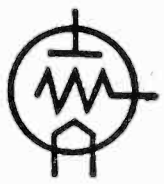
ELECTRONICS

APRIL
1939



KEITH HENNEY
Editor

Crosstalk

▶**500 KW** . . . The passing of WLW as the only 500 kw station probably marks a milestone in broadcast history in this country. It is doubtful if this power will find its way on the air again, soon. Already broadcasters seem to be looking with more interest at the ultra short waves. This means local coverage; it means that the rural listener, who from the social standpoint needs radio most, will probably not get the service he has received from WLW's powerful signal. A few years ago in the heart of the old South we asked a native what station he listened to most. His answer was quick, "Crosley". From WLW he got signals that overrode the local noise. He will get mighty little from a hundred watt apex station a hundred miles away.

Incidentally there seems to be a lot of wasted talk and worry about the number of people who are to sit on the FCC. It is not the number of commission members that count; it is the caliber of the members. Politically appointed experts seem to have much less on the ball, as a general rule, than commissioners appointed for merit.

▶**PAGE MUSSOLINI** . . . On a survey of *Photo Technique* subscribers, one questionnaire came back in which the recipient stated that his occupation was "reproduction".

▶**SERIOUSLY** . . . Has it ever occurred to those industrialists who demand a continually expanding economy, to look into the question of the population trends? Do they know that the population of all western nations is tending to become stable, that its rate of increase is flattening; that a fixed, or decreasing population is not far off, that the number of new automobiles, radios, etc., that can be sold annually because of the new people coming of merchandising age, must slacken?

The excess of births over deaths as short a time ago as 1915 was 11 per 1000 inhabitants. In 1936, according to The American Outlook, it was 5.2 births per 1000. In 1900 only 24 per cent of our population was over 40. In 1930 this number had increased to 30 per cent. From 1900 to 1930 the number of people over 50 doubled; while in the same period the number of children under 5 increased only from 9 to 11.4 million. In 10 years, between 1920 and 1930, the number of children under 1 and under 5 both decreased. Project these figures ahead 15 to 20 years and see how many new homes will be ready for installment buyers.

▶**NOTES** . . . Keuffel and Esser have built several radio engineers' slide rules, No. 4183, designed by J. F. Morrison of the Bell Laboratories. A. W. Clement in December writing about relay contacts stated that dissimilar metals cannot be used for contact points. Engineers in plants where a vast number of high speed relays are in operation state that their experience indicates that dissimilar metals work best. They don't tell us what metals, however. The statement that tungsten is not suitable for relay contacts, also made by Mr. Clement seems to have stirred up considerable comment. Perhaps some of these critics will come forward with concrete evidence to confound Mr. Clement. From the editors standpoint the most important thing was the unusual interest shown in this article on contacts.

A symposium on temperature and its measurement in science and industry will be held next fall under the auspices of the American Institute of Physics. Those interested should contact C. O. Fairchild, Director of Research, C. J. Tagliabue Mfg. Co.

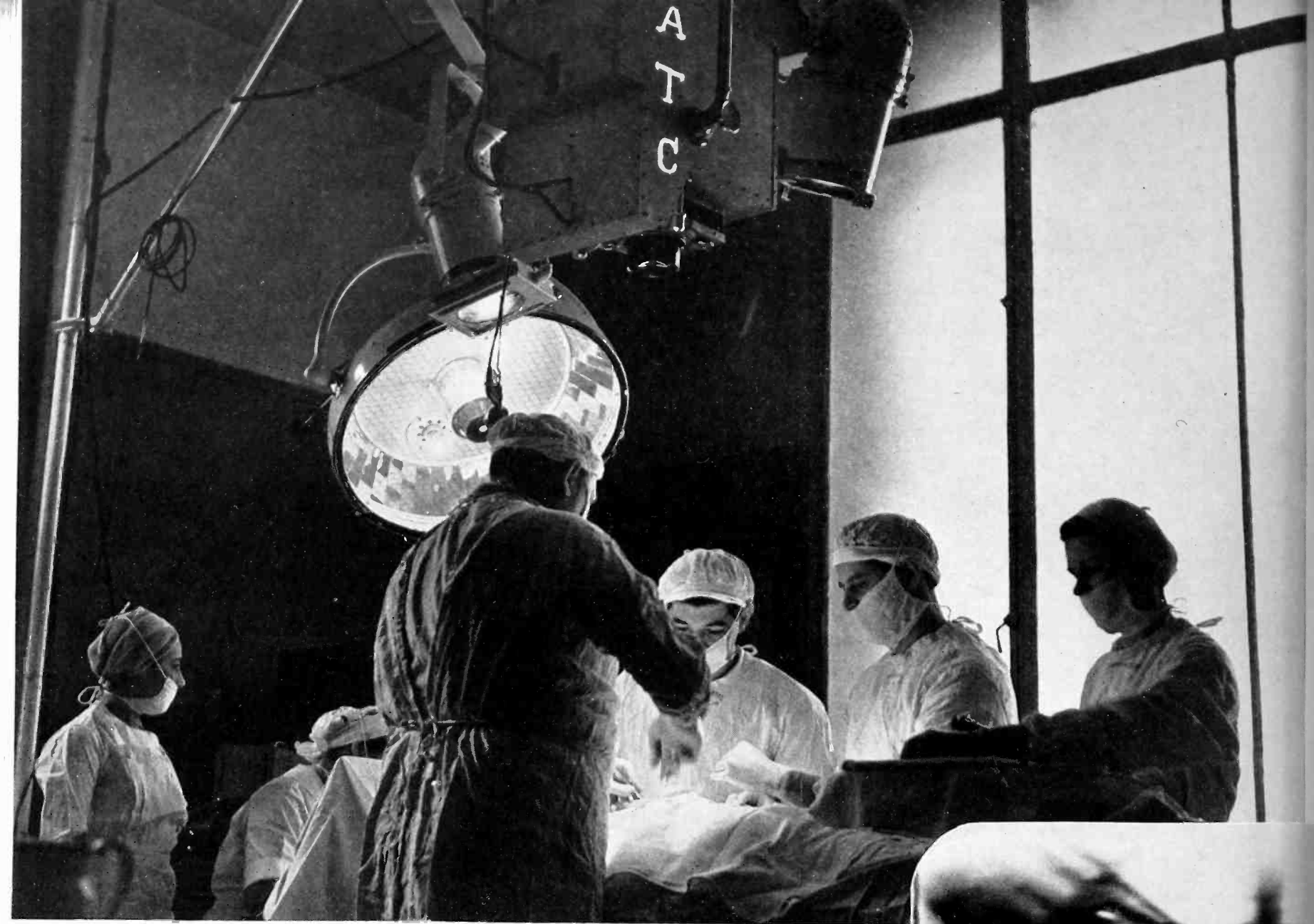
▶**DEAD BEAT DETECTOR** . . . A Middle Western hotel has installed a photocell across the back stairs. Anyone going down the stairs rings a bell in the clerk's desk, who pushes a button and thereby locks the outer door. Amusing, but it works.

The purveyor of electronic devices who told us about this neat trick states that salesmen are not so much needed in this business as teachers. Therefore his best salesmen are engineer graduates with a bent toward instruction. Their job is to tell industrialists what can and what cannot be done with electronic devices; for example a large department store had to be told they could not buy a gadget which would catch shop lifters.

▶**AMATEUR AID** . . . Many broadcast listeners suffer interference from transmitting amateurs. In some cases this is the amateur's fault. More often it is the fault of the listener's own receiver. And in most it is the fault of neither but due to unavoidable proximity of transmitter to receiver.

If manufacturers of wavetraps effective at amateur frequencies placed in the hands of licensed and listed amateurs a few circulars describing such devices in simple consumer terms we suspect that they would get wide consumer circulation. This would be particularly true if the circulars were worded in such a way that they aided harrassed hams to convince incensed listeners that interference elimination must often occur at the receiver.

There are now over 51,00[illegible] licensed amateurs in this country.



Telesurgery

Above one of the operating tables at the United Zion Israel Hospital in Brooklyn, N. Y., is mounted an iconoscope camera. Coaxial cable connects the camera to six 12-inch cathode-ray tubes mounted in boxes (shown in picture at left) in the lecture auditorium several floors away. Doctors, internes and nurses observe operations reproduced life-size on the fluorescent screens. Image above shows surgeon's hands performing an appendectomy. The installation was made by the American Television Corporation

Cathode-Ray Amplifier Tubes

A review of the new beam-group principle and its several applications in tube structures which minimize transit-time limitations and thereby allow the generation of hundreds of watts at wavelengths as short as ten centimeters, with high efficiency and stability

SINCE the basic theory of tube performance at very high frequencies was first worked out, some ten years ago, it has appeared that the final limitation is the time it takes an electron to travel from one part of a tube to another. This so-called "transit-time" limitation can be reduced by employing small spacings between elements, and to a lesser extent by applying high accelerating voltages to the tube electrodes, but these approaches (illustrated by the acorn and door-knob tubes) are soon blocked by difficulties of construction and insulation. It has appeared that our present need for reliable and efficient sources of high power at extremely high frequencies would be unanswered until some new principle was unearthed.

The first evidence that the new principle had been found was the announcement by the authorities of Stanford University of a new tube with an intriguing name, the Rhumbatron. This tube, and its offspring the Klystron, were claimed capable of producing 300 watts, at a frequency of 1000 Mc (30 cm) with an efficiency between 30 and 40 per cent. This was news indeed. Immediate plans to make practical and commercial use of the Klystron were concluded between the Stanford authorities, the Civil Aeronautics Authority and the Sperry Gyroscope Company. The first application is as a source of ultra-high frequency power for blind-landing of aircraft. Tests have already been conducted at M.I.T. show that the device has definite practical possibilities in the Metcalf-M.I.T. system of blind landing.

No sooner had the Rhumbatron-Klystron announcement been made than two other announcements appeared from widely different sources. The first, by a matter of days, was the article "A New U-H-F Amplifier of Unique Design" by A. V. Haeff of the RCA Radiotron Division, which appeared in the February, 1939 issue of *Electronics*. Close on its heels came "Velocity-Modulated Tubes" by Hahn and Metcalf of the G. E. Research Laboratories, which appeared in the February 1939 issue of the *Proceedings of the I.R.E.* In the March issue of *The Journal of Applied Physics* is still another "On Resonators Suitable for Klystron Oscillators" by Hansen and Richtmyer of Stanford University.

The simultaneous development of these new tubes appears to be a truly remarkable coincidence. While the three devices are not strictly the same, they all have in common one central feature, namely the use of a beam of electrons which is modulated at the frequency of the applied (or fed-back) signal. For those who are interested in the genesis of new inventions, this coincidence would make an interesting subject of study.

Our interest here is the basic principle which is common to the new devices. The earliest published reference to this principle which the editors have been able to find is contained in a German publication "On Phase-Focussing of Electrons in Rapidly-Fluctuating Electric Fields" by E. Brüche and A. Recknagel, which appeared in the March 1938 issue of the *Zeitschrift für Physik*. Brüche and Recknagel point out that when a beam of moving electrons is acted upon by rapidly changing (ultra high frequency) electric fields, the electrons tend to collect in groups. These electron groups, in passing through electrodes, or in being collected by anodes, may have a phase relation which interferes with maximum efficiency. This is, in essence, the transit-time problem.

Figure 1, taken from the Brüche and Recknagel paper, shows how out-of-phase electron groups may be "focussed" (strictly speaking, brought into phase) by the action of an accelerating field which alternates at the proper frequency. An analogy, shown at the top of the figure, is given in terms of the action of a thin lens on a parallel beam of light. The light beam, of constant cross-section, is intercepted by the lens, and its rays are bent to the focal point as shown. In the electron case, the constant cross-section of the light beam is replaced by constant separation between groups of electrons (which have been produced, for example, by

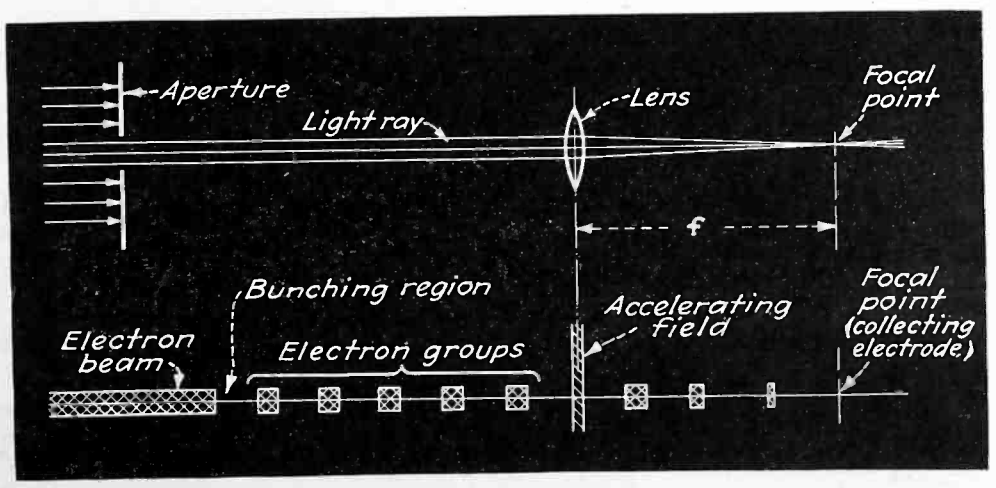


Fig. 1—Phase-focussing of electrons, shown by analogy to the focussing of a light beam. The electric field acts as the "phase lens"

the action of a high frequency signal on an electron beam). The lens is replaced by another electric field which varies at high frequency. If the amplitude and frequency of this latter high-frequency field are chosen properly with respect to the velocity of the electron groups and their spacing, it is possible to slow up the first electrons in each group, allow the central electrons of the group to proceed at their original velocity, and to accelerate the last electrons in the group. When a group is so acted upon, it tends to contract, as shown in the figure and at the focal point the electron group becomes a plane of electrons, all of which pass the focal point at once. Beyond the focal point each group tends to expand again, but at the focal point the charge density is extremely high. If a collector is placed at the focal point, the current induced in the electrode by the arrival of the focussed group is correspondingly great.

Essentially, the phase-focussing process involves two fundamentals. First, an electron beam must be broken up into electron groups, which may be sharply localized or not. Secondly, the electron groups are caused to come into focus by passing them through a rapidly-varying electric field. The focussing action causes the electron groups to contract (that is, causes the charge density to increase) at a certain position beyond the focussing field. The high degree of charge concentration corresponds to a correspondingly high value of electron current, which may be collected by placing an anode at the proper point in the tube. In this manner a beam of electrons is converted into an impulse current (alternating current superimposed on a d-c component). And what is of paramount importance, the transit time effects may be minimized to any desired degree by employing beams of high-speed electrons which pass through fields of comparatively restricted volume. The beam may consume an appreciable time in passing through the tube, but the only important time is that during which the electrons are actually in the focussing field. In other words, by adjusting the length of the tube, the delay between the grouping action and the focussing action may be made equal to any whole number of cycles, so that in-phase conditions are always maintained.

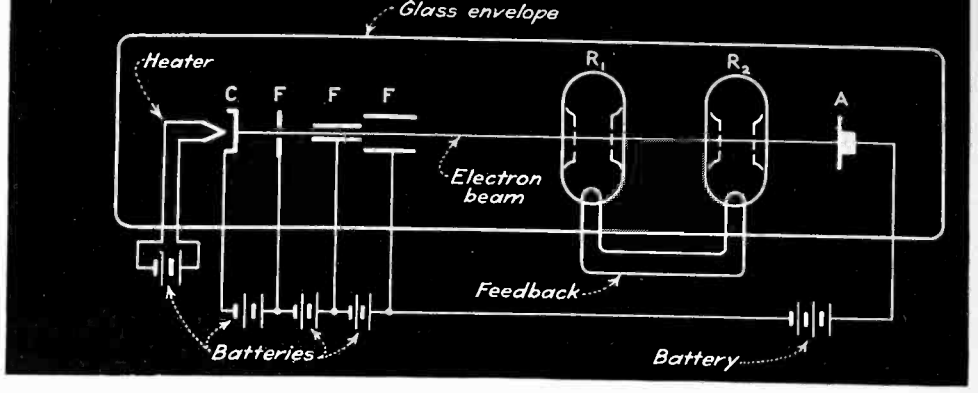


Fig. 2—The Klystron, developed by physicists at Stanford University, which generates hundreds of watts at 10 cms

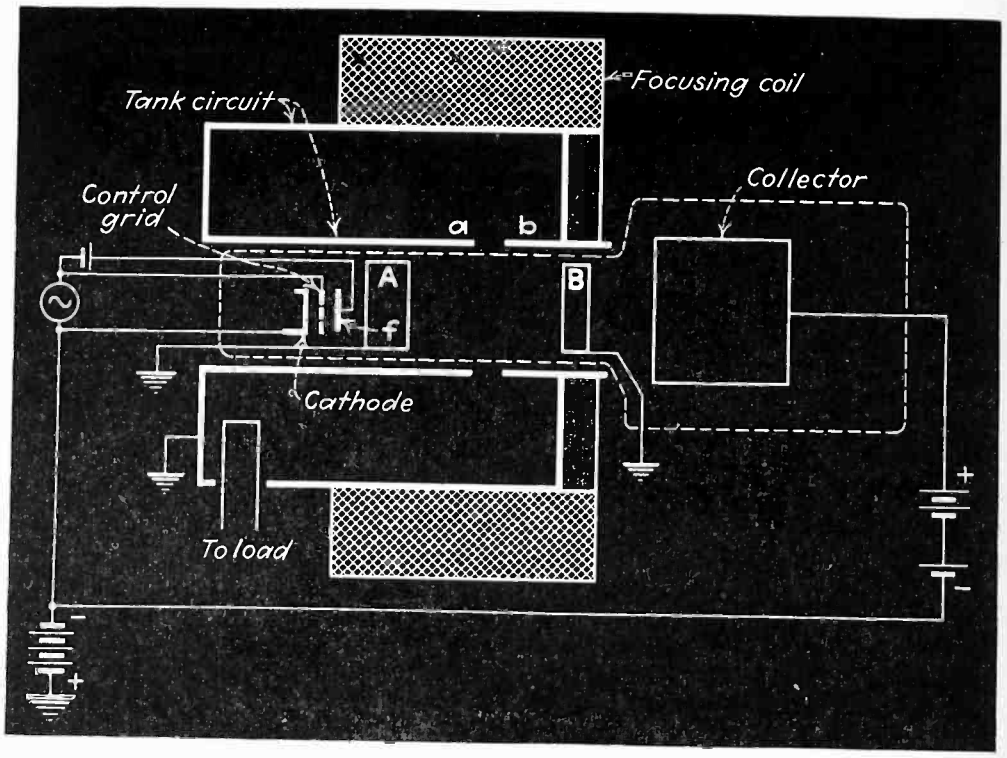


Fig. 3—U-h-f amplifier built on the cathode-ray principle and described by Haeff in the February issue of *Electronics*

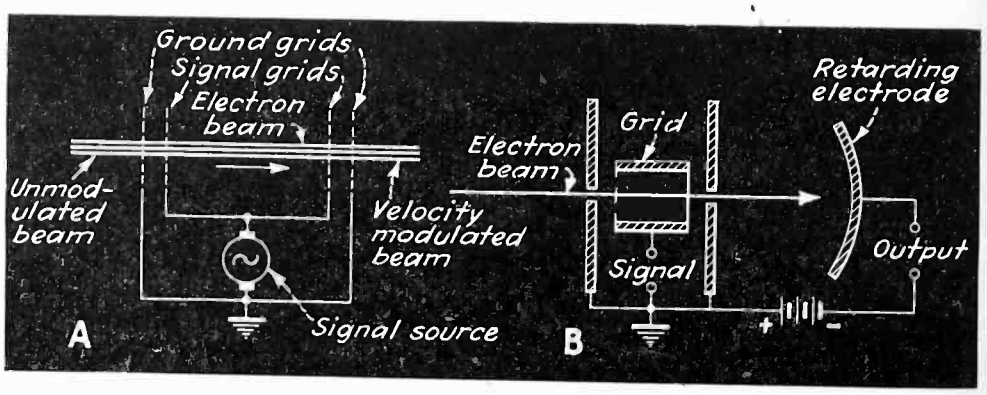


Fig. 4—Double grid arrangement employed in the velocity-modulated tubes developed at the G. E. Research Laboratories. (A) basic form, (B) actual electrode structure

The Klystron

The information released on the Rhumbatron-Klystron, to date, is rather meager. Figure 2 shows the outline of a simple Klystron feedback oscillator. The electrode C is the cathode, those marked F are focussing anodes, and A is the final anode, while between C and A an electron beam passes. This beam is in no way different from the beams used in cathode-ray tubes. The beam passes through two resonant chambers, R_1 and R_2 which perform the bunching and phase-focussing actions previously described. The chambers are hollow metal enclosures of torus, or doughnut, shape, and are closed by wire screens (shown dotted) which permit the electron beam to pass through the chamber.

The theory of resonance oscillations which may be excited in hollow conductors has, of course, been on the books for some time. Recently a special application has achieved prominence in the methods of Southworth and of Barrow

in transmitting extremely high frequency energy through hollow pipes, and from the mouths of horns.

In the resonant chamber case, electric and magnetic fields may be set up within the hollow torus, which vary at a rate dependent primarily on the dimensions of the chamber. Certain simple shapes have been investigated by Hansen.[1] He finds that the resonant wavelength of a sphere, for example, turns out to about 1.14 times the diameter of the sphere. Of more significance to the radio engineer, the Q (ratio of reactance to resistance at the resonant frequency) of one type of enclosure has the extremely high value 50,000, an experimentally-measured value which is very close to the calculated value.

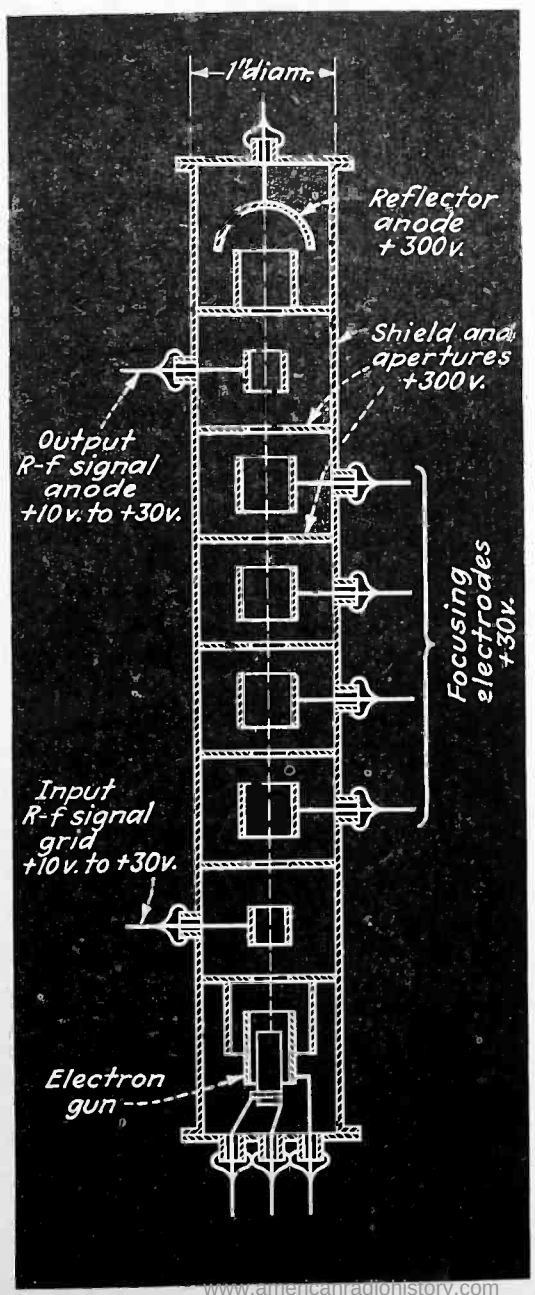
Referring again to Fig. 2, the resonators are such that when excited they produce rapidly-varying differences of potential between the two wire screens, the frequency depending on the dimensions of the resonator. These variations in potential succeed in causing the electrons in the beam to be grouped in chamber R_1 and focussed by R_2. It is necessary of course that the potential variations which appear in the two chambers be related in frequency, and this is assured by a feedback connection, as shown. The feed-back loop consists simply of a wire inserted through two holes in each of the resonators. The loops extending within the enclosure link magnetic lines of force whereby voltages are induced in the feedback circuit. As a result the whole system may be made to oscillate. Oscillating energy may be derived from the anode circuit, if the anode is placed at the point of phase-focus, or it may be derived from the resonators directly by employing another loop, similar to the feedback loop. A Klystron so constructed has developed 300 watts, at wavelengths between 10 and 40 centimeters.

Amplifying by the Cathode-ray Principle

A somewhat different approach, described by Haeff in *Electronics*, is the u-h-f power amplifier shown in Fig. 3. Since this device has already been discussed in detail in these pages, we shall give only a brief description. The electron beam is formed in the gun structure at the left of the tube proper (shown enclosed in dotted lines.) Two cylindrical electrodes A and B act to accelerate the beam, which then passes to the collector anode. Surrounding the tube is a section of a concentric line having a hollow inner conductor. A gap in this inner conductor, between *a* and *b* in the diagram, is so placed that the electron beam passes by the gap, midway between the accelerating electrodes. Finally, surrounding the concentric circuit is a focussing coil which acts in conjunction with the electrode *f* to keep the electron beam in focus.

The input to the amplifier is applied between the control-grid and cathode, as shown. When a signal is applied, it modulates the electron beam (modulating both the charge density and the electron velocity, but principally the former). The beam is thereby broken up into localized groups. When these groups pass the gap *a-b* they induce in the coaxial circuit a varying field, at a frequency dependent on the period of recurrence of the electron groups (determined by the input signal) and on the dimensions of the coaxial circuit. The output is obtained by inserting a wire loop into the coaxial circuit, as shown in the figure.

Fig. 5—A "drift-tube" velocity-modulated r-f amplifier, described by Hahn and Metcalf in the *I.R.E. Proceedings*



This amplifier has produced an output of 110 watts at 450 Mc, with 10 watts of input power, at an efficiency of 35 per cent. In this case the accelerating voltage was 6000 volts, the collector voltage 2000 volts, and the beam (collector) current 150 milliamperes. The advantages of the device are worth summarizing: reduction of transit time effects by employing electrons of high velocity; high efficiency by collecting electrons at low velocity; high power output because shape of collector does not affect performance; input-output coupling reduced to negligible proportions; low circuit losses due to large circumference of circuit parts.

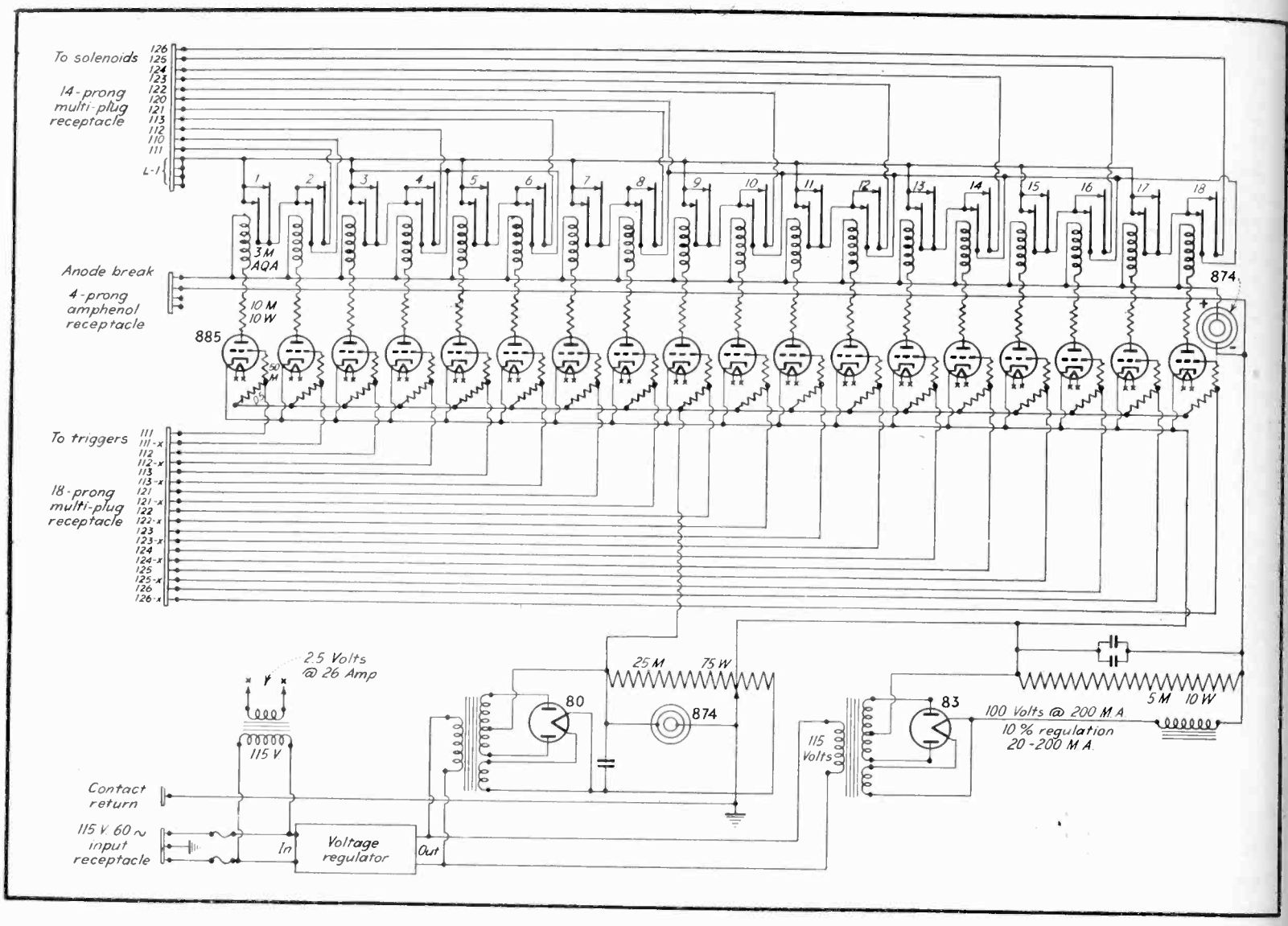
Velocity-Modulation of Electron Beams

The principle of velocity modulation, employed in the tube developed by Hahn and Metcalf is illustrated in Fig. 4. The electron beam passes between two sets of grids shown at the left. The signal source is applied between the grids as shown in the diagram. When the upper terminal of the signal source is positive, with respect to ground, the first pair of grids acts to accelerate the electron beam, whereas the second pair of grids acts to decelerate the beam. Between the two sets of grids there is no field (since the grids adjacent to this region are connected together). The effect of the signal voltage is, therefore, to produce alternate accelerations and decelerations as the polarity of the signal changes. The phase of the velocity change is always opposite in the two sets of grid, hence by fixing the distance between the two sets of grids to produce a transit time equal to any odd multiple of half periods of the signal frequency, the action of the two sets of grids is made additive. Under such conditions, the beam, on emerging from the second set of grids, contains

(*Continued on page* 76)

[1] A Type of Electrical Resonator, W. W. Hansen, *Journal of Applied Physics*, 9, 654 (Oct. 1938).

RECENT TUBE APPLICATIONS



Eighteen trigger gaseous tube measuring, grading, sorting gage

SEPTEMBER, 1938, marks the third year of the more general acceptance of electron tubes in the automotive and allied industries. Three years ago, there were but few tubes used in the production of automobiles and the associated parts which form in the final assembly a finished car.

Today, tubes are being used throughout the entire automotive industry—phototubes for controlling process, inspecting articles for cracks and flaws, counting, grading, measuring and sorting. These are but a few of the applications which when coupled with uses of electron discharge devices other than photoelectric, make up a large portion of automatic inspection to eliminate the fallacies of the human element.

A few typical adaptations of electron discharge devices made within the past three years are:

By
RALPH A. POWERS
Electronic Control Corp., Detroit, Mich.

Balanced amplifier for titration control.

Intercommunication speaking systems, wired and wireless types.

Phototube counter for seat cushion springs.

Phototube temperature control for controlling shrinking operations in spark plug assembly.

Wheel testing equipment.

Phototube spark plug gapping in production.

Phototube attachments for scleroscopes.

Electronic devices for inspection for cracks in permanent mold castings.

Phototube counting of spark plug ceramics.

Explosion proof light source and light relays for automatic spray painting.

Phototube temperature control of resistance silver soldering steering gear assemblies.

Phototube illumination control units.

Multi-stage phototube amplifiers and light sources to control roll-over and shake-out machines.

Phototube units for automatic control from dial indicator face.

Phototube temperature indication of billets for extruding press.

Phototube temperature control of cooling bath of dynamic speaker permanent magnets.

Electronically controlled paint thickness gauge.

Invisible beams of light for automotive shows.

Phototube inspection of rock salt and rejection of discolored pieces.

O AUTOMOBILE MAKING . . .

Phototube temperature control of resistance heating Pittman arm balls.

Phototube control of special valve stem grinding machines.

Phototube temperature control of resistance welding continuous chain producing machines.

Electronic dwell timers for controlling presses during full pressure part of the stroke.

Phototube monitoring of powdered fuel feed boilers as a safety device.

Phototube registration control on bottle labeling machines.

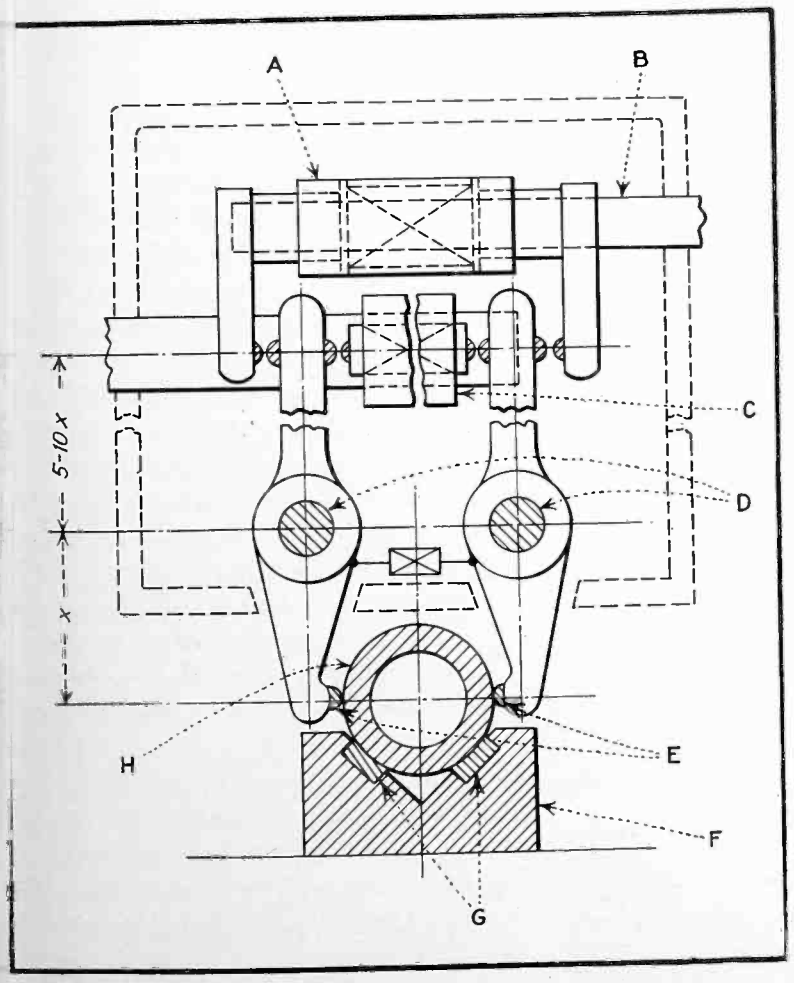
Explosion proof photo-electric equipment for automatic adjustment of carburetors through manometer tubes.

