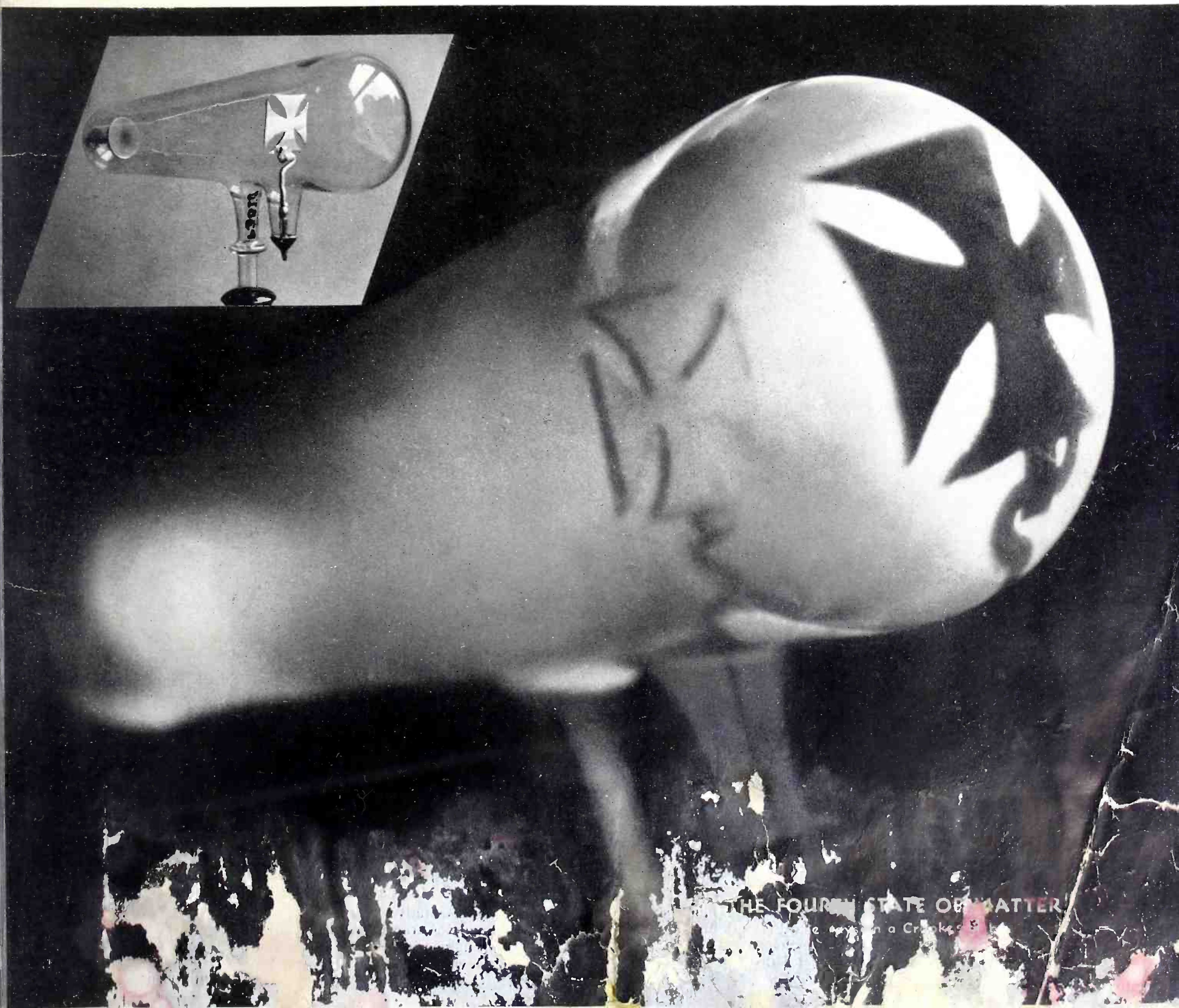
electronics

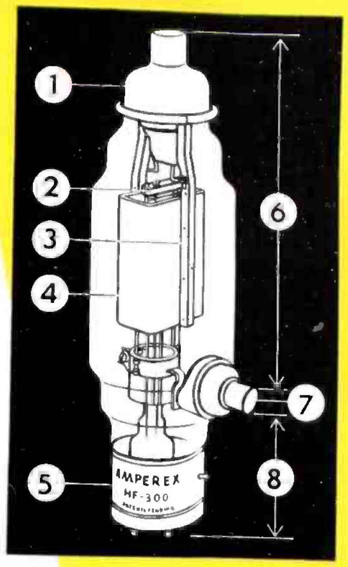
radio, communication, industrial applications of electron tubes . . . engineering and manufacture



JUNE
1937

For high power at ultra high frequencies

AMPEREX TUBES



At 60 megacycles 500 watts plate power output can be obtained from the Amperex HF-300. This tube, together with the HF-200 and HF-100, were developed by Amperex a number of years ago primarily for physiotherapy apparatus in which tubes capable of handling abnormally high currents at ultra high frequencies and at reasonably low voltage were required and none at the time available.

So universal was the recognition of the merits and efficiency of these tubes that now more than 70% of all diathermy ultra short wave generators are equipped with Amperex tubes and thousands more are in operation in almost every country in the world in broadcast, communication, amateur and industrial apparatus where they have replaced more costly or less efficient tubes.

Some of the design features which are responsible for the remarkable efficiency of these tubes at ultra high frequencies are as follows:

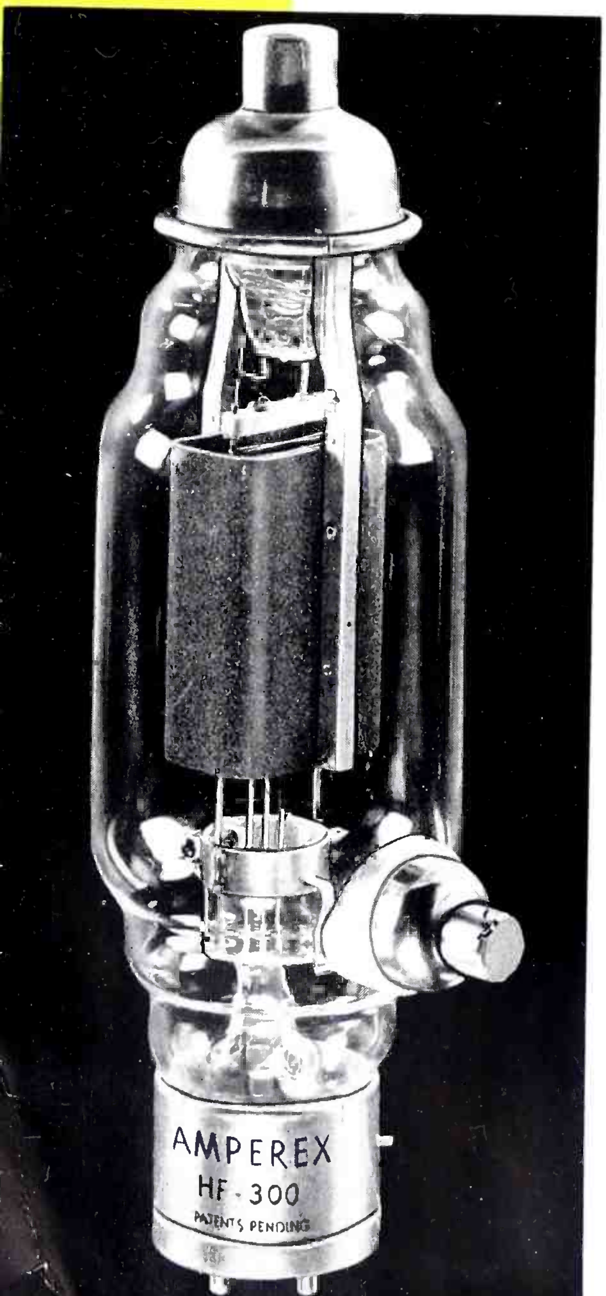
A high mu in combination with a high transconductance reducing requirements for grid excitation and grid power loss to a minimum.

Long insulation paths between electrodes, permitting the safe application of high voltages and reducing dialectric losses.

Extremely low interelectrode capacitances reduce the magnitude of circulating R.F. currents and permit more efficient circuit design.

1. Large heat radiating area at plate terminal
2. One insulating spacer between grid and filament only
3. Large area plate leads
4. Anode of graphite. The perfect heat radiating material
5. Standard 50 watt base
6. Long insulation path, grid to plate
7. Large heat radiating area at grid terminal
8. Long insulation path, grid to filament

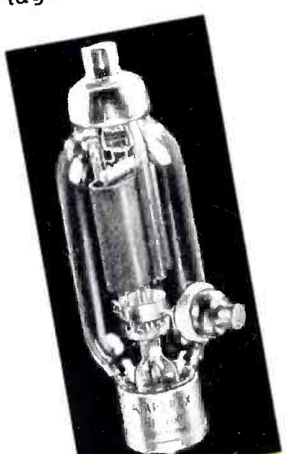
Transit time power losses are reduced to a minimum in the AMPEREX high Gm planar filament structure without sacrificing the decided advantage of extremely low interelectrode capacitance.



HF 300

Filament voltage	11-12 volts
Filament current	4 amperes
INTERELECTRODE CAPACITANCES	
Grid to plate	6.5 mmf.
Grid to filament	6.0 mmf.
Plate to filament	1.4 mmf.
Mutual conductance at 150 ma.	5600 micromhos
Amplification constant	23
Plate dissipation	200 watts
Plate power output	500 watts

$35



HF 200

Filament voltage	10-11 volts
Filament current	3.4 amperes
INTERELECTRODE CAPACITANCES	
Grid to plate	5.8 mmf.
Grid to filament	5.2 mmf.
Plate to filament	1.2 mmf.
Mutual conductance at 150 ma.	5000 micromhos
Amplification constant	18
Plate dissipation	150 watts
Plate power output	350 watts

$24.50

HF 100

Filament voltage	10-10.5 volts
Filament current	2 amperes
INTERELECTRODE CAPACITANCES	
Grid to plate	4.5 mmf.
Grid to filament	3.5 mmf.
Plate to filament	1.4 mmf.
Mutual conductance at 150 ma.	4200 micromhos
Amplification constant	23
Plate dissipation	75 watts
Plate power output	170 watts

$12.50

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NIC PRODUCTS

BROOKLYN

electronics

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

ELECTRONICS, June 1937, Vol. 10, No. 6. Published monthly, price 50c a copy. Subscription rates—United States and possessions, Canada, Mexico and Central American countries, $5.00 a year. All other countries, $6.00 a year or 24 shillings. Entered as Second Class matter, August 29, 1936, at Post Office, Albany, N. Y., under the Act of March 3, 1879.

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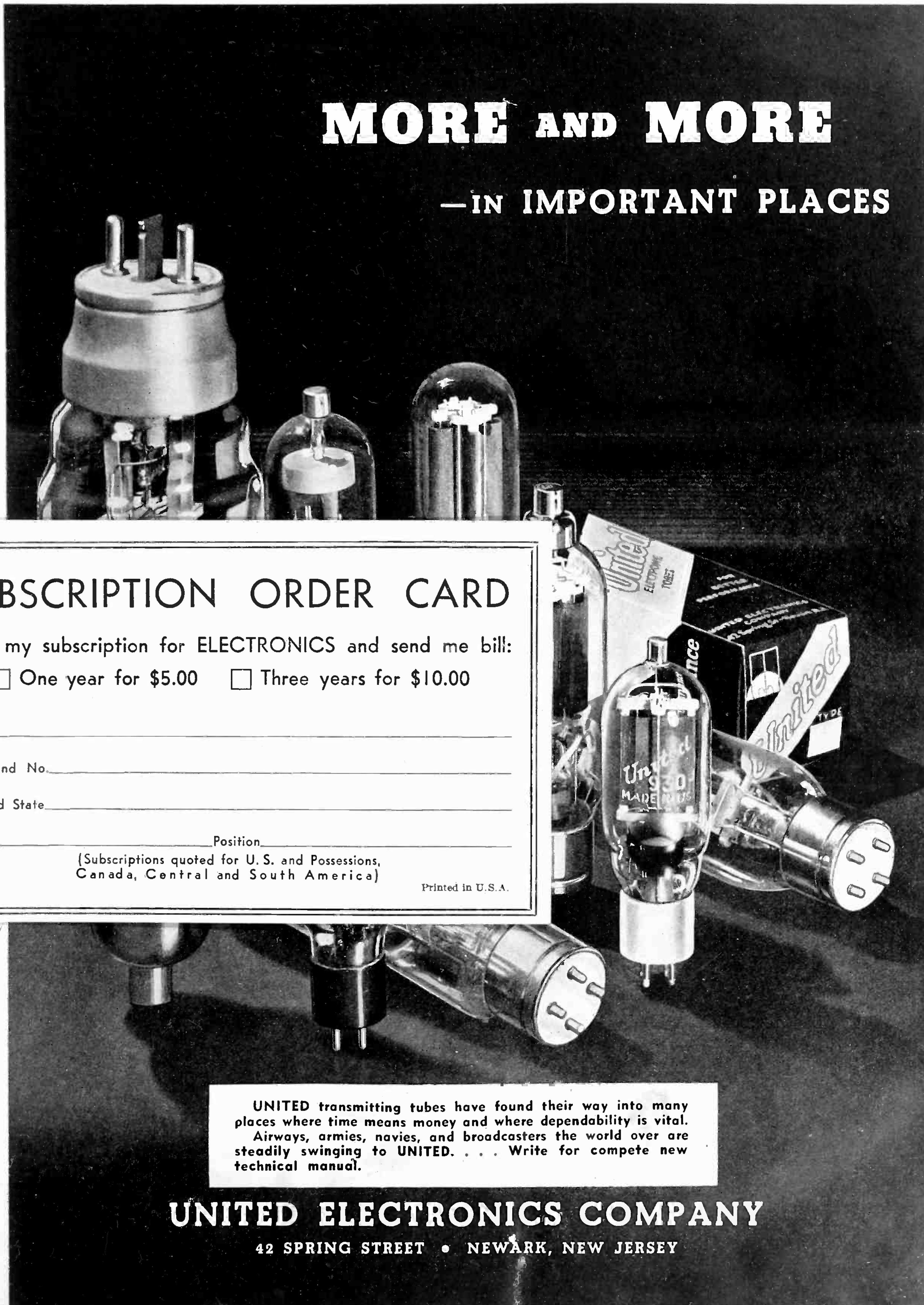

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6-37

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in Large-Set Styling

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Illustrations show conservative modern cabinet of lustrous black Bakelite Molded. Measures 13⅝" x 8¹³⁄₁₆" x 21". Completely formed in one molding operation.

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Condenser Problems where A/C or D/C Dry Electrolytic Condensers may possibly be used—See Mallory.

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ELECTRONICS

JUNE
1937

KEITH HENNEY
Editor

Crosstalk

▶ **BENDS** . . . For many months Ross Hull of the headquarters staff, ARRL, has been recording signals from UHF transmitters trying to unfathom some of the peculiar properties of these frequencies which are not acting according to Hoyle. Remember, theory said waves much below 200 meters wouldn't go very far but the amateurs discovered they did.

Now they say that line-of-sight is all you can get out of waves shorter than approximately 10 meters. And yet Ross Hull shows that they, too, bend, and that they show other variations, which theory doesn't account for.

There is a growing realization that the ARRL is not only a bunch of brass pounders and potential war-time key punchers. The work of Jim Lamb and of Ross Hull and of many other hams will always stand in the way of those who say the amateurs serve no purpose and that it would be better to turn the ham bands over to cold hard cash uses. And as for the theorists and their deprecating manner toward amateur measurements, let the hams "smile as we smile now at the old forsaken bough where we cling."

▶ **BOSS** . . . Howard Ehrlich, Vice President of McGraw-Hill Publishing Company, in charge of electrical publications (which includes *Electronics*) since June 1, 1934, has been elected Executive Vice President of the company.

▶ **GADGET** . . . In this issue Mr. Fink presents a device, called a gadget temporarily (suggestions welcome) which has proved to be of considerable value to a photographer. From an electronic standpoint it is simple and straightforward; from the photography standpoint it will perform many tricks. Based on the principle that a condenser charges and discharges at a rate dependent upon a series resistance, the gadget will turn on or off an enlarging, or other, lamp for predetermined intervals from a fraction of a second up to many seconds. If you hold the initiating button down it will count, audibly, seconds or any other desired interval. These intervals are all alike and the dials can be reset to any value with the certainty that a time exactly like that obtained before is again attained.

In the darkroom the device is most useful. In enlarging one must time his exposure carefully and often at the same time "dodge" so that some portion of the print gets more time than another. Counting and dodging are likely to get mixed up so that one dodges in unison with the count. This device removes completely the time worry from the photographer. If several prints all alike must be made, as in a news service, the exposures must be alike. Furthermore if the operator must count or watch a clock he is inclined to use long exposures, with weak light, to improve his accuracy of timing. With this device a very strong light and very short exposure is possible.

There are many other uses for the device, as Mr. Fink points out. It is but one interesting example of the way electronic principles can be applied to an everyday application.

▶ **WIDEBAND** . . . Through the courtesy of R. H. McMann in New York we have had the pleasure of playing with the new Bosch 680 receiver for a week. This receiver is wide-band, all-wave and proves to our satisfaction that the average radio listener gets a pretty bum sound picture of what is really going on in studios. The deficiency is distinctly in the tones above 3000 cycles. When a receiver (like the 680) is widened out so that the upper range is audible, a totally new conception of radio is possible.

There seems to be little use quarreling with the set manufacturers. For years they have told the public that the current models are most faithful in reproduction of tone quality — even though they were remarkably deficient. Thus they have educated the public to believe that the radio is correct and that the music they hear first hand is wrong. It must be admitted that quantity production makes it necessary to build a receiver that can be used anywhere, within the 5-10 millivolt contour of a high fidelity transmitter, or a thousand miles from that transmitter. But the arbitrariness of the manufacturers in refusing to let the set owner reduce the highs to his own taste is extremely annoying and near sighted.

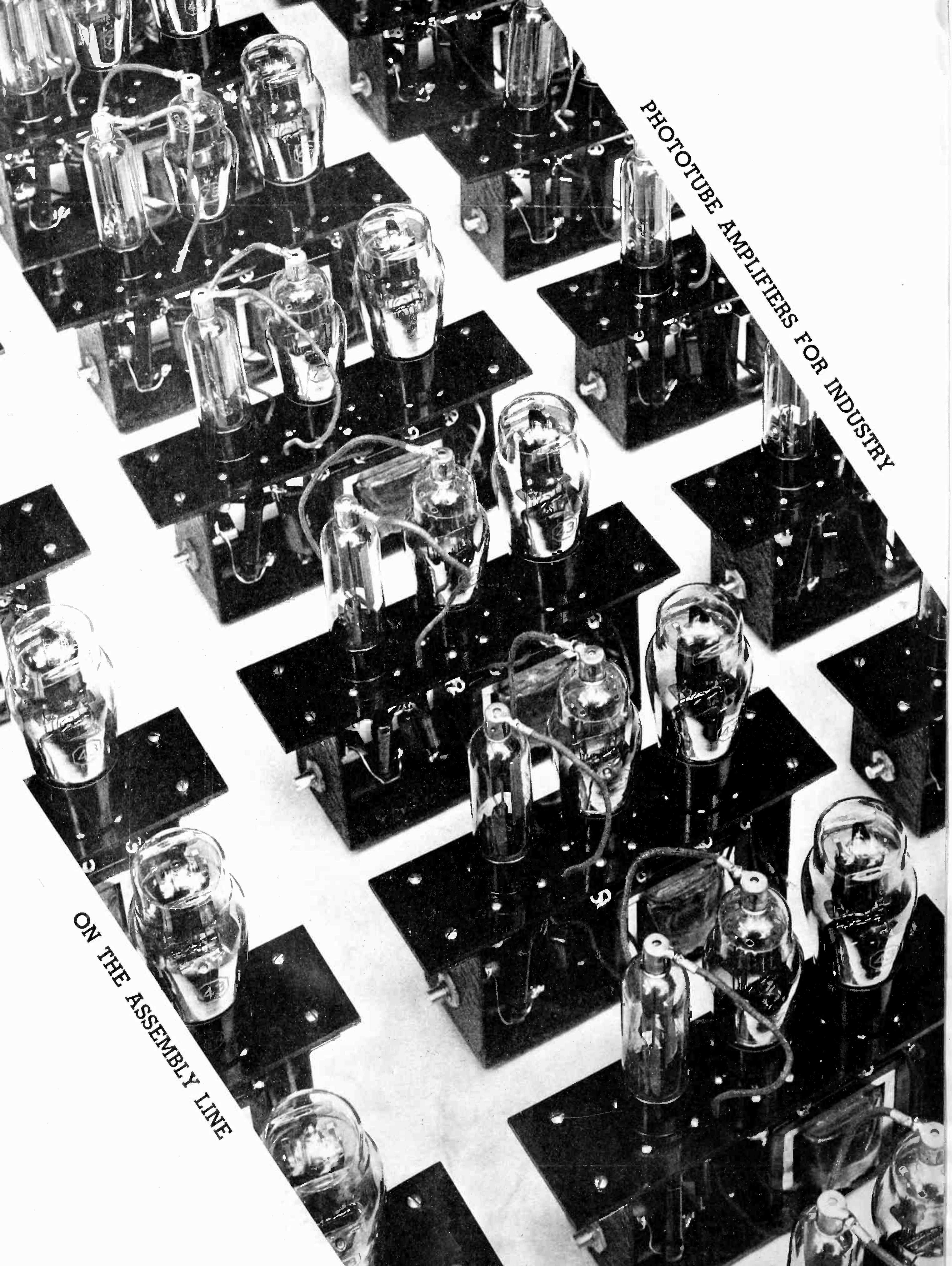
We do not believe the sales department of the largest manufacturers of radio sets are any better judges of what the listener ought to hear than the listener himself. If these arbiters of tone quality are correct, musicians for several centuries have been wrong.

The Bosch set has knobs which permit the listener to cater to his tin ears if he wants to. When you open it up wide, however, as millions of listeners who are near broadcast stations can do it gets out of the radio class immediately.

▶ **SCHOOL** . . . An Electronics Institute, consisting of a special lecture and conference program in electronics will be held in Ann Arbor, Michigan, as a part of the 1937 summer session of the University of Michigan, with the cooperation of members of the technical staffs of the General Electric Company, the Westinghouse Electric and Manufacturing Company, Bell Telephone Laboratories, and RCA.

The Institute lectures will be given by Dr. Saul Dushman, Dr. Lewi Tonks, Dr. H. E. Mendenhall, Dr. F. B. Llewellyn, Dr. Joseph Slepian, Dr. R. C. Mason, Professor L. B. Loeb, Dr. V. K. Zworykin, B. J. Thompson, and W. G. Dow.

The lecture program will consist of two independent four-weeks lecture sequences, dealing respectively with high-vacuum (June 28 to July 24) and gaseous-conduction (July 26 to Aug. 20) electronic principles.



PHOTOTUBE AMPLIFIERS FOR INDUSTRY

ON THE ASSEMBLY LINE

Using projection tubes described at their convention, I.R.E. members saw this television "still" projected on a screen 3 ft. by 4 ft.

I.R.E. Sees Projection Television

WELL over 1200 engineers of the radio industry attended the 25th anniversary convention of the Institute of Radio Engineers May 10, 11 and 12, heard papers on subjects of vital present and future interest to the art, awarded the Institute's Medal of Honor to Melville Eastham, and its Liebmann Award to H. L. Doherty. Taking into account those who attended but did not register it is fair to assume that close to 1500 engineers took part in the convention, pointing to the active state of radio technique.

Outstanding in the way of pointing to the future was the symposium of television subjects presented at the final technical session by engineers and scientists of RCA. The scope of the research undertaken by this single group was disclosed to be very great indeed; the fact that practical results were being obtained was demonstrated amply in the overcrowded banquet hall where the technical papers were delivered.

Other papers of the well balanced program related to aspects of radio communication from automobile radio to directive antennas or to fundamental researches into space charge effects, etc. Circuits, tubes, new apparatus, theory and practice were all given due attention. It is believed, and hoped, that the *Proceedings* of the I.R.E. will soon publish the complete papers. In the meantime the following review of the highlights is presented for those who could not attend the technical sessions.

Television Progress Reported

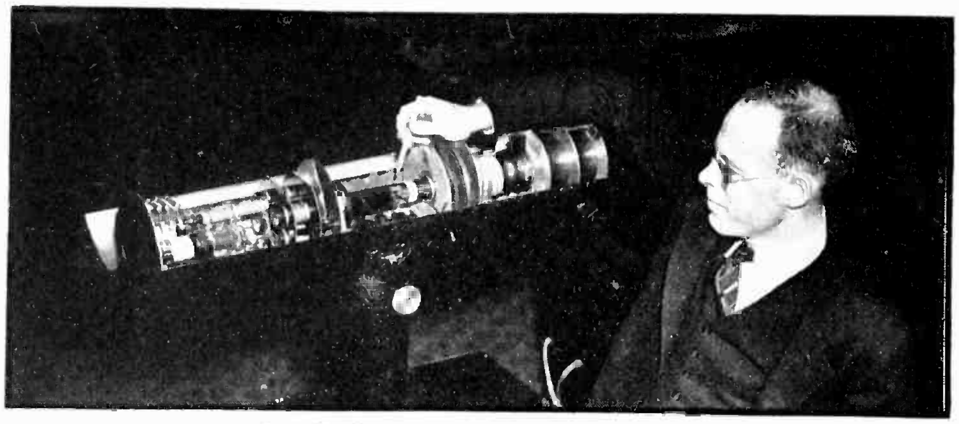
The technical session of Wednesday afternoon was devoted entirely to papers relating to television development. The first two described the newly announced RCA projection television tube, and a demonstration was given of its performance. From the spontaneous applause given at the conclusion of the demonstration, it was evident that the projection tube was a highlight in the technical program.

The first paper, read by Mr. W. H. Painter of RCA Radiotron, and written by Dr. V. K. Zworykin and Mr. Painter, was "The Development of a Projection Kinescope". The authors pointed out that the earliest development of this type of television tube dates back to 1930, when conventional cathode-ray tubes were scaled down to produce a small image of great brilliance which might be projected. These attempts were not successful, and it was not until a completely new approach, including fundamental redesign of the electron gun, was taken that acceptable results were obtained.

The tube demonstrated, shown in the accompanying illustration, contains an electron gun capable of delivering 1.0 to 1.5 ma. at the cathode, of which about 0.4 ma. is actually delivered to the beam itself. This beam is accelerated by a potential of 10,000 volts on the last anode, producing a spot about 0.005 inch in diameter on the fluorescent screen. The brilliance at the screen surface is about 280 candles per square foot, which when projected is capable of producing a highlight brilliance of about 1.9 foot-lamberts. This compares with a brilliance of 2.7 ft.-lbts. for 16 mm. home movies and 2.7 to 5.2 ft.-lbts. for commercial motion pictures.

The standard size for the projected picture is 18 by 24 inches for which the 1.9 ft.-lbts. brilliance is obtained. Much larger pictures, shown in the demonstration, can be projected but at correspondingly lower brilliance. The actual picture on the fluorescent screen itself, before projection, is about 1½ by 2 inches. The projection tube is intended for use with a lens of f/1.5 aperture.

The screen material is principally zinc orthosilicate of carefully controlled crystalline structure, which has a brilliant yellow-green light and which is very stable under prolonged heavy bombardment. Tests with this



Dr. R. R. Law elucidates an interesting point regarding the projection equipment

type of material, under a beam current of 200 μa at 10,000 volts, showed a reduction of lighting efficiency of only 27 per cent in 1200 hours operation.

Design of Electron Gun used in Projection Tube

The electron gun of the projection tube, described by its developer, R. R. Law, in his paper "A High Current Gun for the Projection Kinescope" is of unusual design. The cathode itself is indented and covered with a very small spot of barium-strontium oxide. In front of the cathode are four aligned apertures, each maintained at successively higher potentials with respect to the cathode. The last aperture has a potential of 10,000 volts. The first two apertures nearest the cathode control the brilliance of the spot by their grid-like action on the beam electrons. Both these apertures are operated together as the control grid. The final aperture makes contact with the aquadag coating which returns the electrons from the fluorescent screen.

The final electron lens of the focussing system is an electromagnetic lens of unusual design which reduces the spherical aberration to a small amount. The deflection control is entirely electromagnetic using a conventional scanning yoke.

In the demonstration a video signal from a secondary emission plate ("fixed iconoscope") was fed to the two control apertures. The video signal represented a still picture and was sent 30 frames a second 343 lines, without interlacing. A special directional reflection screen, about three by four feet in size was used to receive the image from the projecting system, which employed a highly corrected f/1.4 lens of about three inches aperture. The brilliance of the image and its high quality were readily apparent. As an additional demonstration the small screen was removed and the image projected onto the standard screen used for the lantern slides. This screen, about 8 feet by 11 feet in size, was completely covered by the image and with a brilliance sufficient to make it readily visible and enjoyable to all those present in the room, which was about 50 feet long. The picture was later further enlarged so that only a small portion of it filled the entire 8 by 11 foot screen.

Burnett Describes Kinescope Resolution Tests

C. E. Burnett, also of RCA Radiotron Division, presented a highly interesting paper on the study of the resolution obtainable from a cathode-ray tube fluorescent screen. To show the quality of the screen and the gun, the tube was supplied by vertical and horizontal saw-tooth scanning voltages of a frequency corresponding to 343 line television (30 per second for the frames and 10,080 per second for the lines). The test consists in covering the whole surface of the screen with alternate black and white dots. To do this it was necessary to apply a square-wave or sinusoidal voltage of 2,222,000 cycles per second, and it was necessary that this voltage be accurately synchronized with the line and frame frequencies. The task of synchronizing periodic voltages of frequencies varying from 30 cycles to 2.222 million cycles was thus presented, and solved by the circuit developed and described by Mr. Burnett. The solution consists in adopting a standard oscillator frequency near 500,000 cycles, and in dividing frequencies by multi-vibrator units down to the lower limit of 30 and multiplying them in doubler and tripler circuits up to the upper limit of 2.2 megacycles. A method of obtaining a varying plate supply voltage for the multi-vibrator units greatly extended their range of frequency and their ability to synchronize with the base frequency.

With a wide variety of saw-tooth-, square-wave, and sine-wave waveforms of various frequencies thus available, Mr. Burnett then applied various combinations, more or less at random, to discover what types of pattern might be obtained. The author explained that these patterns were of small value for test purposes (the resolution test pattern consisted simply of orderly arrays of dots and spaces covering the entire field). Several of these patterns are reproduced on pages 28 and 29 of this issue.

Outdoor Scene Pickup and Unusual Pick-up Tubes

Messrs. Harley Iams, Albert Rose, R. B. Janes and W. H. Hickok in two papers discussed the general subjects of the use of pick-up tubes and of the requirements for good transmission. The output of the picture pick-up tube depends, among other things, upon the amount of light that reaches it from the scene to be transmitted. This amount of light depends upon the intrinsic brightness of the scene. Studies were made to determine the typical brightness values which would have to be covered in television pick-ups.

These values vary from nearly 0 to over 1000 candles per square foot. Typical values recorded by the group were 16 candles per sq. ft. for a football game on a dull day to 100 candles per sq. ft. at a baseball game on a bright day in September and a figure of 2 was obtained in the shadows of tall buildings on a clear day. With recent pick-up tubes (whose sensitivity is approximately three times as great as those of several years ago) scenes with brightness of 15 candles per sq. ft. can be transmitted with an f/4.5 lens. If the surface brightness falls to a figure as low as 2.5, the scene can be reproduced but it is without entertainment value. The authors held out the hope that in time the Iconoscope type of tube would be able to pick up and transmit nearly everything the human eye can see and some things it cannot see.

Following a description of several types of pick-up tubes given by Mr. Iams, a paper by Dr. V. Zworykin, G. A. Morton and L. E. Flory dealt with the theory and performance of the present pick-up type of tube and gave promise of newer tubes now under development.

It was pointed out that still greater sensitivity was desirable in that there were two methods by which this sensitivity could be bettered. One is by use of secondary emission signal multipliers and the second is by using secondary emission intensification. The present overall efficiency of the Iconoscope type of pick-up is about 5 to 10 per cent and the difficulty in amplifying the tube output to desired levels is, as always, the noise. If the signal is 10 times as strong as the noise a good picture will result, but if the noise can be reduced to 3 per cent of the signal, it is unnoticeable.

Calculations of the light required on the mosaic were given taking into account the tube efficiency, the size of the mosaic, and other factors. The authors showed that excellent pictures may be transmitted from scenes with surface brightness of 20 to 50 candles per sq. ft. representing a mosaic illumination of 2½ to 6 millilumens per sq. cm.

Increased sensitivity may be attained by reducing the noise, by increasing the overall efficiency, or by increasing the tube output per unit of light flux. By increasing overall efficiency, laboratory tubes with efficiencies as high as 50 per cent have been made. The authors discussed the development (purely experimental to date) of two types of new pick-up tubes. By using a secondary emission multiplier instead of collecting the secondary electrons unused, the noise that is introduced by input and output resistors to the amplifying tube is eliminated completely. In this manner an increase in sensitivity of about three times is possible.

In this case the sensitivity increases with lower values of beam current and leads to the development of mosaics with thicker insulating layers to reduce the capacity per unit area. Practically, a T-type multiplier (see *Electronics*, November, 1935) has been found useful. Details of the tube construction were given by Zworykin, Morton, and Flory.

The second method of increasing sensitivity consists in intensifying the entire image by a secondary emission amplifier instead of multiplying individual electrons. Here the image falls upon a mosaic whose elements extend through the mosaic. The scanning beam sweeps across the back of the mosaic removing the stored picture in the usual way but with increased output in about the same ratio as that obtainable from the first new type of tube described. Experimental tubes have a sensitivity about ten times as great as the conventional Iconoscope.

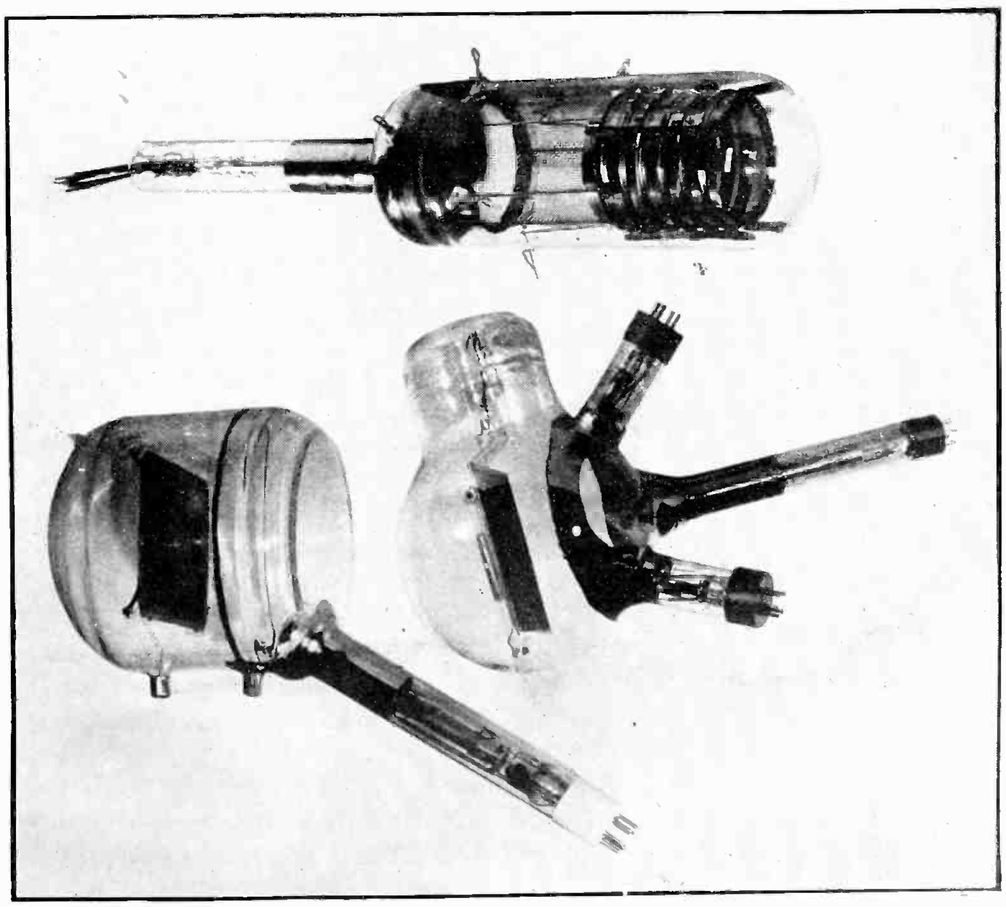
Simplified Method of Determining Antenna Array Relations

In a paper by John F. Morrison, of the Bell Telephone Laboratories, a simple arrangement of apparatus for observing the relative amplitudes and phases of the currents in the various portions of an antenna array were described. The arrangement used is to make use of a pick-up loop placed on each shunt excited element, the voltage of these loops being fed to the measuring equipment through coaxial transmission lines. This arrangement of pick-up loops and transmission lines makes available at a convenient location, samples of the currents in each element. The amplitude and phase of these sample currents bear the same relative relation to each other as the currents in the antenna elements. By this "sampling process", direct observations of the relative phases of the currents is made, and only one set of data is required for the final field strength map.

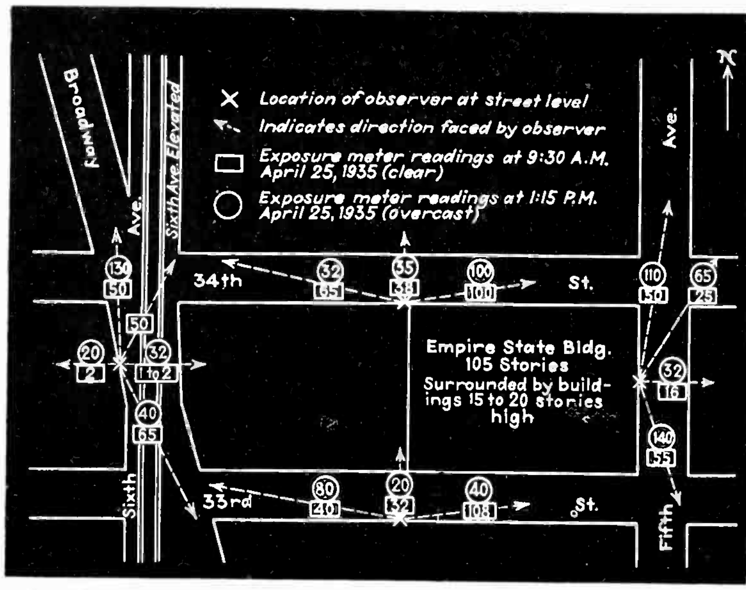
A description of an automatic sound pressure recorder was given by Mr. W. S. Bachman in which a thyratron controlled motor driven attenuator in the output of the amplifier was used to maintain constant output level. The entire audio range is covered with this device in less than five minutes.

