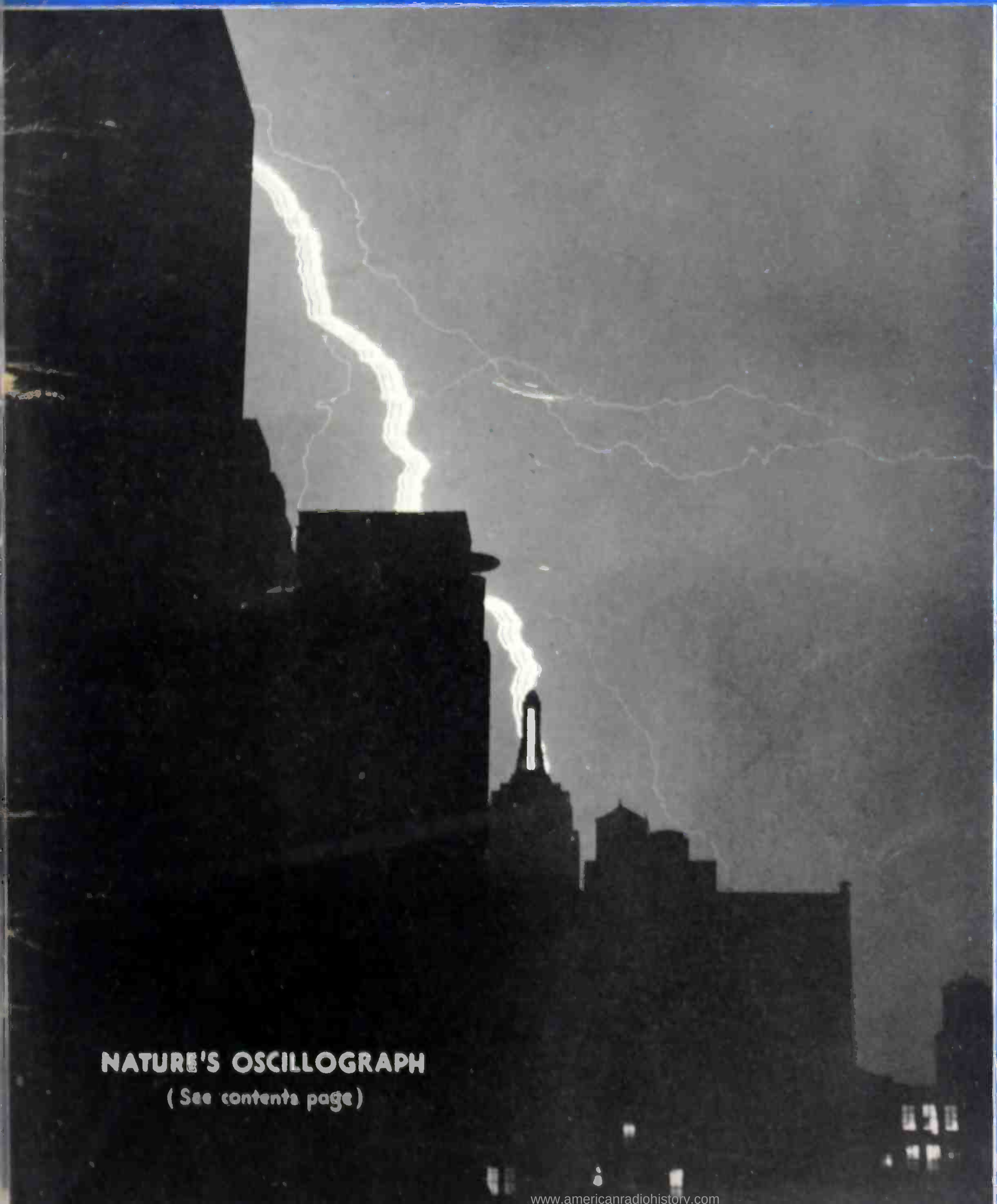
electronics

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



NATURE'S OSCILLOGRAPH

(See contents page)

AUGUST
1937

Price
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TRANSMITTING and RECTIFYING TUBES

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electronics

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

CONTENTS, AUGUST, 1937

DEPARTMENTS

ELECTRONICS, August, 1937. Vol. 10, No. 8. 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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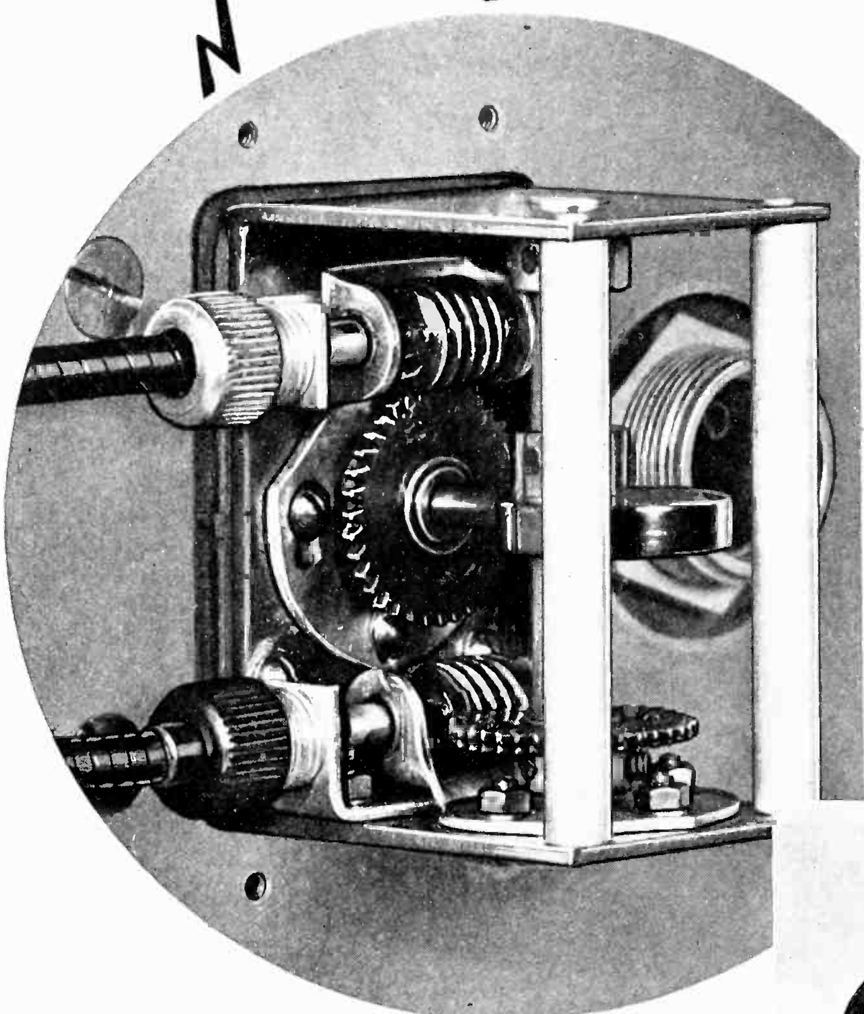
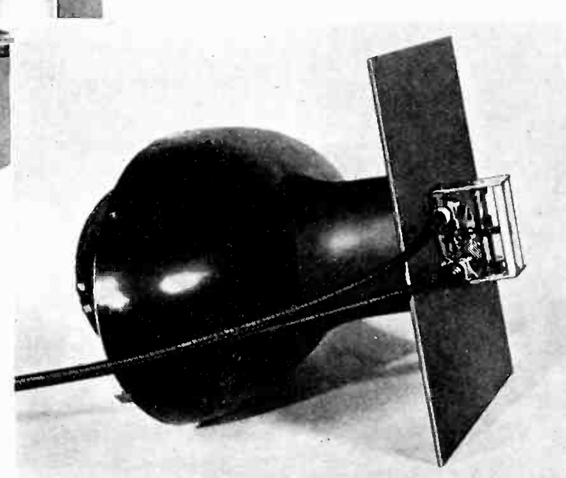
A mass of data is available to show how efficiently and reliably S. S. WHITE Radio Shafts fulfill the purpose for which they were specially developed, namely, remote control of radio equipment.