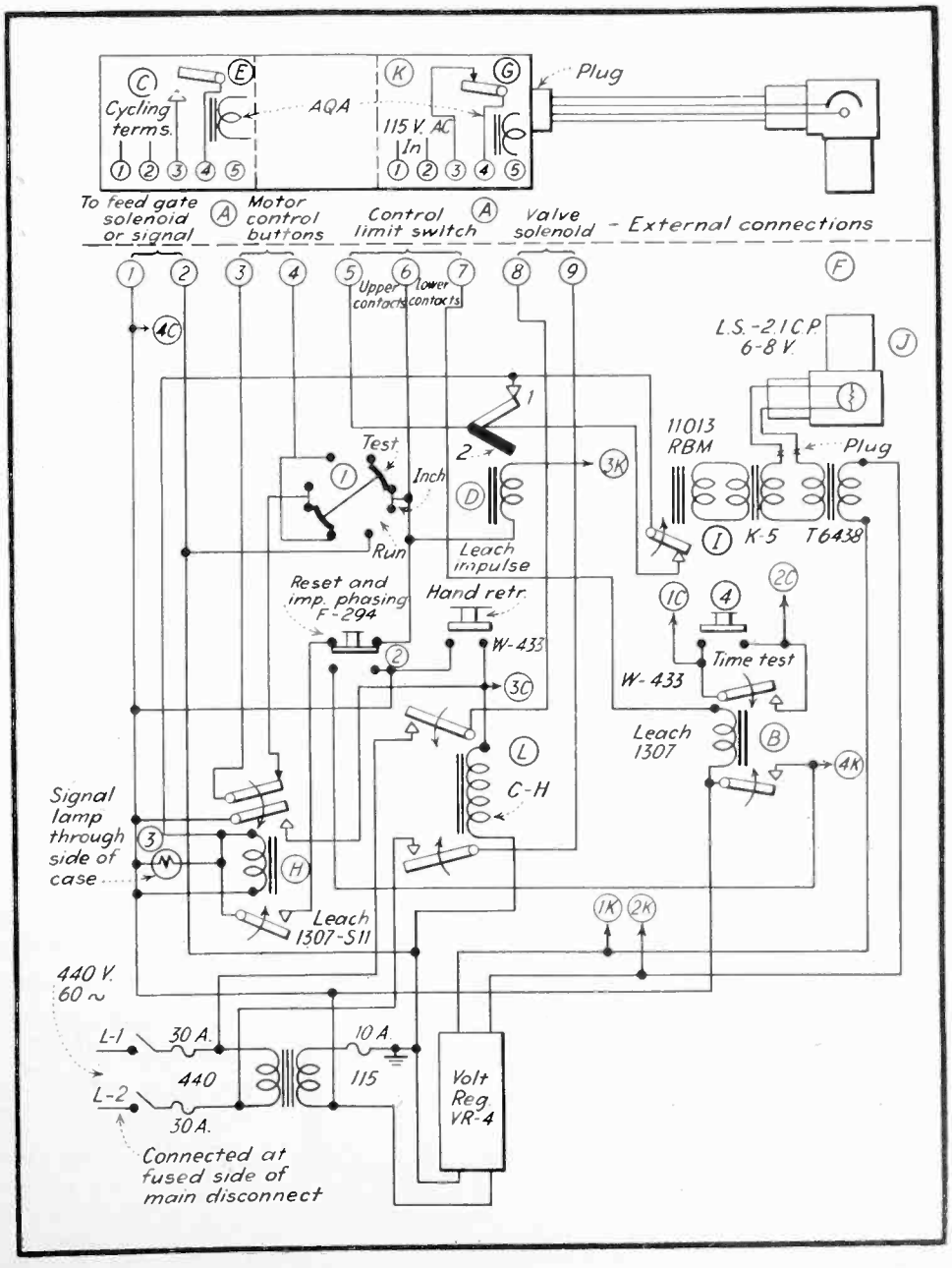
These applications do not take into onsideration the countless uses of tandard light relays.

As a matter of record of progress, rticles in the past have discussed ne applications of phototubes for ieasuring, grading and sorting pis-on pins as *Electronics* for September, 1935; automatic rejection of undersize and oversize articles, application of phototubes to scleroscopes (*Electronics* June, 1936), as a safety device with a "curtain of light" (*Electronics* July, 1937). To these applications of phototubes and their associated beams of light, other hundreds of applications of amplifiers, piezo-electric pick-ups and gaseous triodes have been made. Among the most prominent has been the application of gaseous triodes to "trigger" circuits used with self-centering gauges. These applications are interesting, because they allow rapid routine automatc inspection usually accomplished by means of dial indicators or contour projectors. The application and use of gaseous triodes in this particular application has materially increased production, and, above all, has eliminated the possibilities of error due to human element.

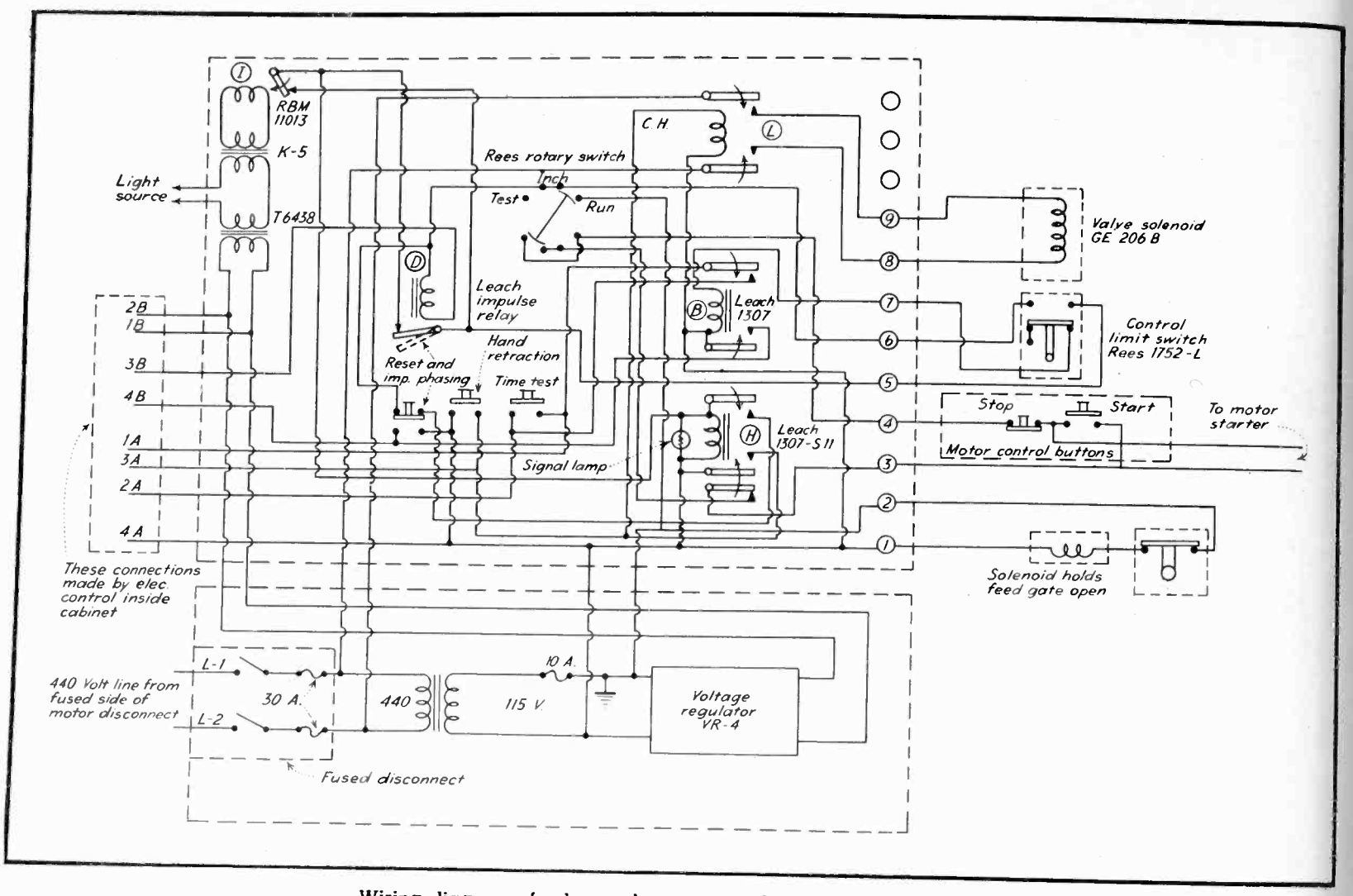
The possibilities of electronic "latching" through the use of gaseous triode tubes with direct current applied to the anode has made possible high speed measuring, grading and sorting gauges. If the object is off size, the desired gaseous triode fires and remains fired until the undesirable piece is rejected through solenoid or other means.

A typical circuit of an eighteen trigger gaseous triode unit is shown. It is used in a complete measuring, grading and sorting gauge for checking out-of-round diameter to .0001 in., overall length, and other inspection requirements of the manufactured piece. The grid circuits of the gaseous tubes are connected to contacts arranged in special self-centering gauge heads. The com-

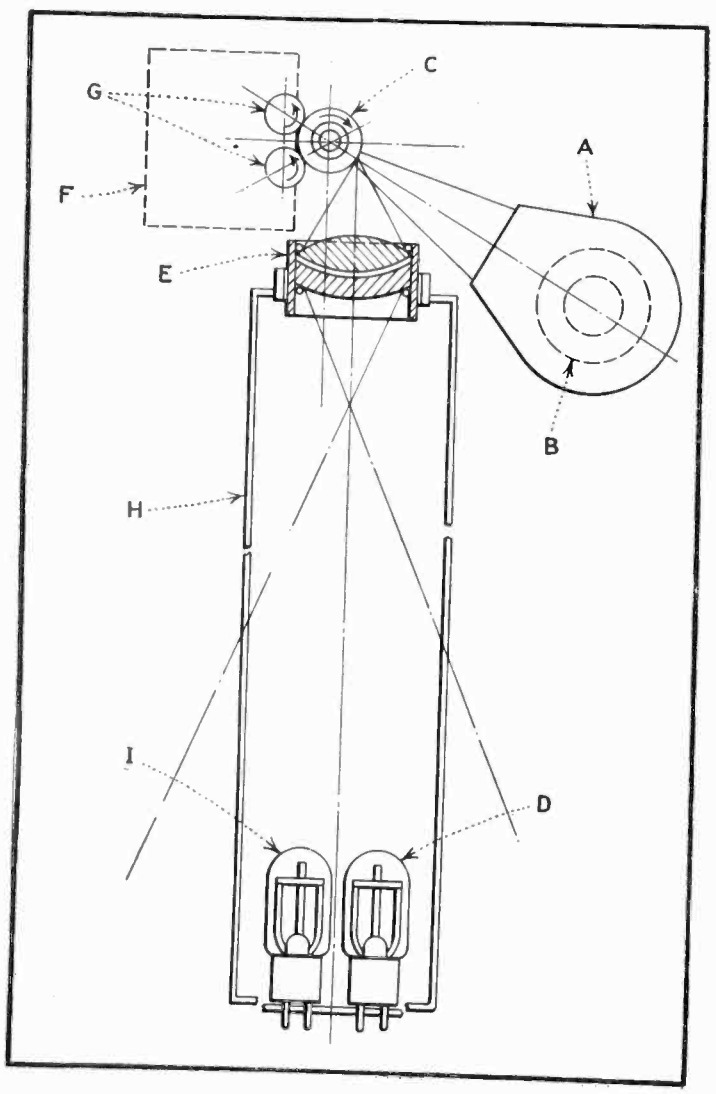




Above, self-centering gage. A, undersize contact gage self-centers on shaft B on which contact assembly can move right or left. C, oversize gage. D, smooth bearings. E, hardened points contacting piece. F, locating block. G, hardened steel or carboloy inserts. H, piece being measured. Right, circuit for rim forming machine



Wiring diagram of relay and power supply sections of sequence control and machine safeguard for rim bending machine



Set-up for roll inspector system. A, housing for mercury high intensity lamp, B. C, roll under inspection. D, phototubes. E, optical system. F, fixture for indexing rolls before optical system. G, driving rolls. H, light-tight housing. I, compensating photo tubes, end on view

plete gauge head is free to float in order to obtain centering over the piece under inspection. In calipering the outside diameter of the part, contacts are arranged which pass a few microamperes of current to the grid of the gaseous triode. If the object is the correct size, no contacts are made. If the object is undersize, the full floating automatic calipers make contact on one side, thereby firing one of the gaseous tube circuits. If the object is oversize, another gaseous tube fires. The impulse of this rapid measuring is then stored in the fired condition of the gaseous triode, due to its d-c potentials. As the piece indexes into the rejection station, it is automatically rejected by the solenoid and at the same time the anode circuit to the gaseous triodes is momentarily opened allowing de-ionization of the gas and restoration of the tube to normal operating conditions. At first the use of this type of self-centering gauge was attempted using electrical latching relays with the coil current traveling through the contacts of the automatic caliper; but, not only due to the momentary arcing or sparking of these contacts, which soon became pitted or oxidized sufficiently to lose the .0001 inch accuracy, but also, because of the speed of operation, accuracy was lost.

This gauging principle was about to be discarded until its users found that it was possible to substitute electron latching tubes for ordinary electrical latching relays. This type of gauge and gauge head is now being accepted due to long life of the contact assembly in the caliper head, the low replacement cost of tubes, and above all, the accuracy now possible because of reduced contact pressure compared to the conventional relay system.

A circuit used in the automatic forming of automobile and truck

rims is shown. Several relays are required to obtain the desired automatic control; but while the relays play an important part, the combination of gaseous-triode time-relays operating in conjunction with the two stage phototube amplifier assures positive success in the operation of the complete machine. The high speed production required eliminated conventional clock timers. The timer and other components had to be accurate, because if production was increased, small percentage inaccuracies, common with synchronous clock timers and relay circuits might result in machine damage.

The following sequence of operations shows how the circuit for this complete machine works. The machine is ready to start if the pilot lamp No. 3 is illuminated. A phasing button is then pushed once, impulsing an impulse relay and the light turns off. The drive motor for the complete machine is then started by momentarily pushing the motor start button on the machine. A bar of stock from which the rim is formed is fed into the roll feed. When the nose of this piece emerges a short distance it will close the limit switch (A), thereby opening the break circuit or lower contacts and making the upper circuit. At this point the bull wheel on the complete machine will close to a bending position. The bar continues to feed into the bull wheel as the limit switch roller rides on the top of the bar until the tail of the bar finally passes, at which time the roller of the limit switch drops down causing the lower contacts to close and the upper contacts to open. In so doing, the relay, shown as (B), is energized. This in turn starts the electronic time delay (C) to start operation and instantaneously the impulse relay (D) indexes its armature to the make circuit No. 1. After a period of time, the electronic time delay runs out and relay (E) becomes energized, its contacts energizing valve solenoid contactor. The contactor in turn energizes the valve solenoid and the air cylinder retracts the bull wheel and the work is ejected. As the formed rim is ejected it passes through the light beam (F) and the contacts of the plate circuit relay (G) momentarily break and then make, thereby operating the impulse relay (D) so that its armature makes contact at 2. If another bar has been correctly loaded, the nose of the following bar lifts the roller of the limit switch and another cycle is started.

The main object of this complete circuit is to eliminate difficulty if the formed rim fails to become ejected from the rolling fixture or bull wheel. If this happens, the armature of the impulse relay (D) will stay on contact (1), as there has been no interception of the beam of light. In this case, if the nose of the following bar raises the roller of the limit switch (A), thereby closing its upper contacts, energization of (H) relay results. This relay electrically latches down through the armature contacts and the normally closed contacts of the phasing button indicated as No. 2 on the circuit. Energization of this relay causes one leg of the armature to break the stop button circuit to the motor starter switch, thereby stopping the machine drive. As an additional feature, another armature of this same relay makes a circuit to sustain energization of the valve solenoid contactor, thereby keeping the bull wheel in the retracted position during and after the time the machine is coasting to a stop. At the same time the indicating lamp (3) is illuminated.

In the event the filament of the light source lamp becomes burned out, relay (I) will become de-energized. This will stop the machine.

As a further precaution against electronic breakdowns causing unreliable operation of the complete equipment in the event the vacuum tubes in the amplifier tubes lose their emission and will not pass sufficient plate current to maintain relay (C) in an energized position when the light beam is intercepted by an ejected rim, the machine will stop as the nose of the following piece actuates the limit switch (A). This sequence is simple because if relay (C) fails to break and make its contacts, the impulse relay (D) will not index its contacts from position 1 to 2.

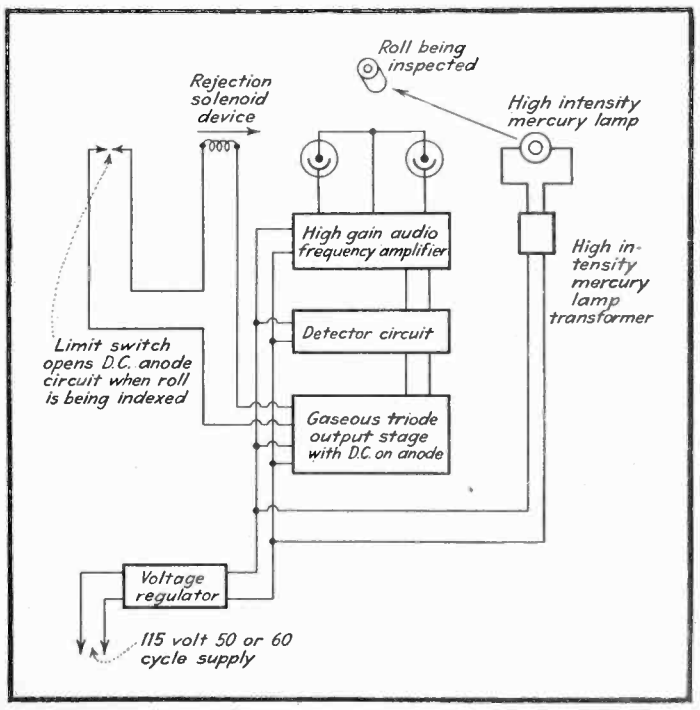
In the event that the machine has been stopped through the emergency stop circuit, it is restarted by depressing the phasing button No. 2 to cause de-energization of relay (H), thereby extinguishing the signal lamp (3). In such a position momentary actuation of the motor start button will restart the machine.

In setting up such a machine it is desirable to sometimes momentarily "inch" the machine while the first few pieces are going through. It will be noticed in the circuit that selector switch No. 1 can be set in the "inch" position. With the selector switch in such a position the machine will run only as long as the start button is depressed. Also, the time delay (C) will not be started by the bar actuation of the limit switch. Consequently, automatic retraction and ejection of the piece will not occur, but these functions can be made to perform more slowly by operating the hand retraction button No. 5. The retraction cylinder will reverse also as soon as this button is released. It will also be noticed that rejection of the bar rim through the light beam will not cause actuation of the impulse relay. As a result, the contact phase relation will not change.

As a further refinement of this complete circuit, the selector switch, which can be set in what is known as the "time test" position, and the bull wheel will reverse from retraction position and the machine will run following momentary depression of the motor start button, but actuation of the limit switch (A) will not start the time delay (C) and breaking of the light beam will not actuate the impulse relay (D). This position and operation is used when it is desirable to check carefully the amount of time it takes for the time delay to run out.

(*Continued on page* 53)

Diagrammatic sketch of roll inspector



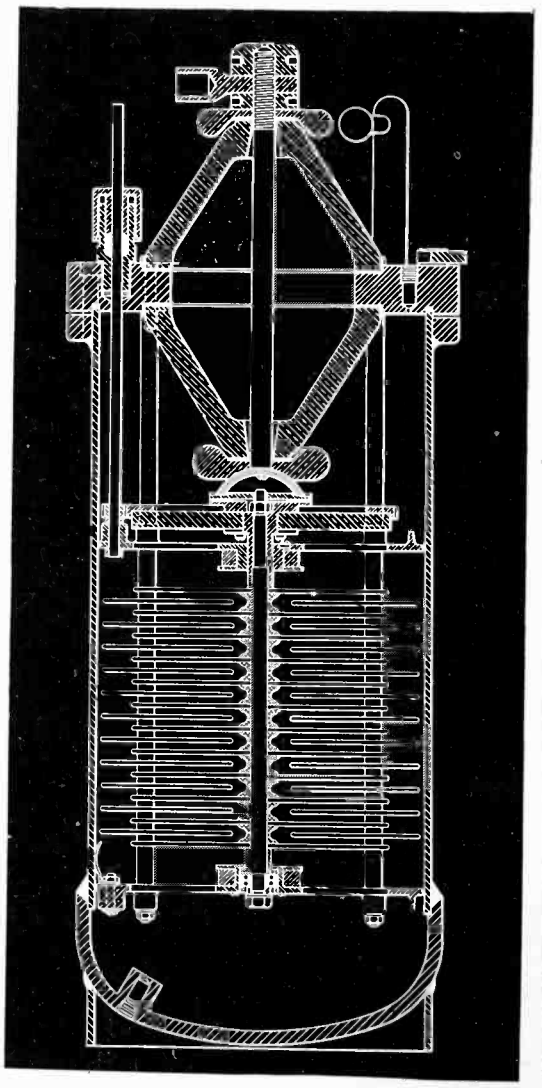
Pressure Capacitors

A modern development in broadcast equipment is the gas-filled variable capacitor, employing nitrogen gas at several hundred pounds per square inch pressure. Extremely low losses and large values of capacitance in small volume are achieved without loss of flexibility

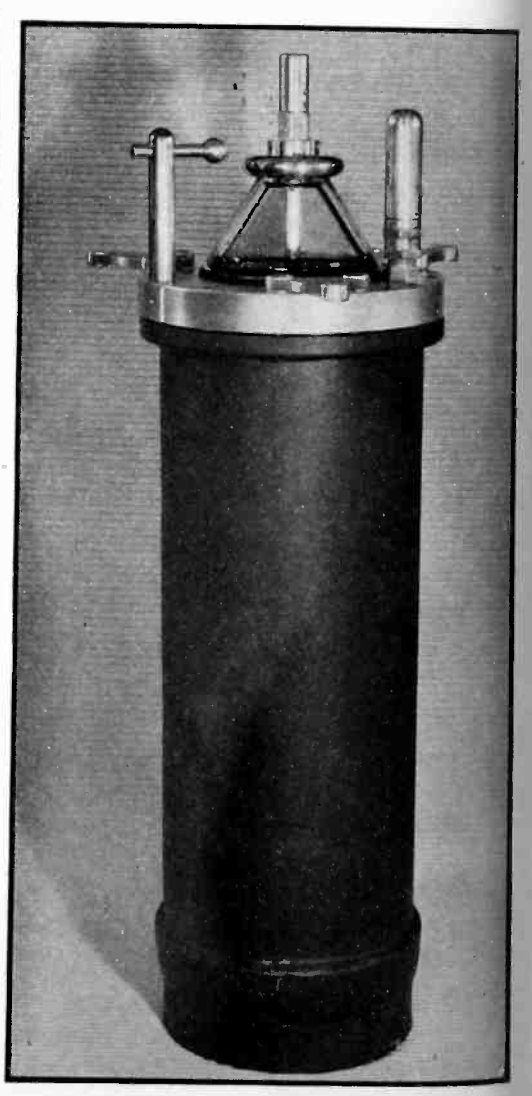
IT OFTEN happens that an idea is tried in radio engineering and dropped for some reason or other, only to be resurrected because a pressing need has been found to apply it. The gas-filled capacitor, which is now enjoying a considerable vogue in the latest broadcast transmitter designs, is a very interesting example.

The advantages of gas as a dielectric have been known for many years, and it is not surprising that gas-filled condensers were tried at an early date. The Bureau of Standards did so in the early 1920's, and such condensers were applied in the early days at Arlington. Later, various manufacturers tried their hand at it, and in recent years condensers of this type have been built by transmitter manufacturers for use on their own equipment. But the early gas-filled units suffered from the fact that they were not variable, and hence could be used only with difficulty in any circuit which required flexibility of tuning. The advantages, the low losses and the small space required, were to some extent counterbalanced by the tendency of the units to leak gas, and consequently to fail without warning, often at a critical time.

Within recent months the gas-filled capacitor has come back with a vengeance. At present there are two manufacturers who have developed large pressure-gas filled units for sale to equipment manufacturers, and all indications are that they have little difficulty in disposing of the new units. The success of the pressure-type condenser, after so long a period of inactivity, may be traced to several causes. In the first place, the need for a low loss condenser of small dimensions has arisen with the increae of power in stations operating in the intermediate and high frequency ranges. The low loss is important because circuit Q decreases with increasing frequency, while the small space permits compact assemblies, with more advantageous L/C ratios in tuned circuits. Finally the fact that small space is used may mean that the cost of the pressure-operated unit is but little greater than that of the equivalent atmospheric condenser, when used for variable-capacitance purposes. Fixed-capacitance units of the gas-filled variety seem to have less advantage over mica and vacuum condensers from the viewpoint of size but there is the advantage of recovery from flashover without harm. The use of nitrogen at pressures from 300 to 400 pounds per square inch increases the breakdown voltage by four times, with respect to



Internal structure of Heintz and Kaufman pressure capacitor, showing tuning control (left)

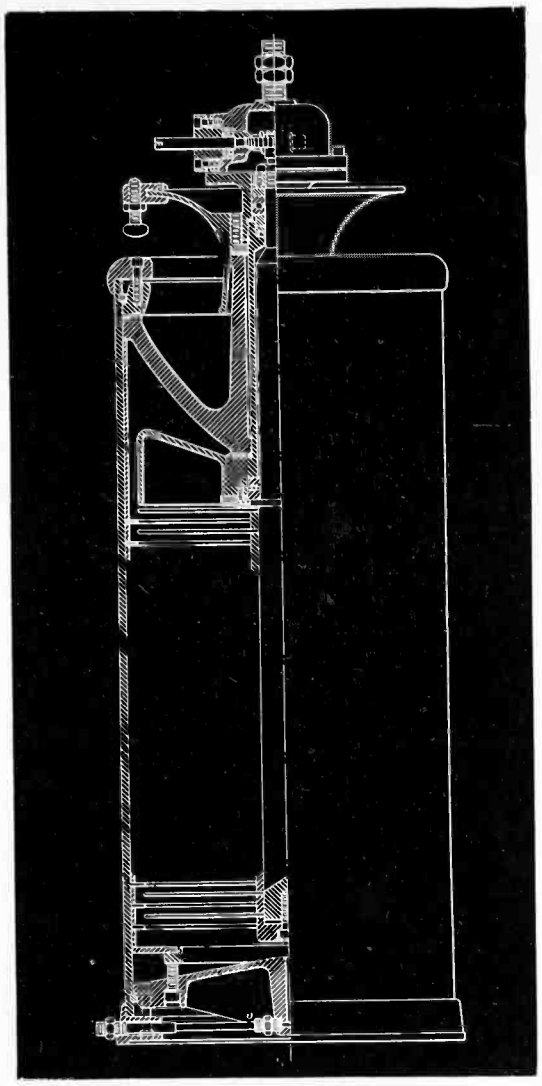


External appearance of H-K unit. Pyrex bowls insulate the rotor. The gap prevents internal flashover

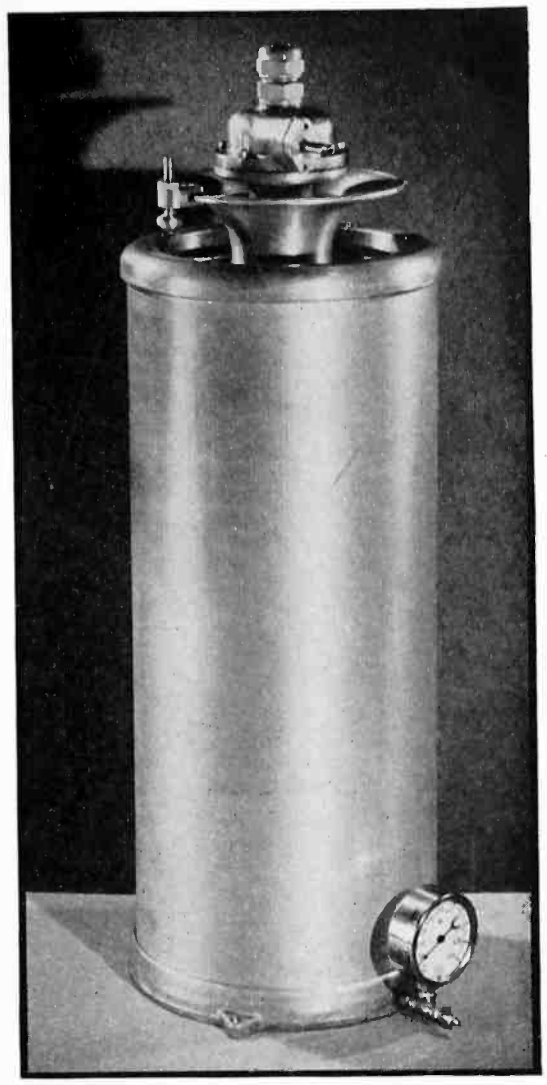
he same structure working at at-
nospheric pressure, while the in-
rease in dielectric constant, together
vith smaller spacing requirements,
nakes the unit about one-third to
ne-fourth the size of the equiv-
lent air-dielectric unit. Curves
howing the relationship between ni-
rogen pressure and breakdown volt-
ge, as well as dielectric constant,
re shown in the figure.

The electrical advantages of the
ressure-type capacitors are obvious
rom an inspection of these curves.
Not so obvious however is the fact
hat loss of the condenser is practi-
ally the same as that of an equiva-
ent air-dielectric condenser, and in
act the loss may be lower, since less
eramic and glass insulation is used
han in the air-type units. Com-
ared with the losses of the solid-
ielectric (mica) unit, the gas-filled
ype displays virtually no losses at
ll. There is practically no change
n capacitance with temperature.
'inally gas-filled units are protected
gainst internal flashover by the use
f air-gaps external to the gas con-
ainer. Even if flashover should
ccur internally, no serious harm is
lone, since the nitrogen quenches
he arc. Internal flashover is unde-
irable, however, in that it causes
›itting of the plates which may re-
luce the breakdown voltage, espe-
ially if any sharp edges are thereby
›roduced on the condenser plates.

The success of the new designs
ies primarily in mechanical engin-
eering rather than in the electrical
aspects, and for this reason many of
he important features may be new
o *Electronics'* readers. In the first
place it must be remembered that
nitrogen at 20 times atmospheric
pressure is a difficult substance to
confine, especially when the casing
must contain an insulating segment,
and when also a tuning rod, capable
of rotation, must pass through the
casing. A major part of the me-
chanical design, therefore, resides in
the choice of proper gasketing ar-
rangements. Gaskets are now avail-
able which are of the self-sealing
type, that is which press against the
parts to be sealed by virtue of the
internal pressure. Even with these
precautions it is not possible to com-
pletely eliminate gas leaks under all
conditions. Hence it is advisable to
keep tabs on the pressure by means
of a gauge attached to the case, or
to have an auxiliary supply of nitro-



Typical pressure capacitor manufactured by the Lapp Insulator Company. Tuning control is at top



External appearance of Lapp unit. Provision is made for monitoring the gas pressure on the gauge

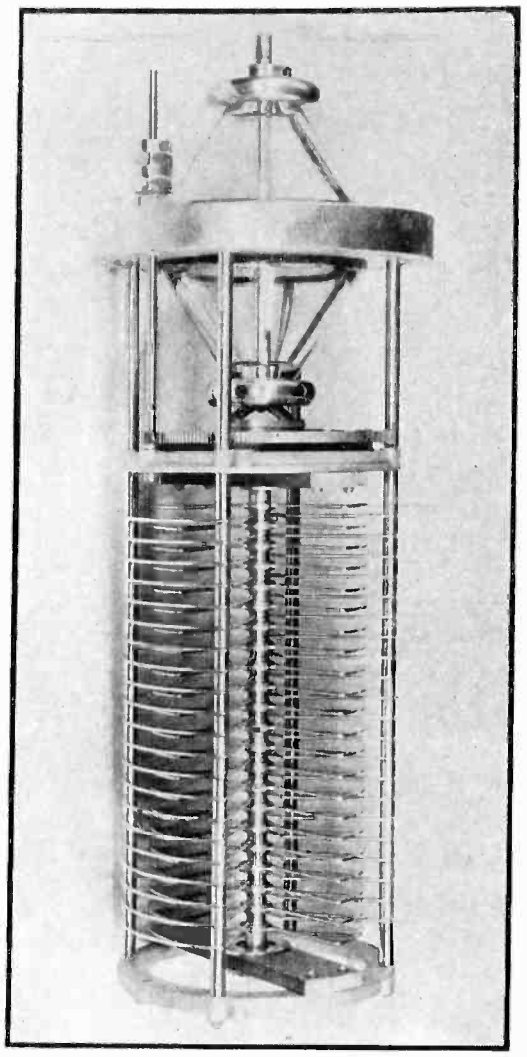
gen (in commercial tanks) available for connection to the condenser, should the need for it arise.

The ratings of the condensers vary from 75 to 2000 $\mu\mu$f in capacitance, from 20,000 to 42,000 volts, peak rating (corresponding to about 15,000 volts r-m-s carrier, 100 per cent modulated) and from 40 to 100 amperes. The voltage and current ratings depend upon the frequency of operation. The accompanying curve shows the relation between voltage rating and frequency recommended for the Lapp Insulator Company units. Similarly the current ratings for the Heintz and Kaufman condensers vary from 94 amperes at 0.5 Mc to 44 amperes at 10 Mc (for the 1000 $\mu\mu$f and larger maximum-capacitance sizes).

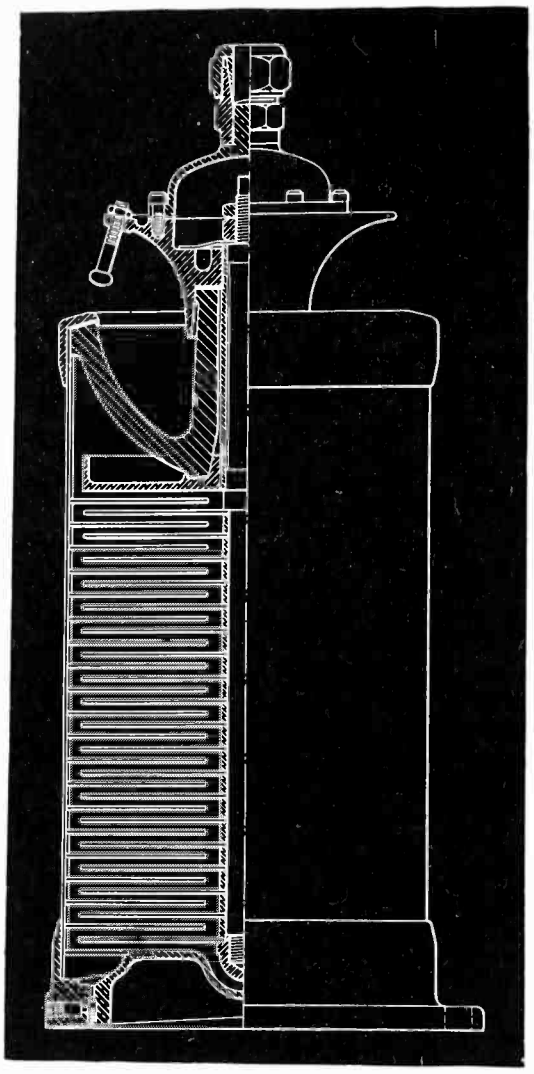
Constructional Details—H and K Units

The major constructional features of the pressure capacitors manufactured by Heintz and Kaufman, Ltd., of San Francisco are shown in the illustrations. The two sets of plates plates are of "butterfly" shape, that is each plate consists of two sectors which are placed opposite each other, with the shaft in the center. This arrangement makes for mechanical balance, and it also insures symmetry in the paths taken by the circulating currents, so that no part of the plate tends to overheat. The stator plates are connected directly to the case by four tie rods which run vertically. The rotor plates are supported, on the central shaft, from a flat bar of mycalex, which constitutes the only internal solid dielectric substance in the assembly. Immediately above the mycalex support is a flat plate with gear teeth cut into its circumference (sector gear). A small pinion gear which engages the teeth of the sector is mounted on a steel shaft which acts as the tuning control. The shaft protrudes through a gas-tight sleeve, or packing gland.

The rotor plates themselves make contact with the rotor terminal through a pair of 3-inch discs, one of silver, the other bronze, which bear against each other under spring



Internal view of H-K variable unit. Note smooth contours to prevent corona



A non-tunable Lapp unit which may be pre-set to any desired capacitance

pressure. Since the entire current must pass through this contact, it is carefully machined to produce even bearing pressure over the whole contact area. The upper contact, which is not movable, connects directly to the main rotor terminal rod. The insulation of this rod is accomplished by using two Pyrex glass bowls of conical shape. The inner bowl bears the whole pressure of the gas; the space between the bowls is open, through a vent, to atmospheric pressure, thus preventing any net pressure on the outer glass. The gaskets throughout are made of neoprene, which is considered superior to rubber.

The case is of seamless steel tubing, copper plated on the inside to reduce eddy current losses. Copper plating is also used on the upper and lower mounting plates, for the same reason. As originally designed, these units were fastened with tie rods on the outside of the case, but a later design omits the tie rods. In the latter design the bottom of the enclosure is welded directly to the case itself, as shown in the drawing. The mounting angles are also welded. All parts at high potential, especially those on the external terminals, are rounded to minimize corona. The external arc-over gap is adjusted for peak voltage before shipment of the unit, but may be readjusted if necessary when installed.

The gas used is dry oil-pumped nitrogen, of the kind readily available in commercial tanks. The normal pressure range is from 300 to 350 pounds per square inch, gauge pressure. No pressure gauge is attached to the condenser itself, but a ¼-inch gas fitting is included on the grounded (casing) portion, so that it may be connected to a gas gauge, or to a supply of gas. In the latter case, it is recommended that a 200 cubic foot tank be used, with a gas reduction valve, a shut-off valve, and a safety valve included in a 22-gauge, ¼-inch copper line to the condenser. The gas contained in a single commercial tank of 200 cubic feet capacity is sufficient for over a year's service on from one to three capacitors, depending on their size and conditions of use.

The physical dimensions are 17 inches diameter, in all sizes, (11½ inches exclusive of mounting lugs), while the height varies from 25 inches for the 250 $\mu\mu$f size to 37 inches for the 1500 $\mu\mu$f size. The capacitance ranges are 75–270 $\mu\mu$f; 125–550 $\mu\mu$f; 215–1025 $\mu\mu$f; 785–1325 $\mu\mu$f; and 1150–1540 $\mu\mu$f; minimum and maximum capacitances, respectively. Fixed-capacitance units within the above ranges are also available.

Design and Construction Data of Lapp Insulator Units

The tank of the Lapp Insulator Co. units is of seamless aluminum tubing. A study of the stresses in a cylinder will show that the longitudinal stress is only one-half the circumferential; it is therefore possible to cut away half the thickness of the tank near the end without changing its strength. This has been done on the inside of the tank and into the groove formed is snapped a carefully machined ring which is called the "pressure ring." Onto the face of this ring is placed a gasket and on this a "loading ring" forming a seat for the insulator and to carry the load to the tank. A gasket is also used between the insulator and the loading ring. In the bottom of the tank a similar arrangement is used: a "pressure ring" snapped into a grooved tank and a bottom plate with a gasket between. These gasket spaces are accurately machined pockets which prevent the gasket material from extruding under the pressure, an important feature in high pressure construction.

