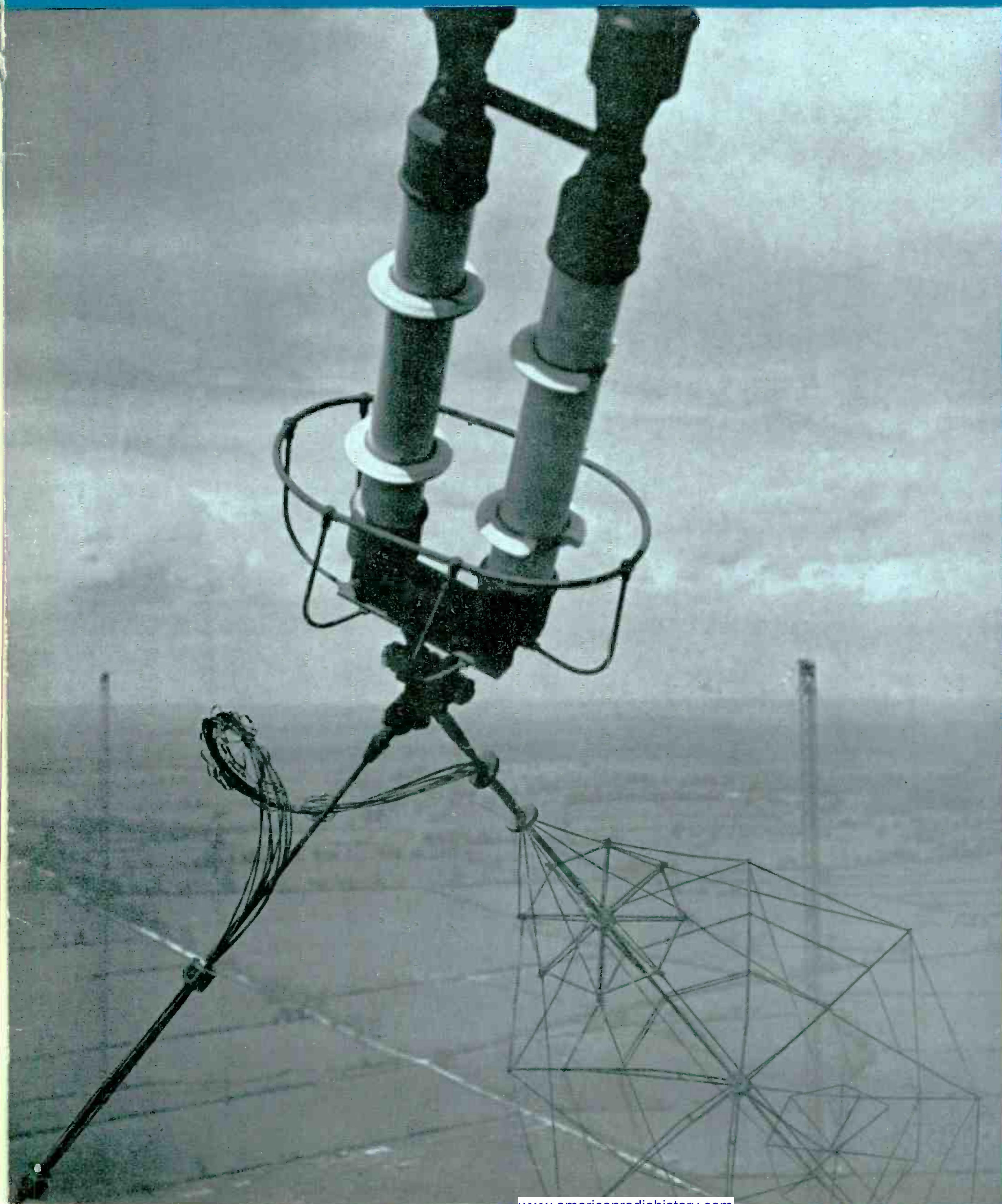
electronics

radio, communication, industrial applications of electron tubes . . . engineering and manufacture



APRIL
1938

Price
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electronics

RADIO . . . COMMUNICATION AND INDUSTRIAL APPLICATIONS OF ELECTRON TUBES . . . DESIGN . . . ENGINEERING . . . MANUFACTURE

CONTENTS—APRIL, 1938

DEPARTMENTS

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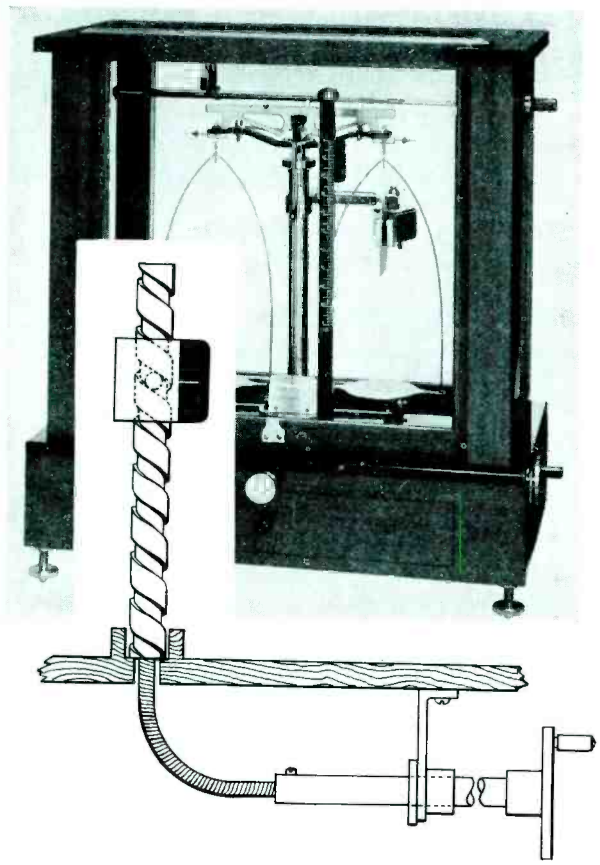

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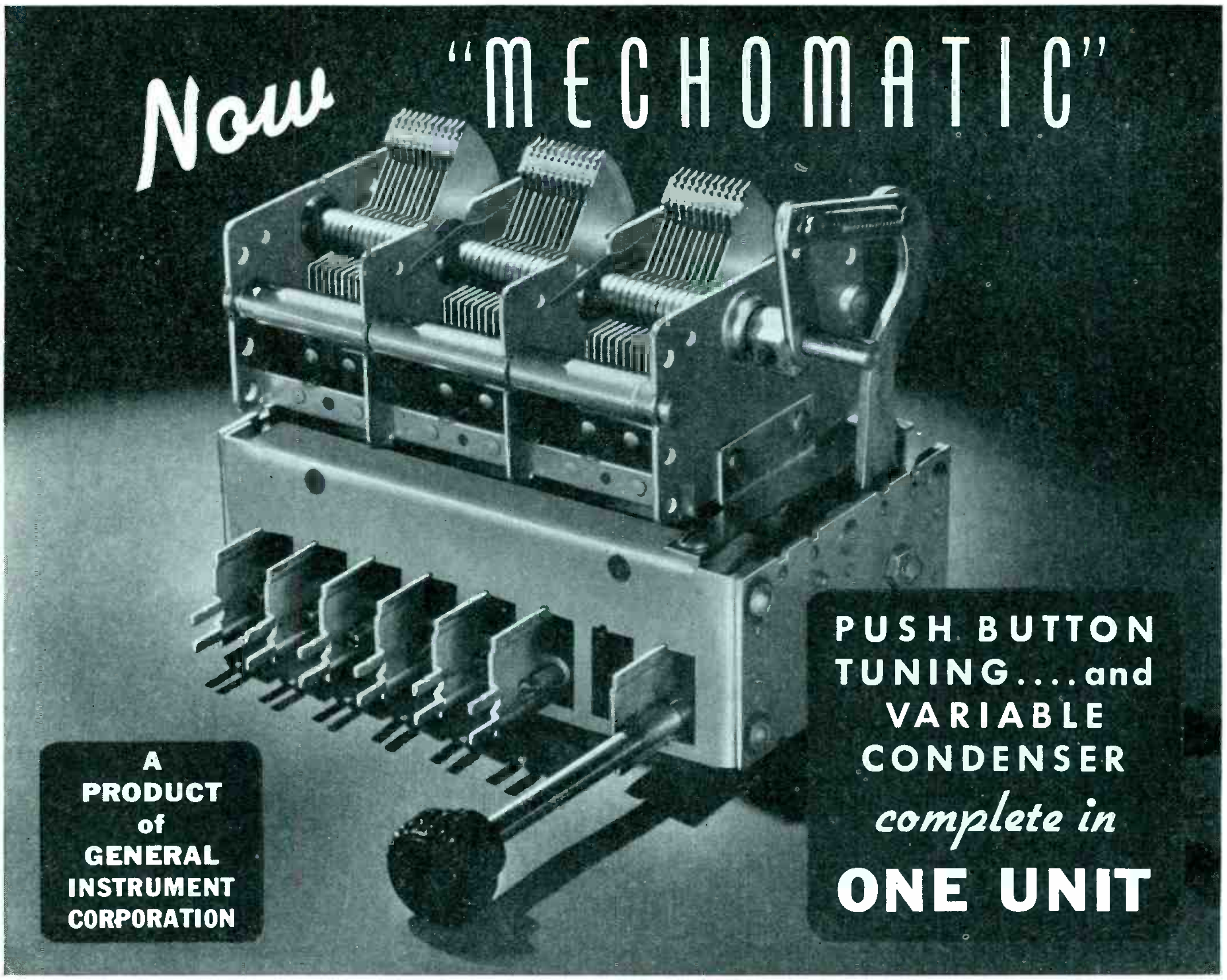

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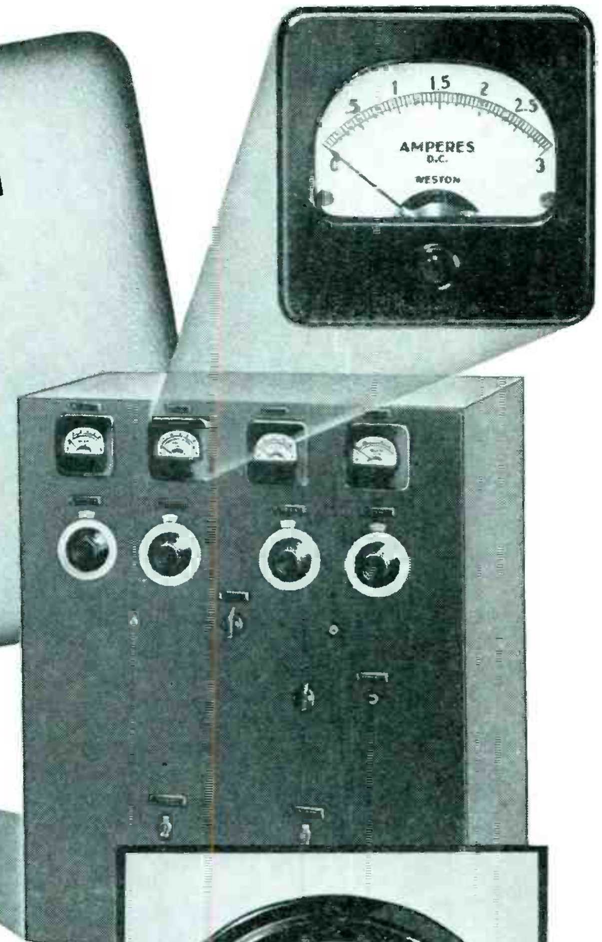

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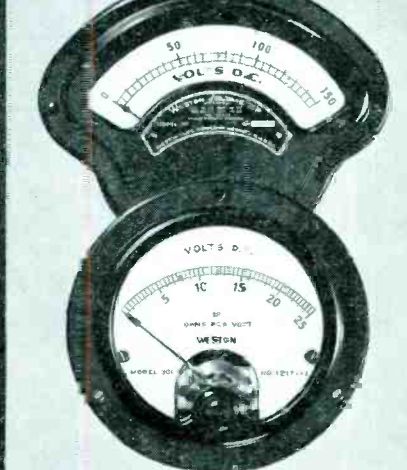

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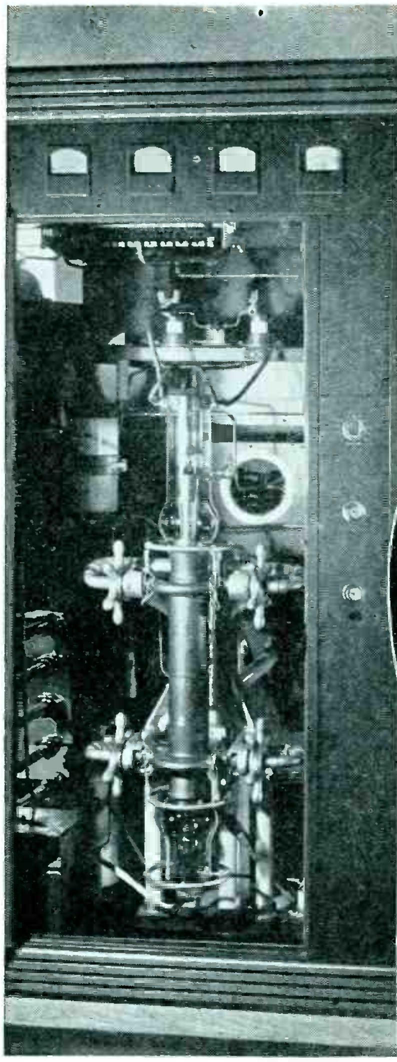
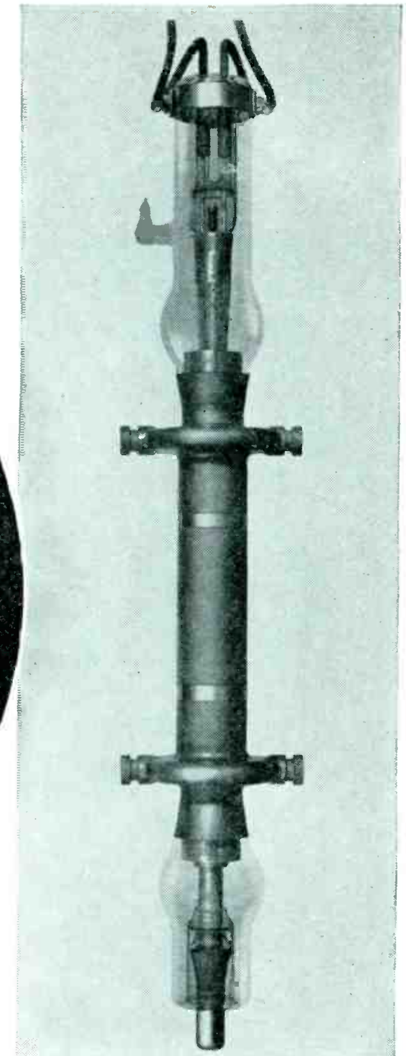


One of two 100 KW tubes in final amplifier stage of Western Electric's new 50 KW transmitter. Note accessibility.

NEW 100 KW TUBE



The Western Electric 298A

. . . with these outstanding features

Extra large filament assures long life and low tube hour cost.

Double ended construction: water jacket is a permanent part of anode structure—permits quick change of tubes without using tools. Also permits operation at higher frequencies than are possible with other tubes of comparable ratings.

In the Doherty Circuit, two 298A's make an ideal final amplifier stage for 50 KW transmitters.

Copper-to-glass seals used for all lead-ins permit safe operation without cooling air streams.

Copper lead-in and terminal for grid allows safe conduction of charging currents and heat.

Filament tension spring located in relatively cool portion of tube.

Hand wheels of tube mounting facilitate quick changes.

Designed by Bell Telephone Laboratories.

Rating Information

Nominal Filament Voltage	27 volts
Average Filament Current	225 amperes
Average Filament Emission	35 amperes
Amplification Factor	32
Average Plate Resistance at 18,000 v. and -250 v. bias	1450 ohms
Transconductance	22,000 micromhos
Normal Water Cooling Flow	40 gals. per min.
Maximum Plate Dissipation	100 kw.
Maximum Plate Voltage	20 kv.
Maximum Plate Current	11 amperes
Approx. Inter Electrode Capacities	
Plate to Grid	48 mmf.
Plate to Filament	10 mmf.
Grid to Filament	31 mmf.

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RADIO TELEPHONE BROADCASTING EQUIPMENT

ELECTRONICS

APRIL 1938

KEITH HENNEY
Editor

Crosstalk

▶ **TRANSLATIONS PLEASE . . .** From time to time *Electronics* has been honored with technical manuscripts from Germany, Russia and other countries in which languages other than English are spoken. Some of these articles have found their way into the editorial pages. The responsibility of having these manuscripts translated has fallen upon the editors who have farmed out this task to engineers more conversant with the languages concerned. This responsibility, however, is a real one since shades of meaning are often not correctly handled with the result that the author is not satisfied.

It has been decided, therefore, that manuscripts for editorial consideration should be presented in English thus shifting to the author the translation difficulty. Authors will be paid at rates which apply to any contributor; whereas authors in the past have only received the difference between these regular rates and the cost of translation.

▶ **WEAF, WJZ . . .** All of NBC's 50 kw stations are undergoing technical changes. WEAF and WJZ are already on the air with the new arrangement which involved widening the transmission band so that it covers without loss the region between 30 and 17,000 cps; the use of reversed feedback to decrease distortion by a factor of 30 db; and extensive changes to reduce audio phase shift so that the wide frequency band could be utilized.

New studios and a new anti-fading antenna are going into WTAM plus the same improvements made at WJZ and WEAF; WRC sports a new high fidelity transmitter and a new anti-fading antenna.

▶ **TRENDS . . .** Much of the economic plight of the railroads is blamed on trucks, airplanes, automobiles. Call this technological advance, or something. Government competition is worrying the public utilities greatly. But diesel motor power plants of small size for use by the private individual are coming into great popularity. Perhaps this is technological advancement.

Increasing numbers of stations in the limited broadcast spectrum require receiver manufacturers to increase selectivity at the cost of tone fidelity. Stereotyped programs, poor receiver tone quality, advertising blurbs that are too long or too blatant may have something to do with the steadily increasing sales of phonographs and records. In March was described a new pickup which has a very wide frequency range, and which conserves record life. Furthermore, frequency modulation as a system for providing high fidelity noise-free entertainment is to undergo its first large-scale test when summer static begins this year.

Broadcasting, complacent technically, has less to fear from Government than from complacance. Radio listeners may find other, and perhaps better, means of getting their music. And engineers may find other and better means of transmitting uncanned music leaving the old timers in the present position of the railroads—lots of track but no travelers.

▶ **ANNIVERSARY . . .** Fifty-one years ago last month one of the most remarkable feats in the history of communication took place. A seven-year-old child, cut off from the world by darkness and silence, found suddenly that there was language and that she could communicate intelligibly with other people. This was Helen Keller, and her teacher was Anne Sullivan (Macy). For the deaf and blind, words are mere thumps and movements of another person's hands, spelling by means of the manual alphabet.

The story has often been told. Day after day Miss Sullivan spelled words into Miss Keller's hands. But there was no answering click. Then one day she pumped water onto Miss Keller's hands and at the same time spelled "water." Then the spark passed. Within a few hours the child, eager for knowledge learned dozens of words and within a few weeks acquired a good working vocabulary.

None of us who get joy out of making things work with the aid of our beautifully fashioned engineering and scientific tools can approach the ecstatic feeling accomplishment that must have flashed through Miss Sullivan's mind as she realized her accomplishment.

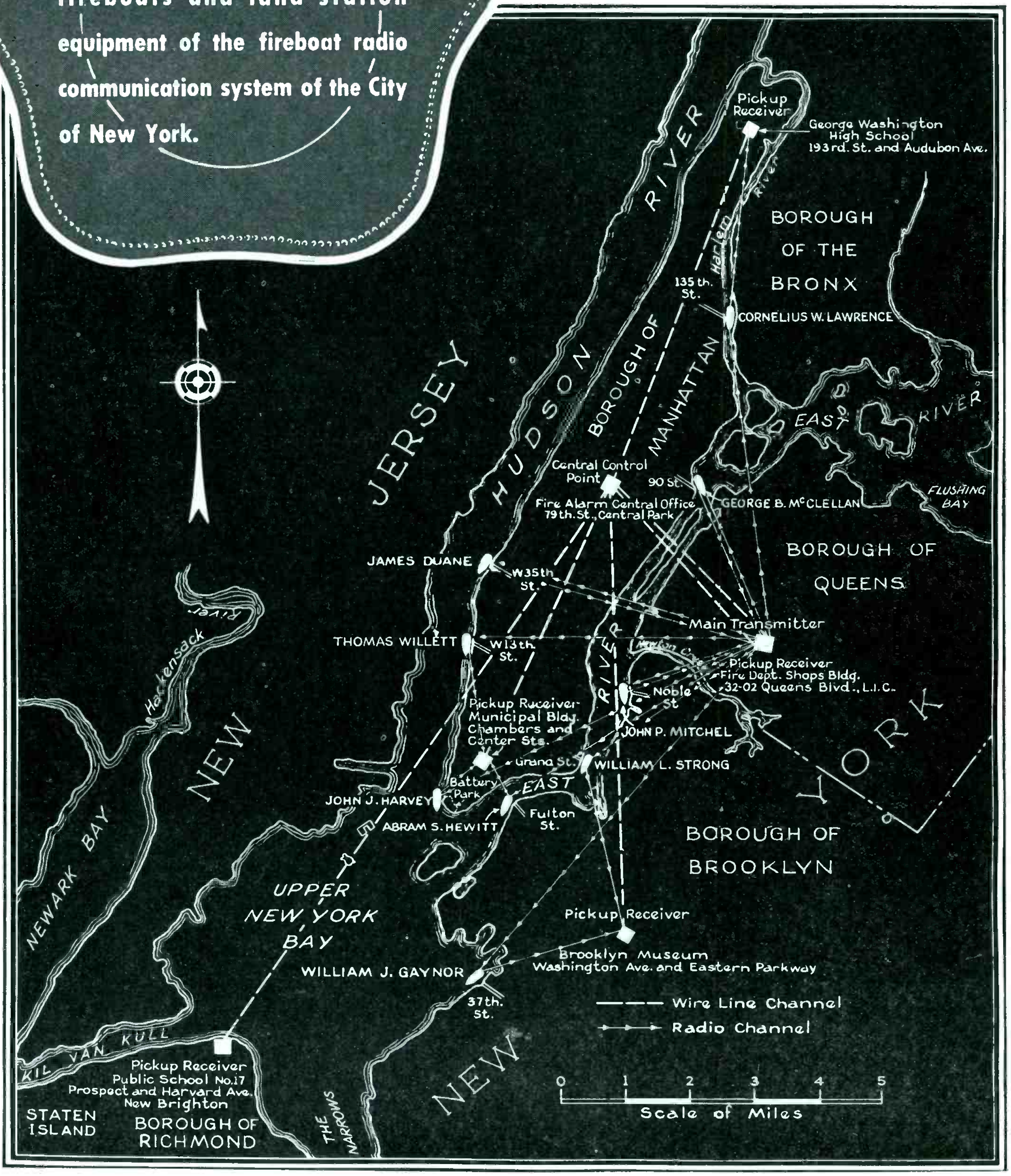
▶ **LOCAL RECEIVER . . .** For years editors and other people who don't know much about the business of manufacturing and selling radio receivers have begged manufacturers to make a local receiver, one with low sensitivity but good selectivity and wide audio range, a sort of set which one could use to hear local programs with a maximum of tonal enjoyment. Manufacturers state that they cannot sell such sets.