T. R. Gilliland, S. S. Kirby, N. Smith, and S. E. Reymer, all of the National Bureau of Standards, gave the results of a series of measurements on the ionosphere which have been made near Washington, D. C., between May 1934 and April 1937. Information for only those layers which are fairly regular in their behavior was presented.

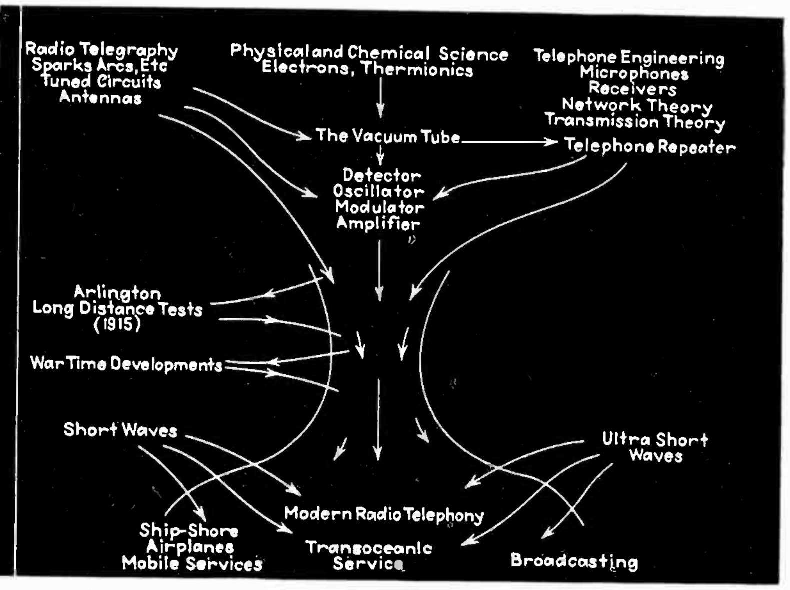
Bernard Salzberg presented the



Three experimental Ikes. Top: image multiplying Iconoscope. Left: "dipper" type showing flat glass surface before the mosaic. Right: electron multiplying Iconscope with T multiplier in each projecting arm



Field map of light intensity measurements for determining average light conditions encountered in television



Flow sheet diagram of developments of radio telephony as given in Mr. Espenschied's paper

paper he prepared in conjunction with A. V. Haeff on the "Effects of Space Charge in the Grid-Anode Region of Vacuum Tubes". After a brief critical review of the work of other investigators in this field, the authors presented the results of their own theoretical and experimental investigations, in which previously unexplored properties of space charge were presented. The paper is highly theoretical and rather than do injustice to an important contribution, we refer the reader to the forthcoming issue of the I.R.E. *Proceedings* in which this significant paper is to appear.

Dr. Lederer presented the Lederer-Walmsley-Widell paper in which was described an experimental type of tube for studying the assumptions which (up to now) have necessarily been made in studying changes of contact potential. Measurements on the contact potential difference between control grid and cathode during aging of a 6K7 tube are also given.

Measurement of Impedance at Ultra-high Frequencies

By measuring impedance in terms of a capacity reactance variation, S. M. Seeley and William S. Barden of the RCA License Laboratory, indicated that transmission lines, resistors and other radio circuit elements could be handled up to a hundred megacycles or higher. A series circuit is tuned to resonance with the desired frequency secured from a source of sufficient power. The circuit element to be measured for impedance is then bridged across a small variable capacity in this series circuit and resonance again secured.

The voltage variation, caused by this addition of the circuit element, across an intermediate tuned circuit is measured by a vacuum tube voltmeter of known characteristics. The value of resistance of the circuit element under test is then equal to $1/P\omega\Delta C$ and the reactance is equal to $1/\omega\Delta'C$ where $P =$ (ratio of two voltages minus 1), ΔC is a value of the small variable condenser and $\Delta'C$ is the new value of this condenser occasioned by bridging the unknown impedance across C.

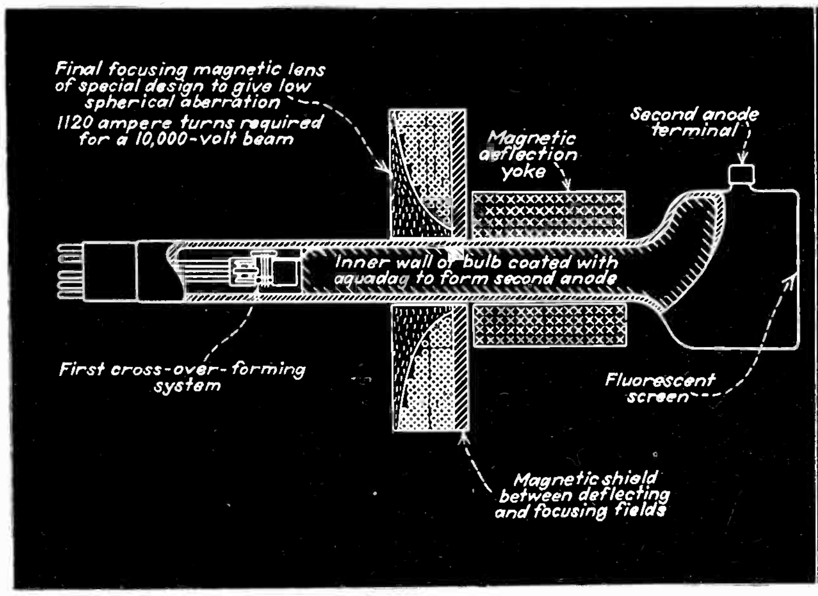
Measurements of half-watt carbon resistors from 100 to 5000 ohms were given as were data on a half-wave doublet with resonance at 36.3 megacycles.

Because of the similar nature of the papers, "The Origin and Development of Radio Telephony" by Lloyd Espenschied and "Transoceanic Radio Telephone Developments" by Ralph Bown, and the limited time available for presentation, Dr. Bown presented a summary of both papers. It was shown in Mr. Espenschied's paper that practical radio telephony was born out of the great advance which occurred along the whole forefront of electric communication and based upon the past triumphs in engineering dealing with wire telephony, electrical circuits and networks, and especially the vacuum tube. In the evolution of the art, three periods may be distinguished. First is the formative one, in which there appeared the three element tube as an amplifier, modulator and oscillator, and the first attempt at producing vacuum tube radio telephone systems, culminating in the test made by Bell System engineers at Arlington during 1915. The second period, that of the war, disarranged normal development but resulted in the spreading of knowledge of the new art among a large number of young engineers. The third period, following the war, witnessed substantial further contributions in the direction of higher power transmitters, acoustics, and high quality reproduction telephony, and with these advances came the two-way radio telephone service and one-way broadcasting as it is known today.

Dr. Bown's paper reviewed the technical advances which made possible widely extended long distance radio telephone service and the outlook for future development. It was pointed out that future development would be along the lines of single sideband transmission in the short wave spectrum, new methods of reception including intricate circuits with highly selective crystal filters and noise reducing circuits, and multiplex radio telephone transmission. In these developments, the economic factors will play an increasingly large role, and is is felt that the engineering and economic problems combined, offer a direct challenge to radio engineers.

New Equipment Described

Among the RCA equipment to be discussed was a new antenna kit, described by V. D. Landon, a wide range beat frequency oscillator, described by J. M. Brumbaugh, and a cathode ray oscillograph by A. C. Stocker. The latter two instruments have been designed with future television test requirements in mind.



Focusing and deflecting coils for use with the high intensity projection television tube

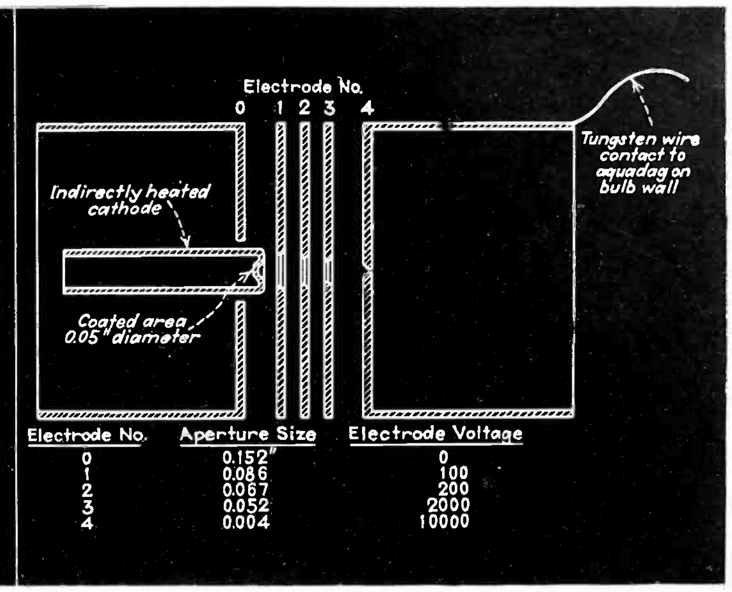


Diagram of the electron gun for projection tube showing beam cross-over electrodes

The antenna kit consists essentially of two similar r-f transformers, one for feeding the transmission line from the antenna, and the other for delivering the signal from the transmission line to the receiver. A multiple output distribution transformer was also described.

The beat frequency oscillator covers from 20 cycles to 3 megacycles by using a fixed oscillator at 9.3 Mc. and a variable oscillator varying from 6.3 to 9.3 Mc. The oscillators are not compensated for drift, but are built, electrically and mechanically, as nearly as identical as possible. The oscillograph discussed has accurate response to transient waves, and sine wave response which is flat to 2 Mc.

Tracing the history of placing radios in automobiles from 1922 when cumbersome equipment was necessary to the present time, F. D. Schnoor and J. C. Smith of RCA Victor outlined the mechanical and electrical problems that had been tackled. Antennas, power supply, acoustical problems, interference from engine ignition and from wheel and tire static were among the problems discussed. The paper ended with a description of a modern (1937) auto radio receiver installation.

Concentric Narrow Band Elimination Filter

Mr. L. M. Leeds of General Electric described a novel wave filter of the narrow band or peak elimination type utilizing the phenomenon of standing waves on concentric transmission lines. A practical difference between this type of filter and one made up of lumped constants is that the concentric transmission line filter can be made relatively easily and accurately at the ultra high frequency range where the customary lumped constant filters become impractical. Filters of the type described have been used in police communication systems for duplex operation from the same antenna without interference between the transmitting and receiving stations, on adjacent channels in the 30 to 42 Mc. Transmitters having powers up to 150 watts have been successfully operated in this duplex arrangement.

Higher Program Level Without Circuit Overloading

The problem of maintaining the highest practical broadcast program level while at the same time avoiding the distortion resulting from overloading of the transmitting equipment was the subject of a paper by O. M. Hovgaard and F. Doba. A vacuum tube device was described which is intended to effect a certain degree of monitoring after the signal passes the monitor operator. Without introducing overloading of any equipment, this device permits a higher general program level than is practicable with manual control.

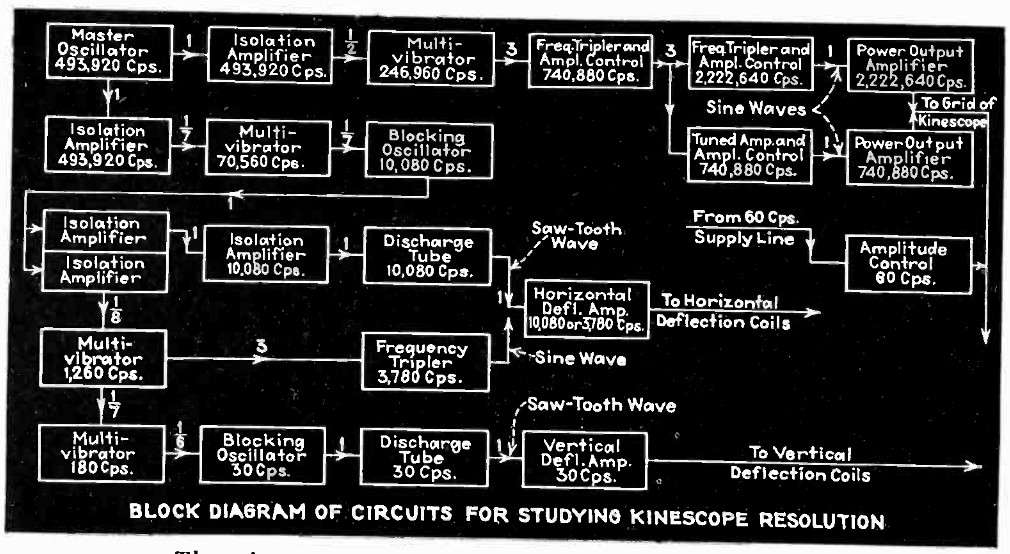
Many modern antenna installations utilize half-wave or quarter-wave systems. Since the cost of erecting a large tower is a major factor in the installation of many stations, it has been thought advisable to investigate the possibility of utilizing antennas radiating at one-quarter wave length (90 deg.) or less. The paper by G. H. Brown, R. F. Lewis, and J. Epstein was confined to a consideration of antennas whose height is 90 deg. (quarter wave) or less. The investigation was carried out at a constant frequency and measurements were made as the antenna height in fractions of a wave length was varied.

Theoretical investigations showed that the success of utilizing an antenna of less than a quarter wavelength in height depended upon the reduction to a minimum of the earth current losses. These losses have been reduced by using a large number of radial wires to improve the ground conductivity near the antenna base.

For a well installed and complete radial ground system, it was shown that the earth currents are almost independent of the height for antennas having a length of 0.3 wavelength or greater. With a radial system of 113 wires, the field strength decreases slightly until the antenna height is approximately 10 deg. (1/36 of a wave length). It was shown that a good compromise is a 1/8 wave antenna, having a fairly elaborate ground system. Such a system works with high efficiency and the cost of installation is relatively small compared to the usual quarter wave radiating systems.

A Basis for Vacuum Tube Design

M. A. Acheson discussed basic units for the expression of vacuum tube dimensional relations and the proper synthesis of these units allowing rigorous calculations of vacuum tube design and performance. Fundamentally, the system is based upon a method of determining the voltage conditions in a given tube structure.



The electron patterns on this and the next page (as well as those on pages 28 and 29) were made with this circuit

to deliver a unit current flowing in the collector electrode. If the voltage required to give unit current for a given diode structure is e_π the current at any other voltage E_p is given by the expression, $i_o = (E_p/e_\pi)^{3/2}$.

Through the use of the unit current voltage, e_π, the dimensional properties of the tube are eliminated and the current of the tube can be expressed entirely in terms of voltage variations. In the case of a triode the expression for the plate current in terms of the actual plate potential E_p and the actual grid potential E_g, together with the potential e_π and e_γ are given by the expression, $i_o = [(E_p + \mu E_g)/(e_\pi + \mu e_\gamma)]^{3/2}$. In this expression μ, e_π and e_γ are voltages which depend upon the structure of the electrodes. When these factors are known the tube current in terms of the operating electrode voltages may easily be determined so that rigorous calculations of vacuum tube design and performance may be made. Calculations by this method are simpler than those where solutions by present methods can be had and often allow solutions where no present solutions exist. For a complete analysis, however, the factors e_π and e_γ, must be determined in terms of the tube structural dimensions.

New Ultra High Frequency Triode

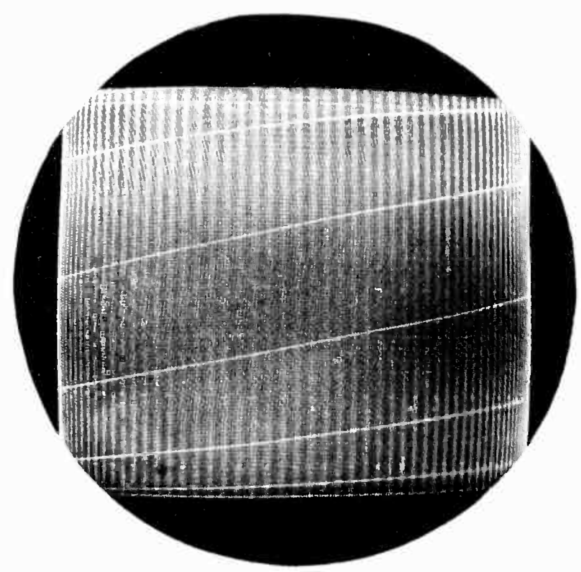
After giving a survey of the power output capabilities of various types of power tubes intended for high frequency operation, Winfield G. Wagener presented the general requirements for the production and amplification of large amounts of power at very high frequencies by means of the conventional type of triode. In addition to the usual structural and electrical features, the tube design for extremely high frequency operation must consider the importance of the complete circuit design, the transit time of all electrons in space, the large currents in the leads to the elements, the abnormal demands on the insulation, and the practical construction of very compact tubes. These problems have been met in a new type of high frequency water cooled triode which will give an output of more than 700 watts at 100 Mc. The tube may also be used as a neutralized power amplifier with reasonably high efficiency for frequencies up to about 200 Mc. The tube operates at a plate voltage of 3000 volts, is about 1 inch in diameter, and 7 inches long and weighs about ½ pound.

Studies of Wave Propagation

A quantitative study of the relationship between the proximity of the magnetic pole of the great circle transmission path and signal stability during magnetic disturbances was given by Dr. Kenrick. The paper, "Relation Between Radio Transmission Path and Magnetic Storm Effects" by G. W. Kenrick, A. M. Bratton and J. General, evaluates the advantages of removing the transmission path from the great circle path passing through or near the magnetic North Pole. Reception from Europe as observed at Riverhead, Long Island and San Juan, Porto Rico, was compared during normal periods as well as those of magnetic storm periods.

To permit the presentation of programs from points not otherwise accessible, radio circuits as an extension of wire line facilities, have now become an integral part of broadcasting. Portable radio equipment for mobile pick-up, as used by the National Broadcasting Company during the past several years, was described in the paper, "Ultra High Frequency Relay Broadcasting" by W. A. R. Brown and E. O. Milne, as well as the operation of this equipment under field conditions. Portable relay broadcast transmitters of various powers and frequencies, together with their associated receivers, were displayed and demonstrations of their use were given. One of the small transmitters (commonly known as the "beer mug") was used throughout the technical session by those desiring to discuss the papers presented. By passing the "mug" around to those interested in discussing the papers, the discussion was made audible over the normal public address system used, without the necessity of having the discusser leave his seat.

The system of ultra short wave



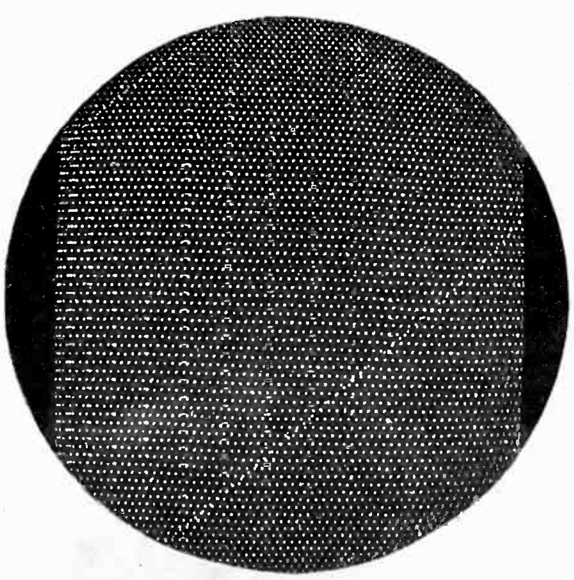
Screen of cathode ray tube when subjected to all elements produced by the block diagram shown above

blind landing beacons developed by the C. Lorenz Company of Berlin was given in his paper, "The Ultra Short Wave Guide Ray Beacons and Their Possibility of Application" by Walter M. Hahnemann. The beam system consists of a radiating antenna and two reflectors, each one of which produces a field pattern of cardioid shape. The antenna is fed continuously at a high frequency.

The two reflectors are switched on alternately by means of relays placed in their center so that one of the reflectors produces a field strength which gives dots of one-eighth second duration and the other produces dashes of seven-eighths second duration. Thus, on the guide beam where both signals are received with the same intensity, a continuous signal results, while on one side of the guide beam dots are heard and on the other side dashes are heard. In this manner it is easy to determine on which side of the guide beam an airplane may be. In addition to this field pattern, two marking beacon signals are employed to indicate to the aviator his distance from the landing field. The outer marker beacon is approximately 3 km. from the edge of the landing field, whereas the inner marker beacon signal is 0.3 km. from the edge of the field.

Steerable Antennas

In transatlantic signals transmitted from England, it is shown that several reflections of the radio waves between the earth and the ionosphere occur and that the vertical angle at which maximum field strength is attained depends upon the number of reflections taking place in the path of transmission. For the various practical conditions encountered in operating such a transmission system it is advisable to be able to vary the vertical plane directivity to meet the varying angles at which short radio waves arrive at a receiving location. The system described by H. T. Friis and C. B. Feldman is the culmination of four years' effort to determine the extent to which receiving antenna directivity may be carried to increase reliability of short wave circuits. The system consists of an end-on array of antennas, of fixed azithmul directivity, the output voltages of which are combined in phase for the desired angle of the radio wave. The output voltage of each antenna is conducted over a separate coaxial transmission line to the receiving building where the proper phasing is accomplished by means of rotatable phase shifters operating at an intermediate frequency. A separate phase shifter is employed for each antenna and the several phase shifters for an array are geared together so that by rotating this phase shift assembly the antenna may be made most responsive to the desired vertical plane directivity.



Pattern on cathode ray tube with two thirds of the elements removed and vertical deflection increased

The experimental system located at Holmdel, N. J., comprises six rhombic antennas extending three-quarters of a mile in the direction of England. Two receiving branches in addition to a monitoring branch are provided. A signal-to-noise improvement of 7 to 8 db. (as referred to one of the six rhombic antennas alone) and a substantial quality improvement due to the diversity action and the reduction of selective fading in this antenna system are obtained.

A method of multiplexing telegraph signals on a common communication channel and the factors governing the application of the method to radio circuits were discussed in the paper, "Time Division Multiplex in Radio Telegraphic Practice" by J. L. Callahan, R. E. Mathes, and A. Kahn.

Measurements of Condenser Chracteristics

A paper by W. B. Buckingham, of the Western Union Telegraph Company, describes an experimental method of analyzing condensers having reversible absorption in the dielectric medium. The method of analysis is therefore particularly suitable to condensers having solid or liquid dielectrics.

The apparatus used to determine experimentally the equivalent circuit of the actual condenser with absorbing dielectrics consists of a simple temperature controlled bridge using a low frequency flat top wave input voltage and a cathode ray oscillograph with a synchronized sweep as the detector element. The flat top input voltage to the bridge is obtained from a battery and motor driven commutator. An auxiliary contact on the commutator shaft controls the sweep circuit so that the spot is started on its travel just prior to each cycle of the voltage applied to the bridge. On the oscillograph screen is a stationary picture of the unbalance existing across the bridge.

The bridge is first balanced as well as possible using the condenser under measurement in one of the arms of the bridge. With a leaky condenser it will be found that a complete balance cannot be obtained so that some kinks in the sweep across the oscillograph screen are always apparent. When the bridge is completely balanced as indicated by the horizontal sweep having no vertical deflection, the electrical equivalent of the actual condenser under measurement is that represented by the opposite arm of the bridge which in general contains a standard condenser with negligible losses in series with a resistor, the standard condenser having shunted across it one or more RC combinations.

After three long days of general handshaking, viewing of exhibits, technical sessions, trips, and the witnessing of a practical demonstration of modern television technique at the N.B.C. in Radio City, the convention wound up with a banquet on Wednesday evening. The Institute's Medal of Honor was awarded to Melville Eastham for his pioneer work in the field of radio measurements, and the Morris Liebmann Memorial prize to W. H. Doherty for his improvements in radio frequency amplifiers. Although Mr. Doherty's speech of acceptance was well received, that made by the Institute's treasurer was so short that it was over before the applause subsided. Mr. Marriott gave a review of some the earlier activities of the Wireless Institute and Dr. Goldsmith followed by outlining the early activities of the Institute. Capt. P. P. Eckersley, who had been put to work in some of the technical sessions, delivered a speech on the broadcast system in operation in England, contrasted this with the system in use in this country, and quite thoroughly dispelled the idea that all Englishmen wear monocles and are stiff and formal.

Television Terminology

A host of new terms has grown up to describe the intricacies of cathode-ray television. Herewith is a review of their meanings, both technical jargon and studio slang, compiled from interviews with men active in television development

ALTHOUGH cathode-ray television has been "out of the laboratory" for a full year, the details of its operation are still largely unknown to the technical public. Information on the subject has been released by some of the leading experimenters, at least in part, but it has not been published widely nor generally understood. Any conversation between two television engineers is likely to contain such terms as: "pedestal", "sync generator", "retrace", "blank-out signal", "line and frame impulses", all of which mean next to nothing to the radio engineer.

As an introduction to a series of articles on modern television development, to be published in *Electronics* in forthcoming issues, it is necessary that the terminology of the subject be defined in terms of the basic principles involved. This task is not an easy one, since there is no complete agreement among the television workers themselves about the meaning of certain words. By interviewing several men active in developing cathode-ray television and by comparing notes, the following summary of the new terms has been compiled. It is not offered as any official or standard treatment of the subject, but simply as an aid to understanding the current literature on television.

Names and Terms Describing Television Equipment

The first element in the television studio, from which the programs start, is the studio camera, or "pick-up" camera which views the subject. The essential element of the camera is the cathode-ray tube which converts the optical image into a signal. This tube has various names: the most widely used name is Iconoscope*, a copyrighted trade name of RCA. Other names for the same type of tube are camera tube, signal-generating tube, or mosaic tube. The other type of tube used for pick-up purposes is the image-dissector, which is the name used by Philo T. Farnsworth to describe his tube, which does not use a mosaic surface, but employs a flat photo-electric surface and gains sensitivity through the use of electron multiplication.

Associated with the camera tube is the video pre-amplifier, a wide-band amplifier which accepts the output signal generated by the camera tube and amplifies it to a sufficient level for transmission from the camera to the monitoring booth. In practice, the camera is mounted in a mechanically controllable mount, and this in turn may be placed on a movable platform or "dolly" so that it can be moved about over the set readily.

The cathode-ray beam in the camera tube is caused to scan the mosaic surface by means of deflecting and control voltages which are applied to magnetic scanning coils situated at the throat of the tube itself. The control of these voltages is supplied from a centrally located synchronizing generator, which provides accurately spaced and timed impulses for initiating the start of each line scanned, and initiating the beginning of each interlaced half-frame, (picture composed of alternate lines). These impulses control two sweep circuits, one for the horizontal line

* The term iconoscope appears in Webster's New International Dictionary (1923) to mean a form of view finder.

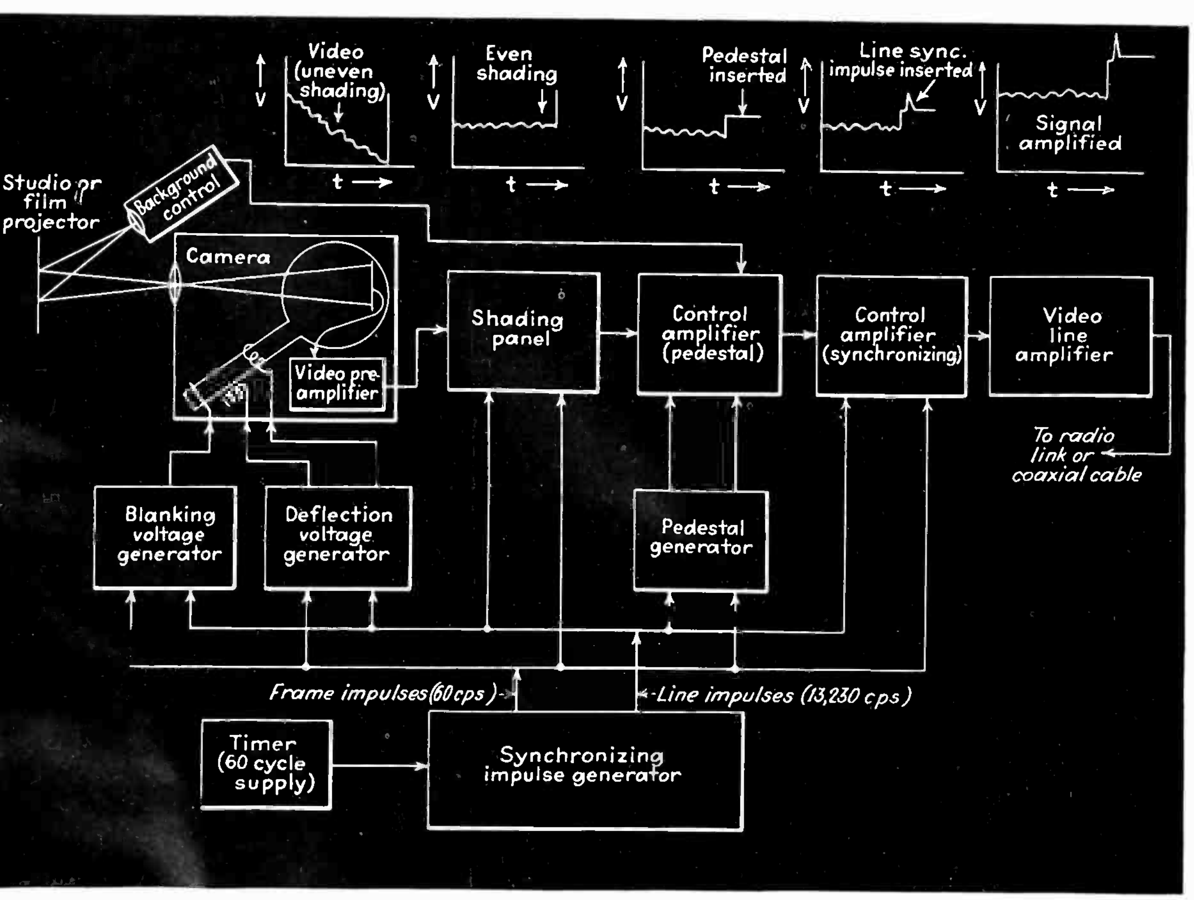


Fig. 1—Typical pickup and control equipment layout, used in studio, film-projecting room and monitoring booth. The waveforms indicate the changes undergone by the signal representing a single line of the image

scanning, and one for the vertical or frame scanning. In addition to the sweep circuits which operate under the control of the synchronizing generator there is also a control voltage applied to the control grid of the camera tube, in the form of a blanking signal, which extinguishes the cathode-ray beam during the return trace following each scanning line, and at the end of each frame.

From the pre-amplifier the signal goes directly to the monitoring booth of the studio or film projecting room. This monitoring booth contains a position for the video monitor operator, who has various controls for regulating the voltages actually applied to, and for modifying the signal which comes from, the studio camera. In addition to being able to view the studio itself, the video operator has before him two cathode-ray tubes. One is an image tube which recreates the image directly from the signal arriving from the coaxial cable. This shows the character of the image, its defects and quality. The second cathode-ray tube is a simple oscilloscope, which shows the video signal arising from the camera as a function of time, that is, it shows the voltage in the vertical direction plotted against time in the horizontal direction. This oscilloscope monitor shows the relative amplitude of the video signal and of the synchronizing impulses, and indicates the exact character of the television signal.

The video operator also has under his control a device for correcting imperfections in the signal produced by the camera tube. As explained in the discussion of the television signal below, difficulties due to secondary emission in the camera give rise to uneven illumination over the surface of the reproduced image. This improper shading is corrected by the application of properly shaped neutralizing voltages generated separately and applied synchronously through a "shading panel," which corrects the imperfections in the camera tube signal. The video operator also controls the overall brightness of the image, its contrast (difference in brightness between light parts of the picture and dark parts of the picture), and he can control to a limited degree the centering of the picture and its apparent size.

From the shading panel the signal goes to a control amplifier where the pedestal level is set. This pedestal is a voltage level corresponding to black, or slightly "blacker than black", on which the synchronizing impulses are placed and which exists throughout the return trace of the cathode beam. The height of the pedestal is controlled with respect to the average level (i.e. background illumination) of the video signal either manually or by an automatic background control, consisting of a phototube illumination-integrator.

When the pedestal level has been established, the line synchronizing impulses are imposed on the pedestal. These impulses initiate the horizontal return-sweep deflecting voltage in the receiver. At the end of each half-frame or "interlace", the frame synchronizing impulses are imposed in a similar manner.

The corrected and monitored signal, containing video, blanking and synchronizing impulses, then passes to a video line amplifier which is simply a wide band amplifier capable of reproducing all the frequencies present in the signal without selective attenuation. This video line amplifier increases the level of the signal and applies it to a coaxial cable which delivers the signal to the transmitter either directly or through a radio frequency link consisting of a television transmitter and receiver. At the transmitter itself another video line amplifier increases the level of the signal which has been weakened by traveling over the cable and applies it to the amplifying and modulating equipment of the transmitter. From the modulator the highly amplified signal containing the video voltage, synchronizing impulses and pedestal is delivered to the radio frequency amplifier whose modulated output is delivered in turn to the radiating antenna.

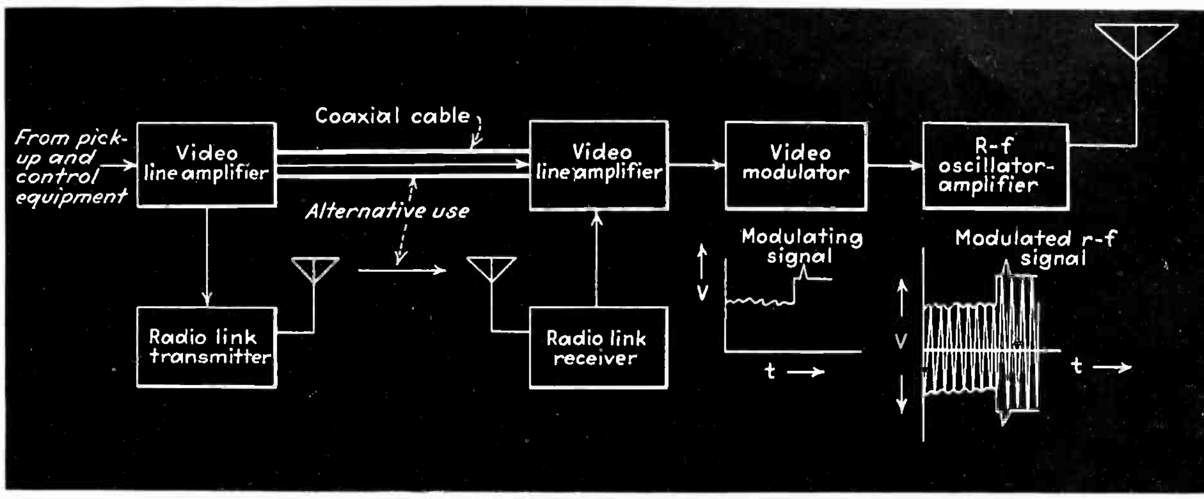


Fig. 2—Cable, radio-relay, modulating and radiating equipment, fed by the pick-up and control equipment shown in Fig. 1. The waveforms show the imposition of the modulating signal on the carrier

At the receiver the elements present are in a large measure counterparts of the elements in the transmitter. The video receiver itself is usually a superheterodyne whose i-f system is capable of passing the wide band present in the signal. Often the superheterodynes make use of two frequency conversions. Also present in the receiver are sweep circuits for generating the horizontal and vertical sweep voltages, required in controlling the cathode-ray beam, and two selective circuits for removing the synchronizing impulses in the signal and applying them to the sweep circuits which they control. The detected video signal is applied to the control grid of the cathode-ray tube, thus modulating the brilliance of the fluorescent spot produced on the cathode-ray screen by the electron beam. At the same time the sweep-circuit voltages are applied to the magnetic deflecting coils which provide the vertical and horizontal motion of the beam over the field of the image. The blanking-out of the cathode-ray beam on the return trace is provided by the pedestal level of the incoming signal itself, in the usual case, rather than by the use of separately generated voltages as is the case at the transmitter. At the receiver are controls for focus, brightness, contrast, and for the control of synchronizing and scanning voltages. By controlling the accelerating volt-

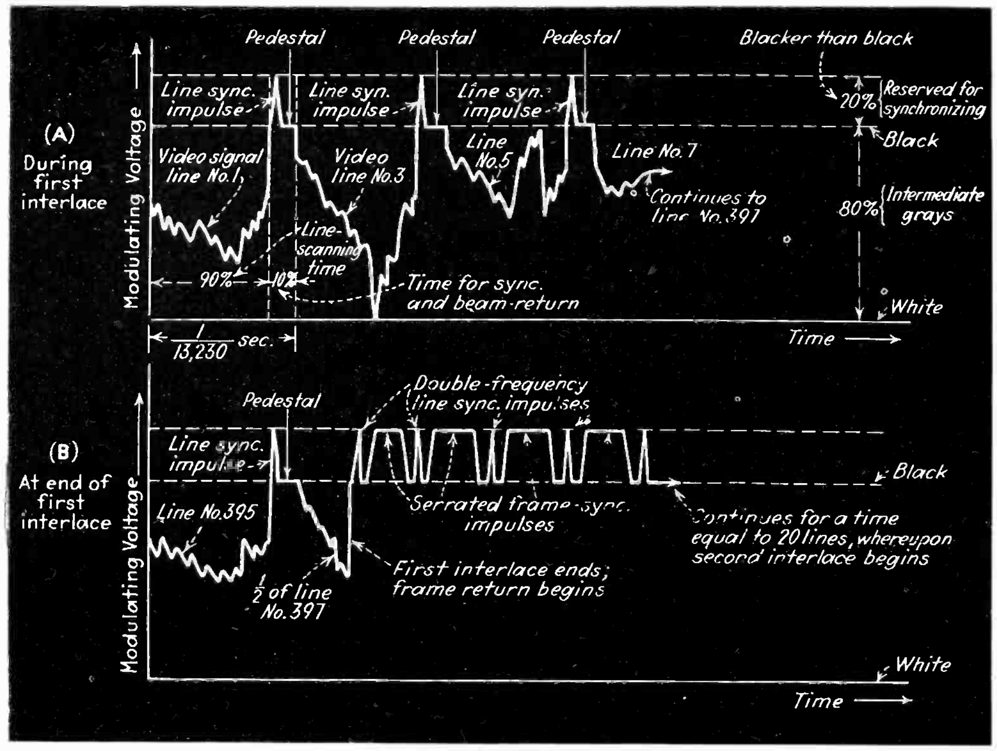


Fig. 3—The television modulating signal, showing video signal of the odd-numbered lines, the blanking pedestal, and the line- and frame-synchronizing impulses. The frame sync impulses are of the serrated type

ages, the focus control determines the size of the cathode-ray beam and of the fluorescent spot produced by it. The brightness control determines the accelerating voltages and the bias on the control grid, thus changing the overall average current present in the cathode-ray beam. The contrast control varies the amplitude of the swing of the video voltage applied to the control grid in the cathode-ray tube, thus determining the range of changes in brightness from the brightest part of the signal to the darkest part.