Equally convincing, however, is the evidence presented by the simple statement that S. S. WHITE Remote Control Shafts are used by RCA and subsidiary companies, as well as by practically all other prominent radio manufacturers.

The wide selection of S. S. WHITE Radio Shafts, and companion casings, satisfies every requirement for sensitive remote control of Automobile, Aircraft and Broadcasting Radio equipment as well as for "coupling" inside the equipment.

Full information about these shafts will be supplied on request. Engineering co-operation for working out specific applications is also offered without obligation. Simply send us the details.





RCA AVR-8 RADIOCOMPASS, remote controlled with S. S. WHITE Radio Shafts—an excellent example of the ready adaptability of flexible shafts to gearing.

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"Symbol of the Radio Age"

WORLD'S LOFTIEST SIGN ON RCA BUILDING, RADIO CITY, N. Y.

The new RCA sign stands 900 feet above Rockefeller Plaza. The letters—24 feet tall on the north and south sides of the building, 18 feet on the west side—are constructed of 5000 pounds of solid aluminum. By night they are brilliantly lighted with a new kind of golden-amber helium gas, contained in 2376 feet of specially constructed Claude-Neon tubing. The sign is visible for many miles around New York City.

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NATIONAL BROADCASTING COMPANY

. . .Vanguard of Industry

"INDUSTRY today is following the vanguard of science into new and infinite realms of knowledge. It would be a rash astronomer who said that he had calculated the outermost limits of space, beyond which there is nothing. It would be a rash physicist who claimed that he had dissected the atom into its ultimate, indivisible fragments. Science and knowledge have no boundaries.

"So it would be a rash economist who predicted any limit to the tangible results of scientific thought in the form of new goods and services placed at the disposal of mankind. In fact, it is only by a constant development of new goods and services that we may expect to re-engage the man-power released by technological improvements in established industries. The market for every new commodity eventually reaches a saturation point and becomes primarily a replacement market, so that a more efficient technology reduces the number of workers needed in that field.

"But science is simultaneously creating new employment, both by the modernization of established industries and by the creation of new ones. In our own generation we have seen the automobile, the airplane, the motion picture, and the radio provide totally fresh fields of activity for millions of men and women. Many of our older industries have engaged scientists, with notable success, to develop new and remodel old products to meet the needs of a modern era.

"The industry which has not learned how to employ scientists to make it new, and keep it new, is doomed. Few industries are so stagnant as not to be aware of this; but there are some so conservative that the scientist is called upon to turn salesman and show them how modern science can rejuvenate them to meet present-day realities and survive."

President
Radio Corporation of America

Your free copy of "TELEVISION" is ready!

This new book of more than 20 recent laboratory and field reports on the new art by leading RCA engineers will be sent without extra charge to all paid-up subscribers to the RCA REVIEW, an outstanding quarterly journal of radio progress. $1.50 per year (foreign, $1.85). Address RCA Review, 75 Varick St., New York City.

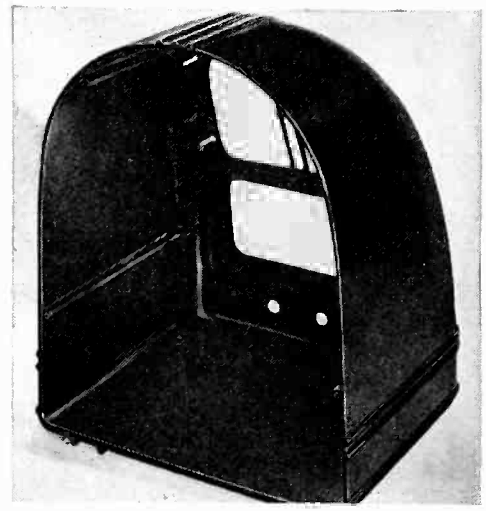
OF AMERICA *RADIO CITY, NEW YORK*

RCA MANUFACTURING COMPANY, INC.

RCA INSTITUTES, INC. • RCA COMMUNICATIONS, INC.

Sturdiness and Style

. . . FOR LARGE CABINETS



THE special merits of Bakelite Molded for the manufacture of radio cabinets include both decorative and structural advantages. Lustrous, colorful, and adaptable to forming into almost any shape, this material affords faithful reproduction of an unlimited variety of decorative designs.

Structurally, the strength, toughness and durability of Bakelite Molded also offer wide latitude in design. Consider, for example, the new Philco Radio cabinet illustrated. Not only does this material provide adequate ruggedness in the three slender panel bars; but, also, it permits complete fastening of a heavy interior unit by means of four assembly studs imbedded in the cabinet.

In addition, Bakelite Molded usually provides important simplifications and economy in quantity production of table models. Complete cabinets may be produced in one operation of the molding press. In the same operation, all openings, through-holes and bosses are formed; metal inserts and assembly studs are firmly and accurately imbedded; and a fine permanent lustre is imparted to all surfaces.

We invite you to obtain detailed information on the decorative, electrical and mechanical characteristics of this material. Write for our 48-page illustrated booklet 13 M, "Bakelite Molded."

(Left) Table radio cabinet 16½" x 13¼" x 10¾" of lustrous black Bakelite Molded. Product of Philco Radio Corp. of Great Britain, Ltd. (Above) Interior, showing two of the four permanently imbedded assembly lugs which provide adequate fastening for complete electrical unit.

BAKELITE CORPORATION, 247 PARK AVENUE, NEW YORK, N.Y.