Now, however, RCA Victor offers for sale just such a receiver. It is called the Symphony model, it sells at $125, covers the broadcast band only, and has an audio range of from 50 to 7000 cycles. It tunes exclusively by push button.

For reasons aside from the purely personal pleasure of proving our point, we hope Victor sells a million of these sets and with it pushes the audio-skimping jobs off the market.

▶ **SLICK . . .** Nifty little items have recently appeared on the market in the form of tape recorders that can be connected to the output of an all-wave receiver (or any other set that gets code). These are inexpensive, employ chemically treated tape, and when connected to the set make it into a code reader. Of course the general run of code stuff that floats through the short waves make poor reading because it is in certain commercial code forms as well as in Continental Morse. But Arlington still sends good English, and certain news broadcasts in code anticipate the newspapers by a half day or so.

Map of New York Harbor and environs showing locations of fireboats and land station equipment of the fireboat radio communication system of the City of New York.



New York City's Fire Boat Communication System

By FRANK BORSODY

Radio Supervisor
Fire Department, City of New York

NINE large "floating engines" or fire boats, in addition to hundreds of pieces of land fire-fighting apparatus, are operated by the Fire Department of the City of New York. Upon the nine fire boats falls the responsibility for protecting the 651 miles of waterfront, and the immense amount of shipping within the boundaries of the Port of New York, one of the wold's largest seaports. It was early realized that radio communication applied to the fire boat fleet would give the marine fire extinguishment service additional speed and flexibility.

Since the initial fire boat radio tests in 1913, the New York Fire Department has conducted extensive tests of various systems of radio communication. It was found that many local factors existed that were detrimental to effective radio-telephone coverage. The dense masses of skyscrapers, and numerous large bridges absorbed the energy contained in radio waves. In many parts of the city, hills rise to three and four hundred feet above the surrounding waterways. The radio noise level, an accompaniment of urban and industrial activity, was found very high.

In recent years, when ultra-high frequency radio apparatus became commercially available, the Fire Department turned to this portion of the spectrum for a possible solution of its communication problem. Many field tests were made, using ultra-high frequency communication with fire boats. However, these field tests, like previous tests with longer waves, proved unsatisfactory.

Fireboat *John J. Harvey* off the Battery in New York Harbor

Early in 1936 a final and intensive study was made of the data obtained by the Fire Department in its many tests with medium-high and ultra-high frequency apparatus. The engineers of the Fire Department concluded that ultra-high frequency channels were unsuitable for use by the Headquarters transmitting station. One reason for this conclusion was that because of the propagation characteristics at least three Headquarters ultra-high frequency transmitters would be needed to avoid dead spots. To avoid interference with one another, the three transmitters would have to be operated selectively as to area, or on different frequencies, or synchronized. The latter method at that time would have been a major developmental problem. Three transmitters would not only be expensive, but would introduce complexities of apparatus and operation. A further disadvantage was the fact that the mobile receiving aerials would be down among interference and effects particularly inimical to ultra-high frequency radio reception.

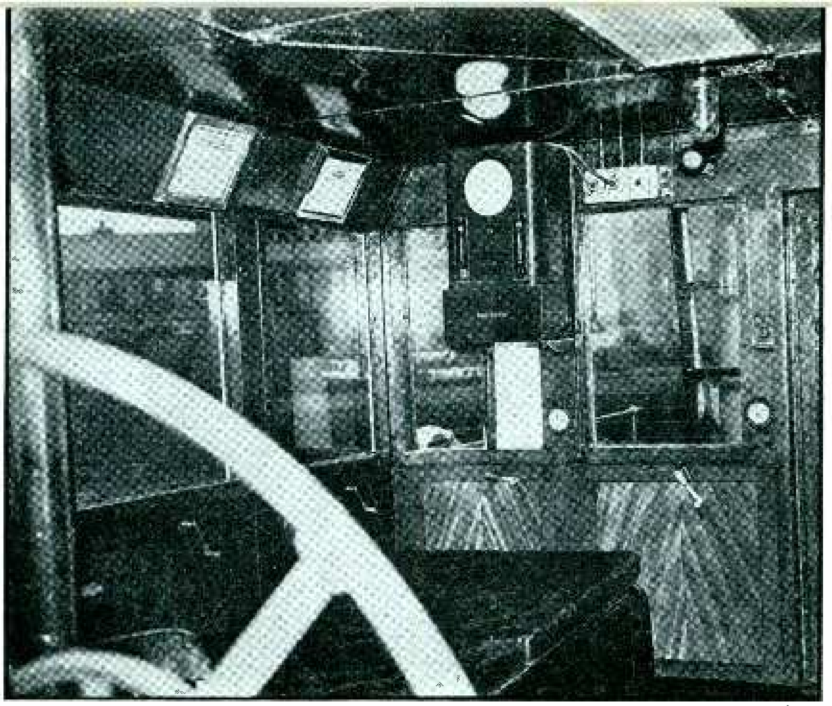
The channel specified for the Headquarters transmitter was 1630 kc, assigned by the Federal Communications Commission to the marine fire emergency service. Transmissions at this frequency exhibit to a considerable degree broadcast wavelength characteristics. A service area of reliable reception surrounds the transmitting antenna, depending mainly upon the ground wave, which can be predicted with a fair degree of accuracy.

For the fire boat transmitters, it was decided that the same frequency used by the Headquarters station, or another medium-high frequency, would be unsuitable. The mobile antenna would be too short to radiate efficiently, and it would be impossible to mount the antenna the desirable half-wave or more above the surrounding water at such comparatively long wavelengths.

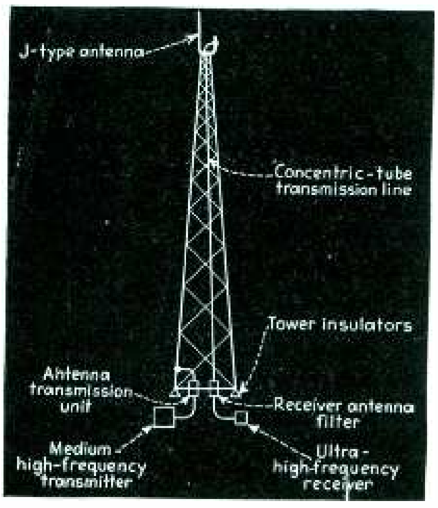
The high frequencies, from 3,000 to 30,000 kc, were considered useless for the fire boats, because of strong short- and medium-distance skip effects, changing radically during each day with the movement of the sun and seasonally.

The channels between 30,000 and 42,000 kc seemed especially suitable for the use of the fire boat transmitters. At such very high frequencies it would be possible to place the antenna so as to polarize vertically the transmitted wave, the most favorable condition with respect to propagation from a low elevation, particularly over salt water. The use of ultra-high frequencies by the fire boats would also make possible two-way radio communication with land fire-fighting units with a minimum of additional apparatus. A study of the results of previous ultra-high frequency field tests, and other data, indicated that about five properly located remote pickup receivers would be sufficient.

When the foregoing general conclusions had been arrived at, a final field test was arranged, with two purposes in mind. The first, to test the suitability of the proposed location of the Headquarters transmitter, and the second, to select the sites of the remote receivers. The site tentatively picked for the location of the Headquarters transmitter was the Fire Department Repair Shops Building, an L-shaped reinforced concrete structure 110 feet high, at Queens Boulevard and Van Dam Street, Long Island City, Queens. Preliminary examination of the site showed that this building commanded a view of the Harlem River valley, an area revealed in every previous field test as unusually difficult to "work" with radio signals. This proposed transmitter site, also, was near those sections of the city with the heaviest traffic and densest groups of tall buildings and bridges, where receiving conditions were most unfavorable. It was desired to locate the transmitter near such difficult areas, in order to place the strongest possible signal in them. In addition, the proposed site was open and elevated enough to reach efficiently the remote and less built up sections. Therefore, during the final field test, a portable transmitter was operated on 1616 kc at the Repair Shops Building, and observed aboard the fire boat making the test trips. This portable transmitter (WIEW) was loaned to the Fire Department by NBC.



Pilot house on the *Harvey* showing placement of the medium high frequency receiver on the wall

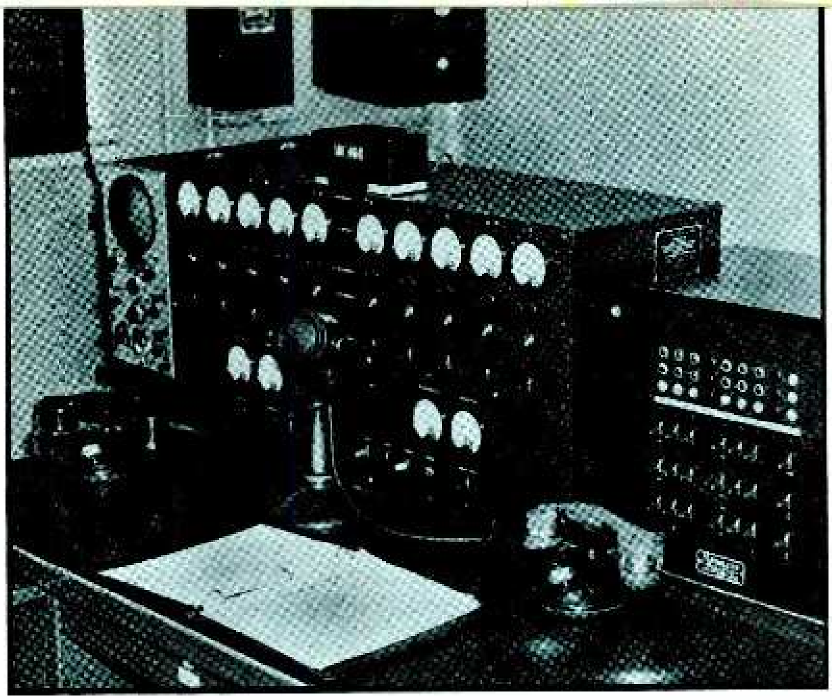


Combination antenna for medium and ultra high frequencies

On June 4th, 1936, the Fire Boat James Duane sailed around Manhattan Island, and made side trips into Long Island Sound, Newtown Creek, the New York Navy Yard, and the Gowanus Canal. On the following day, the Fire Boat James Duane sailed around Staten Island, and made side trips into Gravesend Bay and Coney Island Creek. Throughout the fire boat's travels, the medium-high frequency transmissions from the temporary land transmitter in Long Island City were continuously logged as to readability. At the same time, at eight listening points in the city, the Fire Department recorded audio and meter observations of the 31,600 kc test transmissions from the Fire Boat James Duane. The 25-watt transmitter (W1OXT) used on the Fire Boat James Duane was loaned to the Fire Department by RCA.

As one result of these final tests, the sites of the five pickup receivers were decided upon. These locations had been selected for testing because they were on natural and man-made elevations, and in public buildings. A high position for the receiving aerial was considered essential because all data indicated that the most important single consideration for efficient ultra-high frequency reception was the locating of the receiving aerial as high as possible above the average roof level of surrounding buildings. Public buildings were selected because the Fire Department would not be required to pay rental charges, would have control of the premises, and would be assured of fairly permanent tenure of occupancy.

After the final medium-high and ultra-high frequency field test, a two-way radio-telephone communication system which would cover the entire Port of New York could be visualized. It would consist of a medium-high frequency Headquarters station in Queens, ultra-high frequency transmitters on the fire boats, and five remote receivers strategically located about the City. Accordingly the specifications for the manufacture and installation of the equipment were written.



Central control room of fireboat system. Telephone monitor board, receiver, frequency monitor and power supply unit

The New York Fire Department fire boat radio-telephone communication system was furnished and installed by the General Electric Company, the successful bidder. A list of the apparatus included in the system follows:

(1) A 500-watt Headquarters transmitter with vertical antenna, operating on 1630 kc, located on the roof of the Repair Shops Building in Queens.

(2) Five remote receivers (35,600 kc), with aerials and land-line coupling equipment, located at:

(a) George Washington High School, northern Manhattan.
(b) Municipal Building, southern Manhattan.
(c) Public School 17, Staten Island.
(d) Brooklyn Museum, Brooklyn.
(e) Fire Dep't Repair Shops Building, Queens.

(3) A 50-watt crystal controlled transmitter (35,600 kc), a 1630 kc receiver, with turbo- or motor-generator power source, on each of the nine fire boats:

(a) "John J. Harvey," Battery Park, Manhattan.
(b) "George B. McClellan," East River, Manhattan.
(c) "James Duane," Hudson River, Manhattan.
(d) "Thomas Willett," Hudson River, Manhattan.
(e) "Cornelius W. Lawrence," Harlem River, Manhattan.
(f) "William J. Gaynor," Upper N. Y. Bay, Brooklyn.
(g) "John Purroy Mitchel," East River, Brooklyn.
(h) "Abram S. Hewitt," East River, Brooklyn.
(i) "William L. Strong," East River, Manhattan.

(4) The Central Control Station or Headquarters, located in the Manhattan Fire Alarm Central Office, in Central Park, Manhattan. WYNF, the Headquarters transmitter 3 miles distant in Queens, is remotely controlled from this office. In the control room there are also coupling, mixing, and amplifying devices for combining and utilizing the signals from the remote pickup receivers, as received over their connecting telephone lines. Here, also, are a radio receiver, crystal frequency monitor, and cathode ray oscillograph for monitoring the Headquarters carrier.

How the System Operates

The fire boat radio system, in general, functions as follows. The signals sent from any fire boat transmitter are picked up by some or all of the five remote receivers, and are then automatically conveyed over the connecting land-lines to the control room in Manhattan.

The Dispatcher's voice, or other signals sent from the radio control room are conducted over the connecting land-line to the transmitter in Queens, and there radiated on 1630 kc to the fire boats. To provide intercommunication among the fire boats, the signals received from any fire boat transmitter are re-radiated on 1630 kc to all fire boats, when, at the Manhattan control room the output of the pickup receiving system is connected to the land-line input of the Headquarters transmitter.

From any telephone instrument of the Fire Department two-way communication is possible with the fire boats, by means of the combined operation of the remote pickup receiver system and the Headquarters transmitter. Although different components of the radio system are located in four of the five boroughs of the greater City, all operating and controlling functions are concentrated in the central office in Manhattan.

At the operating position an inductor microphone is used, and a line amplifier equipped with audio automatic volume control. Volume compression action makes overmodulation of the Headquarters transmitter almost impossible, and raises the average signal level in the field approximately 3 decibels, making the 500-watt Headquarters transmitter equal in effectiveness to a 1000-watt transmitter not similarly equipped. In the control room, a calibrated crystal controlled frequency meter indicates Headquarters transmitter carrier deviation. A crystal controlled monitoring receiver affords an aural check, and a 5-inch cathode ray oscillograph permits continuous visual inspection of the carrier for percentage of modulation, hum, noise, and distortion.

The same pair of wires that is used to convey the operator's voice to the Headquarters transmitter, is utilized for the application and removal of filament and plate power, and for re-setting the over- and under-load circuit breakers. The land-lines conveying the incoming signals from the remote receivers are connected to the audio mixing unit in the control room. This unit provides for the combining of the signals from ten remote receivers, five of which are for future use. Each receiver land-line terminal position is equipped with an individual line amplifier, volume indicator, and non-distorting variable attenuation equalizing pad. Switches turn the power on and off at the distant receivers, by means of relays actuated by direct current sent back over the telephone line.

Signals from any or all of the remote receivers may be connected to or disconnected from the output of the audio mixing unit without changing the output impedance, by means of switches fitted with compensating resistors. The output of the audio mixing unit may be switched to the earpiece of the operator's handset,

(*Continued on page 62*)

CATHODE RAY OSCILLOGRAPH

By H. F. MAYER
General Engineering Laboratory
General Electric Co.
Schenectady, N. Y.

TO AN increasingly greater extent the communication engineer is studying the characteristic curves and performance records of his apparatus on the screen of a cathode ray oscillograph rather than a sheet of graph paper. Instead of recording columns of data and plotting a new series of points each time a parameter is varied, he snaps a switch and the curve appears. He may even vary the parameters while viewing the curve, and thereby locate an optimum point quickly and accurately—as in the now familiar system of aligning radio receiver intermediate frequency stages by means of a frequency-modulated signal and an oscillograph.

This paper deals with a single one of the many possible applications of the oscillograph; namely, the tracing of vacuum tube characteristics. The circuits described here are all completely electronic and require no rotating switches or other moving parts. While this limits the performance in certain respects, it extends the opportunity of using the system to those who may be without the facilities for building a mechanical commutator.

The most elementary circuit, designed to trace the plate current vs. plate voltage curve of a diode rectifier, is shown in Fig. 1. As the curve desired has plate voltage for its abscissa and plate current for its ordinate, one of the horizontal deflection plates of the oscillograph is connected to the cathode of the rectifier and the other to the anode; the vertical deflection plates are connected across a resistor, R_1, in series with the rectifier, to receive a voltage proportional to the plate current. Then an alternating voltage of any wave form and frequency may be applied to the rectifier and R_1 in series and the oscillograph spot will move always along the curve of plate current vs. plate voltage.

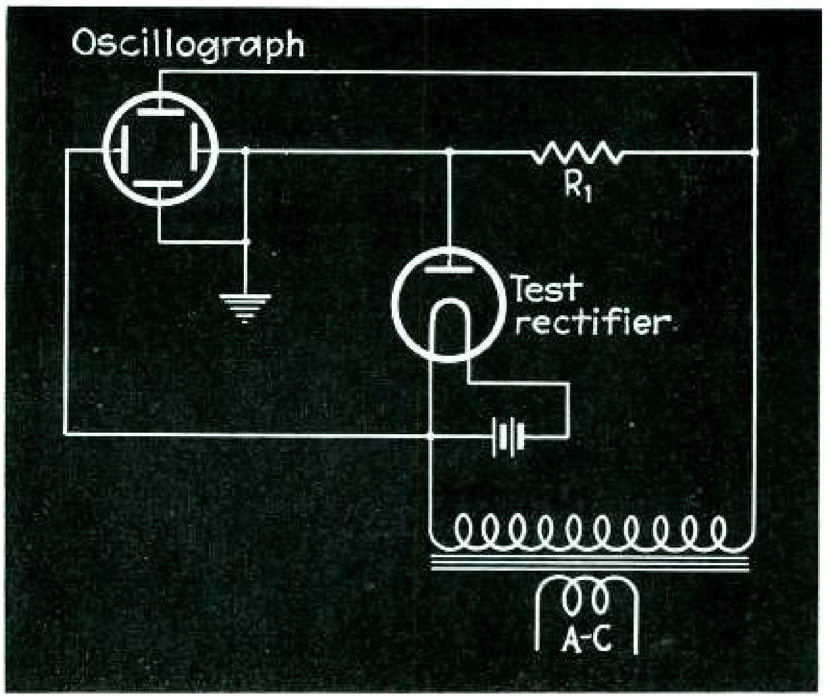


Fig. 1—Elementary cathode ray tube circuit for tracing the voltage-current characteristics of a diode

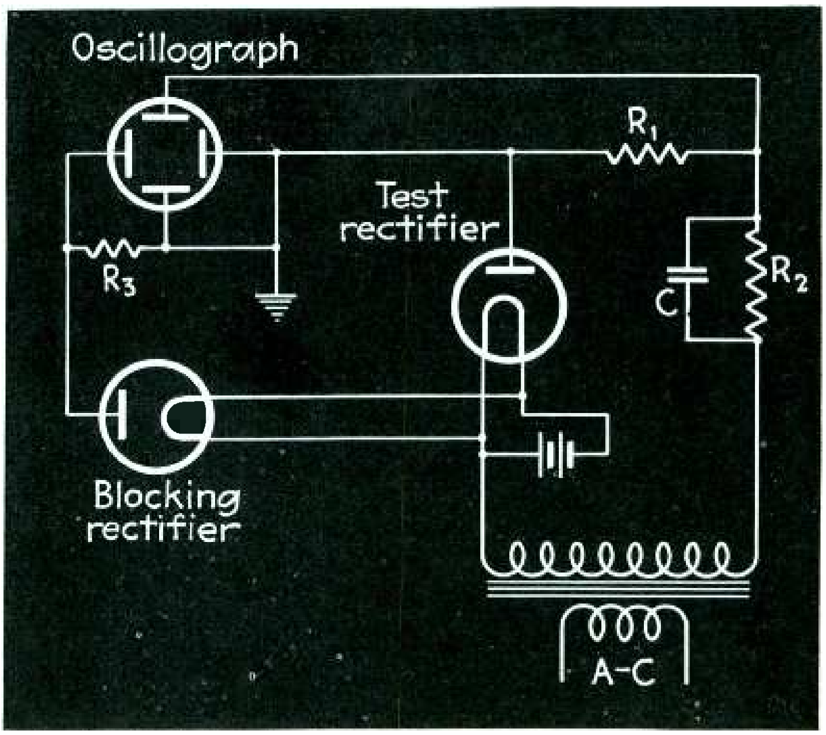


Fig. 2—Refinement of the diagram of Fig. 1 which enables peak values of current and voltage to be recorded