The only loss-contributing dielectric is the porcelain insulator. It is important that this be of such design as to give as little loss as is feasible. The insulator performs the combined functions of a tank sealing means and a mechanical support for the rotor. The porcelain is made the full size of the inside of the tank and the center portion has an extended hub, through which the end of the rotor shaft extends. This single porcelain is entirely open at the top end and permits the free circulation of air which carries off any heat generated in the dielectric.

The voltage distribution over or the flux through the insulator is controlled by means of the shield which is so shaped to produce even heating of the dielectric with conse-

quent minimum power loss. In other words, the loss in each section is so regulated that it is equal to the heat radiating characteristics of the particular section. This is desirable due to the poor heat conductivity of the dielectric material.

The rotor shaft rests on ball bearings top and bottom, the packing which is at the top of the shaft is of the "self-energizing" type with initial sealing against the shaft being produced by means of a spring. The packing is held in place by means of a "jack-nut" at the top into which are screwed three "jack-screws." This permits tightening to any degree with a small set-screw wrench.

On the shaft on the inside of the tank is a current collector of silver-plated beryllium copper sliding on a silver plated copper ring. This prevents the current flowing through the ball bearings and insures their long life.

The plates are held in place by means of annular spacers on a 1½ inch diameter central shaft. These spacers are machined and gauged to ±.001 to insure accurate spacing of the plates. These plates may be of any form desired but as now constructed are of the butterfly type in the variable condenser.

The rotor shaft is turned by means of a worm gear of a 15/1 ratio and the shaft has a resistance of 10 inch pounds torque when the condenser is under full pressure. A supplementary seal of the same type as the main shaft type is provided also on the operating shaft.

Where it is desired to adjust the condenser under voltage a porcelain shaft with universal connections at the end is provided. This is supplied as a regular part of the variable condenser.

The stator is made of plates held in place by means of annular spacers sliding closely in the tank. These are also machined to ±.001. The method of holding the stator plates is interesting. A long sleeve spacer bears on the ground edge of the insulator and on this rests the first stator plate spaced intermediately of the corresponding rotor plates. Alternate spacers and plates build up the stack to the desired length; on the last spacer presses a spring washer of the disc type.

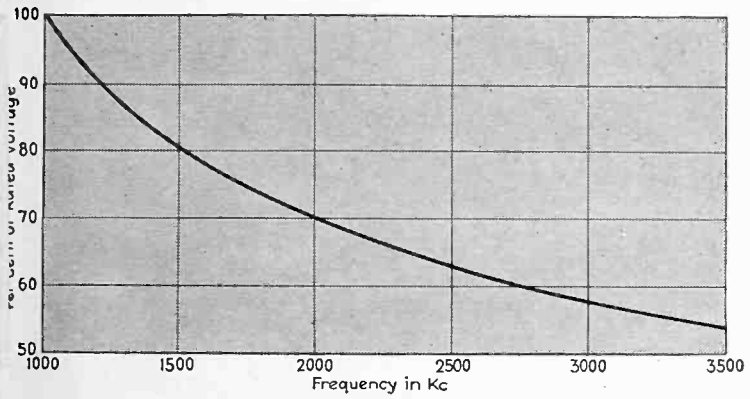
As previously mentioned, the tank is of aluminum and the bottom plate and "loading ring" are of heat treated aluminum. The other parts are of silicon aluminum castings. These are materials ideally suited to radio frequencies due to low inherent losses as well as low weight. The rotor shaft is of heat treated aluminum and all plates of hard rolled aluminum sheet. The weight aspect is clearly illustrated by the 15 kv, 1500 $\mu\mu$f variable condenser which weighs only 85 lbs.

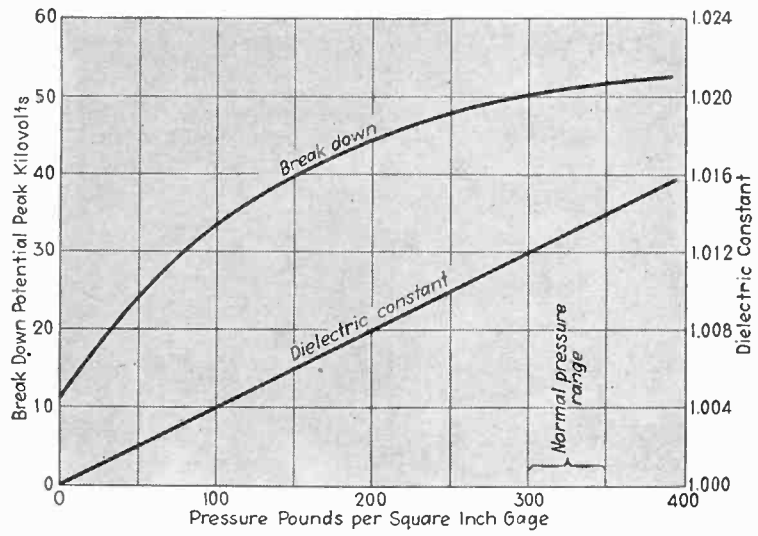
Each type of design has been tested at radio frequency to be sure it will carry the specified continuous voltage, as well as the flashover. All types have been design-tested at 1000 lbs per square inch and all designs will be proof tested to double the recommended operating pressure or 400 lbs per square inch.

For the present the recommended gas is oil-pumped nitrogen which is thoroughly dry. This is cheap and easily available and is extremely stable both under normal conditions and under arcing. Experiments are being conducted with other gases that show promise, and the present designs are adequate both for these gases or for nitrogen.

The standard connector supplied with these condensers is for tubing and is of the circular wedge type, ½ inch for the smaller size, ¾ inch for the medium and 1 inch for the largest. Tubing is the best conductor for radio frequency and these connectors use it most effectively. Supplementary angle connectors can be supplied when desired.

Three basic sizes have been provided, the 7.5 kv, 10 kv, and 15 kv, and these have three types—fixed, adjustable, and variable. Sizes up to 2000 $\mu\mu$f are available. The rating may need some further explanation. By 7.5 kv rating is meant that at 1000 kc a voltage of 7.5 kv rms on the carrier may be applied and continuously modulated 100 per cent. At higher frequencies it is necessary to lower the ratings somewhat due to heating of the insulator. Other types of ceramic for higher frequencies are being developed and with these it will not be necessary to reduce the ratings.





Above, the variation of rated voltage with frequency, recommended by the Lapp Company

Right, variation of dielectric constant and breakdown voltage with gas pressure. The normal range for H-K units is shown

A Stabilize

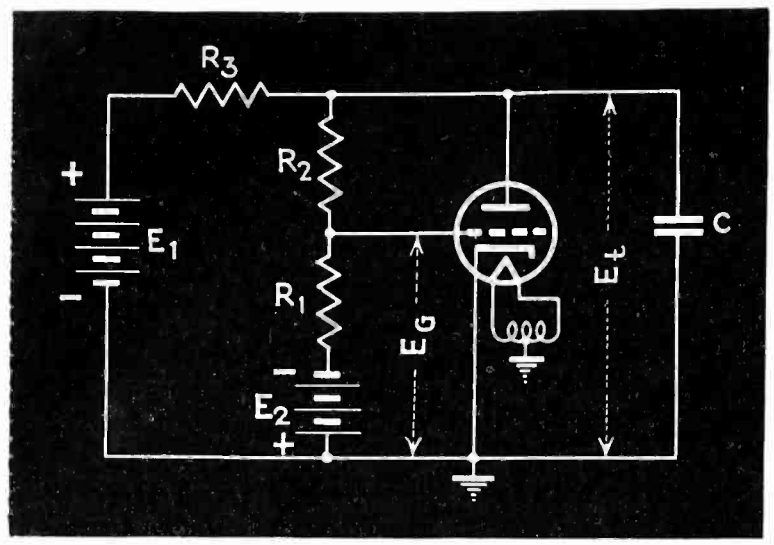


Fig. 1—Circuit for providing coupling between plate and grid in a sweep oscillator

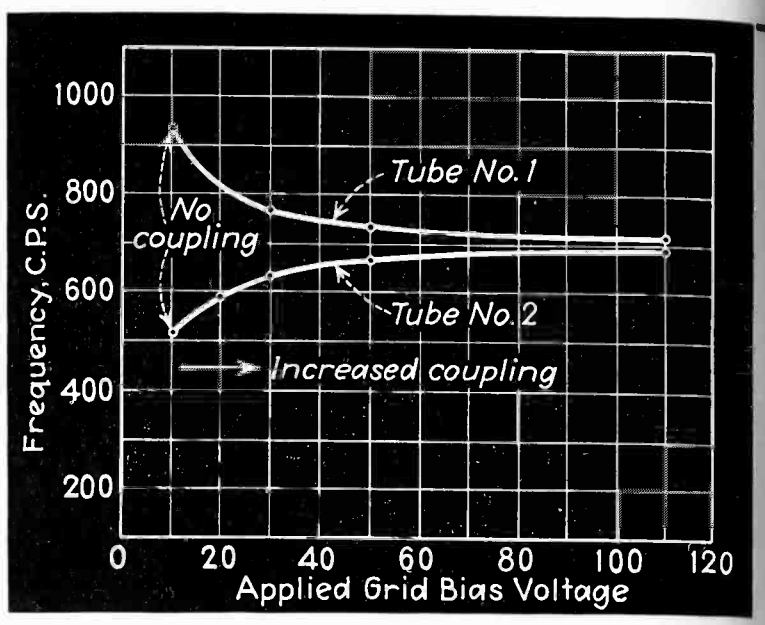


Fig. 2—Stabilizing effect of plate-to-grid coupling. Tube number one has abnormally low ignition potential, oscillates at high frequency

By WINSTON E. KOCK

ONE of the difficulties encountered in the use of gas triodes in a relaxation circuit is the instability caused by the changes which take place in the ignition potential. Although this instability usually shows up as a gradual shift in the frequency of oscillation as the tube ages, erratic instabilities are also present at times, and the problem of tube replacement is serious because of the difference in ignition potential between tubes. For the purposes of this discussion, ignition potential is defined as the anode potential, for a given grid potential, at which the tube discharges.

Manufacturing tolerances cannot be economically held to less than plus or minus 15 per cent. In the usual relaxation circuit this would also mean a frequency difference of about 30 per cent and difficulty would be experienced in providing dependable synchronization of such a circuit upon interchange of tubes. If mercury vapor tubes are used, the trouble is more serious because the ignition potential of such tubes is dependant upon the temperature.

It is the purpose here to describe a method in which the effect of tube changes on frequency can be greatly reduced, but without the limitation of previous circuits in that the cathode may be held at ground potential. This makes possible a considerably greater signal output and minimizes trouble from cathode-to-heater shorts.

Principle of Operation

A varying voltage derived from the discharge circuit is superimposed upon the constant grid bias. This causes the grid to become highly negative immediately after the discharge pulse and to become less negative gradually as the condenser voltage builds up preparatory to the next discharge pulse. The circuit diagram is shown in Fig. 1. (For simplicity, the limiting resistor of the discharge circuit is not shown).

The grid is coupled to the discharge circuit by means of resistor R_2. In the usual circuit (R_2 missing), a tube with an abnormally high ignition potential will oscillate at an abnormally low frequency, and vice-versa. In the circuit of Fig. 1, if the tube has an abnormally high ignition potential, then as the voltage builds up to reach that value, the grid potential becomes less negative and thus reduces the ignition potential and causes the tube to discharge earlier than if R_2 were not present. Likewise, if the tube has an abnormally low ignition potential, as the voltage on the plate builds up, the grid voltage, being initially highly negative, delays the discharge, and the tube fires later than if R_2 were not present. In both cases the frequency of oscillation approaches more nearly the frequency produced by a tube having normal ignition potential.

The amount of stabilization is determined by the relative values of R_1 and R_2; the smaller R_2 relative to R_1, the greater the coupling and stabilization. Increased coupling requires the bias voltage to be increased in order to maintain the same frequency and circuit operation, and the effectiveness of the circuit is limited by the overall supply voltage available. Figure 2 shows the effect of increased coupling on the frequency of such an oscillator for tubes having widely variant characteristics. It is observed that two tubes having ignition and extinction potentials which are so different that they generate oscillations differing in frequency by 100 per cent when placed, in turn, in an ordinary relaxation circuit (no coupling), will generate oscillations differing in frequency by only a few per cent when a sufficient amount of coupling is introduced.

In the circuit of Fig. 1, the anode ignition potential is given by the following relation:—

$$E_i = \frac{E_2 R_2 K_1 - (R_1 + R_2) K_2}{R_1(1 + K_1) + R_2} \qquad (1)$$

veep Circuit Oscillator

where K_1 and K_2 are contants depending upon the electrode spacing, gas pressure, etc. For example, for the type 885 gas triode, K_1 is approximately 10.4 and K_2 is approximately 11.

The condition when $R_1 = R_2$ represents a fair amount of coupling and Eq. (3) reduces to

$$E_i = E_2\left(\frac{K_1}{2+K_1}\right) - 2\left(\frac{K_2}{2+K_1}\right) \quad (2)$$

It is seen that for K_1 and K_2 large with respect to 2, $K_1/2 + K_1 \rightarrow K_1/$

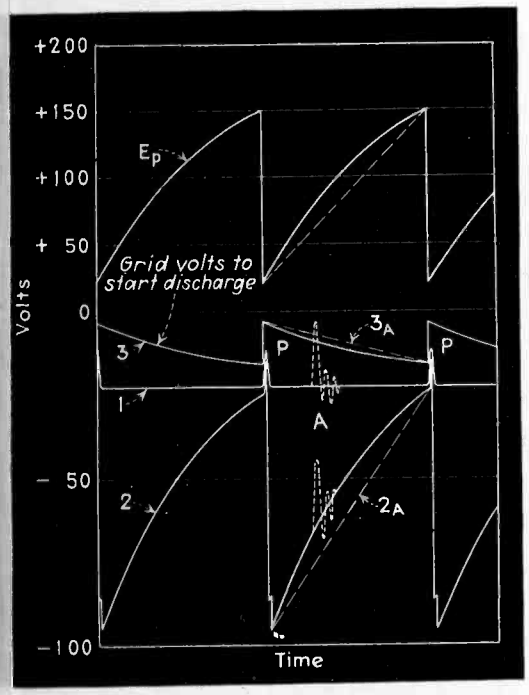


Fig. 3—Grid and plate voltages in a synchronized sweep oscillator

$K_1 = 1$, and the ignition potential E_i becomes independent of changes in either of these constants. Since these constants are the only factors which can affect the ignition potential and since the extinction potential is not as susceptible to change as seriously as the ignition potential, it is to be expected that a decided stabilization in frequency against tube variations will be achieved. By increasing the coupling so that R_1 is large compared to R_2, an examination of Eq. (1) shows that the K factor in (2) is reduced to $K_1/1 + K_1$ which represents a further increase in stabilization. It is also evident that an increase in the value of the factors K_1 and K_2 will lead to a greater stability for the same amount of grid coupling.

It is readily verified that the frequency of oscillation of the circuit of Fig. 1 is dependent upon all of the parameters in the circuit and is seen to be further dependent upon R_1 and R_2 through their effect on E_i.

However, since ordinary variations in these resistance elements are not serious a stabilization against the effects of ignition potential variations heavily outweighs the effect of such resistance variations.

Synchronization

Synchronization of this type of oscillator is also made more dependable by the introduction of grid-to-plate coupling. Figure 3 shows the voltages present in a relaxation oscillator with and without grid coupling. (A simple circuit such as Fig. 1 is assumed). E_p represents the plate voltage and this is kept the same for both cases. Curve 3 indicates the grid voltage necessary to initiate the discharge for the values of plate voltage E_p. Curve 1 indicates the actual grid voltage for an oscillator without grid-to-plate coupling, and at point P a pulse is introduced to synchronize the oscillator frequency with the pulse frequency. Curve 2 illustrates the grid voltage for the case when grid-to-plate coupling is present and with pulse P occurring as in curve 1. It is observed that case 2 is much less susceptible to being thrown out of synchronism by undesired random pulses (as at A), since the undesired pulse in either case must be sufficiently large to cause the grid voltage to exceed curve 3. In case 1, the random pulses need have an amplitude greater only than the difference between curves 1 and 3, whereas in case 2 they must exceed the difference between curve 2 and curve 3.

If the sweep is made linear by the use of a pentode, all of the curves become straight lines (shown dotted). The area enclosed between $2A$ and $3A$ and likewise the factor of safety are thereby further increased. This is particularly noticeable just before ignition.

De-ionization

Another improvement obtained through the use of plate-to-grid coupling is the increased frequency range made possible by the shortening of the de-ionization time. The upper limit of frequency of an ordinary gas-triode relaxation oscillator is determined by the time required for the ions to recombine after each cyclic discharge. When the anode voltage is removed or made sufficiently low to allow interruption of the arc, a definite time is required for the plasma to disappear, that is, for the vapor to "de-ionize." Since recombination occurs mainly at the plasma boundaries and not in the plasma itself, this de-ionization time can become large for heavy arc currents and slowly moving ions. Low atomic weight gases such as argon have shorter de-ionization times than the heavier elements such as mercury because the small mass of the positive ions allows them to acquire greater velocities. The presence of an electrode or other surface favors recombination and thus tends to reduce the de-ionization time, especially if this electrode be held at a negative potential. This is due to the formation of a positive ion sheath around the electrode. The amount of negative voltage applied to the electrode determines the thickness of the sheath and hence the effectiveness of the ion "sink" thus formed in removing the positive ions from the plasma. The comparatively large mass and hence slow speed of the positive ions makes their removal the determining factor in interrupting the arc.

The use of plate-to-grid coupling causes the grid to be thrown highly negative at the instant the discharge occurs and this negative electrode promotes rapid de-ionization and quickly extinguishes the arc. This shortened de-ionization time permits an extension of the upper frequency limit for such relaxation oscillators.

Power for Television Receivers

By E. W. ENGSTROM and
R. S. HOLMES
RCA Mfg. Co. Camden, N. J.

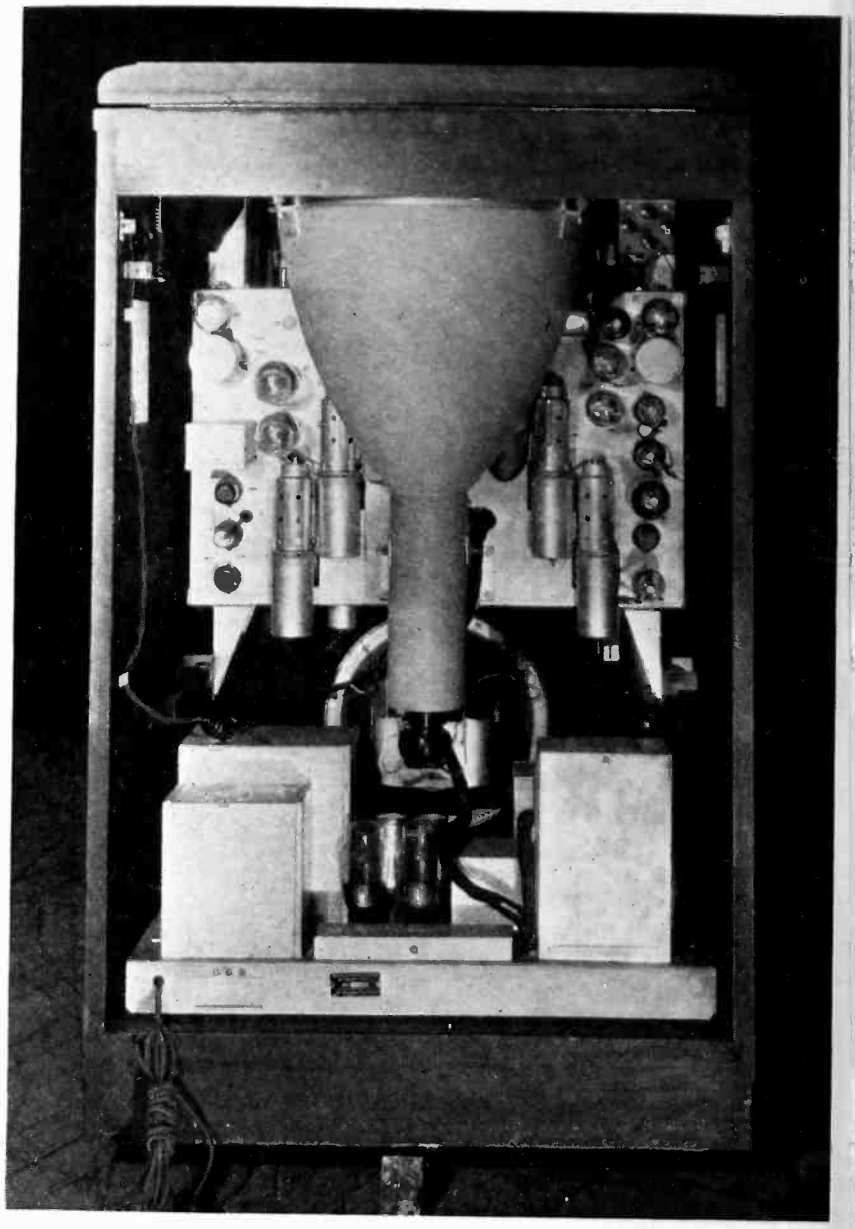


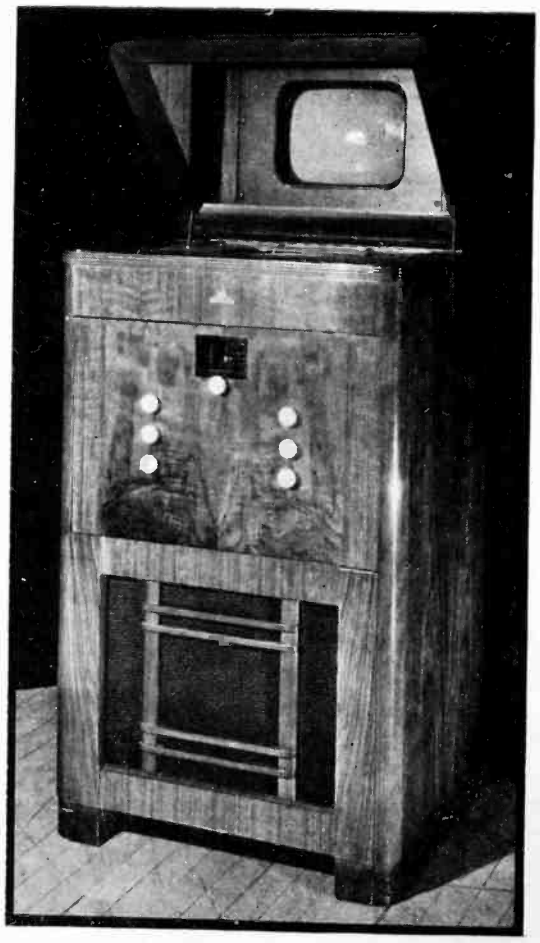
Fig. 1—Front view of receiver. Controls are: Center, tuning; left, video; right, audio. Thin glass in the mirror minimizes double images

Fig. 2—Rear view showing chassis and tube layout. Picture tube is shielded against stray fields

ALTHOUGH the power supply rectifiers in television receiver perform the same function as the power supply rectifier in a sound broadcast receiver, there are certain differences and certain characteristics that are important. At least two rectifiers are needed, one for the plate and bias voltages and the other for the high anode voltages of the kinescope.

The complete circuit diagram (Fig. 3) shows the power supply circuits for the experimental television receivers discussed in this series of articles. There are three separate rectifiers: one for the amplifier tubes, one for the kinescope first anode and one for the kinescope second anode.

The low voltage rectifier is full wave, inductor operated. Since all the amplifier tubes and the deflecting circuits have their plate voltage and bias supplied from this one rectifier, it is important that the regulation be good. The load taken by the i-f amplifier tubes varies with the strength of the received signal, due to the a-v-c action. If this load variation had an appreciable effect on the voltage supplied by the rectifier it would react on the deflecting circuits to change the picture size, and cause variations with the signal strength. A separate filter section isolates the audio power output tubes from the other circuits to prevent crosstalk into the rest of the system.



The loud speaker field coil is connected in series with the negative lead from the rectifier to ground where it acts as part of the filter. The voltage drop across the field is used to supply the a-v-c amplifier tubes.

The horizontal centering potentiometer is also in series with the negative lead, so that the total rectified current flows through it. Since the current is high, the potentiometer resistance can be made sufficiently low so that it has practically no effect on the horizontal deflection.

The second-anode power supply is a conventional half wave rectifier for an output voltage of approximately 6,000 volts. For reasons of conveni-

ence, flexibility, and regulation, a separate rectifier was used for the kinescope first anode. Also, it was found convenient to adjust the kinescope beam focus by varying the primary transformer voltage and thereby avoid high voltage leads and circuit components. (By proper design of circuit elements, first anode supply may be obtained from a bleeder on the second anode rectifier.) The negative side of both rectifiers is returned to the kinescope cathode so that the focusing ratio and screen voltage are not affected by the bias potentiometer setting in the kinescope cathode circuit. Screen grid voltage for the kinescope is obtained from a bleeder on the second anode supply.

In these articles the components and circuits of a television receiver have been reviewed and the principles of design and operation have been discussed. Figure 1 is a circuit diagram of the complete receiver. Receivers incorporating these circuits have performed satisfactorily in the RCA television field tests in New York. Figures 1 and 2 are front and rear view photographs of such a receiver.

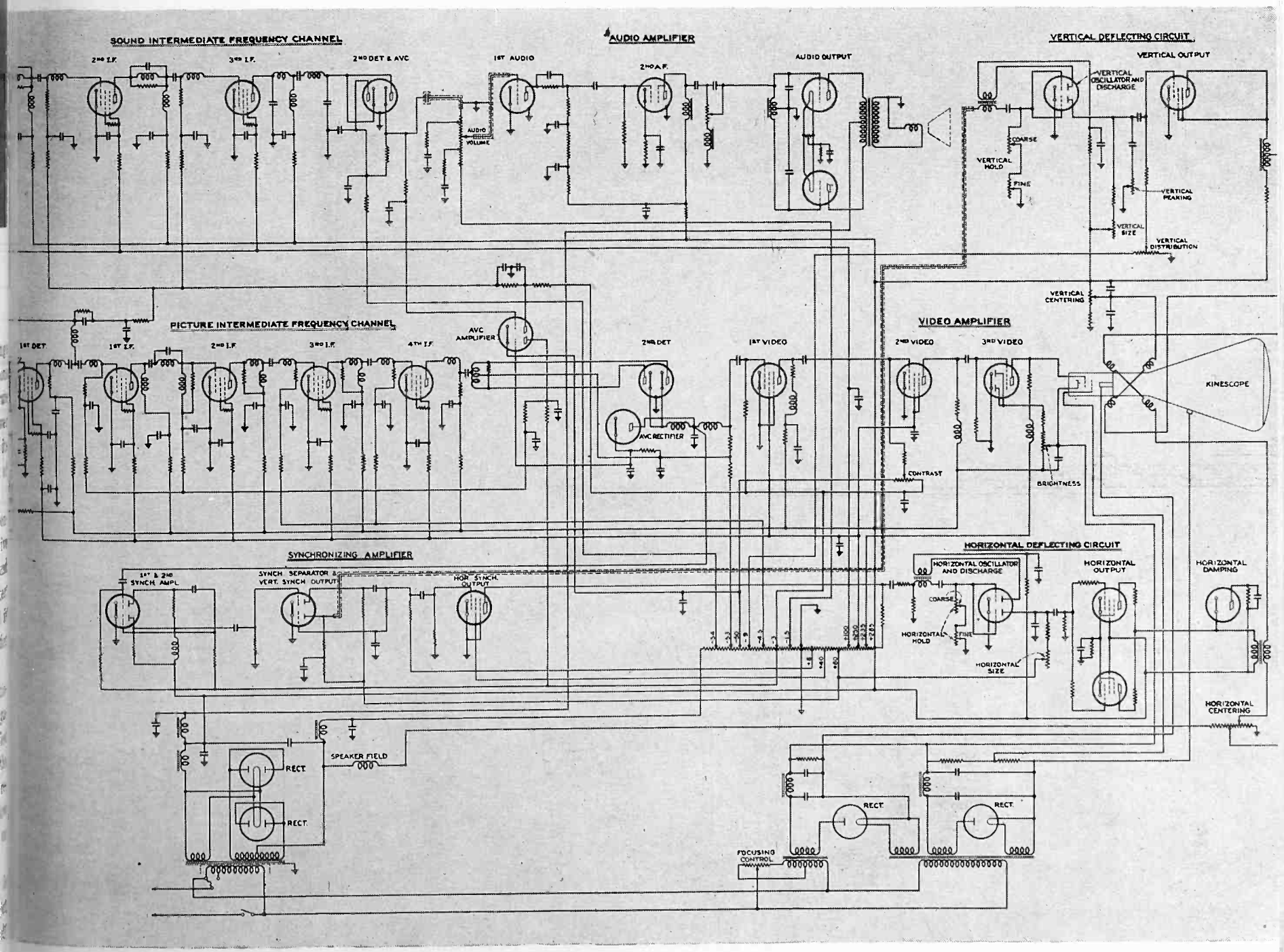
Modifications of Original Circuits

Since this series of articles began, development has brought about certain modifications in the transmission standards. Conclusions have been reached that it is feasible to attenuate one picture side band of the transmitted signal. This has permitted a wider frequency spacing between carriers of the picture and sound transmitters and in turn permitting a wider video frequency band. A spacing of 4.5 Mc has been chosen (3.25 Mc was used as the illustration in an earlier article). Figure 4 indicates a television channel showing the transmission characteristics of transmitter and receiver.

For the r-f circuits this means a wider pass band to include both carriers. For the circuits previously described this means tighter coupling between the two r-f circuits and somewhat more damping to maintain the flat response characteristic.

The picture i-f amplifier may have its band pass characteristic widened to approximately 4 Mc. The original requirement still holds for having 50 per cent response of the overall pass characteristic at the picture carrier. Increasing the band width of the picture i-f amplifier makes it desirable to lower slightly the frequency of the

Fig. 3—Circuit diagram of complete receiver showing picture, sound and power systems



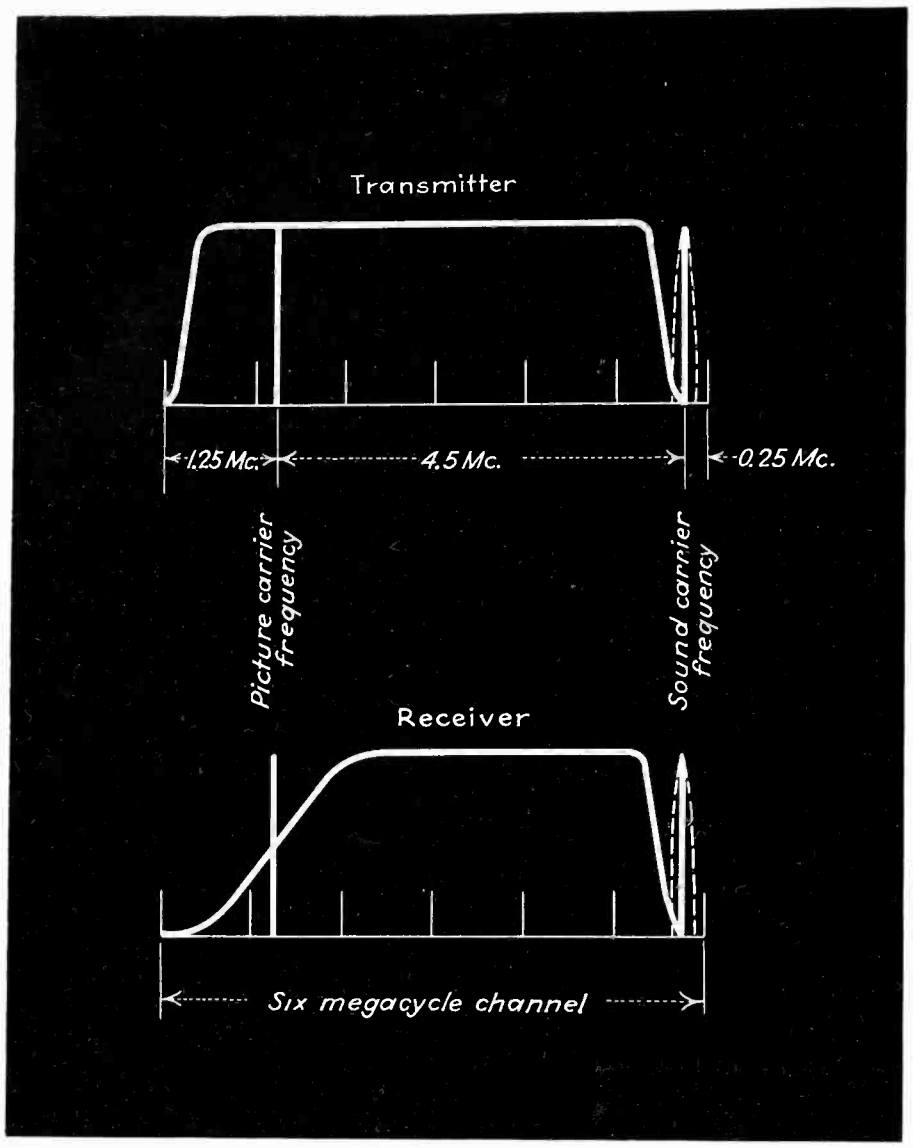


Fig. 4—Selectivity characteristics which conform with RMA Standard T-115

picture intermediate carrier in order to maintain a low response at the 14-Mc amateur band. An intermediate frequency of 12.75 Mc is a good choice for picture. The sound intermediate frequency will naturally be 4.5 Mc lower, 8.25 Mc when using 12.75 Mc for picture.

New Tubes for Television Receivers Available

Tube types have not been indicated in these articles. For earlier work i-f amplifier tubes were of the pentode type with suppressor and screen grid tied together to boost the transconductance. Amplifier tubes of high transconductance suitable for television are now available. These may be used with the regular conections.

During the discussion of i-f amplifiers, rejector circuits were described for reducing the response at the sound intermediate frequency. In cases where it is desirable to reduce the response of the amplifier to an interfering signal on the opposite side of the picture carrier, similar rejectors may be used. For example, if the next lower service in frequency is television, then the sound carrier of this lower frequency television channel will be 1.5 Mc from the desired picture carrier. A rejector circuit in the picture i-f amplifier tuned to 14.25 Mc will reduce the response to such an interfering signal. This problem of adjacent channel selectivity is considered an important and difficult one because of adjacent channel transmitter operation in the same service area.

An example of what may be obtained for overall selectivity in a receiver having a picture band width of 4 Mc with rejector circuits on both sides is given in Fig. 5. This curve is a plot of the signal strength required at the antenna terminals of the receiver to maintain a constant voltage at the receiver output plotted against carrier frequency with the receiver properly tuned to the 50-56 Mc television channel.

This concludes this series of articles discussing the underlying principles of television receiver design and operation which began in the April 1938 issue.

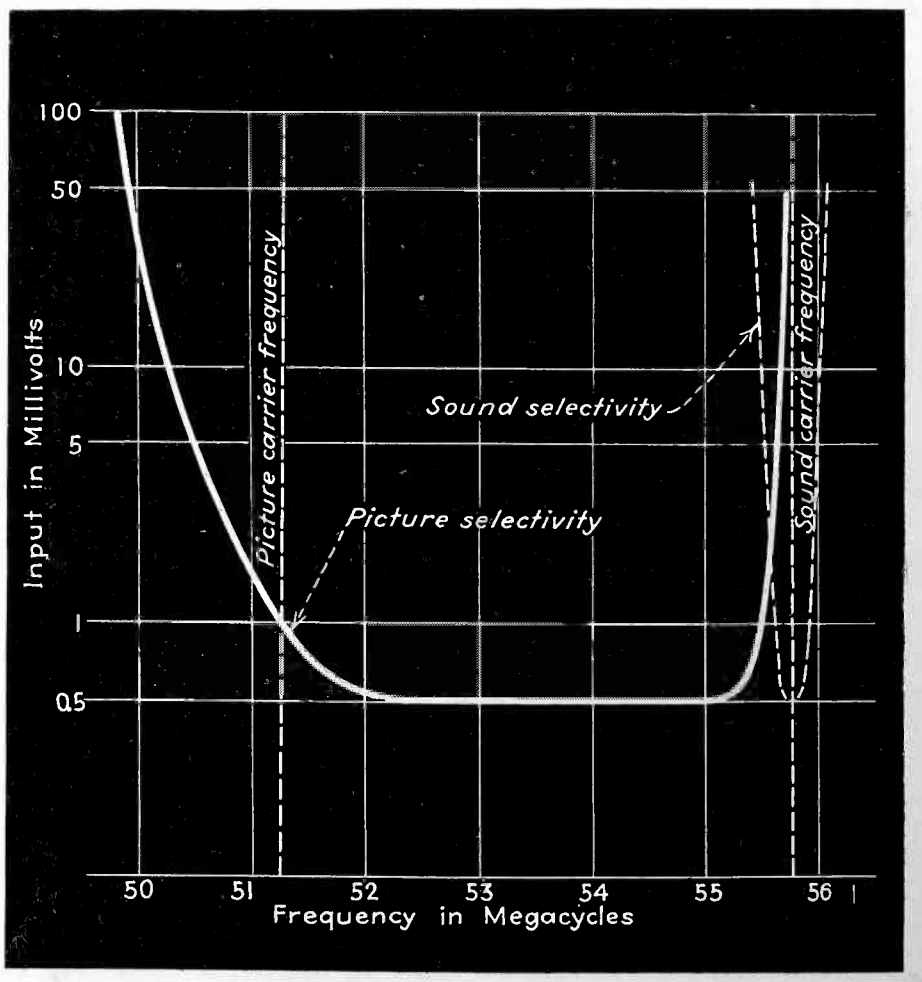


Fig. 5—The receiver sensitivity at the video carrier is reduced to half of its full value and the curve is such that the signal presented to the detector is fully modulated

The Permatron and its application in industry

By WILLIAM P. OVERBECK
Raytheon Production Corporation

CONSIDERABLE interest has been aroused by the announcement, at the AIEE winter convention, of a new electronic control tube, the Permatron. This tube performs a function similar to that of the thyratron except that the control is obtained through a magnetic field applied outside the bulb rather than with an internal grid.