The image reproducing tube itself goes by various names. The word Kinescope is the copyright trade name of the RCA Company. The same type of cathode-ray tube is also commonly called "picture tube", "reproduction tube", "image tube", or plain cathode ray tube.

An important item in the receiver is the automatic background control. This feature is necessary to maintain the average brightness of the picture at a constant value consistent with the average level actually being radiated by the transmitter itself. Since the d-c component of the video signal envelope determines the average brightness, and since the d-c component is very difficult to carry through the video amplifier stages of the receiver, some additional means of providing automatic control of the d-c level must be provided. This is done by means of a rectifier circuit which measures the average height of the signal below the pedestal. This circuit supplies the proper bias value to the control grid of the cathode-ray tube to maintain the average brightness of the picture at the proper value.

Terms Describing the Television Signal

In Fig. 3 the region between the indicated lines is devoted to the video signal. The minimum amplitude of the video signal corresponds to a white or bright spot of the picture, whereas the maximum part of the video signal corresponds to the black portion, with intermediate amplitudes corresponding to intermediate degrees of light and darkness. It will be noticed that above the maximum value of video signal there is considerable range for a possible further increase in the amplitude of the carrier. Such increase in the amplitude makes the signal "blacker than black," and it is in this region that the synchronizing impulses are transmitted. By reserving this region for synchronizing alone, any part of the video signal is restrained from effecting the control of the sweep circuit oscillator. In the Figure is shown the end of the video signal provided by one line of the image and the beginning of the "pedestal" at the end of the line. This pedestal has an amplitude corresponding to somewhat less than the black value, and therefore during this part of the signal the cathode-ray beam in the picture-reproducing tube is extinguished. At the

Facing the cameras from the set in the NBC studio. Note the dolly under the center camera, and the "wind-shield" over the microphone (on the boom) to reduce air-conditioning noise

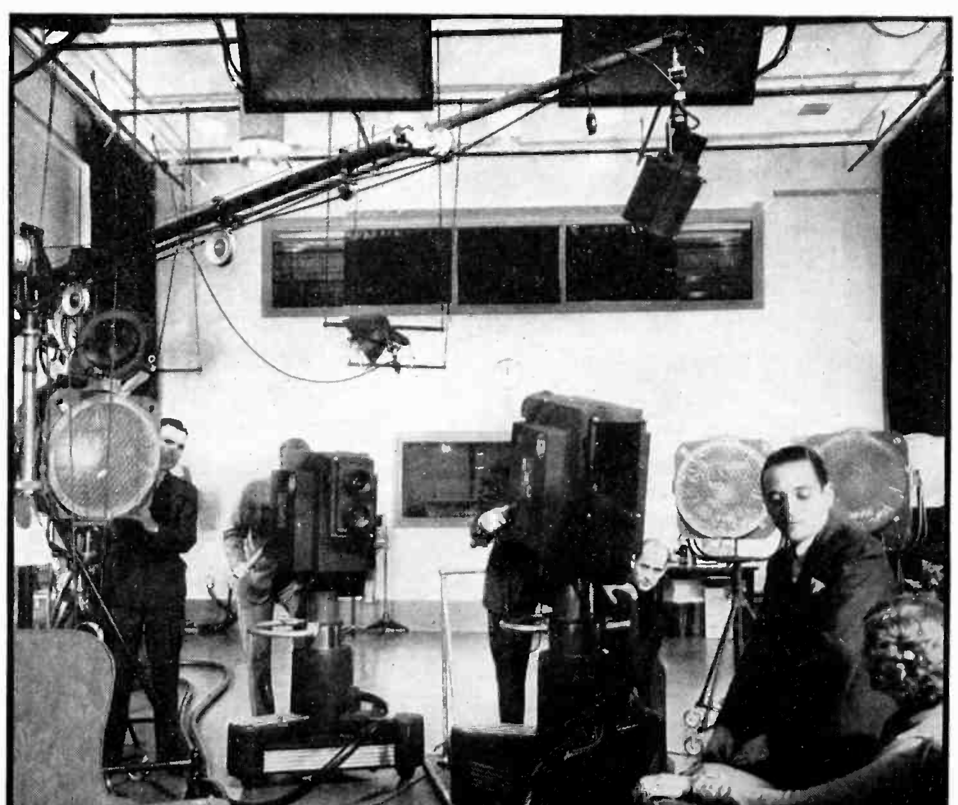
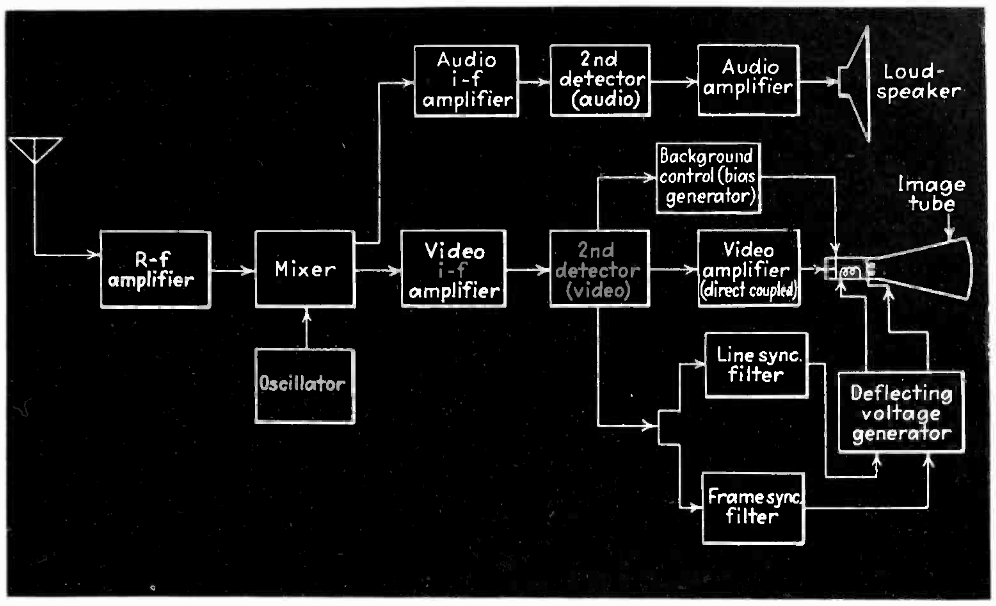


Fig. 4—The elements of the typical television receiver, both video and audio. The average illumination of the picture is controlled by a bias value obtained from the second detector



beginning of the pedestal is a small pulse which increases the carrier to full height and which is the line synchronizing impulse. This pulse terminates the sweep voltage which caused the cathode-ray beam to scan the line and returns it, while it is extinguished, to the beginning of the next alternate line. The pedestal amplitude ends by the time the left-to-right sweep voltage begins and the video signal suddenly drops to the value indicated.

The video signal modulates the brightness of the fluorescent spot as the beam travels across the next alternate line. At the conclusion of this video line the pedestal value is again reached, and the synchronizing signal returns the sweep voltage to the beginning of the next line, while the pedestal value of the envelope keeps the cathode-ray beam extinguished. This process repeats until approximately 200 lines have been covered for the first interlaced half-scanning. At this point the vertical synchronizing impulse, of which there are two types now in use, comes into action.

Of the two types of frame-synchronizing impulses used, one is called the narrow-vertical frame synchronizing impulse. It is the same type of impulse that is used for the line synchronizing, except that its amplitude is much greater. To accommodate this additional amplitude a much larger portion of the available carrier amplitude must be reserved for synchronizing purposes, than is required for the line impulses alone. In order to distinguish between the line impulses and the frame impulses, a difference in amplitude of at least 2 to 1 is necessary. Since this requires a large portion of the carrier amplitude to be reserved simply for frame impulses which occur only 60 times a second, it is considered that the narrow vertical impulse is somewhat wasteful of available transmitter modulation. In order to avoid this difficulty another type of frame synchronizing impulse called the serrated impulse has been devised which consists of indentations on the pedestal of the same amplitude as the line synchronizing impulses but of considerably different shape. These are shown in Fig. 3-B.

The television signals shown in Figs. 3-A and 3-B are ideal signals produced by a perfect camera tube and transmitter without selective attenuation. In actual practice the attainment of this ideal case is practically impossible. One type of distortion has already been mentioned. It is the shading problem which produces an uneven illumination of the field of the reproduced image due to the fact that the Iconoscope produces a video signal from each line whose d-c component is slowly varying. As the camera tube beam scans each line the net charge on successive elements may increase progressively due to the effect of secondary emission. The increase in the video signal upwards, from the beginning to the end of the line, means an increase in the overall brightness corresponding to the increase in amplitude. As a result the beginning of the line is absolutely dark and the end of the line over-bright. Corrections of this effect may be made by altering the lighting so that a major portion of the light is directed toward the beginning of each line. However, this is at best a compromise. To secure a definite correction of this distortion it is necessary to add a decreasing d-c component to the video signal during each scanned line which exactly compensates for the increase in the d-c component in the scanning mechanism itself. This compensating voltage provides a net signal similar to the ideal case previously considered. The introduction of the compensating voltage is made, as previously explained, from a shading panel which is nothing more or less than a source of controllable voltage, synchronized with the line scanning frequency, whose amplitude and rate of increase can be controlled throughout the scanning of each line. In practice the shading panel controls are adjusted until the illumination of the image is of the desired uniformity, as indicated by the image.

Other distortions to the ideal signal are produced by noise introduced at various points along the circuit. One of the possible sources of noise is the mosaic of the camera tube itself, especially at low light levels. Also noise may be introduced at the pre-amplifier, since it is operating at low levels and at an extremely wide band. Noise introduced in the transmission path between the transmitting and the receiving antennas of the system of course is very possible. Other effects due to the passage of the signal through space are the production of double images or "ghosts" which are produced by separate signals arriving over different paths.

Studio Slang

In television studios a very picturesque slang has grown up, based to some extent on movie slang, but largely spontaneous. "Panning", from panorama, means horizontal camera action. "Tilting" is vertical camera action. To "center up" means to center the composition of the picture. To "run through focus" is to check the focus of the entire studio system, and to balance the finder lens against the action lens.

(Continued on page 68)

Class A Push-Pull Calculations

Push-pull power output calculations for Class A amplifiers can be made as readily as single ended amplifiers. Simplified method of obtaining circuit operation from tube characteristics given

By E. W. HOUGHTON
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AUDIO engineers are cognizant of the expediency of the plate-generator circuit method of predicting Class A amplifier performance. The same manner of calculating push-pull action is equally as effective, but unfortunately not as universally understood and used. The dual purpose of this discussion will be to elucidate on this advantageous mode of attack, and to illustrate certain expeditious procedure in its application.

At the outset a design problem typical of those encountered in practice will be stated. An audio output of ten watts is to be obtained by using two 2A3 tubes in push-pull. A plate supply voltage of 250 volts is available. What grid bias should be employed to secure most economically at least the stated output? A minimum percentage of harmonic distortion is, of course, essential. The economic consideration in this case stipulates that a minimum zero-signal plate current is desired.

Before attacking the stated problem a usual method of procedure will be explained. Diagrammatically a push-pull circuit is represented in Fig. 1. Assuming a perfect output transformer by neglecting leakage reactance and resistance and exciting current, then transferring the load resistance, R_2, to its equivalent value in the primary, the simplified circuit, Fig. 2, results.

The voltage developed across the transferred plate-to-plate load is:

$$E = (I_1 - I_2) R_p \qquad (1)$$

The power output is then:

$$P_o = E (I_1 - I_2) = (I_1 - I_2)^2 R_p \qquad (2)$$

The use of static $E_p - I_p$ curves for obtaining the power output and distortion of a single tube operating in Class A is quite familiar. As indicated by Eqs. (1) and (2) the calculation of push-pull performance must involve the use of plate current difference characteristics, $(I_1 - I_2)$. These characteristics can be obtained by a convenient method due to B. J. Thompson.[1] This is illustrated in Fig. 3 for two type 2A3's operating with 250 volts on the plate and 50 volts grid bias. Essentially these curves were produced by constructing two individual static characteristic families, one inverted with respect to the other, with a common zero-signal plate voltage, E_o, then subtracting corresponding static characteristics point by point. The resultant dotted lines trace out the plate current difference characteristics, $(I_1 - I_2)$, flowing in the output transformer for different grid excitation values. The dotted lines representing the equivalent static family of $E_p - I_p$ curves for the two tubes in push-pull can be utilized for predicting their combined effect just as the individual static $E_p - I_p$ characteristics for a single tube in Class A can be used for calculating its output and distortion for a given load. Similarly, the equivalent plate resistance, r_p, of the push-pull tubes is equal to the reciprocal of the slope of the static difference characteristics or to *cot* θ in Fig. 3. Thus, the plate-generator circuit for push-pull tubes evolves from the above considerations as shown in Fig. 4.

The alternating current flowing in the output circuit is:

$$i_p = \mu e / (R_p + r_p) \qquad (3)$$

The power output is:

$$P_o = \mu^2 e^2 R_p / (R_p + r_p)^2 \qquad (4)$$

These plate-generator equations are identical to those used for a single Class A stage; however, notice that: μ is the amplification factor of the tubes, e is the r.m.s. signal applied to one grid, R_p the load transferred to one-half of the output transformer primary, and r_p is the reciprocal of the slope of the plate current difference characteristics.

The chief objection to this method of applying the plate-generator at-

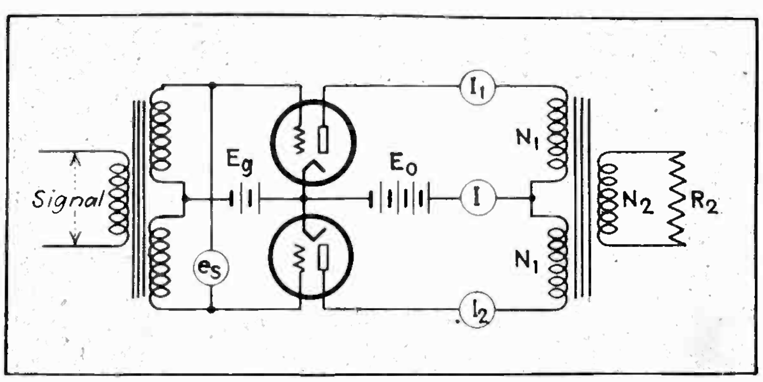

Fig. 1. Actual diagram of push-pull amplifier

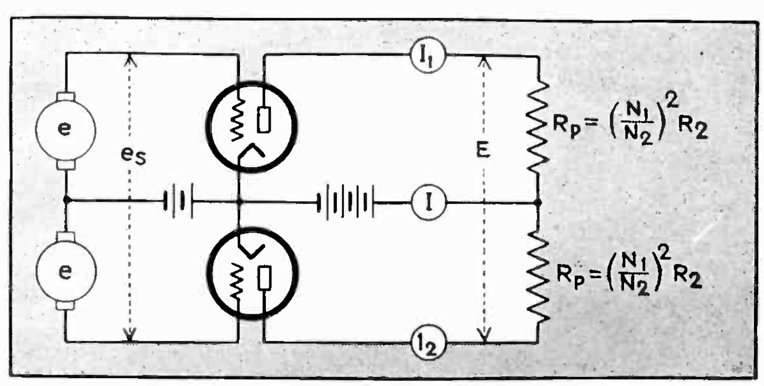

Fig. 2 Simplified push-pull amplifier circuit

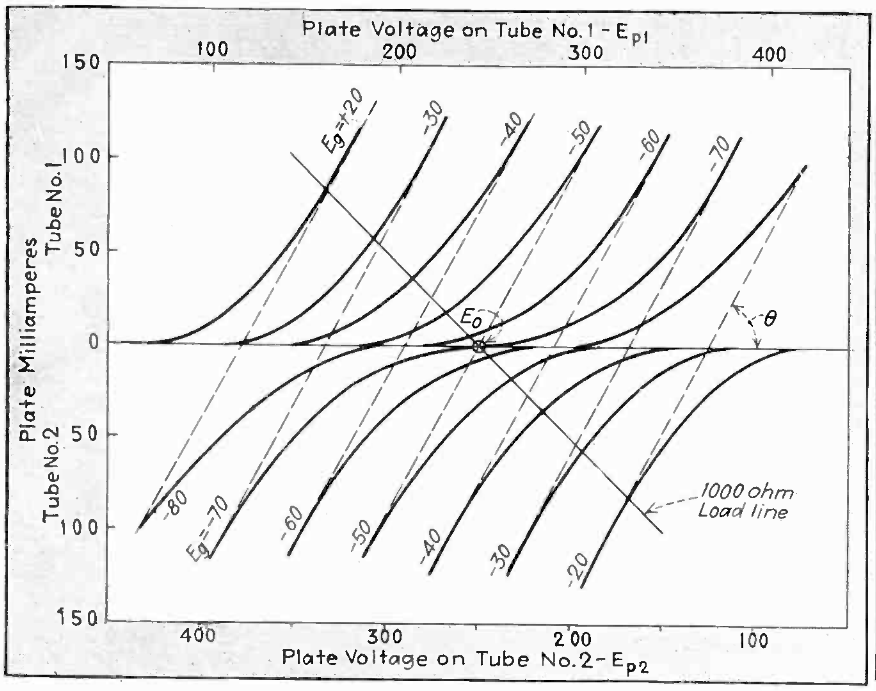

Fig. 3. Double set of plate characteristics for 2A3 tubes

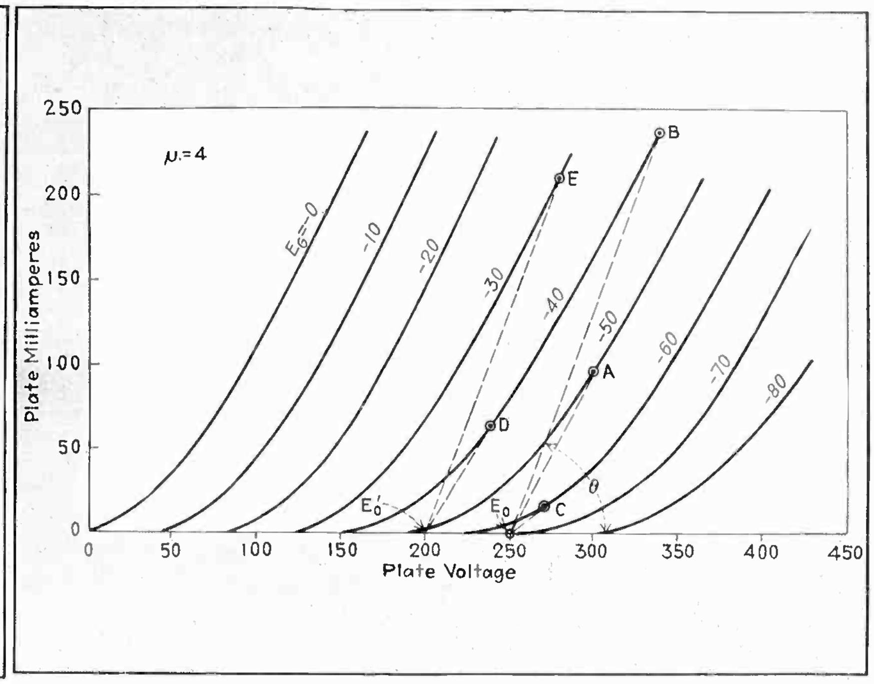

Fig. 5. Plate characteristics of 2A3 tube

tack is that the evaluation of r_p must be obtained by the cumbersome construction of two sets of curves. Examination of the effect of changing either the grid bias or plate voltage further increases the task, since new plots must be made for each different static voltage condition, Fig. 3. A simplifying method which removes the necessity of plotting curves and utilizes only the plate characteristic curves sent out by the manufacturer will be shown.

Notice from Fig. 3 that the resultant characteristics are all very nearly parallel straight lines; hence the effective plate resistance, r_p, can be closely approximated by constructing only one pair inverted curves. Further simplicity results by using the zero-signal characteristics, ($E_g = -50$, $E_p = 250$, in Fig. 3). This difference characteristic passes through the common plate voltage, E_o, and becomes tangent to the static curve of tube No. 1 when

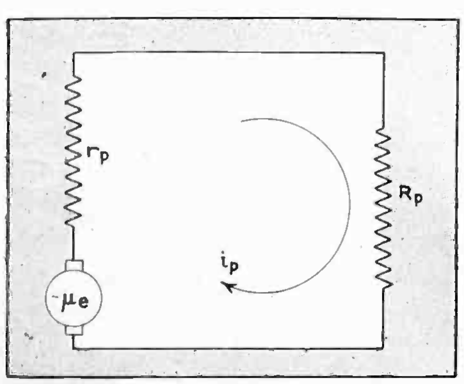

Fig. 4. Equivalent circuit of push-pull amplifier

the plate current in tube No. 2 becomes zero ($E_{p1} = 300$). This point of tangency, E_t, can be calculated by a fundamental relationship,

$$E_t = 2E_o - \mu E_g \qquad (5)$$

where, E_t is the plate voltage at which the difference curve touches the static curve, E_o is the zero-signal voltage, μ is the amplification factor of the tubes, and E_g is the grid biasing voltage.

With the two points E_t and E_o known, it is now possible to connect them with a straight line, which represents the upper half of the difference characteristic for zero signal. The value of r_p can then be readily calculated.

To illustrate the expediency of this plan, calculations will be made using the static plate characteristics of the type 2A3, Fig. 5.

With a grid bias of 50 volts and 250 volts on the plates the tangential point is given from Eq. (5), as $E_t = (2 \times 250) - (4 \times 50) = 300$ volts. The upper half of the difference curve, E_oA, is shown in Fig. 5. The equivalent plate resistance is,

$$r_p = \cot \theta = \frac{50}{0.095} = 525 \text{ ohms.}$$

Comparison of this result with that obtained by taking point by point differences, Fig. 3, shows an exact agreement. This newly developed method was used to investigate the conditions of push-pull circuit operation for several values of grid and plate operating voltages, the results being given in the following table:

Plate Voltage	Grid Voltage	Equivalent Plate Resistance	Difference Line on Fig. 5
200	—30	323 ohms	$E_o'E$
200	—40	625 ohms	$E_o'D$
250	—40	375 ohms	E_oB
250	—50	525 ohms	E_oA
250	—60	1000 to 600 ohms	E_oC

It is evident that a plate voltage of 250 and a grid bias of 60 volts results in an undesirable curved difference characteristic, prohibiting the use of a higher bias than about 50 volts. The chief effects of reducing the bias below —50 volts are to decrease the equivalent plate resistance, and to increase the zero-signal plate current. Therefore, the answer to the problem must be about 50 volts grid bias, the most economical bias value to give low percentage distortion. The expected output can now be quickly approximated.

If $E_o = 250$ volts, $E_g = -50$ volts, and $r_p = 525$ ohms; then for maximum undistorted output, the external load resistance is $R_p = 2r_p = 1000$ ohms and $R_2 = 4000$ ohms if a unity ratio exists between the secondary and entire primary of the output transformer. With a grid-to-grid signal, $e_s = 100$ volts (maximum value), or $e = 50$ volts (maximum value), we can calculate the power output from Eq. (4) to be

$$P_o = \frac{4^2 \times 50^2 \times 1000}{2\,(525 + 1000)^2} = 8.6 \text{ watts.}$$

This plan is an effective means of quickly making a tentative selection of the best grid bias for a given plate

(Continued on page 35)

Thyratron D-C Motor Control

An application of a most useful member of the electron-tube family to wire reeling—but of wide interest and use and typical of a new type of control

By G. W. GARMAN

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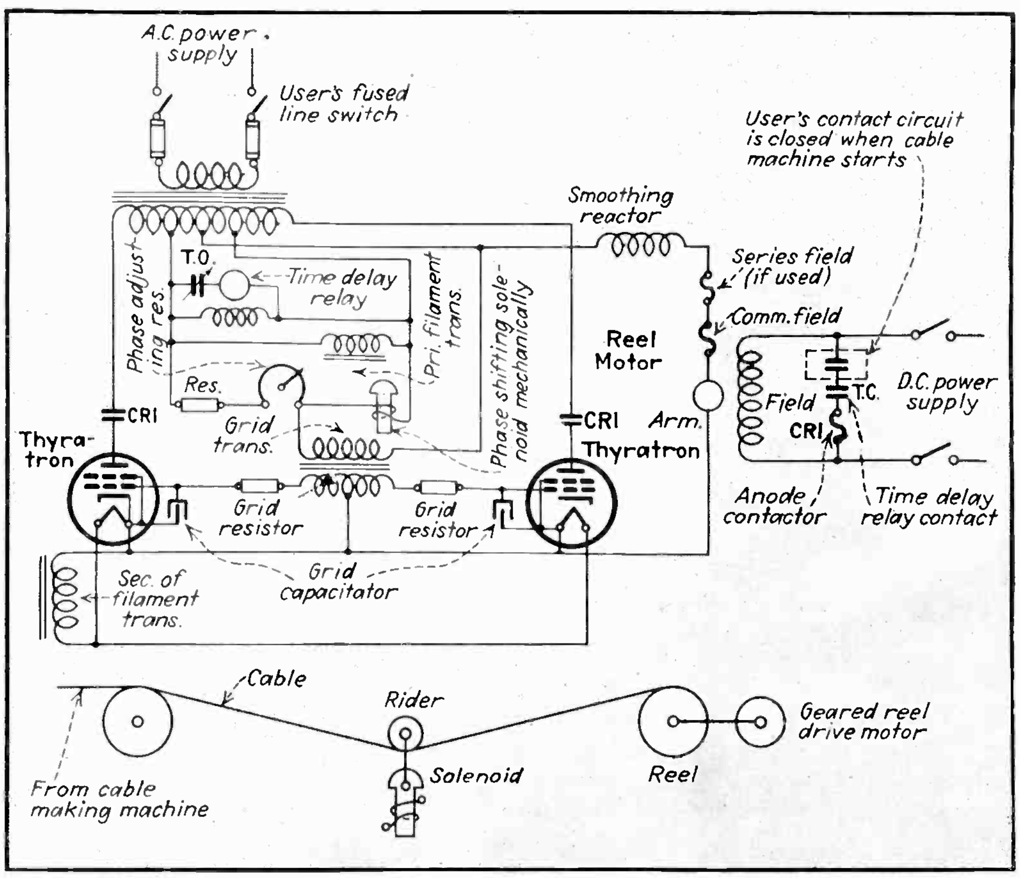
THE thyratron is no longer a stranger, but some of its actual and potential uses are not generally known. Thyratrons have been used to a limited degree in direct-current motor control circuits for the last five or more years, but until recently the lack of data and suitable tubes has materially limited their application. In general, thyratrons can be used to furnish either the armature current or the field current, or both, of direct-current motors. These tubes are particularly suitable for these applications because with a comparatively small amount of grid power the motor speed can be smoothly varied, with a high degree of efficiency, throughout its normal speed range.

Under the two general classifications of armature or field control there are other subdivisions which are determined by the particular application. Two of the most common subdivisions are "mechanical feedback" and "electrical feedback." In any type of control in which voltage, speed, or tension is held constant, some type of comparative means must be employed to determine both when a change occurs and also to initiate the controlling circuit in that direction which will restore the quantity being held constant back to normal. For example, if the speed of a motor is to be held constant, the voltage of a direct-connected pilot generator will give the desired indication of the motor speed. If this voltage is then compared to another fixed voltage, a voltage difference will be obtained. The magnitude and polarity of this voltage difference is a direct indication of the amount and the direction that the motor speed is above or below normal. In this case the comparative means is electrical and for this reason it has been termed "electrical feedback".

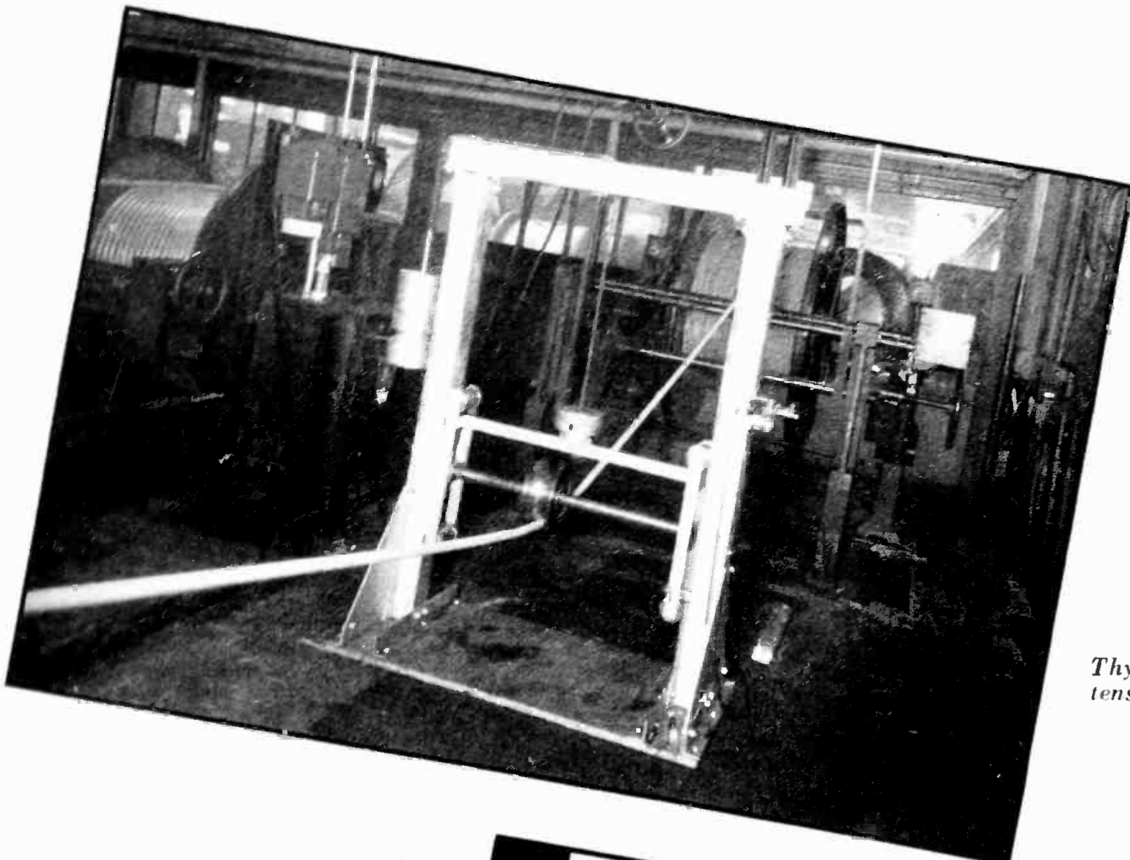
A typical installation of mechanical feedback in which tension is to be held constant is shown in this article. The elementary connections of this installation are shown in the diagram below. Here the problem was to control the speed of the cable reel in such a manner that the cable will be reeled at a uniform speed without producing jerks. The previous method was to set the reel on two revolving drums and to rely on slippage to take care of the differences in the speed between the cable making machine and the reel drive. When making the larger size cables it was necessary for a man to constantly control the speed of the reel drive by hand.

In this application the cable passes under a rider in such a way that if the reel speed is too great, the rider rises, changing the air gap of a solenoid to which it is mechanically connected. The coil of the solenoid forms part of a resistor-reactor phase-shifting circuit such that as the solenoid air gap is decreased, the grid voltage of the thyratrons, obtained from the grid transformer, lags more and more behind the anode voltage of the thyratrons, thereby reducing their output voltage. In this particular application the thyratrons (FG-105) are used to control the magnitude of the voltage applied to the armature, the field supply being obtained from a d-c source.

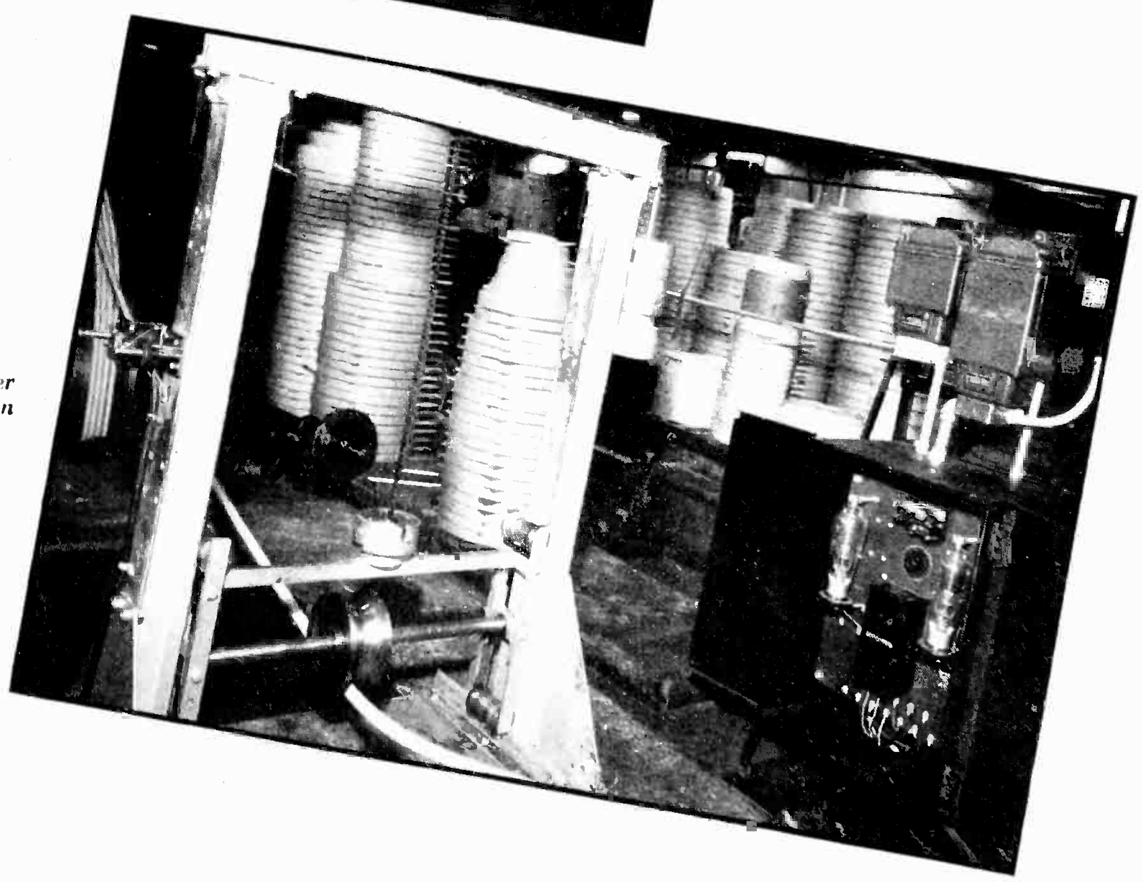
Thus, as the rider rises with an increase in motor speed, the thyratron output is reduced, producing a decrease in the motor speed. The mechanical arrangement of the rider is such that if it varies from its



Wiring diagram for thyratron motor control system



Thyratron - controlled constant - tension drive for high-voltage cable-making machine



Motor control panel and rider assembly for constant-tension reel drive

lowest to its highest position the thyratron output changes from the maximum value (full speed) to zero. Thus for each required motor speed there is a corresponding rider position. With the correct mechanical design, the tension will be the same regardless of the rider position. In this particular case constant tension is not essential, so the change in tension due to the change in angle between a vertical line and the cable for the various rider positions is entirely satisfactory.

The advantages of this type of control are that there are no moving contacts, all moving parts can be made sturdy enough to last indefinitely and a smooth wide range of control can be obtained at high efficiency.

All of these various control circuits are comparatively simple and their operation easily understood. Thyratrons have been and can be used most successfully for controlling d-c motors which control the speed of motor-generator sets, some of the processes in film making, wire drawing, cable making, rubber making, controlling the mixture of two or more elements, and other similar applications. In some applications the speed of the motor is held substantially constant at any desired setting. In others the speed is held as nearly constant as possible, and the actual speed is determined by means of the voltage of a direct-connected pilot generator. In others the speed of the controlled motor follows that of another motor. In other applications the motor speed is varied such that the tension of a wire, a rubber or celluloid sheet, remains constant.

For Engineer-Photographers Only—

An electronic device designed for the engineer whose hobby is photography. It times and controls printing exposures, both in terms of time and of the incident light, measures negative densities and shutter speeds, acts as an illumination meter and phototube relay

By DONALD G. FINK
Managing Editor
Electronics

MANY engineers whose main interest is electronic equipment have a subsidiary interest in photography. The following description is addressed to such men, since it offers an excellent opportunity for combining the two interests. The object described is an electronic device intended to perform service in the photographic laboratory, although it has uses in other fields as well. The instrument is fundamentally a timing-control relay, but it has been "duked up" to serve as many additional functions as the component parts will allow. Besides its timing-relay uses, it serves as a light quantity meter, an illumination meter, and as a photo-relay of widely variable sensitivity, capable of controlling loads from 500 to 1000 watts. Its uses in photography include timing and controlling enlargement exposures, measuring low illumination levels for accurate film exposure, measuring the transmission or density of exposed negative emulsions, and timing shutter speeds.