Fig. 2 shows a more useful refinement of this circuit. In order to make the curve extend to the values of current attained on peaks in actual operation it is necessary to use a voltage which is positive for only a small part of a cycle so as to avoid excessive average current and consequent overheating of the tube. This is accomplished by inserting a load

APPLICATIONS

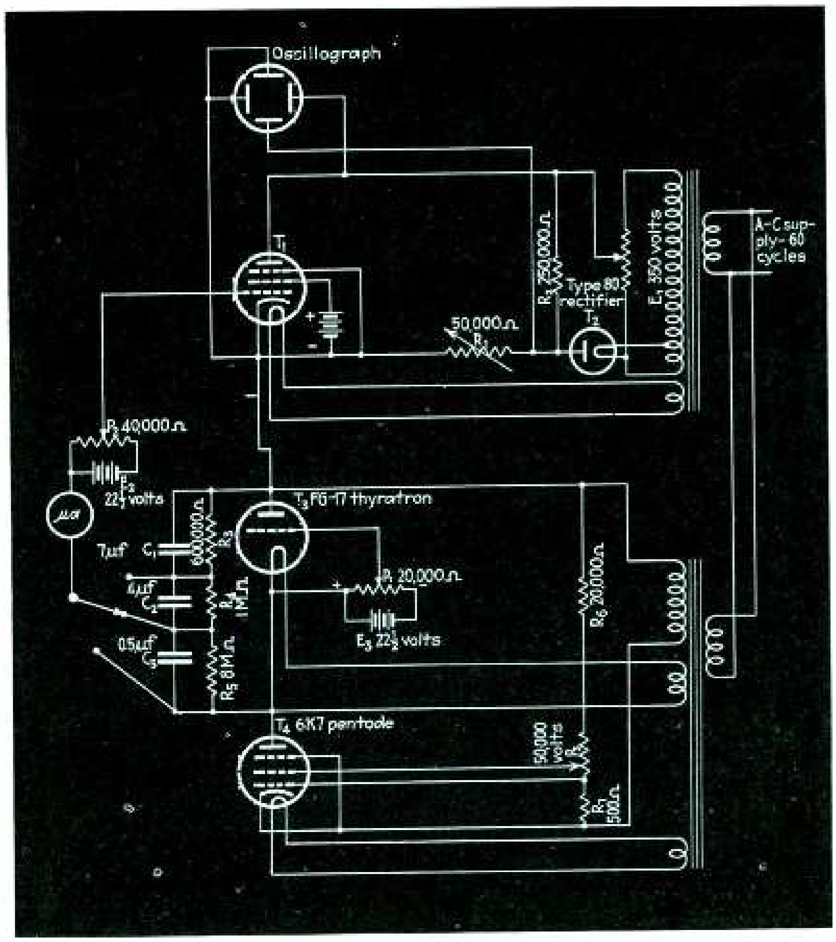
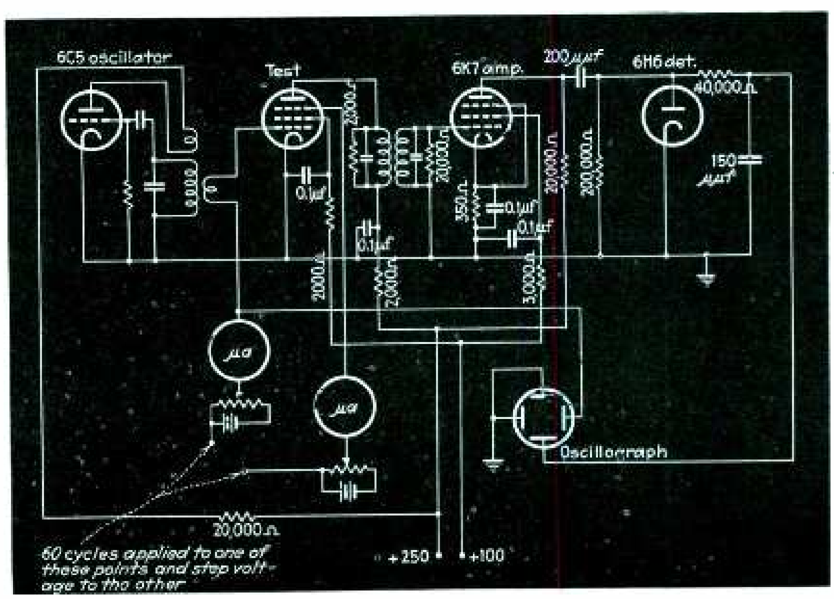


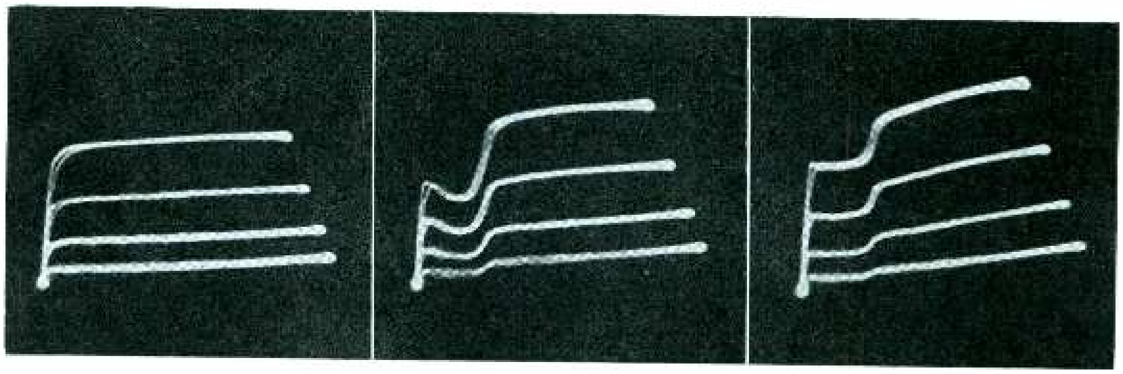
Fig. 3—Schematic wiring diagram of cathode ray oscillograph suitable for tracing the characteristics of multi-element amplifier tubes

resistor R_2 shunted by a condenser, C, and applying a higher a-c voltage. The blocking rectifier is inserted to keep the inverse voltage from reaching the oscillograph plate, and the high resistance, R_3, to permit the charge to leave the plate after reaching it through the blocking rectifier. This circuit became an almost indispensable part of a test set during the development of a small high-vacuum rectifier. In testing the tubes, the load, R_2, and the voltage are adjusted to operate the tube at full output and rated inverse peak voltage. Then with the tube cold, the high voltage and the filament voltage are applied simultaneously, and the building up of emission as the filament heats is observed on the oscillograph. The time required for the curve to reach the lower limit set for satisfactory operation is a measure of the emitting quality of the cathode. The presence of gas is immediately apparent from the shape of the curve, as is low emission. Cathode sputtering is evidenced by a flash of current at lower-than-normal plate voltage, and an arc-back shows as a surge of current in the negative direction.

To trace the characteristic curves of an amplifier tube requires a more complicated circuit. The one shown in Fig. 3 has given good results. This circuit provides a family of curves of plate current vs. plate voltage for various equally spaced grid voltages. The principle of obtaining the proper coordinates is the same as in the case of the diode, the extra apparatus here being for the purpose of providing the various grid voltages. An alternating voltage, E_1, is applied to the tube under test and the series resistor, R_1, through the rectifier, T_2, which, with the high resistance, R_2, serves to block the negative half-cycle of voltage. Thus on each positive half-cycle the oscillograph spot traces the plate-current plate-voltage characteristic of T_1, for the grid bias at that time, and during each negative half-cycle remains stationary at the origin.

Fig. 4—Cathode ray oscillograph circuit for tracing the transconductance as a function of the control grid voltage





Figs. 5A, 5B, and 5C, from left to right, showing the characteristics of a 6J7 tube. The conditions under which measurements were made are given in the text

To trace a complete family of curves for various grid voltages, the grid voltage must be held constant during positive half-cycles, while the spot is moving, and changed by a fixed increment during negative half-cycles. This is accomplished by charging the condenser chain, C_1 C_2 C_3, through the pentode, T_4, in steps, and finally discharging it through the thyratron, T_3. C_1 C_2 C_3 is charged in steps due to the fact that the pentode, T_4, has an alternating voltage on its screen and control grids, and hence conducts only during alternate half-cycles. The voltage, E_6, is phased with respect to E_1 so as to make T_4 conduct during negative half-cycles of E_1. Since the current passed by T_4 is substantially independent of its plate voltage, so long as it exceeds the screen voltage, the increments of charge applied to C_1 C_2 C_3 are equal. The amount of the increment depends upon the setting of the screen potentiometer, P_3. When the voltage on C_1 C_2 C_3 reaches a value determined by the setting of P_1, the thyratron fires and discharges C_1 C_2 C_3.

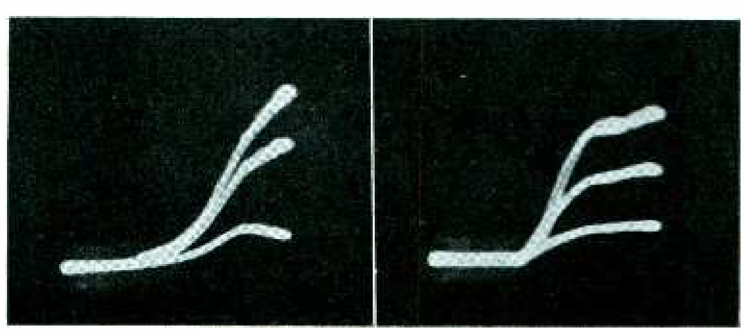
The other details of the circuit are of minor importance, but contribute to the stability and flexibility. The reason for using three condensers C_1 C_2 C_3 instead of a single one is to provide three ranges of maximum bias voltage. The resistors, R_1, R_2 and R_3 permit a reasonable grid leakage current to flow in the tube under test. The potentiometer, P_2, across the battery, E_2, permits adjustment of the minimum bias to zero, which it would otherwise not be, since the thyratron may discharge the condensers to almost any voltage, depending upon the circuit constants. The microammeter in the grid circuit of the tube under test facilitates the adjustment of P_2.

The oscillograms of Fig. 5 show the results of a few minutes' work with the camera. The curve of Fig. 5A represents the characteristics of a 6J7 with current as ordinates and plate voltage as abscissa. The control grid voltage is the parameter. The screen grid voltage is 90 volts and the suppressor grid voltage is 0. Fig. 5B represents the same conditions except that the suppressor is connected to the screen. In Fig. 5C, the suppressor is connected to the plate, but other conditions are the same as in the other two diagrams.

Another tube characteristic which may be traced in a fairly straightforward manner is the mutual conductance vs. grid voltage. The circuit of Fig. 4 accomplishes this by using the tube as a high-frequency amplifier with a low impedance load in the plate circuit and a small grid signal, and plotting the rectified output against the variable grid voltage. The signal is supplied by a 175 kc. oscillator to the grid whose mutual conductance is under consideration. If we wish to plot No. 1 grid mutual conductance against No. 1 grid voltage for various No. 3 grid voltages, then the signal and a 60-cycle voltage are applied in series to grid No. 1, and the step-voltage, generated by the circuit of Fig. 4, is applied to the No. 3 grid. The output of the detector feeds the vertical deflection plates of the oscillograph, and the horizontal deflection plates are supplied by the same 60-cycle voltage as the grid of the tube under test. It is desirable to include a microammeter in the lead of each grid having one of the variable potentials in order to adjust the minimum bias to zero. The order of magnitude of the deflecting voltages obtained from this circuit is such as to require an oscillograph having an amplifier in each of the deflecting plate circuits.

Some curves taken with this circuit are shown in Fig. 6. Fig 6A shows the transconductance of a 6K7 as ordinate with control grid voltage as abscissa and No. 3 grid voltage as the parameter. Fig. 6B shows the transconductance of the 6L7 as ordinate, No. 3 grid voltage as abscissa and control grid voltage as parameter.

Figs. 6A and 6B, left to right. These curves show the transconductance of 6K7 with control grid voltage and with No. 3 grid voltage as abscissae, respectively



A Practical Metal Detector

Originally developed for detecting metallic bits in cigars during manufacture, the tuned-bridge detector described in this article can be applied to a variety of industrial applications, and can be built readily from standard components

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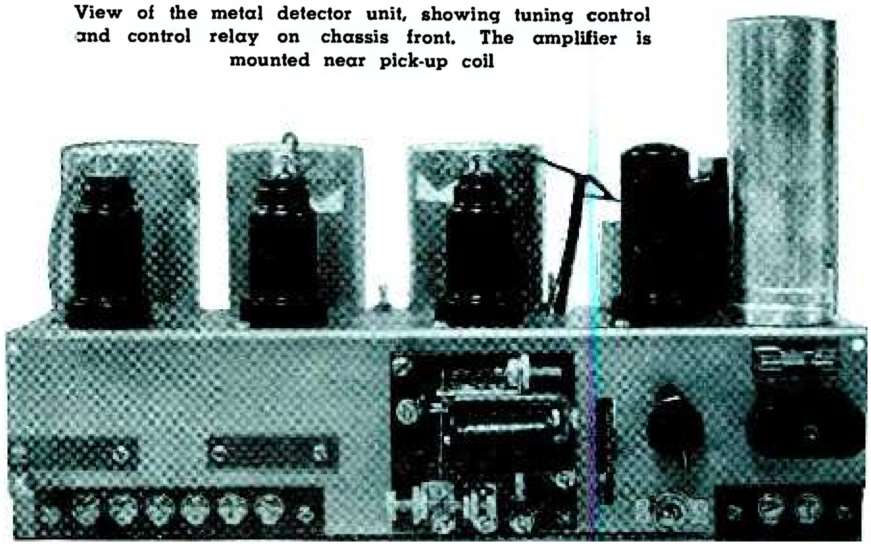
THE device described in this article was developed for the purpose of inspecting finished cigars and automatically rejecting those that contain any particles of either magnetic or non-magnetic metals. The principal requirements were high detecting sensitivity, good stability under all conditions of temperature, humidity, dust and vibration, simple adjustments and compactness. The actual rejecting mechanism offered no difficulties, so it was mainly a problem of detection.

Among the devices for detection of metal which have been tried previous to this, the best known is probably the "Invisible Gun Detector" in prisons. This is an electromagnetic detector working directly on 60 cycles a-c. It is intended mainly for the detection of comparatively large objects of magnetic metal, requires delicate adjustments, indicates the presence of metal by the deflection of the beam of a cathode-ray tube and is obviously unsuitable for the stated purpose, although it possesses remarkable sensitivity.

The presence of metal can be detected by the change in inductance of a coil when the metal passes through its electromagnetic field or by the change in coupling between two coils when the metal passes through the field between the coils, or by a combination of these two methods. The change in inductance or in coupling is the result of eddy-currents set up in the metal, or of its magnetic permeability or of both. Preliminary tests were made by measuring the change in beat frequency between two r-f oscillators when the metal was passed through the coils of one of the oscillators. Frequencies of 100 kc to 1000 kc were used. The diameter of the coils was 1½". The results indicated that in order to be of practical value, the detector should operate on a minimum change of 10 cycles in 1000 kc which would require two extremely stable oscillators. Moreover, it was found that for any oscillator frequency, there is a critical value for the diameter of steel pieces at which the magnetic and eddy-current effects balance each other and cause no change in the beat frequency. For these two reasons the beat frequency method was discarded and a tuned inductance bridge tried instead.

The fundamental arrangement of the coils is shown in Fig. 1, and a schematic circuit diagram in Fig. 2. Coils L_1 and L_2 form two arms of the bridge and are mounted on opposite sides of the driving coil L_3. Adjustable condensers C_1 and C_2, in series with the coils L_1 and L_2 form the two other arms. The mid-point P_1 of the condensers is grounded and the mid-point P_2 of the coils is connected to the grid of the first amplifier tube. If L_1 equals L_2, C_1 equals C_2 and the r-f voltages E_1 and E_2 induced in L_1 and L_2 by L_3 are equal and 180° out of phase, then the r-f voltage on the grid will be zero. A piece of metal, passing through the three coils, will upset this balance twice, causing two r-f impulses on the grid which are amplified and detected in the usual manner. If L_1-C_1 and L_2-C_2 are tuned to exact resonance, or near-resonance, with the frequency impressed on the driver-coil, a small piece of metal will cause a relatively large change in r-f voltage across P_1-P_2. This voltage change may be the result of a change in amplitude of E_1 or E_2, or of a change in their phase relation or of a combination of the two effects. It may reach a maximum at the moment the metal passes through L_1 or L_2 or when it is midway between L_1-L_3 or L_2-L_3. All this depends on the frequency, tuning, spacing, coupling and on the material, size and shape of the metal particle. In most of the tests made, at a frequency of 1000 kc. the change was a maximum when the metal particle was in coil L_1 or L_2 and was caused mainly by a phase shift. This frequency was chosen mainly because it gives a sensitivity for non-magnetic metals comparable to that for steel and also because r-f transformers and other parts are readily available. An even higher and

View of the metal detector unit, showing tuning control and control relay on chassis front. The amplifier is mounted near pick-up coil



more uniform sensitivity could very likely be obtained at a higher frequency. This circuit is fundamentally much more stable than the beat frequency oscillator, because a change in oscillator frequency or amplitude affects both sides of the bridge equally and causes little change in voltage across P_1-P_2 if the bridge is properly balanced.

The electrostatic effects of a relatively large object, like a cigar, passing through the coils, being far greater than the electromagnetic effects caused by a small piece of metal, it was found necessary to provide an electrostatic shield around the path of the cigars. This shield was made by covering the outside of insulating tube S in Fig. 1 with a large number of fine copper wires, parallel to the axis. These wires are connected to the external shield at both ends and are held in place with Bakelite varnish. Practically perfect electrostatic shielding was obtained in this manner without any serious loss in sensitivity.

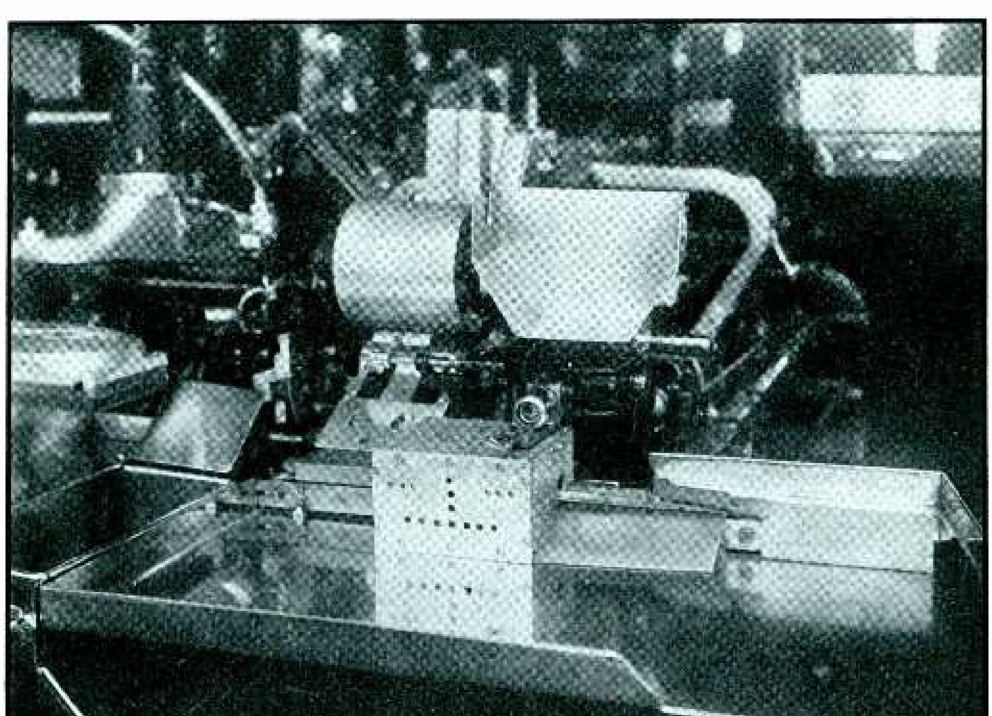
The driver coil L_3 is attached to a Bakelite washer which has three lugs projecting through slots in the external shield. Three rods, outside the external shield, pass through these lugs, supporting the washer and coil. One end of each rod is threaded and screwed into one of the end-frames of the external shield. The position of the driver coil in relation to coils L_1 and L_2 may be changed by turning these rods. This, and the variable air condensers C_1 and C_2 are the only adjustments required to obtain perfect balance of the bridge. To eliminate any change in tuning of the two sides of the bridge, which might be caused by adjustment of the driver coil, two electrostatic shields are mounted between the coils. These consist of fine copper wires held radially against Bakelite washers with varnish. The outer ends of the wires are connected to the external shield. For the two condensers C_1 and C_2, air-padding condensers are used, each with a fixed and a variable section. They are mounted in rubber to reduce the sensitivity to vibration.

The driver coil obtains its power from an oscillator. As any tendency of the oscillator to pull in step with the tuning of the bridge would seriously reduce the maximum sensitivity, the coupling between the bridge and the oscillator has to be reduced to an absolute minimum. For this reason, an electron-coupled oscillator is used.

Space limitations made it impossible to mount the oscillator, amplifier and power supply close to the bridge, so the apparatus was divided into two parts, the pick-up unit containing the bridge and first amplifier tube, and the main or control unit. A step-down transformer is used to match the high out-put impedance of the oscillator to the low-impedance shielded connecting cable and low-impedance drive coil. Another step-down transformer is used in the plate circuit of the first amplifier tube to connect it through a second shielded cable to the first r-f transformer which has a low-impedance primary and is located in the main unit. The second r-f transformer has a high impedance primary. Its output is rectified by the diode section of the last tube and coupled to the grid of the triode section through a 1 μf condenser. A sensitive relay is connected in the plate circuit of the triode. The oscillator coil and the secondaries of the r-f transformers are matched and tuned by a three-gang condenser. The power supply is of the universal type as used in 110-volt ac-dc receivers. The heaters of the tubes are connected in series.