BAKELITE CORPORATION OF CANADA, LIMITED, 163 Dufferin Street, Toronto, Canada *West Coast:* Electrical Specialty Co., Inc., 316 Eleventh Street, San Francisco, Cal.

BAKELITE

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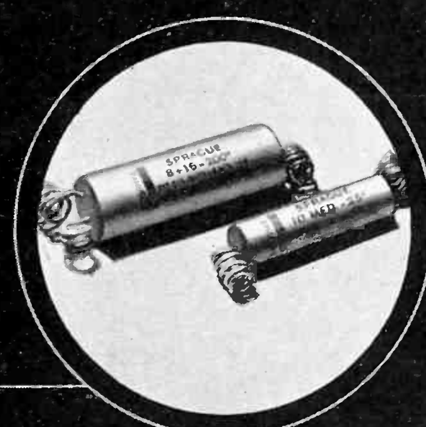
The registered trade marks shown above distinguish materials manufactured by Bakelite Corporation. Under the capital "B" is the numerical sign for infinity, or unlimited quantity. It symbolizes the infinite number of present and future uses of Bakelite Corporation's products.

THE MATERIAL OF A THOUSAND USES

We're glad most condensers are bought on the basis of hard-boiled engineering tests rather than advertising claims. When quality is allowed to speak for itself there can be no mistaking what it says. That's why ***Sprague Condensers*** are today specified by leading radio and electrical manufacturers throughout the world.



SPRAGUE

**GOOD CONDENSERS—EXPERTLY ENGINEERED—
COMPETENTLY PRODUCED**

SPRAGUE SPECIALTIES COMPANY, NORTH ADAMS, MASS.

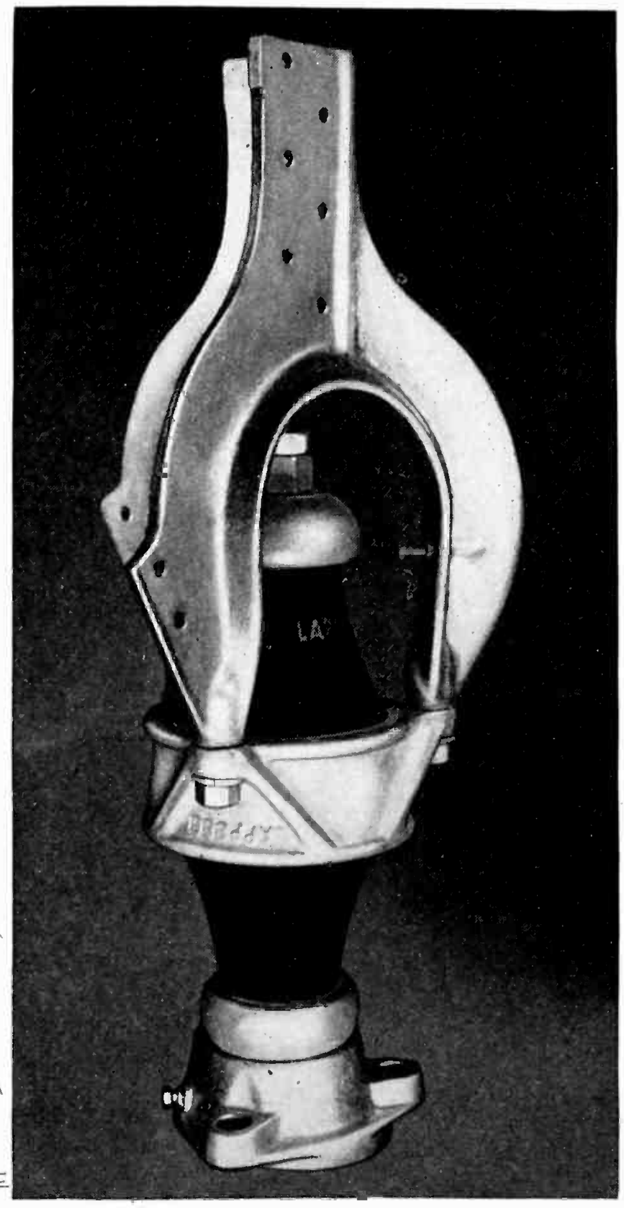
INSULATOR SPECIALTIES FOR RADIO

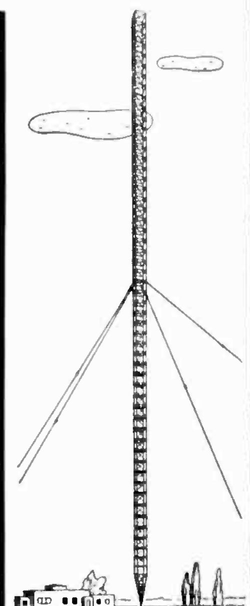
by Lapp

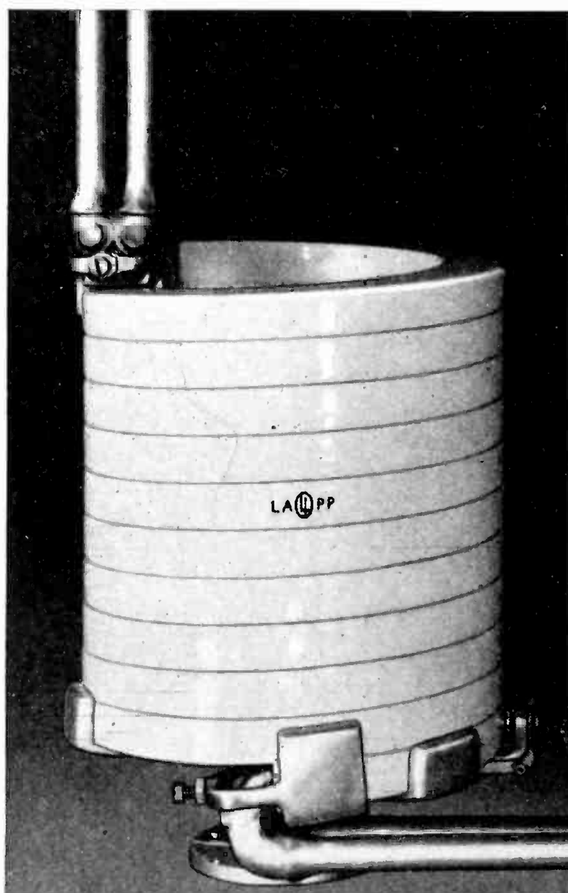
AS foremost supplier of porcelain insulation to the radio industry, Lapp realizes its responsibility for the development and production of dependable and adequate insulation equipment.

Illustrated at right is the latest development in self-supporting radiator insulation, a design which secures utmost efficiency from all materials. Tower leg footing cast integral with insulator frame—economical and easy to install. Generous porcelain cones afford maximum electrical protection. Porcelains in line with tower leg, reducing shear duty.