This type of control was invented some years ago by Percy L. Spencer, and some of its possibilities were discussed in the January 1935 issue of *Electronics* by E. D. McArthur. McArthur's discussion dealt principally with a study of magnetic control effects observed in tubes constructed as thyratrons. The Permatron represents a design in which magnetic control is the major consideration. Thus, improved characteristics for this type of control have been obtained and its possibilities in industrial application have been enhanced.

In addition to the anode and cathode, the Permatron contains a cylindrical electrode, called the "collector", which surrounds the discharge path as shown in Fig. 1. If a magnetic field is applied across the tube, electrons, drawn from the cathode by a positive anode potential, are deflected to the collector and do not gain enough velocity to cause ionization. This action prevents flow of current to the anode. Releasing the magnetic field allows conduction to start to the anode. Conduction continues until the anode potential is removed or becomes negative. The collector may be connected to the cathode or, through a high resistance, to the anode. Connected to the cathode, the collector draws only a microscopic current from the cathode, even when conduction to the anode is blocked by the magnetic field. Connected to the anode, the value of the series resistance may be used to vary

P. L. Spencer, inventor of the Permatron, demonstrates the use of a magnetic control field

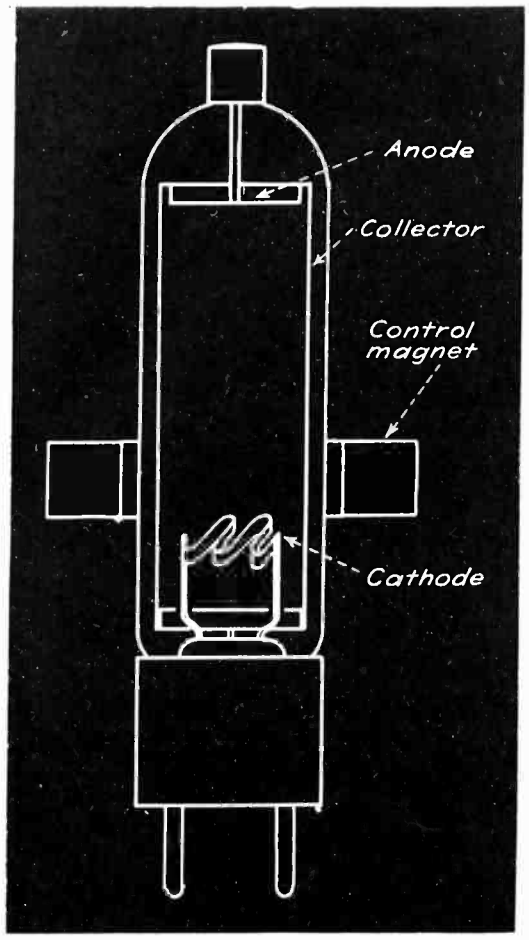


Fig. 1—Arrangement of electrodes and control magnet in typical permatron

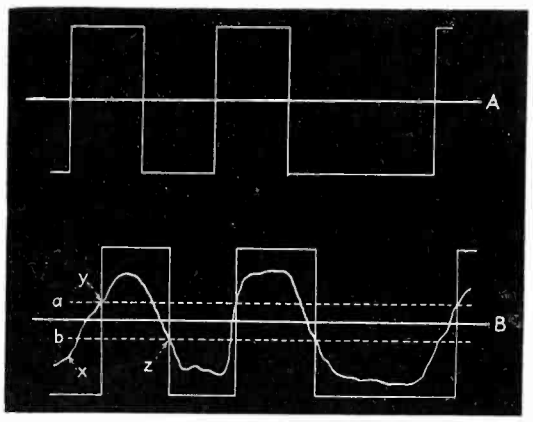


Fig. 2—Application of permatron to telegraph relaying

the sensitivity of the magnetic control.

Successful application of the Permatron to industrial work is possible for four reasons:

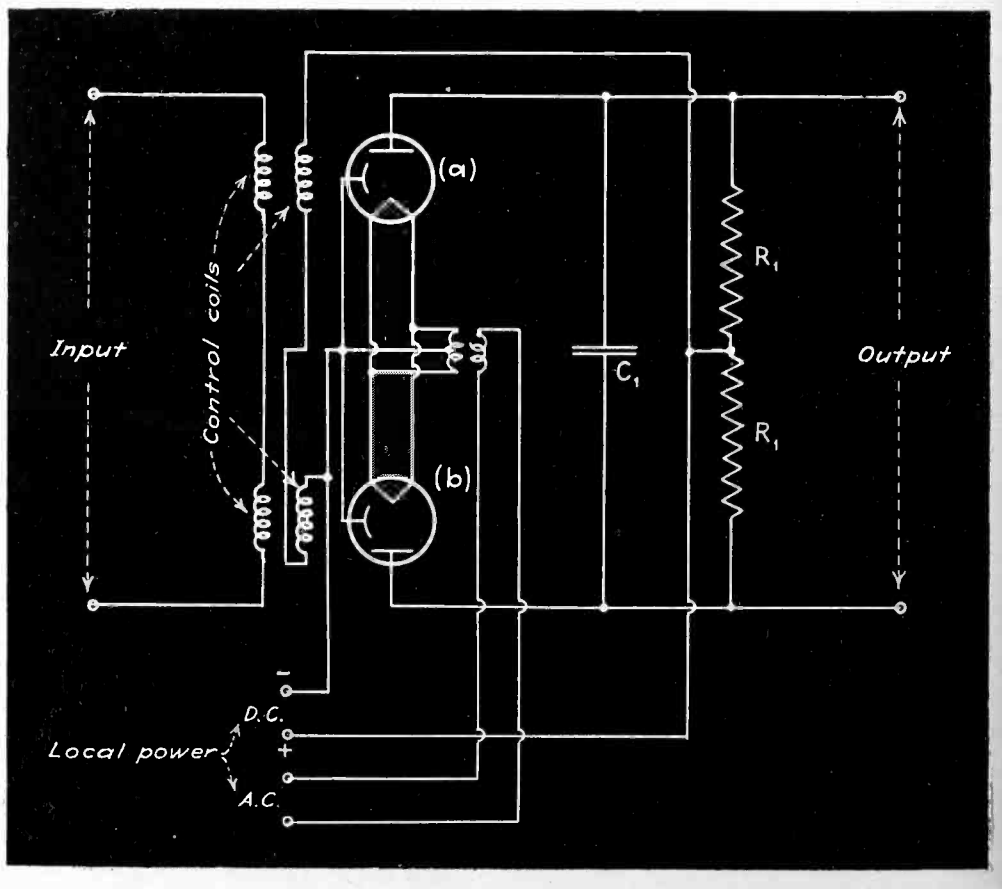
1. Through its special design, the power required for magnetic control has been reduced to a practical value. In experimental tests, less than one watt has been used to control, through the tube, as much as 200 kilowatts. This means that control circuit components, including the magnet, need not be large and cumbersome.
2. Since the control magnet and its circuit may remain insulated from the tube and main power circuit, and since control is not affected by polarity of the magnetic field, a new degree of freedom is given to control circuit design. These factors allow simplification of many circuits as illustrated by the applications described below.
3. Reaction of the tube on the control magnet circuit is so small that the magnet may be operated directly from communication systems without danger of reflections, or from circuits including delicate instruments.
4. Variation in design of the magnet coil allows control to be obtained over a wide range of control voltages. This is particularly useful if the control is from direct current.

The Permatron as a Telegraph Relay

As in all communication systems, the major problem in telegraphy is to rescue a signal which has become distorted by transmission over many miles of lines and to restore it to a condition which will preserve the intelligence which it is to carry for many more miles. An original telegraph signal may be represented by a square wave as shown on axis A of Fig. 2. After transmission over several miles, this signal may appear as shown by the wavy line on axis B.

The Permatron circuit shown in Fig. 3 may be used to correct the distorted wave form. Two tubes (a and b) are used. Each is operated by a magnet having two windings. One set of windings is connected to a local battery and supplies a constant d-c magnetic field to each tube. This "bias" field is represented by the dotted lines in Fig. 2. When the incoming signal is applied to the other set of coils, the dotted lines indicate the value of incoming signal which produces zero magnetic field through each tube. Thus, at point x on the incoming wave, tube (b) is conducting and tube (a) is not. The condenser, C_1, is charged up to nearly the full voltage of the local d-c supply with the end which is connected to the anode of tube (b) negative. At point y on the wave, the field through tube (a) passes through zero, allowing it to start. This forms a connection between the positive terminal of the condenser and the cathode of tube (b) and forces the anode of tube (b) to a negative potential for a period long enough to allow conduction to stop and to allow the magnetic field through it to prevent it from restarting. The condenser then charges up in the reverse direction and is ready to perform the same function in stopping tube (a) when point z is reached. This switching of current

Fig. 3—Circuit for restoring distorted waveform in long-distance telegraph communication, employing push-pull permatrons



from one tube to the other produces a voltage across the output terminals of the circuit which has the wave form shown by the square wave on axis *B*. This wave represents the restored signal which is sent on to the next relay station. The resistors, R_1, and the condenser are chosen so that the time constant, R_1C_1, is greater than the deionization time of the tube (approximately 500 microseconds).

The value of Permatrons in this circuit lies in the fact that the magnetic bias and the plate supply for the tubes are both obtained from the same d-c source and in the fact that the control coils have a linear impedance and may be operated direct from the incoming line without producing interference or reflections.

Automatic Battery Charging with Permatrons

One way in which a rectifier does not equal the performance of a storage battery is in its transient regulation to load. When the output of a rectifier is filtered to the point where it is as smooth as that obtained from a battery, the impedance of the filter causes sharp transient changes in voltage whenever the load is suddenly changed. The major disadvantage of a battery, on the other hand, is its high cost of maintenance and replacement.

The combination of automatic charger and battery possesses several advantages. By proper control of charging, the life of a battery may be more than doubled. If the charging is automatic, the only attention required by the battery is a regular addition of water. The virtues of this combination have become so well recognized in the last few years that many new automatic charging devices have been placed on the market. Most of these employ copper-oxide rectifiers and saturable-reactor control units. Such units have been found very satisfactory and it is unlikely that electronic devices will ever completely replace them. However, it has been found that there are many instances where power ratings and rigid control requirements make electronic control necessary.

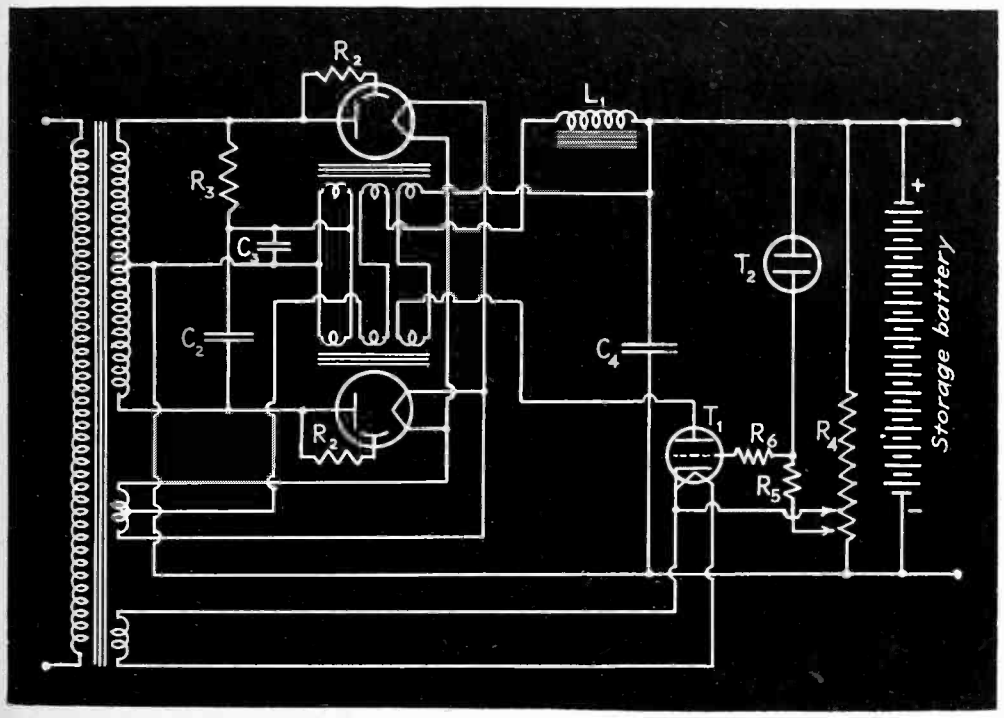


Fig. 4—Circuit employing three-phase-reactor magnetic full-wave control for controlled charging of storage batteries

Figure 4 shows a circuit in which Permatrons are used for automatic charging. The circuit is that of a full wave rectifier in which the Permatrons are controlled by magnets having three windings. One pair of coils is operated from a-c furnished by a phase shift circuit which consists of the plate transformer secondary, the resistor R_3 and the condenser C_2. Another condenser, C_3, is connected in parallel with the control coils and is of a value which resonates, at 60 cycles, with the coil inductances. This reduces the current drawn from the phase shift circuit and makes it possible to use components of lower rating.

The two other sets of coils are operated with d-c and are connected so that the a-c voltages induced in them by the a-c coils are balanced out. One set of d-c coils is connected in series with the output current and provides "current control". The other set of d-c coils is operated by an amplifier tube, T_1, whose grid voltage is the difference between a portion of the output voltage and the constant voltage appearing across a glow discharge tube, T_2. This provides "voltage control". Direct current flowing through either of these sets of coils varies the time in each cycle at which the tubes start by shifting the zero axis of the a-c magnetic flux.

If the output characteristic of the rectifier, without any control, is as shown by the upper line in Fig. 5, the effect of the current control coils, acting in conjunction with the a-c coils, is to produce the drooping characteristic shown by the dotted line. Addition of the voltage control produces a flat portion in the curve at low values of output current. The voltage control, as shown, is effective only to a

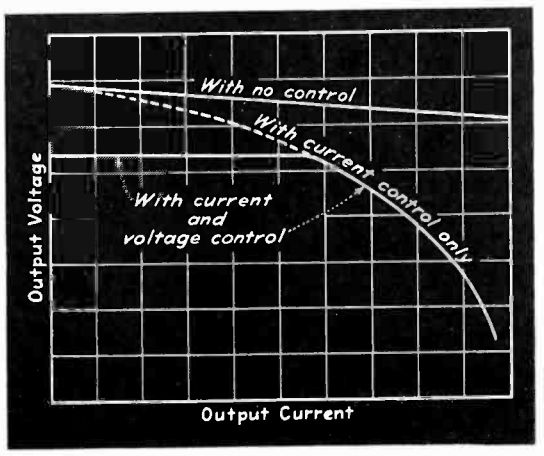
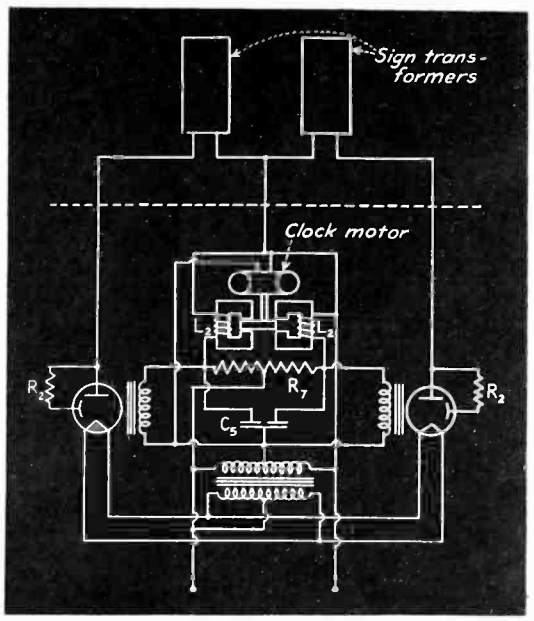
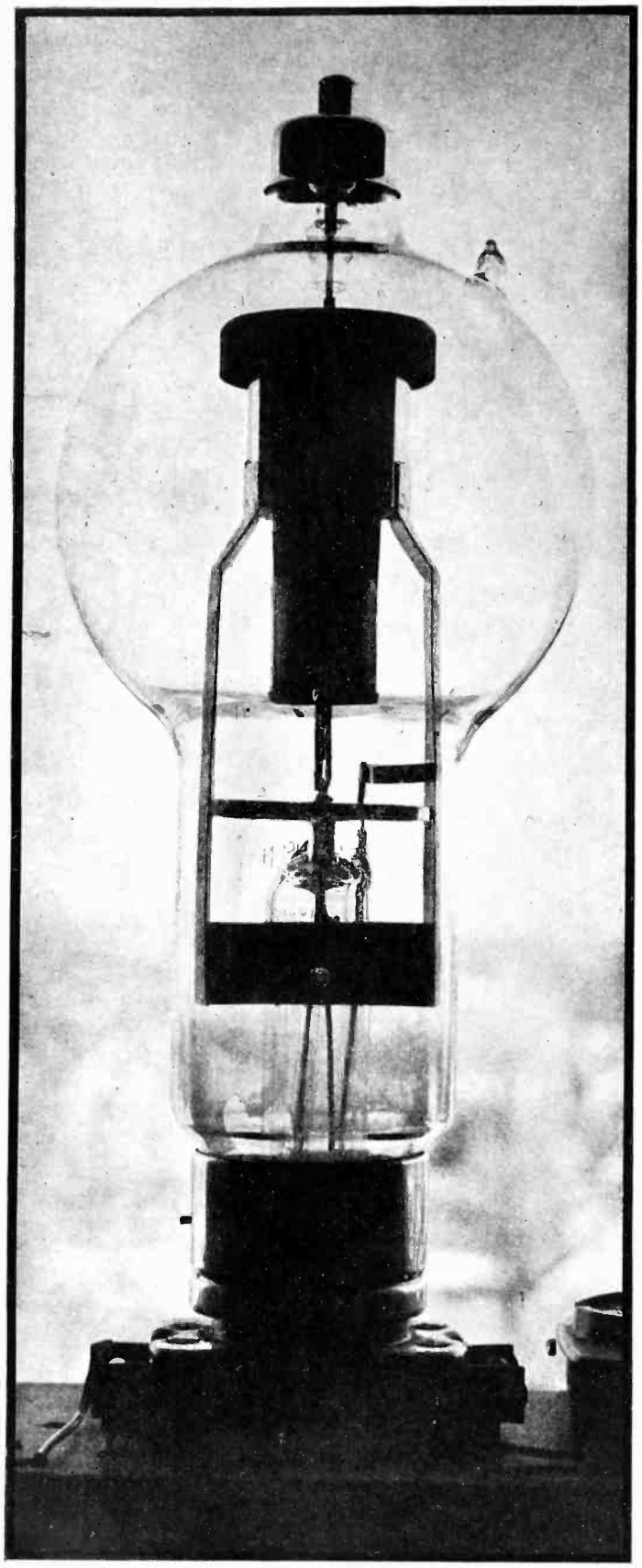


Fig. 5—Comparison of voltage vs magnetic types of control

Fig. 6—Circuit for "fading" two neon signs





Photograph of typical structure, showing enclosed region between cathode and anode

certain value of output current. This is due to the fact that beyond this point, the grid of the amplifier tube is so far negative that its plate current is completely cut off and it ceases to function. By proper design, the point at which the output voltage starts to drop is set at the maximum allowable charging rate of the battery. The sliding taps on resistor R_4 are set to make the value of the flat portion of the curve equal to the voltage at which the battery is to be maintained. When connected to the battery, the action of the entire system is as follows:

With no output load, the rectifier charges at the full rate if the battery is below the required voltage. As soon as the battery is up to full voltage, the rectifier supplies only a trickle charge. When light loads are applied, the rectifier supplies both load current and trickle charge. When heavy loads are applied, the rectifier supplies maximum charging current and the battery supplies the rest. Thus, the battery is able to perform its two specialties: supplying heavy overloads and sudden current surges whenever required. In between times, the rectifier supplies the power and keeps the battery in good condition.

The use of Permatrons in this circuit is helpful in many ways. First, combination of the three controlling systems is greatly facilitated by the use of multiple windings on the control magnets. Second, the current control is efficient, since the voltage drop through the current control coils may be made extremely low, and requires no auxiliary transformers or amplifiers; and, third, the ability to wind the coils for any impedance level enables the designer to match circuit characteristics with the characteristics of the voltage amplifier tube, and to operate the a-c phase shift circuit from the same source which supplies anode voltage to the Permatrons.

An Automatic Fader for Neon Signs

When neon signs were first developed, much of their value was due to the fact that they were different, and that neon signs were conspicuous among many signs using incandescent lamps. Today the neon sign requires new effects in order to maintain its leading position in the advertising field. It is impossible to produce smooth variations in intensity in neon lighting simply by varying the applied a-c voltage. If the voltage applied to the sign transformer is reduced, the glow suddenly goes out before an appreciable reduction in intensity has been obtained.

When a gas-filled control tube is connected in series with the sign transformer primary, the brilliancy may be varied smoothly by varying the time in each cycle during which voltage is applied to the sign. Although this varies the effective a-c input voltage to the sign, surge voltages introduced by the sharp starting of the tubes are sufficient to ignite the sign even when the total brilliancy is extremely low.

The Permatron circuit in Fig. 6 is designed to produce the effect of smooth color change with neon. It operates two sign transformers in such a way that the brilliancy of one neon tube is smoothly increasing while the other is decreasing. This variation is made periodic, so that by arranging two neon tubes, one red and the other blue, close together, the apparent color of the sign may be made to change periodically through red, orange, purple, blue, and back again.

In this circuit each control coil is operated from a phase shift circuit consisting of a reactor L_2 and half of the resistor R_7. The reactors are periodically varied in opposite sequence by an iron cam, which rotates on an eccentric axis so that the iron moves in and out of gaps in the reactor cores. The condenser C_5 is a double-section unit which resonates both control coils to reduce the load on the phase shift circuits. The forces on the cam are so well balanced that it may be turned by a small synchronous clock motor. This periodic variation of the phase shifting reactors produces variation in the time at which each Permatron starts conduction, which in turn produces the continuous variations in brilliancy of the sign tubes.

Several features of the Permatron combine in this circuit to give it the simplicity which is required for sale in a large and highly competitive market. Since no connection is required between the tubes and control circuit, the motor wiring, the phase shift circuit, the filament transformer, and the power circuit are grouped together in every possible way to reduce the cost of materials. The ninety-degree lag between control coil voltage and current makes it possible to operate the phase shift circuits under conditions where maximum variations in sign brilliancy are produced by the minimum variation in inductance of the phase shift reactors. This is very useful, since it is always difficult to produce a large continuous variation in inductance either by changing an air gap or by d-c saturation. The ability to use a continuously varying reactor in this manner eliminates the need of moving electrical contacts, such as might be needed for a variable resistor, and thus adds to reliability of the device and to freedom from maintenance.

WSOC'S PACK TYPE TRANSMITTER

By S. T. CARTER
WSOC, Charlotte, N. C.

THE ultra-high-frequency crystal-controlled pack type transmitter described herein is the result of several years experimentation and experience with pack transmitters of all varieties at WSOC. The models constructed and tried have included modulated oscillators, self-excited oscillators driving modulated amplifiers and the crystal-controlled unit.

This latter unit has several unique features, and should be of interest to broadcast engineers and amateurs concerned with high- and ultra-high-frequency transmitters and receivers of small size and light weight.

The complete unit, with its associated battery power supply, is housed in an aluminum and dural case 11 by 15 by 5 inches. An idea of the construction of the case may also be had from the photographs. The right hand side, or front panel, has attached to it the four eighth-inch thick aluminum shelves. The bottom compartment formed by these shelves houses the battery supply of 180 volts of "B" battery, the 3-volt "A" supply and the two "C" batteries for the speech amplifier and the automatic modulation control. The narrow space between the bottom and middle compartments is for the protection of the wiring of the speech amplifier, modulator, and receiver circuits. The parts for this portion of the unit are mounted on the third shelf. The small upright panel at the rear of this compartment serves two purposes, a support for the r-f shelf, and a mounting for the microphone receptacle and the headphone jack. Corresponding holes are cut in the back of the outer case to pass the plugs of the microphone and headphones as well as the antenna for the receiver.

The top shelf with its 5 by 5 inch baffle shield, supports the r-f section of the unit. All parts, except the antenna coil and condenser, are mounted on this shelf. The front panel supports the antenna condenser with its associated coil mounted directly to its terminals. The oscillator and doubler are mounted to the rear of the shelf with the baffle shield between these two stages and the final neutralized amplifier.

The built-in cue receiver operates on two bands of frequencies, one covering several hundred kilocycles in the neighborhood of 2500 kc and the other covering several thousand kilocycles in the u-h-f band. The unique thing about this receiver is that not only the coils, but complete circuit changes are made in the shift from high to low frequency reception. On the u-h-f range a super-regenerative type of detector is used while for reception on the lower frequencies a straight regenerative detector is used.

Coverage of two bands was felt necessary and desirable at WSOC. Normally, this transmitter works directly to the WSOC mobile unit. This unit (a half-ton truck) has, in addition to the receiver for the u-h-f transmitter, several other pieces of apparatus. Two transmitters are located in the truck. Both operate from the 110 volts ac supplied by a generator. One of these transmitters operates in the low frequency end of the broadcast pickup band with a carrier power of ten watts, the other, a 40-watt transmitter, operates on either 2790 or 2058 kc. With the frequency coverage of the built-in cue receiver, reception is possible from any of the transmitters employed as well as from WSOC direct. In addition to the reception of cues, the receiver is valuable for pre-broadcast arrangements where the pack is at a considerable distance from the truck or where crowds make communication difficult.

With the system of automatic gain control shown, about 12 db of compression is practical and has proven well worth while. The quality of transmission is in no way impaired when the modulation control is switched in. Using inductor types of microphones and with the automatic modulation control operating, sufficient output from the modulators for one hundred per cent modulation is obtained with the gain control about one-third open. With the gain

A quarter-wave rod antenna is connected at the top of the case by means of wing nuts

control full on, considerable variation in pickup level is permissible.

The automatic modulation control (a-m-c) makes use of a small amount of audio from the grids of the 1J6G through the 2:1 audio transformer to the diode plates of the 1B5. The negative voltage developed across the 250,000-ohm resistor in the center tap of the transformer serves as additional bias for the first stage of the speech amplifier, thus limiting the gain of this stage within limits. The 12 volts of bias in series with the 250,000-ohm resistor and ground, controls the point at which effective compression begins. An increase of over 12 db input gives an output increase of approximately 3 db. The switch S_4 provides a means of operation either with or without the modulation control.

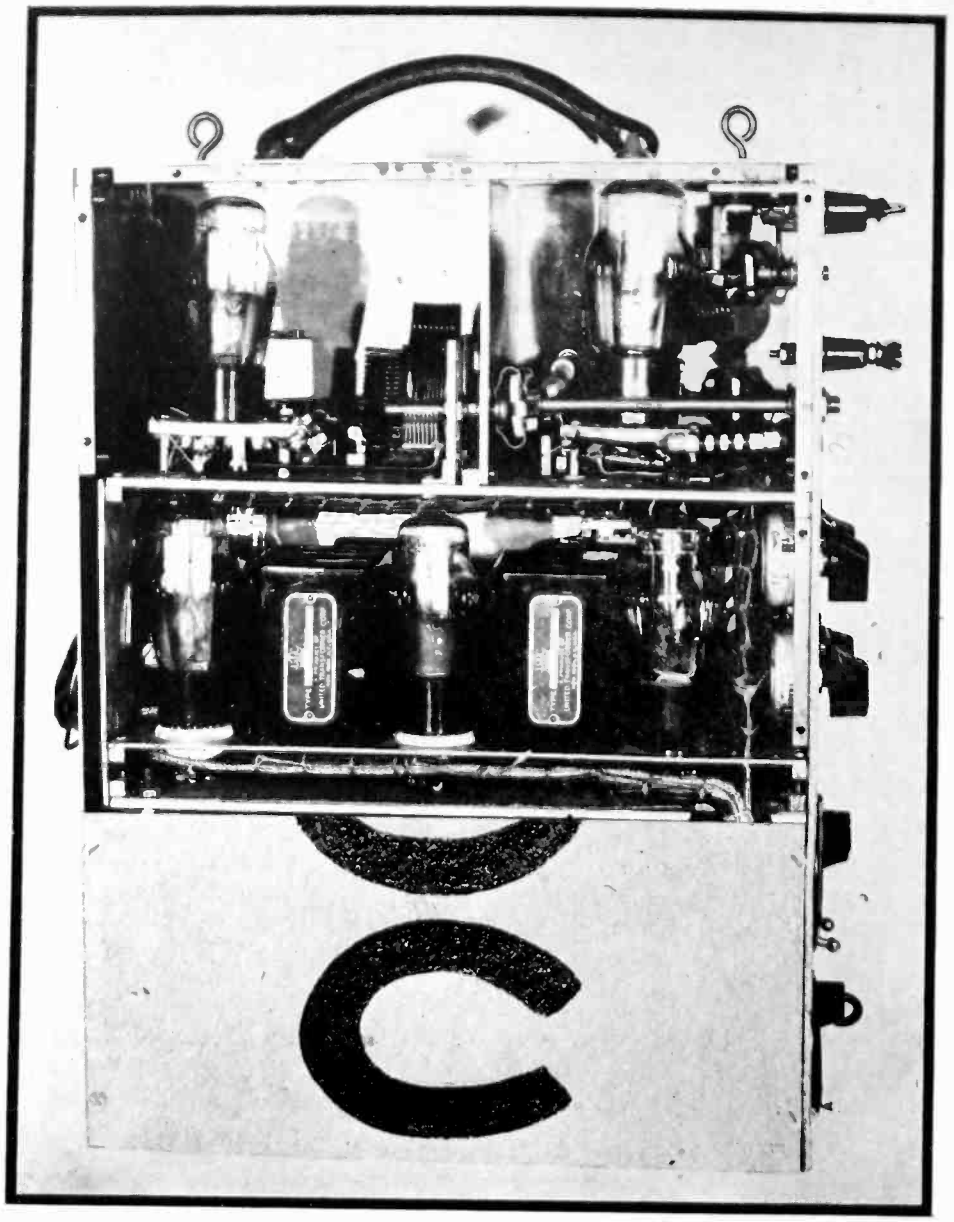
The speech amplifier and the modulators use only two tubes and have more than sufficient gain and output to modulate the four watts input to the final amplifier. The speech amplifier uses a single 1E7G with its two pentode sections connected in cascade. The second pentode section is transformer-coupled to the 1J6G which is used as a class B modulator. Three volts of bias is used on the 1J6G.

An overall frequency run on the tranmitter shows good response between 100 and 5000 cps, the output being down 4 db at 8,500 cps. The output falls off rapidly beyond these limits. Distortion is not noticeable on an oscilloscope. Both the low and high-frequency response can be improved by the elimination of the input transformer. The use of crystal microphones should be practical although they have never been tried on this particular unit. The addition of the automatic modulation control introduces no additional distortion which can be detected on an oscilloscope.

The receiver consists of the type 30 detector and a 1B5 triode as the audio amplifier, the diode plates serving as the automatic modulation control rectifier. The switching circuit of the detector is shown in the diagram.

A SPDT toggle switch, S_3, is provided in the headphone circuit to allow either reception or monitoring the program being broadcast.

The r-f section of the transmitter uses a 1E7G, one pentode section being the oscillator and the other the



The r-f section is mounted on the top shelf. Note that the frequency doubler is tuned by an extension shaft. The batteries are carried in the bottom compartment

frequency doubler. Ample excitation for the final amplifier is obtained from the doubler. Two milliamperes or more of grid current is easily obtained. The modulated amplifier uses a 1F4 with plate neutralization.

With a full voltage set of batteries, loading the final amplifier to four watts input is accomplished without difficulty. With less than 150 volts of battery, it is difficult to obtain the required input for a two watt carrier. However, operation of the battery supply at this voltage is apt to produce noise due to the internal resistance.

Using a quarter-wave vertical rod antenna, coverage at a half mile results in a signal that completely overrides all noise encountered so far. Coverage up to several miles should be practical under favorable conditions. Tests so far have been made without regard to buildings and other obstacles between the transmitter and the receiving point. The receiver has been located in the down town area. Removal of the receiver to a point where the noise level is lower would result in signals useable over a much wider range of signal strength.

No trouble should be experienced in construction of a unit similar to this one, that is, other than that usually encountered in the determination of proper coil sizes.

The antenna coupling system shown has proven best for our needs. Various other systems, including top loading of the antenna, have produced r-f voltages in rather large quantities on the case of the unit and the microphone. With the system shown, no trouble from this source has been noticed so far. Antenna current is in the neighborhood of 0.125 amperes for the two-watt carrier. The use of either a full half-wave antenna or loading the antenna to a half wavelength has produced no noticeable increase in sig-

nal strength at the distances at which tests have been made so far.

The controls for the oscillator, doubler, and final amplifier tank condensers, as well as the antenna tank condenser, are brought out to screw driver slots in the front panel. Only occasional retuning is necessary.

The output of the oscillator-doubler tube depends to a large extent on the value of screen voltage used. Low voltage at this point results in low output and/or instability.

The gain of the 1E7G speech amplifier may be increased somewhat by increasing the screen voltage. However, when the "B" voltage starts to fall off, using the a-m-c will produce squeals. The gain of the stage is ample with the voltages shown.

Two meters are provided to check the operation of the unit. A double-range voltmeter for checking the filament and plate voltage, and a milliammeter for reading plate current of the oscillator, doubler, final amplifier and modulators. This meter is connected through S_2 across the 25-ohm resistors in series with the plate supply leads to these stages.

Some improvement in the construction of the transmitter might be made by making the overall size of the case one inch higher and a half inch wider on the five inch side. The additional inch of height could well be used in the small space between the audio shelf and the battery compartment. Space would be provided for the automatic modulation control and headphone switches, the leads would be shortened considerably and eliminate some crowding of parts into the battery compartment.

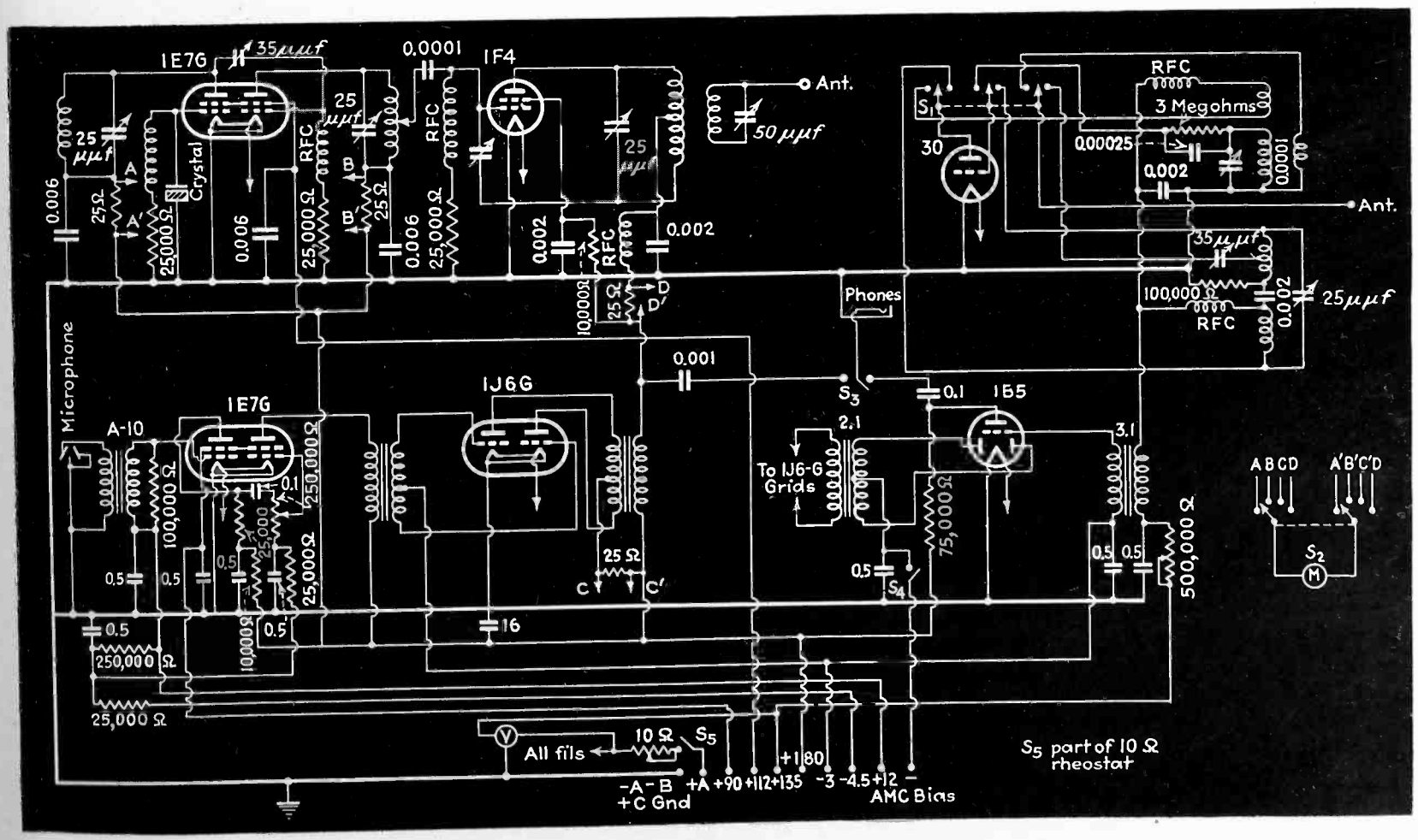
The case is constructed of one-eighth inch aluminum and 18-gauge dural. The corners are formed by using quarter inch square brass rod, drilled and tapped for the assembly screws. The eleven by fifteen inch panel on one side is made in two pieces to simplify inspection of the batteries.