The grid bias of the output tube is adjusted to a point where the relay armature is normally held in. Due to the capacitive coupling in the grid circuit, the relay current is not dependent on the steady value of the r-f voltage across P_1-P_2, but the relay will only drop out for a relatively

Fig. 3—Pick-up unit with rejecting mechanism, installed on cigar-rolling table



$$R_s = \frac{Rl}{2}\left[1+Tan^2\,bl+\frac{Tan\ bl}{bl}\right]$$
$$+\frac{g\,l\,Z^2}{2}\left[1+Tan^2\,bl-\frac{Tan\ bl}{bl}\right] \qquad (21)$$

$$g_o = \frac{gl}{2}\left[1+Tan^2\,bl+\frac{Tan\ bl}{bl}\right]$$
$$+\frac{Rl}{2Z^2}\left[1+Tan^2\,bl-\frac{Tan\ bl}{bl}\right] \qquad (22)$$

If measurements are made at a frequency low enough so that $Tan\ bl/bl$ does not differ much from unity, then $L = L_s/l$ and $C = C_o/l$. Or if C_o and L_s are plotted against frequency the curves will be found to have horizontal asymptotes, which if divided by l, give L and C (see Fig. 1). In the same way from (21) and (22) if $Tan\ bl$ is not too large $R = R_s/l$ and $g = g_o/l$. The asymptotic method can be used here also, but in this case the asymptotes are not horizontal. It is of advantage to plot R_s and g_o on logarithmic paper, since R_s will vary as the square-root of the frequency and the asymptotes will be a straight line. The asymptote of g_o will be a straight line of slope unity if the phase-angle of the dielectric loss is constant.

The length of line to be chosen for measurement will depend upon the highest frequency at which measurements are to be made and upon the wave-velocity, or phase-factor, of the line. As a good practical rule bl should not exceed 0.9 at the highest frequency. Transmission lines may be divided roughly into two classes: (1) copper lines having very little dielectric between conductors, such as coaxial and open-wire lines, and (2) lines having a considerable amount of dielectric between conductors such as twisted-pair lines and coaxials in which the space between conductors is entirely filled with insulation. The wave-velocity of the latter is about half that of light, as compared with that of the first group, in which the velocity is substantially equal to the light-velocity. As a practical guide in this matter the following empirical rules may be employed: For non-dielectric lines,

$l = 140/f$; (feet, megacycles) (23)

and for lines containing dielectric,

$l = 70/f$. (feet, megacycles) (24)

Table I shows the best length of line for measurements at various frequencies.

The components C_o and g_o of the open-circuit admittance are first measured with the remote end of the line open. Connect the line across the condenser terminals on the Q-Meter. If coaxial the outer conductor should be connected to the ground terminal. Resonate the main tuning condenser of the Q-Meter and observe C_2 and also Q_2 of the circuit. Then disconnect the line, resonate the Q-Meter and observe the new tuning capacitance C_1 and new Q_1 of the circuit. The desired quantities may then be computed by:

$$C_o = C_1 - C_2 \qquad (25)$$

$$g_o = 6.3\times10^{-6}\,f\,C_1\left(\frac{Q_1-Q_2}{Q_1\,Q_2}\right) \qquad (26)$$

where the C's are in μf and f is in Mc. This procedure should be repeated at several frequencies in the desired range up to the limit expressed roughly by (23) or (24).

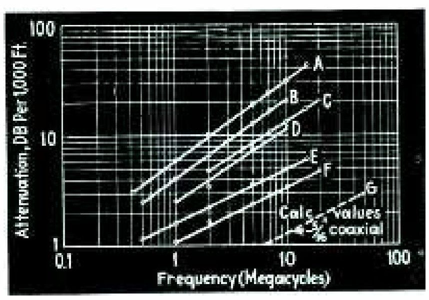


Fig. 2—Attenuation for typical lines

Quantities R_s and L_s are measured next with the remote end of the line short-circuited. This short should be of the lowest possible resistance and inductance and preferably soldered. For these measurements the line is connected in series with the inductance coil used with the Q-Meter. If coaxial the outer conductor should be connected to the "low coil" terminals of the Q-Meter. First resonate the main tuning condenser on the Q-Meter and observe C_2 and also Q_2. Then short the line directly at its input terminals by means of a heavy copper bar of the lowest possible resistance and inductance. In some cases (at low frequencies or with low-resistance lines) the bar must be soldered in place for accurate results. Then reresonate the Q-Meter and observe the new C_1 of the new Q_1. The desired quantities are then given by:

$$L_s = \frac{2.54\times10^4}{f^2}\left(\frac{C_1-C_2}{C_1\,C_2}\right) \qquad (27)$$

$$R_s = \frac{1.59\times10^5}{f}\left(\frac{1}{Q_2\,C_2}-\frac{1}{Q_1\,C_1}\right) \qquad (28)$$

where L_s is in μh, R_s in ohms, the C_s in $\mu\mu f$ and f in Mc. The measurements should be repeated at the same frequencies at which C_o and g_o were measured.

The surge impedance Z may be computed from (12) which, if L_s is in μh and C_o in $\mu\mu f$, becomes:

$$Z = 1000\sqrt{L_s/C_o} \qquad (29)$$

The attenuation factor a may be computed from (15) which, if L_s and C_o are expressed in the above units, may be written:

$$a = \frac{4340}{l}\left[\frac{1}{1+3.94\times10^{-5}f^2L_sC_o}\left(\frac{R_s}{Z}+g_oZ\right)\right]$$
db/1000 ft. (30)

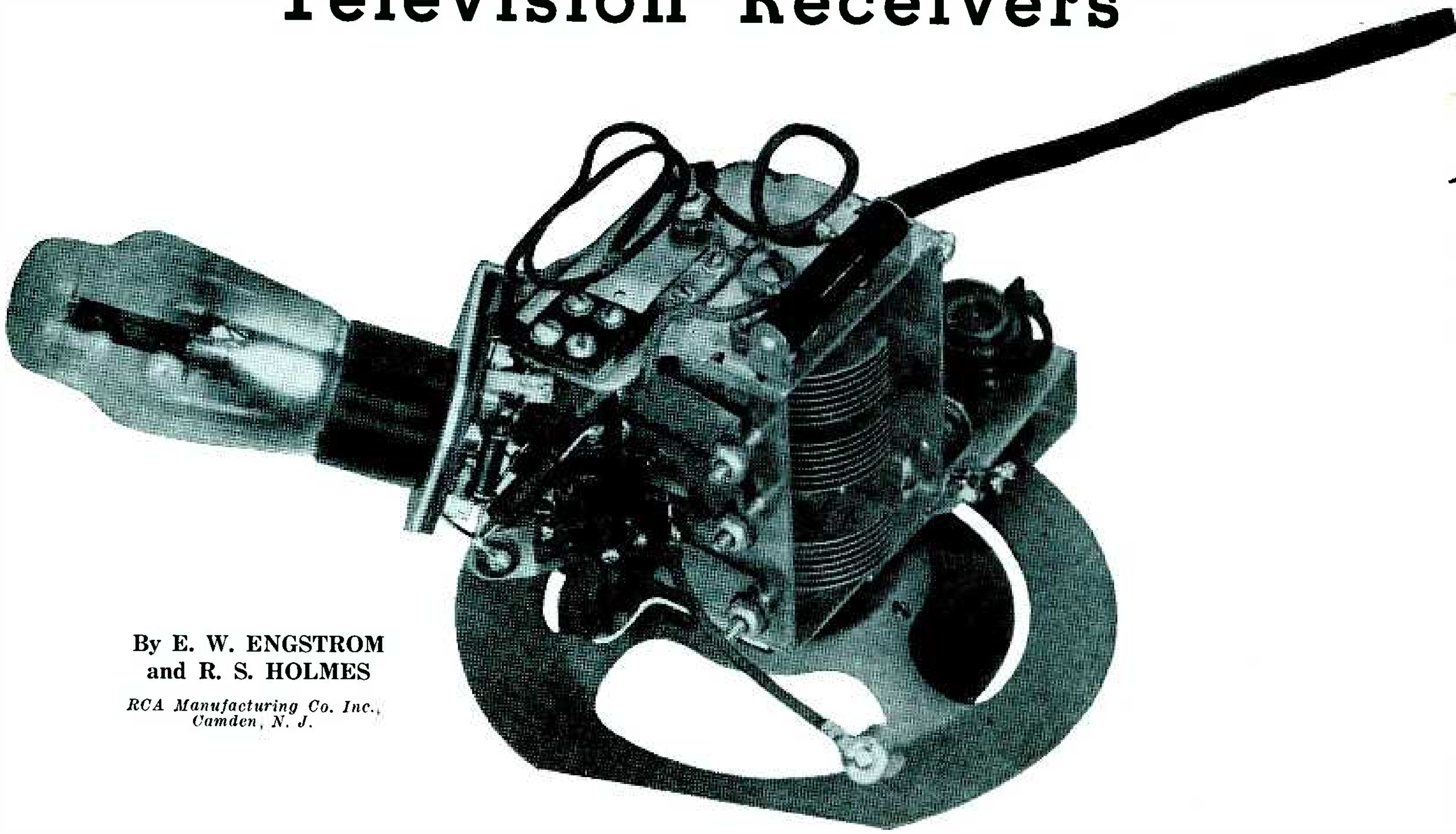
where l is in feet. The values of R, g, L and C may be obtained as described above.

Representative results of measurements on practical lines are shown in Figs. 1 and 2. The rise of the quantities (in Fig. 1) at the higher frequencies due to the line becoming electrically "long" is in evidence and also the method of determining the values of the line constants from the asymptotes is shown. Figure 2 shows the attenuation in decibels per 1000 feet for several lines as follows: A is a twisted-pair line resembling lamp-cord. B is a twisted-pair line of solid No. 12 conductors, covered with waterproof insulation. C is a coaxial comprising a central No. 12 (.080 in.) conductor and an outer flexible braid ½ in. in diameter, the space between being completely filled with soft rubber. Line D is a rubber-insulated line of the same general dimensions as C. Lines B and C are commercial products widely advertised as "low-loss" lines. Line E is a flexible coaxial containing interlocking beads of low loss insulating material. Line F is a solid coaxial of 73 ohms surge impedance, $\frac{5}{16}$ in. in diameter and insulated by Isolantite beads spaced 2 in. The calculated values for this line, based on copper loss, are shown in curve G. It will be seen that the twisted-pair and rubber insulated lines have relatively high losses and are suitable only for short runs or the lower frequencies. A line of the type F is quite suitable for outdoor use in conjunction with the flexible type E line for indoor use and for patching purposes.

TABLE I

Frequency Range (Mc)	Length of line (feet)	
	Non-dielectric	Dielectric
.1 to 1	140 ft.	70 ft.
1 to 10	14	7
1 to 50	2.8	1.4

Television Receivers



By E. W. ENGSTROM
and R. S. HOLMES

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

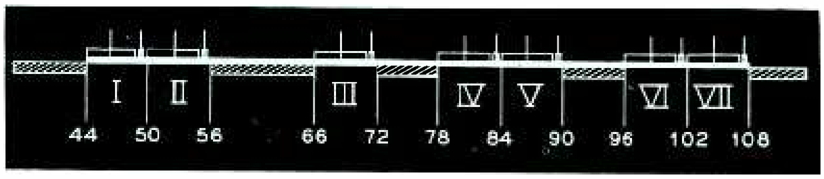
Photograph of 3-section gang capacitor including tuning coils and oscillator tube

TIME is approaching when the radio engineer will be confronted with design problems on television receivers. The radio service man will desire to understand the principles of operation. The ambitious amateur will start experimenting with television circuits. It is with these aspects in mind that this series of articles has been prepared covering the fundamental factors involving the design and operation of television receivers. This first article considers some of the general problems and begins the analysis of the receiver.

In television we are concerned with a broadcast type of service in which adequate coverage of a service area is the prime consideration. The frequency of the radio carrier must be high enough to permit the relatively wide sidebands which are required, and so high that reflections from the ionosphere will not regularly occur. The second requirement is necessary to prevent multiple images caused by reflections from the ionosphere, and to permit duplication of frequency assignments with reasonable geographical separation of stations on the same channel. Further, in television we are concerned with a service requiring high signal strength at the receiver locations. Thus, the radio carrier must be at such a frequency so as to permit generation of adequate power. The carrier frequency must be such that the attenuation caused by obstacles on or near the transmission path is not too great, and so that the shadows cast by obstacles are not too sharp or too dense. All these considerations point to frequencies above and near 40 megacycles, for example, 44 to 108 megacycles, if television is soon to be practicable.

An advantageous channel arrangement for television is one such that each transmission channel is complete within itself, that is, includes means for transmitting the video, synchronizing and sound signals. In such a system, the video and synchronizing signals may be transmitted on one carrier and the sound signals on another carrier. (The video and synchronizing signals are transmitted alternately.) One obvious advantage is that, being adjacent in frequency assignment, these two carriers have nearly identical propagation characteristics. With a fixed separation between the sound and picture carriers within each channel, simplified receiver operation can be obtained and a single control of receiver tuning is possible. Thus, it is possible to include both carriers

Fig. 1—Television broadcast channel allocations



in the frequency band accepted by a single r-f system and separate them in two intermediate frequency channels following a single oscillator and heterodyne detector.

It has been found that the picture carrier and sound carrier should be of approximately the same power. This is determined by considerations of receiver selectivity for separating the picture and sound signals and considerations of the effects of noise on the reproduced image and sound.

As the number of scanning lines in the television image is increased, the frequency band required for transmission also increases. Thus, practical limits are encountered in amplifiers and transmission methods. Limits are also present in resolution and in signal-to-noise ratio of the Iconoscope and resolution of the Kinescope. The most definite limit is probably the frequency space available in the radio spectrum for television channels. Experience indicates that an image of 400 lines or more will provide satisfactory performance for home type television entertainment and results in characteristics which can be obtained in practice. A tentative standard of 441 lines has been adopted for the United States.

The frequency band required for a television image is proportional not only to the amount of detail transmitted, but also to the rapidity with which it is transmitted, that is, the number of frames per second. The frame frequency and field frequency (for interlaced scanning) are determined by flicker and power supply frequency. To reduce the visual effects of a-c ripple in the reproduced image, the frame frequency should have an integral ratio to the power supply frequency; for example, a frame frequency of 30 per second is satisfactory for a power supply frequency of 60 cycles per second. To have satisfactory conditions with regard to image flicker, an effective frame frequency of 50 or more per second is required. This may be obtained without an increase in bandwidth by using interlaced scanning. By this method, odd numbered lines are scanned first and then the even numbered lines, with two fields of scanning for each frame. A tentative standard of frame frequency of 30 per second and a field frequency of 60 per second has been adopted for the United States.

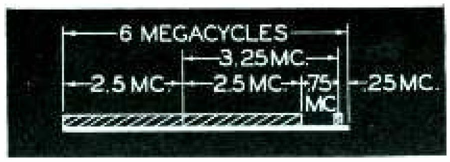


Fig. 2—Television channel make-up

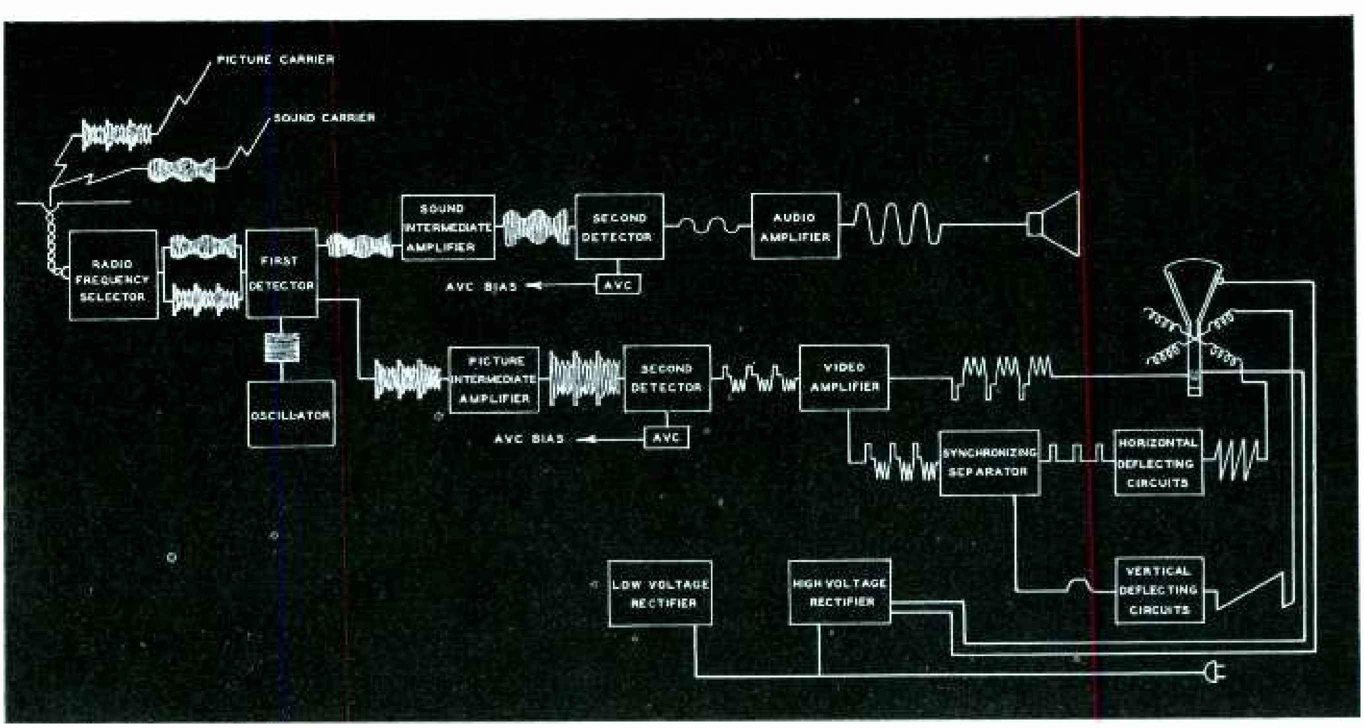
For television channels, a tentative standard has been adopted. This is for a channel 6 Mc. wide and with a spacing between picture and sound carriers of approximately 3.25 Mc. Such a channel arrangement is shown diagrammatically in Fig. 2. For such a channel, the sidebands of the picture transmitter may extend 2.5 Mc. on either side of the carrier, leaving a 0.75 Mc. guard band between the maximum frequency of the upper sideband and the sound carrier. The channels allocated for television broadcasting (in the lower frequency group) are shown by Fig. 1.

New Receiver Problems

The design of a television receiver is based upon many considerations which differ from those encountered in sound receivers. Two signals must be received and simultaneously utilized—picture and sound. The bandwidth required for the picture is many times greater than that required for sound broadcasting. For simplicity of operation, tuning should be uni-control for picture and sound. For many reasons, a superheterodyne circuit is well suited for meeting the receiver requirements.

For the radio frequencies planned for television transmission (above 40 Mc.) there will be practically no natural static. Man-made interference will, however, impose severe conditions. The wide picture fre-

Fig. 3—Block diagram of typical television receiver showing amplifiers for sound and video, detectors, AVC, deflecting circuits, cathode ray tube, etc.



quency bands make the receiver more susceptible to noise pickup than are more selective receivers. These factors point to the necessity of high signal levels at the receiver input, and consequently somewhat less sensitivity is required than is common for sound broadcast receivers.

The picture and sound carriers in all television channels will have the same frequency separation. Therefore, by properly choosing the pass bands of the two i-f amplifiers, both carriers can be heterodyned by a single oscillator. The picture intermediate frequency must be high because of the extremely wide v-f (video frequency) band. This wide frequency band means that more amplifier stages are required to compensate for the low gain per stage. Methods are employed to reduce the total frequency band which the receiver must pass and these contribute to economy in receiver design.

It has been found that if the receiver is designed to accept the carrier and one side band, rejecting a major portion of the other sideband, good performance can be obtained with very much greater economy. It is present practice where only one sideband is fully accepted by the receiver to accept the high frequency sideband and reject the lower. In the discussion of receiver design in these articles it is assumed that this economy is used.

Figure 3 is a block diagram of a typical receiver, showing the respective functions of the various parts of the circuit, and giving an indication of the wave shapes occurring there. Since both sound and picture are to be reproduced by this receiver, it is desirable to use a single antenna for picking up both carriers. Both signals are passed by the r-f circuits to the first detector where they are heterodyned to intermediate frequencies by the local oscillator.

These two bands of intermediate frequencies are amplified through their respective i-f amplifiers and rectified by separate second detectors. Separate automatic volume controls (as per Fig. 3) maintain the proper signal levels on the two detectors. The sound signal passes through a high fidelity audio amplifier to the loudspeaker.

The rectified picture, or video, signal is amplified through the v-f amplifier and impressed on the control grid of the Kinescope. This amplifier must be so designed that it will pass the full video frequency band of approximately 60 cycles to at least 2,500,000 cycles with negligible amplitude and phase distortion. An output of the order of 50 volts peak to peak is usually required on the Kinescope grid.

The input to the synchronizing separator circuit is also obtained from the video frequency amplifier at some point where the amplitude and polarity of the video signal are correct, but ahead of the contrast (video gain) control, so that the synchronizing is not affected by the video contrast control adjustment.

The synchronizing separator must separate the synchronizing pulses out of the composite video signal, and then separate the horizontal and vertical pulses from each other and impress them on the deflecting circuits in the proper amplitude and polarity to synchronize the deflecting oscillators.

The deflecting circuit consists essentially of three parts. First an oscillator which generates pulses of large amplitude, synchronized by the incoming synchronizing signal; second a circuit for changing the large (voltage) pulse into a voltage of sawtooth wave shape, and third, a circuit for changing the sawtooth of voltage into a sawtooth of current through the deflecting coils, to deflect the Kinescope electron beam.

Both deflecting circuits perform essentially the same functions, but the circuit arrangements and constants are different because of the great difference in operating frequency, i.e. 60 per second for the vertical and 13230 per second for horizontal, (30 frames, 441 lines).