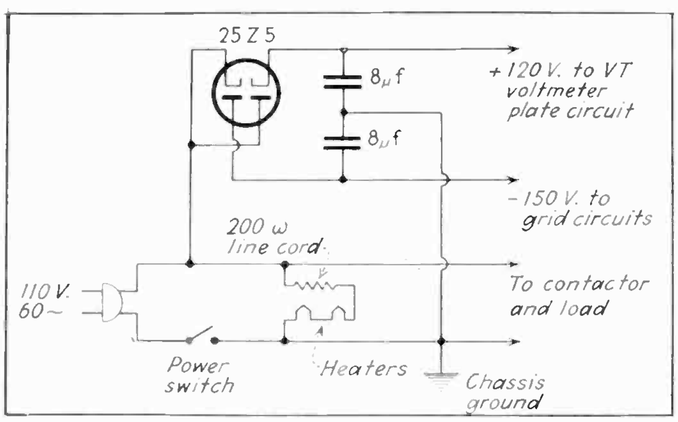


Fig. 1—Voltage-doubler supply for independent plate and grid voltages

The circuit of the instrument consists of four distinct units (1) a rectifier-filter for supplying two independent d-c voltage sources; (2) a resistor-condenser charging circuit (the resistor being a simple ohmic unit for conventional timing applications or a vacuum type phototube for measuring quantities of light); (3) a vacuum-tube voltmeter for measuring the condenser charge; and (4) a push-button relay-contactor arrangement controlled by the plate current of the VT voltmeter.

The Rectifier-filter Supply for Plate and Bias Voltages

The power supply is shown in Fig. 1. It consists of a 25Z5 double rectifier connected in a voltage doubling circuit with separate 8-μf electrolytic condenser sections across each rectifier output. The supply voltage, 110 volts at 60 cycles, is thereby converted into two independent sources of partially filtered d-c voltage of from 100 to 155 volts each, depending on the load. The center point of the voltage doubler (between the 8 μf sections), is connected to the chassis and to the negative return lead of the a-c supply. About 120 volts positive above ground is thus available for the plate supply of the VT voltmeter, while 150 volts negative below ground is available for condenser-charging and bias purposes. Any increase in the measured voltage in the grid circuit always serves to decrease the plate current, a desirable protective feature.

The Grid Circuits: Condenser, Resistor and Phototube Connections

The 150-volt negative supply from the voltage doubler is fed to the grid circuit of the VT voltmeter through the various arrangements of components shown in Fig. 2. The potentiometer R_1 serves to set the level of the calibration of the entire instrument, and is used also to compensate changes in supply voltage.

For timing applications the arrangement in Fig. 2-A is used. The voltage from the potentiometer is fed through the variable resistor R_2 to the condenser C_1. Resistor R_2 is composed of three units in series: a 0-1 megohm linear carbon volume-control, a 0-10 megohm linear control, and a step-switch of five 10-megohm units. The protective resistor (100,000 ohms) is not controllable; R_2 has a continuous range, therefore, from 0.1 to 61.1 megohms. The 2.0 μf high quality paper condenser, C_1, is charged at a rate depending on the size of R_2 and the resulting voltage across its terminals is applied to the grid circuit of the VT voltmeter.

When the instrument is used as a light-quantity meter (Fig. 2-B), the phototube, a 917 or 919 vacuum-type caesium tube, is connected in series with R_2 and C_1 is replaced by the smaller (0.01-μf) unit, C_2. This connection measures the voltage on a condenser charged through a phototube, i.e. whose rate of charge depends on the amount of light falling on the phototube.

Still another switch connection (Fig. 2-C) removes both condensers and connects R_2 as the grid resistor across the VT voltmeter, so that the phototube current is measured in the conventional manner. This circuit is used for illumination measurement and photo-relay applications. The combination of the all three switching arrangements (Fig. 2-D) is not too complicated and it adds immeasureably to the flexibility of the instrument.

The Vacuum-tube Voltmeter

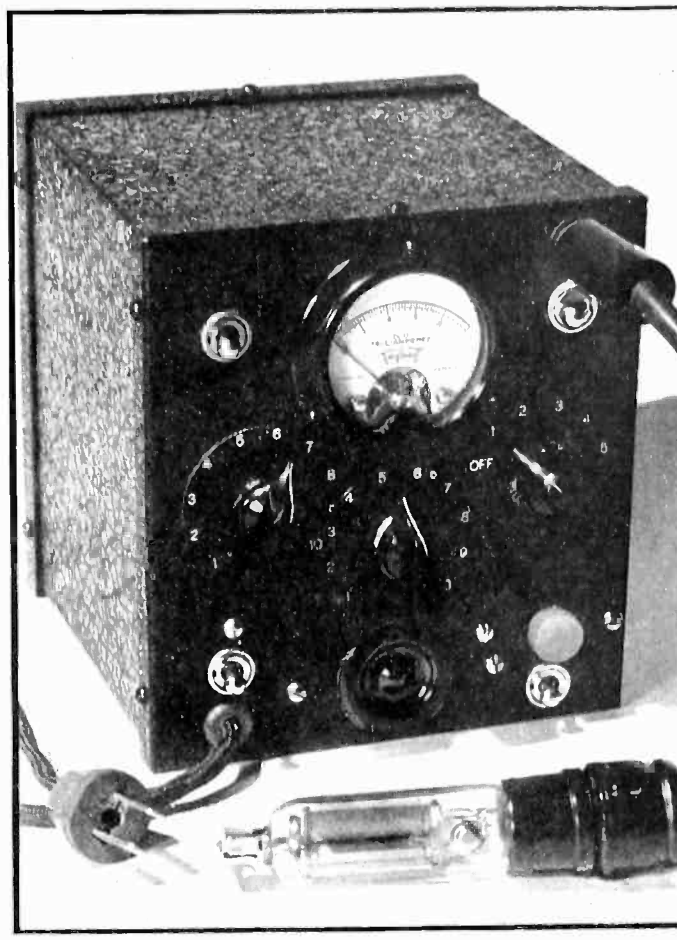
A type 43 tube takes the voltage applied by the circuits of Fig. 2 between its grid and ground and converts it into a plate-current value of corresponding magnitude. In the plate circuit of this tube is a 0-25 ma. moving coil d-c milliammeter, and the control coil of a Western

Electric J-12 single-make relay. The self-bias resistor in the cathode lead of the 43 is adjusted until the plate current of the tube is 25 ma. with the grid shorted to ground. These connections are shown in Fig. 3.

The Relay-contactor and Push-button Connections

The heart of the circuit, from the application standpoint, is the arrangement of the push-button and relay-contactor points, shown in Fig. 4. The contacts of the J-12 relay are permanently connected in series with the control coil of the main contactor (a Struthers-Dunn type CBTX1P, 6-amp.—non-inductive load—contacts, two make and two break, with a common armature contact). These latter contacts control the output power of the device, lock-up the push-button control, and initiate the condenser-charging cycle, simultaneously.

The normal operation, when used for timing and photo-timing control, is as follows: Condenser C_1 or C_2 (depending on which is in circuit) is short-circuited through contacts 1-2, through the protective resistor R_4. Therefore, when the push-button in the cathode lead is closed, the full 25 ma. plate current flows through the control coil of the J-12 relay, closing its contacts. These contacts energize the control coil of the main contactor, causing it to close. Contacts 3-4 apply the 110-volt 60 cycle power directly from the input to the external load. At the same time contacts 5-6 short-circuit the push-button, thus maintaining the plate current when the push-button is released. Simultaneously the contacts 1-2 open, and thus allow the condenser C_1 (or C_2) to charge through R_2 (or through the phototube and R_2). Contacts 7-8 are available for breaking the power flow to an auxiliary ("disconnect") outlet, so that the relay controls two circuits, applying power to one while it removes it from another.



The timing-control-photometer-relay, mounted in a 6x6x6-inch cabinet. The phototube plugs in from a six-foot shielded cable

As the condenser C_1 or C_2 charges, the voltage in the grid circuit of the 43 becomes more negative, decreasing the plate current eventually to the point when the relay J-12 opens. Its contacts thereby de-energize the coil of the main contactor which opens, opening one outlet, closing the other, releasing the push-button and short-circuiting the condenser, all at once. The entire circuit is thereby immediately restored to its normal quiescent condition (no plate current in any tube except that drawn by potentiometer R_1), and it is ready again for the next operation. The complete circuit diagram of the entire unit is shown in Fig. 5.

Application As a Timer and Timing Control

When used for simple *timing* the switch S_1 is the "T" position (i.e. the condenser connected is C_1, C_2 and the phototube being out of the circuit), the switch S_3 is open (push-button operative, not short-circuited), and switch S_2 is in the "T" position (condenser across grid circuit). With the power on, and the load (the lamp in a photo-enlarger, for example) connected to the "supply" outlet, the push-button is momen-

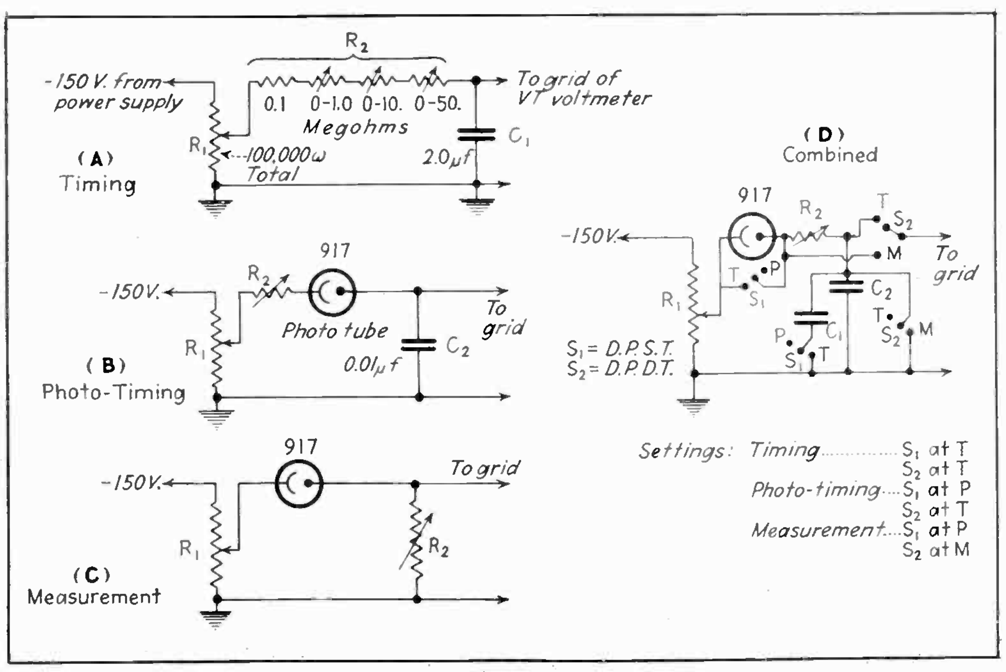


Fig. 2—The control circuits applied to the grid of the VT voltmeter, shown separately for clearness. The connections in (D) are actually used in the instrument

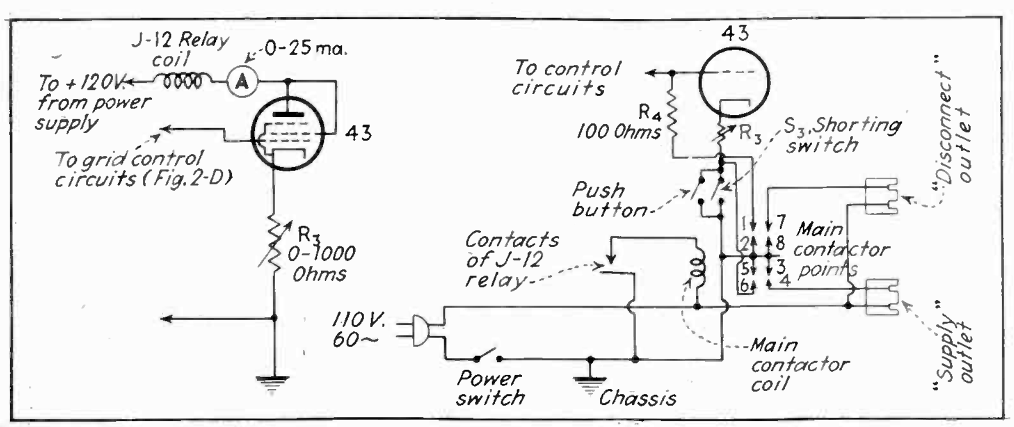
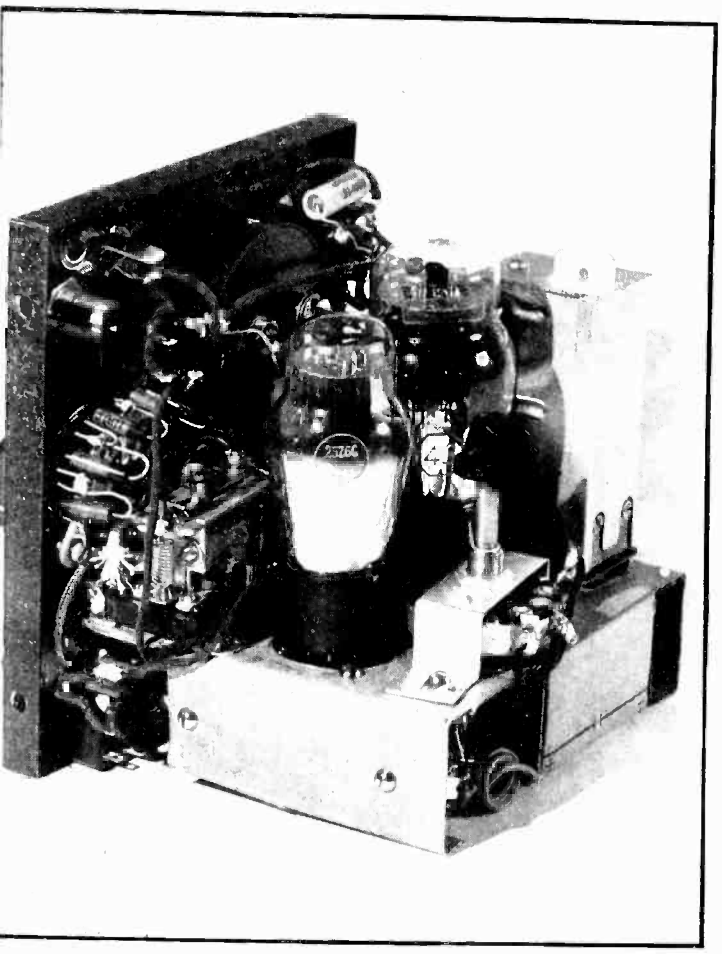


Fig. 3—(left) The VT voltmeter, controlled by the circuit of Fig. 2-D. Fig. 4 (right) the push-button, relay, and contactor interconnections which control the external load



Internal arrangement of the instrument. The contactor is between the rectifier and the panel, while the potentiometer control (R_1) is to the rear.

tarily depressed. Both relays immediately close, applying the power to the load, and initiating the condenser charge. The power then remains on for a length of time dependent on the setting on resistor R_2, the time being more or less proportional to the resistance value. When a sufficient condenser charge is assumed, the J-12 relay opens and restores the circuit to non-operating condition. With about 100 volts supplied from potentiometer R_1, the range of timing obtainable, depending on the setting of the three time-control dials, is from 0.25 to 90 seconds. The accuracy, when the J-12 relay is properly adjusted, is within 2 per cent at all points throughout that range. Calibration of the timing dials is determined by measurement with a stop-watch. Thereafter when using the instrument, if a high degree of accuracy is required, it is well to check one point on the calibration against the sweep-second hand of an electric clock, adjusting the potentiometer control R_1 for calibration. All other points in the calibration range will then automatically fall in line, if high quality resistors, properly protected from moisture, are used.

For *photo-timing* control, i.e. control of exposure interval in terms of incident light, switch S_1 is thrown in the "P" position, thus inserting the phototube and substituting C_2 for C_1. R_2 should be reduced to minimum. When the push-button is pressed momentarily, the power is applied to the "supply" outlet for a length of time dependent on the amount of light falling on the phototube. Thus, for any given size of condenser C_2, the relay remains closed until a definite quantity of light has been received by the phototube, whereupon it opens. With the constants given, the time of operation is about 2 seconds when the incident illumination covering the phototube cathode is about one lumen per square foot, or 8 seconds for one-fourth lumen per square foot, and so on. This is about the average condition for exposing bromide papers. For other emulsions, other sizes of condenser C_2 must be used; they can best be determined by trial.

The photographic advantage of the above action is obvious. By directing part of the image from an enlarger onto the phototube and by properly proportioning the constants, it is possible to obtain perfect exposures automatically, since the phototube "holds" the exposure lamp on until it has received an amount of light sufficient to expose the paper. Automatic correction for variations in negative density, for change in illumination with the degree of enlargement, for blackening of exposure lamp during use, etc. is obtained. The method of obtaining part of the enlarged image on the phototube may simply consist in holding the phototube at the edge of the enlarged field in some portion not required in the print, or by the use of a plane sheet of plate glass placed at 45° to the enlarging beam. The paper is exposed by the reflected light, the transmitted light hitting the phototube and controlling the exposure.

Timing Shutters

The same connection used for photo-timing control (switch S_1 in the "P" position) can be used for comparing the timing of the different settings of camera shutters, as follows. The phototube is placed behind the camera, viewing the ground glass but protected from all other light. A photoflood lamp is set up before the lens. When the shutter is opened, the amount of light admitted during the exposure is registered by the "throw" of the meter. With a type 1 photoflood one inch from a 13.5 cm lens, operated at f/4.5 a throw of 10 ma. is obtained with a timing of 1/200 second. For longer times, it is best to adjust the stop opening until the same throw is obtained, and to compare the timing in terms of the stop opening, since it is difficult to calibrate the "throw" of the meter directly in fractions of a second. Inaccuracies in the Compur shutter of the author's Voigtlander were discovered in this manner.

Photometric and Densitometric Measurements

For measurement purposes, the switch S_3 is closed*, thereby short-circuiting the push-button switch and maintaining the plate current path. The switch S_2 is thrown to the "M" position removing the condensers, and inserting R_2 as a variable grid resistor in the grid circuit of the 43. Now if the switch S_1 is in the "P" position, the phototube delivers current directly to this resistor R_2 and the resulting voltage drop is measured in the plate milliammeter. The relays will operate whenever the plate current passes through the pull-in and drop-out values of the J-12 relay, but for measurements this is of no consequence.

For photometeric measurements, the following procedure is used. The illumination from one sample is allowed to fall on the phototube, in the absence of stray light. The timing dials (which are now grid-resistor controls) are then adjusted until a plate current of, say, 15 ma. is obtained, and the resistance value noted from the calibration of the dials. The second sample of illumination, to be compared with the first, is then allowed to strike the phototube in the same manner, and the timing dials readjusted until the same value of plate current is obtained, and the new resistance value noted. Then, if the same area

* If the condensers are in the grid circuit when S_3 is closed, the circuit will "repeat," that is, operate in recurring cycles, which can be made very accurate if the protective resistor R_4 is not too large. These repeated time intervals can be of considerable value, although the device was not designed with this mode of operation in mind.

of the phototube is covered with the same distribution of light in the two cases, the ratio of the illuminations is in the inverse ratio of the observed resistance values. This substitution method is highly reliable if high grade resistors, capable of holding their calibration, are used, or if some accurate means of measuring their resistance is at hand. For photographic purposes accuracies greater than 10 per cent are rarely needed; this degree is readily available even with poorly calibrated resistors.

The two photometric samples may be reflections from paper surfaces, from prints, or transmissions through negatives, in fact from any two comparable light sources. The density of negatives (the logarithm of the reciprocal of the transmission ratio) may thus be measured.

The same measurement method may be used in evaluating the illumination level of scenes to be photographed. The sensitivity of the circuit when the full 60 megohms are present in the grid circuit is very high; it will respond to 1/10 foot-candle or less, with deflections differences of over 1 milliampere. The instrument thus takes up where the usual photoelectric type of exposure meter leaves off. Accurate measurement of very low light levels is not very important in monochrome photography since in general time exposures must be taken and wide latitude is available in the film. For indoor color photography, however, such is not the case. Here a real measure of light intensity, suitably corrected for spectral response, is required. The device has not yet been applied to this problem but it can readily be adapted to it.

The exposure time control is highly valuable in three-color separation negative exposure and printing, since it gives accurately proportioned relative exposures through the three filters in accordance with the published filter factors. An earlier model of the timer has been in use for over a month for exactly this purpose with great success.

Photo-relay Action; the "Also-ran"

This rather forbidding array of circuits and connections was found to have many interesting capabilities not calculated for in the original design. One of the most spectacular is its marginal action as a photo-relay. With S_1 on "P", S_3 closed and S_2 on "M" (photometric connection), the plate current can be driven from cut-off to full scale (25 ma.) by a relative small change of light, provided that the resistor R_2 is set at its maximum value, i.e. at maximum sensitivity. When the plate current increases to about 5 ma. (the pull-in current value of the J-12 relay) the main contactor closes and will supply power to any load connected to the "supply" outlet. When the light change is sufficient to cause the relay to pull-in, therefore, the load will be energized. Pulling a shade down three inches in a brightly lighted room is sufficient to cause the relay to close when the phototube is properly situated with respect to the light coming from the window. Furthermore, by adjusting the resistor R_2, the sensitivity of the relay can be changed and the absolute value of plate current changed also, so that the plate current can be set in the near vicinity for the pull-in value (5 milliamperes) for *any* available light level from the weakest to the strongest. An interesting possibility for the younger set of electronic engineers appears if the lamp load is connected to the "disconnect" outlet. In this event, pulling the shades down turns the lights *off*.

Trouble-shooting

While no claim for excellence in the application of circuit principles is claimed for this instrument, it does represent a straight-forward design and should give no trouble to any constructor who is familiar with the basic action of its four sub-circuits. One or two precautions should be given. Since the maximum value of the charging grid resistor R_2 is very high, compared with the tube leakage resistances commonly encountered, it is wise to choose the VT voltmeter tube with care. High grid-cathode leakage is fairly common, but even worse is the plate-grid leakage, which may persist in charging the condensers C_1 or C_2 positively, from the plate supply, against all the efforts of the charging resistor, when the latter has a high value. The author has tried four tubes, three of which were satisfactory, so it is believed that no trouble should be found in obtaining good tubes for the purpose. Since the 25Z5 and 43 are widely used in midget receivers they are inexpensive and widely available.

A voltage regulator tube (such as the 874) might be used in place of the potentiometer R_1, for accuracy of calibration, but at the expense of flexibility of range.

The author wishes to express appreciation to members of the New York Y.M.C.A. Evening Electronics Course, especially Messrs. Beauchea, Boilen, Dewhurst, Genodman, Holstrom and Klein for many helpful suggestions in the design of this unit, and to Mr. Keith Henney for pointing out many of its uses in advanced photographic practice.

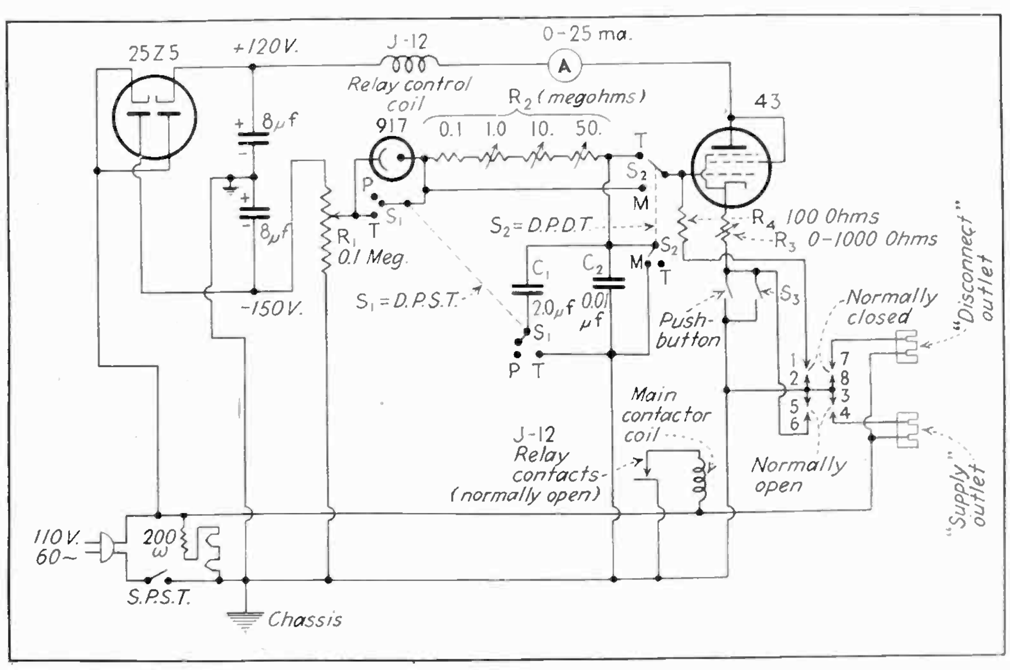


Fig. 5—The complete circuit diagram, combining the sub-circuits shown in Figs. 1, 2, 3, and 4. The complete cost of parts, at current mail-order prices, is about 30 dollars

An Amplifier Without Phase Distortion

An amplifier without cathode by-pass condensers, screen by-pass condensers, decoupling condensers and no output condenser in B-supply filter

THE amplifier circuit shown in the circuit diagram is an interesting solution for an unusual problem in amplifier design. The problem arose during the development, by Mr. O. H. Schade of the RCA Radiotron Division, of an oscillograph for tracing tube characteristic curves. The function of the amplifier in this oscillograph is indicated in the simplified diagram of Fig. 1. As is shown in this figure, the amplifier applies to the oscillograph a vertical deflecting voltage which traces a curve of plate current against plate voltage for the tube being studied. It can be understood that an amplifier and oscillograph, which can trace tube characteristics rapidly in this way, make an extremely useful tool for tube design. But in order that the oscillograph should trace accurate curves, the amplifier has to meet a requirement which presents an unusual problem in amplifier design.

The requirement is that the amplifier have negligible phase distortion over a wide frequency range. To understand the reason for this requirement, suppose it is desired to trace an I_p-E_p curve for a beam power

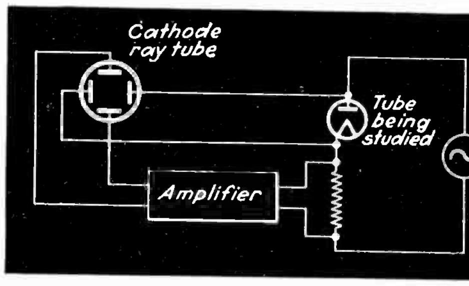
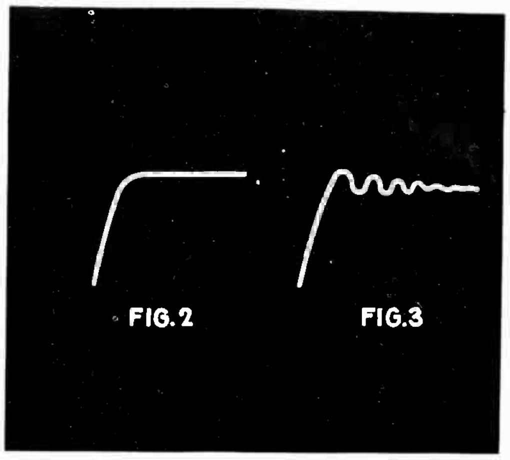


Fig. 1—Position of amplifier in oscillograph for studying tube characteristics

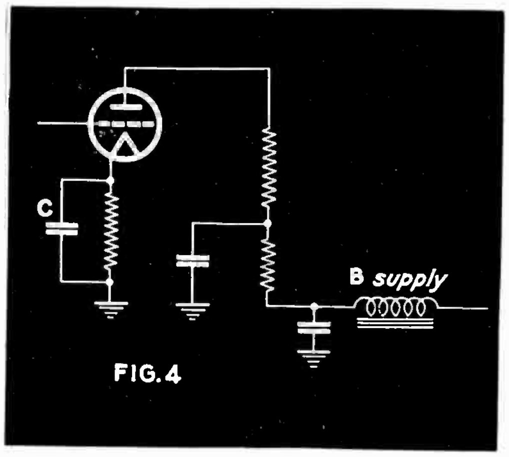
tube. The true form of this curve is shown in Fig. 2. If an amplifier of conventional design is used in tracing this curve, the oscillograph may trace the curve shown in Fig. 3. The explanation for this false reproduction is that the sharp bend in the true curve is, to the amplifier, a fundamental frequency plus strong high-order harmonics. Because the amplifier shifts the phase of different frequencies by different amounts, the harmonics lag the fundamental in the output of the amplifier and appear as ripples. In other words, the false reproduction is due to phase distortion in the amplifier.

From this explanation, it can be understood that for accurate curve tracing, the amplifier must have no appreciable phase distortion from the lowest to the highest frequency important in the shape of the curve. In the application of the curve tracer, it is desirable to be able to use 60 cycles as the tracing frequency. It is also desirable to be able to trace several curves in one oscillograph pattern; for example, it is desirable to trace in one pattern I_p-E_p curves for six different grid-bias voltages. For tracing six curves in the same pattern with a tracing frequency of 60 cycles, the lowest important frequency is 10 cycles. For tracing sharp right-angle bends, such as exist in the I_p-E_p curve of a beam power tube, the highest important frequency is the hundredth harmonic of 60 cycles, or 6000 cycles. Hence the requirement on the amplifier is that phase distortion should be negligible from 10 cycles to 6000 cycles.

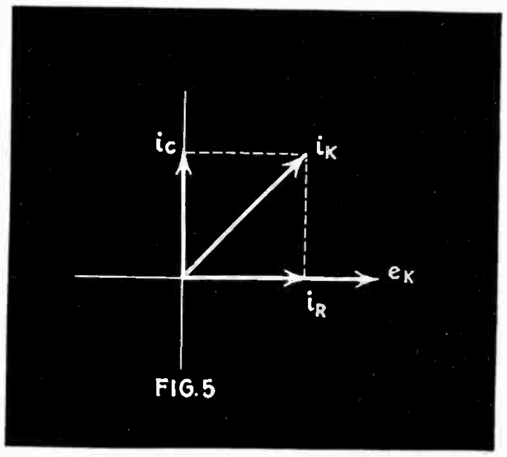
This requirement cannot be met by an amplifier tube connected in the conventional manner (indicated in Fig. 4) with a cathode-bias resistor and condenser, a decoupling resistor and condenser, and a filtered plate supply. The reason is that the condensers in the circuit introduce phase distortion. As an illus-



True and false beam power tube curves



Conventional amplifier with cathode-bias resistor

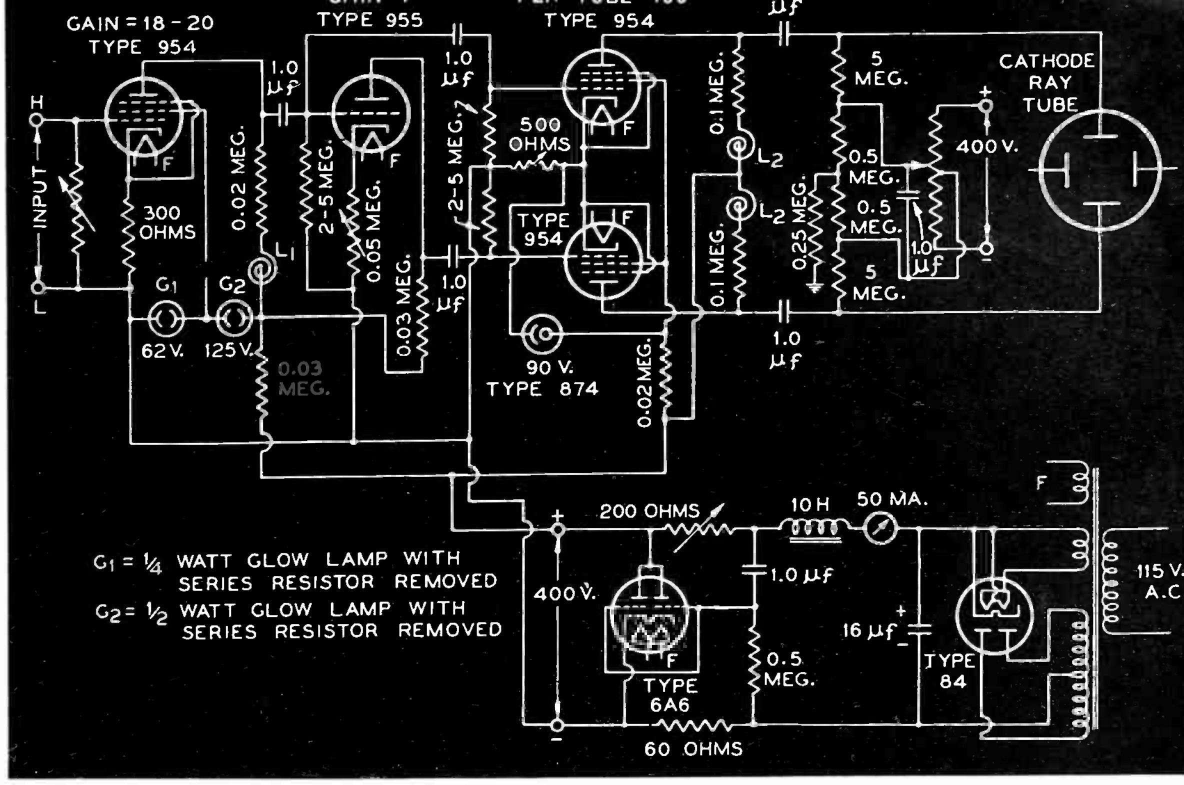


Vector diagram demonstrating phase distortion tration of the phase distorting effect of these condensers, consider the cathode by-pass condenser. A simple vector diagram serves to show how this condenser causes phase distortion. Suppose the signal component of current through the cathode-bias resistor is i_R. Then the voltage across the resistor, which must be in phase with the current through the resistor, can be drawn as e_K. Since this voltage is also across the condenser and since the current through a condenser leads the voltage across it by 90°, the current through the condenser can be drawn as i_c. The cathode current of the tube can then be drawn as i_K because the cathode current is the sum of the currents in the resistor and the condenser.

The point demonstrated by this diagram is that the cathode by-pass condenser draws a current, i_c, which causes a phase difference between cathode current and cathode voltage. In a similar manner it can be shown that the decoupling condenser and the B-supply filter cause a phase difference between plate current and plate voltage. Furthermore, if the amplifier tube is a pentode, the screen by-pass condenser causes a phase difference between screen current and screen voltage. Because these phase differences change with frequency, and because they produce a phase shift between signal input voltage and signal output voltage, the result is phase distortion of the signal. This phase distortion may not be serious for high frequencies, but for frequencies as low as 10 cycles it is intolerably large, even if the condensers are several thousand microfarads. It is not feasible to avoid this phase distortion by the use of B batteries because B batteries, after a short time of use, produce the same kind of phase distortion that a condenser does. Hence part of the amplifier design problem is to design an amplifier having *no cathode by-pass condensers, no screen by-pass condensers, no decoupling condensers, no output condenser in the B-supply filter, and not operated from B batteries.*

Mr. Schade's circuit

This unusual problem is solved in an ingenious manner as shown in the circuit diagram. The use of a condenser is avoided in the output section of the power supply filter by means of a 6A6 connected as a filter. To understand the action of this tube as a filter, suppose that a positive pulse of ripple voltage comes through the 10-henry choke. Because this positive voltage pulse is applied to the grid of the 6A6 through the 1.0-μf condenser, plate current through the 6A6 increases and the IR drops across the 200-ohm plate resistor and the 60-ohm cathode resistor increase. The increase in these IR drops is just equal to the pulse of ripple voltage; hence the ripple voltage is cancelled at the output terminals of the power supply. In this way, the 6A6 smooths out ripple, or voltage surges from the line, but does not introduce phase distortion as a filter condenser would.



Complete circuit of Mr. Schade's amplifier

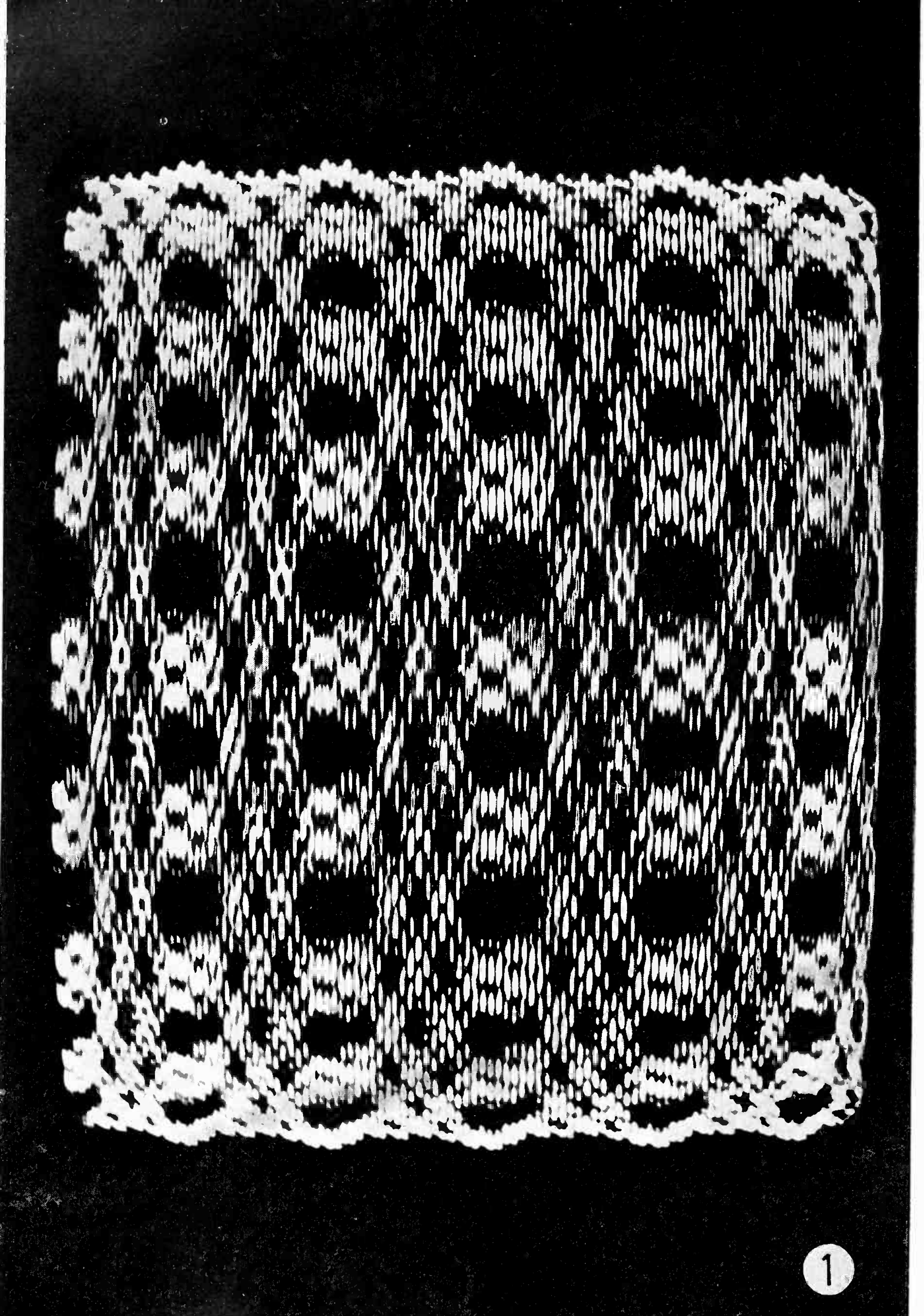
The use of screen by-pass condensers and decoupling condensers is avoided by the use of neon tubes and an 874 tube. These tubes act as voltage regulators and therefore perform, with negligible phase distortion, the same function as by-pass condensers.