The entire case was given a coat of French Grey enamel and baked to obtain a wrinkle finish. Small screw eyes are located along the top and sides to provide a means of attachment for the shoulder straps. The case size shown is the result of some experimentation on case sizes and has been the most comfortable to wear when strapped to the back. However, the small changes in size recommended should make little or no difference in this respect. The crystal used in the oscillator is of the Tourmaline type.

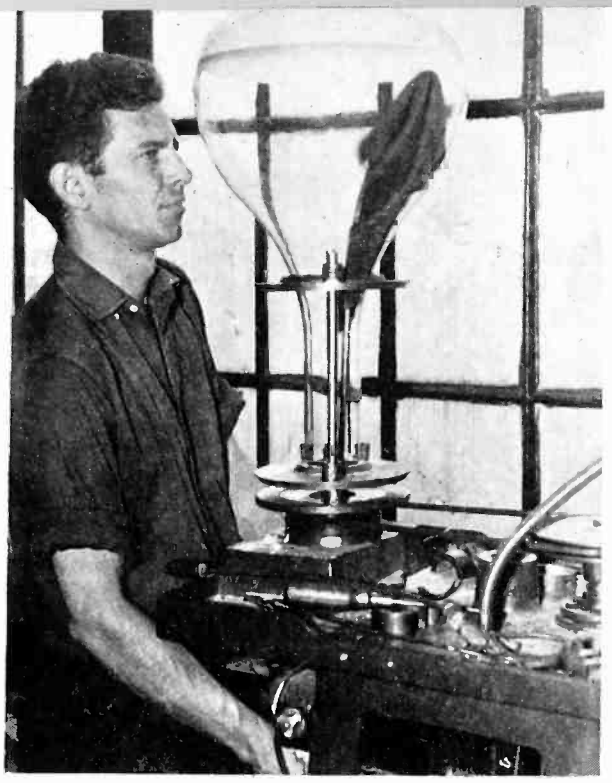
In the photograph of the control panel, the controls shown are as follows: the top right screw driver slot is the antenna condenser, the lower right hand slot is the final amplifier tank condenser, the center control is for the oscillator tank condenser and the left hand control is for the doubler tank, the top left hand bar knob controls the receiver band change switch, top left hand bar knob is for the audio gain control. The second row of bar knobs are: right, receiver tuning and left, receiver regeneration control. The two bar knobs near the bottom of the panel are: top, filament rheostat, and bottom, milliammeter switch. The toggle switches are the controls for the headphone transfer and the automatic modulation control off-on switch.

In the event crystal types of microphones are tried, the A-10 input transformer should be eliminated, the 100,000-ohm resistor in the grid of the first stage grid should be replaced by a five megohm resistor and a 0.1 μf condenser should be used in series with the "hot" side of the microphone. The gain remains fairly constant with either type.

Circuit diagram showing transmitter circuit on the left and cue receiver circuit on the right. Note the frequency range switch of the cue receiver. The tubes used are of the 2.0 volt series

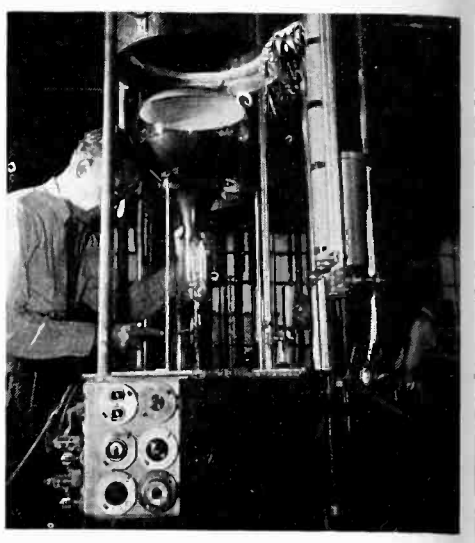


Cathode-ray Tubes IN THE MAKING

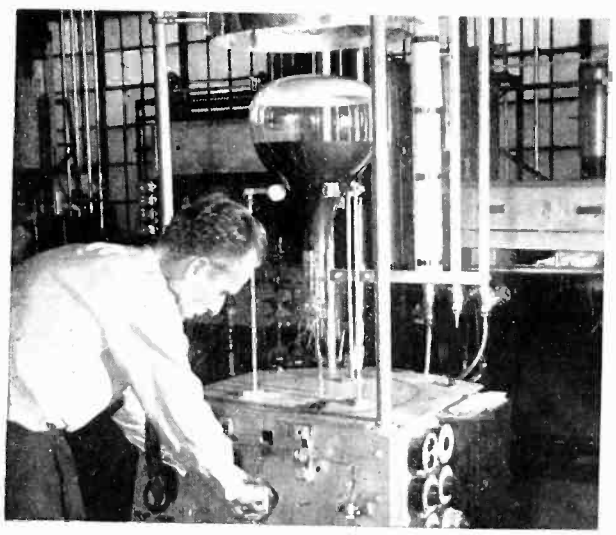


These pictures, taken at the Allen B. DuMont Laboratories, Passaic, N. J., show steps in cathode-ray tube manufacture. First, the fluorescent screen is applied and then trimmed on a vertical lathe as shown above. The collodial graphite shield is then applied and the mount assembly is inserted and sealed in place

Removing the soot which was left after annealing to prevent too rapid cooling and guard against cracking

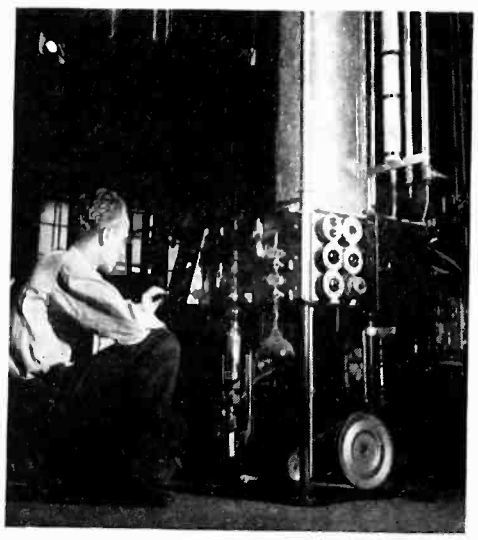


The metal oven above is lowered and heats the tube to approximately 400° C to drive off the occluded gases



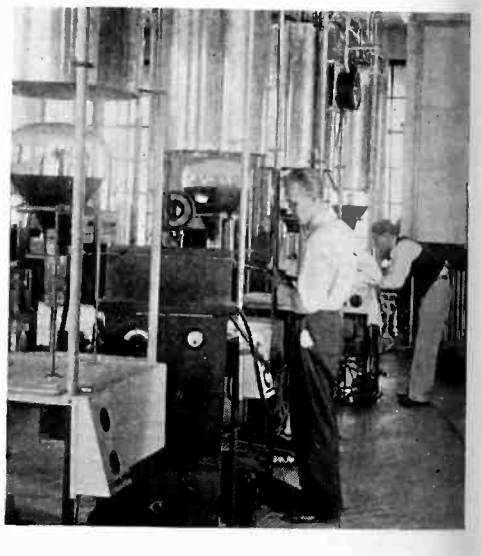
Adjusting the stopcocks above the moisture trap. The vacuum necessary is approximately 10^{-3} microns and is obtained by a mercury condensation pump

Close-up of bombarding. The temperature required is 800°-1000° C. The electrodes are connected to break down the cathode coating and to check quality



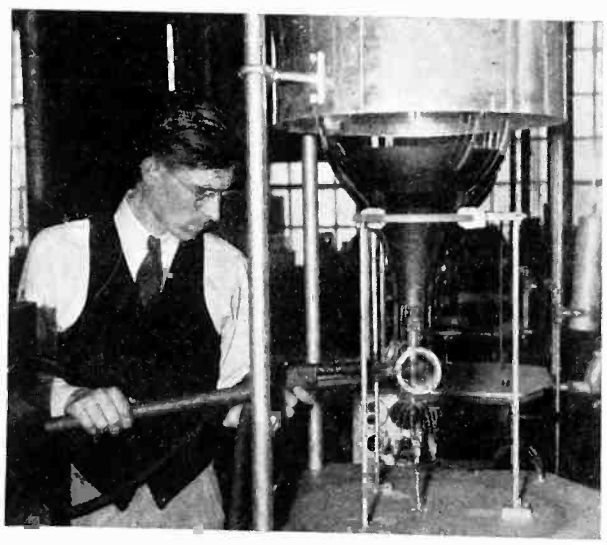
The Pirani gauge indicates when the gases are driven from the glass to the proper degree

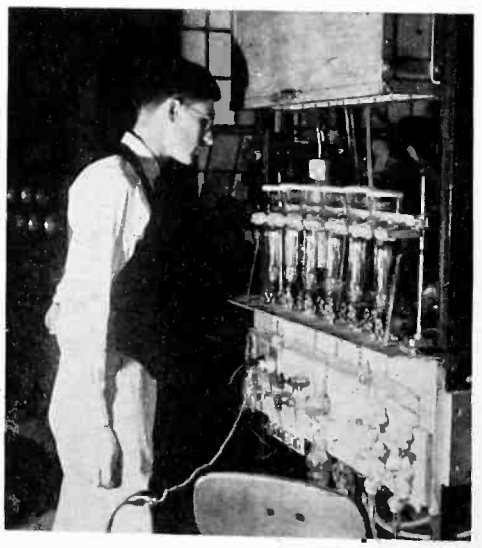
The screen material is being inspected. Overheating may alter color characteristics and reduce luminous output

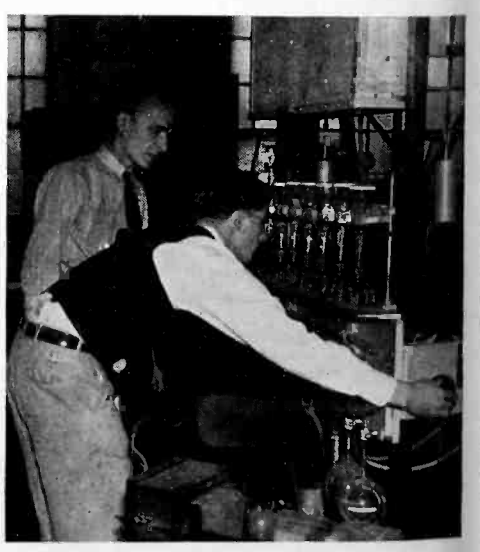


The metal parts of the mount assembly are freed of occluded gases by being heated to incandescence by induction

Three-inch tubes are produced on "trolley" exhaust machines to gain the advantages of multiple production







Properties of Ceramic Materials

A comprehensive listing of the mechanical and electrical properties of porcelain, commercial and low-loss steatite, cordierite, titania, and lava materials, compiled from average values listed by manufacturers and standard references

By HANS THURNAUER

		UNITS	PORCELAIN		STEATITE		TITANIA BODIES		CORDIERITE BODIES Low Thermal Expansion Bodies	LAVA Natural Machined Stone
			Dry Process	Wet Process	Commercial	Low Loss	High Dielectric Constant Bodies			
Typical Applications			Low Tension Insulators	Low and High Tension Insulators	Low and High Tension and High Frequency Insulators		High Frequency Condensers 1	2	Low Tension and High Frequency Insulators	
Specific Gravity			2.3–2.5		2.5–2.6		3.9	3.0–3.9	2.0–2.2	2.3–2.8
Water Absorption		%	0.5–1.0	Nil	Nil to 0.1		Nil		0.1–1.0	1.0–1.5
Water Absorpt. of Impreg. Mat.		%	Nil	Nil	Nil		Nil		Nil	Nil
Tensile Strength	Unglazed	Lbs. per in.²	1000–2000	5000–6000	6000–7000	7000–8000	5000–6000	4000–5000	1000–3000	850–1250
	Glazed		1500–2000	6000–8000	7000–7500	8000–8500				
Compressive Strength	Unglazed		30,000–50,000	45,000–60,000	70,000–100,000		80,000–100,000	70,000–90,000	20,000–60,000	20,000–30,000
	Glazed		40,000–50,000	60,000–100,000	80,000–100,000					
Modulus of Rupture	Unglazed		6000–8000	10,000–11,000	18,000–20,000	20,000–22,000	18,000–20,000	16,000–19,000	4000–10,000	10,000–14,000
	Glazed		7000–8000	12,000–18,000	21,000–23,000	22,000–24,000				
Resistance to Impact (Charpy)		Ft. lbs. per in.³	.....	.....	1.5–1.7	1.7–2.0	1.7–2.0	1.5–1.7	0.8–1.2	1.3–1.4
Linear Coefficient of Thermal Expansion 20°–100°C		....	3.0–6.0 × 10^{-6}		6.0–7.0 × 10^{-6}	6.0–6.5 × 10^{-6}	7.0–8.0 × 10^{-6}	5.0–7.0 × 10^{-6}	1.1–1.8 × 10^{-6}	9.0 × 10^{-6}
Dielectric Strength		Volts per mil	40–100	250	200	200–250	200		100	80–100
Dielectric Constant 1,000–1,000,000 cycles		.....	6.0–7.0		5.5–6.5		80–85	14–80	5.0–5.5	5.0–5.5
Volume Resistivity at 75° F.		Meg ohm /cc	Above 10^8		Above 10^8		Above 10^8		Above 10^7	Approx. 10^6
Power Factor	60 cycles	%	1.7–2.5		0.25–0.35	0.10–0.15	.....	.....	1.5–2.0	0.8–1.0
	1000 kc		0.8–1.0		0.18–0.25	0.03–0.06	0.06–0.10		0.4–0.8	0.3–0.8
	10,000 kc		0.6–1.0		0.18–0.20	0.01–0.04	0.06–0.10		0.3–0.5	0.25–0.5
Loss Factor	60 cycles	%	10.2–17.5		1.37–2.27	0.55–0.97	.....	.....	7.5–11.0	4.0–5.5
	1000 kc		4.8–7.0		0.99–1.37	0.16–0.39	.....	.....	2.0–4.4	1.5–4.4
	10,000 kc		3.6–7.0		0.99–1.10	0.05–0.26	.....	.....	1.5–2.7	1.25–2.75
Impregnated and After 1,000 Hrs. in Water: Dielectric Constant	1,000 kc	....	6.0–7.0		5.5–6.5		80–85	14–80	5.0–5.5	5.0–5.5
	10,000 kc									
Impregnated and After 1,000 Hrs. in Water: Power Factor	1,000 kc	%	0.8–2.0		0.27–0.37	0.06–0.12	0.06–0.10		0.6–1.2	0.45–1.2
	10,000 kc		0.6–1.5		0.27–0.30	0.03–0.08			0.45–0.75	0.45–0.75
Impregnated and After 1,000 Hrs. in Water: Loss Factor	1,000 kc	%	4.8–14.0		1.48–2.35	0.33–0.78	.....	.....	3.0–6.6	2.2–6.6
	10,000 kc		3.6–10.5		1.48–1.95	0.16–0.52	.....	.....	2.2–4.1	2.2–4.1
Temperature Coefficient of Capacity °C Between 20–80° C.		....	+ 6.5 × 10^{-4}		+ 1.2 × 10^{-4}	+ 1.2 × 10^{-4}	— 6.5 × 10^{-4}	—6.5 × 10^{-4} to + 1.2 × 10^{-4}	+ 2.5 × 10^{-4}	+ 1.0 × 10^{-4} to + 2.5 × 10^{-4}

These data represent average values and vary according to composition, size, method of manufacturing, etc, and are generally obtained by A. S. T. M. test methods.

ELECTRONICS REFERENCE SHEET

Revised U-H-F Allocations

The service allocations of channels between 30 and 300 megacycles have recently been revised by the FCC. This listing supersedes the chart published in *Electronics*, December, 1937

30.02–30.50	G(13)	33.38	RB	37.10	P	39.90	P	130.86	ATC	138.00	PR
30.54	CSH	33.42	AV	37.14	SV&EX	39.94	FO	131.00–131.28	GB	138.14	EX
30.58	P	33.46	SV&EX	37.18	EM	39.98	PR	131.42	ATC	138.28	F
30.62	GMP	33.50	P	37.22	P	40.02–40.98	G(25)	131.56–131.70	GB	138.42	P
30.66	EX	33.54	GMP	37.26	CSH	41.00	F*	131.84	ATC	138.56–138.70	B(2)
30.70	P	33.58	PR	37.30	G	41.02–43.98	B(75)	131.98	GB	138.84	SV&EX
30.74	F	33.60	F*	37.34	RB	41.80	F*	132.12	F	138.98	F
30.78	F	33.62	SV&EX	37.38	P	44.00–56.00	T(2)	132.26	B	139.12	P
30.82	RB	33.66	AV	37.40	F*	46.20	F†	132.40	SV&EX	139.26	EM
30.86	PR	33.70	G	37.42	PR	47.30	F†	132.54	CSH	139.40	F
30.90	G	33.74	RB	37.46	FO	48.40	F†	132.68	EX	139.54	SV&EX
30.94	FO	33.78	P	37.50	P	49.50	F†	132.82	P	139.68	PR
30.98	P	33.82	EM	37.54	EX	56.00–60.00	AM	132.96–133.10	B(2)	139.82	F
31.02	SV&EX	33.86	F	37.58	CSH	60.02–65.94	G(116)	133.24	F	139.96	EX
31.06	GMP	33.90	F	37.62	RB	66.00–72.00	T(1)	133.38	SV&EX	140.10–143.88	AV(28)
31.10	P	33.94	P	37.66	IS	72.04–77.90	G(82)	133.52	P	144.00–155.88	G(80)
31.14	EX	33.98	PR	37.70	G	78.00–90.00	T(2)	133.66	EM	156.00–168.00	T(2)
31.18	SV&EX	34.02–34.98	G(25)	37.74	MF	90.10–95.90	G(57)	133.80	F	168.04–179.86	G(68)
31.22	RB	35.02	RB	37.78	P	96.00–108.00	T(2)	133.94	F	180.00–192.00	T(2)
31.26	CSH	35.06	EX	37.82	EM	108.10–111.90	G(39)	134.08	B	192.10–203.90	G(60)
31.30	G	35.10	P	37.86	AV	112.00–116.00	AM	134.22	PR	204.00–216.00	T(2)
31.34	FO	35.14	EM	37.90	P	116.11–117.91	B(16)	134.36	E	216.11–223.81	G(36)
31.38	F	35.18	PR	37.94	CSH	118.10–126.00	G(3)	134.50	P	224.00–230.00	AM
31.42	F	35.20	F*	37.98	RB	126.10–128.90	ATC(20)	134.64	F	230.12–233.72	G(16)
31.46	EM	35.22	P	38.00	F*	129.06–129.18	GB	134.78–134.92	B(2)	234.00–246.00	T(2)
31.50	P	35.26	RB	38.02–38.98	G(25)	129.30	ATC	135.06	P	246.12–257.76	G(47)
31.54	SV&EX	35.30	G	39.02	PR	129.42–129.66	GB(3)	135.20	F	258.00–270.00	T(2)
31.58	FO	35.34	CSH	39.06	AV	129.78	ATC	135.34	SV&EX	270.14–281.88	G(44)
31.62	RB	35.38	F	39.10	P	129.90–130.16	GB(3)	135.48	B	282.00–294.00	T(2)
31.66	CSH	35.42	F	39.14	SV&EX	130.30	ATC	135.62	SV&EX	294.15–299.85	G(20)
31.70	G	35.46	SV&EX	39.18	P	130.44–130.72	GB(3)	135.76	B		
31.74	EM	35.50	P	39.22	CSH			135.90	PR		
31.78	P	35.54	GMP	39.26	RB			136.04	F		
31.82	F	35.58	MF	39.30	G			136.18	P		
31.86	F	35.62	RB	39.34	EM			136.32	F		
31.90	P	35.66	CSH	39.38	P			136.46	EM		
31.94	FO	35.70	G	39.42	FO			136.60	F		
31.98	PR	35.74	FO	39.46	EX			136.74–136.88	B(2)		
32.02–32.98	G(25)	35.78	P	39.50	P			137.02	F		
33.02	PR	35.82	RB	39.54	SV&EX			137.16	CSH		
33.06	EM	35.86	IS	39.58	CSH			137.30	P		
33.10	P	35.90	P	39.60	F*			137.44	SV&EX		
33.14	F	35.94	FO	39.62	RB			137.58	MF		
33.18	F	35.98	PR	39.66	EM			137.72	F		
33.22	P	36.00	F*	39.70	G			137.86	SV&EX		
33.26	PR	36.02–36.98	G(25)	39.74	FO						
33.30	G	37.02	RB	39.78	P						
33.34	EX	37.06	SV&EX	39.82	RB						
				39.86	EM						

* Available for low power fixed service in Hawaii only.

† Existing authorization for low power fixed service in the Territory of Hawaii to remain unchanged for the present

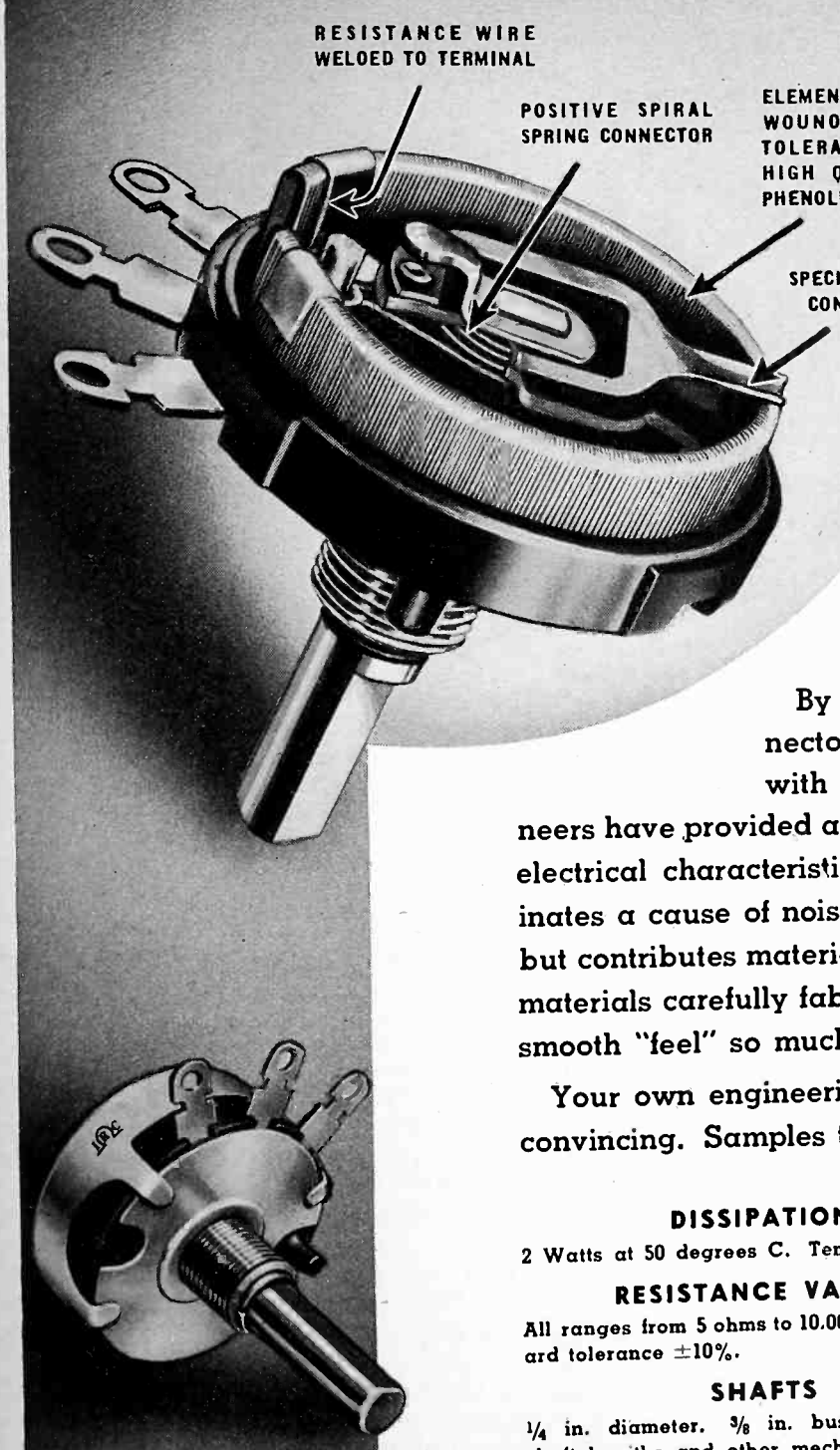
SYMBOLS

AM — Amateur
ATC — Airport Traffic Control
AV — Aviation
B — Broadcast
CSH — Coastal and Ship Harbor
EM — Special Emergency
EX — Experimental
F — Fixed
FO — Forestry
G — Government
GB — Guard Band
GMP — Geophysical and Motion Pictures
IS — Intership
MF — Marine Fire
P — Police
PR — Mobile Press
RB — Relay Broadcast
SV — Special Services
T — Television

Numbers in parenthesis indicate number of channels

ELECTRONICS REFERENCE SHEET

New! ADVANCED DESIGN



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NEW BOOKS

Fundamental Electronics and Vacuum Tubes

By A. L. Albert, Prof. of Communication Engineering, Oregon State College. Macmillan Co., New York. (422 pages. Illustrated. Price, $4.50).

THIS BOOK HAS been written as a textbook on the use and applications of electron tubes for electrical engineering students. Throughout, the main emphasis has been placed on engineering methods and principles, and only enough fundamental theory has been included to enable the student to understand the mode of operation of electron tube devices.

Viewed in this manner, the title of the book may be somewhat misleading, for less than three of its 14 chapters are devoted to fundamental electronics. Much of the material in these three chapters has been summarized without proof, or references have been given to elementary textbooks rather than to original sources of information. The student is, consequently, glided over a difficult and involved subject, perhaps without a full realization of the complexity of modern fundamental electronics, or the rapid changes and developments which are taking place in that field. The person who looks for the equations of trajectories of charged particles, for the effect of transit times, or a thorough treatment of space charge, for example as representing "fundamental electronics", is likely to feel a bit short changed. Viewed as a college text for students majoring in power or communication engineering, however, the book is highly satisfactory.

The chapter headings include: basic electronic theory; emission of electrons; thermionic cathodes; two-electrode thermionic vacuum tubes; three-electrode thermionic vacuum tubes; multi-electrode thermionic vacuum tubes; rectifiers; vacuum tube voltage amplifiers; vacuum tube power amplifiers; oscillators; modulators; demodulators; photoelectric devices and circuits; and cathode ray tubes and measuring devices.

The author is well aware of the impossibility of covering this vast amount of material in the confines of a single volume with any degree of exhaustiveness, and frankly admits that no attempt has been made to cover completely both communication and power applications. The wide range of subjects which are covered makes it impossible to develop in detail all of the important equations and concepts. The instructor will be able to develop, as class room work, details of such subjects as space charge and emission equations which are given without proof. For those who may be required to study alone, the large number of references at the end of each chapter provide a source of material for further study. Each chapter contains a number of problems or suggested assignments.

Important features of the book are the large number of illustrations, the completeness with which the field is covered, the inclusion of quite recent developments, the direct approach and practical aspect in treating each topic, extensive use of references, and freedom from unnecessary mathematics. The book is well edited, printed and bound, is well organized, has a good index, is justly priced, and is admirably suited to the needs of engineering students for whom it was primarily written.—B.D.

The Radio Handbook

By the Editors of RADIO. *Fifth edition, 592 pages, 1938. Price, $1.50. Radio, Ltd., Los Angeles.*

IN THIS new edition of their radio handbook the editors of *Radio* have not been content merely to revamp a certain portion of the previous texts. They have constructed new equipment, and have described it; they have revised rather completely certain of the sections. Although some of the material is reprinted from *Radio*, most of the material has been written expressly for this annual handbook.

Among the 20 sections that on antennas seems to be particularly good with many diagrams showing construction, directivity, methods of coupling to exciters, etc. Thirty pages are devoted to the characteristics of modern receiving and transmitting tubes, showing the complexity of the present tube lists.

Although the book is written largely with the amateur in mind it is a practical book for anyone working in the art.

The Engineers' Manual

BY RALPH G. HUDSON, *Professor of Electrical Engineering, Massachusetts Institute of Technology. (2nd, ed., 340 pages, Illustrated.) John Wiley & Sons, New York.*

IT IS SAFE TO SAY that very few who have graduated from engineering colleges since the World War are unacquainted with "The Engineers' Manual"; most engineers who have used it, regard it second only to a good slide rule in essential professional equipment.

The second edition of this popular manual has just appeared, and when a technical book can sell for twenty-two years without fairly extensive revisions, all indications point to thorough, accurate work in preparing and organizing the text.

The second edition differs from the first only in being somewhat more complete and comprehensive. All of the desirable features which have made this book popular have been retained, including the important method of presentation which explains the use of the formulas, and indicates the units in which the measurements are to be made. The main sections of the book deal with mathematics, mechanics, hydraulics, heat, electricity, and mathematical tables and conversion factors. The book is of convenient, pocket size, with flexible cover. All indications are that it will continue to provide handy, compact, useful information for the student or practicing engineer.—B. D.

Proceedings of the International Telephone Consultative Committee

Plenary Meeting, Copenhagen, June 11–20, 1936. International Standard Electric Corp., New York. Price $2.50, 388 quarto pages.

THE RECOMMENDATIONS of the "Comite Consultatif International Telephonique" in promoting and coordinating long-distance telephone communication on an international scale are described in this volume. An important feature is the index which covers all material in the 1934 as well as the 1936 edition and indicates whether the material is new, modified or maintained unchanged. The bibliography of English, French and German publications contains over 1200 references covering all phases of the telephone art.—C.W.

Radio Facsimile

Published by RCA Institute's Technical Press, New York. (353 pages. Illustrated. No price stated.)

THIS VOLUME IS "an assemblage of papers from engineers of the RCA laboratories relating to the radio transmission and recorded reception of permanent images." Of the twenty papers included in this collection, no less than thirteen have been reprinted from publications receiving wide dissemination in the radio engineering field. Thus the main contribution of this volume is that it collects in handy form papers by RCA engineers. The fact that "in assembling what may be regarded as the first book, or treatise, devoted exclusively to radio facsimile" the editors have found it desirable to include only one point of view would seem to definitely limit its value to a disinterested reader who may, after all, be aware that more than one firm has been engaged in the development of facsimile equipment.

The book is divided into four parts dealing with the historical development of facsimile, status of radio facsimile in 1938, radio facsimile communication methods and equipment, and facsimile in broadcasting.—B.D.

Direct-Reading Schering Bridge for Capacitance and Power Factor Measurements On

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- **INSULATORS**
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With its direct-reading feature this bridge is very convenient for laboratory measurements and production testing of condensers; determining dielectric properties such as power factor or phase angle, dielectric constant, dielectric loss and the change of these properties with moisture absorption; measurements of resistance of electrolytes and capacitance and power factor tests on insulators and insulator bushings.

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TUBES AT WORK

The choice of tubes for the increasingly important wide-band amplifier applications, a phototube galvanometer control of logarithmic type, and a mercury rectifier arc-back indicator

Choice of Tubes for Wide-Band Amplifiers

By DALE POLLACK

RCA Manufacturing Company, Inc., Camden, N. J.

THE DESIGN OF AN AMPLIFIER to pass a wide band of frequencies presents many awkward problems, one of them being the choice of the most suitable tubes from the multitude of available types. The circuit to be considered here is the fundamental resistance-capacitance coupled amplifier of Fig. 1. It will be shown that the utility of a tube in such a wide-band amplifier, so far as its frequency response is concerned, can be expressed in terms of a simple figure of merit. While the figure of merit will be derived with reference to the simple resistance coupled amplifier of Fig. 1, the same criterion may be applied to any similar amplifier circuit in which the gain at high frequencies is limited by the shunt capacitance.

Figure 2 shows the equivalent circuit of the resistance coupled amplifier. The gain at high frequencies is given very closely by

$$\alpha = \frac{g_m R}{1 + j\omega CR} \qquad (1)$$

where α = complex gain of the amplifier stage $= |\alpha| \angle\theta$

g_m = mutual conductance of tube

R = effective load resistance $= \dfrac{1}{\dfrac{1}{R_L} + \dfrac{1}{R_g} + \dfrac{1}{r_p}}$

R_L = load resistor

R_g = grid leak of succeeding tube

$\omega = 2\pi f$

r_p = plate resistance of tube

C = total plate circuit shunt capacitance, including input capacitance of succeeding tube.

The maximum gain, from eq (1), is

$$\alpha_{max} = g_m R \qquad (2)$$

The gain is reduced to 0.707 its maximum value (3 db) when the frequency is such that the imaginary part of the denominator of (1) equals unity, that is, when

$$\omega_h CR = 1 \qquad (3)$$

where $\omega_h = 2\pi f_h$ is the angular velocity for which the gain is reduced by 3 db. Eliminating R between (2) and (3) gives

$$\alpha_{max}\,\omega_h = \frac{g_m}{C} \qquad (4)$$

which relates the maximum gain, and the frequency at which the amplifier response is 0.707 the maximum, to the tube and circuit parameters. In a wide band amplifier it is always desired to obtain the greatest gain for a specified frequency range. Equation (4) shows that the maximum gain and the frequency response are each directly proportional to the ratio of the mutual conductance to the total shunt capacitance. Consequently, to obtain the greatest gain for a desired frequency range the g_m/C ratio should be as large as possible.

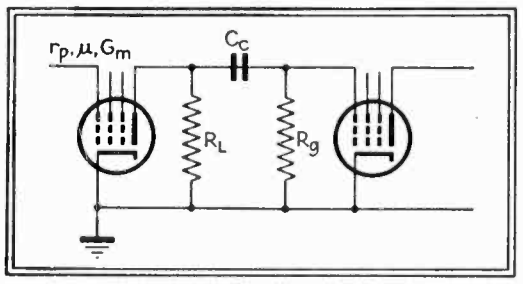


Fig. 1—Actual circuit of wide-band amplifier

The shunt capacitance, if it is assumed for convenience that the amplifier is made up of similar stages, is

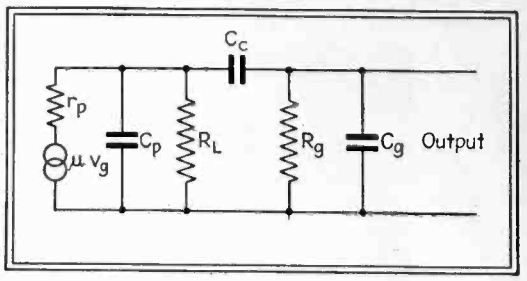


Fig. 2—Equivalent circuit for calculating wide-band response

$$C = C_p + C_g + C_{pg}\left(2 + |\alpha|\cos\theta + \frac{\cos\theta}{|\alpha|}\right) + C_{stray} \qquad (5)$$

This expression is readily shown to be true, if the output capacitance of the preceding stage is included as well as the input capacitance of the succeeding stage. At the frequency for which the gain is 3 db down,

$$|\alpha| = 0.707\,\alpha_{max} \text{ and } \theta = 45^\circ$$

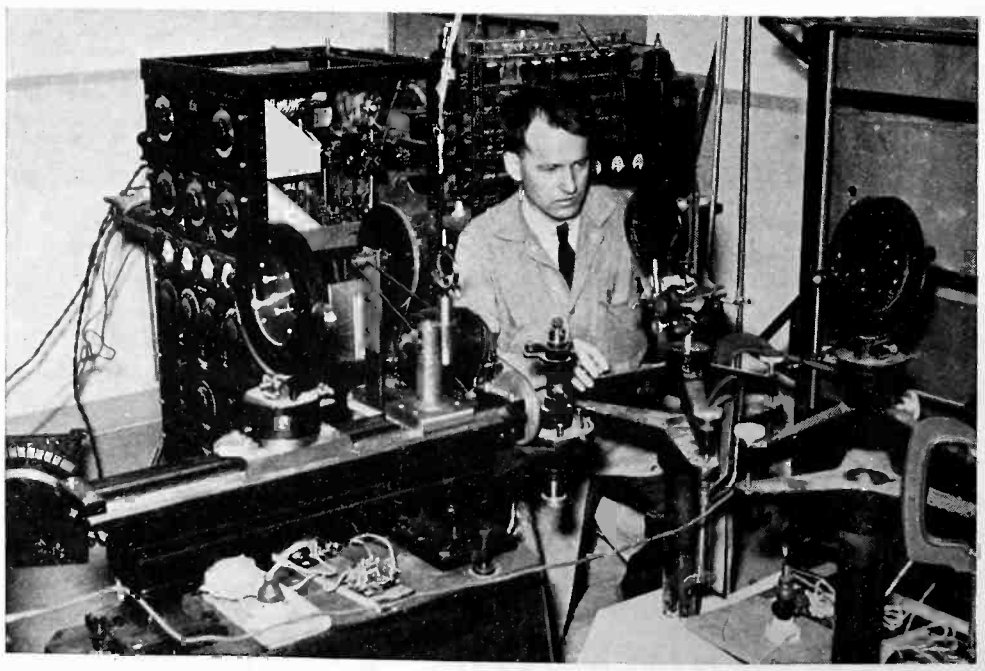
Consequently (5) may be written

$$C = C_p + C_g + C_{pg}\left(2 + \frac{\alpha_{max}}{2} + \frac{1}{\alpha_{max}}\right) + C_{stray} \qquad (6)$$

The stray capacitance includes all capacitance except that of the tubes. A distinction must be made between two principal cases, first, that for which the tube capacitances predominate, and, second, that for which the stray capacitances are large compared with the tube capacitances. In a wide-band voltage amplifier the tube capacitances are normally much larger than the stray capacitance. In a modulator stage the capacitance presented to the modulator by the radio frequency circuits may be much larger than the modulator tube capacitance.