Other components of importance in the receiver are the power supplies,

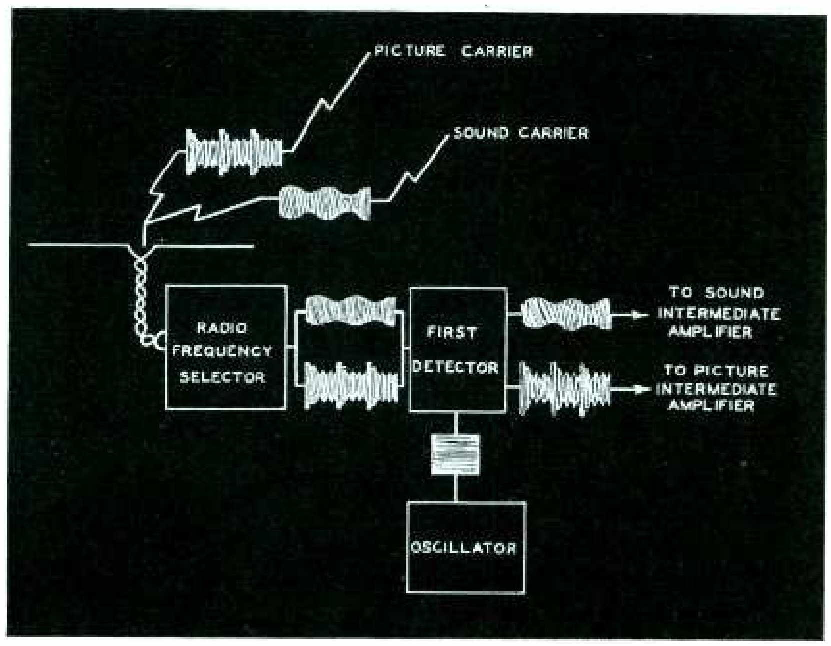


Fig. 4—Portion of television receiver reviewed in this discussion

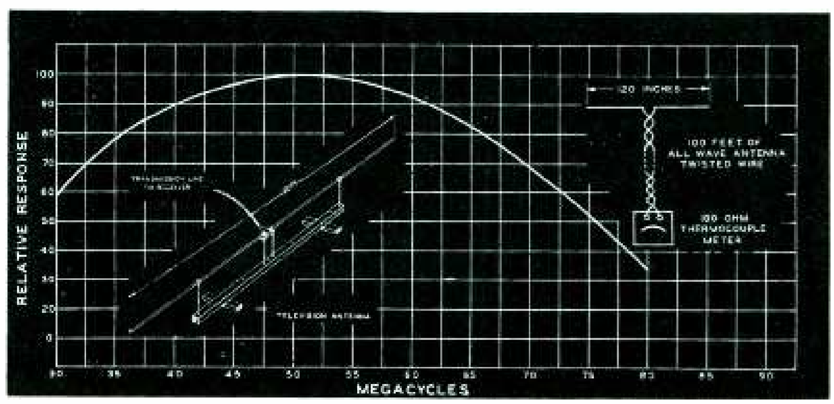


Fig. 5—Dipole antenna and its response as a function of frequency

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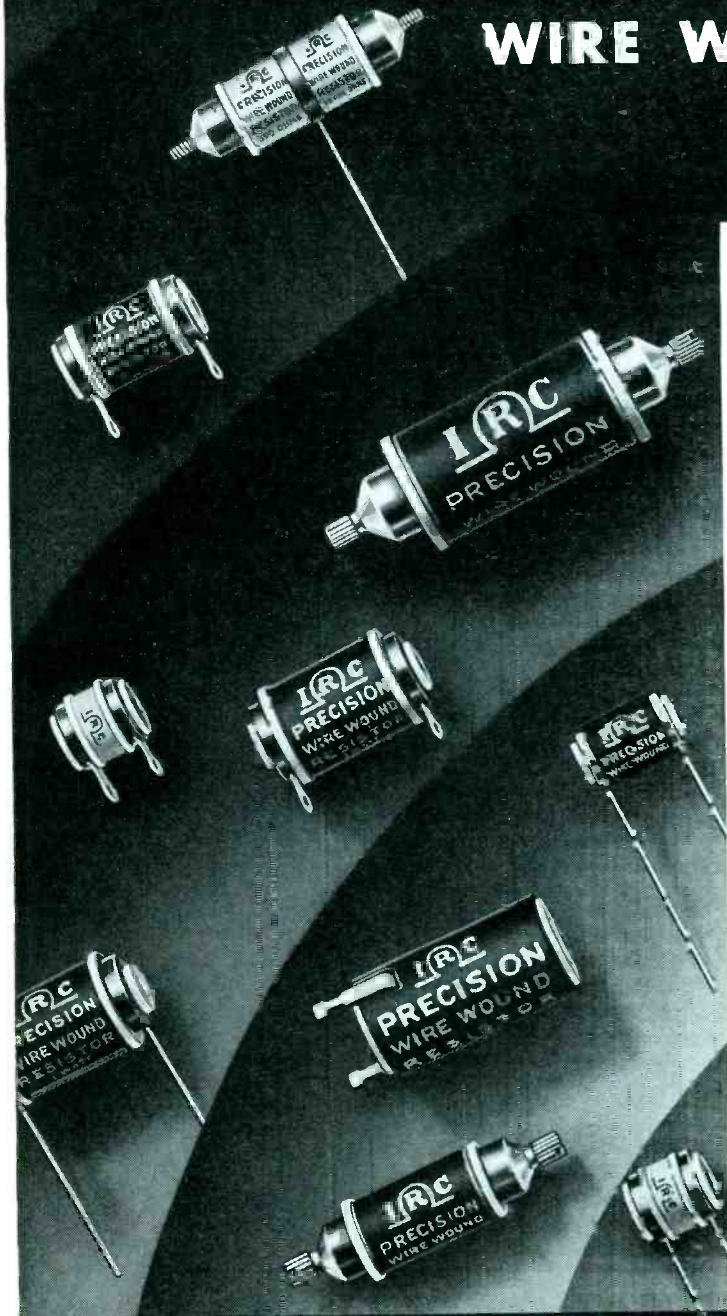

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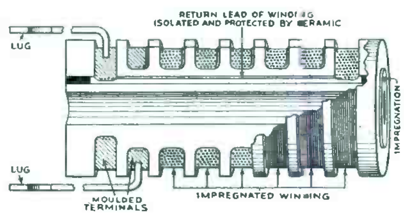

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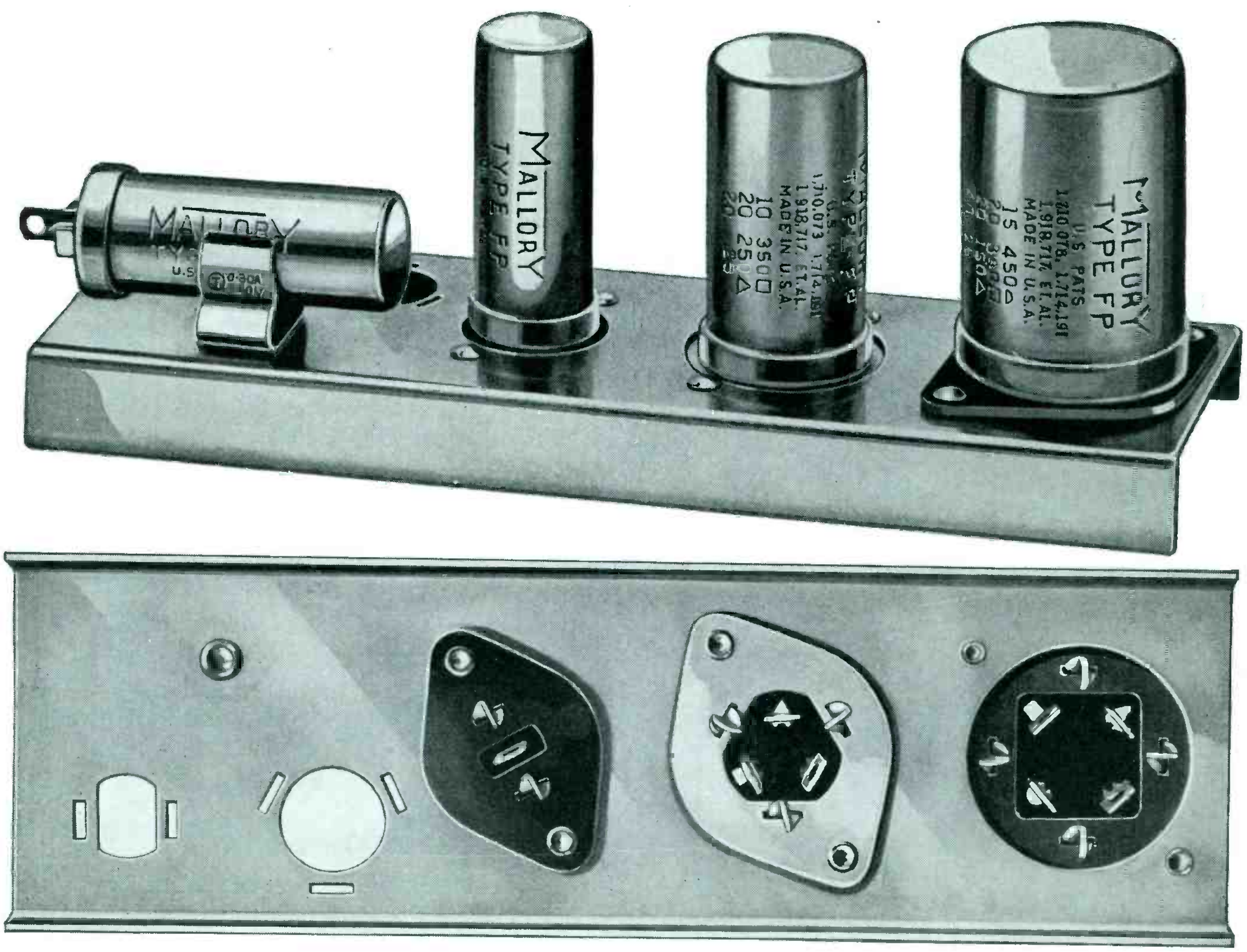


TUBES AT WORK

Photochemical Combination Used as a Switch Control

By JOHN H. JUPE

ONE OF THE MOST interesting exhibits at Physical Society's Exhibition, recently held in London, was a new type of photoelectric switch. It depends on a photochemical action well known to all chemists, namely, that if hydrogen and chlorine be mixed and exposed to light, combination takes place, the rate of combination being dependent on the intensity of the light. With sunlight, the action is instantaneous. In darkness there is none at all.

To make practical use of this phenomenon, a relay has been designed consisting of a transparent container with electrodes contained in it and partly filled with a solution of hydrochloric acid and calcium chloride. One wall of the chamber is in the form of a flexible diaphragm operating directly on a switch or by squeezing a tube of mercury.

The cycle of action is as follows. Electrolysis takes place when direct current is passed through the cell; hydrogen and chlorine gases are produced and eventually close the local circuit by reason of the gas pressure on the flexible wall. A high resistance is then put in series with the electrodes to prevent further electrolysis. If now, the cell is in darkness the local circuit will remain closed, but upon exposure to light, the gases will recombine, the pressure fall and the switch open. Above a certain light intensity the gases will recombine as fast as they are formed and consequently no pressure rise will take place.

These switches have been used to operate lights at dusk in a similar way to the more usual photocells and are particularly suitable for use on low voltages such as are met with on automobiles. A number of them are in use in France on taxicabs.

No internal destruction takes place provided that the cells are polarised continuously. This requires a small dry cell to be connected across the electrodes during shipping and storage.

• • •

An Improved Meter Shunt Circuit

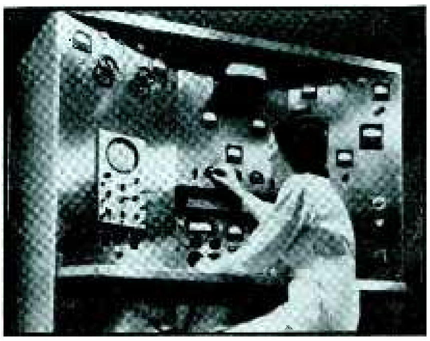
By VERNE O. GUNSOLLEY
Minneapolis, Minn.

WHEN IT IS DESIRED to make a low range ammeter cover a higher range, the first thought likely to come to mind is that illustrated in Fig. 1. In this hook-up it is evident that the safety of the meter depends entirely upon the perfection of the contacts on the switch. and that any variation in the resistance of the contact will cause variations in indication, especially on the high current ranges. Such a method of shunting results in many burned out meters, especially if switching is done while the current is on. The fuse *F* will protect the meter, but due to its resistance a shorting switch *B* must be closed while taking readings. Outside of these disadvantages, the circuit has the advantage that it presents a progressively lower resistance to the external circuit as the range is increased, that is, for ten times the current, the circuit presents one tenth the resistance. This feature is of utmost value when measuring high currents due to low voltages in low resistance circuits, as for example, in the voice coil circuit of a 5-ohm loudspeaker, where ten watts of power would represent a current of 1414 ma. A thermoammeter of 115 ma. range and having a resistance of 5.2 ohms when shunted to have twenty times this range, or 2300 ma., would present a resistance of 5.2/20 = 0.26 ohm only, in series, thus making the effective load on the output transformer 5.26 ohms instead of 5 ohms. Due to the broad characteristics of the power curve on most output tubes, the effect of the meter in series with the voice coil would be negligible, and if not, corrections could be easily made by calculation. However, if the meter shunt were not increased in direct ratio, then the effects of series insertion might be undesirably great.

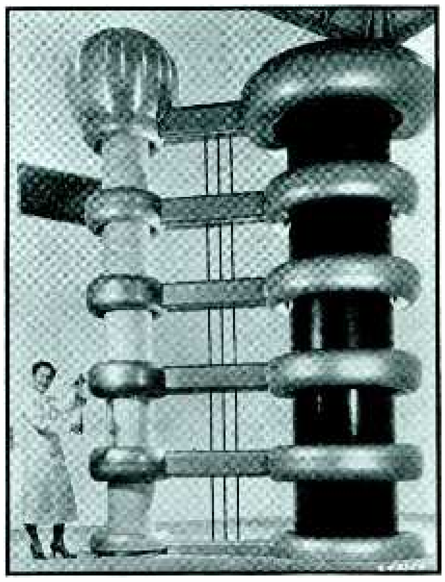
In an effort to fortify the meter against burnout, the circuit illustrated in Fig. 2 is sometimes, though rarely used. In this circuit, the main shunt is designed to have a rather high volt-

(*Continued on page* 42)

NEW SUPER-POWER X-RAY INSTALLATION



Above is the control panel of the installation, at which the strength of the radiation is measured and controlled



At the Los Angeles Institute of Radiology, a new million-volt X-ray installation has recently been completed. Above is the upper half of the X-ray tube, with corona shields to regular intervals along the transformer (right) and porcelain tube housing

The treatment room is completely isolated by lead shields. The patient is observed through a periscope, which prevents exposure of the operator to the radiation

Solving a Rectifier Problem

By REUBEN LEE
*Westinghouse Elec. & Mfg. Co.
Chicopee Falls, Mass.*

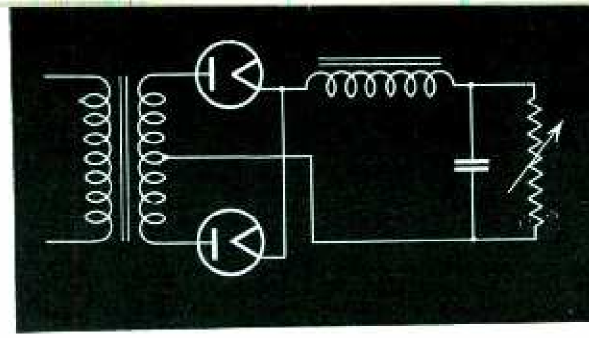


Fig. 1—Fundamental rectifier circuit

IN ANY particular engineering difficulty, the engineer usually first encounters the difficulty, then analyzes it to determine the cause, and finally, by applying his new knowledge, seeks to remove the cause. But in the analysis, he may have to go back to fundamental principles and carefully reason his way out. At least, it was so in the case of a rectifier having over 40% regulation instead of the required 5%; the lower figure was obtained finally without any material increase in size. For the sake of logical order, the analysis is here presented first and the application later.

The regulation of a rectifier comprises three distinct components:

1. The d-c resistance or IR drop.
2. The commutation reactance or IX drop.
3. The condenser charging effect.

The first component can be reduced to a small value in most cases by the use of tubes, transformers, and reactors having low resistance drops. Mercury vapor tubes are of noteworthy usefulness in this respect, as the internal voltage drop is low and almost independent of load current variations.

Commutation reactance can be kept to a low value by proper transformer design, particularly in those cases where the ratio of short-circuit current to normal load is high. Rectifiers for radio apparatus virtually all fall in this class.

If the rectifier had no filter condenser, that would be the end of the matter. The rectifier would deliver the average value of the rectified voltage wave, less regulation components 1 and 2. But with a filter condenser, there is the ever present tendency at light loads for the condenser to charge up to the *peak* value of the rectified wave. At zero load, this amounts to 1.57 times the average value, or a possible regulation of 57% in addition to the other components, for single phase full wave rectifiers. This effect is less in magnitude for polyphase rectifiers, although it is present in all rectifiers to some extent.

The discussion here will be limited to the common rectifier circuit shown in Fig. 1. In this diagram, the single phase full wave rectifier output shown in Fig. 2 is delivered to a choke input filter and thence to a variable load. In such a circuit, the filter reactor keeps the condenser from charging to a value greater than the average E_1 of the rectified voltage wave, provided the load resistance is low enough. There is a value of load at which the condenser charging effect sets in for a given filter. At lighter loads than this, the d-c output voltage rises above the average of the rectified wave, as shown by the typical regulation curve of Fig. 3.

Starting at zero load, the d-c output voltage E_0 is 1.57 times the average of the rectified wave. As the load increases, the output voltage falls rapidly until the current I_1 is reached. For any load greater than I_1, the regulation is composed only of the two components IR and IX. It is good practice to use a bleeder load I_1 so that the rectifier operates between I_1 and I_2.

The filter elements bear an important relation to each other and to the load I_1, and this relation is arrived at as follows:

The rectifier pulsating output voltage delivered to the filter may be resolved into d.c. plus superposed a.c. fundamental and harmonic components. The filter, if it is effective, attentuates the a-c components so that across the load there exists a d-c voltage with a small ripple voltage superposed. The unattenuated a-c components are of comparable magnitude to the d-c component. Standard books on rectifiers* give the values of these a-c components in percentage of the d-c component as follows:

Rectifier	Supply	Fund. Ripple Freq. times Freq.	A-C Fund.	2nd Har.	3rd Har.
1—Ph. Full	Wave	2	66.7%	13.3%	5.7%
3—Ph. Half	Wave	3	13.3%	3.2%	1.4%
3—Ph. Full	Wave	6	5.7%	1.4%	0.6%

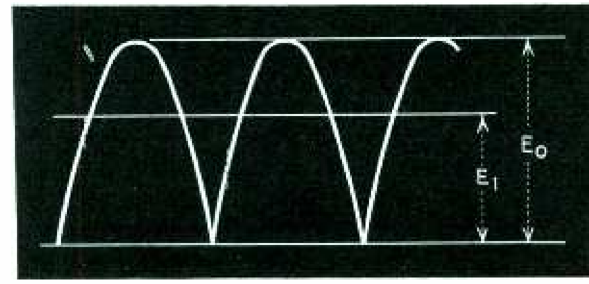


Fig. 2—Wave form of the circuit of Fig. 1.

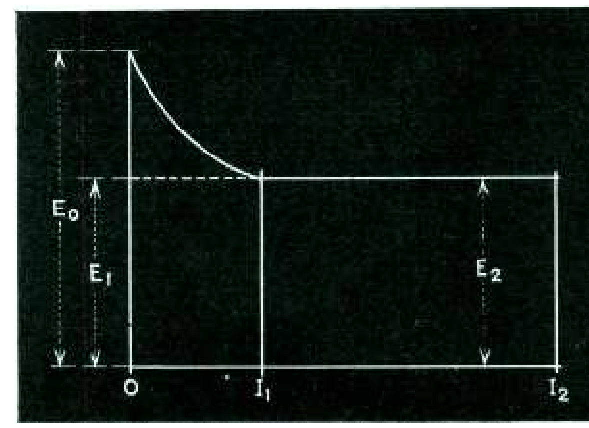


Fig. 3—Regulation curve of typical rectifier

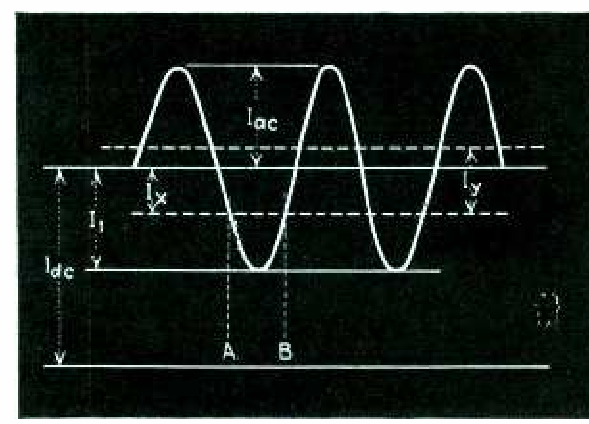
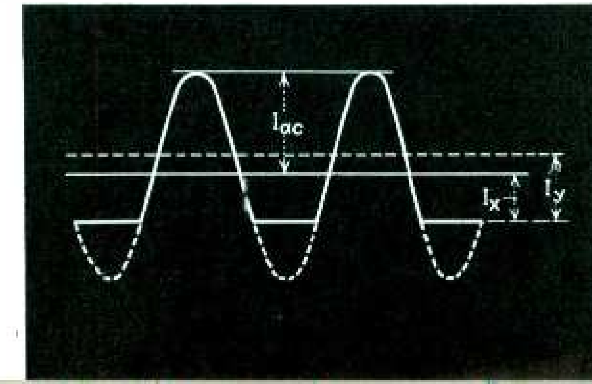


Fig. 4—A-c and d-c components of rectifier output

Fig. 5—Effect of increasing load resistance of rectifier



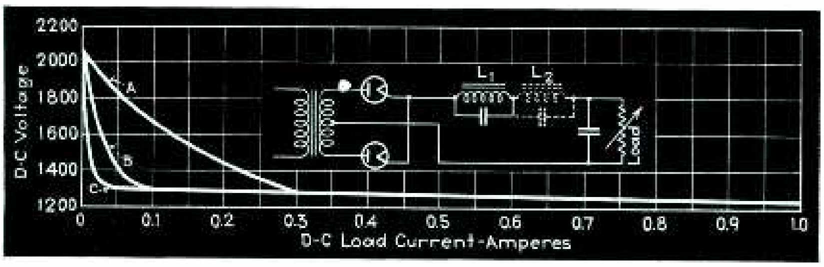


Fig. 6 (insert) and Fig. 7—Use of tuned choke and the result on regulation. A, Conventional circuit; B, one tuned choke; C, two tuned chokes

A filter of the type shown in Fig. 1 attenuates the harmonic components much more than the fundamental component, and since the harmonics are smaller to begin with, the main function of this filter is taking out the fundamental a-c component. This has a value, according to the table, of 66.7% of the average rectified d-c voltage. Since this component is purely a-c it encounters only a-c impedances in its circuit. If, in Fig. 1, we designate the choke impedance as X_L, and the condenser impedance as X_c, both at the fundamental ripple frequency, the impedance to the fundamental component is $X_L - X_c$, the load resistance being negligibly high compared to X_c in an effective filter. The d-c voltage, on the other hand, produces a current limited mainly by the load resistance, assuming the choke IR drop is small.

