical equipment which can be operated by a non-technical person. The instrument is mainly for use in neurology, but it can also be used in detecting epileptic tendencies in men selected for aviation training, as well as in the diagnosis of brain injuries associated with head wounds.



It consists of a vacuum tube amplifier and an oscillographic recording system. Small electrodes are placed in selective positions upon the scalp of the patient. The minute electrical potentials generated by the brain are picked up by the apparatus and amplified and recorded as an oscillogram which reveals to the diagnostician such information as the presence and location of brain tumors, focus of scars causing epilespsy, and epileptic tendencies.

Electro-Medical Laboratory, Inc., Holliston, Mass.

Air Raid Siren

A NEW ELECTRONIC TYPE air raid siren called "Electro-Siren" is designed to give great volume for alarms. It makes use of a vacuum-tube tone generator which can either duplicate the rising and falling tone of a mechanical siren, or can be set at any pitch for best audibility over traffic or manufacturing noises. It can also be used to send code messages to air raid officials by dots and dashes. It has an arrangement so that a microphone can be used for voice announcements over the same system, which takes the place of a PA system. The unit operates from 110 volts source, but in case of current failure can be switched to 6 volt storage battery operation. It can also be used in police cars or other vehicles, operating from the car battery. The largest system can be operated continuously for four hours from a fully charged battery.

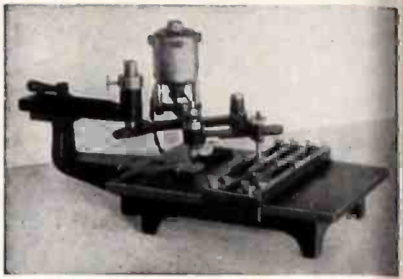
Audiograph Div., John Meck Industries, 1313 W. Randolph St., Chicago.

Aircraft Relays

THREE NEW RELAYS for aircraft or tank service have been announced. The first of these is a single-pole relay which is available in two forms—a single circuit form with one normally open contact (CR2791–B100A), and a two-circuit form with one normally open and one normally closed contact (CR2791–B100C). It has a maximum continuous current rating of 20 amps at 12 or 24 volts, and a maximum make or break rating of 100 amps at 12 or 24 volts. The coil operates at 1.2 watts. The relay weighs 3 ounces in the normally open form, and 3.4 ounces in the normally open, normally closed form. Tip travel is $\frac{1}{32}$ inch and tip pressure is 40 grams. The relay measures 1⅜x1⅜x1⅝ inches.

The high-voltage relay (CR2791–D100F) is designed especially for use with aircraft radio transmitting equipment. The use of ceramic insulation and double-break contacts permits control of circuits as high as 1,000 volts direct current. The contacts have maximum current ratings of 0.020 amp. at 1000 volts direct current, and 0.100 amp. at 500 volts direct current. This relay has a coil wattage of 1.2, a tip travel of $\frac{1}{16}$ inch double-break, and a tip pressure of 25 grams. The contacts are arranged for double-pole, double-throw, double-break operation. The relay measures 2$\frac{5}{16}$x1$\frac{1}{16}$x1$\frac{1}{16}$ inches.

The two- and three-pole relays are provided in two forms. One form (CR2791–B100D,G) has one normally open circuit per pole, and the other (CR2791–B100F,J) has one normally open and one normally closed circuit per pole. These relays have maximum continuous current ratings of 8 amps. at 12 or 24 volts, and the maximum make or break ratings at 25 amps. at 12 or 24 volts. The coils operate at 1.2 volts. Both two-pole forms are 1$\frac{25}{32}$x1⅜x1$\frac{31}{32}$ inches, and



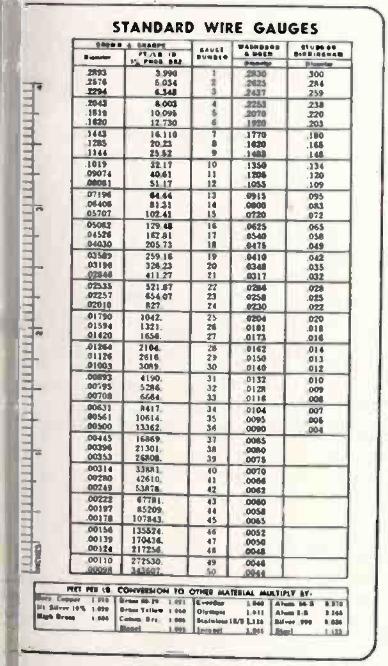
igh 3.5 ounces. The three-pole forms e 1$\frac{3}{32}$x1$\frac{7}{8}$x1$\frac{3}{32}$ inches and weigh 3.75 nces. All four forms have a tip ivel of $\frac{1}{32}$ in. and a tip pressure of grams.

These relays are designed for use m minus 40° C to plus 95° C. They suitable for use from sea level to 000 feet, and are corrosion-proof, eting Navy 200-hour salt-spray ts. They are good for mechanical quencies of 5 to 55 cps at $\frac{1}{32}$ inch ximum amplitude ($\frac{1}{16}$ inch total vel) applied in any direction. The tacts remain in the correct position ven the relays are subjected to a line acceleration of ten times gravity any direction.

eneral Electric Co., Schenectady, Y.

iterature

ire Data Chart. A useful chart for sons who employ wire in their des or specifications. In columnar ulation are given the B & S, Washin & Moen and Stubs or Birmingham meters for gauge sizes 1 to 50. The S column shows feet per pound each size of standard 5 percent sphor bronze. Also a table of conion factors for obtaining ft/lb



STANDARD WIRE GAUGES

BROWN & SHARPE Diameter	FT/LB IN 5% PHOS BRZ	GAUGE NUMBER	WASHBURN & MOEN Diameter	STUBS OR BIRMINGHAM Diameter
.2893	3.990	1	.2830	.300
.2576	5.034	2	.2625	.284
.2294	6.348	3	.2437	.259
.2043	8.003	4	.2253	.238
.1819	10.096	5	.2070	.220
.1620	12.730	6	.1920	.203
.1443	16.110	7	.1770	.180
.1285	20.23	8	.1620	.165
.1144	25.62	9	.1483	.148
.1019	32.17	10	.1350	.134
.09074	40.61	11	.1205	.120
.08081	51.17	12	.1055	.109
.07196	64.44	13	.0915	.095
.06408	81.31	14	.0800	.083
.05707	102.41	15	.0720	.072
.05082	129.48	16	.0625	.065
.04526	162.81	17	.0540	.058
.04030	205.73	18	.0475	.049
.03589	259.16	19	.0410	.042
.03196	328.23	20	.0348	.035
.02846	411.27	21	.0317	.032
.02535	521.87	22	.0286	.028
.02257	654.07	23	.0258	.025
.02010	827.	24	.0230	.022
.01790	1042.	25	.0204	.020
.01594	1321.	26	.0181	.018
.01420	1656.	27	.0173	.016
.01264	2104.	28	.0162	.014
.01126	2616.	29	.0150	.013
.01003	3089.	30	.0140	.012
.00893	4190.	31	.0132	.010
.00795	5286.	32	.0128	.009
.00708	6664.	33	.0118	.008
.00631	8417.	34	.0104	.007
.00561	10614.	35	.0095	.005
.00500	13362.	36	.0090	.004
.00445	16869.	37	.0085	
.00396	21301.	38	.0080	
.00353	26808.	39	.0075	
.00314	33881.	40	.0070	
.00280	42610.	41	.0066	
.00249	53878.	42	.0062	
.00222	67781.	43	.0060	
.00197	85209.	44	.0058	
.00178	107843.	45	.0055	
.00156	135524.	46	.0052	
.00139	170436.	47	.0050	
.00124	217256.	48	.0048	
.00110	272530.	49	.0046	
.00098	343607.	50	.0044	