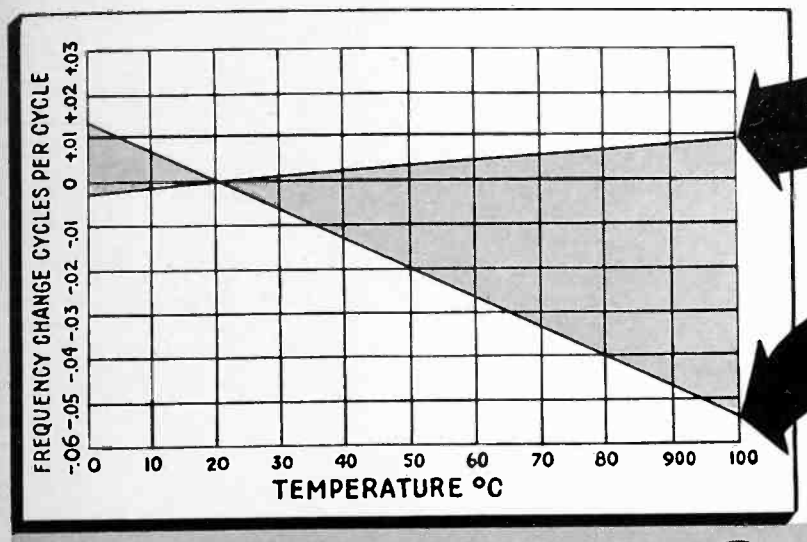
The transconductance g_m is, of course, a property of the tube alone. Consequently, when the tube capaci-

MEASURING THE SPEED OF LIGHT



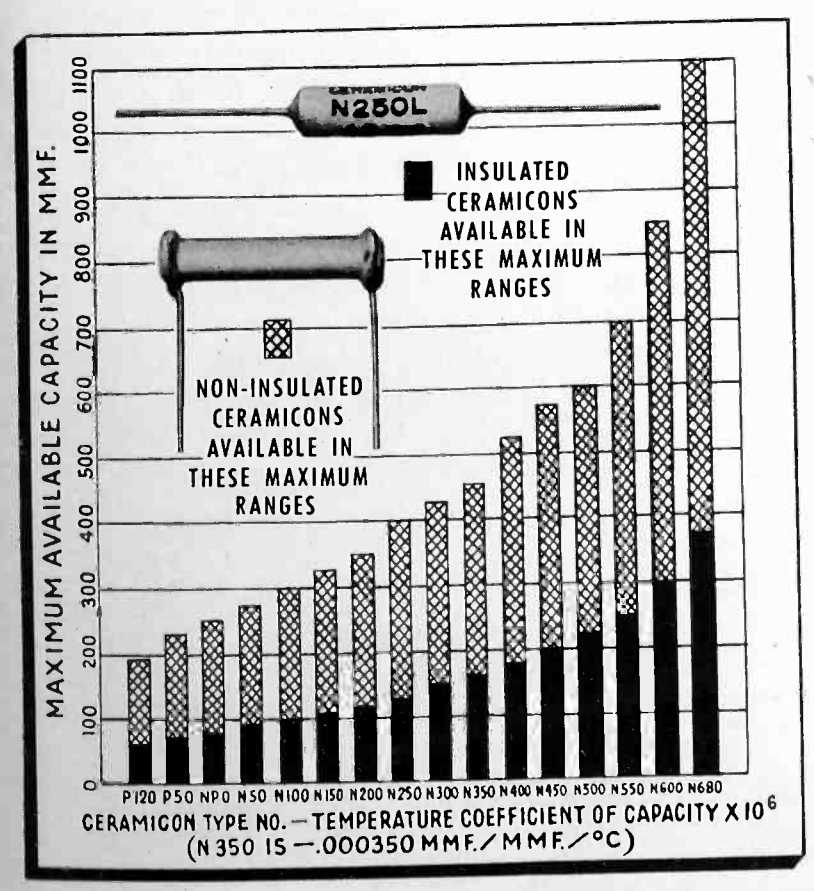
A new method of measuring the speed of light, which is completely automatic, has been devised by W. C. Anderson of Harvard, shown here with his apparatus. The limit of accuracy at present is two and one-half miles per second

Now! YOU CAN COMPENSATE FOR ANY FREQUENCY DRIFT FROM +.00012 per °C TO −.00068 per °C *with a*



SINGLE UNIT *Erie* CERAMICON

REG. U. S. PAT. OFF.



New wide range in single units provides larger capacities in both insulated and plain types.

The recent development of improved ceramic materials now makes it possible for Erie to offer *single unit* Ceramicons with any desired temperature coefficient of capacity between +.00012 and —.00068 per °C. Since the temperature coefficient of these silver-plated ceramic-dielectric condensers is definite, linear and entirely reproducable, they will accurately compensate for reactance changes caused by temperature variations in other components.

As shown in the chart at the left, completely sealed and insulated Erie Ceramicons are available with the proper capacity and temperature coefficient for most applications. Where higher capacities are required, non-insulated Ceramicons are supplied.

Their excellent operating characteristic plus the wide range of capacities and temperature coefficients make Erie Ceramicons ideal for your radio frequency uses.

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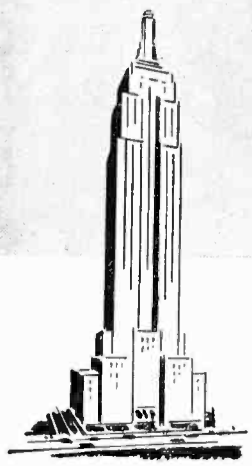
RCA and NBC Announce

TELEVISION

Television Broadcasting Begins on April 30th in the New York Ar



...and RCA Victor Television Receivers Are Ready Now!

Years of patient effort in RCA Laboratories —millions spent on research—now convert a fantastic dream into a splendid reality . . .

April 30th marks the birth of a new industry—television. On that day sight will join with sound to bring you a wealth of new experiences.

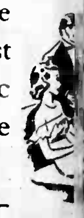
Television offers something everyone wants. If you live in the New York metropolitan area you can have it right now. No prediction can be made as to how soon television will be available nationally, but RCA is bending every effort to meet popular demand.

When television becomes a nationwide service it should provide new opportunities for workers. Think how recently radio was an experiment and a toy. Swiftly it became a great industry. Today, radio is a source of livelihood to thousands. RCA hopes to help in a similar growth of television in the future.

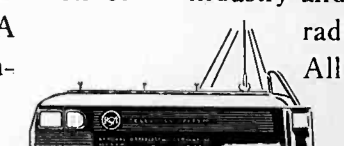
The development of television has required much research. To insure success RCA gathered in Camden, a distinguished group of scientists and engineers. A long step forward was their development of the Iconoscope, the "eye" of television, and the Kinescope, the "screen." These are the bases of RCA electronic television, and have been made available to the entire industry.

Television also had to be proved in the field. RCA has spent more than two million dollars in practical field tests of television in New York. RCA and its various subsidiary companies have been, and are, en in every phase of television—re engineering, manufacturing, insta broadcasting and service. This ence is unmatched anywhere.

Now the great day has arrived. n era begins. Through RCA Victo vision Receivers you can take part in one of the greatest adventures in all scientific history. It is an adventure you will never forget.

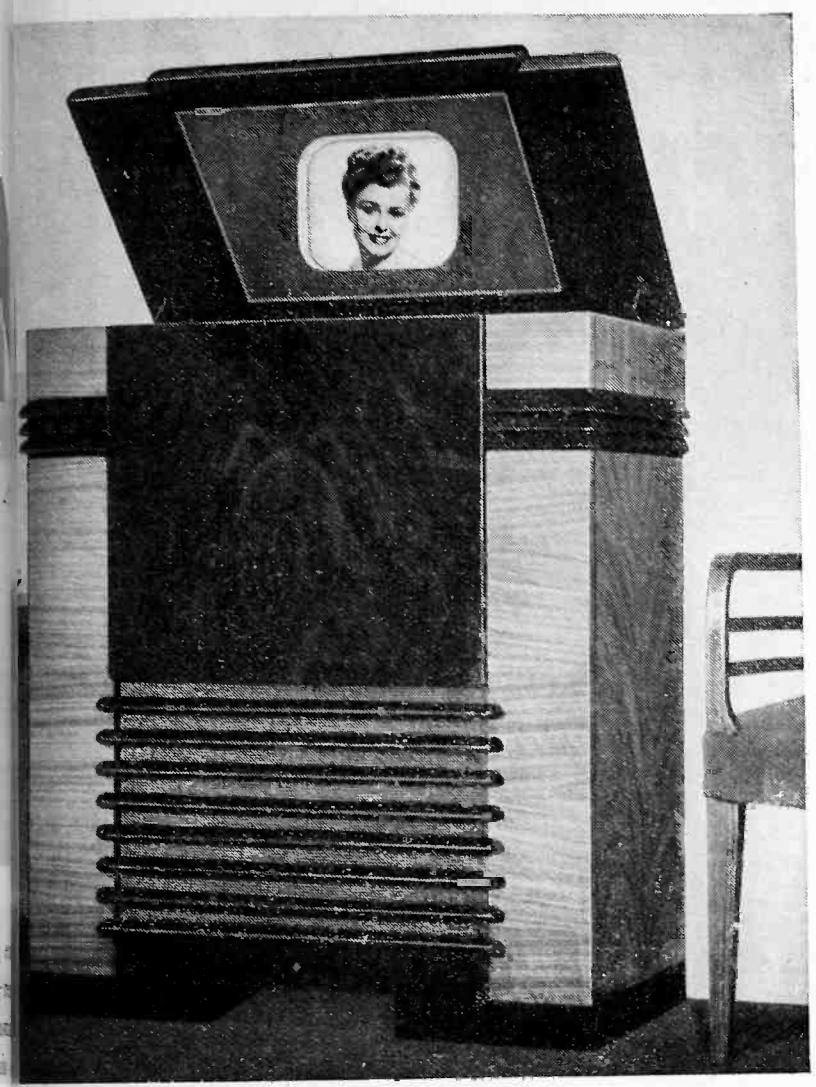


The development of television is one more example ceaseless research of RCA and ious subsidiary companies. By looking ahead, RCA seeks not improve the general services of but to produce equipment of standards at moderate prices for industry and laboratory. That's v radio and television, it's C All the Way.



FACTS YOU'LL WANT TO KNOW ABOUT TELEVISION

Indications point to the operation, in the near future, of three stations in the New York area; also one at Schenectady, N.Y., and one at Los Angeles, Calif. At the average electric rate it will cost about one cent an hour to operate a television receiver. Size of pictures are shown set descriptions on these pages. Beginning about April 3 NBC will provide two one-hour programs per week, pl special event pick-ups of sports, visiting celebrities, et



(*AT LEFT*) MODEL TRK-12 is the finest television instrument offered by RCA Victor. It contains an RCA 12″ white screen Kinescope which provides a picture size of $7\frac{3}{8}$″ by $9\frac{3}{4}$″, viewing is indirect through mirror attached to cabinet top. Other fine features of this instrument are as follows: 36 tubes exclusive of Kinescope, 4 chassis (1 video, 1 power supply for video, 1 all-wave, 1 power supply for all-wave), 5 television channels, selector switch for television tuning, 12-tube all-wave sound chassis, 12 watts (pentode push-pull) sound power output, high fidelity reproduction, inverse feed-back included with control, 12″ high fidelity speaker, phonograph jack. This instrument also uses sprayed silver compensated condensers and Styrol R-F and I-F transformers as mentioned below in description of Model TRK-5.

ELOW) MODEL TT-5 RCA Victor Television Attachment is for use nnected to modern radios through which sound is heard. It contains RCA 5″ white screen Kinescope . . . presents a picture about $3\frac{3}{8}$″ by ″ in size . . . uses direct method of viewing . . . has 16 tubes exclusive Kinescope . . . is a table model . . . has 5 television channels and selec- switch for television tuning. Like the TRK-5 this instrument uses rayed silver compensated condensers and Styrol R-F and I-F trans- rmers.

CA Victor Model TRK-9 (not illustrated) is similar to Model RK-12, except that it is direct viewing and uses a 9″ Kinescope.

(*ABOVE*) MODEL TRK-5 RCA Victor Television Console. Features of this instrument in which you will be interested include an RCA 5″ Kinescope with white screen . . . 24 tubes exclusive of Kinescope . . . 3 chassis, one an all-wave radio receiver, one an all-wave power supply and one for television . . . 5 television channels . . . a selector switch for television tuning . . . a 8-tube, 3-band push-button radio . . . 5 watts (pentode push-pull) of sound power output and a 12″ loudspeaker. This instrument reproduces a picture in size of about $3\frac{3}{8}$″ by $4\frac{3}{8}$″. Picture may be seen by direct method of viewing. Sprayed silver temperature compensated condensers are used in this instrument. These have proper temperature coefficient to maintain circuit stability regardless of temperature changes. This instrument uses Styrol R-F and I-F transformers to greatly simplify mechanical and electrical construction and to give highest type insulation.

• • •

You can buy RCA Victor Television Receivers on C.I.T. easy payment plan . . . For finer radio and television performance—RCA Victor Tubes. In Television—from Camera to Kinescope—It's RCA All the Way.

RCA Victor TELEVISION RECEIVERS

RCA Manufacturing Company, Inc., Camden, New Jersey • *A Service of the Radio Corporation of America*

tances predominate, Eq. (4) is a convenient figure of merit for the high frequency performance of a tube. If, on the other hand, the stray capacitance is large, the shunt capacitance, C, is largely independent of the tube employed and the criterion of a tube, from Eq. (4), is simply its mutual conductance.

In the first case, when the tube capacitance predominates, the g_m/C ratio is a constant for a given type of tube construction. Thus, the mutual conductance may be increased by increasing the length of each of the elements, but the capacitances will be increased in approximately the same proportion. The figure of merit may be increased, however, by making more fundamental changes in the construction, such as by altering the grid structure or by the use of the beam power principle.

Table I gives the figures of merit for a number of common tube types at rated operating conditions, since some of this information is not readily available. In computing the capacitance reflected through the grid-plate capacitance of the succeeding tube in the amplifier, the gain of pentodes has been assumed to be 10, for triodes $\mu/3$, except for the 6F5 for which the assumed gain is 5. In general, it will be seen that the preferable tubes to be employed in wide band amplifiers, when tube capacitance is the determining factor, are the acorn types, the beam power tubes, and the television tubes of the 1800 series.

When the stray capacitance predominates, as noted above, the choice of tube is governed largely by its mutual conductance, which is also given in

NEW FASHIONS IN SPEAKERS

A shallow or flat loud speaker, shown above the fireplace, has been built by an English designer to assist in solving the problem of multiple sound outlets for the average home. The surrounding wall behaves as a baffle to prevent loss of bass tones

Keep Your Cabinet-Styling

Tuned to Popular Demand

with Bakelite Materials

"Style that sets a new standard" is the description applied by RCA Victor to its 'New Yorker' set in lightweight, heat-resisting, moisture-resisting Bakelite Molded. Cabinet molded by Mack Molding Company.

The DeWald 'Bantam' demonstrates how a clever handling of the grill can give a two-tone effect to this Bakelite Molded cabinet. Molder: Richardson Company.

IN AROUSING popular demand for radios today, style is as big a factor as performance. Given a choice of several receivers, all of reputable make, the average buyer prefers the one most attractive to the eye, most decorative in the home.

That is why so many of radio's best sellers are housed in Bakelite molded cabinets. With versatile Bakelite plastics, radio manufacturers are given more latitude in the creation of distinctive, original designs that would be difficult and costly to obtain with other materials Of vital importance, also, are the production economies that can be gained through molding, in a single operation, a complete cabinet with self-contained color and lustre.

There are more than 600 Bakelite molding materials available in virtually any color desired, from delicate ivory to rich jet black—presenting you with an opportunity to lower production costs while keeping in tune with popular demand for improved radio styling. Write for Portfolio 13 of illustrated booklets describing varied types of Bakelite Plastics.

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Consult Bakelite Headquarters for Plastics

At this single central source, more than 2,000 plastic materials are available, including molding materials, laminated stock and insulating varnishes of unusual value to radio designers. They offer wide selection of color, transparent or opaque effects, toughness, power factor and other characteristics.

Fill your needs more accurately with Bakelite POLYSTYRENES, UREAS, CELLULOSE-ACETATES, PHENOLICS.

BAKELITE

The registered trade marks shown above distinguish materials manufactured by Bakelite Corporation. Under the capital "B" in the numerical sign for infinity, or unlimited quantity, it symbolizes the infinite number of present and future uses of Bakelite Corporation's products.

PLASTICS HEADQUARTERS

VISIT THE BAKELITE EXHIBIT, HALL OF INDUSTRIAL SCIENCE, NEW YORK WORLD'S FAIR 1939

Table I. In this case the most desirable tube types are the 1800 series the 2A3 and the beam power tubes. The g_m/C ratio may be increased by paralleling tubes, which is not the case when the tube capacitance is the major factor.

In intermediate cases, when the stray capacitance and the tube capacitance are of the same order of magnitude, the choice of tube must be made by computing the total capacitance for each type. For convenience in making such calculations the approximate total tube capacitance

$$C_{tube} = C_g + C_p + C_p\left(2 + \frac{\alpha_{max}}{2} + \frac{1}{\alpha_{max}}\right)$$

is also given in Table I.

The concern here has been solely with the frequency response of the amplifier. The ultimate choice of a tube must, of course, depend upon other considerations. Among these are the required voltage swing and power output, the availability of supply voltages, and permissible distortion and noise.

TABLE I

	Tube Type	C tube* (micro-micro-farads)	g_m (micro-mhos)	g_m/C tube* (micromhos per micro-microfarad)
Triodes	2A3	57	5250	92
	6C5	27	2000	74
	6F5	27	1500	55
	6J5	26	2600	100
	801	28	1800	64
	955	11	1700	155
Receiver Pentodes	1A4P	16	750	47
	6C6, 57	12	1200	100
	6K7	19	1650	87
	954	6	1100	180
	956	6	1800	290
	1851, 1852	17	9000	520
	1853	14	5000	360
Transmitter Pentodes	802	22	2250	100
	803	48	4000	83
	837	27	3400	125
Beam Power Tubes	6L6	26	6000	230
	6V6	23	4100	180
	6Y6G	28	7000	250
	25L6	26	8200	320
	807	19	6000	320
	813	31	5000	160
	814	28	3300	120
	832	12	3300	275

* Approximate figures, assuming, for triodes a gain of $\mu/3$ (except for the 6F5, for which 5 is assumed) and for pentodes a gain of 1(

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Phototube Controls Logarithmic Response in Galvanometer

By J. H. JUPE

FROM FRANCE, comes news of a photocell which has been adapted to cause a galvanometer to give logarithmic readings instead of linear. The scheme depends on the galvanometer coil being deflected by the current in the circuit under test, but at the same time being controlled by a current depending on the position of the mirror.

What's New?

WELDRAWN—a New Welded Cold Drawn Tubing Comparable to Seamless in All but Price . . .

Now that this unusual tube product has proved itself highly satisfactory to our regular customers we offer WELDRAWN with complete confidence in its value to many industries.

Produced from 18-8 Stainless Steel Strip by welding and then Cold Drawing, WELDRAWN offers the advantage of interior and exterior surfaces which are equal. Compared with seamless, this finer inside surface will, in all probability, mean better performance in most applications . . . At 75% the cost of seamless, WELDRAWN is now available in sizes up to ⅝ inches O.D., and wall thicknesses from .012 to .083 . . . Write for testing samples sized to your requirements.

SUPERIOR FOR FINE SMALL TUBING

SUPERIOR TUBE PRODUCTS

MECHANICAL SEAMLESS STEEL
STAINLESS SEAMLESS STEEL
PURE NICKEL SEAMLESS
INCONEL SEAMLESS
BRAWN MONEL
ALUMINUM
BUTTWELDED
STEEL COLD DRAWN
LOCKSEAM & SEAMLESS
CATHODES

SUPERIOR TUBE CO. NORRISTOWN, PENNA. WELDRAWN (WELDED DRAWN) STAINLESS TUBING

SUPERIOR TUBE COMPANY • NORRISTOWN, PA.

SUPERIOR TUBING

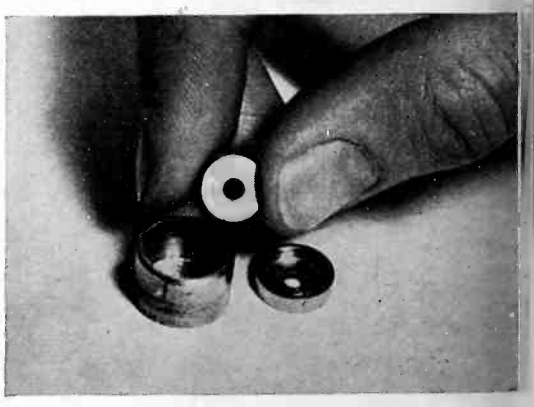
An ordinary reflecting galvanometer is set up with lamp, lens and scale, but with a mask, having an opening varying in width exponentially, over the lens. The mirror can be considered as being in a logarithmically shaped beam and receiving more or less light according to its position. Close by the scale is a photocell with a large surface area and so placed that no light falls on it when the light spot is in the zero position.

Immediately the mirror moves the spot up scale, the cell receives light at the same time and sets up a current which is arranged to oppose that of the circuit under test. Thus, the stronger the deflecting current, the greater is the opposing current from the cell, the two being connected in opposite polarity. As the light received varies exponentially with the deflecting force on the mirror the galvanometer has an exponential control and so the reading of the scale is logarithmic instead of linear.

• • •

Improved Form of Alnico Magnet Displays Great Pulling Power

BY THE USE of a new steel jacket surrounding a small magnet made of iron-aluminum-nickel-cobalt alloy, W. E. McKibben of the General Electric Research Laboratory has succeeded in producing a magnet capable of lifting



This tiny magnet can support 1500 times its own weight

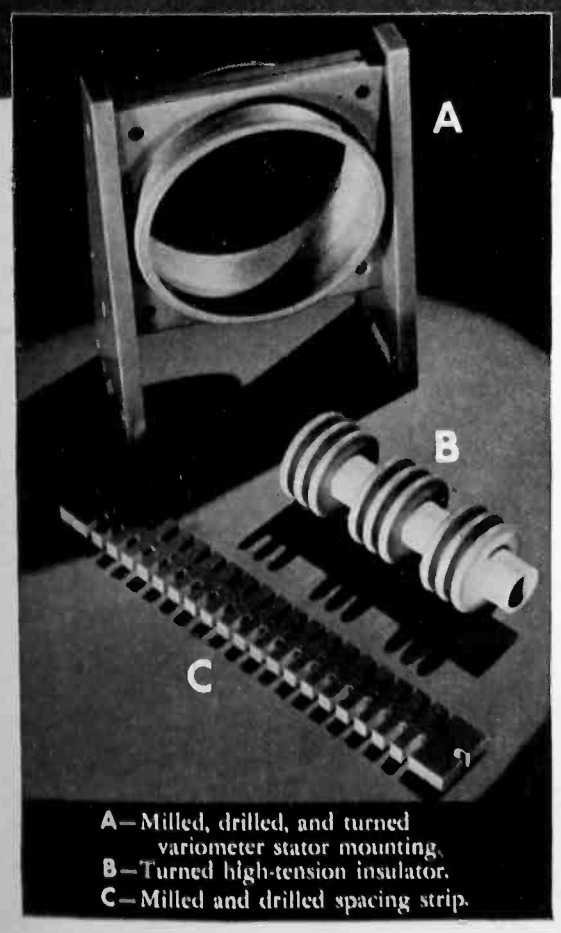
weights equal to 1,500 times its own weight. In a test recently conducted, a magnet weighing 1.85 grams lifted a weight of 2750 grams. The use of the steel jacket not only serves to direct the magnetic flux against the object to be attracted, but also protects the magnet against demagnetization when not in use.

• • •

Audimeter Records Listening Habits of Radio Audience

A NEW DEVICE for producing a permanent record of the listening habits of a large group of radio listeners is the Audimeter, which is based on the design of Professors Elder and Woodruff of M.I.T., and is under commercial development by A. C. Nielsen Company. Essentially the device consists

Buy leather to make your own shoes? Hardly!



A—Milled, drilled, and turned variometer stator mounting.
B—Turned high-tension insulator.
C—Milled and drilled spacing strip.

THEN WHAT ABOUT PARTS FOR YOUR OWN PRODUCT?

When you want shoes you don't buy leather, install shoe machinery and set about making them yourself. It wouldn't pay. Yet you may be making parts for your product that you should buy . . . where conversion by you isn't worth its inconvenience and cost. We may be able to help you as we've helped others.

First, by the use of Synthane Bakelite-laminated . . . a versatile material with a combination of many desirable properties. Second, by doing the entire job of machining.

When you turn the whole job over to us you relieve yourself of the responsibility for jigs and fixtures, for tooling up, for mistakes and rejects, for deliveries. You eliminate capital expense for production equipment, interest charges and charge-offs for depreciation. You take advantage of the economies which come from our special equipment, specialized experience and methods.

What you pay for is always a *known* quantity in your costs. In short, you get what you want, when you want it, at a definite price, without any production worries, and most important . . . usually at an attractive saving in conversion costs.

As an example, it paid three widely different manufacturers to have us produce the products at the left. If you are interested in this convenience and economy write us your requirements. You have nothing to lose.

If you are already set up to machine parts economically we can supply you with Synthane Sheets, Rods, and Tubes . . . help you in every way possible.

SHEETS • RODS • TUBES • FABRICATED PARTS • SILENT STABILIZED GEAR MATERIAL

SYNTHANE CORPORATION, OAKS, PENNSYLVANIA

SYNTHANE

Bakelite— laminated

of a mechanically operated stylus which traces a line on an electrically driven paper tape. The tape is driven by a synchronous electric clock motor, and its longitudinal displacement represents the time axis of the record. The pointer is coupled directly to the tuning dial of the receiver in such a way that its lateral displacement on the tape indicates the frequency to which the receiver is tuned at any given time. The purpose of the instrument is to show definitely what programs are listened to by individual members of the radio audience. A supply of tape is sufficient for 30 days, and tests have indicated that the instrument records reception from as many as 60 to 70 different stations. Some 200 of the instruments have been in use since last September.

One of the problems associated with the device is the possibility of power failure. A clockwork drive provided in the instrument is automatically released in case of power failure. A solenoid switch is used to indicate on the record when the receiver is turned on and off so that the position of the dial during the off period is not interpreted as listening time. The device is mounted in a cabinet small enough to be included within the cabinet of most console radios. Provision is also made for remote recording in the event the instrument itself cannot be placed in the cabinet.

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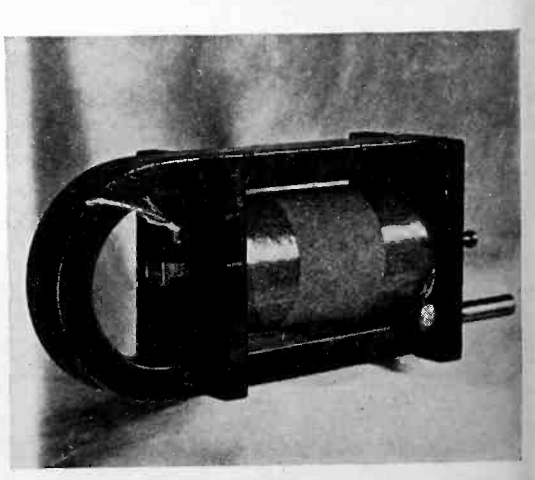
Indicators for Arc-Back in Mercury Vapor Rectifiers

By E. WARREN LOGAN

WMC, Memphis, Tenn.

WITH THE PRACTICALLY UNIVERSAL acceptance of the mercury vapor rectifier as a power source for radio broadcasting transmitters, countless numbers of rotating machines are now retired from service. There is no question of the advantages of the rectifiers from a standpoint of noise, efficiency, trouble, etc., but the mercury vapor rectifier can be quite a stubborn animal at times. When it takes off on a tangent and starts arcing back and blowing main line fuses—what is there to do? One



The arc-back indicator developed at WMC

IN SERVICE OVER A YEAR

— still going strong!

FEATURES OF 342A and 343A

1. Molded glass construction
2. Fewer and cleaner metal parts
3. New radiant energy shields
4. Improved grid construction and characteristics
5. Copper-to-glass seals throughout
6. Better performance with fewer outages
7. Larger filaments with fewer supporting elements

342A and 343A effect worthwhile savings in TUBE HOUR COSTS!

Some of your fellow broadcast engineers are using 342As and 343As. Ask them what they think of these popular water-cooled tubes, many of which are still going strong after more than a year of service.

Engineered to give you maximum performance within the ratings of the component parts of Western Electric transmitters, the performance characteristics of these tubes have been a revelation to the industry.

Increased filament sizes—to allow for a greater amount of tungsten evaporation—call for added filament heating power from 11 to 40 per cent. Though your power costs may be $10 to $25 per socket higher, your annual tube hour costs should be $75 to $100 *lower!*

Invest in these advanced Western Electric tubes—spend a little extra for power—*save three to ten times your extra power cost!* And cut your time off-the-air, too!

DISTRIBUTORS

Graybar Electric Co., Graybar Building, New York, N. Y.
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In other countries: **International Standard Electric Corp.**

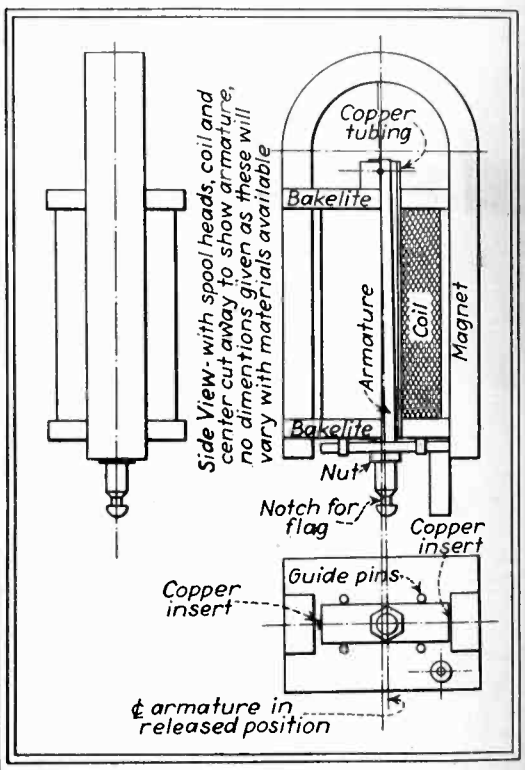
Western Electric
ELECTRONIC EQUIPMENT

Distributed by GraybaR ELECTRIC COMPANY

answer is to watch the bank of tubes and try to catch the culprit in the act. But if the flashes are several hours apart, this is impractical. The practical answer is an arc-back indicator.

Under certain conditions, usually well along in the life of a mercury vapor rectifier tube, a surge will occur in the reverse direction to normal, putting a very heavy load on the opposite tube on that phase so that the brightly glowing one is not the one flashing back but is the opposite one. Now, inasmuch as the flash back is a surge of current in the reverse direction, it should be simple to devise an indicator. A polarized relay that drops a flag instead of closing a contact will promptly show which is guilty. The flag should remain tripped until manually reset which can be done when the rectifier is shut down.

Units of this type were built and installed at WMC over a year ago and have proven invaluable for quick trouble shooting. Quite often a line surge will cause quite general flag tripping.



Structural details of the indicator

This should not be taken to mean bad tubes, but when the same flag repeats the performance accompanied by the usual fuse blowing it is an indication that that tube should be removed from service. Often the faulty tube may be used in a lower voltage service and many more hours obtained.

The main rectifier at WMC is in two sections, three phase, full wave, using six 872A tubes in each section. The two in series work at 14,000 volts feeding a pair of 892's. To equip this rectifier with commercial arc-back indicator units would cost the price of another big tube. In our case the units were built under pressure of a recurrence of rectifier trouble.

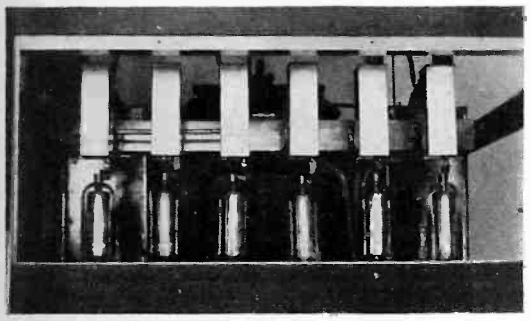
The photos and drawings show the installation and construction of the

units. It was deemed best to work all units in the same parts of the circuits so that they would be interchangeable. This requires operation above ground and a good mounting is to use a large standoff insulator adjacent to or just above the respective tubes. One lead can drop out to the tube plate and the other from the case out to the circuit.

The device consists essentially of an armature in a solenoid, suspended between the poles of a polarizing permanent magnet. The polarizing magnets in our case were "borrowed" from some hand-cranked magneto generators that were available. They were of a size to permit a low resistance winding with sufficient ampere turns for the necessary sensitivity. Also, the large magnet allows an assembly that is simple and sturdy and trouble free.

By using a winding of about four hundred turns of number 16 single-cotton-enamelled covered wire a sensitivity of better than one-half ampere in the reverse direction was obtained together with a very low resistance coil.

This sensitivity will be controlled somewhat by the magnet strength but more so by the size and permeability of the iron used in the armature and



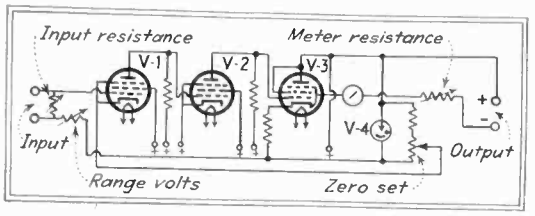
Six indicators mounted on their respective rectifiers

by the gap between armature and polarizing magnet. We made the coilspools from ½-inch thinwall copper tubing and ¼-inch sheet bakelite spoolheads notched to pass the magnets. The armature is a ⅜-inch carriage bolt with a cross bar of ⅛ x ½ inch soft iron and is pivoted on a pin through the armature and a projection of the ½-inch tubing. By setting four escutcheon pins in the spoolhead the armature may be kept aligned and the simple pivot is sufficient. The ends of the armature bar should have small copper inserts driven in and filed not quite flush. This is to prevent an iron to iron contact and possible "freezing" up. The end of the armature is notched to engage the flag and the bar is cut to allow just enough movement to allow positive release of the flag.

The units were put into cases bent up from sheet brass and the back of each unit case was provided with a boss drilled and tapped to screw onto a standoff. The flag is a piece of the same material as the case pivoted on a short piece of wire through holes in the side of the case and soldered to the flag. It is adjusted to engage freely with the notch in the end of the armature and to drop into view when the armature is drawn over to the opposite side on a reverse surge.

Direct Current Amplifier for Industrial Use

THE FEBRUARY ISSUE of the General Radio Experimenter gives a description of a new and interesting direct-current amplifier intended for industrial applications. Three stages are used, two pentodes and a triode. Degeneration is used to minimize changes in circuit gain. The degeneration voltage fed from the last stage to the first is controlled by a resistance which may be adjusted to give any desired



Degenerative d-c amplifier for industrial use

gain. The input resistance can be varied from 10 ohms to 10 megohms. The output of the amplifier is 5 milliamperes at output voltages from 1/10 volt to 1 volt. The device may also be used as a current amplifier, since a 0.01 microampere current passing through a 10 megohm resistance in the input will produce a 5 milliampere output current. A regulated power supply, having a low internal impedance, is compensated for operation over a range of power supply voltages from 100 to 130 volts. Small changes in the heater current of the first stage are apt to cause great shifts in the output. To overcome the diffculty, a regulator transformer is used in conjunction with ballast lamp to stabilize the current of the first tube. The diagram of the instrument is shown in the accompanying figure.

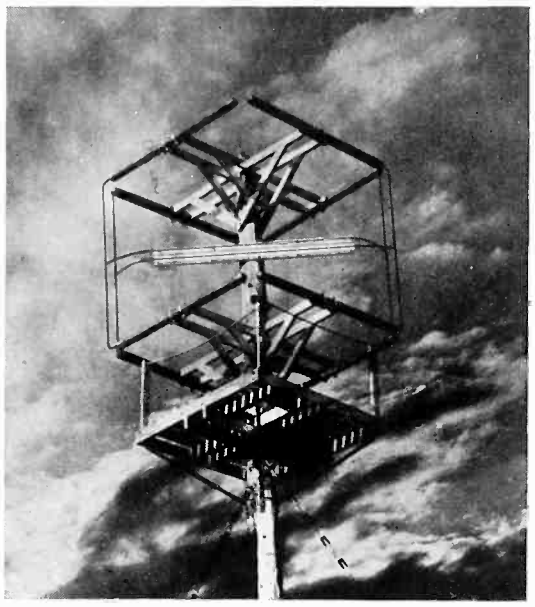
Automatic Facsimile Telegraph Put in Service by Western Union

THE ULTIMATE in simply-operated communication systems has been announced by the Western Union Company with the installation of an automatic facsimile telegraph at the Essex House, New York City. The instrument is housed in an attractive cabinet fastened to the wall and contains a slot into which the message, either typed or written in black ink or black pencil, is dropped. The telegram blank used is of special shape, making it impossible to insert the message improperly. In operating the device it is necessary to push a small button until a small sign lettered "Deposit message" is lighted. The message is then dropped into the receiving slot with the message facing outward. Thereafter the message is scanned photoelectrically by the device and facsimile signals are sent to main office at 60 Hudson Street, New York. The message is retained until the receiving office acknowledges receipt of the message, whereupon the original telegram is deposited by the machine in the bottom of the cabinet. The rate of transmission is 15 sq. in. per min., an extremely high speed for commercial facsimile telegraphy.