Currents due to the a-c and d-c components are shown in Fig. 4, with the ripple current I_{ac} superposed on the load direct current I_{dc}. If the direct current be made smaller by increased load resistance, the a-c component is not affected because load resistance has practically no influence in determining its value. Hence, a point will be reached as the d-c load current is diminished, where the peak value of ripple current just equals the load direct current. Such a condition is given by d-c load I_l which is equal to I_{ac}. If the d-c load is reduced still further, say to the value I_x, no current flows from the rectifier in the interval A-B of each ripple cycle. The ripple current is no longer a sine wave, but is cut off on the lower halves, as in the heavy line of Fig. 5. Now the average value of this current is not I_x but a somewhat higher current I_y. That is, the load direct current is higher than the average value of the rectified sine wave voltage divided by the load resistance. The amount of voltage increase necessary for this increased current is made available by the tendency of the condenser to charge up to the peak of the voltage wave between the intervals A-B. Hence, the term *condenser effect* which is applied to the voltage increase. The limiting value of this effect is obviously the peak value of the rectified voltage, which is 1.57 times the sine-wave average, at zero current load.

To keep the condenser effect from happening the choke must be large enough so that I_{ac} is equal to or less than the bleeder current I_l. This consideration leads directly to the value of choke inductance. The bleeder current I_l is E_l/R_l, where R_l is the value of bleeder resistance. The ripple current is the fundamental ripple voltage divided by the ripple circuit impedance, or

$I_{ac} = 0.667\ E_l/(X_L - X_c)$.

Equating I_l and I_{ac}, we have

$$R_l = \frac{X_L - X_c}{0.667} \quad \ldots\ldots\ldots\ (1)$$

Here we see that the value of capacity reactance also has an effect, but it is minor, relative to that of the choke, else the filter would not do much filtering. Hence, in a well designed filter, the choke reactance X_L is always high compared to X_c. So the predominant element in fixing the value of R_l (and of I_l) is the filter reactor. By making this reactor larger and larger, we can make the bleeder power necessary for good regulation smaller and smaller.

Now for the application. The rectifier in question had the regulation curve A shown in Fig. 7. The current which has been called I_l in the foregoing was 300 ma. and full load was 1.0 amp. The bleeder load was 50 ma., and increasing it to 300 ma. was out of the question; the rectifier would not deliver the extra power. Increasing the size of the filter choke was prohibitive because of space limitations. Besides, the increase in inductance would have to be accompanied by no increase in choke resistance, as the IR drop alone accounted for nearly 5% regulation, the amount desired for proper amplifier operation. Mercury vapor tubes were used; all the usual design precautions had been taken. Still stood the ominous 40% regulation between bleeder and full load.

A glance at equation (1) shows that the bleeder resistance depends upon the filter choke impedance. If this impedance could be increased without increasing the size of the choke, the problem would be solved. The impedance of any inductance can be raised by tuning it, so this was tried. The choke (L_1) was tuned to the ripple frequency as shown in Fig. 6 and a new regulation curve resulted at light loads, that shown by curve B in Fig. 7. This was a decided improvement, but still exceeded the desired 5% regulation between 50 ma. and 1.0 amp.

The value of bleeder current now needed for 5% regulation was 110 ma. A choke having a fair amount of inductance at this value of current has only a small fraction of the size of the 1.0 amp. filter choke. Such a choke (L_2) was placed in series with the main filter choke and was likewise tuned as shown dotted in Fig. 6. The regulation curve with both tuned chokes was as shown by curve C of Fig. 7 and was within the 5% regulation limit.

All three added elements were of such small size that they could be located easily among the larger rectifier elements. For instance, the main filter choke was tuned with 0.25 μf and the small choke with 0.6 μf, as compared to 12 μf across the load.

Another feature observed in this instance was the fact that the load ripple decreased as well as the regulation. This was to be expected, because of the increased filter choke impedance.

Hence it follows that if a filter is originally designed to use tuned chokes, these advantages accrue:

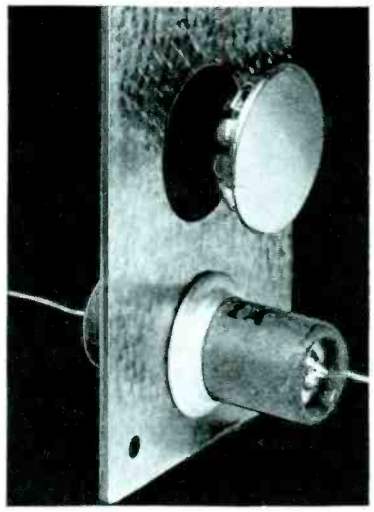
1. For a given value of permissible regulation, less bleeder power and/or smaller filter choke are needed.

2. For a given amount of bleeder power, less regulation and ripple result and/or smaller filter choke is needed.

3. The use of smaller filter chokes makes it easier to obtain the desired regulation by reducing the choke d-c resistance.

* Prince & Vogdes, "Mercury Arc Rectifiers and Circuits," page 92.

The story of a plug button that became a condenser mounting



WHEN IS A PLUG BUTTON

When is a plug button used? Introduced by Cinch to plug holes in the chassis when a standard chassis is used for a variety of sets and hook-ups. Also for grounding cable connectors. Cinch engineers have expanded plug button uses. Mentioned here is an outstanding example of when it was more than a plug button, or,

. . . NOT A PLUG BUTTON

To serve a certain set requirement for wiring through the chassis, the plug button became a condenser mounting unit. Cinch parts are the most efficient for the purposes designed but in a number of instances they have been adapted most satisfactorily for other uses. That's Cinch Engineering, *"Ingenuity"*— and of course, for users, the acme of efficiency and economy.

Cinch and Oak Radio Sockets are licensed under H. H. Eby socket patents

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Tubes At Work

(*Continued from page* 36)

age drop, even on low currents. The meter is connected to the suitable tap for the range desired. This circuit while entirely satisfactory for high resistance circuits, is totally unsuited for making voice coil measurements. The reasons are obvious from the previous

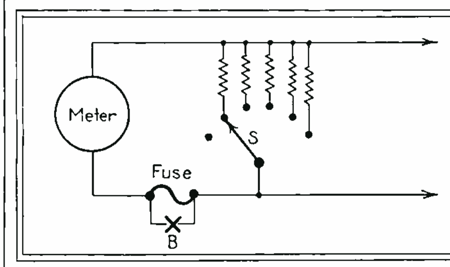


Fig. 1—Elementary shunt circuit

calculations. It is further evident that the meter cannot be used on its lowest, or fundamental range, because of the permanent shunting effect of the main shunt.

As a more convenient modification of the circuit in Fig. 2, the circuit in Fig. 3 is the one now almost universally recommended. In this circuit all the shunts are in series, and the meter is permanently connected to them.

The two principal disadvantages of this circuit lie in the fact that the full

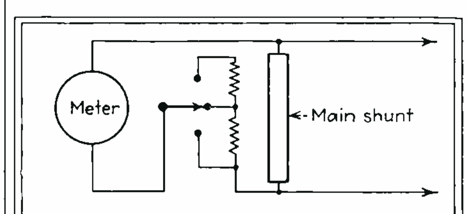


Fig. 2—Circuit for safeguarding meter

sensitivity of the meter cannot be employed, since it is permanently shunted, and the voltage developed across shunt *A* has to be high enough to make up for the drop that results in shunts *B* and *C* before the current gets to the meter. With this arrangement it is nec-

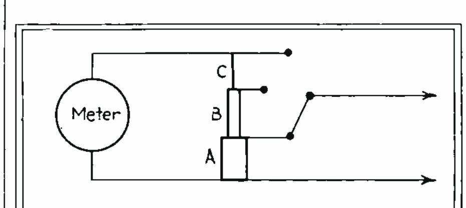


Fig. 3—Improved form of safeguard circuit

essary to calibrate the meter with the shunts in place. In the circuit in Fig. 1, any calibrated meter may be multiplied by any practicable amount and yet the lowest range may be used.

This is a very great advantage around the laboratory.

In order to retain the safety of the method in Fig. 3, and yet procure the lowest possible resistance and the cali-

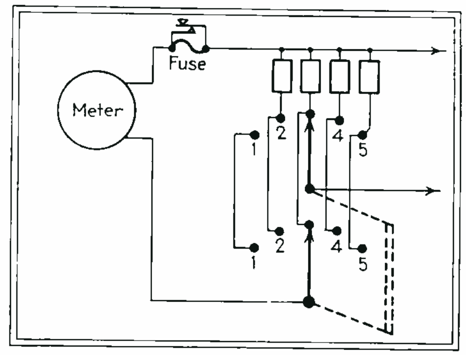


Fig. 4—Gang-switch system, which combines advantages of Figs. 1 and 3

brating advantages in Fig. 1, the circuit in Fig. 4 was devised. Observation will reveal that there is no possible way to burn out the meter, other than to have the shunts themselves fail. If the meter arm fails to make contact, then only the meter circuit opens, causing no harm. If the current arm fails to make contact, then only the external circuit is opened; and the load is again taken off the meter. There is no com-

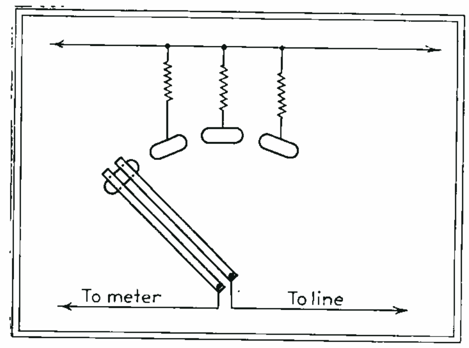
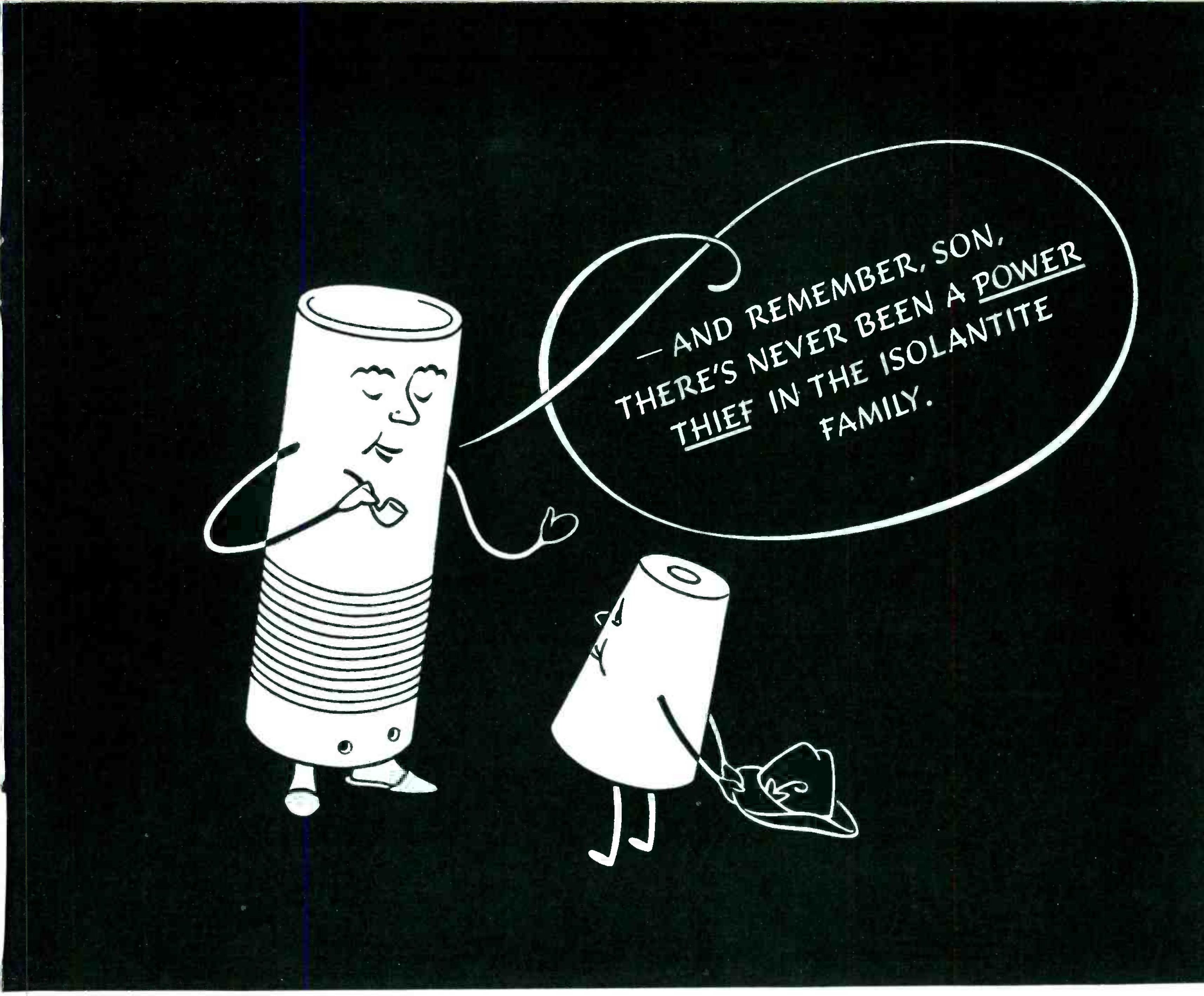


Fig. 5—Method of minimizing switch lead reactance effects

bination of make and break in either switch that can result in the loss of the meter. A fuse in this circuit is essential only to provide against overload in the external circuit.

In Fig. 4, the switch illustrated is of the two-gang type, and bus wiring is used between contacts bearing the same number. The essential precautions in the construction of such a circuit are: First, be sure that the bus wiring is more than adequate to handle the currents to the meter. In the shunt circuits use wire corresponding to the current to be measured. Use no less than #18 wire in any case. Second, be sure that the wire is mechanically connected to the lugs well enough to carry the current without solder, then solder perfectly taking every precaution to avoid rosin joints. This applies particularly to the shunts, for if a shunt opens up, the meter will be lost unless the circuit is fused. Third, take care to


— AND REMEMBER, SON,
THERE'S NEVER BEEN A POWER
THIEF IN THE ISOLANTITE
FAMILY.

determine that the two contact arms cannot be shorted together any place but at the points of contact on the switch, as shown. Fourth: The switch must have a detent to insure that measurements are not made on two shunts at once.

On meters to be used in high frequency work, the reactance of the bus wiring becomes of importance. The two gang switch in Fig. 4, is most desirable for this purpose since the bus wiring is the shortest possible, it be merely necessary to bridge the wires straight across between gangs, about a half inch, and in some types of switch the lugs can be bent together and soldered. For particular work, however, a special switch may be advisable. Fig. 5, shows how such a switch may be built. Switches in Fig. 4 are readily available on the market.

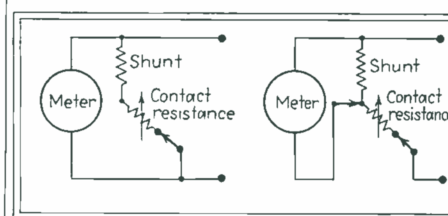


Fig. 6—Effect of contact resistance

Fig. 6 illustrates the subject of contact resistance. In the circuit at the left with a 5.2 ohm ammeter, the resistance of the shunt on the 100-times range would be on the order of 0.0525 ohm. With the best contacts likely to be used in such a circuit, the resistance would be on the order of 0.002 ohm. Since this is effectively in series with the shunt, a variation of contact resistance by this amount would therefore cause a variation of the meter reading on the order of 0.4 amp. in 10. If ordinary type range switches were to be used, the variation might easily be great enough to cause the burnout of the meter. In the circuit at the right the resistance is in series with the external circuit, and so variations have no effect on the meter reading.

CHECKING PROPAGANDA

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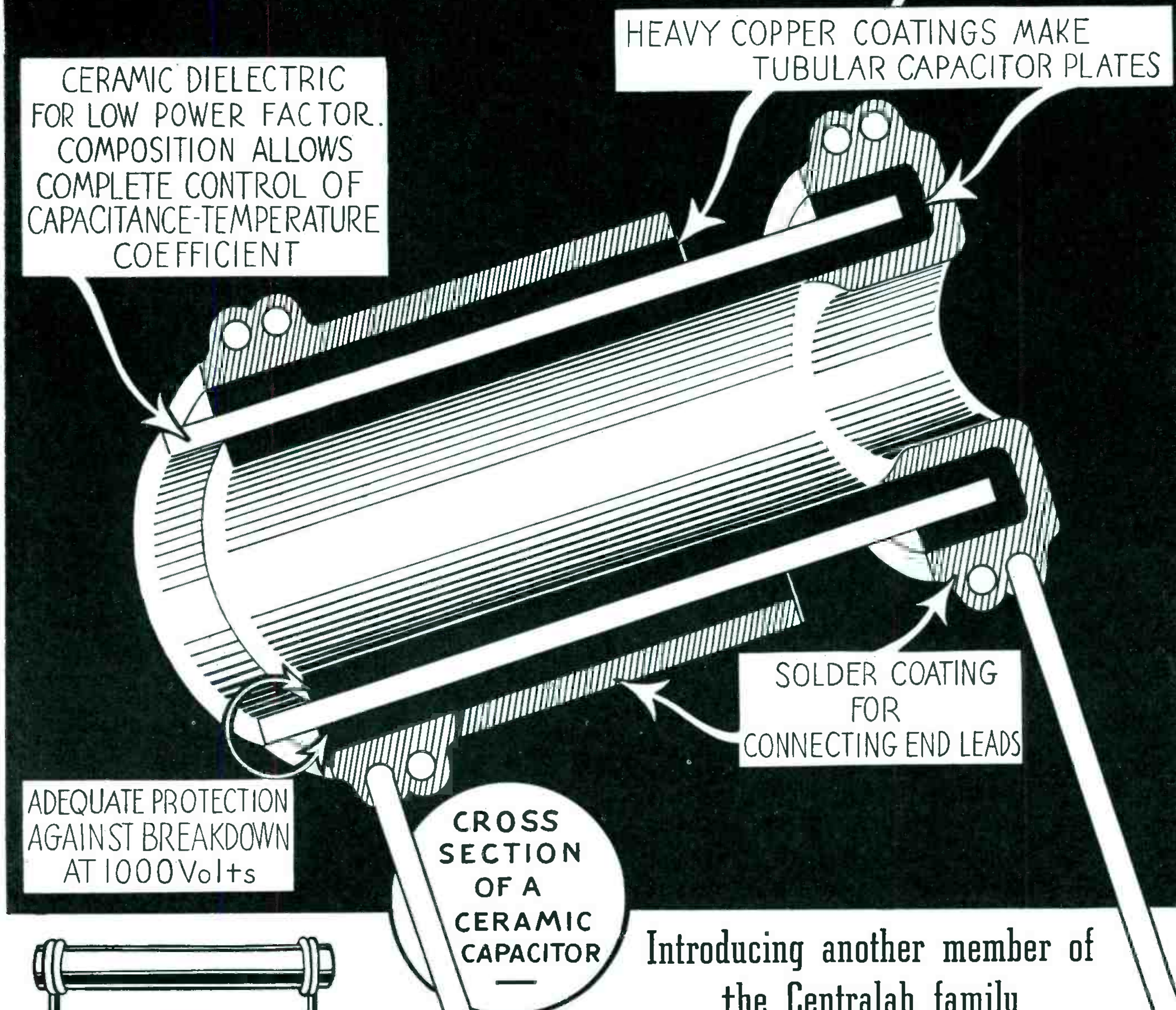

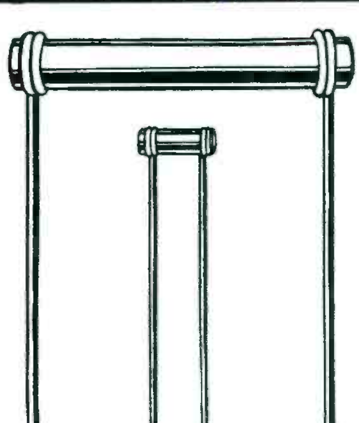

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THE ELECTRON ART

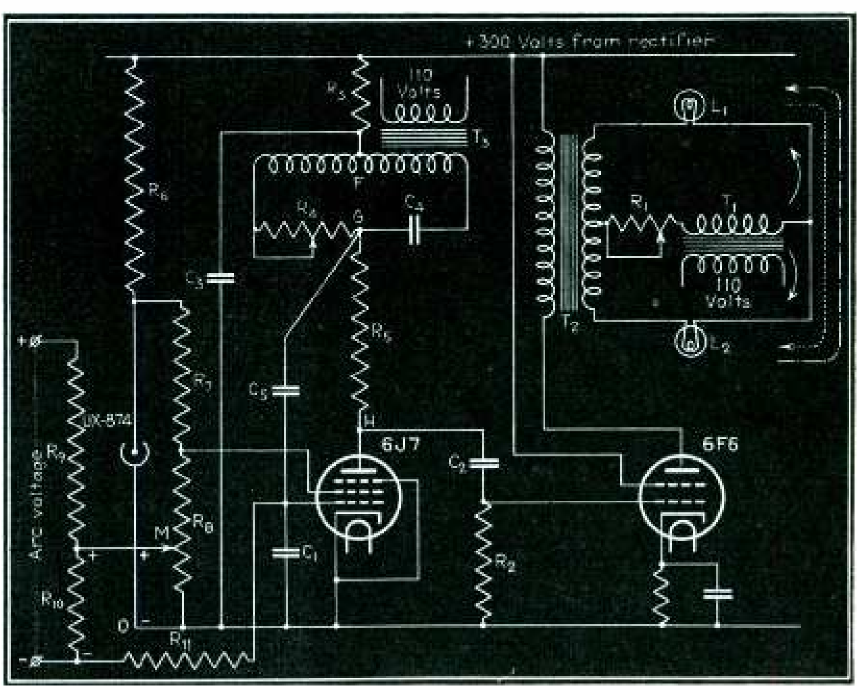
Each month the world's technical literature is scanned to see what physicists and engineers are doing with tubes, for presentation in tabloid form to *Electronics'* readers

Electronic Arc Length Monitor

AN INSTRUMENT for determining the voltage used in d-c arc welding is described by Walter Richter in the March issue of *Electrical Engineering* under the title, "An Electronic Arc Length Monitor". The device is an improvement over the voltmeter for d-c arc welding described in the March 1935 issue of *Electronics* in that it indicates deviations from some established arc voltage directly to the welder without requiring that he look away from the arc. The device may be considered as a null type of instrument in which two lamps are used to indicate deviations from normal arc voltage. When the arc voltage is established at the desired value, both lamps are extinguished. If the voltage rises above the established value, one of the lamps becomes incandescent, while the other lamp lights up if the voltage falls below the value for which the monitor is set.