FEET PER LB CONVERSION TO OTHER MATERIAL MULTIPLY BY:

[illegible] Copper	1.010	Brass [illegible]	1.021	Everdur	1.040	Alum 56-S	3.370
Ni Silver 18%	1.020	Brass Yellow	1.060	Olympic	1.011	Alum 1-S	3.266
High Brass	1.004	Cutman Brz	1.006	Stainless 18/8	1.126	Silver 999	0.006
		Monel	[illegible]	Inconel	[illegible]	Nickel	1.133

es for 15 other common wire maals. On the reverse side of the details of the composition, strength hard and soft grades, percentage elongation, and density are given. card is heavy white celluloid, vest ket size. Callite Tungsten Corp., e Division, Union City, N. J.

Definitions of Electrical Terms. A ne American Standard known as Defi tions of Electrical Terms, C42, spo sored by the American Institute Electrical Engineers, is now ready f general distribution. It is the first ti the definitions of the important terr common to all branches of the art well as those specifically related to ea of the various branches have be assembled and printed under one cov This glossary is the result of more th twelve years of work of a section committee. The thirty-four organiz tions represented on this sectional co mittee include the national engineerin scientific and professional societie trade associations, government depar ments and miscellaneous groups.

The primary aim in the formulati of the definitions has been to expre for each term the meaning which generally associated with it in electric engineering in America. The definitio have been generalized wherever pra ticable to avoid precluding the vario specific interpretations which may attached to a term in particular applic tions.

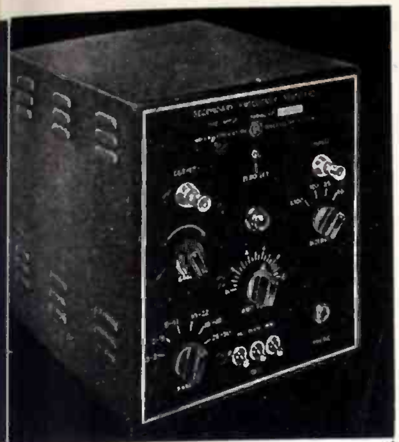
The book contains three hundr pages, size 8 x 11 inches, and is indexe It sells for $1.00 net each in U.S. and $1.25 outside of U.S.A. The price the same for single copies or quantiti Checks should be made payable American Institute of Electrical En neers, and addressed to their headqua ters at 33 West 39th Street, New Yor N. Y.

Electronic Equipment. A 16 pag catalog listing various stock items i rheostats, resistors, tap switche chokes and attenuators. It contain illustrations, descriptions, rating prices and other helpful informatio A copy of catalog 18 may be obtaine from Ohmite Mfg. Co., Dept. 4-A, 483 Flournoy St., Chicago, Ill.

Switches. The application, overtrave operating mechanism and maintenan and inspection of small precision lim switches is described and illustrate in a new listing of dimension shee by the Square D Co, Milwaukee, Wisconsin.

Induction Heating Data Sheet. data sheet covering the fundamental of induction heating. It gives a description of induction heating, current frequency, magnetic fields, and hea producing losses. This is the first o a series of data sheets and from no on they will be released monthly by th Induction Heating Corp., 389 Lafayett St., New York City.

Rubber Conservation. This bookle gives explicit instructions for the prope care of many types of rubber good such as electrical tapes, wires and cables, mountings, etc. Harmful effect of grease, oil and solvents is also discussed. U. S. Rubber Co., Rockefelle Center, New York, N. Y.



Tube Data Sheets. Application, characteristics, operating conditions and performance of several kinds of tubes are given in these sheets released by Eitel-McCullough, Inc., San Bruno, California.

Air Raid and Blackout Devices. A four page booklet describes automatic air raid siren controls, automatic blackout relays and automatic auxiliary systems. A brief description of other items manufactured is also included. This may be obtained from the Automatic Electric Mfg. Co., Mankato, Minnesota.

Quick Selector Catalog. A 64 page book covers safety switches, nofuse breakers, multi-breakers, panelboards, motor control and motors. New application data on latest equipment has been included. Electrical ratings, physical dimensions and circuit diagrams help in the selection of equipment. This revise may be obtained from Dept. 70-N-20, Westinghouse Elect. and Mfg. Co., E. Pittsburgh, Pa.

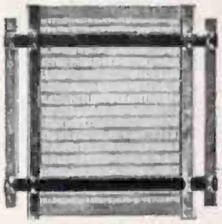
Electronics Parts and Equipment. The purpose of this booklet is to introduce the type of jobs which can be done for manufacturers of signal apparatus, transmitting and receiving apparatus, devices and parts. Insuline Corp. has expanded its facilities for large scale production of complete jobs or special jobs such as screw machine work, stamping, engraving, machining, finishing, or assembly.

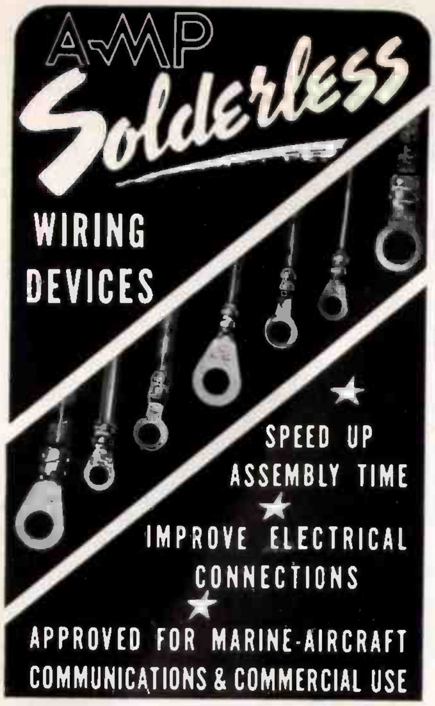
The booklet describes and illustrates such equipment as various types of cabinets, amplifier units, trim mouldings and plates, handles, heavy duty bases, chassis bottom plates, front chassis, panels, and over twenty-five different component parts.