Cubical Television Antenna for G. E. Station at Albany

AN ANTENNA OF UNUSUAL design is now being installed for the new 10 kw television station of the General Electric Co. in the Helderberg mountains about 12 miles outside of Albany, N. Y. The antenna, shown in the accompanying photograph consists of eight hollow bars, of copper, each about 7 feet long and 4 inches in diameter. The radiators are arranged on the edges of a perfect cube, being supported by a wooden framework. The radiators are fed from opposing apexes of the cube. The use of one system of radiators above the other gives additional signal strength at low angles close to the ground.

Programs for the station will be radiated on a 1.9 meter wave from the studios in Albany. The ultra-high-frequency transmitter under the call



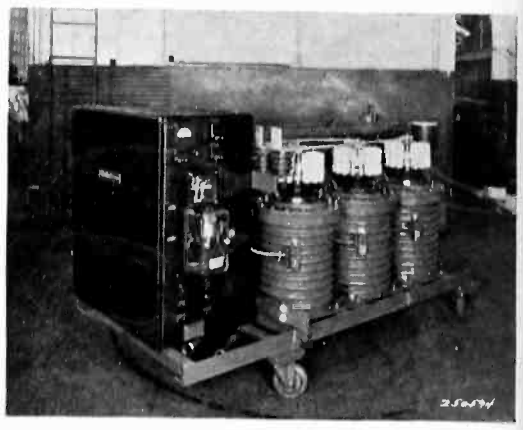
G. E. Television antenna, arranged as a cube

W2XH will operate with a power of 40 watts. The main transmitter, W2XB, on the hilltop will have a receiver for picking up the relay transmission. It is claimed that the new main station will have a higher signal power than any existing television transmitter in America and that it will succeed in covering adequately all regions within a 40-mile radius of the station.

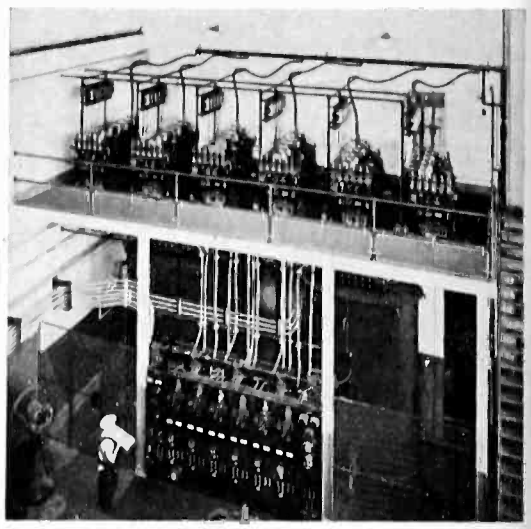
Use of Ignitrons in Railway Operation

USE OF METAL-TANK mercury-arc rectifiers in the transportation industry was reviewed by J. H. Cox and G. F. Jones before the A.I.E.E. winter convention in New York. They pointed out that the combined rating of rectifiers used in railway systems of the United States now exceeds 500,000 kw.

For 600-volt electrification two mercury-arc rectifiers of the ignitron type have been installed, capable of handling 3,000 kw. When the voltage is as low as this, the arc voltage drop across the rectifier constitutes an appreciable fraction of the total load voltage, and represents a proportionately large loss. With the ignitron type of rectifier, the arc voltage drop across the tube is from 14 to 18 volts.



Portable high-current ignitron rectifier



Battery of low voltage ignitrons for electrochemical processing

The illustration shows a 1,500 kw unit for a 600-volt service, consisting of six separate ignitron rectifier units complete with auxiliary vacuum system and grid control circuits. The 600-volt system is particularly applicable to subway systems and similar heavy duty traction service.

Another use of the ignitron rectifier is in the chemical industry, as illustrated by the installation at the Buffalo Electrochemical Company, Buffalo, N. Y. An installation of six ignitron rectifiers is used to supply a total load current of 4,800 amperes, and has done so almost continuously since the installation in January, 1938. Each of the six units supplies 800 amperes at 200 volts to a bank of cells used for the production of hydrogen peroxide. The current regulator was used to maintain the current at any level predetermined between 2,000 and 4,800 amperes. The arc drop is from 12 to 17 volts, as compared with 20 or 30 volts for a conventional rectifier of the same rating.

Electronics in Automotive Plants

(*Continued from page* 15)

Inspection for cracks and checks in rollers always presents a problem. At the present time groups of 40 to 50 girls in the average bearing factory perform this inspection function. The girls, or operators, at their inspection tables watch rollers for roller bearings as they pass on a horizontal spindle, which not only indexes the roll ahead, but, moreover, revolves it as it passes.

Inspection

Several years have passed since a patent was granted on methods and means of phototube inspection of rollers from roller bearings for cracks and flaws. This patent disclosed methods of individually scanning progressively each linear inch and in a spiral the circular surface of the outside of the roller; yet, to inspect and reject the undesirable rolls, the slowness of such a set-up would merely replace a few inspectors, who at the present time view these rolls under a cylindrical lens.

While still in the experimental stage, the newer proposed photoelectric method, as shown, was devised, in which 57 phototubes will scan the highlights on one surface of the roller (illuminated by a mercury tube) for the entire length at one instant. The use of a mercury tube lamp, as illumination of the roller, allows a-c amplification of phototube current output. There are two rows of phototubes within the housing. Each row acts as a compensating circuit and, thereby, eliminates the necessity of sensitivity adjustment due to uneven color or unequal light reflection from one roller to the next. If the roller has a general overall dark appearance, the light intensity on both groups of the balanced phototube system diminishes, thereby allowing the balance to remain. If, however, as the roll is automatically turned, a crack of any size appears, it will cast a shadow, or an image of this brightly illuminated crack, upon one row of phototube cathodes. The result will be a complete unbalance of the input circuit of the phototube amplifier.

THE ELECTR ON ART

FROM the technical literature this month: Degeneration for voltage regulation, a narrow-band television system that works, copper-oxide rectifier applications, photo-tube analyses, and a dissertation on the February cover.

Regulation By Means of Variable Negative Feed-back

THE IDEA of using a variable negative feed-back in low frequency amplifier regulation is in itself not new, but a new application of this method is made in the October, 1938 issue of *Funktechnische Monatshefte*. This principle found early use as an industrial tool. It is true that the circuit is not as simple as previous control hook-ups, but the advantages derivable from the dynamic type of regulation supersede by far all previous kinds of control.

In Fig. 1, tube 1 serves to amplify the low-frequency currents which flow through the detector G. The rectified currents are tapped off potentiometer P and fed into tube 3. The cathode of tube 2 is coupled with the plate-cathode circuit of tube 3 which is a pentode with two negative control grids. The control of the tube's resistance depends equally on both control grids. In order that the dynamic working point of tube 2 shall be independent of the degree of negative feed-back, its negative grid voltage is fed through a cathode resistor R_k around which is shunted the a-c component through a by-pass condenser C_k in the usual manner. The a-c voltage which the negative feed-back controls, arises from the potential drop in tube 3. In order to use this circuit as a dynamic equalizer it is necessary to have the control voltage so connected that with increasing signals it will raise or weaken the resistance of the control tube and thereby strengthen or weaken the negative feed-back.

A circuit with transformer input and output of the low-frequency voltage is shown in Fig. 2. The control circuit in this case is not in the cathode-coupling, but instead is formed by resistance R and the transformer connected in parallel with it from which network a feed-back voltage is obtainable through condenser C.

It is well to consider that the negative feed-back voltage is somewhat distorted since the control-tube resistance is varied not only by the input grid control voltage, but also it changes directly under the influence of plate voltage on tube 3.

The author claims that this new circuit incorporates, through the ingenuity of the designer, material advantages over the well known control circuits which utilize two tubes connected in opposition.

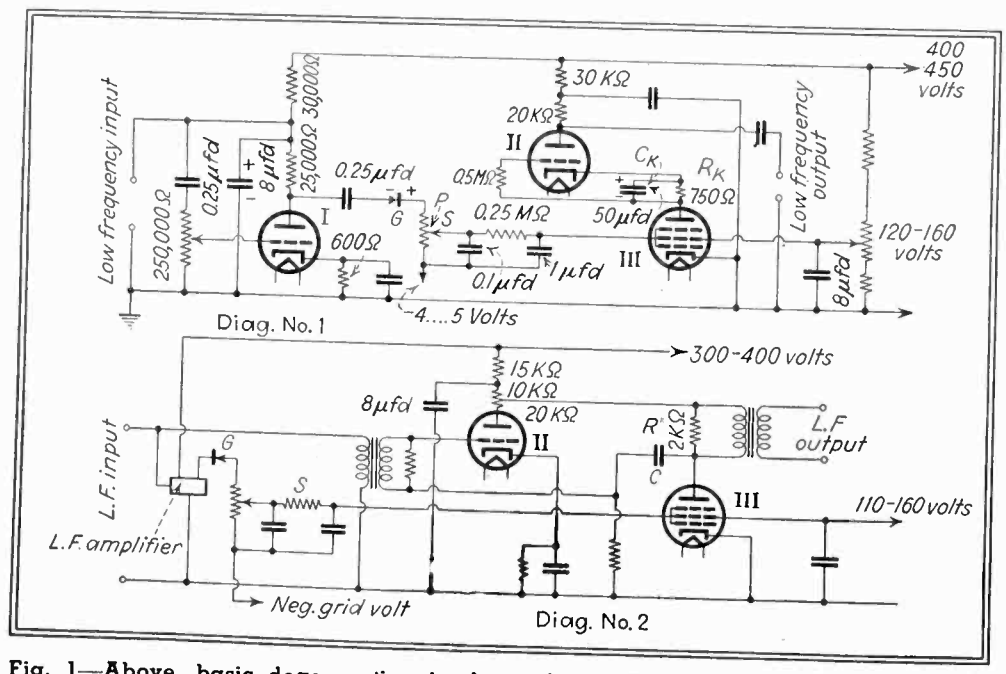
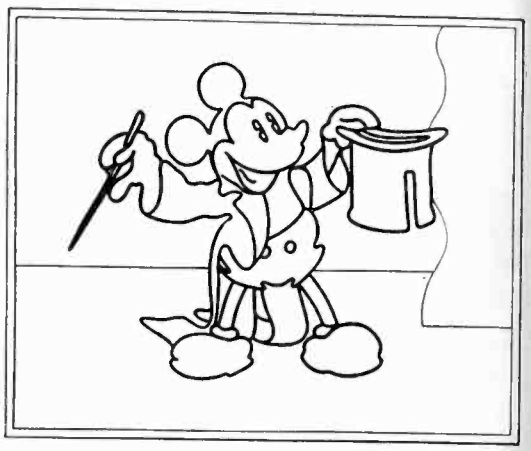


Fig. 1—Above, basic degeneration in the cathode circuit. Fig. 2—Below, another degenerative circuit using a cathode-coupled i-f stage

Narrow Band Picture Transmission

A METHOD of transmission and reproduction of line images is described by A. M. Skellett in the March issue of *Electrical Engineering*, which system utilizes a cathode-ray tube for reproduction, the spot of the tube is made to trace out the line image twenty or more times per second, and the method employed does not require the high detail which is essential for high quality television performance. In an experimental set, a drawing of a woman's head was reproduced in outline with an equivalent total band width of approximately 2,600 cycles. This is made up of two bands, each 1,300 cycles wide



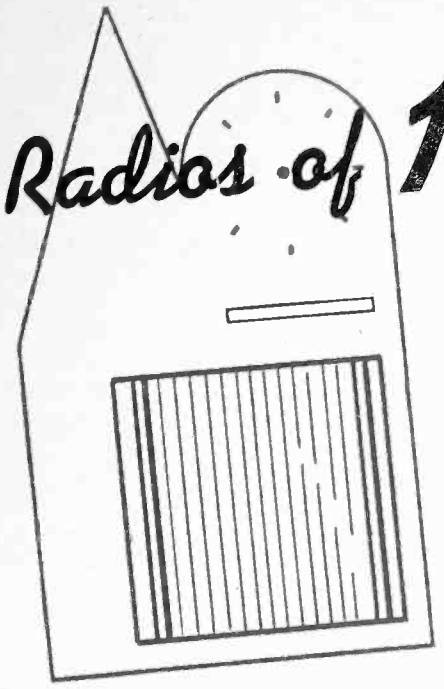
This Mickey Mouse cartoon can be reproduced with a band width of approximately 10 kc

for the potentials of the two sets of deflecting plates on the cathode ray tube. Analysis of a more complex image, such as that of an animated cartoon shows that such material could be transmitted and reproduced by the method given by the author within a total band width of 10 kc.

Illustrations shown in the original article are each in the form of a closed loop in which the spot on the cathode ray tube is made to traverse by applying simultaneously the proper instantaneous voltages to the horizontal and vertical deflecting plates. The voltages are, of course, directly proportional to the x and y coordinates of the point of the drawing, taken along the path of the spot in the direction in which it moves. Thus, the system essentially resolves itself into the problem of making one (or more) line drawings, determining the x and y coordinates for each point on this line, generating deflection voltages proportional to the x and y coordinates, and transmitting the two voltages simultaneously through some medium after which they may be picked up in an appropriate receiver, and reassembled in such a manner that x and y displacement voltages are applied to the horizontal and vertical plates of the reproducing cathode ray tube for the reproduction of the image.

The primary advantage of this method is that it enables certain types of drawings to be reproduced with much less band width than is neces-

The Radios of 1940 ARE IN electronics TODAY



The radio receivers that will make their debut to dealers this summer are news stories and engineering articles in ELECTRONICS this spring. For that reason the entire radio manufacturing industry keeps its eyes on ELECTRONICS for the latest engineering developments and trends in receiver design. And with equal attention the industry follows the advertising columns because they serve as a catalogue of parts and materials available for manufacturing and experimenting.

The Advertisers who want to reach the Manufacturing And Experimental Radio Market are using ELECTRONICS

The only, economical means of advertising components and radio set materials to the manufacturers and designers of the 1940 receivers is through ELECTRONICS. Proof of ELECTRONICS acceptance is the following honor roll — companies who have used ELECTRONICS in the first three months of 1939 to present their sales messages on components and materials for radio set manufacturer and design.

Acheson Colloids Corp.
Aerovox Corp.
Alden Products Corp.
American Lava Corp.
American Transformer Corp.
Bakelite Corp.
James G. Biddle Co.
Callite Products
The Carborundum Co.
Centralab Div., Globe Union
Cinaudagraph Corp.
Cinch Mfg. Corp.
Clarostat Mfg. Corp.
Continental-Diamond Fibre Co.
Cornell Dubilier Elec. Corp.
Drake Mfg. Co.
Wilbur B. Driver Co.
Erie Resistor Corp.
Ferranti Electric Inc.
Ferrocart Corp. of America
The Formica Insulation Co.
General Electric Co.
Goat Radio Tube Parts, Inc.
International Nickel Co.
International Resistance Co.
Isolantite, Inc.
Jensen Radio Mfg. Co.
Howard B. Jones
Lenz Electric Mfg. Co.
Littelfuse Labs.
Mallory & Co.
Mfgs. Screw & Supply
Mica Insulator Co.
National Union Radio Corp.
Ohmite Mfg. Co.
Precision Resistor Co.
R. C. A. Manufacturing Co.
Remler Co., Ltd.
The Richardson Co.
Shakeproof Lock Washer Co.
Shallcross Mfg. Co.
F. W. Sickles Co.
Solar Mfg. Corp.
Speer Carbon Co.
Superior Tube Co.
Synthane Corp.
Thomas & Skinner Steel Products Co.
Thordarson Elec. & Mfg. Co.
Ward Leonard Elec. Co.
S. S. White, Ind. Div.
Zophar Mills Inc.

Your sales message has three important and profitable functions when presented through ELECTRONICS to the radio manufacturing industry:

- You sell design and research engineers who are interested in the technical application of your products to the new circuits and designs they are creating.
- You sell the production engineers and managers who must see your product as it applies to mass-production lines, ease of assembly, strength and durability in handling.
- You sell the executives and purchasing agents who refer constantly to ELECTRONICS as a catalogue of parts and materials available — as a ready-reference book of information on components ordered by their design and engineering staffs.

ELECTRONICS reaches all three of these groups — every company, every man of importance in the industry. They come to ELECTRONICS each month because they want — and need for their business — the two primary functions of this industrial publication, namely presentation of:

- Editorial material designed to keep them up-to-date on every development in the design, engineering and manufacture of radio sets and allied equipment.
- Advertising which serves to make ELECTRONICS a market place for components and materials which go into the manufacture of these same radio sets and equipment.

The time to reach these manufacturers is NOW! The way to reach them is ELECTRONICS! Plan your Spring and Summer advertising schedule with ELECTRONICS as the focal point of your concentration on the radio manufacturing market.

PUT YOUR SALES MESSAGE IN ELECTRONICS

sary at the present time with the usual scanning method of television operation.

The author points out that the two kinds of detail which will suffer most are straight portions and sharp bends. The overall shape and form of the image and the larger details are dependent on the lower frequencies which are present in the transmission band. These frequencies are therefore the most important ones. If the bands include enough harmonic to reproduce the small detail, even in approximate form, the larger details of general form will be reproduced with good fidelity.

A cartoon of one of Walt Disney's popular figures was chosen for determining frequency band required to reproduce a sketch of considerable complexity. It was resolved into one continuous line such as would be followed by the cathode ray spot for reproduction. This reproduction is shown on page 54. Parts of the line are over dark paths which are not shown. The total band width necessary for satisfactory reproduction of this image was judged to be 10,000 cycles. This total is made up of 5,000 cycles each for the x and y deflecting potentials.

In the transmission of writing or script, a total band width of 10,000 cycles is judged adequate for about seven words of average length. The total band width for script is proportional to the total number of letters and spaces, or to the number of words of average length.

In conclusion the author shows that the type of images which are capable of transmission by this method include drawings, diagrams and maps, either with or without animation, animated cartoons, etc. Script, including signatures and foreign language characters, which could not be readily handled by ordinary existing communication facilities might also be transmitted, and sketches, primarily of news value, would also lend themselves to transmission by this method which, compared to the usual television system, is comparatively simple.

Degeneration in Television Amplifier

A NEW USE for the vacuum-tube is found in television circuits wherein the tube's property as an amplifier is neglected and instead very heavy negative feedback properties are utilized. This novel application is described in an article entitled, "Cathode-Coupled Circuits" in the *Wireless World* of Dec. 15, 1938.

The load impedance is placed in the cathode circuit instead of the anode circuit thereby causing the stage to have a very low output impedance. With a plate circuit load it is well known that appreciable feed-back through the grid-plate capacity is obtained and the author stresses the analogous situation which exists in the grid-cathode circuit when a cathode load is used.

The basic cathode-coupled circuit is shown in Fig. 1. If the cathode load Z is fairly large compared to the a-c resistance of the tube, the value of e_z is very nearly (80–90%) equal to e_1.

An interesting feature of this circuit is that in anode coupling a negative input resistance is obtained when the anode load is a fairly high valued inductive load. In the cathode circuit, however, an inductive load gives a positive input resistance and a capacitive load is necessary for negative resistance effects.

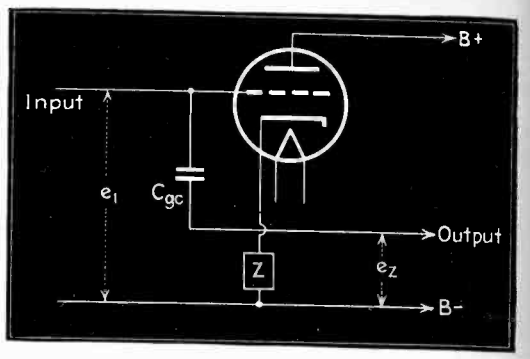


Fig. 1—Television amplifier circuit in which degeneration is provided by means of the cathode impedance, Z

The application of the latter type of coupling is shown in this paper. It is of importance to note the possibility of parasitic oscillations when using this type circuit.

In an a-f circuit, for instance, the cathode coupling resistance always has some capacity in shunt with it and this is generally of the same order as the grid-cathode capacity. For ultra-high frequencies this will give a very low negative input resistance. Under such conditions it is apparent that if the grid circuit wiring forms a tuned circuit and its damping is not high, parasitic oscillations will take place. Trouble from this cause is usually avoided because the wiring in a-f circuits is very short and a resonant circuit is therefore not formed within the operating frequency range.

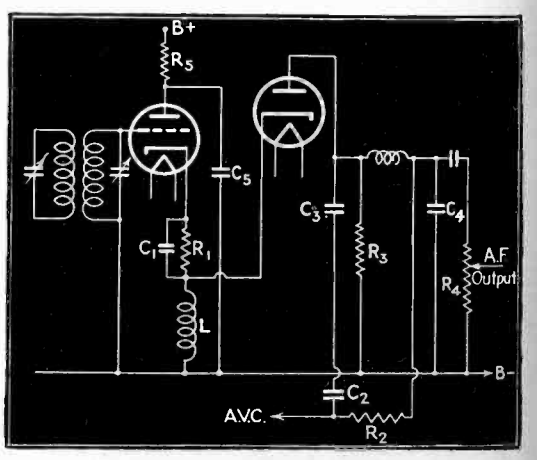


Fig. 2—Improved degenerative amplifier which eliminates the heavy damping of the diode detector

The drawback inherent in the diode detector, in that its input impedance may be very low and therefore damp the input tuned circuit very heavily, may be overcome by using a cathode-coupled i-f stage feeding into the diode detector. This circuit is shown in Fig. 2. Suitable values for the component parts are given in the paper.

Our February Cover

THE MULTIPLE EXPOSURE photograph which was used on the cover of the February issue of *Electronics* may be considered as having been quite successful if the number of responses which it elicited can be considered as any criterion of the interest. Moreover, the analysis on page 11 came in for its share of praise—and condemnation.

Undoubtedly many persons have discovered by this time that in putting together this story at the last minute, we not only apparently misplaced a few decimal points in our slide rule calculations, but presumably also got mixed up with the wrong scales as well. And while, perhaps, the majority of readers who observed this state of affairs did not bother to write in, we have various communications—in various degrees of indignation and scorn—from several people, and enough calculated information to make up our income tax blanks. At any rate, the replies we have received should settle once and for all the analysis of the cover photograph, if it does not open new controversies. But before proceeding, we wish to acknowledge information received from Eldred Hough, Tucson, Ariz., Robert L. Alcorn, Jr., Chamberlain, Pa., Milan W. Garrett of Swarthmore College, Swarthmore, Pa., and J. M. Snodgrass, of Boston, Mass. Mr. Snodgrass, incidentally, went to the trouble of preparing the velocity-time curves shown on page 58 which show the velocity of the club and golfer's hand.

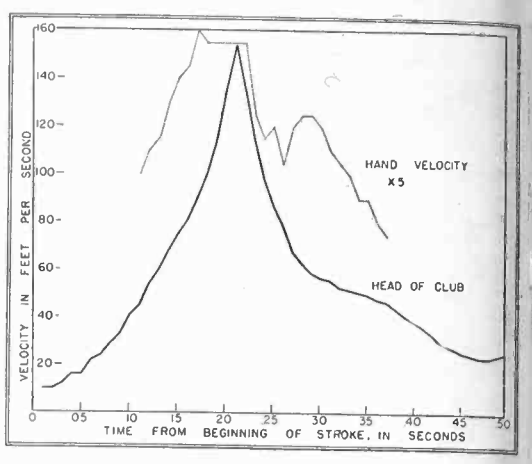
Mr. Hough points out that the golf club weighs 15.5 oz., the ball weighs 1.96 oz. and that consequently the acceleration of the ball is 7.95 times that of the club, or 64,000 ft./sec.^{2} The force at impact is 195 pounds. If the contact lasts for 0.01 second the velocity is given as 500 feet per second. Mr. Hough calculates the kinetic energy at impact to be 976 foot-pounds, and observes that "the horse power is then 8.86 which is a very reasonable value for an athlete to exert over a very short time."

Mr. Alcorn shows up an error in the calculation of the kinetic energy and says that "actually the ball appears to have a velocity of approximately 450 feet per second corresponding to about 314 foot-pounds of energy." He claims the curve showing the speed of the golf ball is in error but makes no further comment.

Being interested in muscular activity, J. M. Snodgrass went through the calculations himself, from which he prepared the velocity-time curves shown. He writes: "Counting the first exposure as zero, it is interesting to note that the hand velocity remains practically constant between the 16th and 22nd exposure intervals. (On this basis of counting exposures, the ball was hit between the 21st and 22nd exposures.) Thus, during this interval no driving power is being supplied to the club by means of body or hand acceleration.

"The club shaft at the hand is mov-

ing freely with only its accumulated momentum. The club head is, however, accelerating due to the angle of the shaft and the centrifugal component of the motion. The tangential photographic error unfortunately becomes rather serious in this region. It is thus clear that long before the ball is actually hit the golfer has expended all his muscular energy and control that can possibly effect the drive. In this connection the shape of



Time velocity curves for the head of the golf club and the velocity of the golfers hand, as determined from our February cover by J. M. Snodgrass

the club shaft is interesting. The projection of the shaft leads the head up to exposure 15. Then as the hand acceleration becomes zero the club head begins to lead as the result of the centrifugal component.

"The velocity curve of the club head is too greatly smoothed as published as there is actually a decided and significant hump in the velocity. This hump corresponds with a rapid increase rather than decrease in the hand velocity." Like several others, Mr. Snodgrass is quick to point out our difficulty with the slide rule, and appends for our information a number of references on animal movement and locomotion which treat with the above noted constant velocity and momentum phases of human activity.

We are taken to task by Milan Garrett of the Department of Physics of Swarthmore College for calculating the force at impact, since there is not sufficient information available to make this determination. On the basis of reasonable assumptions regarding the length of the wooden scale at the foot of the golfer, a maximum velocity for the club head is calculated to be 190 feet per second. The maximum velocity of the ball must then be less than 380 feet per second, which is the limiting value if the mass of the club head is infinite.

But there is humor in the story as well as seriousness. The Juggernaut on the February cover is compared to a human whirlwind who possesses more arms than the image of an Indian diety. Taking us at our words for the energy developed, Mr. Garrett wonders if it wouldn't be cheaper to "breed a race of these fellows than to go on building expensive hydroelectric installations".

Application of Copper Oxide Rectifiers

AN ARTICLE in the March issue of *Electrical Engineering*, by E. W. Morris, under the title given above, has for its purpose, a description of a few of the representative installations made in the various industries so far as concerns copper oxide rectifiers.

It is pointed out that since the rating of a disk rectifier unit depends upon the ability to dissipate losses, rectifier disks are frequently made with cooling fins and spaces to assist in heat dissipation. The assembled unit may be connected into groups for half- and full-wave rectification, for any number of phases and in parallel or series for increased current or voltage ratings.

One of the first uses for such types of rectifiers was in the field of battery chargers. Whereas the first units to be made were of small size, such as those required for radio receiver use, the units are now available with ratings up to 6 amp. at 130 volts. A bridge type copper oxide rectifier has been used in a self-regulating charger for automatically charging batteries at some predetermined rate.

In the field of industrial control, versatility has been added to former equipment by the use of the copper oxide rectifier. The advantages for d-c operation of contactors and relays can be obtained from an a-c source and a rectifier unit. For rotating machinery, the d-c fields can be excited from an a-c supply and regulated by means of the proper arrangement of the reactors and the rectifiers. Circuit breakers may be tripped from an a-c source by the use of the copper rectifiers and condensers, and give excellent service, since the rectifiers require no additional attention after being installed.

The author states that "Corrosion of underground structures can be mitigated by the use of cathodic protection, and is conveniently accomplished by connecting the underground structure to the negative terminal of the d-c source and by maintaining it negative to the earth by 0.30 volts or greater. Corrosion occurs in underground structures due to stray current from d-c systems, and from electrochemical reactions between the structure and the surrounding soil. More current flows from the underground structure through the soil to other parts of the structure, corrosion occurring when the current leaves the structure."

In this article no attempt has been made to list all of the possible applications, but a few representative installations using copper oxide rectifiers, together with a number of wiring diagrams, are given. Units have been assembled with ratings which vary from 0.001 watt to several kilowatts. While the article makes no attempt to be exhaustive, it is one of the very few which attempts any kind of a survey of the uses of dry rectifiers and as such, merits considerable attention.

Equivalent Modulator Circuits

THE JANUARY ISSUE of the *Bell System Technical Journal* contains an article, under the above title, by E. Peterson and L. W. Hussey.

Equivalent modulator circuits are developed in the form of linear resistant networks. They are equivalent in the sense that the current magnitude in any mesh of the network is equal to the current amplitude of a corresponding frequency component in the modulator. The elements of the network are determined by the property of the modulator, while the terminating resistances are those physically existent in the connector circuit.

With this correspondence demonstrated, the operating features of the modulator may be inferred from the known properties of linear network. Among the properties considered are the transfer efficiency from signal to side band, and the input resistance to signals as affected by the side band load resistance.

Equivalent networks are worked out for a number of interesting cases, involving different impedances to unwanted modulation products together with different non-linear characteristics. The equivalents come out comparatively simple in form under the restrictions noted are followed in the text, which makes the carrier large compared to the signal and the circuit element purely resistive.

Electron Optics

SINCE comparatively little has appeared in the American technical press dealing with electron optics, it is worth calling the attention of readers of electronics to the article on "Electrostatic Electron Optics," by Frank Gray in the January, 1939 issue of the *Bell System Technical Journal*. As might be expected the article is reasonably long and fairly mathematical, and an adequate summary of it cannot be given here.

The scope of the article, however, is indicated by the following author's summary: Certain types of electrostatic fields may be used as lenses to focus electron beams. The theory of these lenses is developed for electric fields that are symmetrical about the central axis. The introduction of the two velocity functions exactly reduces the partial differential equations of electron motion to a series of ordinary differential equations. The first equation describes the action of a lens for electron paths near the axis; the remaining equations determine the higher order aberation terms. Sections on the following subjects are included: the general equations of electron objects, thin lenses, thick lenses, aberration, the reduction of aberration, apertured plates, and concentric tubes. A list of symbols and lens equations is also included at the end of the article.

Photoelectric Cell Used for Chemical Analysis

AN ARTICLE by R. M. Eavens and E. P. Silberstein, describes "An Opacimeter used in Chemical Analysis" in the March issue of the *Journal of the Society of Motion Picture Engineers*. The instrument is designed to measure the light transmission of a colored or turbid solution and the essential measuring equipment consists of a barrier type photoelectric cell connected to a microammeter.

Other parts of the equipment, as shown in Fig. 1, consist of a suitable

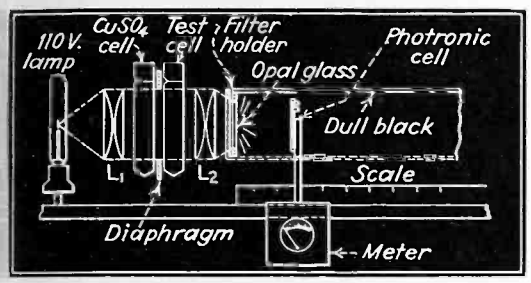


Fig. 1—Diagram of apparatus used in the opacimeter for chemical analysis

light source, collimating and condensing lens, the samples to be tested, a suitable diaphragm and other accessory electrical and optical parts.

A barrier type photoelectric cell is used to measure the intensity of the light transmitted by the solution under test. Since the cell is color selective, the light source must be maintained at a constant color temperature. The light intensity falling upon the photoelectric cell is maintained within a given range by varying the distance between the photoelectric cell and the opal glass diffusing disk which is illuminated by the light passing through the solution under test.

A glass tank containing a 4 per cent copper sulphate solution is placed on the light source side of the test solution in order to reduce the sensitivity to infra-red radiation.

The concentration of the test solution is obtained from a calibration curve which has previously been determined from known samples. Use of the instrument is not restricted to chemical reaction giving rise to a clear, colored solution. In practice it has been found that the amount of constituents present can be reliably determined by measuring the change in light transmission arising from the formation of uniformly dispersed precipitates, and especially if settling of the precipitate is prevented by the use of suitable dispersing agents.

Light Filters for Television

ONE OF THE research items published in the March, 1930 issue of the *Electro Technical Journal* published by the Institute of Electrical Engineers of Japan, at Tokyo, deals with "Light Filters for Television Studio Illumination."

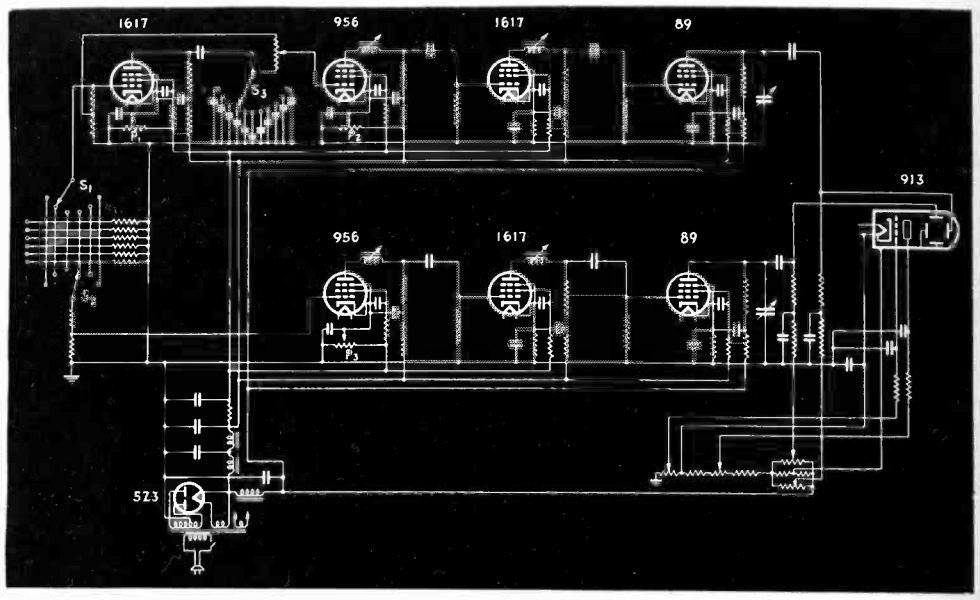
THE INDUSTRY IN REVIEW

A Cathode-Ray Antenna Phasemeter

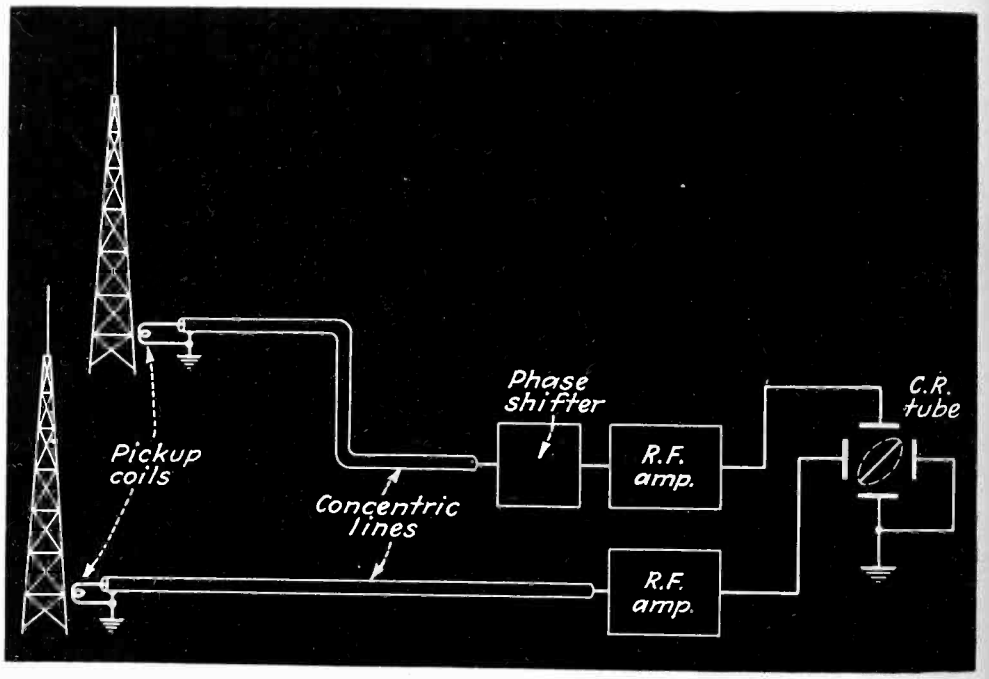
By JOHN P. TAYLOR

ONE of the most interesting of recent developments in the broadcast field is a cathode-ray-type r-f phasemeter[1]. While designed originally to serve as an aid in adjusting broadcast directional arrays, this device will undoubtedly find a much wider field—not only in other frequency bands, but also for numerous types of phase measurements other than those on antennas.

Anyone who has had even the most casual contact with the installation or maintenance of a directive array has some appreciation of the practical difficulties. In no small part these difficulties have sprung from the lack of a simple, accurate method of measuring such factors as the mutual impedance and the phase differences between the currents in the several elements. Ordinarily the desired relationships can be calculated without much difficulty but adjusting the actual installation to obtain these has always been a tedious operation—with accurate results guaranteed only by field intensity measurements. Moreover, it has been found that in some instances the adjustment of the array has inadvertently, and unknowingly, been shifted with the result that the installation has been operated for extended periods with totally incorrect adjustment. The use of a phasemeter to overcome these difficulties has already been suggested[2]. Previous models, however, have been rather complicated in design. The cathode-ray type phasemeter is fundamentally very simple.