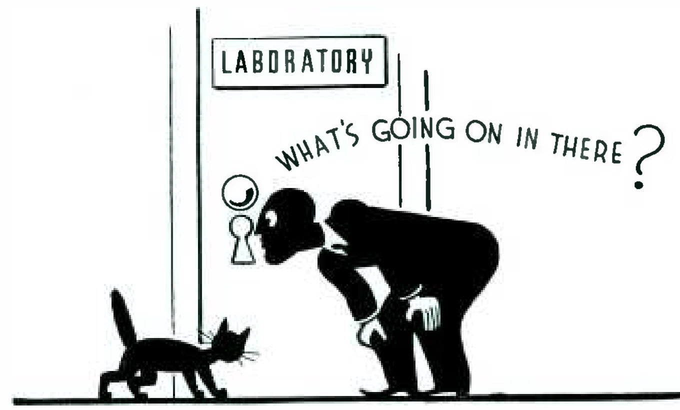
Except for the rectifier, which is of the conventional type, the wiring diagram of the complete unit is shown in the accompanying schematic circuit. The arc voltage is applied to two terminals at the left. A portion of this arc voltage is obtained from the opposing voltage drop across OM, obtained from the 300 volt source. For purposes of maintaining the voltage as nearly constant as possible, a voltage regulator tube is placed across R_7 and R_8. The differential voltage is fed through a smoothing filter, $R_{11}C_1$, so that the mean value of the difference voltage becomes the grid bias for the 6J7 amplifier tube.

An alternating voltage, whose magnitube depends upon the grid bias voltage of the 6J7, is produced by applying a small alternating voltage to the grid of the first amplifying tube and varying the amount of amplification by changing the d-c grid bias voltage. The amplified alternating voltage appearing in the output of the first tube is connected in series with a fixed alternating voltage of opposite phase. The sum of these two alternating voltages is a new alternating voltage which changes its phase as well as its magnitude. This new alternating voltage is fed into the primary winding of a transformer, the secondary of which is center-tapped,



Schematic wiring diagram for electronic arc-welding voltage determining device

Low Cost



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through a second amplifying tube, 6F6. The two sections of the secondary winding and the bulbs L_1 and L_2, form a bridge arrangement. Between the center tap of the transformer and the junction of the lamps, a fixed alternating voltage is introduced. The current produced by this fixed voltage is adjusted to a valve just below that required for the lamps to glow. Grid excitation of the 6F6 amplifier will produce currents in the bridge circuit in the direction of the arrows, depending upon the phase of the excitation voltage. A voltage induced in the secondary winding of the center-tapped transformer will then increase the current in one lamp and decrease it in the other, depending upon the phase of the induced voltage actuating the grid of the 6F6 tube.

Secondary Emission in Amplifying Tubes

THE PRINCIPLE of amplifying electron currents by means of secondary emission, and the application of this principle in conjunction with photo-electric tubes is discussed by J. L. H. Jonker and A. J. M. v. Overbeck in the March issue of *The Wireless Engineer*. The article describes a construction and gives characteristics of an amplifying tube having an indirectly heated cathode, in which the amplification is effected by secondary emission, and in which the electrons are subjected to electrostatic deflection before reaching an auxiliary cathode.

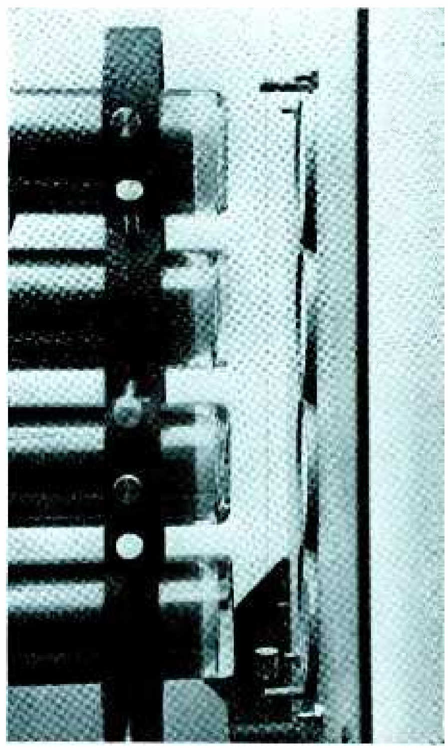
Air Purification by Electrical Means

A METHOD of air purification developed by engineers of the Westinghouse Electric and Mfg. Co., which removes practically all of the dust, dirt, smoke, and soot from the atmosphere passing through the purifier, uses electronic methods exclusively, and shows promise of opening up new fields for electronic applications in the construction of individual small homes as well as large apartments and business buildings.

Essentially the precipitating purifier depends upon the fact that particles of dirt become electrified in passing through an electric field, and may then be collected on a charged plate. In this respect the precipitator is similar to others which have been used for several years. In the Westinghouse system, however, the functions of ionization and precipitation are performed in two stages. In the first, the dust laden air is ionized by passing it through wires and plates having a high voltage gradient. The ionized air is then made to pass through parallel plates having a potential difference between them of 5,000 volts, the dirt being accumulated on either one of these plates. When the charged plates become dirty, they may be cleaned by turning off the voltage, and washing with the spray from a garden hose. It is claimed that the cost of operation is exceedingly nominal.

Four Trace Oscilloscopes

Two new types of four trace oscilloscopes are described by Manfred von Ardenne in the December 1937 issue of *Archiv für Technisches Messen.* One of these oscilloscopes, consists essentially of two double trace tubes as described in the October 1936 issue of *Electronics*, and produces two pairs of oscilloscope traces on the screen, one pair from each two trace structure.



Close up of the screen ends of the four single trace cathode ray tubes which are used to produce four simultaneous traces. The screens of the individual tubes are viewed through the four lenses seen at the right. Set screws on the yoke holding the tubes may be loosened so that the tubes can be rotated for proper orientation. Vertical traces may be aligned by means of the thread between the lenses and the tube screens

The filaments, which operate at 4 volts, are connected in parallel within the tube, and all four tube structures are operated from a common anode supply with voltages up to 10,000 volts. Separate terminals are provided for each of the eight vertical deflectors as well as for the horizontal timing traces.

Single trace cathode ray tube which is used in the four trace oscilloscope. The screens are 2 in. in diameter and are ground plane

The other four trace oscilloscope consists of four single trace cathode ray tubes, mounted one above the other. Since each tube has no internal connections with any other, strays and interactions are easy to eliminate. Furthermore, the fundamental idea may be used for any number of traces by the simple expedient of adding more tubes.

Orientation of the traces is accomplished by rotating the tubes, so that electrical circuit complications are avoided. Three sets of adjusting screws are provided near the front of the tube supports which permit the tubes to be rotated on their axis until the vertical traces of all four tubes are properly aligned.

Cornstalk Acoustical Board

FOR SEVERAL YEARS the Engineering Experiment Station of the Iowa State College has been concerned with the utilization of industrial waste products. As might be expected from a college in the center of the corn belt, the waste products of corn have been given considerable attention in this program. Perhaps the outstanding development in the past few years in the utilization of agricultural wastes has probably been the development from them of insulating board. Although often confused with wallboard, insulating board is an entirely different product intended to supply the need for a structural material which is uniform in quality, low in price, and which has relatively high thermal insulating and sound absorbing properties.

The subject of utilization of agricultural wastes is treated at some length in the following publications from Iowa State College:

Corn-Stalks and Cobs in Industry, *Scientific Monthly*, May, 1929.

Cornstalks as an Industrial Raw Material, *Bulletin 98*, June, 1930.

Agricultural Wastes in Industry, *Jour. Chem. Ed.*, December, 1931.

Utilization of Agricultural Wastes and Surpluses, *Bulletin 113*, March, 1933.

Studies of the Manufacture of Insulating Board, *Bulletin 136*, August, 1937.

Cornstalk Acoustical Board, *Bulletin 137*, August, 1937.

The last publication is probably the most significant to those engaged in the electronics or related fields, and deals with fundamentals of sound and acoustic, apparatus and testing methods for making determinations on cornstalk acoustical board, the effect of composition, and surface treatment upon the coefficient of absorption, and the effects of various applications of this agricultural acoustical board.

When measured at 512 cycles per second, the absorption of cornstalk acoustical material is about 21% to 36%, depending upon the thickness of the solid board, the method of manufacture, and the surface treatment. The absorption may be increased by varying the paper content of cornstalk board, as well as by boring holes in the board. The absorption increases as the number of quarter inch holes per unit area is increased, reaching a maximum at about 225 holes per square foot, when the absorption coefficient is about 95% at 512 cycles.

Up to a certain point, depending upon the absorptiveness of the basic board and the size of grooves cut in it, the addition of grooves increases the sound absorption in proportion to the number of grooves added. Certain hollow types of cornstalk board were found to be acoustically more effective than the same amount of material in the form of solid sheets.

It is apparent that those in the electronics field must depend, at least in some small measure, upon the activities of the American farmer. This dependence is more real than is apparent at first glance. Maybe it is beside the point; perhaps we occasionally engage in idle day dreaming. But with alterations going on on the 30th floor where *Electronics* is edited, we were just wondering how much we might expect to collect from the government for not writing this story because the office is too noisy, because some farmer was paid a nice lump sum of money not to raise the corn which might be used to quiet the office so that this squib might be written.

High Mu Tubes in Resistance Coupled Amplifiers

TRIODES having amplification factors of 70 to 100 are widely used in resistance coupled amplifiers. In such circuits, the voltage actually applied to the plate of the tube is likely to be in the vicinity of 50 to 150 volts, so that a grid bias of 1 to 1.5 volts is required. Such values of bias are of the same magnitude as the inherent positive grid bias exhibited by tubes. A grid bias sufficient to counteract the inherent grid bias and provide for the application of signal voltage often results in the use of a bias voltage so large as to affect the gain adversely.

In a study of this problem, engineers of the National Union Laboratories made measurements on a number of types of tubes under different circuit conditions. In the conventional circuit, the grid bias is obtained by a bias cell in series with a 1 megohm resistor. In the other circuit, the grid bias is provided by means of a 15 megohm grid resistor.

Tests on two hundred 6Q7G tubes and an equal number of 6B6G tubes indicate that high gain, greater uniformity of gain, and less distortion result for the circuit using the 15 megohm grid leak rather than for the 1 megohm leak in conjunction with the bias cell. The same conclusions hold when the heater is 8.0 volts as well as when it is 6.3 volts.

MANUFACTURING REVIEW

News

✦ Lear Developments, Inc., announce the opening of a new office, laboratory, factory, and service shop at Roosevelt Field, Bldg., 31, Mineola, N. Y.

✦ The appointment of E. F. Carter as assistant chief engineer for Sylvania radio tubes has been announced by Sylvania Chief Engineer, R. M. Wise. Mr. Carter has been a member of the Sylvania Engineering Dept. since Sept., 1932, when he was appointed consulting engineer on tube application problems. In 1933 he was made division tube engineer for the Emporium, Pa., plant.

✦ Fully confident of an early business recovery from the depression which started last August, the Aerovox Corp., 70 Washington St., Brooklyn announces the leasing of additional floor space for further expansion of its plant and office facilities.

✦ For the purpose of manufacturing and distributing a new audio replacement vibrator called "Vibrapower," the Pauley-James Corp., of 4619 Ravenswood Ave., Chicago, has been founded.

✦ A report for the year ended December, 1937, showing a net profit over that for 1936 of approximately 36 per cent was announced by the International Nickel Company of Canada.

✦ According to the annual report to stockholders for the year ending December 31, 1937, the Western Electric Co.'s volume of business in 1937 showed a marked improvement over 1936. Sales for the year increased 39 per cent, payrolls 61 per cent, and profits 4 per cent over 1936, notwithstanding a substantial reversal in trend of business during the latter part of the year due to a nation wide depression. Sales totalled $203,467,000 in 1937 as compared with $146,421,000 for the previous year.

✦ Dr. Joseph Slepian becomes Associate Director of Westinghouse Elec. & Mfg. Company's Research Div., after 21 years of service with that company. Dr. Slepian is the inventor of a lightning arrester using thin carborundum

and clay discs in a porcelain container—also supervised the development of a de-ion circuit breaker. He has made numerous contributions to electrical engineering literature.

✦ The 18th annual report of the Radio Corp. of America for the year ended December 31, 1937, shows a total gross income for RCA of $112,639,498 in 1937, compared with $101,186,310 in 1936. This represents an increase of 11.3 per cent for the year due to increase in business during the first three quarters of the year. The consolidated net profit of RCA amounted to $9,024,858 for 1937, representing an increase of 46.6 per cent over 1936 figure of $2,868,921.

✦ Total operating revenues of the Bell System in 1937 were $1,051,400,000, an increase of $56,500,000 or 5.7 per cent over the previous year according to the report of the directors of the American Telephone & Telegraph Co. More than two-thirds of the $69,000,000 increase in expenses was due to increased taxes and higher wage rates.

Literature

Manufacturers' literature constitutes a useful source of information. Readers who wish copies of items listed below may obtain them by contacting the manufacturers.

Power Tubes. Descriptive table giving informative data on various types of power tubes is contained in a four-page leaflet recently issued by Collins Radio Co., Cedar Rapids, Ia.

Signal Generator. An illustrated 4-page folder showing the characteristics and construction of a standard signal generator having a frequency range of from 9.5 kc. to 30 Mc. is available from the General Radio Co., Cambridge, Mass. The output is continuously adjustable from 0.5 microvolts to .01 volt.

Television Parts. A folder describing new television parts and giving wiring diagrams is available from the Parts Division, Radio Corporation of America, Camden, N. J.

Vacuum Thermocouple. Bulletin E, describing some of the applications for, and containing a list of vacuum thermocouples, is available from American Electrical Sales Co., Inc., 65 East 8 St., New York.

Relays, Timers, and Thermostats. These products are all thoroughly treated in the new technical catalog just issued by Struthers-Dunn, Inc., 139 N. Juniper St., Philadelphia, Pa.

Explosion Protection. An electron tube device designed to shut off gas and prevent explosion in case of flame failure, is described in Bulletin 1102 which may be obtained from the Wheelco Instrument Co., 1929 So. Halsted St., Chicago.

Screw Products. A 4-page folder, "Third Hand Information" outlines the advantages of the Phillips recessed head manufactured by the American Screw Co., Providence, R. I.

Self-Locking Fasteners. For aircraft purposes, self-locking fasteners are described in Catalog C issued by Dzus Fastener Co., Inc., Babylon, N. Y.

Testing Plastics. A bulletin, No. 20584, on the testing of finished pieces of plastic and moulded insulating materials for physical properties, is available from Testing Machines, Inc., 468 West 34 St., New York.

Laminated Sheets. A 48-page, illustrated booklet, "Bakelite Laminated," discussing the physical, electrical and mechanical properties of laminated sheets, tubes, and rods is a new catalog by Bakelite Corp., 247 Park Ave., New York.

Instrument Bulletin. A publication devoted to extending the benefits of electric instruments is a new house organ entitled "Instruments in Industry" which will be issued periodically by the Meter Division, General Electric Co., Schenectady, N. Y.

Springs and Wire Forms. A new booklet on designing and production facilities for springs of all kinds is offered by the Hunter Pressed Steel Co., Lansdale, Pa.

Monel Strip. A new price list covering Monel and "A" nickel strip has recently been released by the Somers Brass Co., 350 Madison Ave., New York City.

Cone and Voice Coil Assemblies. A two-page speaker bulletin giving instructions for installing cone and voice coil assemblies in Magnavox speakers is available from the Magnavox Co., Fort Wayne, Ind. Also available is a two-page leaflet describing high capacity a-c and d-c receiver supply filter.

Velocity Microphone. Instructive information on a velocity type microphone requiring no polarizing voltage but generating its own signal voltage is available in a single page brochure issued by the Bruno Laboratories, 30 West 15th St., New York.

New Products

Tube Developments

NEW TUBES announced by the RCA Manufacturing Co., Harrison, N. J., for this month include the type 1851 television amplifier pentode. The RCA-1851 is a heater-cathode type, metal tube intended for use in experimental television receivers, especially in the radio frequency and intermediate frequency stages. Heater voltage is 6.3 volts, with a current of 0.45 amperes.

Maximum plate voltage is 300, screen voltage 150 volts maximum. Plate resistance is 0.75 megohm, plate current is 10 milliamperes, and the screen current is 2.5 milliamperes. An advantage of this pentode is its high transconductance of 9,000 micromhos. The tube uses the standard octal base but the control grid cap is considerably smaller than usual.

A triple grid super-controlled amplifier, 6S7 is a pentode tube in metal envelope intended for high frequency stages of radio receivers designed for low heater power consumption. The heater operates at 6.3 volts and 0.15 amperes. Maximum plate voltage is 250; screen voltage is 100 volts maximum. Plate resistance is 1 megohm and the transconductance is in the vicinity of 1,500 micromhos, the actual value depending upon the electrode voltages.

Resin Adhesive

A NEW PHENOLIC resin adhesive, No. 5116, is announced by the General Plastics, Inc., North Tonawanda, N. Y. Used as a coating it is capable of withstanding a 50% caustic soda solution and retaining its bond strength up to 100°. Softening point is between 115° and 120°.

Amplifier Multi-Stage Inverse Feed-Back

A 25 WATT amplifier having frequency characteristic to within plus or minus

1½ db from 50 to 10,000 cycles and using multi-stage degeneration was announced by the Webster Co., Chicago. It has 2½ per cent distortion at 25 watts output.

Compact Velocity Mike

A SMALL velocity microphone complete with output transformer, cable connector and switch has been announced by the Amperite Co., 561 Broadway, New York. It has an output of —70 db and a frequency response flat within 2 db from 60 to 7,500 cycles, and is obtainable in either low impedance (Model ACL) or high impedance (Model ACH).

Voltage Regulation

A VOLTAGE REGULATOR which stabilizes an a-c voltage that may be varying from 95 to 130 volts and holds it constant at 115 volts plus or minus 1% automatically and instantaneously was recently announced by the Raytheon Mfg. Co., 190 Willow Street, Waltham, Mass. It is a magnetic device without moving parts or adjustments and will operate from any commercial a-c power source. It delivers one or more required voltages with power outputs up to several thousand voltamperes.

Television Transformers

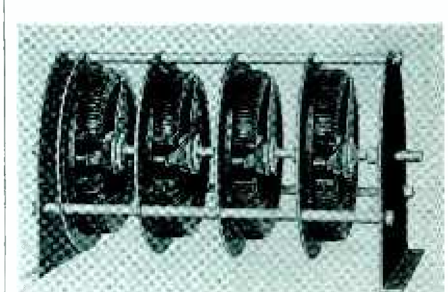
THREE TRANSFORMERS, for use with the new kinescope television tube have been announced by the Thordarson Electric Manufacturing Co., 500 West Huron St., Chicago. One of these is a 2½ volt, 2.1 amp. transformer for the heater. One transformer delivers 3,000 volts or 2,000 volts at 3 milliamperes as well as filament voltage. The third transformer delivers 3,000, 4,500, or 6,000 volts at 5 milliamperes, in addition to the filament power.

Sensitive Panel Instrument

A NEW LINE of panel instrument with vertically disposed pivots is announced by the Sensitive Research Instrument Corp., 4545 Bronx Blvd., New York City. These new meters are available as voltmeters, milliammeters, or microammeters with as low as 1½ microamperes full scale deflection. The line also includes wattmeters with a full scale as low as 0.2 watts.