Insuline Corp. of America, 30-30 Northern Boulevard, Long Island City, N. Y.

Snubbing Mountings. The application of bonded rubber vertical snubbing mountings for vibration control and shock absorption in equipment is described in a 20-page Bulletin No. 103. In addition to describing the complete line of mountings available, the booklet also contains basic engineering information. Lord Manufacturing Co., Erie, Pennsylvania.

Photoelectric Cells. A booklet describing the principle of operation, characteristics, temperature factor, fatique effect, internal resistance, operating temperature, time lag, permanence, and spectral sensitivity. There is also a table of standard sizes. Emby Products Co., 1800 West Pico Blvd., Los Angeles, Calif.





AMP solderless wiring devices eliminate the faults of soldered connections and give assured service under conditions of the lowest operating currents and over the range from DC to the highest radio frequencies, as well as under normal current rating.

The design of these thoroughly engineered electrical devices assure economy, efficiency and convenience in production. A few outstanding characteristics are listed below:

1. greater flexibility of installation
2. greater resistance to bending failure under repeated reversals of mechanical loading.
3. greater resistance to corrosion.
4. many types available with unique AMP "Diamond Grip" insulation support which protects wire, eliminates tape and insulation tubing illustrated at right. (Write for Bulletin #13)
5. facilitates insertion of wire.
6. more intimate electrical contact.
7. greater mechanical strength of the connection.
8. high safety factor for overload conditions.
9. greater tensile strength than required by government specifications.
10. quality of electrical joint can be determined by visual inspection.

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Backtalk

This department is operated as an open forum where our readers may discuss problems of the electronic industry or comment on articles which ELECTRONICS has published

I-F Stability

If the inductance of the i-f coils in an i-f stage having two double tuned transformers are too high, the i-f tube will oscillate as a tuned grid-tuned plate oscillator. The following formula gives the maximum values of inductance that can be used:

$$L = \frac{A^2\left(1 + \sqrt{\frac{16\pi fCg_m R_p^2}{A^2}}\right)}{16\pi^2 f^2 Cg_m R_p Q}$$

where

Q = average Q of the coils in cans
R_p = plate resistance of i-f tube in ohms
g_m = mutual conductance of i-f tube in mhos
C = grid-to-plate capacity of i-f tube in farads
f = intermediate frequency in cycles/second
L = average inductance of coils in henries
A = phase shift factor depending on the coupling factor K (the average coupling of the transformers)

For $K = 1$ (critical coupling) $A = 2.52$
$K = 0.9$ (90% critical) $A = 2.44$
$K = 0.8$ (80% critical) $A = 2.4$
$K = 0$ $A = 2.$

A is obtained from:

$$A = \frac{(4X^2 + 1 - K^2) + 4K^2}{4X^2 + 1 + K^2}$$

where X is the solution of:

$$8X^3 - 4X^2 + 2X(1 - K^2) - (1 + K^2) = 0$$

Thus to determine values of A not given in the table above, substitute values of K in the cubic and solve for X. Then

Inductance of I-F Coils
At Which the I-F Tube Will Oscillate

Values of Maximum L in Millihenries for $Q = 100$

$B+$	Tube	$K = 1$ (critical coupling)	$K = .9$ (90% critical coupling)	$K = .8$ (80% critical coupling)
250	6K7G	1.42	1.37	1.34
100	6K7G	2.15	2.05	2.
250	7A7	1.43	1.38	1.35
100	7A7 12SK7G	2.24	2.15	2.1
90	1LN5 1N5	1.87	1.81	1.77
67.5	115	2.05	1.97	1.92
67.5	6SD7GT	1.38	1.33	1.31
67.5	7H7	0.805	0.776	0.762

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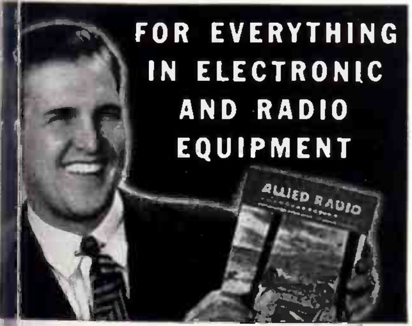

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using this value of X and the value of K solve the equation above the cubic for A. About 20 percent should be allowed for being within regeneration limits.

In the table are values for 455 kc i-f calculated from the first formula for a $Q = 100$. For any other value of Q multiply by $100/Q$. Values are calculated on the handbook values of grid to plate capacity, mutual conductance and plate resistance.

J. J. ADAMS,
Zenith Radio Corp.

More on Conversion

Editor's Note—Late in March, ELECTRONICS wrote to many suppliers of components, materials and assemblers of communication and industrial electronic equipment to determine the impact of the stoppage of production of home radio receivers on April 22. The following letters are typical of the answers received:

"We are not doing any defense work. We have tried to get some of this work, visited Washington, but so far, no prints have been shown us.

"Our plant is ready for defense work, our people are ready, in fact they would like to work 48 hours per week without overtime if the Government would let them.

"We advised the Government that we were ready and if defense work could not be given us directly, they, the Government could have and use our plant for the duration without recourse or compensation, including the writer's service."

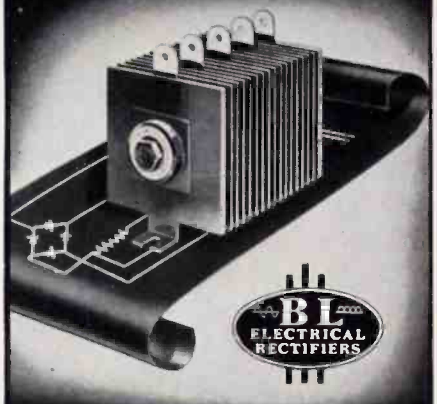
"For over a year we have tried to

• • •

RECORDING VOICES

The Australian Broadcasting Service recorded the voices of the defenders of Tobruk. The messages of the Scottish gunners who manned this anti-aircraft position will be relayed to Scotland. The men are shown listening to their own voices after they had been recorded

AC TO DC
WITH
BL RECTIFIERS



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APPLICATIONS

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secure government work without success. Since our civilian business definitely ends this week, it was necessary either to close down or secure defense work, and in a last supreme effort we were fortunate in stumbling across a defense item. At the present time we are converting and by the first of next week we will be 100 percent on government work.

"Just for the sake of clarification: I should like to go on record as saying that the fact that we have not converted and have not been doing war work in the past is because we were utterly unable to obtain any kind of contract despite several trips to Washington, Fort Monmouth and Dayton in an effort to get something!

"We have been making strenuous and diligent efforts to obtain war production business for many months. As a matter of fact, long before the curtailment of the radio industry was even contemplated.