The use of cathode by-pass condensers is avoided by designing the amplifier stages so that these condensers can be omitted without much loss of gain. In the first and third stages, the cathode-bias resistors are small resistances. The cathode-bias resistor in the first stage can be small because the signal-input voltage to this stage is small; the cathode-bias resistor in the third stage can be small because the d-c current of the 874 flows through this resistor. With these small values of cathode-bias resistors, there is not much degeneration in the first and third stages. The second stage, a phase inverter, is operated at unity gain; degenerative loss of gain in this stage is therefore not a disadvantage. Thus there is not much gain sacrificed by the omission of cathode by-pass condensers. With the cathode by-pass condensers eliminated, and with the screen by-pass condensers, decoupling condensers, and output filter condenser also eliminated, phase distortion is small.

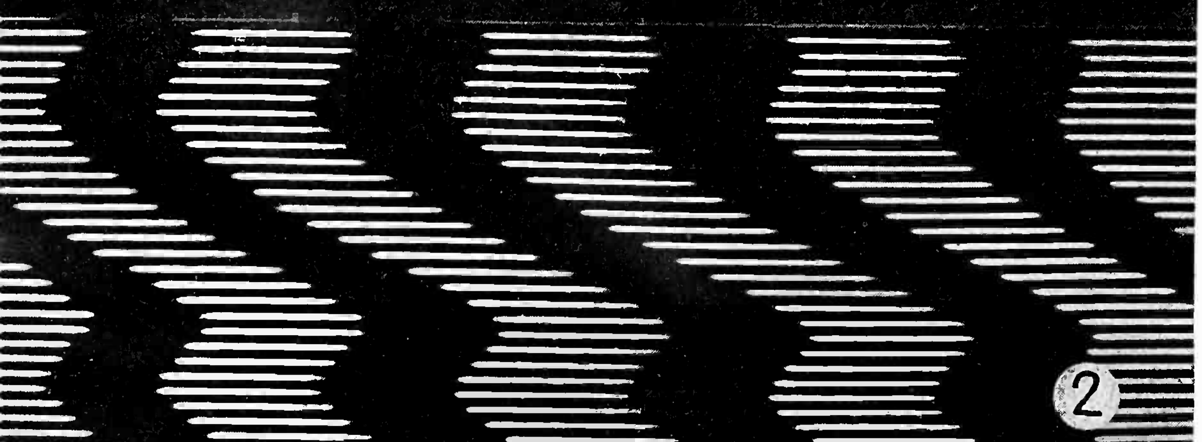
There are three other features of this amplifier which make phase distortion still smaller. One is the use of acorn tubes. These tubes combine large mutual conductance with small interelectrode capacitances. They therefore can provide high gain with little phase distortion. The little phase distortion that is produced by the output capacitance of these tubes is made still smaller by a second feature, the use of chokes in series with the plate resistors. These chokes reduce phase distortion because they cause a phase shift in the opposite direction to the shift caused by the output capacitance of the tubes. A third feature which reduces phase distortion is the use of a large capacitance value, 1.0-μf, for the coupling condensers. Because these condensers are large, their reactance is small compared to the resistance of the grid resistors. The phase distortion due to these condensers is therefore negligible. As a result of all the design features in this amplifier which reduce phase distortion, the amplifier can cover all frequencies between 10 and 30,000 cycles with no phase distortion perceptible on the oscillograph.

Electron

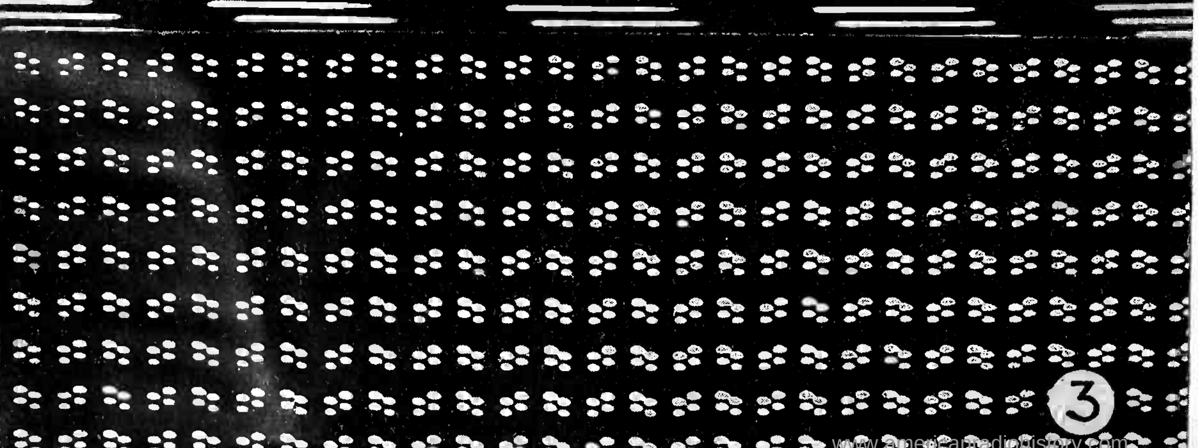
Unusual cathode-ray screen patterns produced by C. E. Burnett of RCA Radiotron in testing television tube characteristics. Various combinations of synchronized deflecting and control-grid voltages were applied to the tube as outlined below. The photographs were obtained directly from the screen of a 9-inch magnetic-deflection tube operated at 6,000 volts, the exposure time in each case being about 15 seconds.



1 *Deflection: vertical, 3780 cps sine-wave plus small components of 1260 and 180 cps; horizontal, 30 cps saw-tooth. Control grids simultaneous application of three voltages, 246,960 cps, 70,560 cps, and 30 cps, all square-waves*

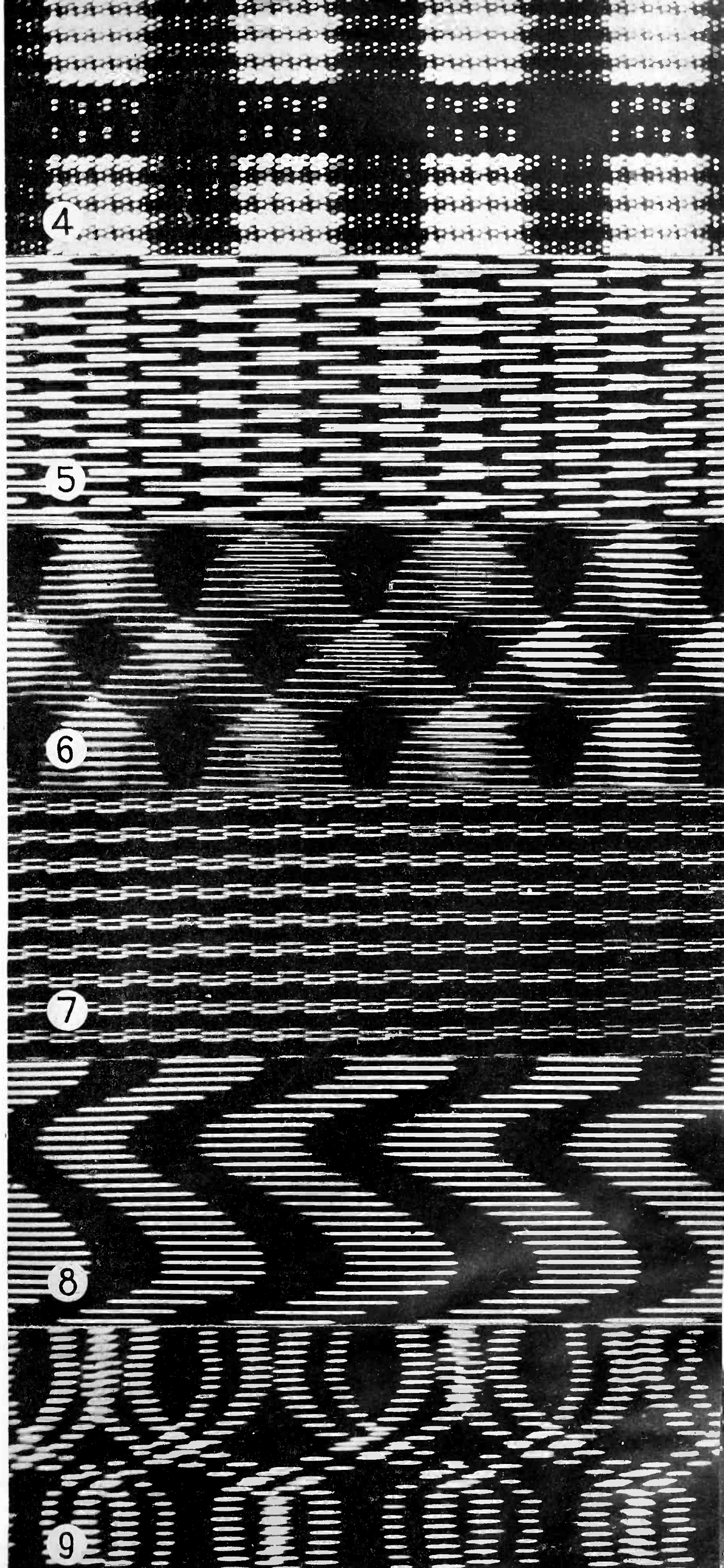


2 *Deflection: vertical, 30 cps saw-tooth; horizontal, 3780 cps sine-wave plus components of 1260 and 180 cps. Control grid: simultaneously, 30 cps square-wave, 3780 cps sine-wave, and 70,560 cps square wave*



3 *Deflection: vertical, 30 cps saw-tooth; horizontal 10,080 cps sawtooth. Control grid: simultaneously 30 cps square-wave, 10,080 cps square-wave, 740,880 cps sine-wave, 246,960 cps square-wave, 1260 cps square-wave*

Patterns



4 *Deflection: vertical, 30 cps saw-tooth; horizontal, 10,080 cps saw-tooth. Control grid: simultaneously 30 cps square-wave, 10,-080 cps square-wave, 2,222,640 cps sine-wave, 740,880 cps sine-wave, 246,960 cps square-wave 70,560 cps square-wave, 1260 cps square-wave, and 180 cps square-wave*

5 *Deflection: vertical, 30 cps saw-tooth; horizontal 3780 cps sine-wave, plus small component of 1260 cps. Control grid: simultaneously, 30 cps square-wave and 70,560 cps square-wave*

6 *Deflection: vertical, 30 cps saw-tooth; horizontal 3780 cps sine-wave plus small components of 1260 and 180 cps, phase changed from that in 5 above. Control grid: simultaneously, 30 cps square-wave and 70,560 cps square-wave*

7 *Deflection: vertical, 30 cps saw-tooth; horizontal, 10,080 saw-tooth. Control-grid: simultaneously, 30 cps square-wave, 10,080 cps square-wave, 246,960 cps square-wave, 1260 cps square-wave*

8 *Deflection: vertical, 30 cps saw-tooth; horizontal, 3780 cps sine-wave plus small components of 1260 and 180 cps. Control-grid: simultaneously, 30 cps square-wave, 3780 cps sine-wave, and 70,560 cps square-wave*

9 *Deflection: vertical, 30 cps saw-tooth; horizontal, 3780 cps sine-wave, plus small components of 1260 and 180 cps. Control-grid: simultaneously, 30 cps square-wave, 70,560 square-wave, and 246,960 cps square-wave*

Tubes at Work

Reported this month are a rotating commutator which remembers the causes of ignitron failures, a phototube skew-control for cotton-cloth manufacture, a surface analyzer, and a highly stable d-c vacuum tube microvoltmeter for use in biophysics

Rotating Commutator "Remembers" Ignitron Failures

To detect arc-backs in ignitron operation, engineers of the Westinghouse Research Laboratories in Pittsburgh have developed a device called the "Memnoscope" which retains an oscillographic image of the ignitron current for 1/30 of a second. Essentially the Memnoscope is a rotating commutator having 147 segments, which is rotated at a speed of 1800 r.p.m. (30 r.p.s.). Connected with each segment is a condenser which can be charged by voltage supplied to each segment by brushes. Each condenser retains its charge for one revolution, whereupon the charge is removed by another brush. Just before removal, the condenser voltages are caused to actuate a cathode ray tube, so that a "step-by-step" oscillographic pattern of the two cycles in each commutator revolution is produced. When an arc-back occurs a camera is caused to photograph the cathode ray tube screen, which is recording continuously but lagging 1/30 of a second behind the actual ignitron current. When an arc-back occurs, therefore, the voltage conditions which precede the arc-back are preserved on a photographic record of the oscilloscope screen, from which more accurate diagnosis of the cause of the arc-back can be made.

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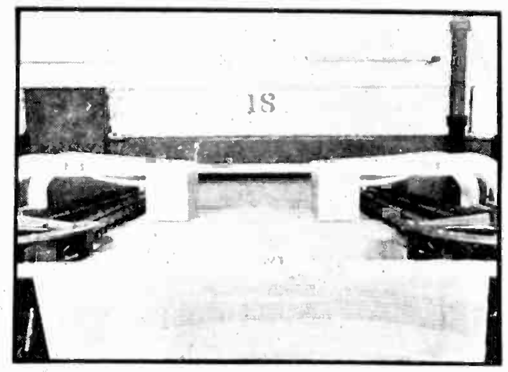
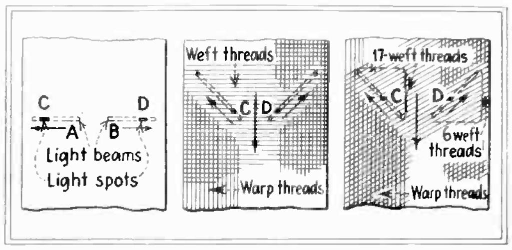
Photo Tube Detects Skew in Cotton Cloth

A new weft-straightening control, which uses phototubes to detect skew in cotton cloth, has been developed in the laboratories of the General Electric Company. When the cloth passes through the last finishing operation it is necessary to adjust the selvage edges so that the weft threads are square with the warp threads. If the cloth is not made uniformly square, patterns subsequently printed on the cloth will become distorted when the cloth straightens in use. Heretofore the straightening operation has been under the manual control of an operator, who at best could detect small skews at cloth speeds not in excess of 40 yards a minute. The photoelectric device is capable of handling the same job automatically at a cloth speed of 140 yards per minute.



Weft-straightening control installed at the plant of the Mount Hope Finishing Company. The two phototube scanners are shown above the cloth

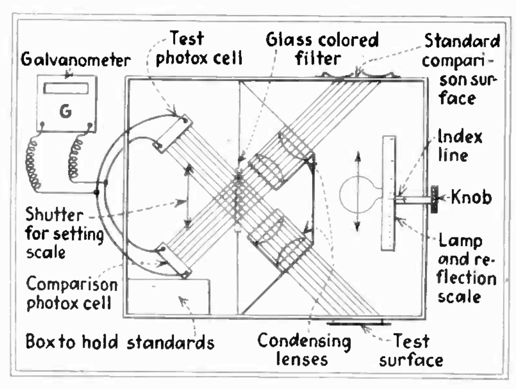


Relation between warp and weft threads, in relation to light spots which scan the cloth

Two phototubes, one on each side of the cloth frame, are mounted so that they scan the threads as the cloth moves along the frame. Depending upon the speed and the closeness of weave, the number of threads passing the phototube varies from about 280 to about 8,400 per second. The light beam entering each phototube is thus interrupted at a definite frequency between these limits. If the cloth is straight, the frequencies on the two phototubes are equal. But if the cloth is skewed, the light is interrupted at a higher frequency for one tube than the other, at least momentarily. In the output circuit of the phototube is a frequency responsive circuit which operates relays for the control of the straightening motor. This motor, which is mechanically connected to the edge of the cloth, advances or retards one edge of the cloth, until the skew is removed.

"Cross-Beam" Reflectometer for Surface Comparisons

An unusual arrangement of two self-generating Photox cells for comparing the reflecting properties of different surfaces has been developed by the Gardner Laboratories in Washington, D. C. The arrangement of the device is shown in the diagram. At the right is a knob on which is mounted an electric light bulb, so that the axis of the bulb is displaced from the axis of the knob. By rotating the knob, therefore, it is possible to move the bulb in either of the directions indicated by the arrows. Immediately above and below the bulb are openings in the case of the instrument which admit the light from the bulb to the test surface (below) and the standard comparison surface (above). The light reflected from these surfaces is reflected to two systems of condensing lenses producing parallel beams which cross each other near the center of the instrument. At the point where the beams cross a colored glass filter is inserted. This arrangement makes use of one filter for both beams, reducing the cost, and eliminating errors which might arise from different filter characteristics.



Construction of photoelectric cross-beam reflectometer

The beams, having passed through the filter, are intercepted by two Photox self-generating cells which are connected in series as shown. Centered across both cells is a sensitive galvanometer (recommended sensitivity 0.02 microamperes per millimeter and 1,000 ohms resistance).

If the two beams are of equal intensity, the net voltage developed across the two photocells is zero, and the galvanometer maintains its center position. However, if one beam is stronger than the other the galvanometer indicator moves to the left or right depending upon which beam is the most intense. In operation the knob on which the lamp is mounted is turned, thus moving the lamp until the galvanometer reading comes to zero. A scale attached to the knob then indicates the relative degrees of reflectance of the standard and test surfaces. To calibrate the instrument the knob is adjusted so that the lamp is midway between the two surfaces, and a standard surface is placed in the test position. The two beams, as they cross the filter, are then of equal intensity. If the galvanometer does not then read zero, because of differences in the characteristics of the two Photox cells, a shutter which intercepts part of the beams is adjusted until one cell receives more light than the other, thereby compensating for the error. By this means the galvanometer is adjusted to zero, and thereafter one of the standards may be replaced by a test surface for determining relative reflectance. An accuracy of better than 0.2 per cent is obtainable when white surfaces are measured.

By the use of different colored filters (red, green, and blue) comparisons of color and color differences can readily be made with an accuracy so great that the eye cannot detect the difference measured by the instrument. By making reflection determinations in blue light, it is possible to determine the degree of yellowness or yellowing which is of great importance in the preparation of white pigments. For measuring reflectance the test sample is usually compared with a standard of clear magnesium oxide whose reflectance is taken to be 100 per cent. Another interesting application of the device is the measurement of "hiding power" of paint and enamel. The reflectance of a surface is measured before and after the application of a coat of paint of standard thickness and the difference in reflectance is taken as a measure of the hiding power of the paint.

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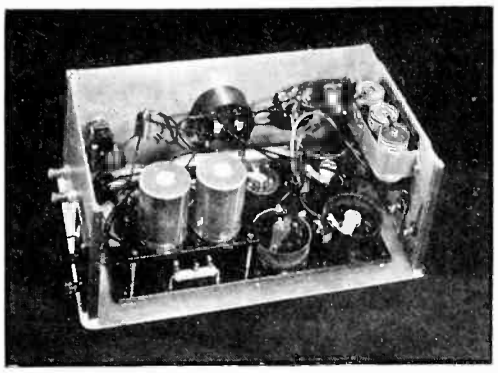
D-c Amplifier for Measuring Potentials in Living Organisms

C. T. Lane
Sloane Physics Laboratory, Yale University

A GROUP OF INVESTIGATORS in the Yale School of Medicine during the past year has been interested in measuring minute d-c potentials in a variety of living organisms. By co-relating these potentials with various known physiological factors a number of quite astonishing results has been obtained, among which may be mentioned the detection of cancer in mice antecedent to its gross appearance, electrical recording of the instant of ovulation in the rabbit, detection and measurement of electrical fields in fluid media surrounding live embryos, etc.



Arrangement of parts and wiring in the modified Wynn-Williams microvoltmeter. The tubes are inside the shield cans, and are packed in glass wool

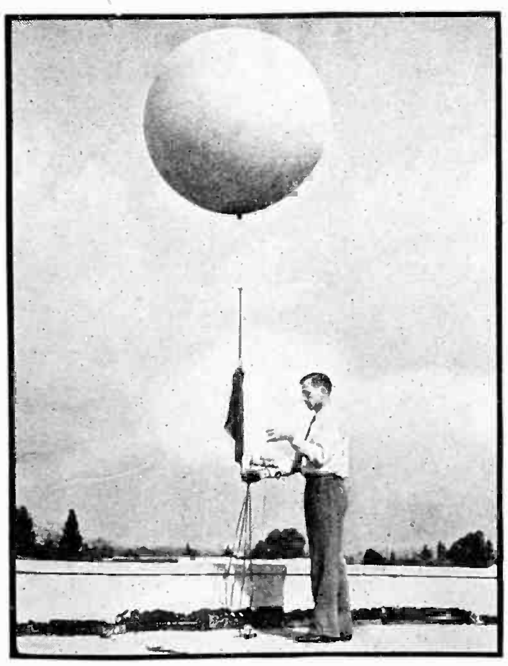
The problem of adapting a physical instrument to the somewhat special needs of the physiologist was given to the author. The specifications laid down by the physiologist required that, as a lower limit, an e.m.f. of about 5 microvolts should be measurable, the instrument should possess a high degree of stability so that small changes in e.m.f. over a period of time could be recorded photographically. Further, absolutely minimal current should be drawn from the subject under test, since even very small currents may cause disturbances in the functioning of delicate cell membranes. No shielding of the specimen under test was permissible, since in many cases microscopical observations had to be carried out while the electrical measurements were in progress. Finally, the apparatus must be portable, capable of being constructed from drawings by any reasonably skilled mechanic, and capable of being used by those not particularly skilled in the operation of electrical instruments.

Since these requirements called for a microvoltmeter of high impedance, attention was directed to the use of vacuum tubes in conjunction with a galvanometer. Tubes of the FP-54 type were unsuitable since, at the sensitivity required, short period fluctuations and a tendency to continuous drift are well nigh impossible to eliminate. Accordingly, a tube of lower input impedance and consequently greater mutual conductance was chosen.

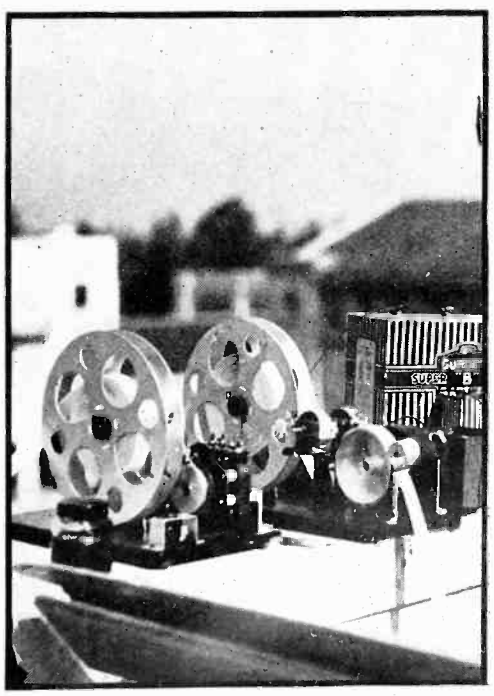
For the sake of stability a double tube bridge circuit was used and the design followed that of Wynn-Williams and a large number of other physicists who used this method to measure small currents prior to the advent of the electrometer tube. Since it was convenient not to have the supply batteries shielded a tube (triode) of low plate impedance was chosen. Both the 112-A and the 30 have been found to be suitable.

Figure 1 gives the circuit. The effects of "A" and "B" battery fluctuation were both automatically compensated. An elementary computation shows that a change in grid voltage (Δe) will give rise to a change in gal-

STRATOSPHERE STUDY



This Caltech explorer balloon travels 60,000 feet up with one pound of equipment, including a radio transmitter, an aneroid barometer, bimetallic thermometer, and humidometer. These instruments control clock-work contactors in the transmitter



The radio signals are picked up on the ground and actuate this tape recorder. The time intervals between signals are translated into pressure, temperature, and humidity readings vanometer current (Δi) such that

$$\Delta i = \frac{\mu \Delta e}{\left[1+R_o\left(\frac{1}{R_g}+\frac{1}{Z_g}\right)\right]\left[2X+G\left(1+\frac{X}{R}\right)\right]}$$

wherein X, Z_g are the dynamic plate and grid impedances respectively; R, R_g, G are the plate resistor, grid resistor, and galvanometer resistance, and R_o is the resistance of the specimen plus electrodes (as much as 1 megohm with micro-electrodes). For good sensitivity it is clear that $\frac{\mu}{X}$, Z_g, R_g should be as large as possible. By making R_g 10 megohms about the best compromise between sensitivity and shielding requirements was obtained. The troublesome grid current in commercial tubes had to be reduced to a low figure partly to prevent current passing through the specimen and partly because the d-c resistance of the specimen cannot readily be measured and hence the potential drop due to a grid current through it would be an unknown quantity. This current was reduced to a figure of about 10^{-12} ampere by properly biasing the input grid to equilibrium potential, the value of Z_g at that point being of the same order of magnitude as the chosen R_g, which was satisfactory. The tube filaments were of course operated at as low a current as was consistent with maintaining a high value for the mutual conductance. In line with what has been said about making the equipment as simple as possible, the grid bias controls were flush "screw-driver" controls in the top panel. Provision was made on the input switch so that the grid resistor could be shorted out at one position, as the circuit shows. The steady deflection of the galvanometer caused by cutting out the grid resistor is, of course, a measure of the grid current and the proper biasing point is quickly determined since the direction of the grid current changes sign in passing through this equilibrium point. The grid of the second tube was tied directly to the filament without any grid resistor; the stability of the set under these conditions was found to be somewhat superior than when a separate bias battery was used for this tube.

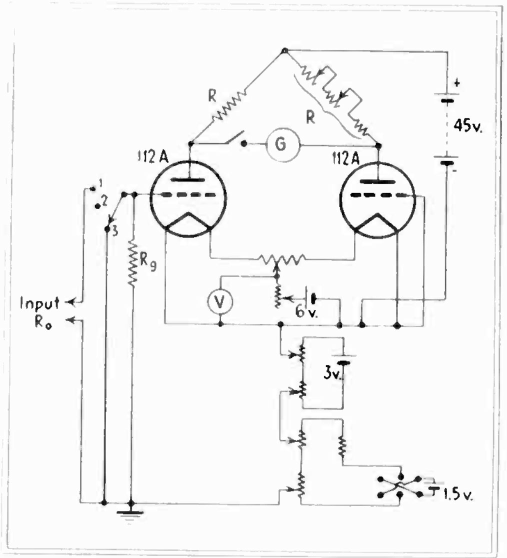
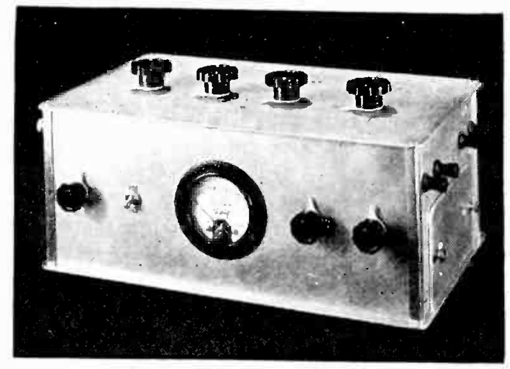


Fig. 1—Connection diagram of the microvoltmeter

A simple calibrating potentiometer was included in the set as shown, and this was also useful when one wanted to study variations of a few microvolts superimposed on a steady potential of several millivolts, since without the bucking potentiometer the galvanometer would be off scale.

Amber insulation was used for the grid lead to the first tube, the grid input terminal running through an amber bushing and the input switch being a commercial "anti-capacity" type rebuilt with amber insulation. Following the usual practice, tube bases were removed and the cavities filled with ceresin wax. The tubes themselves were packed in glass wool and protected with tube shields. All other equipment were standard parts on the market. A removable compartment on the side of the instrument contained the three 1.5 volt flashlight cells, making it unnecessary to dismantle the set for replacements. The power supply consisted simply of one 6 volt storage cell and one 45 volt "B" battery, external to the set and unshielded.

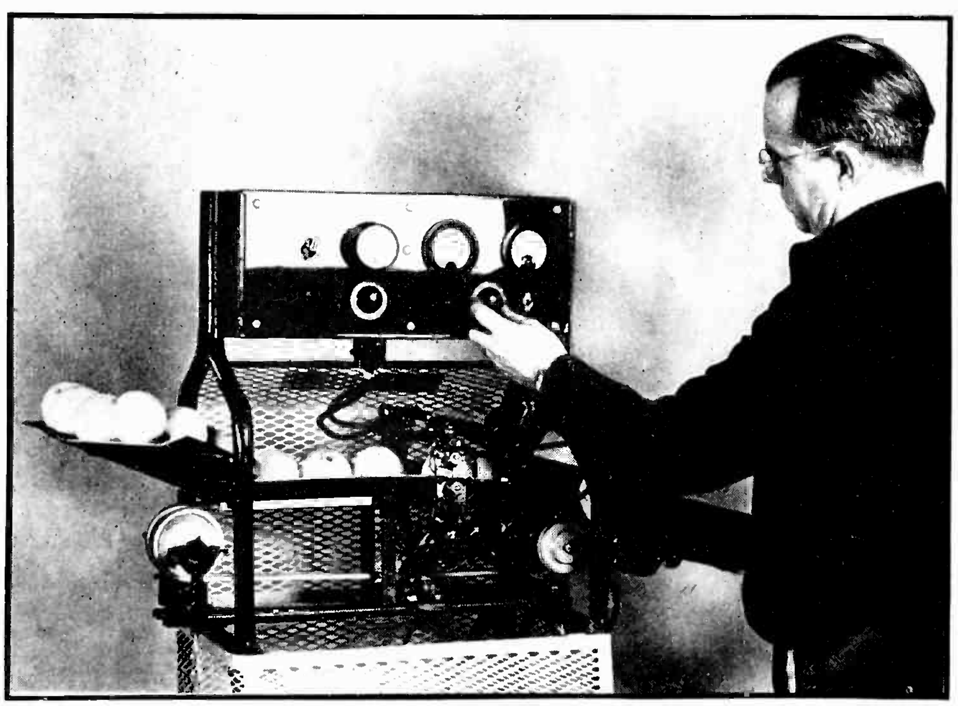


External appearance of the microvoltmeter

It is well known that the chief source of trouble with d-c amplifiers is, of course, instability of the zero, and this trouble becomes less as the tubes age. In order to bring the set to the desired stability artificial aging was employed, that is, a new instrument is subjected to about 350 hours of continuous operation with all adjustments made. This process was found to be highly effective; thereafter the set could be switched on at any time and stability attained within two minutes.

A dozen or more of these instruments have been constructed and all of them have shown very similar characteristics, namely with a galvanometer of 300 megohms sensitivity and 3 seconds period the voltage sensitivity has been of the order of 5 microvolts per mm with a steady drift rate of about 2-3 mm per hour and no observable short period fluctuations under normal operating conditions. This is with a flexible shielded cable of several feet to the input and no shielding whatever of the specimens under test. The overall dimensions of the instrument are approximately 15 x 9 x 6 inches.

ELECTRONIC FRUIT SORTER



This device measures the electrical resistance of individual citrus fruits to determine interior damage due to frost or decay, and automatically sorts out those which are below standard. Its capacity is about a carload a day

NEW BOOKS

Electrical Measurements

By HARVEY L. CURTIS. *McGraw-Hill Pub. Co., New York, N. Y. (302 pages, 66 illus. Price, $4.00.)*

A FEATURE OF this addition to the International Series in Physics is that Dr. Curtis's book limits itself to a discussion of those methods of measuring and determining fundamental electrical quantities which will give results of the highest precision. In the description of most of the methods is included a discussion of features that introduce errors in the final result of one part in a million, as well as the strong and weak points of the various systems of electrical determinations.

A feature of the book which appealed to the reviewer is that the logical development of each subject begins with an outline of the methods of measurement which are available so that before the details of any one system are entered into, the relative importance and suitability of all methods for a given purpose has already impressed itself on the reader. A discussion of the various electrical units, both absolute and legal, and the best results in their determination which have been arrived at by various national physical laboratories is given. By and large the electrical measurements discussed are limited to determinations of E, I, R, L, and C, but once these fundamental units have been determined others can be derived in terms of them.

This book, which can be used as both a reference and text, does not hesitate to use fairly involved mathematics, but mathematics is used to obtain a desired result and not to impress the reader. For those interested in precision measurements, some very practical suggestions are included, such as methods of turning porcelain cylinders on a lathe in the construction of inductance standards, for example. All in all, it is the sort of book that electrical laboratories will find essential if precision measurements are undertaken.—B. D.

Television Reception

BY MANFRED VON ARDENNE. *Translated by O. S. Puckle. D. Van Nostrand Co., Inc., New York, 1936. (121 pages, illustrated. $2.75).*

THIS SHORT BOOK is the first on cathode-ray television which can lay claim to the interest of engineers who already know something about the subject. The original edition appeared in Germany in 1935, and was written by one of Germany's foremost experimenters in electronics. The English translation, which was written in England, has included supplementary material which brings the book up to date, including all developments in use at the end of 1936. As the title implies, the book is concerned with the television receiver rather than with television in general, but much material on the general principles of television transmission is included.

Since television is a visual subject, it is gratifying to note that this book contains a great many very fine half-tone reproductions of actual television images, which show the effects of various disturbing factors, such as incorrect synchronizing, hum from power lines, over- and under-biasing of the cathode-ray control grid, noise, and the like. The original text was concerned with images of not more than 180 lines, which is of course far behind the times. However, the translator has included much material on English systems, using 240 and 405 lines, the latter of which is comparable with present American practice.

The book is not particularly well organized from the reader's point of view, and it assumes a certain amount of knowledge of television on the part of the reader. But it does concern itself with technical details of circuit operation, which no other book in English up to the present has done. The chapters include: The Technical Problem, Television Tubes and Their Operation, Power Supply Apparatus, Sweep Circuits, Amplitude Filters for Separation of Synchronizing Impulses, and Television Detectors. The final chapter gives structural details for a complete superheterodyne picture receiver, the construction of which, however, should be undertaken only by an expert. The translator uses British terms, of course, but these are readily translated into their American equivalents. The book, while not concerned with the details of American practice and while far from perfect editorially, is a distinct technical contribution to the published material on the visual radio art.—D.G.F.

Dielectric Phenomena in High Voltage Cables

BY D. M. ROBINSON. *Instruments Publishing Co., Pittsburgh. (173 pp., illustrated. $5.00).*

THIS BOOK, which is Vol. III of a series of monographs on electrical engineering, is concerned with the performance of cable dielectrics and the manner in which the performance may be affected by the construction and subsequent history of the cable.

The first chapter is devoted to the technique of testing and examining dielectric faults, several chapters are used to discuss the various types of faults which occur, and dielectric losses and cable design form the basis for two other chapters. The book is well illustrated with drawings and photographs showing the effects on the dielectric of various faults and each chapter contains a summary and a bibliography. Gas and oil filled cables as well as solid dielectric cables are discussed. The book is easy to read and should prove useful to those engaged in the manufacture or application of various types of cables.—B. D.

Push Pull

(*Continued from page 19*)

voltage. The expected output can be approximated for the push-pull tubes by predicting their combined effect directly from individual static plate characteristics, obviating the necessity of tedious constructions. Then, if greater accuracy is needed, the output and distortion can be predicted by the usual constructional operations performed on a point-by-point curve, such as Fig. 3.

This procedure is equally applicable to all types of audio push-pull circuits. A particular circuit was selected merely for the clarity in explanation obtained by using a concrete illustration. Although this method must necessarily involve certain approximations, this is certainly nothing new to the engineer, who daily must utilize intelligent approximation in order to get immediate results.

To test the merits of this method a push-pull 2A3 output stage was constructed using the same operating values employed in the above calculation. For a grid-to-grid excitation of 100 volts, maximum value, the measured output was 9.3 watts, a difference between calculated and measured values of 8%. In order to further substantiate this scheme of predicting push-pull power output calculations, calculations for a number of different conditions were made in the manner already described, after which measurements were made on an actual circuit for the conditions selected for graphical analysis. The results obtained indicate that the graphical method of analysis checks experimental observations quite well, the mean error of a number of observations being of the order of about 10%.

REFERENCE:—B. J. Thompson, Proc. I.R.E., vol. 21, p. 591, April 1933.