Below, Lapp porcelain water coil, a design that eliminates sludging. Require no cleaning, and because water is left pure, eliminates cleaning other parts of system and frequent water changes. Regularly used by all transmitter manufacturers and available for replacement in existing sets.







WRITE FOR YOUR COPY OF LAPP BULLETIN 137
DESCRIBING COILS AND STRUCTURE INSULATORS

LAPP INSULATORS

LAPP INSULATOR CO. INC — LE ROY - N.Y. - U.S.A.

MALLORY

P. R. MALLORY & CO. Inc.

MALLORY Dry Electrolytic Capacitors do not cause inter-circuit coupling

The Mallory capacitor shown is designed to restrict inter-circuit coupling. This particular unit is intended for an Auto Radio chassis where temperature and R.F. impedance are also important.

It is rated as follows:

Lug 1 8 mfd. 450 volts—1st Filter Section (Low R.F.)
Lug 2 8 mfd. 400 volts—2nd Filter Section
Lug 3 4 mfd. 150 volts—Screen bypass.
Lug 4 10 mfd. 25 volts—Cathode bypass.

The method of connecting the cathode to the container eliminates coupling difficulties. Meanwhile, vibrator hash is at a minimum as the first filter section has an extremely low R.F. impedance at from 10 to 20 megacycles, which is the region of vibrator hash frequencies.

An actual saving of $.13 per chassis was accomplished over the cost of the two separate capacitors originally specified. In addition a paper bypass capacitor was eliminated and the chassis assembly cost reduced.

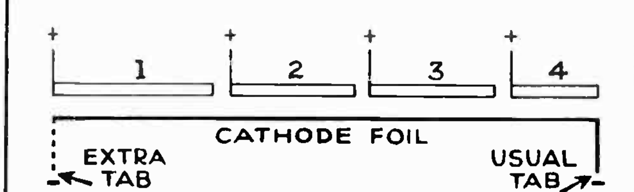
This Mallory capacitor is not a stock item. It is, however, of standard construction and was designed by Mallory engineers based on circuit information supplied by the customer.

Let Mallory engineers work with you on such problems. Submit the needed circuit information or preferably the complete chassis for a Capacitor Analysis.

P. R. MALLORY & CO., Inc.
INDIANAPOLIS INDIANA

Cable Address — PELMALLO

*Mallory Dry Electrolytic Capacitors are manufactured under U. S. patents 1,710,073; 1,714,191; 1,918,716, et al.



SCHEMATIC OF MALLORY QUADRUPLE CAPACITOR

Coupling effects noted in ordinary multiple section capacitors are caused by voltage drop in the cathode foil and an improper sequence of the anode plates. In fact, the entire matter is due mainly to mechanical rather than electrical design. The voltage drop in the cathode was corrected by the proper placing of the cathode tabs. Each tab was assured positive contact to the container by a special rivet (see arrow). The plate sequence was arranged after careful analysis of the circuit. The remarkable R.F. impedance characteristic was obtained through the proper relation between cathode and anode tabs.

ELECTRONICS

AUGUST
1937

KEITH HENNEY
Editor

Crosstalk

▶ **GONE WITH THE WIND** . . . The cover this month discloses a phenomenon never seen and rarely photographed—a multiple lightning flash blown up on itself in a high wind. When the picture was offered to us for publication we sought an explanation from K. B. McEachron, of G. E.'s Pittsfield Lightning Laboratory. Mr. McEachron, an internationally known authority on the subject, writes as follows: "The discharge path was evidently blown along by the wind. From work with a rotating lens camera it is known that a multiple stroke may consist of as many as 40 flashes, the interval between each ranging from 0.0006 to 0.53 second, and may have total duration as long as 0.93 second. With a wind velocity of 40 miles per hour, this would mean a total distance between the first and last discharges of the order of 55 feet. . . . The reason why the discharges follow the same path is that the air remains ionized for a sufficiently long period so that when the cloud again reaches a sufficient potential, due to the flowing in of charges from other sections of the cloud, a new discharge is established over the same path." The photograph was taken from the ninth floor of a building at 22 West 48th Street, New York, looking south toward the Empire State Building, behind which the flash disappeared. The photographer is in the sound-system business, is the first member of our newly established Cover Club.

▶ **GO WEST, YOUNG MAN** . . . Inside rear cover of the July issue of the *Proceedings of the Institute of Radio Engineers* heralds a new theme in the radio engineering employment situation. Originally opened to I.R.E. members seeking employment, the employment page has reversed its usual message, and this at a time when radio activity is usually dull. There are no advertisements from men seeking jobs. There are, however, four jobs looking for men; three of these in the Great Lakes area and the other location not stated.

Other indication of returning prosperity: July is the fifth month General Radio has used a silver imprint on the back cover. Nor must we overlook the technical achievements—on the part of the printer in making silver ink stick to oatmeal gray stock.

▶ **FISHBONES** . . . In a spread of pictures made at the pole-raising fete of RCA Communications, published in *Electronics*, May 1, it was stated that the fishbone antennas were developed by Mr. Beverage, who points out that Mr. H. O. Peterson did the work on these structures and that the patents were taken out in his name.

▶ **WIDE BAND** . . . Taking exception to the Crosstalk item in June which stated that manufacturers were not wise in widening the response band of home receivers, chief engineer of one of the largest companies (Middle West) reported on his experiences. The laboratory men had "gone to town" with an 8000 cycle receiver. They were enthusiastic. At last good reception was possible; sales would be heavy.

In the field, however, the control was used more as a selectivity control rather than as a fidelity improver. No one kicked about the set; but no one seemed to notice that it sounded better. Most people merely used the radio as a background noise-maker anyhow and never discovered that it really was much better in response than what they had been used to.

▶ **RADIO'S LOSS** . . . As *Electronics* goes to press newspapers carry news of the loss to the radio industry of Annings S. Prall, chairman of the Federal Communications Commission. Member since 1934, chairman since 1935.

▶ **RUMORS** . . . Persistent rumors float around that the bottom is about to fall out of the photocell market. A large producer is reported to be ready to release a cesium type tube which will list for about one dollar. Perhaps this is what is needed to put life into the slowly progressing electron-tube-in-industry business. We have heard of several applications that would require upwards of a hundred cells or so and the inhibiting influence has been the cost per cell, about $4.

▶ **ANNUAL REPORT** . . . National Union Radio Corporation reported to its stockholders that some $45,000 had been written off to profit and loss in the year ending April 30, 1937. This loss was "occasioned by the use of certain equipment purchased during the past two years for the manufacture of metal tubes. Due to a reduced demand for this type of tube this equipment is not now being used."

Incidentally, National Union and several other tube companies showed a profit for the year's operations, some of them for the first time in their histories.