"We have a beautiful plant, occupying some 75,000 square feet of space, a trained personnel all of them adept and skillful in the handling of small assemblies, and we know that we could be of real service if given the opportunity to perform.

"We have been successful in lining up a few jobs for the Fall which will take about 35 percent of our plant capacity, but it is far from being enough work to keep our organization together, particularly from April 1st to September 1st. If there is anything that you people can do to call this to the attention of the proper people, we certainly would appreciate it."

• • •

RADIO DEVICE DIRECTS ARMY DOGS

A short-wave device for transmitting instruction by remote control to army dogs on the battlefield enabling them to locate wounded soldiers, carry messages and supplies. The dog carries a small receiver on his back, to which is attached a small circular aerial. The dog wears a small head set from which he hears the commands of his master. It takes three months to train a dog and ten days to train the man. Carl Spita, noted animal trainer, will submit this to U. S. Army shortly

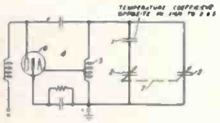
RECENT U.S. PATENTS

Each week the United States Patent Office issues grants to many hundreds of inventions that pass the acid test of that office. A few of those relating to electronics are reviewed here

Non-communication Applications

equency Generator. A varying capacitor with a means to derive a signal from it. One capacitor is polarized with direct current and a high frequency is impressed upon the d-c polarizing potential. L. Hammond, Mach 2, 1940, No. 2,281,495.

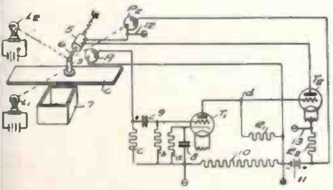
mperature Compensation. Means for temperature compensating a variable condenser throughout its capacity range, comprising a second variable condenser similar to and mechanically ganged with the first condenser, a fixed condenser having a temperature coefficient opposite in sign to that of the two variable condensers, connected in series with the second. The two series-connected condensers are in parallel with the variable condenser. K. D. Smith, Bell Telephone Labs, Inc., Sept. 24 941. No. 2,281,461.



umidity Measurement. Combination of an elongated hygroscopic element expanding and contracting with changes in humidity, and a three element tube as a measuring device. E. A. Keer, Brown Instrument Co., March 31, 938. No. 2,280,241.

elding Apparatus. Apparatus using electron tubes to control the spacing of the electrode in an arc welding apparatus as a function of the voltage between an electrode and the work. V. J. hapman, G.E. Co., Aug. 9, 1940. No 2,280,629.

spection System. A light sensitive system with a set-up responsive solely to the rate of change of illumination on the phototube. F. H. Gulliksen, WE&M Co Sept. 7, 1939. No. 2,280,948.



Number Displaying Device. Use of a cathode ray tube in a character outline displaying apparatus. J. W. Bryce, I.B.M. Corp., April 10, 1940. No. 2,281,350.

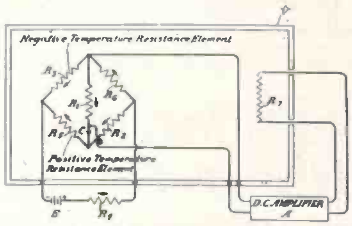
Flaw Detection. A method for testing non-conductive material for flaws by subjecting the material to a high voltage discharge. Two means are provided for automatically checking or discontinuing the discharge at a flaw for a short interval, and establishing another current effective to prolong the interval for a predetermined short time after the checking or discontinuance of the discharge. L. J. Gorman and R. L. Morris, Consolidated Edison Co. Sept. 21, 1940. No. 2,280,119.

Precipitation Circuit. Electrical precipitation apparatus for cleaning gases, comprising the use of half wave rectifiers. H. J. White, Research Corp., Aug. 22, 1940. No. 2,280,330.

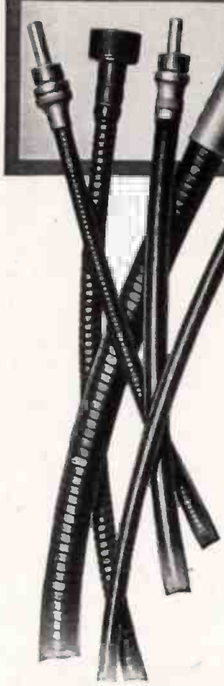
Tube Testing. Apparatus for simultaneously electrically treating and individually electrically testing a number of tubes. J. G. Pfeiffer, Western Electric Co., Dec. 1, 1939. No. 2,280,448.

Ultra High Frequency Apparatus

Generator. Frequency determining apparatus made of rod-like inductance elements parallel to each other, electrically connected to each other and having a balanced tuning condenser arrangement coupling one end together with shield surrounding the inductances. R. W. George, RCA. June 20, 1939. No. 2,277,638.

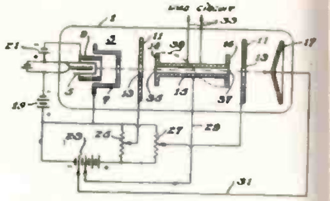


Feedback Balancer. In a high frequency relay system with receiving antenna connected to the input of an amplifier and a transmitting antenna con-



nected to the output of the amp
through coaxial transmission
with auxiliary electrodes within
of the transmission lines in adjus
relationship to the inner conduc
and an auxiliary transmission line
necting the auxiliary electrodes
means for adjusting the length of
auxiliary transmission line wherel
small amount of energy of pred
mined phase and amplitude is in
duced into the first transmission
from the second. F. H. Kroger, R
Jan. 31, 1939. No. 2,276,497.

Centimeter Wave Generator. Me
for forming electrons from a gun in
beam, a hollow resonant electrode
shielding electrons from external fie
this electrode having an effective len
equal to an integral number of
wave lengths of the oscillatory curr
established therein, directing the b



of electrons through the hollow el
trode along its longitudinal axis
adjusting the velocity of the electr
so that the distribution of oscilla
potentials along the path of the el
trode alters the energy of the el
trons. E. G. Linder, RCA. June
1939. No. 2,276,320.

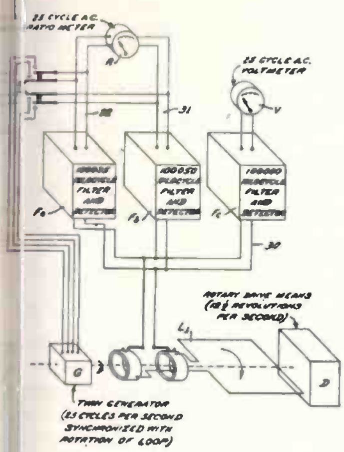
Aircraft Radio Application

Drift Corrector. Apparatus for
on a navigable vehicle comprising
energy collecting means having a n
mal angular relation to the source
radiated energy and to the longitudin
axis of the vehicle, means for au
matically keeping the vehicle upon
predetermined heading, and responsi
to deviations of the vehicle from t
predetermined course for angularly di
placing the collecting means from
normal relationship to the longitudin
axis of the vehicle. C. J. Crane and
K. Stout, Dayton, Oct. 18, 1939. N
2,280,117.