UNIVERSAL AMPLIFICATION CHARTS

By F. E. Terman

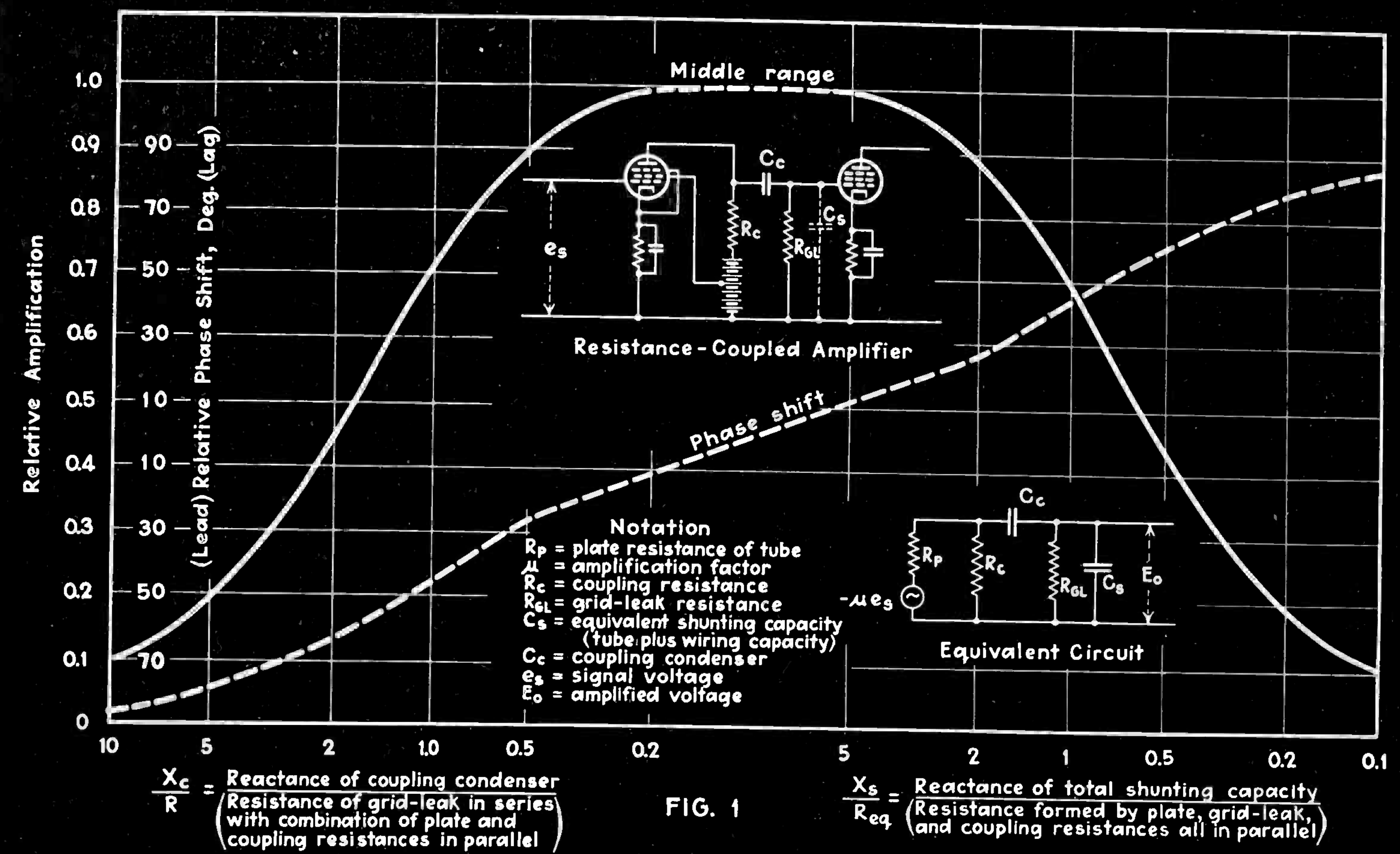


FIG. 1

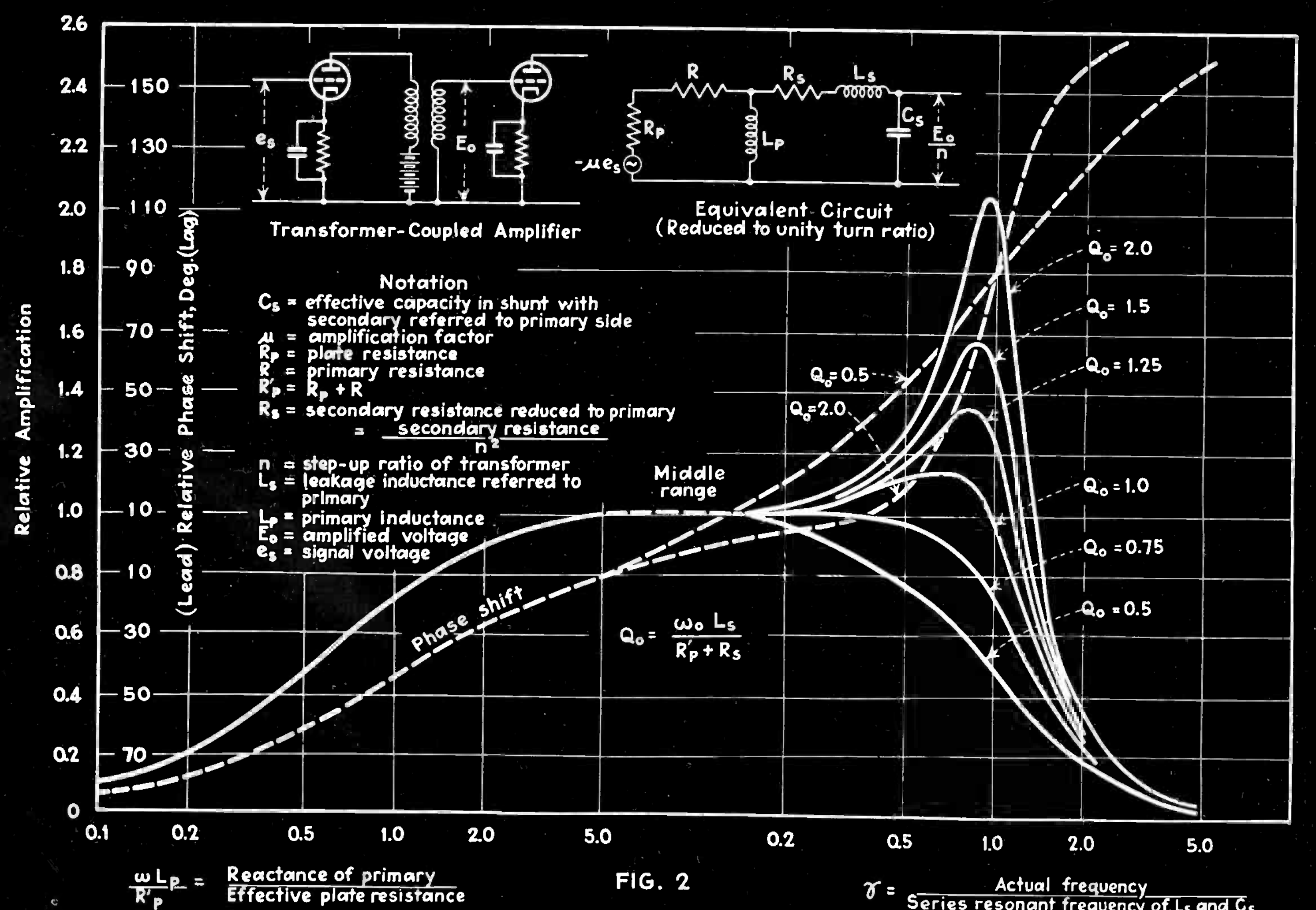


FIG. 2

Universal Amplification Charts

For determining the gain-frequency characteristics of conventional resistance- and transformer-coupled amplifiers in terms of their component parts, from the forthcoming second edition of Professor Terman's "Radio Engineering"

By FREDERICK E. TERMAN

Stanford University, California

THE curves in Figs. 1 and 2 on the reverse side of this reference sheet show the way in which the relative amplification of resistance and transformer-coupled amplifiers, respectively, vary with frequency. The basis of these universal curves and their use is described below.

Universal Curve for Resistance-coupled Amplifier

The actual and equivalent circuits of a typical resistance-coupled amplifier are shown in Fig. 1. In the middle range of frequencies the coupling condenser C_c has a reactance so low as to be essentially a short circuit while the shunting capacity C_s has such a high reactance as to be practically an open circuit. Under such conditions the midrange amplification is found to be

$$\text{Midrange amplification} = A = G_m R_{eq} \qquad (1)$$

At low frequencies the amplification falls off because the coupling condenser C_c can no longer be considered to be a short circuit. A manipulation of the voltage and current relations for this condition shows that

$$\text{Low-frequency amplification} = \frac{G_m R_{eq}}{\sqrt{1 + (X_c/R)^2}} \qquad (2)$$

Since the reactance X_c of the coupling condenser is inversely proportional to frequency, the relative falling off at low frequencies can hence be plotted in terms of the ratio X_c/R to give the low frequency part of the universal amplification curve in Fig. 1.

At high frequencies the condenser C_c is effectively a short circuit but the shunting capacity C_s can no longer be neglected. A manipulation of the voltage and current relations for this case leads to the result

$$\text{High frequency amplification} = \frac{G_m R_{eq}}{\sqrt{1 + (R_{eq}/X_s)^2}} \qquad (3)$$

The high frequency portion of the universal amplification curve of Fig. 1 is accordingly simply a plot of the factor $1/\sqrt{1 + (R_{eq}/X_s)^2}$, with the frequency being introduced through the fact that R_{eq}/X_s is directly proportional to frequency.

Universal Amplification Curve for Transformer-coupled Amplifiers

The actual and approximate equivalent circuits of the transformer-coupled amplifier are shown in Fig. 2. In the middle range of frequencies the primary impedance is substantially infinite while there is negligible resonance between the leakage inductance and secondary capacity so that the amplification becomes simply μn where μ is the amplification factor of the tube and n is the step-up ratio of the transformer. At low frequencies the amplification falls off however as a result of the low primary reactance of the transformer at low frequencies and this leads to the approximate result:

$$\text{Low-frequency amplification} = \frac{\mu n}{\sqrt{1 + (\omega L_p/R'_p)^2}} \qquad (4)$$

The low frequency part of the universal amplification curve of Fig. 2 is therefore simply a plot of the factor

$$1/\sqrt{1 + (\omega L_p/R'_p)^2}.$$

At high frequencies the primary inductance has an extremely high reactance but the amplification is affected by series resonance between the leakage inductance and the secondary capacity. A manipulation of the voltage and current relations in this circuit shows

$$\text{Amplification at high frequencies} = \frac{\mu n}{(\gamma/Q_o^2 + (\gamma^2 - 1)^2)^{\frac{1}{2}}} \qquad (5)$$

The high-frequency portion of the universal amplification curve of Fig. 2 is accordingly a plot of the factor that multiplies μn in Eq. (5).

Examples

The use of universal amplification curves of Figs. 1 and 2 can be understood by the following two examples:

Example one. It is desired to determine the amplification characteristic of a pentode resistance-coupled amplifier in which the coupling, grid-leak and plate resistances are respectively ½, ½, and 5 megohms, while the coupling condenser capacity is 0.01 μf. The shunting capacity is estimated to be 30 $\mu\mu$f, while the mutual conductance of the tube is 400 micromhos. For these circuit constants R_{eq} = 238,000 ohms, and R = 955,000 ohms. By Eq. (1) the midrange amplification is $238{,}000 \times 400 \times 10^{-6} = 95.2$. From Fig. 1 the low-frequency amplification falls to 70.7% of this (3 db) when $X_c = R_{eq}$, which is at $f = 1/2\pi C_c R = 16.7$ cycles. From Fig. 1 the gains at frequencies that are one-half, one-fifth, and one-tenth as great, i.e., at 8.3, 3.3, and 1.67 cycles, are down to 45%, 20%, and 10% of the midrange value. At high frequencies the gain is down to 70.7% of the midrange value (down 3 db) when $X_s = R_{eq}$, which is when f = 22,300 cycles. At frequencies twice, five times, and ten times as great, namely 44,600, 111,500, and 223,000 cycles, the gain is down to 45%, 20%, and 10% of the midrange value, respectively.

Example two. It is desired to determine the amplification characteristic of an interstage audio transformer in which

Primary inductance	= 20 henrys
Turn ratio	= 3
Leakage inductance referred to primary	= 0.18 henrys
Series resonant frequency of secondary	= 15,000 cycles
Primary resistance	= 800 ohms
Secondary resistance	= 9,000 ohms
Amplification factor of the tube	= 14
Plate resistance of the tube	= 9,000 ohms

With these constants one has:

$$R_p' = 9{,}000 + 800 = 9{,}800 \text{ ohms}$$

$$Q_o = \frac{2\pi \times 15{,}000 \times 0.18}{9{,}800 + \frac{9{,}000}{9}} = 1.57$$

$$\text{Midfrequency gain} = \mu n = 42$$

At low frequencies reference to Fig. 2 shows the response has fallen to 70.7% (3 db) when $\omega L_p = R'_p$, which is at 78 cycles. At half, one-fifth, and one-tenth this frequency or 39, 15.6, and 7.8 cycles, the response will have fallen to 45%, 20%, and 10% respectively of the midrange value. At high frequencies reference to Fig. 2 shows the response at the series resonant frequency of 15,000 cycles is 1.57 times the midrange value, reaches a peak of 1.63 times at about 12,000 cycles, while at one-half, and twice the resonant frequency, or 7,500 and 30,000 cycles, is 1.23 and 0.35 times the midrange value.

International Broadcast and Sound Engineer — 1937 Yearbook

A. L. J. BERNAERT, Editor. *International News Co., New York. (225 pp., illustrated. $1.50).* . . .

IN PRESENTING this new volume the publishers state, "Recognizing the difficulty of keeping abreast of developments in the field of broadcast and sound engineering and being aware of the amount of useful information scattered throughout numerous publications, we have decided to publish this yearbook. Its purpose is to provide a digest of contemporary progress accompanied by authoritative articles of great practical value, and followed by some independent technical reviews of typical equipment and apparatus."

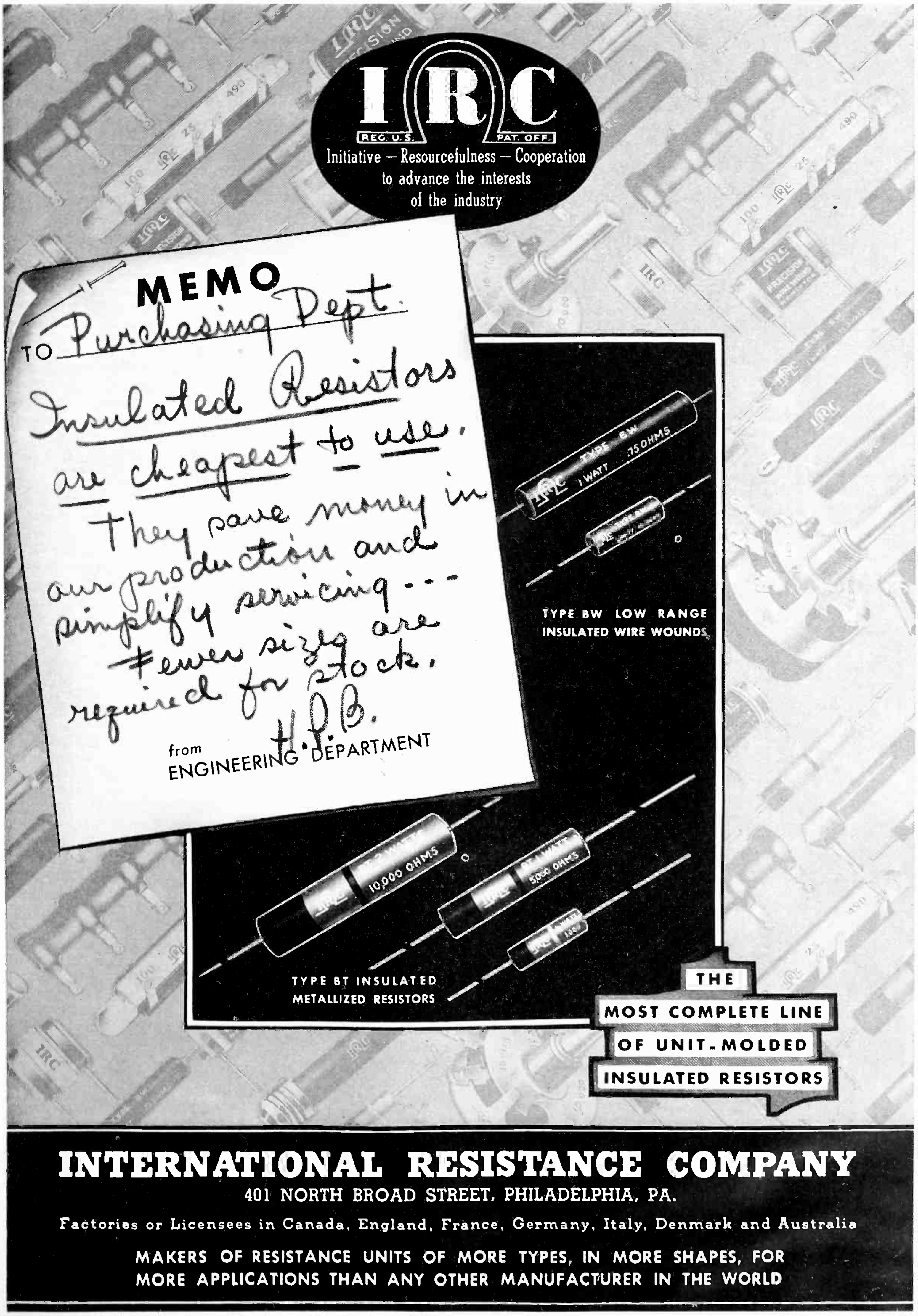
Forty-seven pages of the yearbook are devoted to a summary of important developments in radio engineering as reported in technical journals throughout the world. This is particularly useful since the outstanding papers in several foreign languages have been reviewed. In addition to this review are given twenty-three articles, summaries, or translations of papers covering specialized branches of broadcast and sound engineering. To one whose time and knowledge of foreign languages is limited, this volume should prove useful and interesting.—B.D.

Mercury Arcs

By F. J. TEAGO and J. F. GILL. *Methuen & Co., London. Distributed by the Chemical Publishing Co., New York. (Price $1.25, 104 pages.)*

THIS SMALL VOLUME is one of a series of monographs giving essential information on physical subjects in condensed, compact form. This latest Methuen monograph has formed the basis of a course of design lectures on the mercury arc given in the electrical engineering department of the University of Liverpool. It is not intended to replace the larger and more detailed textbooks on the subject.

For pedagogical purposes, the arrangement does not seem to follow the most orderly and systematic treatment of the subject. For example, the last chapter of the book, on the mathematics of mercury arcs, follows chapters on rectification, inversion and regeneration, and grid control of voltage and current all of which are equally mathematical. A familiarity with electrical engineering principles, and the mercury arc in particular, is assumed, so that this small volume does not seem to be well suited as an introductory volume. But for the advanced student who desires a condensed, mathematical treatment, or for the engineer involved in the design or application of mercury arcs, this handy book provides a very considerable amount of information in a small space. —B.D.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They save money in
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MORE APPLICATIONS THAN ANY OTHER MANUFACTURER IN THE WORLD

THE ELECTRON ART

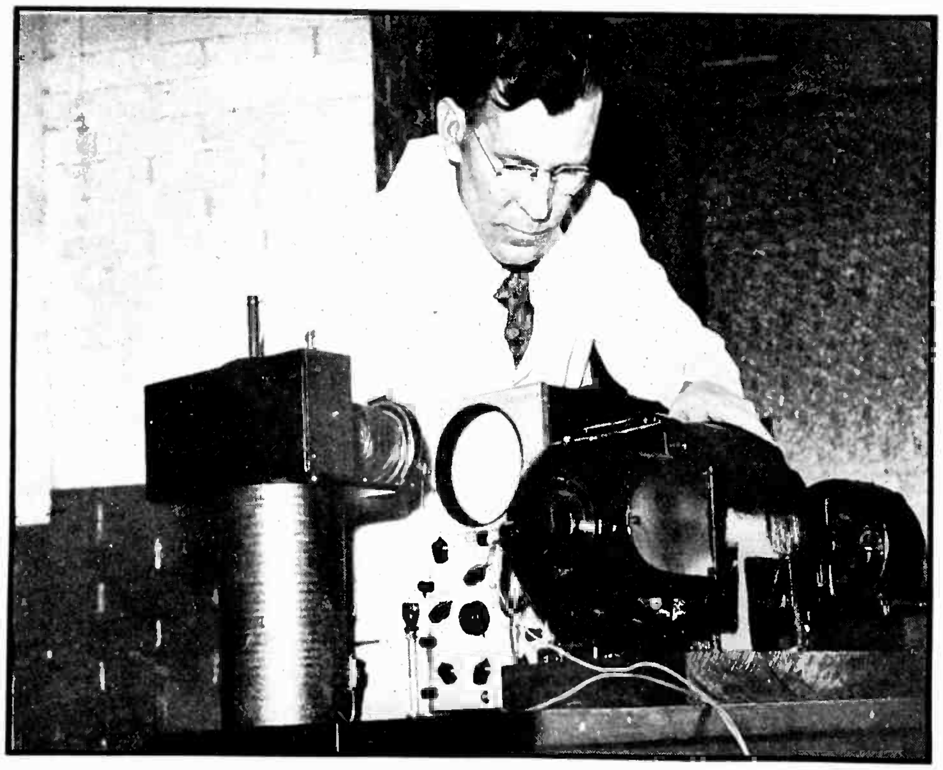
EACH month the world's technical literature is scanned to see what physicists and engineers are doing with tubes, for presentation in tabloid form to Electronics' readers.

Re-Ignition of an Arc

FROM THE APRIL ISSUE of the *Journal of Applied Physics* we obtain the following author's abstract from an article "The Application of Paschen's Law to the Re-ignition of an Arc," by J. D. Corbine and R. Burton Power.

An a.c. arc, in order to restrike, after passing through zero current, requires a potential considerably higher than the normal furnished potential. This re-ignition potential is investigated for short gaps in nitrogen, using pure graphite electrodes with spacings up to two millimeters and pressures up to 500 centimeters of mercury. The re-ignition potential is found to have two characteristics. One of these characteristics is the following for the arc in which the cathode spot is maintained by field emission and the other is followed for the thermionic arc. Relations are obtained between this reignition potential and both the gas pressure and the gap spacing with the arc current as parameter. These relations may then be combined into a single relation between re-igition potentials and the product of the pressure and spacing. This gives a function which is of the same form as the Paschen law for the initial sparking potential of a gap. The constants of this function are dependent on the arc current, the gas in the space, and the constants of the circuit. That the constants of the re-ignition function are not the same as those for the sparking potential law is to be expected from the very dissimilar conditions applying in the space. Extreme purity of electrode material and of gas, as well as extreme care in obtaining the experimental results, are essential.

CATHODE RAY ARC-BACK RECORDER



The "Memnoscope," which stores charge impulses from an ignitron for 1/30 of a second. If an arc-back occurs, the disturbance is thereby retained long enough to be photographed. *(See page 30, this issue).*

Design Data on Thyratron Characteristics

A PAPER ENTITLED "Dependence of Thyratron Characteristics on Electrode Spacing and Design" by J. A. B. Fairbrother appearing in the April issue of the *Wireless Engineer* gives the results of some measurements made on an experimental thyratron in which the distance between the cathode and the anode could be varied at will while making measurements.

In this tube, the grid is a nickel cylinder 1¾ in. in diameter and 2½ in. long. A carbon anode, to which electrical connection is made by means of a spiral nickel spring, is mounted on telescoping glass tubing which permits the distance between the cathode and the anode to be varied at will. The cathode is a nickel strip coated with barium and strontium oxides suitably activated during exhaust. During the experiments the mercury vapor was maintained at a pressure corresponding to a room temperature of 20 deg. C. Electrical measurements were made on this tube for plate voltages up to 500 volts and for grid or control voltages up to –60 volts for cathode-anode spacing of from approximately 1 mm. to almost 3½ cm.

From the experimental data presented in this article it is shown that the equation connecting the electrode voltages with the cathode-anode biasing can be represented by the equation

$$E_p - E_s = kx^p$$

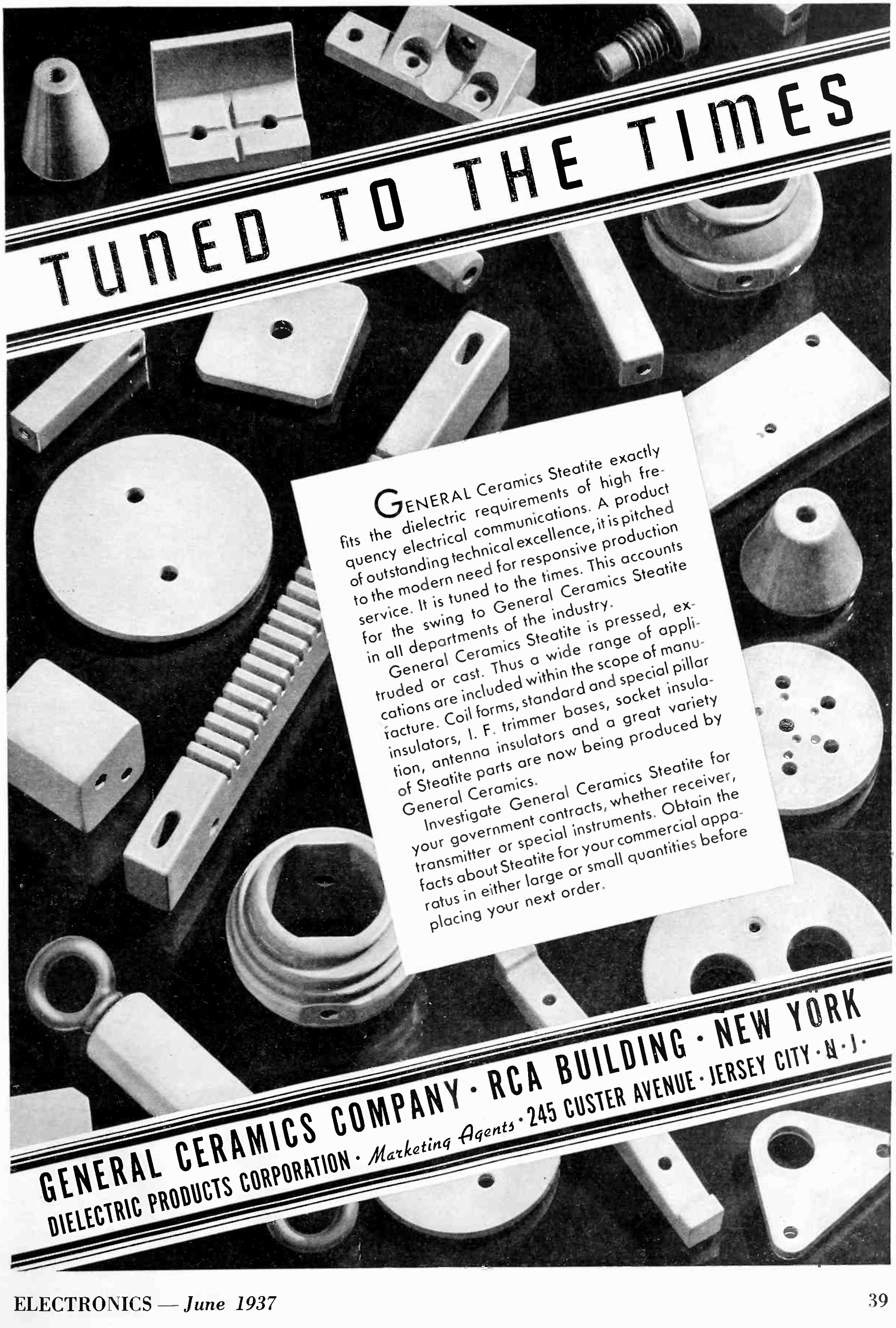
where the E_p is the anode voltage, E_s is the plate or anode voltage required to initiate the discharge, k is a factor of proportionality, and x is the cathode-anode basing. For the values of voltage and basings covered in the article, it is shown that for low values of grid voltage, k is equal to the grid voltage, e_g and at high values of the grid voltage, $k = 2e_g$. For low values of grid voltage, the value of p approaches 4 and at high values it is approximately 8/3. Hence, for low grid voltages (less than about 10 volts negative) the equation of the tube becomes

$$E_p - E_s = e_g x^4$$

whereas for grid voltages greater than 10 volts negative the equation becomes

$$E_p - E_s = 2e_g x^{8/3}.$$

The authors point out that a variation of anode-cathode distance of one per cent, for a given plate voltage, can cause a variation of from 4 per cent to 2.7 per cent in the critical grid voltage to produce ionization. For this reason, great care must be taken in assembly if it is desired to manufacture a large quantity of tubes with identical characteristics. To insure constancy of characteristics throughout the life of a thyratron, it is necessary so to design, position and operate the cathode that the arc current drawn from it is distributed uniformly over its surface, thus avoiding the production of inactive regions.


TUNED TO THE TIMES
GENERAL Ceramics Steatite exactly fits the dielectric requirements of high frequency electrical communications. A product of outstanding technical excellence, it is pitched to the modern need for responsive production service. It is tuned to the times. This accounts for the swing to General Ceramics Steatite in all departments of the industry.
General Ceramics Steatite is pressed, extruded or cast. Thus a wide range of applications are included within the scope of manufacture. Coil forms, standard and special pillar insulators, I. F. trimmer bases, socket insulation, antenna insulators and a great variety of Steatite parts are now being produced by General Ceramics.
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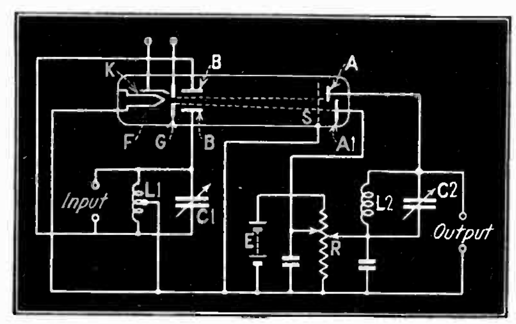
Beam Controlled Amplifier

A SYSTEM OF AMPLIFICATION which depends for its operation on the deflection of the beam in a cathode ray tube rather than on the intensity control of an electron stream in the usual type of equivalent triodes, is described in the article "The Deflection Amplifier" by E. T. Rudkin in the March 26 issue of the *Wireless World*. A gas focused multi-element cathode ray tube is used in an arrangement wherein the voltages to be amplified are used to control the position of an electron beam directed against an collector plate or anode. The electron beam flowing from the cathode to the anode produces a maximum anode current when all of the beam impinges upon the entire anode surface. The position of the beam is controlled by the voltages to be amplified so that the spot may move partially or completely off of the anode thereby providing a current in the anode circuit which varies from zero to its maximum value. These anode current variations flowing through the anode impedance circuit result in a voltage across the anode impedance which is an amplified replica of the input or control voltage.

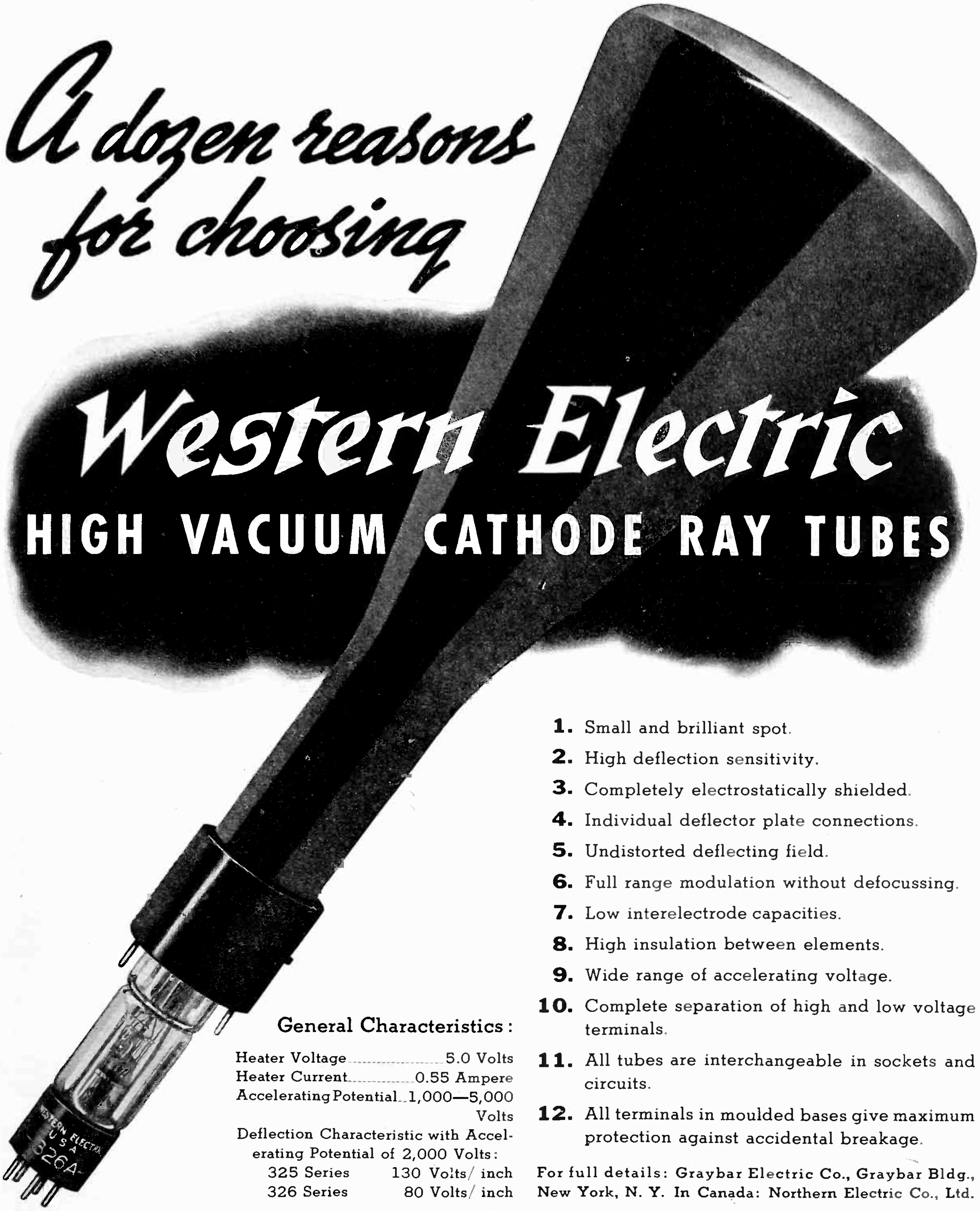
A simple type of deflection tube is shown in Fig. 1 and consists of a cathode K, a cathode shield F, the gun aperture, G, deflecting plates B-B, a screen grid *S*, a collector plate or anode A and a secondary or residual collector plate A_1. The deflector plates B-B are intended to deflect the beam at right angles to its direction of propagation and as indicated below (a radio



frequency amplifier) each one of these plates is connected to the sides of a center tap input circuit. A tuned output circuit, L_2C_2 is connected to the collector plate A which has a positive potential applied to it, the voltage being adjusted by means of the voltage divider, R. The residual or secondary collector plate, A_1, is likewise maintained at a positive potential whose magnitude is determined by the tap on the voltage divider R.

In operation, current flowing through the tuned circuit L_1C_1, produces voltage variations on the plates B-B which deflect the beam in such a manner as to split the total beam current between the anode or collector plate A and the residual collector plate A_1. The gun aperture, at G, is so designed as to produce a rectangular spot of the beam on the anode surfaces. If this rectangular beam spot impinges on anode A at a frequency to which L_2C_2

A dozen reasons for choosing



Western Electric

HIGH VACUUM CATHODE RAY TUBES

1. Small and brilliant spot.
2. High deflection sensitivity.
3. Completely electrostatically shielded.
4. Individual deflector plate connections.
5. Undistorted deflecting field.
6. Full range modulation without defocussing.
7. Low interelectrode capacities.
8. High insulation between elements.
9. Wide range of accelerating voltage.
10. Complete separation of high and low voltage terminals.
11. All tubes are interchangeable in sockets and circuits.
12. All terminals in moulded bases give maximum protection against accidental breakage.

For full details: Graybar Electric Co., Graybar Bldg., New York, N. Y. In Canada: Northern Electric Co., Ltd.

General Characteristics:

Heater Voltage .... 5.0 Volts
Heater Current .... 0.55 Ampere
Accelerating Potential .. 1,000—5,000 Volts
Deflection Characteristic with Accelerating Potential of 2,000 Volts:
325 Series 130 Volts/inch
326 Series 80 Volts/inch

	325A	326A	325B	326B	325C	326C
Max. Length (in.)	16½	22	16½	22	16½	22
Max. Screen Size (in.)	4⅝	7⅛	4⅝	7⅛	4⅝	7⅛
Fluorescent Characteristics	Green. Medium Persistence.	Green. Medium Persistence.	Blue-Green. Long Persistence.	Blue-Green. Long Persistence.	Blue. Highly Actinic.	Blue. Highly Actinic.
Application	Visual Observation. Photography with green-sensitive film.		Observation and Photography of non-recurrent and low frequency phenomena.		Photography with blue-sensitive film.	

is tuned, a voltage will be built up across the anode circuit. Deflection of the beam by the voltage developed in L_1C_1 will be set up so as to remove a portion of the beam by some anode A thereby varying the voltage across the plate impedance composed of L_2C_2, which feeds the output circuit.

By providing a rectangular spot of the beam which alternates from plate A to plate A_1 it is possible to produce a voltage across the output circuit which is an amplified, linear function of the voltage in the input circuit and applied to plate B-B.

The article discusses several other types of circuits including a push-pull amplifier and an oscillator. Limitations in high frequency application and the use of a high vacuum other than a gaseous discharge cathode ray tube are discussed. Regeneration as well as deflection amplification may also be used.