▶ **FUSES** . . . In an article on inter-office communication systems, published in *Electronics in* May, it was stated "as a rule the best time to make corrections to the incoming line is when one is positive that the building superintendent is no where near the fuse box."

The Underwriters' Laboratories point out that the alteration of wiring by unauthorized persons is not recognized as good practice and in many cases is contrary to local regulations.

GUGLIELMO MARCONI

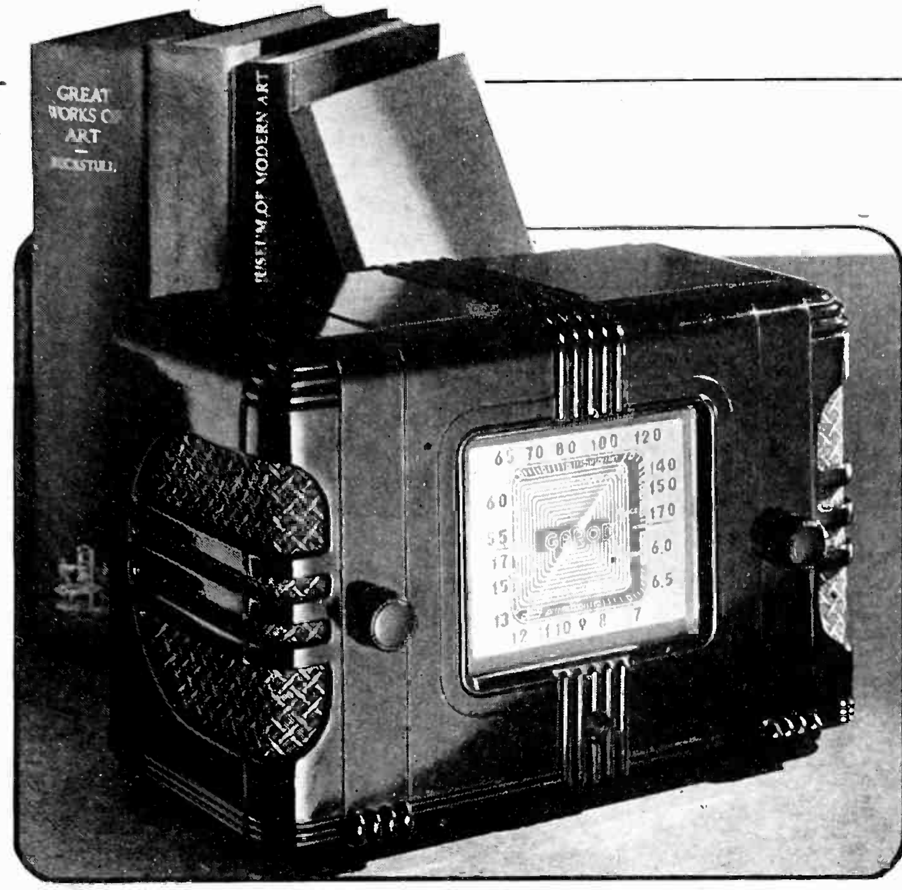
April 25, 1874—July 20, 1937

"The passing of Marconi removes one of the most significant figures of our time. His spectacular success in first sending messages across the ocean from St. John to London may be looked upon in the sense of beginning the modern development of the whole art of communications, which development is the most characteristic feature of our modern civilization."

—Robert A. Millikan in the *N. Y. Times*

Developments in 1938 Receivers

Electrical circuit developments in 1938 broadcast receivers eclipsed by mechanical features; automatic tuning controls most evident advance. Armchair sets with push buttons make operation easier than ever



Modern cabinets are being made of plastic materials in increasing numbers. This Garod receiver with twin speaker grilles as an integral part of the moulded Durez cabinet is typical of the smaller 1938 receivers

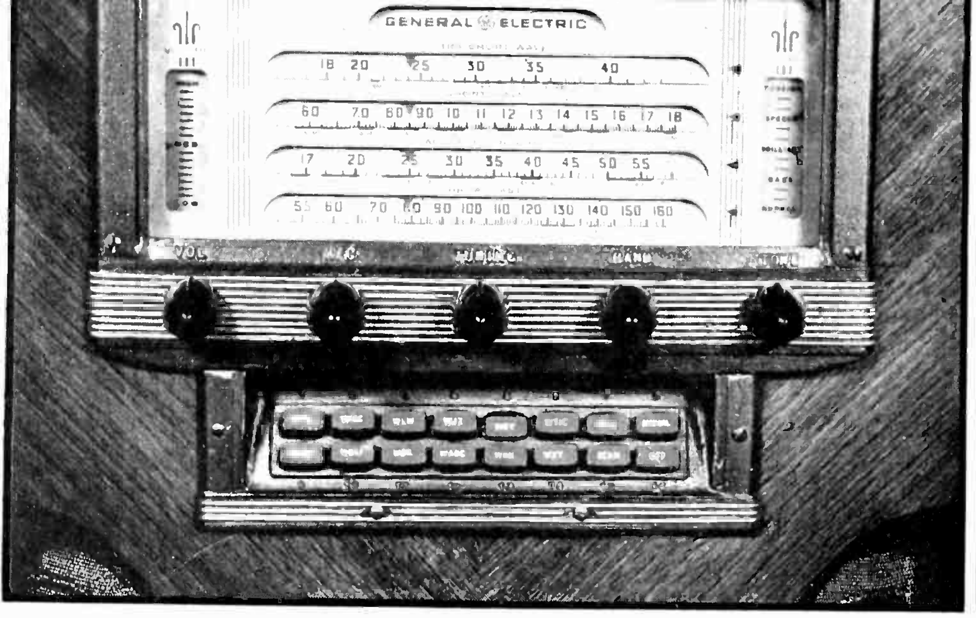
WITH particular emphasis placed on the tuning mechanisms, the dominant note in the newly announced 1938 broadcast radio receivers appears to be improvements in mechanical design and refinements throughout the entire receiver rather than new tubes, new circuits, new acoustic features or new automatic operating controls. With AVC, AFC, ASC, forms of automatic acoustic control, highly selective circuits and (if you wish to pay for them) excellent audio reproducing systems available for use in receivers, there appears to be little opportunity remaining under the present system of broadcasting for the development of new features which will change radically the functional operation of the receiver. This does not mean that electrical circuit development has reached a static stage, nor does it mean that the 1938 receivers are devoid of circuit improvements. It does mean that so far as this year's sets are concerned, mechanical design temporarily eclipses advances which have been made in the electrical circuits or in the acoustic systems.