Glide Path. Method of guiding ai
craft along a linear inclined path
approaching a field for landing b
radiating from several points on th
field to define in space the incline
plane in which the desired linear an
inclined approach path is located, pro
ducing on the aircraft from the visua
image of three spots in the relativ
relationship as viewed from the air
craft, of three points in the incline
plane, one point being the desire
point of contact of the desired approach
path with the landing field and the
other points being above and symmet
rically located with respect to the first
point. I. R. Metcalf, Research Corp.
July 26, 1938. No. 2,280,126.

pacity Altimeter. An oscillator nd pair of capacitors connected to it or rying the amplitude of oscillation, he apacity of one condenser being a n on of its altitude above ground, he pacity of the other being variable. J Shepard, Jr., RCA, Nov. 30, 1938. ,280,725. See also No. 2,280,109 n beat frequency altimeter, A. A. a, Washington, D. C., Apr 7, 1941.

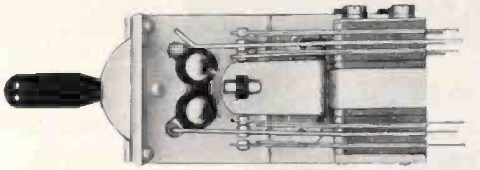
ding Beacon. Guiding an aircraft ducing two overlapping radiation ns extending over a plane in opposition to one another and a common plane of polarization ntially intersecting the first receiving energy from the two s, and comparing the receiving from them to determine the lane. A. G. Kandoian, Interna- Tel. Development Co., Jan. 31, No. 2,280,514.

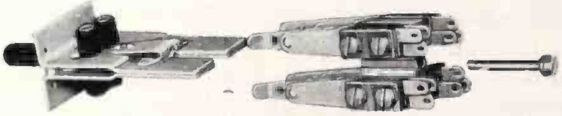


mmunication Circuits

e Limiter. Between a source of and a receiver is connected a ear impedance acting as a trans- ween signal and receiver. This nce is biased whereby the trans- ans is non-conducting for signals ng predetermined cut-off amp- Frequency selective circuits ted with the non-linear imped- ary the cut-off amplitudes as a n of the signal frequency. s Travis, Philco. July 27, 1939. 81,395.

m System. In a radio telephone for transmitting from a central to a movable vehicle voice mes- concerning how the vehicle be manipulated, a tone gener- nd a microphone at the central , with switching means so that may be used. A person on the may detect from the failure to either the tone frequency or a essage the fact that the system e out of order. V. C. Chappell, l Railway Signal Co., Aug. 21, No. 2,280,420. See also No. 2,280, Chappell.

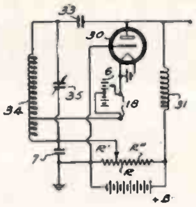




Voltage Bridge. In a radio receiver in which there is a conductive connection between the power lines and the anode circuits of the tubes, a metal housing or chassis supports the receiver components and a means is provided for a lower impedance r-f path between the conductive connection and the chassis. Stray capacitance between the chassis and a high potential r-f portion of the receiver causes undesired currents to flow in the low impedance path. An impedance between the chassis and the r-f portion of the receiver causes equal and opposite currents to flow in the path, thereby preventing r-f voltages across the low impedance path. E. C. Freeland, Philco. Nov. 16, 1940. No. 2,281,488.

Relay Circuit. A rectified reaction tube circuit comprising a multigrid tube, a feedback circuit and a condenser in the feedback circuit for controlling the relation between the characteristic curve of anode current with respect to input to the circuit on increasing input and the characteristic curve for decreasing input. R. M. Kalb, BTL, Inc. April 26, 1941. No. 2,281,040.

Voltage Compensator. Circuit for compensating variations in voltage on an r-f oscillator. R. E. Schock, RCA. August 20, 1938. No. 2,281,205.

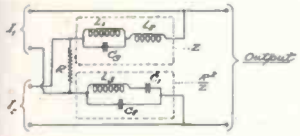


Relay Circuit. In a telegraph system, two lines with means for impressing code telegraph signals on one of the lines and a thermionic repeater for relaying the signals to the other line. L. W. Franklin, Western Union Tel. Co., No. 2,280,308, Dec. 3, 1938.

Variable Band-Pass Receiver. A band-pass selector of adjustable bandwidth having a mean resonant frequency normally bearing a predetermined relation to the mean frequency of the carrier, the relation between the mean frequencies being subject to deviations which may be substantial as compared with the bandwidth of the signal, the selector initially having a pass band sufficiently wide to include the signal and the deviations, and means responsive to the mean frequency of the carrier signal for reducing deviations substantially to maintain said normal predetermined relation, and means for contracting the pass band of the selector in response to the translation of a carrier signal. H. A. Wheeler, Hazeltine Corp., Jan. 23, 1941. No. 2,280,139. See also No. 2,280,187 to N. P. Case, Hazeltine, July 10, 1940, on a system

receiving a signal the amplitude of ich may be less than that of an adjent undesired carrier by means of untunable broadly-responsive auxiry signal-translating channel coud to the main channel and including ans for limiting to a uniform predetmined amplitude level all received crier signals in the vicinity of and incding the desired carrier signal plus cer means selectively response to the dired carrier signal for deriving the crier signal from the auxiliary chann and applying it to the main channel develop therein a desired carrier sig, the amplitude of which is in excess that of the undesired signals.

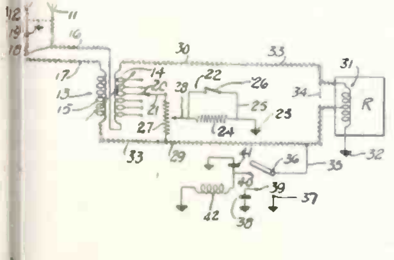
oupling Circuit. A circuit for coup two a-c input circuits of different quencies to a common output cirt, comprising elements which prest a high impedance to currents of frequency of the input circuit be-



ten the terminals of which it is conted and a low impedance to currents the frequency of the input circuit ween the terminals of which it is not nected. C. D. Colchester and A. T. rr, RCA, Nov. 5, 1940. No. 2,280,282.

oop Circuits. The planes of a pair oops of equal resistance and equal al voltage pickup are arranged in utually perpendicular manner. Each is tuned to a desired signal frecy and the loops are reactively ling loosely so that the signal cur induced in one of the loops is in lrature with the signal current ind in the other loop and means for ying the signal voltage developed ss one of the loops between the rol electrode and cathode of the . R. A. Weagant, RCA, July 2, . No. 2,280,562.

atic Eliminator. Method of elimintg r-f disturbances while maintaindesired signal energy, including an nna system and a counterpoise and connected to each with a movable



e shifting coil connected to the terpoise. The currents in the terpoise are transmitted to ground ugh a variable resistor. Samuel sk, Brooklyn, N. Y. October 6, 1941. 2,280,461.