• • •

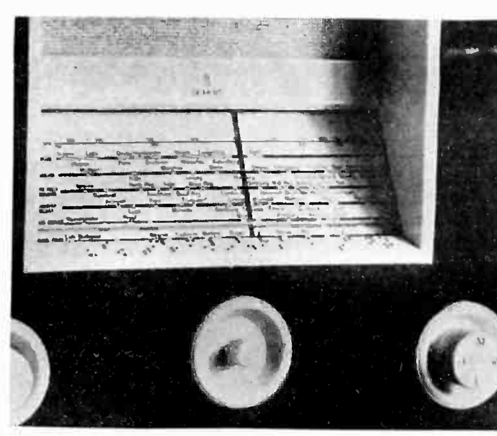
German Superhets

THE MARCH ISSUE of *Engineering Progress* reports that modern German superheterodyne receivers using from three to five tubes are available. The selectivity and saving compensations are reported to be particularly good in the three and four tube sets. All of the receivers are fitted with tuning indicators and three electrode tubes are used almost exclusively in the output stage, these tubes being used singly or two in a reflex connection.

One superheterodyne is built to cover the wave length range from 200 to 2,000 meters. Instead of the usual rotary condensers, the set uses individual fixed condensers connected in accordance with a definite system. These condensers are in the form of silver coatings burned in on a ceramic insulation body made of a material of high dielectric constant and low loss factor. The condensers are cut in the circuit by a steel contact spring and a dependable "ball motion". Tuning operation is effected with the aid of a dial very similar to those of automatic telephones. Each station name is designated by a two-figure numeral.

• • •

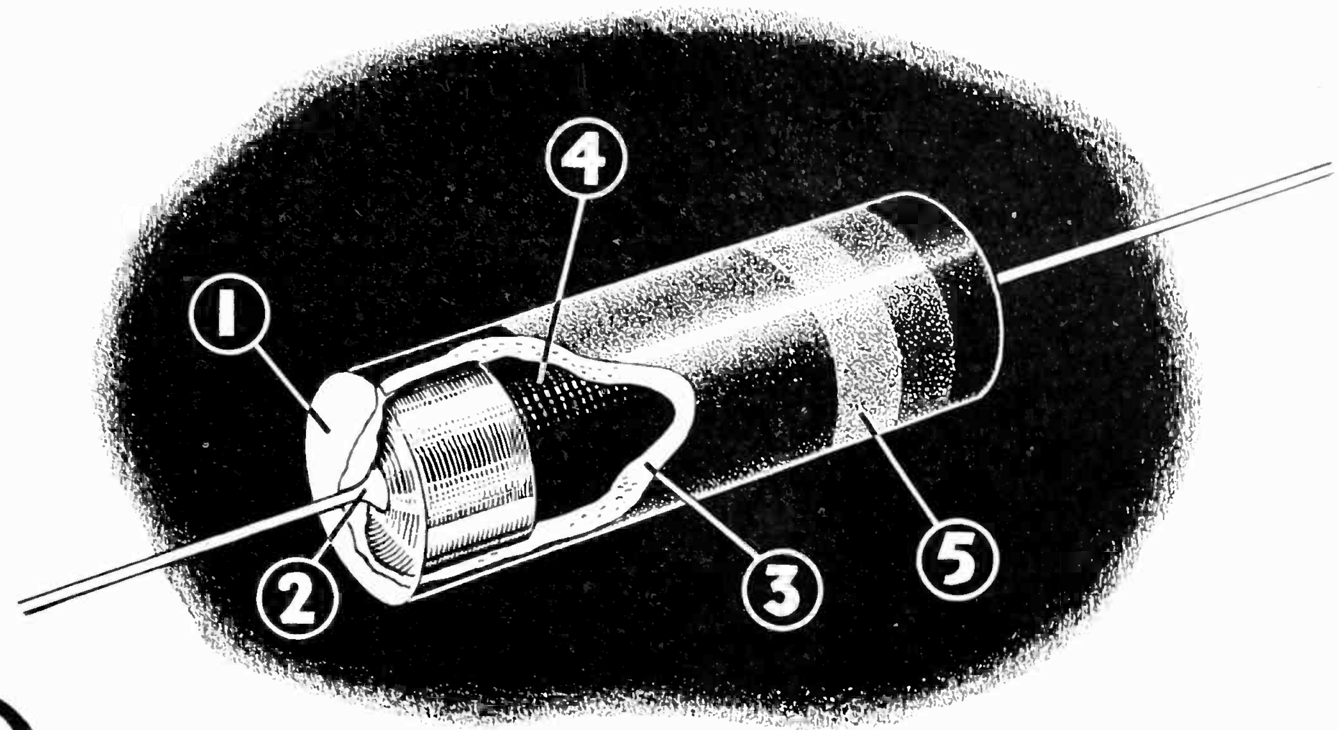
TUNING AID FOR BLIND



In this German radio receiver the tuning scale is provided with raised dots to enable the blind to tune in any one of 22 different stations

Take a look inside

ERIE *Ceramic-Sealed* RESISTORS



4 TIMES ACTUAL SIZE

Quality IS BUILT INTO EVERY DETAIL

(1) 100% sealed with moisture-proof, ceramic material that bonds to the ceramic shell, terminal wire and metal cap.

(2) Terminal caps are applied by patented process that makes a firm, lasting contact with the carbon resistance element. Impossible to loosen tinned-copper terminal wires by longitudinal pull or side thrust.

(3) Pre-formed uniform ceramic shell that will withstand 3,000 volts A. C. without insulation breakdown assures positive, uniform insulation. Erie Ceramic-Sealed Resistors may be located anywhere in the set chassis without danger of shorts or grounds.

(4) Years of research and testing have produced a combination of raw materials that imparts all-round balanced performance to the solid moulded carbon resistance element. Erie Ceramic-Sealed Resistors more nearly retain their actual rated values under all kinds of operating conditions.

(5) Because the insulating shell is pure white, resistance and tolerance color bands retain their true hue when applied; are easy to read under all types of artificial illumination. With Erie Ceramic-Sealed Resistors there's no guesswork in the assembly line when selecting proper resistance values.

CARBON RESISTORS AND SUPPRESSORS

ERIE RESISTOR CORPORATION

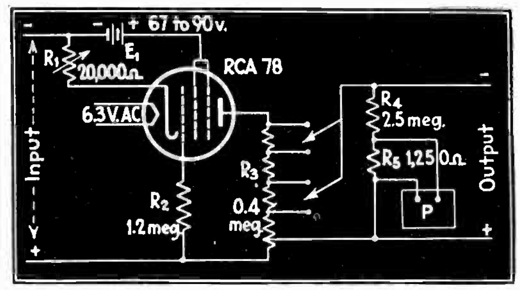
AUTOMATIC INJECTION MOLDING

TORONTO **ERIE, PENNSYLVANIA** LONDON

Voltage Stabilizer

UNDER THE TITLE "A Voltage Stabilizer Circuit," J. A. Ashworth and J. T. Mouzon describe a voltage stabilizer circuit of the bridge type wherein an essentially constant current is maintained. This article appears in the April issue of the *Review of Scientific Instruments*. The particular feature of the circuit is the elimination of transients in the output voltage due to changes in emission of the cathode of the stabilizer tube, which in this case is a type 78.

The stabilizer unit and associated apparatus for varying and measuring the output voltage is shown in the attached schematic wiring diagram.



The control grid of an RCA 78 pentode works at a positive potential. The screen and suppressor grid, connected together, serve as the control element which is biased by the voltage drop in R_1. Acting in opposition to the battery voltage E_1. The drain on the battery is less than one milliampere so that the useful life of the battery is practically its shelf light. Transients in the output circuit, due to changes in the temperature of the cathode, may be balanced out since the control grid draws current. The action of the circuit is described by the authors as follows: "The current drawn by the control grid flowing through R_1 provides part of the bias on the screen suppressor combination. This current is determined principally by R_2. The plate current may be made to be independent of small variation in emission if the change in the control grid current and the screen suppressor current alter the screen suppressor bias by the proper amount."

The authors further state that RCA 6B6 and 57 type tubes might be used instead of the type 78 tubes with equally satisfactory operation. The battery, E_1, may be eliminated by using the relatively stable voltage obtainable across a neon glow tube.

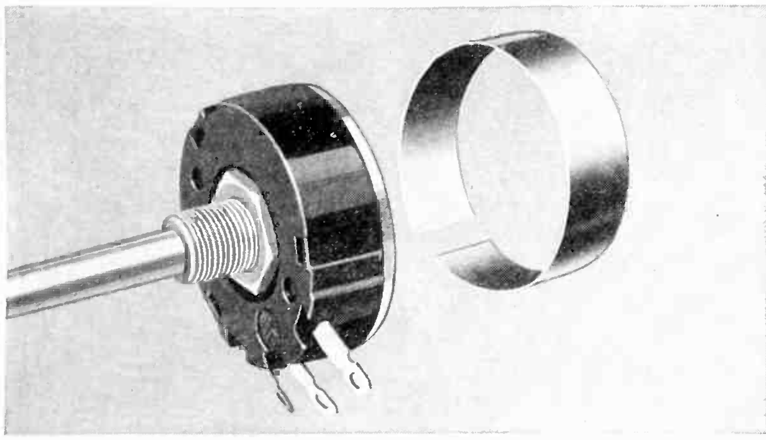
The stabilizing unit is balanced by adjusting the resistance, R_1, so that a change in the line voltage does not affect the voltage in the output circuit. It is pointed out that it is necessary to use the resistors of ample power ratings for all parts of the circuit, especially in the case of the resistor R_2. The authors use twelve 100,000 ohm resistors having a rating of 10 watts each in series for R_2. The current through R_2 depends upon the power supply voltage.

The LONGEST *path is the* SHORTEST

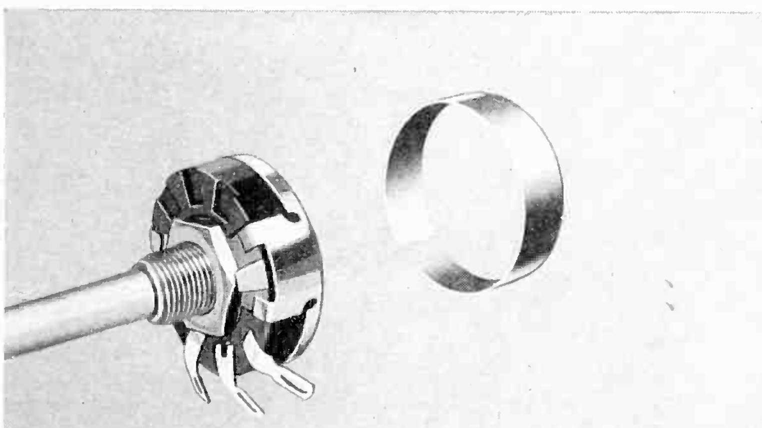
in

Centralab

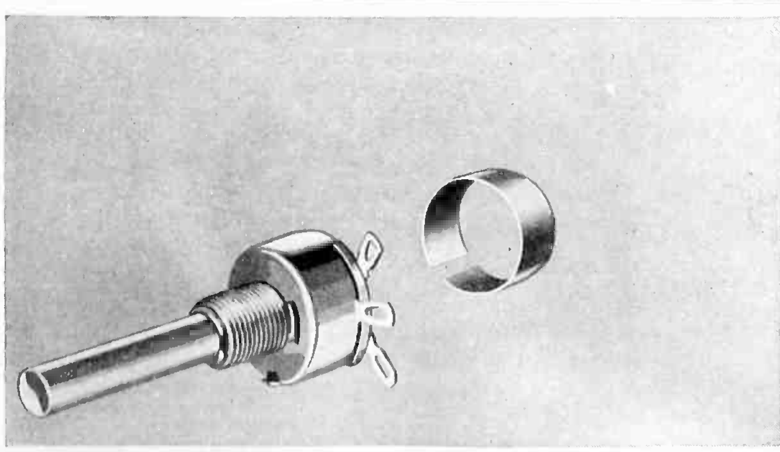
Variable Resistors



STANDARD RADIOHM



MIDGET RADIOHM



New! **SUBMIDGET CONTROL**

Yes . . . the shortest path to good control is a Centralab Variable Resistor for the "wall type" resistor illustrated with each control hugs the inner circumference of the case. This resistor has these distinct advantages:

1. **Maximum resistor length for case diameter**
2. **Close uniformity between resistors**
3. **Accurate tapers**
4. **Uniform current distribution**
5. **Lower specific resistance and attendant low noise level**
6. **Better power dissipation**
7. **Longer life**

Complete specification sheets are available on each of these controls. A postcard will bring this descriptive literature—just mention this ad.

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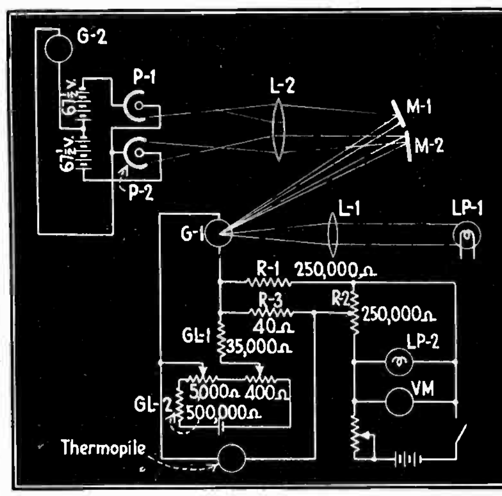
Amplifier for Galvonometer Deflections

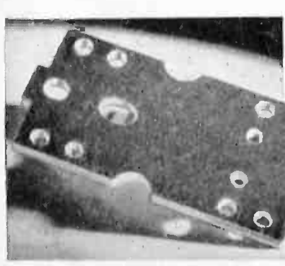
A METHOD BY WHICH two photoelectric cells may be used as an amplifier for galvonometer deflections is described by A. H. Taylor, in the April 1937 issue of the *Review of Scientific Instruments* under the title "The Amplification of Galvonometer Deflections." The primary galvonometer, suspended so as to be free from vibration, and its associated circuit is shown at the lower portion of the schematic wiring diagram. By means of the lens L-1, light from the lamp LP-1 is brought to a focus at a point about 8 in. in front of the galvonometer mirror and is reflected by the mirror M1 and M2. The lens L2 focuses the image a short distance in front of the two phototubes P 1 and P 2. The light is spread over a large part of the cathode area of these phototubes.



The entire circuit is so designed that when the two phototube currents are equal, no current flows through the second galvonometer. If the first galvonometer, G 1, deflects a small amount, the amount of light on one phototube increases and decreases on the other phototube, thereby causing a current to flow through the secondary galvanometer circuit. The zero drift of the first galvanometer can be restored by electrical means using a high resistance parallel circuit consisting of two voltage dividers, two high resistance grid leads, GL 1 and GL 2 and a single dry cell source of power. An auxiliary circuit consisting of a battery, lens LP 2, voltmeter, rheostat, and a high resistance, R 2, can be used to calibrate the amplifier.

Light reflected from the mirror of the secondary galvonometer, G 2, is focused on a scale at the opposite end of the laboratory, at a distance of about 18 ft. The scale divisions are about 45 mm. apart. Under these conditions, the authors report that the deflection of one division on a scale is obtained for a current of approximately 1.5×10^{-10} ampere flowing through the primary galvanometer circuit.

SOMEONE "PULLED A BOX"



It's a fire! A signal—an eye winks—a relayed signal—answering men spring out like jacks-in-boxes—coat-tails flying, before a gong dies—sirens scare a path through traffic—hose unbends—swells—there's water! . . . And only a moment ago, pale fingers "pulled a box" . . . The efficiency of water for fires depends upon the speed with which it can be rushed into action. Such speed requires perfect performance from a chain of electrical apparatus. SYNTHANE laminated bakelite contributes to the dependability of emergency fire-fighting equipment. SYNTHANE is used in fire-alarm telegraph systems, automatic controls for booster pumps and on motors, primarily because of its low moisture absorption, high dielectric strength and machineability. SYNTHANE laminated bakelite is a uniformly dense, solid material possessing a combination of desirable physical and electrical characteristics. It is tough, strong and light in weight; one of the most effective dielectric materials; chemically inert and corrosion resistant and easy to machine.

The uses for SYNTHANE are legion. Just as SYNTHANE is a material aid to fire-fighting, so its use may make a *material* difference in the reliability of your product. Write for "Synthane laminated bakelite for Mechanical Applications". (Please note on your request an indication of your requirements.) . . . SYNTHANE gives you MATERIAL SATISFACTION.

SYNTHANE CORPORATION, North River Road, OAKS, PA.

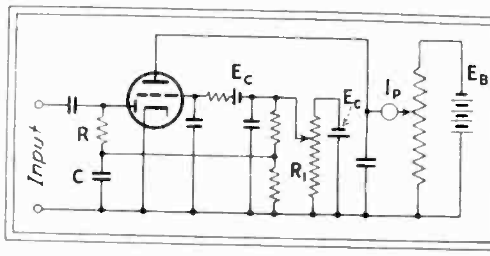
SYNTHANE

LAMINATED BAKELITE

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

Vacuum Tube Voltmeter Capable of Standing Heavy Overloads

When measurements are made in resonant circuits, the voltage and current under measurement may vary by several orders of magnitude quite rapidly, and in so doing, tend to endanger the measuring instruments in the circuit. An instrument which is not subject to these deleterious effects is described by W. Kauter, of the Telefunken Laboratory, Berlin, in *El. Nachr. Tech.* Vol. 14, pp. 45-48, 1937. In this arrangement a diode-triode tube in the same envelope is used, the alternating voltage being applied to the diode with the triode being used as the null setting and measuring circuit. The schematic wiring diagram is as indicated.



With an alternating voltage applied to the diode, linear rectification takes place; the varying component of the current flowing through RC produces a steady (d-c) voltage component which affects the grid bias of the triode in such a way that the negative bias is increased as the input voltage increases. The operating plate is adjusted by means of the voltage divider across the plate supply, and the plate current is measured by a suitable milliammeter having a full scale range of about 5 ma. The current flowing in the absence of an applied voltage is adjusted by means of the battery and resistor, R_1. Because of the linear characteristics of the diode circuit, a wide range of voltages can be measured. With a given set of adjustments, a useful range of 0.1 to 6 volts, (or from 6 volts to 60 volts with other adjustments) has been obtained. Automatic protection is afforded since the plate current decreases as the input voltage increases.

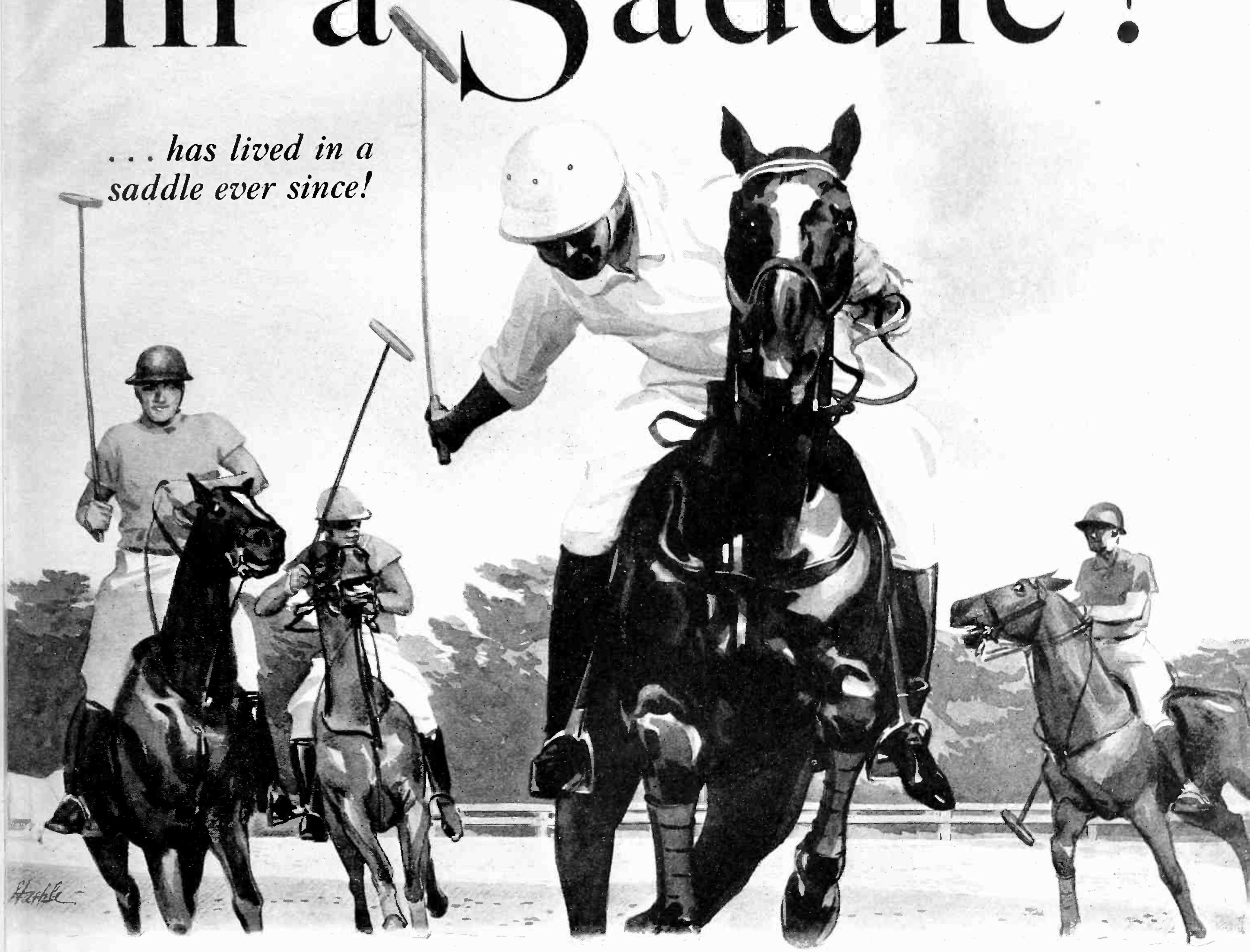
Phototube Detects Stamped Mail

The Postoffice Research Station, Dollis Hill, England, has developed photoelectric equipment for examining letters, indicating the presence of letters in correct position for cancellation, and discriminating between stamps of different colors. By means of a revolving shutter reflected light from two regions of the envelope is caused to fall alternately on the cell; if the stamp is in the proper place an a.c. having the frequency of the shutter is generated. The current is amplified and used to operate mechanical devices for separating the letters with stamps in the correct position from letters without stamps in the corner.

HE WAS BORN

in a Saddle!

. . . has lived in a saddle ever since!



BORN into a polo family. Years of "living with the game" . . . through childhood, through boyhood. Ceaseless coaching, practice, hard play.

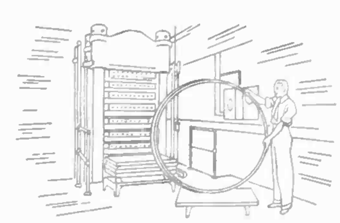
Now . . . a ten-goaler . . . he thunders down the turf in international play. A superb product of specialized training and experience.

Forty-two years ago, the Mica Insulator Company originated MICANITE electrical insulation. We, too, have been "living with the game" ever since. A lifetime of *specialized* effort . . . devoted to one job . . . the job of developing and making electrical insulations which assure the utmost in efficient, trustworthy service.

Let us make available to you the definite advantages of this specialized experience and our unusual research facilities.

200 Varick St., New York; 542 S. Dearborn St., Chicago; 1276 W. 3d St., Cleveland. Birmingham, Boston, Cincinnati, Los Angeles, San Francisco, Seattle. Montreal, Toronto

MICA Insulator Company



A MAN-SIZED MICANITE RING

The blueprint came through for the largest commutator rings we had ever seen.

Close tolerances were demanded. New problems of shrinkage, uniformity, mould design, pressing, had to be solved.

Our engineers were prepared. Experience and foresight had warned them to scrap old methods and machinery.

Automatic equipment, new pressure and temperature methods, selected raw materials . . . all were ready. And the order went through without a "hitch".

OVER 40 YEARS OF SPECIALIZATION MAKES THE DIFFERENCE!

MICANITE . . . EMPIRE VARNISHED INSULATIONS . . . LAMICOID LAMINATED PLASTIC MATERIALS

MANUFACTURING REVIEW

News

✦ According to the annual report of the Fansteel Metallurgical Corp., North Chicago, Ill., and prepared by Mr. R. J. Aitchison, president of the company, net earnings for the year 1936 are reported to be $161,066.39, as compared with $78,796.96 in 1935. Sales for the first quarter of the present year show an increase of slightly more than 50 per cent over the net sales for the corresponding period of 1936.

✦ Mr. R. L. Thompson has recently been appointed new chief engineer for the Turner Co., Cedar Rapids, Iowa.

✦ Mr. W. A. Winterbottom, vice-president and general manager of the I.C.A. Communications, Inc., announces that his company has filed with the Federal Communications Commission a schedule of reduced rates for domestic night letters to become effective June 1. Similar announcement in the reduction of rates for overnight telegraph services throughout the United States comes from Clarence H. Mackay, chairman of the board of the Postal Telegraph & Cable Corp.

✦ Advertisers gross investment in NBC network increased 19½ per cent in April over the same month in 1936. Total revenue for the month was $3,277,321 against $2,741,928 in April 1936. The April figures bring NBC's four months' total for 1937 to $13,729,385, a gain of 22.8 per cent over the first four months of 1936.

✦ Mr. David Sarnoff, president of the Radio Corporation of America, has released a statement of income and surplus of the RCA and its subsidiaries for the first quarter of 1937, ending March 31. The statement showed a net profit for the quarter of $2,243,057 which represents an increase of $956,366 over the corresponding quarter of 1936.

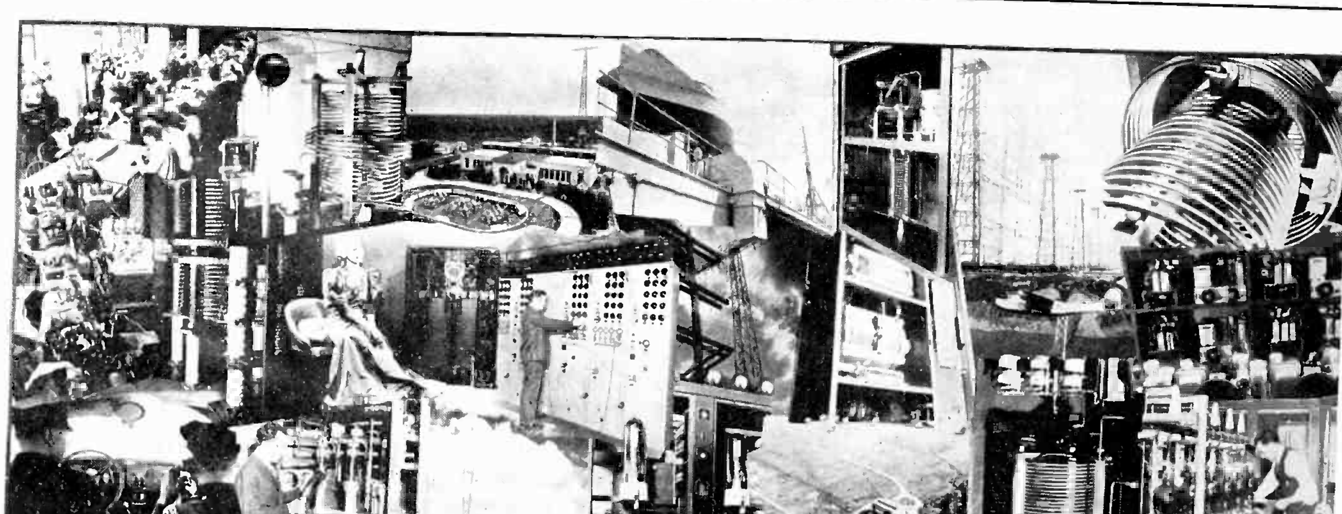
✦ The Synthane Corporation of Oaks, Pa., manufacturers of laminated bakelite, announce the appointment of Mr. William H. Borden as their Detroit representative.

✦ Mr. H. R. Peters, president of the National Union Radio Corporation, reports additions to the company's engineering staff. Dr. Frederick Holborn, well known in the radio industry became chief engineer of National Union on April 1. Dr. Holborn studied physics, mathematics and chemistry in Germany, receiving his doctor's degree at the University of Jena in 1921. His experience both in Germany and in the United States includes extensive work in research and development both in radio circuits and in vacuum tubes. In addition to Dr. Holborn, the National Union engineering staff has been augmented by Mr. Paul Schwerin, who has been connected with the tube industry both in this country and in England for several years. Mr. H. A. Wilder, who joined the staff early in the year, had specialized for several years on cathode ray tubes for television work.

✦ The Electrical Research Products, Inc., has started active construction on their new Hollywood plant which will have general offices, a warehouse, garage, review room and complete laboratory. The structure will be located at the corner of Seward & Romaine Sts., adjacent to the General Service Studios, Hollywood, Calif. According to President Whitford Drake, "the laboratory will be provided with every facility for the investigation and solution cooperatively with the producers of practical field problems associated with motion picture sound recording and reproduction."

✦ Recently resigned as sales manager of the Clough-Brengle Co., which position he held from the earliest days of that organization, John S. Meck has become president and general sales manager of the Electronic Design Corp., 154 North Main St., Chicago, Ill. The newly formed corporation will be engaged in the manufacturing and merchandising of a complete array of sound amplifiers and accessory equipment. Mr. Meck earned his bachelor's degree in electrical engineering at Armour Institute of Technology, Chicago, and has been associated with a number of well-known mid-west manufacturers in the radio field.

✦ Million Radio & Television Laboratories have moved to new and larger quarters at 671-99 West Ohio St., Chicago, according to an announcement by the company's president, J. W. Million, Jr.



Background of the radio industry is graphically portrayed in this modern photomural which will decorate the offices of Isolantite, Inc., manufacturers of ceramic insulators, at 233 Broadway, New York City

electronics

Catalog & Literature Service

Manufacturers' literature constitutes a useful source of information. To make it easy to keep up to date, "Electronics" will request manufacturers to send readers literature in which they are interested. Merely fill in the card—we do the rest.

1. **Tubes.** Technical data sheet on several new Raytheon tubes have been released by the Raytheon Production Corp., 55 Chapel St., Newton, Mass. These data sheets cover the 6T5, a high vacuum tube designed to indicate visually changes of the control grid bias and intended for use as a cathode ray tuning indicator, the 6AB5, a cathode ray tuning indicator tube operating at 135 volts, the 6U7G variable mu pentode amplifier intended for use as a class A amplifier or for use in the first detector in superheterodyne circuits, and the 6U5 cathode tuning indicator operating at a maximum of 250 volts.

2. **Gas Rectifier.** A folder describing the new Argus half wave, gas-filled rectifier bulb for relatively low voltage, high current use, such as battery charging is available from the Argus Manufacturing Corp., 1890 East 40th St., Cleveland, Ohio.

3. **Fluorescent Material.** The Electronics Department, Callite Products Div., Eisler Electric Corp., 540 East 39th St., Union City, N. J., has recently published a 16-page brochure giving information relative to the physical characteristics of fluorescent materials and their application. In addition to listing a wide variety of Cal-Lux materials available for fluorescent and phosphorescent applications, several pages are devoted to a general discussion of the properties of the materials and their general application.

4. **Coaxial Cable.** A single page folder describing semi-flexible cables of the coaxial type for radio frequency transmission lines has been released as Bulletin 72 by Victor J. Andrew, 7221 South San Francisco Avenue, Chicago, Ill.

5. **Zinc Products.** Three large booklets dealing with zinc products are available from the New Jersey Zinc Co., 160 Front St., New York. The first of these "Zamac Alloys for Zinc Alloy Die Casting," is a 42-page research bulletin giving the technical and engineering data on zinc alloys containing 4.1 per cent of aluminum, up to 2.7 per cent of copper and up to .04 per cent magnesium. This booklet is of maximum usefulness to those actually engaged in the processing of zinc alloys. The second bulletin, "Zinc Alloy Die Casting" is a more popular treatment illustrating the applications of zinc through the use of numerous half-tone illustrations in this 80-page booklet. A supplement to this bulletin and also entitled "Zinc Alloy Die Casting" contains additional photographs illustrating a wide variety of applications of zinc in the home and in industry.

6. **Automatic Temperature Control.** A booklet of loose-leaf sheets, entitled "Data on Temperature Indicating and Control," describes a variety of no contact temperature control and indicating devices manufactured by the Wheelco Instrument Co., 1929 South Halsted St., Chicago, Ill.

7. **Tuning Indicator.** A technical data sheet from the Hygrade Sylvania Corp., Emporium, Pa., gives the technical characteristics of a new 250-volt tuning indicator in which the visible indication is annular in shape.

8. **Vibrator.** An 18-page lithographed bulletin of the Electronics Laboratories, Inc., Indianapolis, Ind., describes an unusually complete line of mechanical vibrators for electric power supply systems.

9. **Electric Cleaner.** An electric cleaner suitable for vacuum cleaning, blowing, or spraying of liquids, is described in a 4-page folder issued by the Ideal Commutator Dresser Co., 1221 Park Ave., Sycamore, Ill.

10. **Electrical Control Apparatus.** Catalog 4071-A of the American Automatic Electric Sales Co., 1033 West Van Buren St., Chicago, Ill., describes a complete line of a-c and d-c relays, stepping switches, impulse senders, keys, lamps and sockets, plugs and jacks, and miscellaneous remote control accessories. The equipment described is applicable either to communication or industrial application within the proper power limitations.

11. **Amplifier Catalog.** An 8-page catalog giving technical descriptions on a series of amplifiers having power outputs from 10 watts to 50 watts and suitable for either portable or permanent installation, is described in a brochure entitled "Gold Medal Amplifiers," issued by the Amplifier Co. of America, 37 West 20th St., New York City.

12. **Instrument House Organ.** The first issue of "InstrumenTopics" has been released by the Clough-Brengle Co., 2815 West 19th St., Chicago. The purpose of this house organ is to gather together for users of electronic instruments applications and uses of vacuum tubes which have been found useful.

13. **Transformers.** The Kenyon Transformer Co., 840 Barry St., New York have announced a newly revised edition of their T line catalog.

14. **Color Code Chart.** A convenient chart of vest pocket size, illustrating the standard RMA mica capacity color code has been made available by the Cornell-Dubilier Corp., South Plainfield, N. J.

15. **Resistance Units.** Bulletins on field rheostats, manual starters for motors, relays, and similar equipment on which price changes have been made effective May 1 have been released by the Ward Leonard Electric Co., Mount Vernon, N. Y. These bulletins include 60B covering field rheostats, 501 on manual d-c starters, 701 on d-c compound manual starters, 1201 on d-c manual speed regulators, 1301 on d-c compound manual speed regulators, 1302 on d-c compound manual speed regulators, 1901 covering d-c magnetic contactors, 3651 on a-c manual speed regulators, 3701 on a-c manual speed regulators and 4401 dealing with a-c magnetic contactors.

16. **Nickel.** A well-illustrated 48-page booklet entitled "Riverside Nickel Silver Alloys," has been prepared to meet the requests for specific information about nickel silver received from fabricators, engineering staffs, research laboratories, and purchasing departments. This revised bulletin is available from the Riverside Metals Co., Riverside, N. J.

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ELECTRONICS

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17. **Light Weight Pick-Up.** A single page descriptive folder showing the various models of pick-up devices which they manufacture is available from the Upco Engineering Laboratories, 254 Canal St., New York City.

18. **Ultra-Violet Phototubes.** Bulletin No. 10 bearing the date of April 1937, is available from the Westinghouse Lamp Division, Westinghouse Electric & Manufacturing Co., Bloomfield, N. J. This bulletin describes three phototubes having their sensitivity between the range of 2200 and 3600 Angstrom units.

19. **G. R. Products.** Form 442-A of the General Radio Co., 30 State St., Cambridge, Mass., describes their type 620-A heterodyne frequency meter and calibrator, designed for use between 10 and 300 mc. Form 424-A gives the specifications on the "Variac" variable voltage autotransformers.

20. **Condensers and Transformers.** The popular series of MTC transmitting condensers for medium power ultra-high frequency transmitters is described in form 1004-37. The "HF" micro condensers are described in form 1001-36 and intermediate frequency transformers made by the Hammarlund Manufacturing Co., 424 West 33rd St., New York, are described in form 1002-36.

21. **Super Sensitive Analyzer.** A folder featuring the radio service analyzer with a voltmeter having a sensitivity of 20,000 ohms per volt, but also describing other Weston equipment for the radio service man is available from the Weston Electrical Instrument Co., Newark, N. J.

22. **Insulating Tubing.** An illustrated 6-page folder illustrating synthane laminated bakelite tubing is available from the Synthane Corp., Oaks, Pa.

23. **Communication Equipment.** The following bulletins describing receiving and transmitting equipment for communication systems are available from the RCA Manufacturing Co., Camden, N. J. Form 1135 gives characteristics and specifications of the type 77-A unidirectional microphone. Form 1137 describes the type 62-A remote pick-up equipment, form 1848 outlines the features of the type 40-D program amplifier, a three-channel pre-amplifier, type 41-C is described in form 1842, and bulletin No. 36 describes the type 40-C program amplifier. A mixer and switching panel

24. **Electro Dynamic Microphone.** The "Bullet" electrodynamic microphone manufactured by the Transducer Corp., 30 Rockefeller Plaza, New York, is described in a single page folder issued by that firm.

25. **UTC Products.** Modulation, driver, public address, and line matching transformers, manufactured by the United Transformer Corporation, 72 Spring St., New York, are described in their 8-page bulletin entitled "Varimatch Transformers."

26. **Sprague Condensers.** A 24-page catalog giving the complete line of Sprague condensers is available from the Sprague Products Co., North Adams, Mass.

27. **Insulating Material.** A 12-page bulletin describing oiled tubing, insulating materials and known as Bulletin No. 10 is available from the William Brand & Co., 268 Fourth Ave., New York. A 16-page booklet from the same company describes other electrical insulating material.

28. **Resistance Products.** The technical characteristics of precision wire wound resistors, manufactured by the Shallcross Manufacturing Co., Collingdale, Pa., are given in Bulletin 121. Bulletin 140 describes various laboratory assemblies of precision resistors such as bridges, multipliers, decade boxes, etc. The type 900 megohm decade resistance box is also described in a separate loose-leaf sheet which also contains a description of the type 635 megohm bridge.

29. **Reactance Chart.** Engineering News Letter No. 39, published by the Hygrade Sylvania Corp., of Emporium, Pa., includes an alignment chart relating inductance, reactance, capacitance, and frequencies from 1 cycle to 1,000 mc. per second.