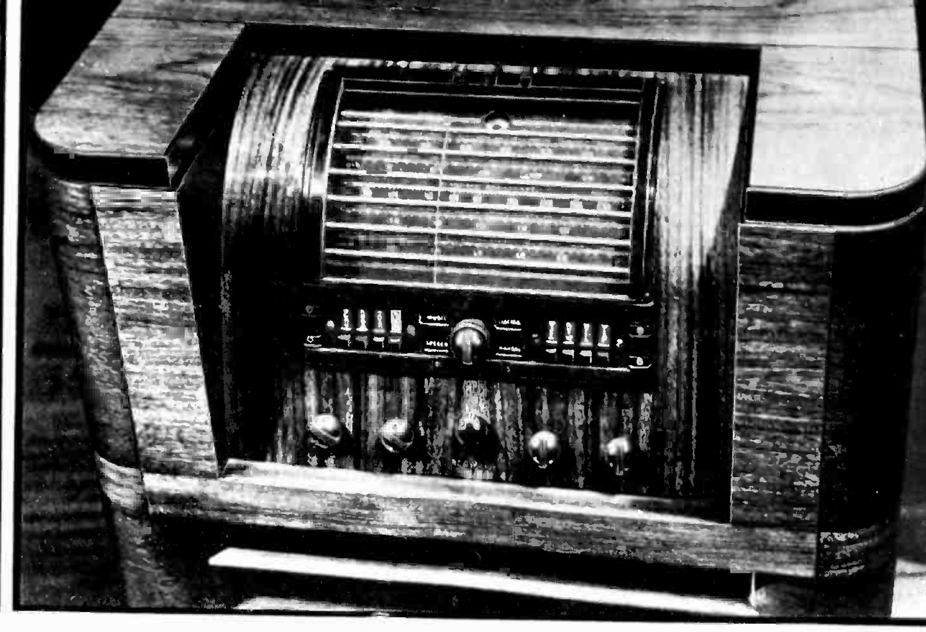
The most obvious feature of the 1938 receivers is the decided trend toward the use of mechanical tuning arrangements, almost all of which are intended to minimize the physical work and mental agility of the operator in selecting the desired program. But the appearance of the dials has, in most cases, been improved, and the controls on the receiver panel are more legible, easier to set, and more smooth and uniform in operation.

Automatic Tuning Devices

The use of telephone dial, push button, "automatic tuning," fake automatic tuning, and similar devices for selecting a limited number of programs correctly and with a minimum of effort is much in evidence, although these tuning aids are provided supplementary to the more usual rotary tuning control so that the receiver need not be restricted to the reception of a few stations. Two different systems of operation of the tuning system are used for the push button or telephone dial forms of automatic tuning. One of these is a purely mechanical arrangement in which the tuning is accomplished through the selection of the proper set of tuning or padding condensers associated with a particular push button (as in Sparton receivers) or telephone dial rotation. The other arrangement, which may be either push button or telephone dial controlled, employs a motor drive for rotating the tuning condenser shaft to the proper position for selecting the desired station. The RCA and GE sets, for example, are in this latter classification. Obviously those types of control having electrical connections between the control panel and the receiver chassis lend themselves readily to *remote* tuning control, but this feature has not been pushed very actively, probably because of the difficulty of providing simple, inexpensive, and foolproof remote volume control. RCA features remote control push button tuning in some of their models, but without remote volume control.

In the class of mechanically operated tuning controls, there appears to be no technical limitations on the number or the frequency distribution of the stations selected for push button control. However, several high quality tuning condensers, which must not change their characteristics with age, temperature, or humidity are required, and these must be adjusted by the service man





or dealer after determining from the purchaser which stations are to be selected for automatic tuning. With telephone dial tuning, not only is the number of stations which may be chosen for automatic tuning limited, but the frequency distribution of the stations is, in general, likewise restricted. This is because each finger port is usually associated with a given range of carrier frequencies to which it can be adjusted for the proper selection of only one station in that range. For example, if there are ten finger ports in the dial, each would correspond to a frequency spectrum of approximately 100 kc., and could be used to select any one of the ten channels in this 100 kc. spectrum. At the same time, other broadcast channels in this 100 kc. range could not, in general, be tuned in by using this automatic tuning feature. In general it would not be possible to select for automatic telephone dial tuning two stations 10 kc. apart, like WOR and WLW, for example.

The introduction of push button or telephone dial tuners is likely to raise a new type of service problem since none of the automatic tuning systems are intended to be adjusted by the user of the receiver. The services of a technician would also be required to realign the automatic tuning adjustments in the event of change of capacity of the padding condensers due to aging, heat, or humidity. A possible exception to the statement that a service man is required to align the set might be made in the case of RCA sets, since the automatic tuning feature used by RCA is sufficiently simple in adjustment as to be capable of being lined up by the user if proper and adequate instructions are provided.

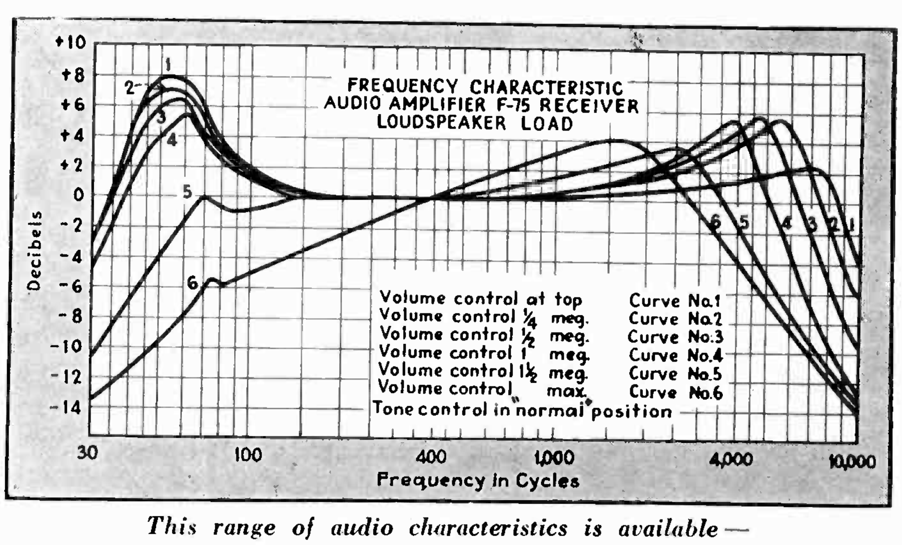
With the general acceptance of push button and telephone dial controls, drastic improvements in the frequency stability of all circuits—but especially that of the oscillator circuits—have become a necessity. Perhaps this is putting the cart before the horse and it would be more precise to say that the introduction of automatic tuning devices has been made practical and relatively inexpensive through the extended use of frequency stabilizing systems.

Two methods of frequency stabilization have gained acceptance; AFC and compensation of circuit changes against temperature (and perhaps humidity) variations. Of those receivers using automatic tuning controls, about half make use of AFC to assure that the desired program is properly tuned in for a given adjustment of the tuning system. Present indications are that there are approximately four times as many models now using AFC as had this feature a year ago. Automatic frequency control can now be found in automobile sets (GE).