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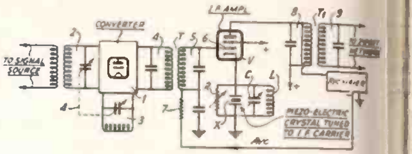
Piezo Circuit. A network for pr ducing exaggeration of the carrier wi respect to the modulation side ban comprising a parallel resonant circu tuned to the carrier frequency and a ranged between cathode and a groun The circuit is of low resistance and piezo crystal is connected in shunt wit it and tuned to the carrier frequenc Degeneration is applied so that th amplitudes of the side band components are decreased uniformly with r spect to the carrier frequency. W. v Roberts, RCA, Jan. 7, 1939. No. 2,280 605.



Automatic Selectivity Control. In superheterodyne, means for automatically adjusting the degree of selectivit of the i-f circuit including a devic which is responsive to energy of a frequency equal to the difference betwee the i-f and the signal energy representative of an undesired adjacent channel frequency. Julius Weinberger, RCA Nov. 25, 1935. No. 2,280,563.

Frequency Modulation. The followin patents relate to various aspects o frequency modulation: No. 2,280,56 on a detector circuit passing wave of carrier frequency with maximum intensity, and attenuating waves of lesse and greater frequency as a functio of their frequency spacing from th carrier frequency, and combining th total wave energy to produce a resultant wave of varying amplitude and constant frequency. W. G. Crosby, RCA No. 2,280,570, also to Crosby, refers t a system for receiving f-m signals by a double channel system, one channe passing a wide band and the other a narrow band with means for varying the bandwidth of the system. No 2,280,530 to G. Mountjoy, RCA, July 17 1940, is on a detector for f-m waves comprising a pair of rectifiers, each rectifier having a resonant input circuit and an audio output circuit, the input tuned circuits being oppositely and equally mistuned with respect to the center frequency of the modulated waves. The output circuits are arranged in phase opposition, and the inputs are arranged in series with each other and with the rectifiers. The tuned circuits are connected by capacity to the rectifiers and the individual tuned circuits are sufficiently coupled together magnetically to cancel out the effect of the capacity coupling. No 2,280,822 to C. W. Hansell, RCA, July 1, 1938, on a relaying system. A repeater comprising an oscillator and an amplifier excited by the oscillator has means for holding by the amplifier the oscillator frequency equal to the frequency of the repeated circuits. No. 2,280,707 to R. D. Kell, RCA

May 31, 1940, on a method of producing frequency modulation by generating frequency stabilized waves and applying a portion of the waves to establish saw-tooth waves which are combined with the desired modulation to produce pulses having an amplitude and a width corresponding to the modulation. The amplitudes of the pulses are limited to derive currents of square wave form, and the square waves are differentiated to form a series of pulses having a spacing corresponding to the modulation. These pulses produce waves of substantially constant mid-frequency and an extreme frequency corresponding to the applied modulation. No. 2,280,607 to W. vB. Roberts, RCA, Aug. 29, 1940, on an f-m receiver tuning indicator. A direct voltage component is produced in a discriminator network which is zero upon accurate adjustment of the tuning to the desired station. This direct current is used to provide a visual indication, the amount of which can be varied. No. 2,280,545 to R. E. Schock, RCA, June 18, 1940, on a frequency modulating detector comprising two rectifiers on each side of a push-pull circuit.

Automobile Radio System. A removable self-contained radio receiver including a storage battery and means for electrically connecting the set in the circuit with the car generator to cause both the set battery and the vehicle battery to receive charging current when the engine is running. A switch forms part of the set and is removable with it to permit charging current to flow to the set battery but not in a reverse direction. D. J. Barrett and L. G. Pacent, Sept. 11, 1940. No. 2,280,465.

Wide Band Amplifier. An amplifier for producing uniform ratio between input current and output voltage and having resistance and capacity in shunt with the input to which the current is supplied. The current has frequencies extending over a wide band and having intensities only slightly above the noise level. In the intermediate frequency portion of the band above the carrier of the most intense noise the currents are attenuated without changing the characteristic relation between intensity of voltage on the resistance and capacity and the frequency in the high frequency portion of the band. At a later stage of the amplifier low frequency currents are attenuated to produce uniform amplification at all frequencies below said high frequency portion and thereafter accentuating voltages in the high frequency portion of the band by an amount sufficient to overcome the attenuation produced by the shunt resistance and capacity, said accentuation occurring at a point in the amplifier subsequent to a stage following the point where the low frequency accentuation occurs to avoid overloading the last stage with currents to be attenuated. D. E. Norgaard, G.E. Co., May 1, 1941. No. 2,280,532.

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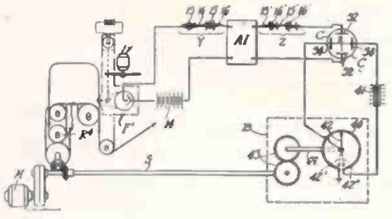
Industrial Applications

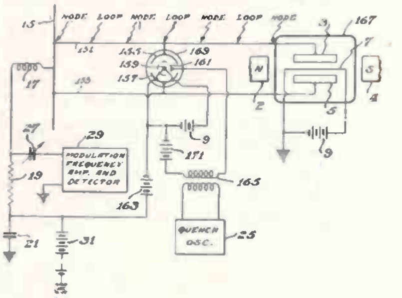
Temperature Control Apparatus. A Wheatstone bridge made up of negative and positive temperature resistance elements with a d-c amplifier across the bridge balance point which controls a heating element to raise the temperature in a chamber. V. B. Bagnall, AT&T Co. Aug. 15, 1940. No. 2,278,633.

Printing Press Control. A photoelectric registering system. Hermann Kott, to Speedry Gravure Corp. June 2, 1938. No. 2,278,933.



Recording Apparatus

Magnetron Receiver. Method of using a magnetron in a superregenerative circuit by varying the shunt impedance of a transmission line at a voltage loop at a quench frequency. R. A. Braden, RCA. Feb. 29, 1940. No. 2,277,841.



Sound Film Recording. Two patents, Nos. 2,274,529 and 2,274,530, to M. E. Collins, RCA, the first comprising means for continuously projecting a light beam on a motion picture film with a means to overmodulate a galvanometer to eliminate light beam from film, means for advancing the film, a second light source and means for periodically projecting the second light source on the film. The overmodulating means eliminates the first light beam during the advancement of a predetermined length of film, this length of film having images thereon made by the second light source. The second patent involves intercepting a certain frequency portion of a light beam and utilizing this portion to maintain the total light of the beam at a constant intensity.