Complete circuit of the cathode-ray phasemeter



Method of using phasemeter in lining up antenna

Principle

The ability to indicate phase balance—or phase difference—is one of the best-known properties of the cathode-ray tube. When the voltages applied to the two pairs of plates have the same frequency and are in phase, or are of opposite phase, a straight-line trace appears on the tube. For small phase differences the trace becomes an ellipse—enlarging to a circle (for equal amplitudes) for a 90 deg. difference. It is not practical to read phase difference directly from such a pattern. However, if a phase-shifting device is interposed in one voltage lead, the phase of this voltage may be adjusted until a straight-line trace is obtained. The phase shift so introduced is then equal to the phase difference in question. The phase shifter may be calibrated, thus providing a direct reading. This principle, in brief, is utilized in the antenna phasemeter.

Small pickup coils (of equal dimensions) are coupled to each of the antenna elements—and the "samples" of r-f energy thus obtained brought in over concentric lines to the phasemeter, which may be located in the transmitter building or in any convenient location. The calibrated phaseshifter is connected directly in one input. Both voltages are amplified and applied to the plates of a small cathode-ray tube. When used as a measuring device the phaseshifter is rotated until a straight line is obtained on the screen and the phase difference read directly from the scale. When used as a monitor the final adjustment is simply left fixed—in which case any deviation from the straightline pattern indicates drifting or detuning at some point in the system.

Circuit Details

To provide for arrays of more than two elements, six input connections are provided. Thus six lines may be permanently connected and the phase difference between any two checked by setting switches S_1 and S_2 to the desired positions. The input connections are separately terminated in impedances of approximately 80 ohms to correctly terminate concentric lines. The signal required at this point is less than a volt.

Referring to the diagram it will be seen that S_1 feeds one of the input voltages into a 1617 connected as a

pentode amplifier. The load circuit of this tube is such that the output voltage leads the grid voltage by 90 deg. A high resistance potentiometer connected from the output circuit back to the grid makes it possible to obtain a voltage of any in-between phase. This adjustment is secured by a large dial calibrated to read directly in degrees of phase difference. The constants of the circuit are chosen such that this calibration is obtained for equal output at either end of the scale. Thus by a manipulation of the adjustments provided, and without the use of other equipment, the calibration can be easily checked—and readjusted if necessary by means of P_1. Switch S_3, offers a choice of capacities suitable for different frequency ranges. By setting this to the correct range the instrument is automatically set up for use and no further tuning adjustments are required.

The two r-f amplifiers are identical. They are of the fixed-type, broadly tuned so as to require no adjustment in use—although P_2 and P_3 are provided for making adjustments of gain. Since relatively high voltages are required for good deflection on the oscillograph, three stages of amplification are provided—with 89 type tubes being used in the output. It is essential that these amplifiers either have no phase shift, or that they introduce equivalent phase shift. Semi-variable reactors take care of this requirement. In addition to the controls mentioned there are the usual adjustments of centering, focus and intensity for the cathode ray tube itself.

Construction

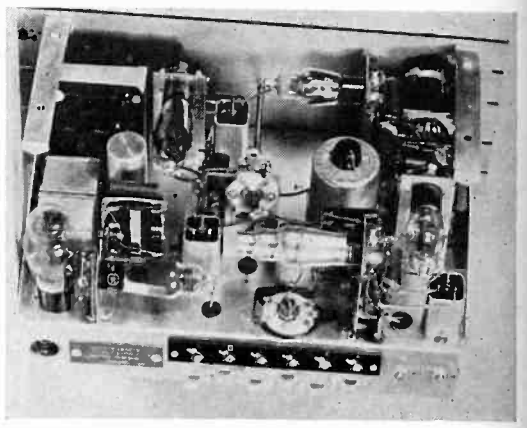
Mechanically this phasemeter is a single unit intended either for rack or table mounting. Front panel controls include the two line input switches (S_1 and S_2), the two gain adjustments (P_2 and P_3), the calibration control, and the focus and intensity controls for the tube. The centering controls, since they require adjustment only on substitution of another tube, are made by screw driver adjustments from the rear. In the right center may be seen the capacity selector switch which provides for operation at any frequency from 200 kc to 1600 kc.

Applications

This particular phase meter was designed primarily for broadcast stations. The most important aspect of such application is its use in monitoring the operation of a directive array. Up to six antenna elements can be accommodated. If desired, a v-t voltmeter can be used to check the amplitude of the several antenna currents, although in most installations other means of reading these are already available.

In using the phasemeter as a monitor the only operation ordinarily required is that of rotating the phase adjuster until the straight-line trace is obtained, and then reading the phase difference directly. If only two direc-

tional elements are employed the phase shifter can be left in position. In this case it will only be necessary to snap on the monitor and observe the shape of the trace. With regard to the measured phase difference, it will be noted that if the lines are of equal length this will be the same as the desired phase difference between antenna currents. When this is not the case, the additional phase shift occasioned by the difference in lines can be easily subtracted or added, as required. The necessary correction can be accurately determined by making a measurement of the phase shift of the line. This is most conveniently done before installation; i.e. by coiling the line up so that both ends are easily accessible, feeding



Interior of phasemeter

rf in one end, and comparing the phase of the voltage at this point and that at the farther end of the line.

A phasemeter of this type will also be of great convenience in making the original adjustments on a directive system. The procedure in the past has been to lay out all the components of such a system on paper, build up the calculated branching and phase shifting networks, and then, by painstaking field intensity surveys, to check the resulting pattern. Often small errors or intangible factors cause unexpected variations with the result that time-taking surveys have to be repeated. With a phasemeter the necessary field work is greatly facilitated. The phasing networks can be accurately checked and adjusted before installation (assuming, of course, that the line impedance to be used is known). This is done by feeding rf into one end of the network and using the phasemeter to read the phase difference between this input voltage and voltage at the output of the network. The phasemeter has an input impedance of 80 ohms, so that it will itself correctly terminate a network designed for use in standard coaxial lines. For higher impedance lines, resistance can be added in series to obtain the proper termination. When networks are thus accurately preadjusted, the system can be immediately placed in operation—and the final adjustments of phase relation between element currents made by using the phasemeter (in normal connection) as an indicator. If the system has been correctly designed, the desired pattern will be obtained when the phase and

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amplitudes of these currents agree with the calculated values. Thus no field measurements need be made during the adjustment. It will still be desirable to make a survey after the work is complete. However, this will be in the way of a final check, rather than a part of the procedure.

The phasemeter is also of convenience in making certain other measurements connected with the installation of a directive antenna, for example, the mutual impedance between elements. This impedance is ordinarily calculated in advance and from it and the other dimensions of the system the proper element currents are calculated. Thus the proper operation of the system depends, for one thing, on this calculated impedance being obtained in the actual installation. Recognition of this is given by the FCC in requiring a measurement of this mutual impedance as a part of the "proof of performance" of a directional installation. The method of measurement is not specified. One method used in the past has been to measure the individual resistances and reactances for conditions of the other element in floating and parasitic operation, respectively—from which the mutual impedance can be calculated by substitution in the proper relations[3]. The phasemeter can be used for more accurate determination by employing it to measure the phase difference between the current fed the first antenna element and that induced in the second when the latter is tuned as a parasitic reflector. From this phase relation and the amplitudes which can be read with meters the mutual impedance is easily established.

Another interesting measurement which can be made with a phasemeter is that of the self-impedance of one antenna during operation. In a directional system this is important because the impedance of the elements are, in general, quite different during operation than for static conditions. Heretofore, no method for measuring the operating impedance has been available. With the phasemeter shown it is a relatively simple procedure. The same method can be used in measuring the impedance of a single-element antenna, although in this case other methods, such as the substitution or bridge, may be more convenient.

All of the above measurements apply especially to broadcast systems. They will also be of equal benefit in connection with adjustment of directive systems for other applications. The design and installation of radio range beacons is a good example. There are obviously many other types of rf measurements for which this instrument should lend itself, not only in the transmitter field but also in receiver and allied fields.

[1] G. H. Brown and G. Swift, A Radio Frequency Phase Meter, *Broadcast News*, June 1938

[2] J. F. Morrison, Simple Method For Observing Current Amplitude and Phase Relations in Antenna Arrays, *Proc. I. R. E.*, Oct. 1937

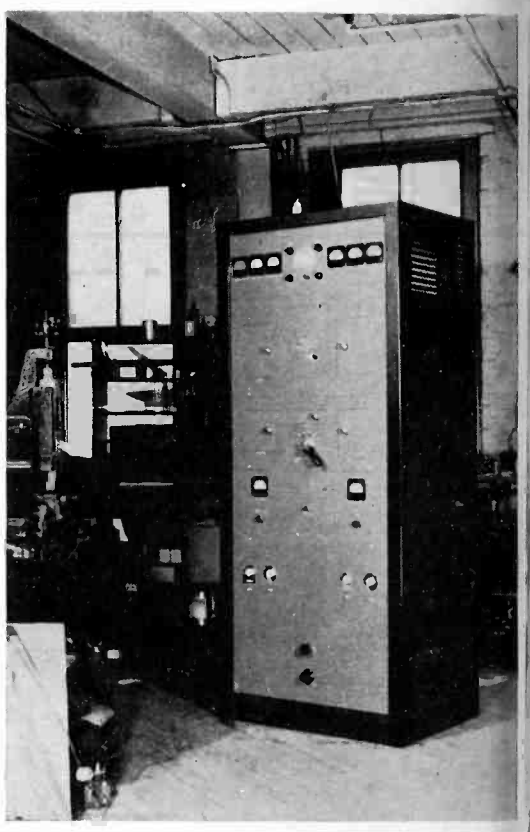
[3] G. H. Brown, Directional Antennas, *Proc. I. R. E.*, Jan. 1937

Multi-Frequency Marine Transmitters

FIVE NEW radiotelephone and telegraph transmitters, rated at 200, 350, 500, 750 and 1000 watts, have been announced by the Marine Radio Corporation, 91 Third Avenue, New York, N. Y.

The transmitters proper are mounted in modern dual wall type cabinets and finished in slate gray wrinkle with corner trim of smooth black. The high gain speech amplifier is furnished in a separate console cabinet for desk mounting. Components are mounted on removable chasses so arranged that every part is readily accessible. Interconnecting cables are carried inside the inner walls and terminate in newly developed Mycalex insulated connectors, eliminating unsightly cables and lugs.

All units are of ample rating and will not overload nor cause loss of stability when operated at their maximum rated output, nor will distortion occur in the audio channels. A feature of "Marine" transmitters is that all transformers from the largest plate transformer and choke to the smallest audio component are oil filled, an advantage when used under tropical and humid conditions.



Multi-channel transmitter

The transmitters are built for operation on a number of pre-determined frequencies. Either manual or automatic frequency change control may be had. The manual frequency change control is a single handle on the front panel. The automatic frequency change

control is a group of push buttons (each button representing an operating frequency), or a telephone type dial, which are duplicated on the panel of the speech unit for complete remote control of the transmitter. All circuits, including the antenna, are completely pre-tuned. Quartz crystals are used for frequency control.

Modulation is high level Class B, capable of 100% modulation, at which the amplitude distortion is less than 5%. The a-f response is virtually flat from 50 to 10,000 cycles, plus or minus 1.5 db. The transmitters include a built-in cathode ray modulation indicator (oscilloscope) with a 3-inch screen, upon which both the trapezoidal and modulation envelope type of figure may be produced.

The Marine antenna network efficiently transfers the output of the transmitter to the antenna as well as eliminates the radiation of harmonics of the operating frequency. Normally, provision is made for connection to a balanced two-wire transmission line having small reactance and a resistive impedance of about 500 ohms. With the Marine method the full output is transferred to the antenna on the fundamental frequency, harmonics being almost entirely eliminated. The energy lost in harmonics with other methods is therefore used to full advantage on the fundamental, increasing the overall effective output of the transmitter.

Power is taken from 115 or 230 volt, single phase 50/60 cycle lines, although other voltages and frequencies may be provided on special order. A panel control auto-transformer compensates for variations in line voltage. Vacuum tubes, transformers and other components are at all times protected by the extensive use of automatic fast-acting relays, time-delay devices and fuses. A master relay is incorporated in the frequency control mechanism which removes all plate voltages while changing frequencies so that quick frequency change may be accomplished without the necessity of shutting down the transmitter. Illuminated meters are used to provide complete metering of all essential circuits. Adequate ventilation is provided by fine mesh bronze screened louvres in the side walls and doors as well as a ventilating fan.

News

✦ Licensing agreements have been concluded between American Screw Co., of Providence, R. I., and the following: Chandler Products Co., Euclid, O.; Scovill Mfg. Co., Waterbury, Conn.; Pheoll Mfg. Co., Chicago; Lamson & Sessions, Cleveland; Continental Screw Co., New Bedford, Mass.; Corbin Screw Corp., New Britain, Conn., and National Screw Mfg. Co., Cleveland. The Phillips recessed head screws have a wide application in air-craft, electrical appliances, motor cars, etc. . . . Clark Controller Co., Cleveland, has acquired

Chief Engineer Jesse Marsten (left) who has recently assumed additional duties as Vice President, and Harry A. Ehle, who will remain in charge of Industrial Division sales in addition to assisting the President at International Resistance Company, Philadelphia

control of the Invex Corp., Bethlehem, Pa., an electrical research organization which is being moved to the Clark plant. Invex is retaining its corporate identity with W. H. Williams as President and Palmer H. Craig as Vice-President and its developments will be made and sold by the Clark organization. . . . Ansley Radio Corp., makers of the Dynaphone radio-phonograph combinations and electronic pianos, has acquired the Cornell-Dubilier plant at Bronx Blvd., and 238th St., Bronx, N. Y., as its new factory. . . . Nathan Schnoll, former chief engineer with Solar Mfg. Corp., has organized his own company known as Industrial Instruments, Inc., Bayonne, N. J. . . . Roller-Smith Co., Bethlehem, Pa., announces the appointment of James E. Bevan as Assistant Chief Engineer. . . . Finch Telecommunications Labs announced that arrangements have been made with International News Service to use highlights of their general news reports for facsimile transmissions from their station W2XBF.

Literature

Mobile Radio. Bulletin 250 describes two-way mobile radio for police and fire service. Bulletins 252 and 253 contain information on uhf radio telephone stations, and bulletin 255 describes Frequency Meter Monitor and Signal Generator. Radio Engineering Labs., Long Island City, N. Y.

Handbook Catalog. Illustrates and describes wires, cables and flexible cords for industrial uses. Rockbestos Products Corp., New Haven, Conn.

Control Thermometer. Industrial Indicating Control Thermometer, Series 4200 described in bulletin 4201. Wheelco Instruments Co., 1929 S. Halsted St., Chicago.

Wide Frequency Response Recorders. Various models illustrated and described. Allied Recording Products Co., 126 West 46th St., New York City. A new catalog which lists recorders and other products is also announced.

Engineering Bulletins. "Heater-Cathode Leakage as a Source of Hum" gives methods of predicting hum by calculation and means of reducing hum in Bulletin 38-1. "Effects of Electrode Voltages on Conversion Gain of Pentagrid Convertors 6A7, 6A8GT" tables and discussion given in Bulletin 39-2. Radio Tube Division, Tung-Sol Lamp Works, Inc., Newark, N. J.

Receiving Tube Characteristic Chart. No. 1275-B gives data on 191 RCA tubes. Commercial Engineering Section, RCA Mfg. Co., Harrison, N. J.

Transformer Catalog. Spring-Summer edition. No. 400-CX. Thordarson Electric Mfg. Co., 500 W. Huron St., Chicago, Ill.

Radio "A" and "B" Batteries. For standard makes of 1.4 volt portable receivers. Leaflet available. U. S. Electric Mfg. Corp., 222 West 14th St., New York City.

Agastat. A timing unit described in bulletin No. 4. American Gas Accumulator Co., Elizabeth, N. J.

Magnets. "Little Giant Magnet" describes cast permanent magnets for loud speakers and electrical instruments. Crucible Steel Co. of America, Chrysler Bldg., New York City.

General Catalog. No. 10-A. Describes microphones and cable connectors. Carbier Microphone Co., 439 S. La Brea Ave., Inglewood, Cal.

Cathode-ray Tube Wall Chart. A two-color lithographed chart tells the story of cathode-ray principles at a glance. Price 50c. Allen B. Du Mont Labs, 2 Main Ave., Passaic, N. J.

Pilot Light Assemblies. Also signal indicator jewels and socket assemblies. Dial Light Co. of America, 136 Liberty St., New York City.

Time Recorders. "The Graphic" tells how to select, apply and use them. 6-page bulletin, No. 139. The Esterline-Angus Co., Indianapolis, Ind.

1939 Catalog. Second Edition, includes new items of Hammarlund Mfg. Co., 424 West 33rd St., New York City.

Switchboard Instruments. Round and rectangular types described in catalog No. 48. Catalog No. 48-b describes Type FA (4 inch) a-c frequency meters. Roller-Smith Co., Bethlehem, Pa.

Electricity and Wheels. An interesting booklet tells about the progress of electricity. General Motors Corp., B'way and 57th St., New York City.

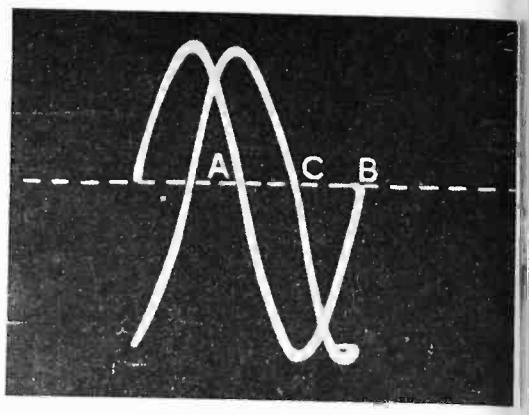
Application Note. No. 102. On the 6SK7 as an i-f amplifier. RCA Mfg Co., Harrison, N. J.

Rectifier Power Supplies. Also vibrator-operated instruments. Described in catalog No. 139. American Television & Radio Co., 300 East 4th St., St. Paul, Minn.

New Products

Electronic Switch

A SQUARE WAVE GENERATOR, with no moving or vibrating parts, Type 185 of Allen B. Du Mont Labs., Inc., Passaic, N. J., provides electronic switching so that two phenomena appear to be present at the same time. It is possible to observe not only the amplitude



and form of two waves, but also their phase relationship. The switching rate is approximately 6 to 2,000 times per second, permitting observations of either extremely low or high frequencies. As a generator it may be used between 60 and 400 cps.

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Among its pages will be found articles for the commercial photographer; the advanced amateur; the scientist and industrial engineer who use photography for technical purposes; for physicians, surgeons and x-ray technicians; for news photographers; for the motion picture photographers, and others who want to make use of improved scientific photography.

There will be considerable space devoted to the technique of the various branches of photography: — processing films — plates and prints — printing by contact and projection — exposure meters — filters — light sources — high speed motion — quick operating light sources — crime prevention and solution — radiographic — x-ray — infrared — ultraviolet — astronomy — astrophysics — spectroscopy — metallography — stress analysis — mineralogy — photomicrography. Emphasis will be placed on the measurement and specification of the characteristics of photographic materials, their advantages, uses and applications.

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4-39-L

Coaxial Cable Connector

DEVELOPED BY Cannon Electric Development Co., Los Angeles, the plug is housed in a wall fitting and the receptacle is mounted in a 90° shell. The coaxial poles are completely shielded through the plug and the receptacle. The unit is designed for television cameras.

Instantaneous Recorders

DESIGNED FOR MANY uses by RCA Mfg. Co., Camden, N. J., console Model MI-12700 will record and reproduce at speeds of 78 or 11⅓ rpm, using 10, 12, or 16 inch records, either outside-in or inside-out, and has a visual indicator meter, h-f amplifier, loudspeaker, tone and volume controls. Portable Model MI-21701 is complete with microphone and records and reproduces 10 or 12 inch records, at 78 rpm.

Portable Magnetometer

TRIPLETT ELECTRICAL Instrument Co., Bluffton, Ohio, announce an indicating instrument (4 inch sq type), which has a D'Arsonval movement without magnet. The magnet to be tested is placed in contact with protruding pole pieces, furnishing the required magnet field for the instrument. The pointer moves

across the scale in accordance with the setting of the milliammeter, and indicates the comparative strength of the magnet. Variations of the rheostat-milliammeter control makes it possible to check magnets of different strengths. Source of current is self-contained No. 6 dry cell battery.

Fuse Clips

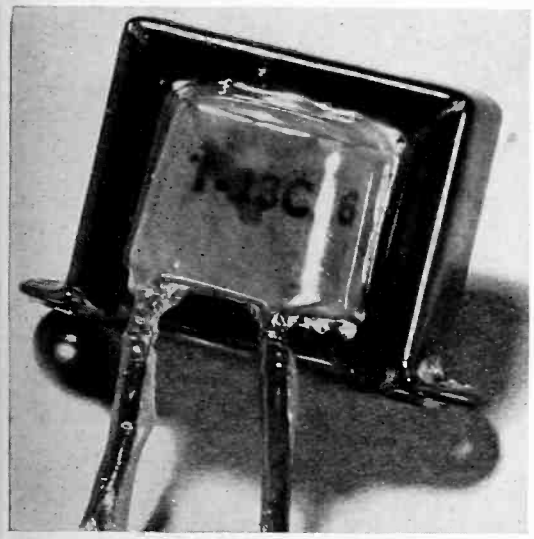
FOR CAP SIZES ¼ to 13/16 inches of beryllium copper having high resistance to fatigue, heat and vibration in aircraft, portable tools, etc., Littlefuse, Inc., 4238 Lincoln Ave., Chicago. Beryllium copper will withstand a vibration pressure of 35,000 to 40,000 lbs. per sq. in. almost indefinitely. These clips will withstand prolonged temperatures up to 200° C. without losing tension. The standard finish is cadmium plate.

Screw Thread System

"AERO-THREAD" SCREWS and studs feature the use of a spirally wound insert or bushing of precision formed, high tensile, bronze spring wire. This insert fits into the tapped hole by screwing into the threads and when once it is installed it becomes a fixed part of the tapped hole and in final assembling the stud or cap screw bearing is against and in direct contact with the spiral bronze insert instead of against the softer metal of the light alloy part. The Screw Thread system, available in all sizes from Air Associates, Inc., Garden City, N. Y., has application to all threaded parts, particularly those where high strength and shock resistance are required, or where fastenings are to be made in the light alloys or similar soft metals.

"Tropex" Transformers

"TROPEX" IS A SPECIAL transparent and elastic compound which is highly resistant to salt air, high humidity, excessive



moisture, etc., and is used by Thordarson Electric Mfg. Co., 500 W. Huron St., Chicago, as an additional protection for their "Tropex" transformers.

Time Totalizer

AN INSTRUMENT OF Production Instrument Co., 710 W. Jackson Blvd., Chicago, "Time Totalizer" consists of number of wheels geared to a synchronous motor so that they record time in hours and tenths of hours. When connected in parallel with a motor, radio, X-ray or diathermy apparatus, lighting circuit or other ac circuit, the instrument automatically accumulates the total "on time." It can be used to measure the actual life of tubes and other apparatus.

Fluorescent Materials

FOR TELEVISION TUBES. Callite Products Div. of the Eisler Electric Corp., Union City, N. J., announces that silicates and tungstates in all colors in the spectrum are now available.

Pencil Drafting Cloth

"PENCIL-TEX" MAY SOON eliminate the use of ink in drafting rooms, claim Frederick Post Co., Box 803, Chicago, Ill. The new item is of similar appearance to fine tracing cloth but has a new and patented velvety surface with a good affinity for pencils of all degrees of hardness. Line intensification, together with a glass-like transparency, permits the production of a blue print without the characteristic fuzzy lines of an ordinary pencil drawing. A sample kit is available.

Set Tester

"HAMMETER" IS A SELF-CONTAINED, pocket-size, portable instrument (designed primarily for the amateur) of Simpson Electric Co., 5216 S. Kinzie St., Chicago, Ill., which was built expressly for checking high voltage and all component parts of transmitters and receivers. Some of its features are: Guaranteed accurate within 2% on dc and 5% on ac; a copper oxide rectifier is built into the meter for ac voltage ranges, and a battery is provided for ohmmeter ranges; voltage 3000; test cables insulated for 5,000 volts; Simpson D'Arsonval movement with bridge-type construction and soft pole pieces. Literature is available.

Microphones

A DYNAMIC MICROPHONE, Type 1245 for high impedance and Type 1245A for low impedance (200 ohms), utilizes a moving coil mounted on a Dural diaphragm. The frequency response is at from 50 to 9,000 cycles and the output level is —56 db. The assembly includes a balanced quadropi type winding transformer to eliminate stray electromagnetic pickup.

Webster-Chicago Co., Chicago, also announce Type 1236, a diaphragm type crystal microphone which is especially adapted to high quality PA work. The high capacity torsion-drive crystal is moisture-sealed. Reproduction range is from 40 to 10,000 cycles and the output level is —52 db.

Generating Plant

A SELF-CONTAINED self-regulating electric generating plant, Model H-H-9, 80 KVA unit, is manufactured by Bardco Corp. of America, Los Angeles. An automatic voltage regulator, containing no moving parts, tubes, spring tensions, or carbon piles in its construction, will maintain 2% voltage from no load to full load. Time interval from cold start to full speed and voltage is reported to be 4.5 seconds. It was designed mainly for broadcasting stations for an emergency standby plant that can be put into operation at a moment's notice. Range of plant capacities are from 5 kva to 80 kva.

Vacuum Tube Voltmeter

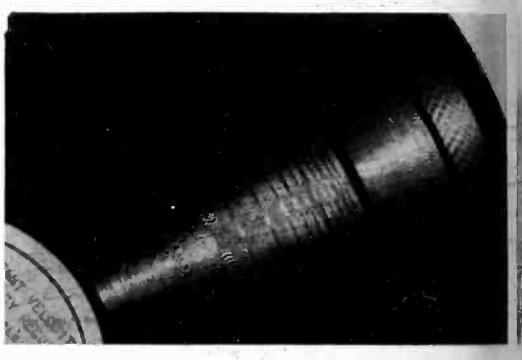
MODEL XII VOLTMETER is an electronic potential measuring device featuring pushbutton ranges from 3 to 3,000 volts on a-c or d-c circuits. It will not disturb circuit under test; has an input impedance of 24 megohms. The instrument covers 30 cycles to 40 megacycles and is a-c operated. Million Radio & Television, 685 W. Ohio St., Chicago.

Grid Control Rectifier

UNITED ELECTRONICS CORP., 42 Spring St., Newark, N. J., announced a new rectifier, No. 967, which corresponds to the 866-A with the exception that it is a thyratron and may be used for voltage regulation, voltage control and keying circuits in amateur transmitters.

Constant Velocity Record

A STANDARD 12-INCH PRESSING recorded at 78 rpm has 3 frequency runs, the first consisting of the glide frequency recording from 50 to 10,000 cycles with



breaks at regularly spaced intervals. During the breaks in this Universal Microphone record (Inglewood, Cal.) a voice announces the frequency.

Blue Print Machine

ELPRO PRINTER of Electronic Products Mfg. Corp., 208 W. Washington St., Ann Arbor, Mich., is: Portable; easy to operate; produces drawings of a limited size, and makes prints in from 1 to 5 minutes.

Microphones

SHURE BROS., 225 W. Huron St., Chicago, enter the dynamic microphone field with two models. Model 50 "Rocket" (utilizes the principle of a moving-conductor in a magnetic field) is intended for PA, remote broadcasting, recording, call systems, etc., and has a response of high-quality wide-range (± 5 db 70–7000 cycles) with semi-directional pickup characteristics. Available in 35–50, 200–250 ohms and high impedance output. Model 55, "Unidyne" is a cardiod type uni-directional moving coil dynamic microphone covering a frequency range of from 40 to 10,000 cycles.

Amplifier

AMPLIFIER CO., OF AMERICA, 37 West 0th St., New York City, announce a 34 att, master beam power amplifier with ne following characteristics: High and w frequency equalization, 10 db cut or oost at 20 cycles or at 10,000 cycles; egenerative inversion; dialogue filter; ush-pull beam power drivers; stabi- zed power supply; calibrated output eter; automatic volume expansion and ompression; two microphone input annels, one photo input channel; uni- ersal output for from 0.3 to 500 obms; ve stages, 135 db maximum gain, esponse is flat within 1 db 20 to 20,000 cles, noise 60 db below maximum out- ut.

Telephones

CA MFG. CO., CAMDEN, announce a und powered telephone which has en in use by the U.S. Navy for several ears and is now commercially avail- ble. Model PB112B1 handset type in- udes a transmitter unit, a receiver nit, and a line-connecting switch de- gned to operate under pressure with- t loss of efficiency or change in uality, especially in locations where anges in pressure, or constant pres- ures other than normal atmospheric ressures may be expected such as in a ip's fire room, etc. The unit is water- roof and will stand total immersion. rinciple of operation is described in etail in available literature.

ESTERN ELECTRIC announce Models 50A and 751A loud speaking tele- hones, which will handle speech or usic with maximum peak powers of 20 atts. Characteristics are: Impedance, pproximately 8 ohms; efficiency is qual to direct radiator type speakers similar size; a wider and more uni- orm frequency response range (from 60 10,000 cycles); angle of coverage etween 30 and 45 degrees.

Also announced by Western Elec. is a ound powered magnetic telephone, Model 11A, designed primarily for ship- oard where failure of an electrical sup- ly system will not affect the telephone peration because its electrical voice urrent is generated internally by the mpact of sound waves on a special iaphragm independent of external ower. A self-contained, hand operated enerator provides for signaling. The nit is water-tight, weather-resistant nd can be adapted for service in con- truction camps, warehouses, and other xposed locations.

Mike-Lite

A STAND MICROPHONE with adjustable pot lights to halo the features of rtists or speakers is available from stastic Microphone Lab., Inc., Youngs- own, O. Each unit is equipped with 5 ft of one-wire shielded cable and 5 ft of a-c lamp cord with trans- ormer. Also announced is Model E4P rystal pickup with tone equalizer.

Televerter

MODEL 772 WILL EXTEND the range of 20,000 ohms-per-volt analyzers to 5,000 volts. The unit consists of resistor tube, two test leads, prods, and a mounting clamp. Maximum current drain is 50 microamperes with an input impedance of 100 megohms on the top range. This is a new Weston Electrical Inst. product.

Concentric Cables

DISC SPACER TYPES TELCON cables have been designed for hf transmission over considerable distances and have a dielectric embodying the maximum amount of air space consistent with mechanical stability. The dielectric constant is less than 1.1 and a power factor less than 0.0005. Several types are available from Charles Parrag & Co., Inc., 56 East 11th St., New York City, in which the ratio of diameters of outer and inner conductor is arranged to give minimum capacity or minimum attenuation, or a definite characteristic impedance according to requirements.

Other products available from Parrag Co. are: cables for broadcast relay; and also Gutta-Percha aluminum foil (widths from ½ inch to 24 ins) which can be used for screening against electrical interference or other uses. Literature is available.

Filter

AN ELECTRIC SHAVER FILTER has been developed by J. W. Miller Co., Los Angeles, Cal. It consists of two duolateral wound chokes of .03 mh inductance and a condenser of 0.03 μf. The filter is plugged in between the electric shaver and the lamp socket.

Other New Products

Because of space or time limitations the following new products cannot be accorded a paragraph by themselves. They merit attention, however.

Volume Level Indicator, Type 30, of Weston Electrical Instruments, Newark, N. J., which is a monitoring instrument whose performance conforms with the joint findings of NBC, CBS, and Bell Telephone Labs. See February 1939, page 28, and also July 1938, page 62, *Electronics* for further descriptions.

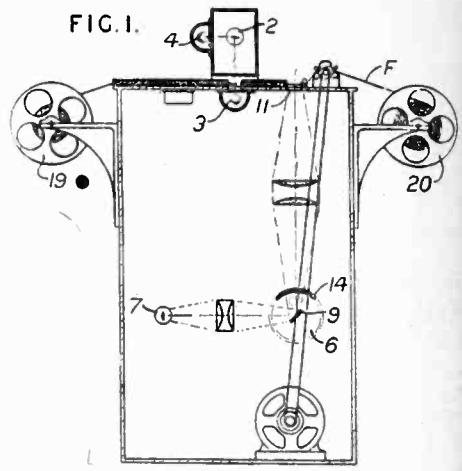
Improved paper tubular capacitor, Cornell-Dubilier Elec. Corp., S. Plainfield, N. J. **Improved radio noise locator Model** 239, Tobe Deutschmann Corp.,

Electrode Materials. A secondary-electron-emitting electrode comprises a conductive base, for example of nickel, aluminum, silver, copper or alloys thereof, carrying a thin layer of an insulating derivative of an alkaline-earth metal, particularly the borate, on which is deposited an electron emissive layer, preferably an alkali-metal such as caesium or its oxide. The layers are preferably not greater than ·001 inch. The electrode exhibits the thin film field emission phenomenon of Malter. The borate is evaporated onto the conductive base from a heated filament. 491,287, Marconi Co.

Direction-finding. Apparatus for detecting and indicating the presence of objects, for example aircraft. W. J. Rickets. No. 494,667.

Exposure Control. The second exposure in the treatment of reversible photographic films is controlled by a system comprising two photoelectric

FIG. 1.



cells of the barrier type connected in series opposition and in parallel with an ammeter and a galvanometer. No. 493,932. A. L. Debrie.

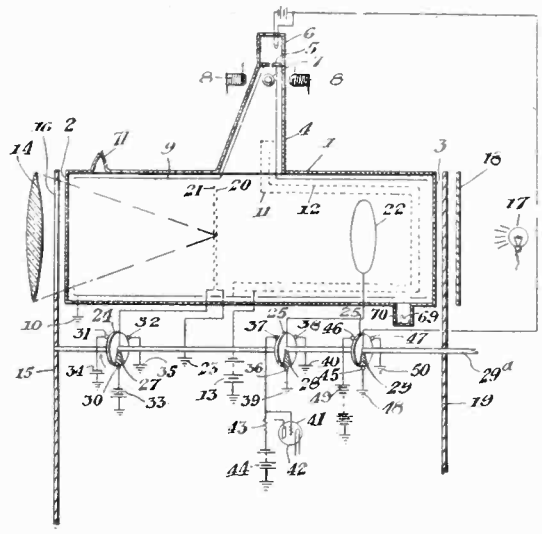
Drilling Machine Control. Application of photoelectric tube to drilling machines. Patents No. 495,762 and 495,818, to Associated Equipment Co.

Television

The following patents have been granted to P. T. Farnsworth of Farnsworth Television Inc., San Francisco: No. 2,135,615, a current amplifier of the multipactor type. No. 2,139,813, secondary emission electrode. No. 2,139,814, cathode ray tube. No. 2,140,284, projecting oscillight. No. 2,140,285, a multiplier coupling system. No. 2,140,832, means and method of controlling electron multipliers. No. 2,143,145, projection apparatus for projecting optical images from a motion picture film. No. 2,143,146, method of operating electron multipliers by generating electrons of random velocities, separating those electrons having velocities within a desired range, admitting a number proportioned to the amplitude of the signal to be amplified, etc.

Television System. Impressing an image upon a photosensitive surface, means for scanning a surface other than the photosensitive surface to cause the emission of an electronic stream of constant intensity from the other surface, means for causing the formation at one time of an electrostatic reproduction of the whole of said image to modulate said stream, an anode for picking up the modulated stream, and means for thereafter causing said electrostatic reproduction to disappear. F. C. P. Henroteau, RCA. Application dated Dec. 15, 1932. No. 2,146,822.

Transformer. A high frequency coupling network comprising a transformer with primary and secondary windings and a shielding for preventing the capacitative coupling effect in order to have a purely inductive coupling between primary and secondary;



etc. Kurt Schlesinger, D. S. Loewe. No. 2,147,553 to 2,147,559, inclusive.

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E.E.; RADIO, MEASURING and Control Devices; ten years experience in Development and Production; Mechanically skilled; also Ultra High Frequency experience; Business experience; Excellent references; salary secondary to opportunity. PW-203 Electronics, 330 W. 42nd St., New York, N. Y.

RADIO ENGINEER, now employed, desires permanent connection anywhere. Experience, four years broadcast engineer and three years development and manufacture of inter-communication equipment. Best of references, first class telephone license. PW-200 Electronics, 520 N. Michigan Ave., Chicago, Ill.

JUNIOR ELECTRICAL ENGINEER, communication, electronics, B.S., Maine University. Desires interview for employment on trial anywhere. Research, design, production, service. PW-196 Electronics, 330 W. 42nd St., New York, N. Y.

POSITION WANTED

DEVELOPMENTAL ENGINEER having three years of electrical experience, also registered patent attorney, desires developmental work with concern that can advantageously use patent attorney. Best references. MSEE degree. Can prosecute patent applications, design non-infringing apparatus, and prepare priority records. PW-201 Electronics, 330 W. 42nd St., New York, N. Y.

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SALES OR DEVELOPMENT ENGINEER, American born citizen, five years business experience England, traveled Europe, Far East, hold patents automatic machinery, tensile testers, printing scales, photo electric circuits, 5 years textile plant maintenance, age 35, locate anywhere. SA-202 Electronics, 330 W. 42nd St., New York, N. Y.

SPECIAL INSTRUCTION

RADIO Code Course on three Records with Instruction Book. Self-teaching. Dealer's Net $5. Poinsettia, Inc., Ralston, Pitman, New Jersey.

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ANYTHING within reason that is wanted in the field served by Electronics can be quickly located through bringing it to the attention of thousands of men whose interest is assured because this is the business paper they read.

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