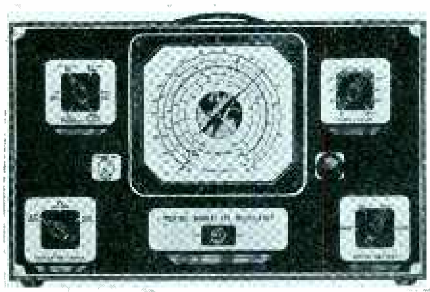
Resistor Assembly

FOR THE CONTROL of electrical apparatus where several circuits are to be varied simultaneously, a tandem construction and assembly of standard Ohmite units has been designed by engineers of the Ohmite Manufacturing Co., 4835 Flournoy St., Chicago. This assembly can be supplied for two, three, four or more rheostats in tandem, using standard Ohmite rheostats. The same assembly can also be used with Ohmite tap switches. The assembly unit shown is 12 in. in diameter and contains four rheostats having a power rating of 1 kw. each.



A-C Operated Oscillator

A TEST OSCILLATOR featuring precision control of frequency and output level has been introduced by the Weston Electrical Instrument Corp., Newark, N. J. Automatic amplitude control for any level from 1 microvolts to 0.1 volt may be obtained from the unit which operates from any 60 cycle, 110-120



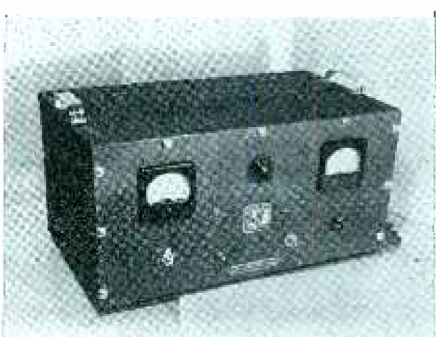
volt line. Six individually calibrated, direct-reading frequency scales are provided covering the range from 50 kc. to 30 Mc. The frequency calibration is guaranteed accurate to ½ of 1 per cent except for the three shorter wave bands for which the precision is 1 per cent.

Portable Potentiometer

SPECIALLY DESIGNED and built in three different models for use in field or laboratory service, a portable potentiometer, standardized with regulation standard cell, and equipped with precision slide wires and multipliers, is a new product of Wheelco Instruments Co., 1933 S. Halstead St., Chicago. A taut suspension galvanometer, complete with lock and zero adjuster is used. The units are obtainable with scales calibrated in millivolts or in degrees Fahrenheit or Centigrade, or both.

Power Units

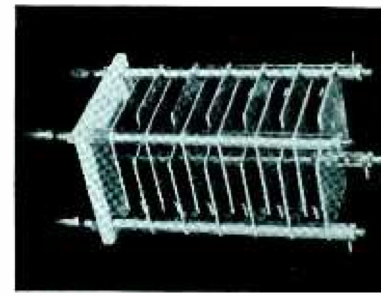
A D-C POWER SUPPLY delivering from 15 to 20 amperes, intermittent use, and with voltages from 1½ to 18 volts, is an-



nounced by the B-L Electric Manufacturing Co., St. Louis, Mo. The unit uses a circuit in which the number of rectifier junctions is varied in accordance with the desired voltage.

Plug-in Condenser

A NEW LINE of fixed capacitance, plug-in type condensers has been announced by the Allen G. Cardwell Manufacturing Corp., Brooklyn, N. Y. Plates are



readily removable for fixed capacitance adjustment. The units are available in such ranges as to be especially suitable for circuits of amateur transmitters.

Multiple Contact Relay

MULTIPLE CONTACT direct-current relays in three types have been made available by the C. P. Clare & Co., 4541 Ravenswood Ave., Chicago, Ill. These units may be obtained for fast operation—fast release; delayed operation; or delay release.

Gain Set

A TRANSMISSION measuring set having a range of 99 db. is announced by the Cinema Engineering Co., 7606 Santa

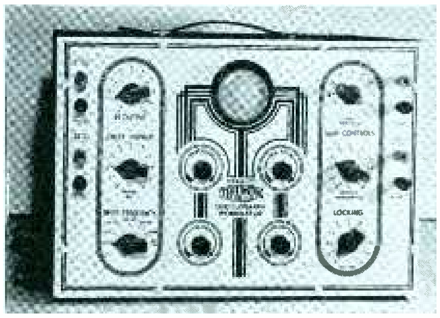
Monica Blvd., Hollywood. The unit may be obtained in standard cabinet or standard relay rack mounting.

Frequency Monitor

TO ENABLE POLICE radio operators to check station frequency, a monitor having a frequency range of 1,500 to 3,000 kc and 30 to 42 megacycles, a frequency stability of plus or minus .02 per cent, and an audio output of 600 milliwatts has been introduced by the Radio Department of the General Electric Co., Schenectady, N. Y. It is a-c operated from the 110 volt, 60 cycle line.

Oscillograph Wobbulator

A NEW OSCILLOGRAPH wobbulator, Model 77-2 employing a 2 in. cathode ray tube has been announced by the Triumph Mfg. Co., Chicago. It employs a built-in 840 kc. frequency modulator automatically synchronized to the linear sweep circuit. Complete analysis of r-f and i-f circuits can be made by observing the resonance curve of each tuned circuit.



The oscillograph proper performs all the standard oscilloscope functions with a linear sweep of 10 to 45,000 cycles. A pattern-locking control assures stable patterns.

Mica Condensers

A NEW CONDENSER, type BR, has been introduced by the Cornell-Dubilier Electric Corp., South Plainfield, N. J., to meet the rigid frequency requirements of push button tuning systems. The

condensers are encased in a low loss Bakelite, have a temperature coefficient of + 0.003 per deg. C., are rated at 1,000 volts d-c, and may be obtained in capacitances from 10 to 1,100 micro-microfarads.

Constant C Condenser

THE TYPE TB condensers introduced by the Solar Manufacturing Corp., 599 Broadway, New York, are intended for use with automatic frequency control receivers where the tendency to drift due to aging and temperature changes must be kept to a minimum. With these condensers a maximum to minimum capacitance range of 6 to 1 can be obtained. The condensers may be obtained with either a ceramic or a bakelite supporting strip.

Midget Volume Control

WITH VARIOUS interchangeable extensions a new line of volume controls was announced by the P. R. Mallory & Co., Inc., Indianapolis, Ind.

N. Y. City Radio System

(Continued from Page 13)

or to a dynamic loudspeaker, or to the land-line input of the Headquarters transmitter (for two-way communication between fire boats), or to a remote Fire Department telephone instrument. In the latter position, a differential or hybrid coil eliminates audio feedback or "loop singing."

The Headquarters transmitter is of the modern broadcast type, installed in a penthouse on the roof of the Repair Shops in Queens. Nearby, on the roof, is the quarter-wave vertical insulated steel tower antenna, connected to the transmitter by a co-axial transmission line. The upper 22 feet of the vertical antenna is built to serve as a "J" receiving aerial. A tuned filter in the receiving co-axial line permits simultaneous use of the vertical antenna for transmission and reception. The Headquarters transmitter is operated unattended.

The remote pickup receivers were specified to conform to stability and selectivity standards which anticipated the recent action of the Federal Communications Commission in establishing relatively much closer channeling in placing the ultra-high frequency band on a commercial service basis. The pickup receivers are crystal controlled superheterodynes, and therefore relatively free of warming-up drift, need for frequent peaking or other attention. Vertical doublet receiving aerials are used with co-axial connecting lines.

On eight of the nine fire boats steam turbo-generators furnish 120-volt, 60-cycle current for the radio installations. On the ninth fire boat, the "John J. Harvey," which is gasoline-electric driven, a motor-alternator is used. On each fire boat the control equipment and the superheterodyne receiver with its loudspeaker are in the pilot house. The fire boat transmitters are remotely controlled from the pilot houses, and connected by co-axial lines to vertical "J" antennas mounted high above the decks.

The system has been in operation for several months, and has furnished complete two-way coverage of the Port of New York.

Television Receivers

(*Continued from page* 31)

tor grid and to provide a satisfactory image response ratio.

This simple arrangement could be a single tuned circuit loaded with resistance to make its bandwidth sufficient. However, in practice a coupled circuit arrangement usually proves more satisfactory. The coupled circuit has the advantage of a much greater useful bandwidth for a given selectivity against undesired signals.

Capacitors may be used to tune this bandpass circuit. If the capacitors are variable so that the receiver can be tuned to the several television channels, the maximum capacitance must be large compared to the minimum capacitance plus stray circuit and tube capacitances. With a large capacitor the L/C ratio of the tuned circuit and consequently the circuit impedance becomes low. This in turn results in low overall gain, since the gain is essentially a function of the ratio of the input to output impedance of the system. These considerations point to the desirability of limiting the maximum capacitance of the tuning capacitor and consequently the tuning range of the receiver to as small a value as possible.

The tuning range in some experimental receivers covers the lower five television channels shown in Fig. 1, that is, about 44 to 90 Mc. The tuning capacitors then have a capacitance range of approximately 10 to 100 $\mu\mu$f. Typical selectivity curves of such a tuner are shown in Fig. 6.

These curves show that the effective pass band of the tuner is nearly constant at all frequencies. If the tuner is adjusted so that the sound carrier frequently falls at one side of this response characteristic, and the picture carrier at the other side, then both carriers and the upper picture sideband will all be approximately uniformly passed. This uniformity of bandwidth over the tuning range is obtained by using principally conductive coupling between the two circuits. This conductive coupling occurs in the common impedance of the gang capacitor shaft and decreases with increasing frequency, since the current through the trimmer capacitors and circuit distributed capacitances does not flow through the coupling impedance. The resistance loading on the circuits is just sufficient to reduce the double peak due to overcoupling at the low frequency end of the range to a satisfactory degree. With the decreased coupling at the higher frequencies the response becomes more rounded.

In designing the r-f circuit, the characteristics of the antenna and transmission lines must be considered. Both impedance matching and loading effects of the transmission line must be taken into account. Also the loading effect of the grid of the detector tube must be considered; this may be considerable at the high frequencies involved. The curves of Fig. 6 were taken with the input properly matched and the detector tube operating.

The impedance in the detector tuned circuit, while it is as large as can be used, is still very low compared to ordinary sound broadcast practice. The thermal agitation (hiss) in this circuit is consequently very low. Most of the hiss in the receiver is therefore caused by the shot effect in the plate circuit of the detector rather than thermal agitation in its grid circuit, as is usual in broadcast receivers. For this reason, great care must be used in choosing the type of tube to be used. Other things being equal, the hiss is a function of the plate current. The gain of the tube is a function of its transconductance. Therefore, a tube having a high ratio of transconductance to plate current should be used so that the signal-to-hiss ratio will be high.

In sound receiver practice it is common to use one or more r-f amplifier stages ahead of the detector. In the case of television the gain possible with conventional receiver tubes is low. For example, with circuits whose wide bandwidth and tuning range reduce their impedance to 1000 ohms or less, a tube with transconductance of, say 2000 micromhos would give a gain of less than two. To make a radio stage feasible, either the circuit impedance must be increased by decreasing either the bandwidth or the tuning range, or a tube of higher than ordinary transconductance must be used. To obtain really effective r-f amplification with present receiving tubes, the tuning range would have to be reduced to where the receiver would tune to only a single television station. This would of course greatly impair the usefulness of the receiver. However, using tubes having a transconductance of the order of 5,000 micromhos, a satisfactory and effective radio stage may be designed.*

Combination oscillator-detector tubes do not oscillate readily at these ultra high frequencies, and their plate current is high and transconductance low. It has been found that a sharp cutoff tube with separate oscillator excitation on its control grid operates very well as a heterodyne detector in a television receiver. To prevent the tube from drawing grid current, and to make the amount of oscillator excitation less critical, self bias on the detector, possibly in combination with AVC bias, has been found very satisfactory. If the detector tuned circuit is coupled to the oscillator circuit in a manner similar to that used in coupling it to the antenna circuit, the oscillator excitation remains reasonably constant over the tuning range.

The tuning unit of Fig. 6 uses two sections of a three-section gang capacitor, with the tuning coils and oscillator tube mounted on the frame of the capacitor. The detector tuned circuit is in the center, so that it is coupled to both the oscillator and antenna circuits. The circuit of the oscillator in this unit, which has been found to be highly satisfactory in performance, is shown in Fig. 7. This circuit is a more or less conventional grid leak biased oscillator, with the feature that the series condenser not only helps make the oscillator frequency track properly with the r-f circuit, but it is also placed in such a position in the circuit that the feedback coupling increases at the low frequency end of the range, due to the increasing ratio of reactance of the series capacitor to that of the tuning capacitor. This desirable effect helps to maintain uniform oscillation strength over the frequency range.

In addition to the requirement that the oscillator furnish uniform excitation to the detector grid circuit there is a rather stringent requirement that it have very small frequency drift. It has been found

* RCA Radiotron has recently announced a new tube (1851) designed for television purposes. It has a trans-conductance of 9000.—The Editor.

that a tuned plate oscillator has certain advantages in this respect over a tuned grid oscillator. Circuits which require that both sides of the tuning capacitor be at high r-f potential are undesirable for this particular application for the simple reason that it is more convenient to use a common rotor at ground potential for all three capacitors.

The oscillator frequency is best made higher than that of the incoming carrier so that full advantage can be taken of the tuning range of the radio circuits, and to obtain the advantages of the series capacitors in the oscillator circuit. With identical tuning capacitor and proper series and parallel trimming capacitor on the oscillator, very accurate tracking of the oscillator with the radio circuits can be obtained over the entire tuning frequency range.

We have now reviewed the fundamental requirements of the antenna, radio frequency selector, oscillator and input portions of the first detector circuit. In terms of the block diagram for the complete receiver shown in Fig. 3, the portions reviewed are shown in Fig. 4. In schematic form, these receiver input circuits are outlined in Fig. 7.

The second article of this series will cover the i-f amplifier circuits for picture and sound.

Adjudicated Patents

(C. C. A. N. Y.) Lowenstein patent, No. 1,231,764, for telephone-relay claims 1, 2, 4, 5, 6, and 7 *Held* valid and infringed. *Western Electric Co.* v. *General Talking Pictures Corp.* 91 F. (2d) 922.

(C. C. A. N. Y.) Arnold patent, No. 1,329,283, for thermionic amplifier, claims 7, 10, and 13 *Held* valid. *Id.*

(C. C. A. N. Y.) Arnold patent, No. 1,403,475, for vacuum-tube circuits, claims 8, 9, and 10 *Held* valid and infringed. *Western Electric Co.* v. *General Talking Pictures Corp.*, 91 F.(2d) 922.

(C. C. A. N. Y.) Pacz patent, No. 1,410,499, for metal and its manufacture, claims 25 to 27 *Held* invalid. *General Electric Co.* v. *Wabash Appliance Corp.*, 91 F.(2d) 904.

(C. C. A. N. Y.) Mathes patent, No. 1,426,754, for circuits for electron-discharge devices, claim 8 *Held* valid. *Western Electric Co.* v. *General Talking Pictures Corp.*, 91 F.(2d) 922.

(C. C. A. N. Y.) Arnold patent, No. 1,448,550, for thermionic amplifier circuits, claims 1 and 12 *Held* valid and infringed. *Id.*

(C. C. A. N. Y.) Arnold patent, No. 1,465,332, for vacuum-tube amplifier, claims 1, 3, 5, 8, 10, and 11 *Held* valid and infringed. *Id.*

(C. C. A. N. Y.) Arnold patent, No. 1,520,994, for electron-discharge amplifier, claims 1 and 4 *Held* valid. *Western Electric Co.* v. *General Talking Pictures Corp.*, 91 F.(2d) 922.

(C. C. A. Mass.) Mershon patent, No. 1,141,402, for electrolytic apparatus employing filmed electrodes, claim 5 *Held* invalid. *Mershon* v. *Sprague Specialties Co.*, 92 F.(2d) 313.

(C. C. A. Mass.) Mershon patent, No. 1,784,674, for film formation and operation of electrolytic condensers and other apparatus, claims 10 and 12 *Held* invalid. Claims 5, 8, 13, 14, 15, and 16 *Held* not infringed. *Mershon* v. *Sprague Specialties Co.*, 92 F.(2d) 313.

1,710,073, 1,714,191, S. Ruben, Electrical condenser, D. C., W. D. N. Y., Doc. 1855, *Ruben Condenser Co. et al.* v. *N. Abelsob et al.* (*United Radio Service*). Dismissed for lack of prosecution Nov. 9, 1937.

1,403,475, H. D. Arnold; 1,403,932, R. H. Wilson; 1,507,016, L. de Forest; 1,507,017, same; 1,618,017, F. Lowenstein; 1,702,833, W. S. Lemmon; 1,811,095, H. J. Round; Re. 18,579, Ballantine & Hull, filed Nov. 10, 1937, D. C., S. D. Calif. (Los Angeles), Doc. E 1279-J, *R. C. A. et al.* v. *L. Lowenstein* (*Low Radio Co.*).

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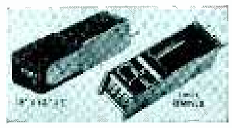

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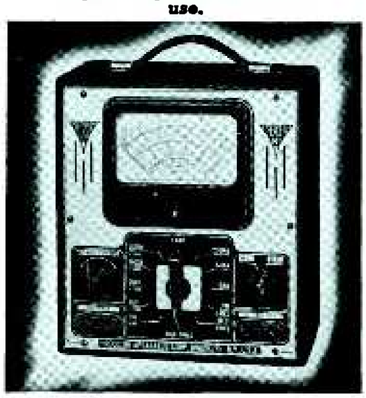

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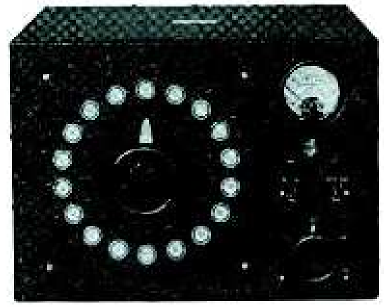

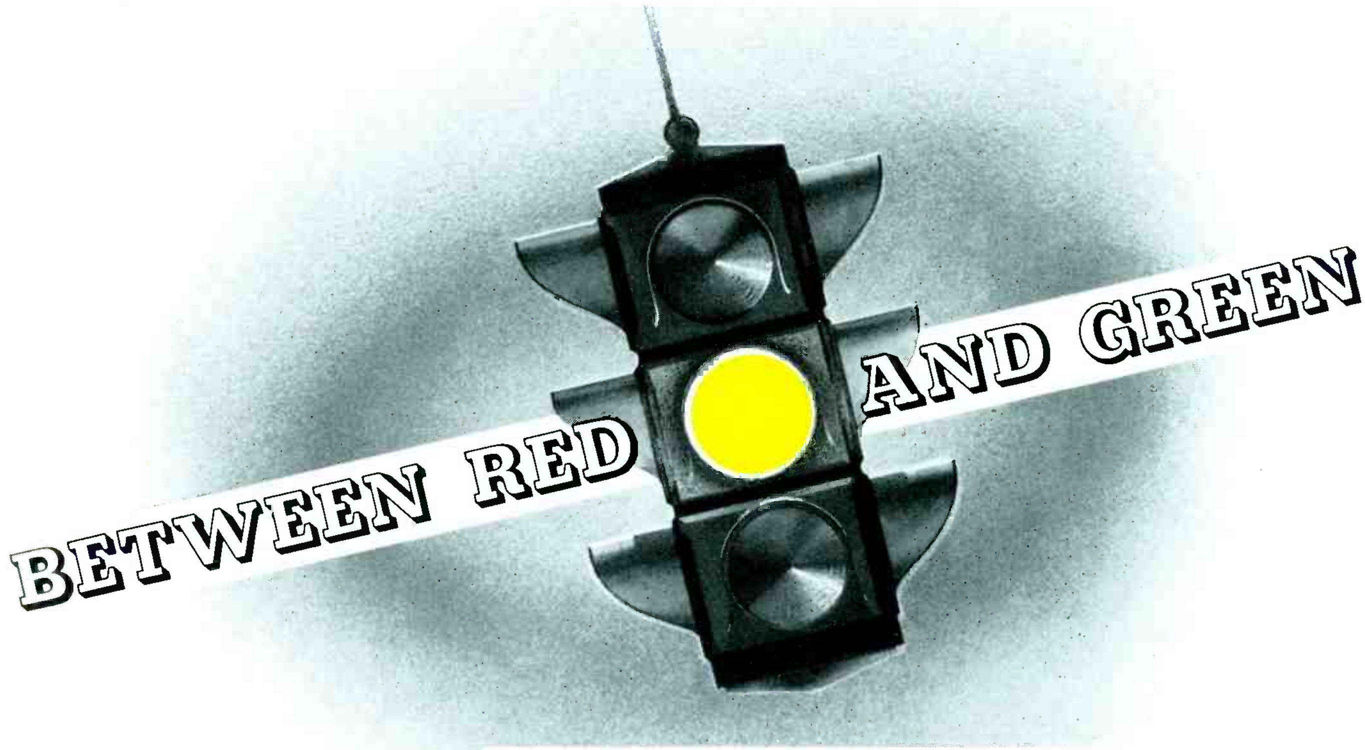

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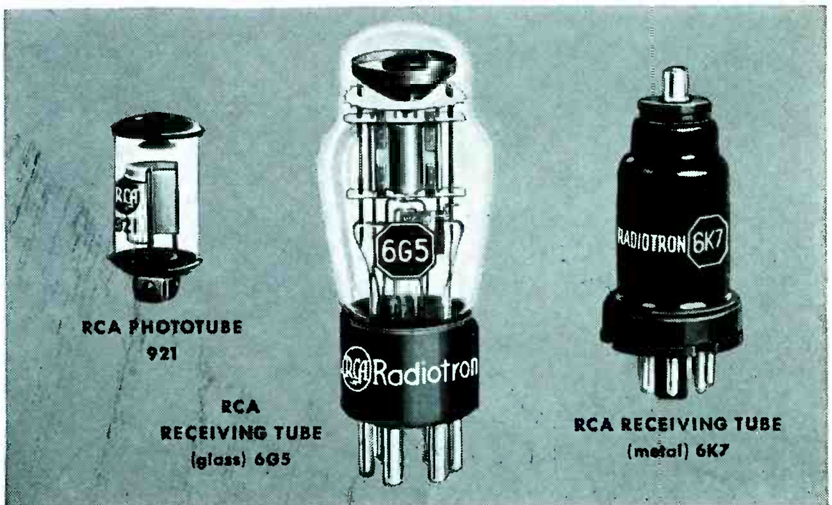

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