Sound Film Projector. Mechanical equipment for moving sound film for television scanning. C. F. Mattke and R. V. Terry, BTL, Inc. Jan. 10, 1941. No. 2,275,540.

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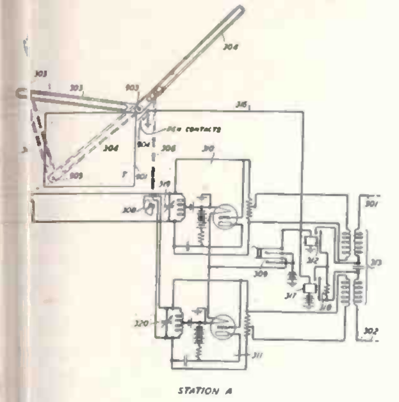
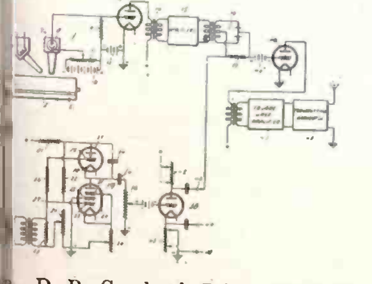
elautograph System. An electrostatic capacity at the receiver is varied as the scribing point of the receiver moves in one direction of a coordinate system, and means at the receiver for establishing the frequency of an alternating current by the capacity. Under the control of this variable frequency a form for changing the capacity which is proportional to the instantaneous difference of a variable-frequency current from a transmitter and the frequency of alternating current established at the receiver. V. E. Rosene, BTL, Inc. Nov 15, 1939. No. 2,274,638.



Sound Record. A negative sound film record is made on film and is then treated with a light sensitive dye. The dye in the areas not occupied by the sound wave envelope is then removed. E. . Kellogg, RCA. Aug. 20, 1940. No. 268,752.

Microfacsimile System. Producing a series of picture signals from subject matter moved through the transmitter at a uniformly relatively slow rate, means for producing horizontal and vertical synchronizing signals and means for rapidly and cyclically scanning substantially each element of the subject matter to be transmitted at a relatively rapid rate in bi-dimensional directions so that each element of the subject matter is scanned a relatively large number of times during its passage through the transmitter to produce series of picture signals, and for projecting the produced light images on a recording medium in minified form. N. Goldsmith, RCA. Aug. 22, 1939. No. 275,898.

Transmission System. Method of eliminating spurious additions to radio



na. D. R. Goodard, RCA, April 16, 1940. No. 2,274,829.

Monitoring System. Means for obtaining a penumbra shadow light beam from a source and for projecting this shadow through an optical system to a motion picture film with means for vibrating this shadow in accordance with a signal to be recorded. Simultaneously a second light beam is obtained from the source coaxially with the optical axis of the optical system for the observation of the condition and position of the incandescent element which provides the light for the penumbra shadow. M. T. Schomacker, RCA. Sept. 1, 1939. No. 2,270,350. See also No. 2,270,247 to C. N. Batsel dealing with the production of beams of a predetermined shape, the light forming means providing a linear relationship between the amplitude of the sound waves and the amount of said beam passing to the film over a range of signal amplitudes of the sound waves corresponding to 80 percent of the film range and a non-linear relationship between the amplitude of the sound waves and the amount of beam passing to the film over a higher range of amplitudes of the sound waves, this higher range being recorded in the remaining 20 percent of film range.

Sound Recording System. A movable armature actuates the mirror which vibrates a beam of light with respect to a film and surrounding this armature is an inductance with the means for impressing currents having varying amplitudes and frequencies on the inductance for moving the armature and the mirror and another inductance mounted on the armature having voltages generated in it directly proportional to the movements of the armature and the mirror. W. V. Wolfe, RCA. May 31, 1939. No. 2,270,367.

ANTENNA SYSTEMS

Vehicle Antenna. A self-contained resonant antenna utilizing a continuous portion of the structure of the vehicle as the antenna for operation at frequencies substantially independent of the equivalent electrical length of the portion of the structure utilized, containing a reactance adjacent to one end of the vehicle structure and electrically exposed to space at least in part, the reactance having a value such that the equivalent electrical length of the system is substantially equal to an even number of quarter-wavelengths of the desired operating frequency. Malcolm Bruce, Plymouth, Mass. March 21, 1941. No. 2,279,130.

Directive Antenna. A conductor positioned at an angle greater than zero degrees and less than 90 degrees to a frame perpendicularly related to the path of propagation of a wave and having a length substantially equal to a half wavelength of the desired wave plus the projection of the antenna on the path of the propagated wave. Edmund Bruce, B. T. L. Inc. Feb. 28, 1933. Re-issue No. 22,051.

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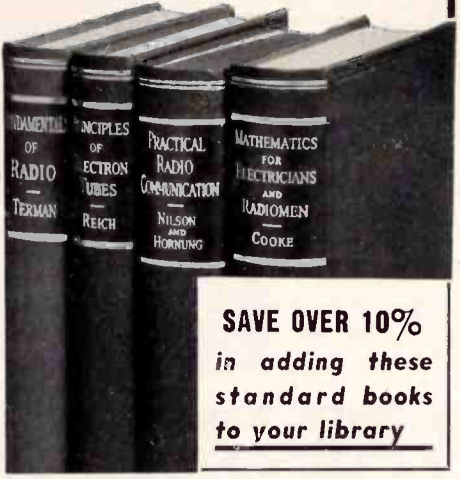

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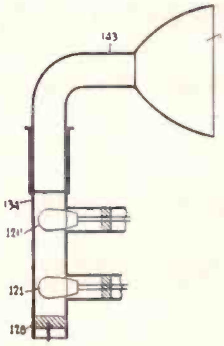
Multiple Antenna. Conductors arranged with their length parallel to the generatrix of the surface of a solid cone of revolution, means for energizing the conductors at their most closely adjacent ends and terminating the conductors at the other ends so that a traveling wave is set up along the conductors such that the instantaneous phase relationship of energy in the conductors progressively advances around the surface whereby a rotating field of radiation is established. Wilhelm Peters, Telefunken. No. 2,278,560. Sept. 30, 1939.

Repeater. In a repeater an antenna including a wave directive structure and means for eliminating radiation from the edges of such structure including a resonant structure tuned to offer a high impedance to the operating frequency of the antenna at the edge. N. E. Lindenblad, RCA, June 30, 1939. No. 2,281,196.

Wave Guide. Antenna comprising at least one conducting surface and serving as transmitting and receiving antenna and a conducting tube coupling the transmitter and receiver to the antenna, the receiver and transmitter being placed inside this conducting tube. W. Dallenbach, Berlin, July 12, 1938. No. 2,281,274.