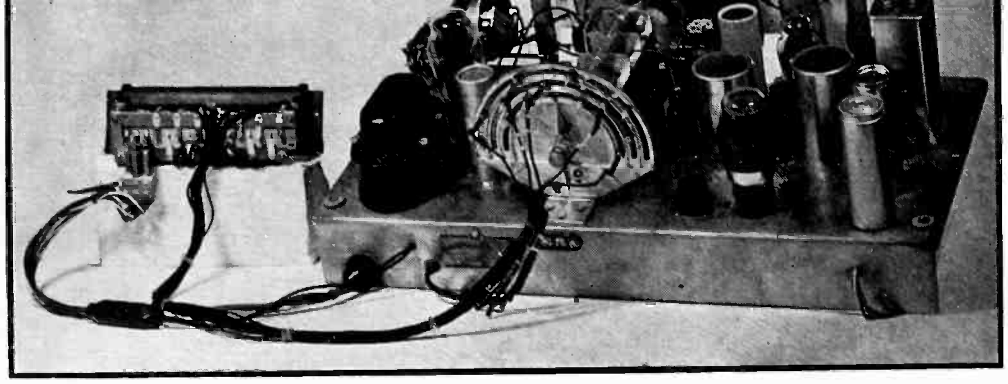
In those receivers which do not use AFC, it has been found necessary to make use of temperature compensated tuning elements to make certain that desired adjustments will be maintained throughout the life of the receiver. Wells-Gardner, for example, uses temperature compensation especially in the oscillator circuit, rather than AFC for making the receiver behave. The fact that some receivers use temperature compensation rather than AFC is further evidence of the trend toward refinement and the consideration of small details rather than to shoot the works on fancy sounding developments of considerable advertising appeal but which may, nevertheless, be of problematical value.

Increased frequency stability of the i-f circuit, high gain stages coupled with noise elimination or noise minimization, silencing or muting of the receiver between station changes, and variable or adjustable i-f band widths, trends which were initiated last year in most cases, are continued in greater degree this year. Greater stability in i-f circuits is evident, especially in the higher priced sets.

Improvements in the frequency response curve of the i-f amplifier have been effected in most cases through the use of better trans-



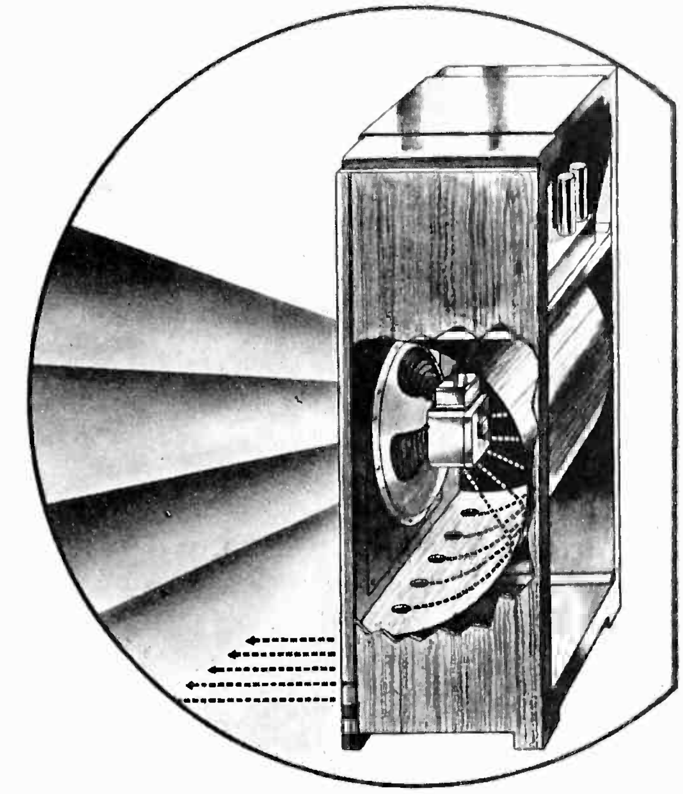
This range of audio characteristics is available—



Above—Chassis of receiver having motor driven tuning control. Thirteen stations may be selected by push buttons

Opposite page. Left—Photograph of tuning panel of this early experimental receiver indicates the trend of this year's push button sets. Right—"Overseas dial and controls," push buttons, and sloping panel; all the trimmings of the 1938 receivers

Follow the arrow and you follow the style—so say "sonic arc" proponents



formers which frequently employ three tuned circuits coupled to give the desired response characteristic. The selectivity curves are much improved over those of former years. A typical curve of the complete i-f system in one receiver gives a response which is symmetrical about the carrier frequency and extends to 4 kc. on either side of the carrier before appreciable attenuation occurs. At 12 kc. from the carrier, the attenuation is about -32 db. and crosses the response curve of an equivalent i-f system of a year ago. Thus, the improved receiver has a flatter characteristic up to 4 kc. of resonance, and a much sharper cut-off skirt than the equivalent amplifier of a year ago.

Iron core transformers seem to be used to slightly greater extent than air core transformers in this year's sets, especially where temperature compensation is used.

Approximately one fifth of the new models have variable or adjustable frequency i-f circuits. Automatic selectivity of the i-f circuit is not used to any great extent, although manual and simplified manual control is the general rule, and many of the semi-automatic or manually operated selectivity controls are tied up in some way or another with the tone control of the receiver —a feature which will probably be found in future receivers.

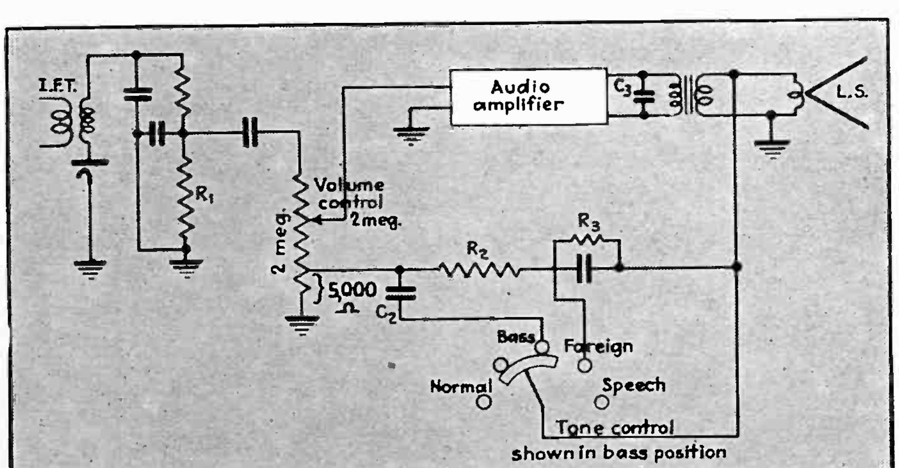
Acoustic Features

In the advertising handouts, little is being said about the purely acoustical developments of radio receivers for this year. While it is safe to assume that the acoustic characteristics of modern radio receivers are as good (if not better) than they have been in the past, the trade is relatively silent on boosting to the skies as such moth eaten weazel phrases as "high fidelity," especially when Big Bertha claims can be substantiated only by pop gun performance. The acoustic labyrinth of Stromberg-Carlson and the "magic voice" of RCA are retained. In addition, RCA has brought out an acoustic reflector arrangement known as the "sonic arc" which, it is claimed, increases the audio fidelity response. Knowles of Jensen Radio Mfg. Co., has developed a system of speakers with properly spaced ports or vents to improve fidelity characteristics of speakers; these are used in Motorola and other receivers.