30. **Ceramic Insulation.** Bulletin No. 101 lists the various fittings which are found desirable or necessary in a complete co-axial transmission line system. Bulletin No. 103 shows a variety of stand-off insulators manufactured by Isolantite, Inc., 233 Broadway, New York.

31. **Tube Engineering Bulletin.** Bulletin TEB 37-14 gives a report on "The 6C8G Double Triode Amplifier with Phase Inverter and Infinite Impedance Detector Data," while the subject of "Degenerative Amplifiers" covered in Bulletin TEB 37-17, both of which are issued by the Kenrad Tube & Lamp Corp., Owensboro, Ky.

32. **Fixed and Variable Resistors.** A 4-page cardboard folder gives the specifications and engineering data on fixed and variable resistors manufactured by the International Resistance Co., 401 North Broad St., Philadelphia, Pa.

33. **High Frequency Test Oscillator.** Bulletin 403 describing the essential characteristics of shortwave oscillators for glow lamp and vacuum tube testing may be obtained from the Lepel High Frequency Laboratories, Inc., 39 West 60th St., New York City.

34. **Radiophone Equipment.** The ACT-20 amateur transmitter capable of delivering a power of 20 watts to the antenna and suitable for operation from 1715 to 30,000 kc. is described in Bulletin 1787 of the RCA Manufacturing Co., Inc., Camden, N. J.

35. **Graphite.** A technical bulletin on "Utility of Graphite Surfaces," and known as Bulletin 270.1 has recently been released by the Atcheson Colloids Corp., Port Huron, Mich.

36. **Iron Core Inductors.** "Aladdin Presents Genuine Polyiron Inductors" is the title of a bulletin describing iron core inductance products manufactured by the Aladdin Radio Industries, Inc., 466 West Superior St., Chicago.

37. **Speakers and Condensers.** The specifications of the complete line of Magnavox speakers is given in form R 15 and the model 305 dynamic speaker is described in a single page bulletin of the Magnavox Co., Fort Wayne, Ind. An engineering bulletin on wet-electrolytic condensers is also available from Magnavox.

38. **Test Instruments.** A 6-page catalog folder of the Triplett Electrical Instrument Co., Bluffton, Ohio, describes a wide variety of meters and test equipment suitable for the service man. Model 1503 multi-purpose power output tester, a power output tube tester, model 1200-C volt-ohm-milliammeter, and model 666 universal instruments are described in separate Triplett information sheets.

(*Continued on page* 54)

ELECTRONICS **June**

Please have sent me, without obligation, manufacturers' literature identified by numbers circled below.

1	2	3	4	5	6	7	8	9	10	11	12	13	14
15	16	17	18	19	20	21	22	23	24	25	26	27	28
29	30	31	32	33	34	35	36	37	38	39	40	41	42
43	44	45	46	47	48								

NAME.............................. TITLE....................

COMPANY ....

ADDRESS ....

CITY.............................. STATE....................

PANEL BOARDS *Marked and Ready for Assembly!*

THESE marked panel boards for the Hemovitameter Laboratories of Denver, Colo., were produced complete with all markings in the Formica factory and shipped ready for assembly in the instrument.

Formica operates equipment for marking panels in several different ways: hot stamping with different colored tapes; printing by the Verichrome process in gold, silver and other bronze colors; engraving; and printing on the next to the top lamination which is then covered by a translucent protective sheet of Formica.

Good looking panels with simple or elaborate markings are produced to your specifications. Send your blue prints for quotations.

THE FORMICA INSULATION CO., 4638 Spring Grove Ave., Cincinnati, O.

FORMICA

39. Magnetic Speakers. The catalog No. 237 of the Cinaudagraph Corp., Stamford, Conn., lists a permanent magnet type of loud speaker for every application.

40. Industrial and Transmitting Condensers. A 22-page catalog listing industrial and transmitting condensers is manufactured by the Cornell-Dubilier Corp., 4377 Bronx Blvd., New York City, and is available. Catalog No. 133-A describes their amateur transmitting condensers.

41. Attenuators. A new Daven attenuator is described in Bulletin 534 issued by the Daven Co., 158 Summit St., Newark, N. J.

42. Transmitting and Laboratory Accessories. Several bulletins are available from the Premier Crystal Laboratories, Inc., 53-63 Park Row, New York City describing their products. Bulletin 104-A gives the specifications on their type 350-A crystal oscillator and buffer amplifier with temperature control, and normally supplied to operate between 550 and 1500 kc. Bulletin 107 gives data on the type 500 crystal holders with automatic temperature control.

43. Layer-Bilt Batteries. A special edition of the descriptive catalog No. C 1197 of the National Carbon Co., New York contains a price list and the characteristics of Eveready batteries suitable for radio purposes.

44. Resistance Devices. A loose-leaf catalog containing a number of separate and individual bulletins describing their line of resistors, is available from the Clarostat Manufacturing Co., 285 North Sixth St., Brooklyn.

45. Spring Design. Bulletin D entitled "How to Design Flat Springs to Meet Definite Requirements" prepared by the Research Department of the Beryllium Corp. of Pennsylvania, Reading, Pa., is a technical treatment of the design of flat springs.

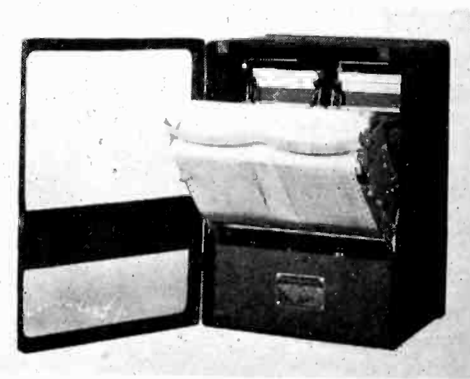
46. Studio Acoustics. A well-illustrated brochure entitled "Studios by Johns-Manville," illustrates photographically a number of broadcast studios which have been built or equipped by Johns-Manville, 22 East 40th St., New York City.

47. Signal Generators. The model 17B microvolter operating from 100 kc. to 30,000 kc. and intended for general radio laboratory use is described in an 8-page bulletin by the Ferris Instrument Corp., Boonton, N. J. A standard signal generator model 16B is described and illustrated in a separate 16-page booklet. These instruments are definitely precision laboratory jobs rather than suitable for service men requirements.

48. Voltage Regulator. Bulletins 5601 and 5602 describe electronic automatic alternator voltage regulators, manufactured by the Ward Leonard Electric Co., Mount Vernon, N. Y. These devices depend for their control action upon the characteristics of tubes.

Photoelectric Recorder

A PHOTOELECTRIC instrument which will record simultaneously on one chart two electrical quantities as low as 1 microampere full scale, and representing a power consumption of 10^{-10} watt from the measured circuit, has been placed on the market by the General Electric Co. The device is known as a double photo-electric recorder and can be applied wherever simultaneous readings are desired. This double photo-electric recorder came into existence

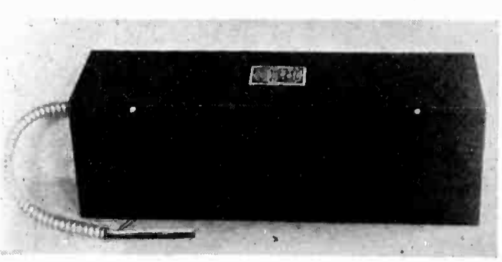


because of a demand for an instrument which could measure and record the surface irregularity of steel strips, but the instrument can be applied for many other measurements, however. In temperature recording, it is possible to record outdoor and indoor temperatures for air conditioning work, wet and dry bulb temperatures, refrigeration temperatures, etc. Other applications are the recording of high resistance voltmeter-ammeter measurements, illumination measurements, and other measurements requiring galvonometers or other types of measuring elements.

• • •

Power Line Filter

THE MODEL TR 25 power line filter manufactured by the Tobe Deutschmann Corp., Canton, Mass., provides a 60 db. attenuation for frequencies between 200 kc. and 30 mc., is designed to operate on any 110-volt, single phase circuit and will handle 25 amp. without excessive heating or voltage drop.



This filter effectively isolates receiver and instrument test room from high frequency disturbances present on electric power circuits in factory and industrial areas. Because of its wide frequency range, this power line filter allows modern receivers to be tested at full sensitivity on all frequency bands.


Here's the Answer!
ALSIMAG 196
The steady advance of radio demands better insulation. Alsimag 196 was developed by our Research Laboratory to meet this demand.
Every application of Alsimag 196 in the radio field has effected definite improvement.
Lower losses at radio frequencies—greater mechanical strength.
35 years ceramic leadership
Whose display held the largest crowds at the New York Show of the Institute of Radio Engineers?
AMERICAN LAVA CORPORATION
Chattanooga, Tennessee
Sales Offices
New York
Boston
Philadelphia
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Chicago
St. Louis
Los Angeles
San Francisco

Apologies

THE LAST MINUTE RUSH in putting together our May issue resulted in several errors in the Manufacturing Review Department.

The RCA microphone described on page 93 was incorrectly illustrated with a cut of the "Bullet" microphone of the Transducer Corp.

Another incorrect illustration appeared on page 92. The "Strainscope" of the Polarizing Instrument Co. is a different instrument from this company's photoelastic polariscope which was described.

The two models of the Bruno Laboratories, Inc. microphones referred to on page 98 were the models SP listing at $13.50 (illustrated) and the model WM, listing at $39.00.

To the manufacturers concerned as well as to our readers, we offer our apologies.

• • •

Tube Checker

A NEW RADIO TUBE checker of unusual flexibility has been announced by the Weston Electrical Instrument Corp., Newark, N. J. In the circuit used in this tube checking device total emission tests of various types of tubes are made on a specific load basis, thereby reflecting service conditions for general types of tubes, battery operated tubes, and diodes and eliminating possibility of tube damage. A new feature of the unit is the "noise test" jack where headphones or amplifier units may be plugged, if desired to check possible sputtering, frying, or other tube noises in any or all of the electrode circuits. A hot cathode leakage test is also provided and the neon chart check can be made quickly while the tube is hot in order that intermittent shorts may be determined. A direct reading line voltage measurement can be made at any time while the tube is under test. This fundamental tube checking device is available in an angular mounting base for use on the counter, but is also available in a wooden carrying case either alone or in conjunction with equipment of similar design appearance for portable use. The illustration shows the angular mounting base for counter use which features the rotator type reference index covering all types of tubes in current use, so arranged in the base that tube test data is instantly brought into view beneath a glass covered opening.

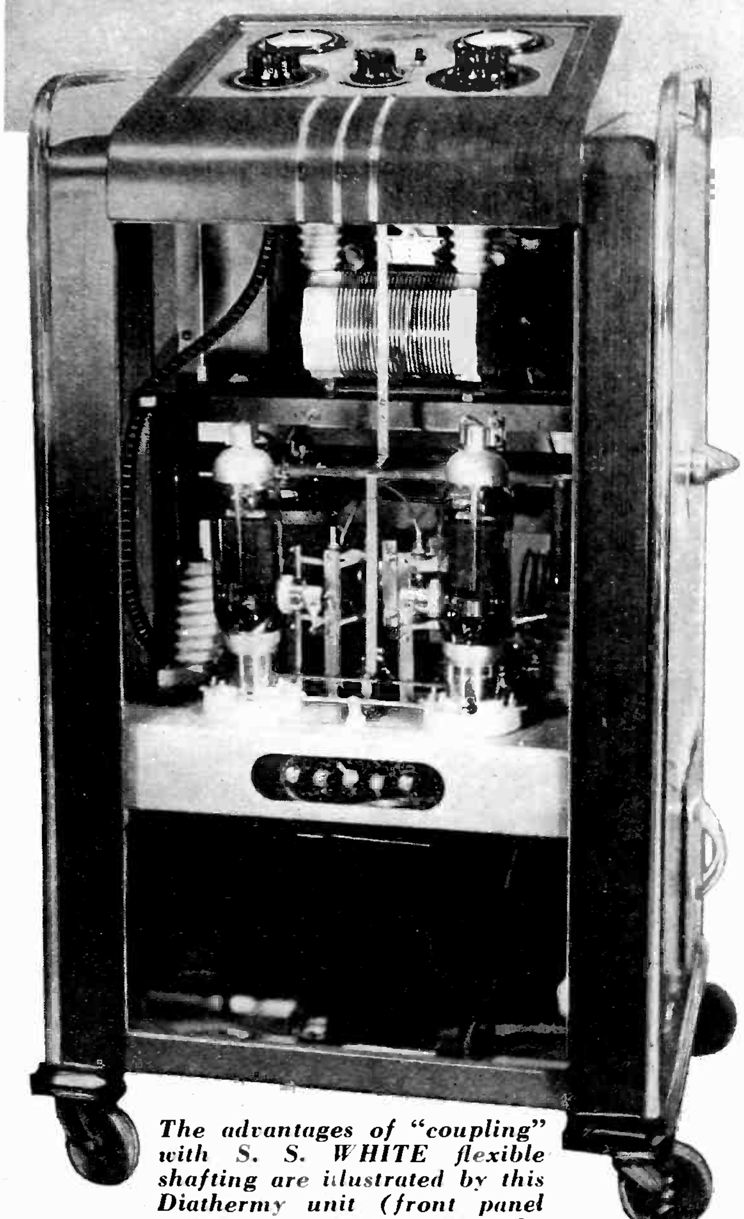
• • •

Air Cell Resistor

AN INEXPENSIVE DEVICE which converts to air cell operation, radio receivers originally designed to be powered by 2-volt storage batteries, has been placed on the market by the National Carbon Co. These resistor units, 5½ in. long, are made in five different values, to match the current consumption drains of different makes and models of radio receivers.

"Coupling" with S. S. WHITE FLEXIBLE SHAFTING

simplifies and improves equipment design . . .



The advantages of "coupling" with S. S. WHITE flexible shafting are illustrated by this Diathermy unit (front panel removed), a product of the Burdick Corp., Milton, Wis. The shaft connects the control knob on the left, to a variable condenser at the back of the unit.

Many pieces of equipment contain parts which require manual adjustment from the outside.

Often it is desirable to place these parts at some distance from the control knobs to satisfy considerations of electrical circuit, easy assembly, space saving or convenient servicing.

S. S. WHITE Remote Control flexible shafting makes it possible to place knobs and parts wherever it is best for them to be. It will reliably transmit movement from one to the other *regardless of their relative positions or the distance between them.*

Likewise, where movement must be carried from one part to another, inside the equipment, "Coupling" with flexible shafting will readily do it. It also avoids the need for accurate alignment of parts.

S. S. WHITE Power Drive Shafting offers the same advantages for transmitting power between parts.

If you have a power drive or remote control problem of this kind, we'll gladly help you work it out. No obligation. Send us the details.

The S. S. WHITE Dental Mfg. Co.
INDUSTRIAL DIVISION
10 East 40th St., Room 2310E, New York, N. Y.

Over 60 years of uninterrupted flexible shaft manufacture and development.

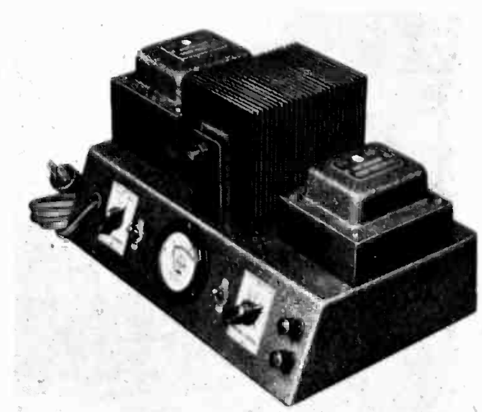
Modern Microphone Stand

A NEW MICROPHONE stand especially suitable for reducing shock and enabling the microphone to be rotated in practically any position is announced by the Amperite Co., 561 Broadway, New York City. By placing the microphone horizontally, the center of gravity is lowered, making the stand unusually stable. The microphone can be rotated in practically any position. The horizontal position makes it excellent for pulpit, desk, and footlight installations.

• • •

Power Pack

DESIGNED TO FILL the need for a dependable, accurately metered source of direct current for demonstrating automobile radio receivers and accessories under actual service conditions, a new line of power packs has recently been announced by the Standard Transformer Corp., 850 Blackhawk St., Chicago.



The Junior model has an output of 5 amp. at from 5 to 7½ volts, the Standard model has a power output of 12½ amp. from 5 to 7½ volts, while the De Luxe model has an output of 15 amp. at 2 to 8 volts. The latter model is equipped with high and low voltage switch and a continually variable voltage control. Each model is perfected with a circuit breaker in a primary and is provided with a meter. All models are electrostatically shielded.

• • •

Phototube

THE CONTINENTAL ELECTRIC Co., of Geneva, Ill. announce a new photocell known as their type CE-868 which has been designed to fill the need for a low cost industrial type phototube which will enable present users and prospective manufacturers to produce phototube equipment at attractive prices. The CE-868 is 1 in. wide and 3 9/32 in. high overall. The surface measures ⅝ in x 1½ in. and a standard 4-prong base is used. The operating voltage is 90 and the average output is from 50 to 80 microamperes per lumen. The list price is $2.70.

The broadcast engineer in far off China—the radio serviceman in Rangoon—the "Ham" in Iceland—the "Sparks" of a tramp steamer plying tropic seas—the Manufacturer of radio receivers in America—all know, approve, and use Cornell-Dubilier Condensers.

Because C-D Condensers are engineered and constructed to withstand the rigors of every conceivable degree of abuse—because they provide dependable service consistently—they are the internationally accepted standard by which condensers are judged. Look for the C-D trademark. It is truly a symbol of quality.

WORLD'S LARGEST EXCLUSIVE MANUFACTURERS OF CAPACITORS
MICA • PAPER • WET & DRY ELECTROLYTICS • DYKANOL

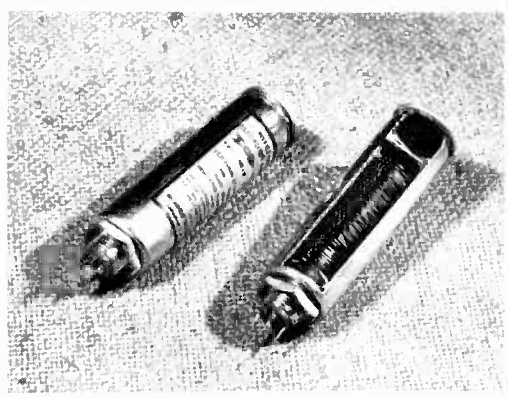
CORNELL-DUBILIER
CORPORATION
SOUTH PLAINFIELD • NEW JERSEY

Tube Tester

THE MODEL AC-51X tube tester recently announced to the trade by the Hickok Electrical Instrument Co., Cleveland, Ohio not only tests all commercially available receiving tubes but also indicates voltage, resistance, current, power output, capacity and microfarads, condenser leakage, and power ratio in decibels. As a tube tester either the "poor-good" scale or the scale graduated directly in microohms may be used. The device may also be used to indicate the amount of hum in the filter system and checks the inductance of chokes whether these coils have direct current flowing through them or not. The a-c voltmeter used in the construction of this equipment is accurate on all commercial and audio frequencies.

Wet Electrolytic Condensers

MICAMOLD PRODUCTS CORP. announce a wet electrolytic condenser, incorporating a new design of the anode structure so that the current has the shortest average path from the can to all



points on the anode surface. This results in a low power factor. The condensers are made in cans of standard dimensions and fit the standard holes in radio chasses. Each condenser is equipped with a self-locking nut.

Farm Radio Receivers and Power Supply

TWO NEW 5-TUBE all-wave farm radio receivers and a new power supply unit providing universal operation by converting the instrument from 2 volt operation to 6-volt storage battery operation have been added to the 1937–38 battery set line of RCA Victor. An output of 2.2 watts is obtained with minimum battery drain by the use of class B output amplifier with a special driver stage. Permanent magnet speakers are used as the electro-acoustic transducer. These farm radio receivers, bearing models No. 85DK, 85DT, 86DK and 86DT, are designed for two-volt power supply using the conventional air cell A, B and C batteries, RCA has introduced a conversion unit known as their model BB-8 Pak-O-Powr which easily adapts the new receivers to 6-volt operation.

Resistors and Pads

TWO NEW PADS for general use in audio circuits and four types of precision resistors have been announced by Hector I. Skifter, St. Paul, Minn. The type P-4 pad is designed to plug into a four-prong tube socket and is 2¾ in. high and 1½ in. in diameter. The type W-4 is made in a fiber tube 2 in long and 1 in. in diameter and is furnished with flexible leads. Accurate wire-

wound non-inductive resistors, impregnated in wax, are used and both types may be had in any value of attenuation and impedance. The precision resistors are made in four types, all are non-inductive and have an accuracy of ½ of 1 per cent. Other resistors having an accuracy up to 1/100 of 1 per cent are also available. Card type resistors are available up to 100,000 ohms but other types of windings are available for values up to 10,000 ohms.

U. S. Patents

Electron Tube Applications

Editor's Note—So many patents have been issued under this general classification recently that it is impossible to give more than a subject and the number as shown below. Readers interested in the non-communication uses of tubes are urged to look at these patents, many of which disclose very unusual features.

Flaw Detection, Metal Treating

Can end inspector. No. 2,070,339, M. E. Moore, Maywood, Ill. *Metal testing device.* No. 2,055,672, H. D. Roop, Detroit, Mich. *Method of treating metal.* No. 2,041,029, A. R. Stargardter, Gillette Safety Razor Co. *Flaw detector.* No. 2,065,118, A. H. Davis, Jr., Steel & Tubes, Inc. *Rail flaw detector car.* Reissue, No. 19,991, Sperry Products. See also No. 2,056,-291 and No. 2,053,704 to Sperry.

Geophysical Use, Etc.

Apparatus for measuring depths. No. 2,044,820, E. E. Turner, Submarine Signal Co. *Method of geological exploration.* No. 2,049,724, H. R. Prescott and F. L. Searcy, Continental Oil. See also 2,053,841. *Geophysical apparatus.* Measuring the intensity and the frequency of the sound produced by flowing gravels in rivers, etc. No. 2,047,529, Walter Turk, Karlsruhe, Germany. *Seismic prospecting.* No. 2,055,477, to L. W. Blau, Standard Oil Development Co. *Sub-surface surveying.* No. 2,059,018, W. North, geophysical research Corp.

Rotating Machine Control

Control system. H. L. Bernarde, WE&M Co. No. 2,044,146. *Regulating apparatus.* George W. Smith, Pittsburgh, Pa. No. 2,049,669. *Polyphase regulating system.* H. C. Jenks, WE&M Co. No. 2,057,490. *Dynamo-electric regulator.* J. W. Dawson and F. H. Gulliksen, WE&M Co. No. 2,057,515. *System for maintaining constant an electrical quantity.* No. 2,057, 520. F. H. Gulliksen, WE&M Co. *Motor generator control.* A. L. Matte. No. 2,046,-422, 2,046,438. AT&T Co. *Position control.* B. A. Wittkuhns and H. L. Hull, Sperry Gyroscope Co. No. 2,047,-988. See also No. 2,054,945 to Sperry. *Reversing mechanism.* A. S. Riggs, Sperry Gyroscope. No. 2,047,984. *Variable speed motor control* in a follow-up system. B. A. Wittkuhns and F. M. Watkins, Sperry Gyroscope. No. 2,064, 454. *Carriage reverser.* No. 2,069,493. W. H. Howe, Cincinnati Milling Machine Co. *Uniform speed system.* E. Janetschke, WE&M Co. No. 2,066,938. *Voltage regulating.* L. V. R. Philpott, WE&M Co. No. 2,066,943. *Induction motor control.* H. E. Young, Chicago, Ill. No. 2,066,508. *Motor rebalancing system.* H. L. Bernarde, WE&M Co. No. 2,065,421.

Power Supply

Patents on methods of securing high voltage d-c from a low voltage d-c source by means of a vibrator: No. 2,053,326. H. M. Dressel; and No. 2,-065,597, E. J. Mastney, both to Oak Mfg. Co. No. 2,060,025, A. D. Burt and A. J. Rohner and F. Shoup, RCA.

Miscellaneous Applications

Register control. Patents No. 2,050,-315 and No. 2,050,316, F. H. Gulliksen, Westinghouse, and No. 2,052,256, D. R. Shoults, G.E. Co.

Grain treatment. J. H. Davis, Baltimore, Md. No. 2,064,522. Method and apparatus for treating materials for the destruction of insect life therein.

Traffic control. No. 2,060,798. E. F. Critchlow, WE&M Co.

Weighing apparatus. W. H. Rees, Berkeley, Calif. No. 2,055,730.

Drying mechanism control. R. S. Elberty, Jr., American Laundry Machinery Co. No. 2,045,381.

Shooting gallery. No. 2,042,174 to G. A. Foisy, Winchester Repeating Arms Co.

Precipitator control. D. D. Knowles, WE&M Co. No. 2,042,181. See also 2,050,367.

Filament wire testing. L. L. Matson G.E. Co. No. 2,049,306.

Storage battery charge control. F. G. Beetem, Electric Storage Battery Co. No. 2,066,603.

Photo electric engraving process. M. D. McFarlane, Mackinner Corp., New York. No. 2,063,614.

Alarm system. B. F. Miessner, RCA. Feb. 28, 1931. A supersonic beam system. No. 2,071,933.

Colorimeter. H. B. Marvin. G.E. Co. No. 2,046,958. *Photoelectric colorimeter.* R. H. Múller, Brooklyn, N. Y. No. 2,043,589. *Color matcher.* E. D. Wilson and C. C. Hein, WE&M Co. No. 2,046,714. *Comparative colorimeter.* No. 2,042,281. A. E. Traver, Socony-Vacuum Co.

Consistency regulator. No. 2,047,-592. O. M. Nickerson, Millinocket, Maine. Useful for paper pulp manufacture.

Fluid meter. No. 2,050,674, E. F. Stover, Wynnewood, Pa. Measuring the flow of liquid in a conduit.

Oil bath temperature regulator. No. 2,042,182. D. D. Knowles, WE&M Co.

Regulating system. No. 2,066,934. F. H. Gulliksen, WE&M Co. Source of light passing through a treated fluid and a second beam through a standard sample.

Oil tester. J. A. Logan and L. F. Spear, Gilbert & Barker Mfg. Co. No. 2,062,588.

pH control. D. K. Allison, Los Angeles, Calif. No. 2,063,140.

Electric hydrometer. No. 2,071,607. Magnus Björndal, Jersey City, N. J.

Tempering glass. E. M. Guyer, Corning Glass Works. No. 2,068,799. Method of tempering a glass body which includes heating it by creating dielectric losses within it and cooling its surface while it is being heated.

Skill radio and recording manipulator. H. L. Grundstein, Bronx, N. Y. No. 2,045,947. Game making use of radio set.

Theater dimmer control. D. D. Knowles, WE&M Co. No. 2,046,691.

Photoelectric relay. W. D. Cockrell, G.E. Co. No. 2,049,355.

Device for indicating magnetic directions. Kolbein Sydnes, Norway. No. 2,049,232.

Illumination control. A. J. McMaster, G-M Laboratories, Inc. No. 2,043,671.

Impact meter. D. D. Knowles, WE&M Co. No. 2,053,436.

Air conditioning. Photocell controls the rate of production of ozone. T. E. Foulke, General Electric Vapor Lamp Co. No. 2,056,663.

Heat sensitive resistance control. Max-Ulrich Buchting, Siemens & Halske. No. 2,056,769.

Sealing welding. Carl Herzog, RCA. No. 2,056,398. Tube control of tube-welding machine.

Furnace regulator. G. A. F. Machlet, Elizabeth, N. J. No. 2,056,285.

Paper tester. M. N. Davis and H. E. Malmstrom, Paper Patents Co. No. 2,050,486. Apparatus for testing smoothness of paper surface.

Flux meter. R. F. Edgar, G.E. Co. No. 2,054,672.

Patent Suits

1,573,374 (*a*), P. A. Chamberlain; 1,707,617, 1,795,214, E. W. Kellogg; 1,894,197, Rice & Kellogg; 2,052,316, R. E. Sagle, Variable condenser, filed Feb. 8, 1937, D. C., S. D. N. Y., Doc. E 84/302, ***R. C. A.*** *et al.* v. ***Amplex Radio Corp.*** *et al.*

1,573,374 (*b*), P. A. Chamberlain, 1,707,617, 1,795,214, E. W. Kellogg; 1,894,197, Rice & Kellogg, same; 1,728,879, same, D. C. S. D. Calif. (Los Angeles), Doc. E 1065–J, ***R. C. A.*** *et al.* v. ***B. S. Rothenstein*** *et al.* Decree pro confesso Feb. 10, 1937.

1,403,475 (*a*), H. D. Arnold; 1,403,932, R. H. Wilson; 1,618,017, F. Lowenstein; 1,936,162, R. A. Heising; Re. 18,579, Ballantine & Hull, D. C., S. D. Calif. (Los Angeles), Doc. 1064–C, ***R. C. A.*** *et al.* v. ***B. S. Rothenstein*** (***Pathe Radio & Television Co.***). Decree pro confesso for plaintiff, injunction Feb. 8, 1937.

1,403,475 (*b*), 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, D. C., S. D. Calif. (Los Angeles), Doc. 1064–C, ***R. C. A.*** *et* al. v. ***B. S. Rothenstein*** (***Pathe Radio & Television Co.***). Decree pro confesso for plaintiff, injunction Feb. 8, 1937.

TELEVISION

(*Continued from page 17*)

A "dolly" is the movable carriage on which the entire camera and camera mount are moved about the studio. A "wind-shield" is a small perforated metal cover which fits over the microphone, to protect it from "drafts", i.e. the wind currents caused by the very powerful air-conditioning system used to remove heat from the set. "Gobos" are light-deflecting fins used in directing light and protecting lens from glare. A blonde actress is a "blizzard head". Any sudden video surge goes by the name "womp", origin unknown.

Lighting, a most important part of the new television studio technique, has its quota of terms. A "hot light" is a concentrated light used for "modelling", i.e. for emphasizing features and bringing out contours. "Broads" are general illumination units used in "flat lighting", i.e. in the general illumination of the set, sometimes called "key lighting" or "primary lighting". "Scoops" are multiple lighting units; "bowls" bowl-like lighting units used for general illumination.

Most picturesque of all is the simple word "business", which is a general term for anything not otherwise designated, or whose proper term the speaker has forgotten. This word is overworked, since things move so rapidly in the television development that names are not thought up as fast as new objects appear.

The British have a television jargon which is very different from the American. "Flyback" is the return trace of the cathode-ray beam. "Tilt and bend compensator" is the name for shading panel. There are also differences in standards. The polarity of the modulating voltage is opposite from that used in America (see Fig. 3). The antennas used are usually vertically polarized, whereas in the United States horizontal polarization is the rule. In England also, the d-c component of the video signal is transmitted, i.e., the receiver second-detector output contains all frequencies from 0 to 2.5 megacycles. Separate blanking signals, ("flyback neutralization,") are generated in the receiver to aid in suppressing the beam during "flyback". These are relatively minor differences.—D.G.F.

SEARCHLIGHT SECTION

(Classified Advertising)

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10 CENTS A WORD. MINIMUM CHARGE $2.00
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Engineer or Physicist

with experiences in vacuum tube construction wanted as chief of a vacuum tube laboratory in Switzerland.

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Aldwych House, Aldwych, London WC 2

POSITION VACANT

ENGINEER—trained in electronic and allied fields to assume charge of engineering work in new growing Western company. We want a man 30 to 40 years old; of unimpeachable character, good education, and training, with the ability to do things and "take it." Give complete qualifications—in detail—including

+ EXPERIENCE +

Eleven years of it—is our assurance that we can recondition your transmitting tubes properly and build in Long Life and Proper Characteristics.

Aircooled Tubes 100 to 1000 watts

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TELEVISION

(*Continued from page* 17)

A "dolly" is the movable carriage on which the entire camera and camera mount are moved about the studio. A "wind-shield" is a small perforated metal cover which fits over the microphone, to protect it from "drafts", i.e. the wind currents caused by the very powerful air-conditioning system used to remove heat from the set. "Gobos" are light-deflecting fins used in directing light and protecting lens from glare. A blonde actress is a "blizzard head". Any sudden video surge goes by the name "womp", origin unknown.

Lighting, a most important part of the new television studio technique, has its quota of terms. A "hot light" is a concentrated light used for "modelling", i.e. for emphasizing features and bringing out

American. "Flyback" is the return trace of the cathode-ray beam. "Tilt and bend compensator" is the name for shading panel. There are also differences in standards. The polarity of the modulating voltage is opposite from that used in America (see Fig. 3). The antennas used are usually vertically polarized, whereas in the United States horizontal polarization is the rule. In England also, the d-c component of the video signal is transmitted, i.e., the receiver second-detector output contains all frequencies from 0 to 2.5 megacycles. Separate blanking signals, ("flyback neutralization,") are generated in the receiver to aid in suppressing the beam during "flyback". These are relatively minor differences. — D.G.F.

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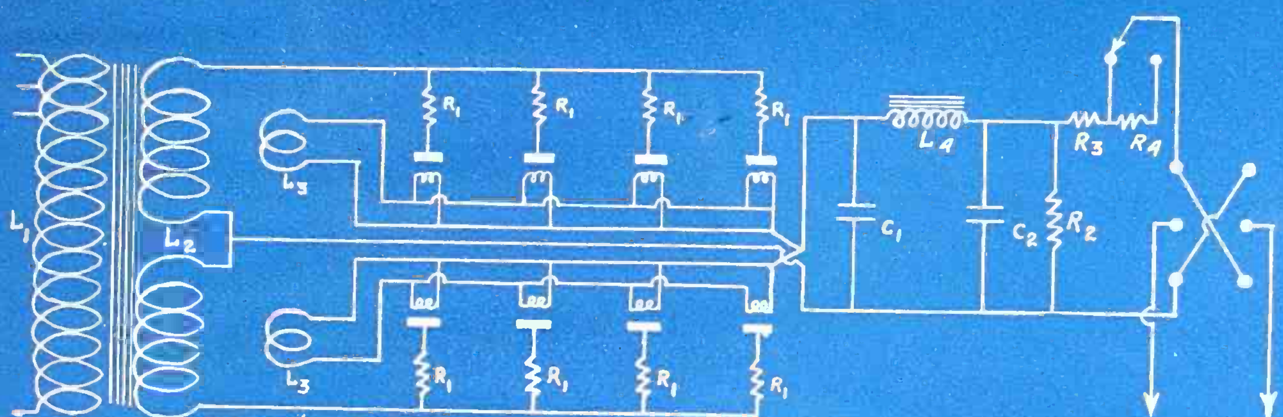

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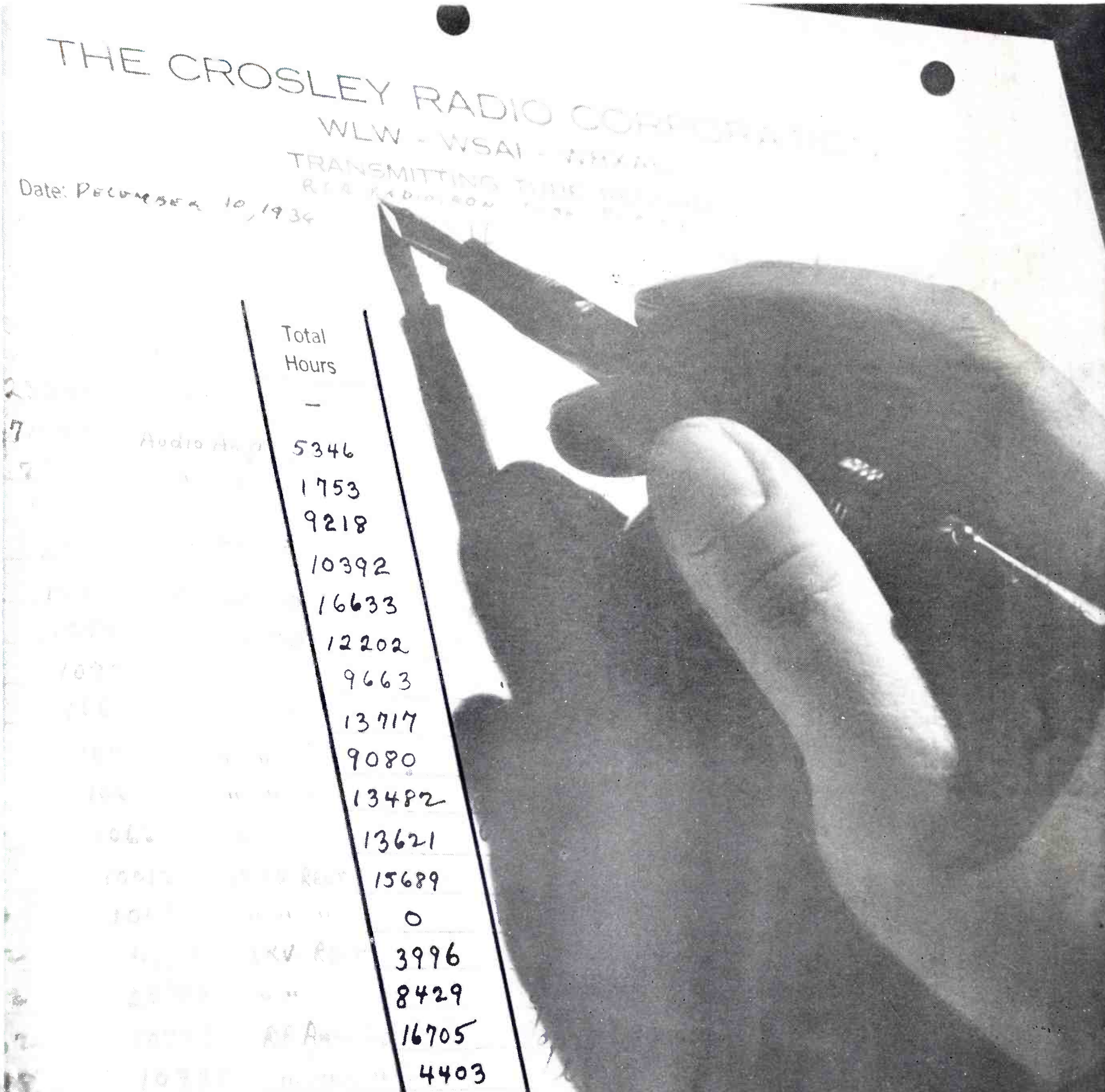

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