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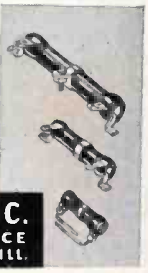

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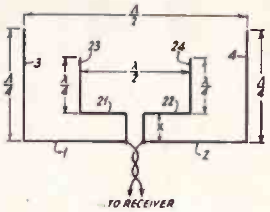
between the systems, the systems being energized in an opposing phase relationship. W. Ilberg, Telefunken, April 12. 1941. No. 2,280,235.

Antenna. A short wave antenna comprising a pair of L-shaped conductors like the illustration. De Witt R. Goddard, Nov. 26, 1938. No. 2,281,-429.

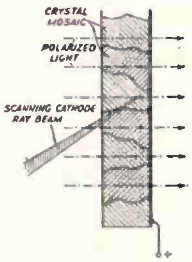


TELEVISION

Receiving System. A picture scanned sequentially at a certain frame frequency, the receiver comprising a cathode-ray set-up for reproducing the picture and a second cathode ray for reproducing the picture in superimposed relation to the first picture utilizing a picture storage tube comprising a double-sided mosaic. G. L. Beers, RCA. Feb. 23, 1940. No. 2,273,172.

Electron Image Amplifier. An apertured insulated grid and a means to project a flood of electrons through the grid, means to produce on the grid electrostatic charges representative of a picture and a target element located on the side of the apertured grid opposite the source of electrons. P. T. Farnsworth, July 6, 1937. Re-issue No. 22,009.

Projection System. The target area in a cathode-ray tube is scanned electrically and cyclically with a modulated beam of electrons at a predetermined rate. Polarized light is intermittently projected against the unscanned surface of the target, the intermittent rate of projection being greater than the scanning rate and bearing a whole number ratio with respect thereto. Means including a projection lens for directing the light reflected from the target upon an observation screen. Manfred von Ardenne, Berlin. March 18, 1940. No. 2,276,750. See also Nos. 2,277,007–2,277,008, inclusive on projection apparatus, also to von Ardenne.



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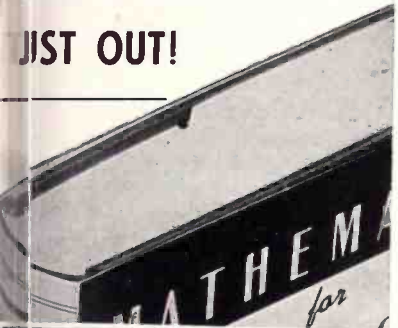

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Supersonic System. A supersonic wave light modulating device and a light source for illuminating the device plus means for applying picture signals to produce in this device a train of moving supersonic waves modulated in amplitude in accordance with the signals with means for forming optical and electron images. A. H. Rosenthal, New York. No. 2,270,232. Jan. 12, 1939.

Television and Cathode-ray Circuits

Signal Producing System. In a television system, a cathode-ray image-reproducing tube having an apertured grid with one surface of dielectric material and an opposite surface of secondary electron-emissive material. The surface is scanned with a signal-modulated beam to produce a charge image on the surface, and upon the other surface of the grid is directed an electron stream for developing a source of low voltage electrons of uniform density and of a cross-sectional area comparable to the area of the grid. Means for physically blocking the direct path of electrons of the stream through the grid, whereby the density of the electron stream through the grid is space-modulated by the charge image on one surface, and means for utilizing the modulated electron stream to produce a visible image. R. C. Hergenrother, Hazeltine Corp., Sept. 30, 1939. No. 2,280,191.

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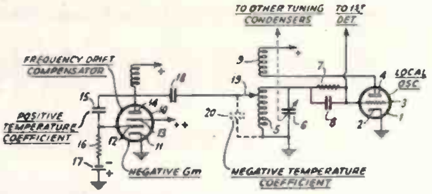
Synchronizing-Signal System. In a synchronizing-signal separating apparatus energized by a composite signal including line-synchronizing and field-synchronizing pulses for each field-underlap interval of the same polarity as, by having a greater duration than the line-synchronizing pulses, an integrating circuit responsive to a predetermined one of the field-synchronizing pulses of each field-underlap interval and unresponsive to the line-synchronizing pulses means for deriving a sensitizing signal initiating at the trailing edge of each predetermined field-synchronizing pulses, plus means responsive jointly to the sensitizing signal and to the field-synchronizing pulse for deriving a control signal. J. C. Wilson, Hazeltine Corp., July 13, 1940. No. 2,280,181.

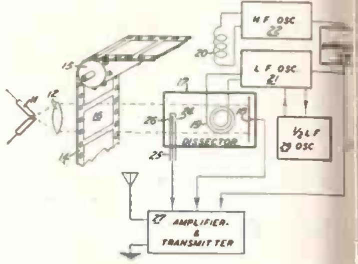
Generator. System for producing deflection voltage variations for a magnetically deflected cathode-ray beam having saw-tooth wave characteristics. E. L. C. White, E&MI, Ltd., May 15, 1940. No. 2,280,990.

Oscillator Drift Compensation. In combination with a resonant circuit varying in frequency by virtue of temperature effect on the circuit reactance and an electron tube having a cathode and two cold electrodes, an alternating voltage is applied across the circuit between the cathode and one electrode and a phase shifter connected with the other cold electrode develops from this voltage a second voltage in phase quadrature with the first. The phase shifter includes a reactive element has a temperature coefficient of predetermined signal so related to the mutual conductance of the tube that a reactive effect is produced between one electrode and cathode which has a temperature coefficient compensating frequency variation. C. N. Kimball, RCA. No. 2,280,527, Sept. 7, 1940.



Electron Device. An electrical n- denser comprising conducting elen separated by an insulating gap, an electron beam normally separated contact with the gap and at t moving the beam to such a positio to render the gap conductive. V Zworykin, WE&M Co., Nov. 26, No. 2,280,877.

Scanning System. A cathode beam scans a picture field, means deflecting the beam in two direct a high frequency oscillator suppl one of the deflecting elements, a frequency oscillator supplying the of the deflecting elements, said lators having commensurable freq cies, means for interlocking the quencies, with an additional oscill operating at a frequency lower the said low frequency oscillator nected to the output of the low quency oscillator. P. T. Farnswo 1934. No. 2,280,572.



Negative Transconductance De Two stages having a common sourc anode voltage, control means conne to the grid of the first stage, an direct connection from the grid of second stage to a junction between load resistor and the source of volta W. B. Roberts, RCA, Dec. 20, 1939. 2,280,987.

Response Adjustment. A multi-s tion filter having a rising freque response characteristic, and a load cuit having a response characteris complementary to the filter respo connected intermediate to the ends the filter. D. E. Foster, RCA, June 1940. No. 2,280,695.