Practically all receivers have acoustic compensation of some sort or another. This feature may be beneficial in many cases, but is difficult to evaluate accurately and objectively. It appears that any really worthwhile contributions are to be found only in receivers of the higher price range. Such improvements as have been made in this year's receivers consist of boosting up the low frequency response, loading the loud speaker to smooth out some of the peaks, and eliminating speaker and cabinet resonance which was objectionable in some of last year's models, especially since some peaks were at or near 60 cycles.

Negative feedback has been used in a number of receivers to assist in producing a more uniform frequency response. Some of the General Electric sets use a combination of both positive and negative feedback to obtain the desired frequency response curve. Positive feedback is used on the low frequency end and negative feedback is used at the high frequency end. The feedback control may be varied by the operator at will to give any desired effect within the range of the adjustments provided.

(*Continued on page* 42)



through the use of this feedback circuit

Directional Array Field Strengths

A method for computing the performance of directional arrays and comparing it with the performance of a single vertical radiator of the same height, useful in planning improvements in broadcast radiation systems

By A. R. RUMBLE

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THE design of a directional antenna array involves two important factors, the shape of the pattern and the absolute magnitude of the signal strength contours in the pattern. E. A. Laport has previously shown[1] how to calculate the shape of the directional pattern of an array of two vertical grounded radiators. However, his patterns are relative only, and therefore provide no comparison (except shape) between different arrays, or between an array and a single radiator. The purpose of this article is to show how to extend the usefulness of the method he uses, so as to provide comparisons.

The usual assumptions are made, i.e., each radiator is a vertical wire with its lower end very near a ground of perfect conductivity. In this article, as in Laport's, we will deal only with arrays composed of radiators of equal height. The field strength of an array will be expressed in terms of the field strength of a single radiator of the same height with the same total power input. Thus we have a direct comparison of the performance of an array and a single tower, or between two arrays.

For purposes of comparison the horizontal pattern of one radiator alone (i.e. not in the presence of other conductors) will be a circle of unit radius. If the absolute radius of this circle in MV/m at one mile is desired it can be determined from previously published data[2]. However, for comparison purposes this radius will be unity.

When operating two radiators near each other, the current in each will induce a voltage in the other. The problem then is to determine the total current in each radiator. It is not necessary to determine the actual current, but merely the ratio of current in one element of an array, to the current in a single radiator alone with the same total input power as the array.

The following symbols will be used. If the current in one element of an array is not the same as the current in the other element, then the element with the greatest current will be designated as element No. 1.

I = Current in single radiator when used alone.

I_1 = Current in element No. 1 of the array.

I_2 = Current in element No. 2 of the array.

k = Ratio of the magnitude of I_2 to I_1.

ϕ = Phase angle of I_2 with respect to I_1.

$Z_{r1} = R_r + jX_{r1}$ = Self impedance of element No. 1 alone.

$Z_{r2} = R_r + jX_{r2}$ = Self impedance of No. 2 alone.

X_{r1} and X_{r2} consist of self reactance plus any loading reactance in each antenna.

$Z_m = R_m + jX_m$ = Mutual impedance between the two elements.

$Z_1 = R_1 + jX_1$ = Total effective impedance of element No. 1.

$Z_2 = R_2 + jX_2$ = Total effective impedance of element No. 2.

By definition:

$$I_2 = kI_1$$

$$I_2 = kI_1 (\cos\phi \pm j \sin\phi)$$

And since power in array = power in single radiator alone,

$$I_1^2 R_1 + I_2^2 R_2 = I^2 R_r$$

And by Kirchoff's Laws:

$$E_1 = I_1 Z_{r1} + I_2 Z_m$$

$$E_2 = I_2 Z_{r2} + I_1 Z_m$$

Combining above equations and solving for current ratio

$$\frac{I_1}{I} = \sqrt{\frac{1}{1+k^2+2k\frac{R_m}{R_r}\cos\phi}}$$

In Laport's equations $\frac{I_1}{I}$ is always unity. By multiplying his equations by the above correction factor we obtain equations which give a comparison between the performance of a two element and a single radiator of the same height.

Horizontal Pattern

$$E_\theta = \sqrt{\frac{1}{1+k^2+2k\frac{R_m}{R_r}\cos\phi}} \times \sqrt{1+k^2+2k\cos\alpha}$$

Vertical Pattern

$$E_{\theta,\delta} = \sqrt{\frac{1}{1+k^2+2k\frac{R_m}{R_r}\cos\phi}} \left[\frac{\cos(A\sin\delta)-\cos A}{\cos\delta}\right] \sqrt{1+k^2+2k\cos(\gamma+\phi)}$$

where $\alpha = S'\cos\theta + \phi$

S' = Spacing of elements in electrical degrees or radians

Θ = Azimuth angle with respect to the line of the two elements. In same units as S' and ϕ.

A = Height of the two elements in electrical deg. or rad.

$\gamma = S'(\cos\Theta)(\cos\delta)$ = Phase difference due to difference in lengths of paths of two radiations.

δ = Angle of elevation above ground. Same units as other angles.

These are the same units as used in Laport's article except that he dealt only with quarter wave elements where $A = 90$ degrees.

Determination of R_m/R_r

Values of R_m/R_r for spacings up to one wavelength of heights of $\lambda/4$, 3λ/8, and .528λ (190 degrees) are plotted in Fig. 1. For other heights and spacings, approximate values may be estimated from the curves, and exact values may be calculated from the following formulae by G. H. Brown[3].

Example

As an example of the use of this method suppose it be desired to determine the field strength at right angles to the line of the towers of two quarter wave towers spaced .7λ with currents equal and in phase.

$$S' = .7 \times 360 = 252. \text{ degrees}$$
$$\phi = 0$$
$$\alpha = 252 \cos 90 + 0 = 0$$
$$\frac{R_m}{R_r} = -.338$$
$$E_{90} = \sqrt{\frac{1}{1+1+(2\times -.338\times 1)}}$$
$$\sqrt{(1+1^2+2\cos 0)}$$
$$= .87 \times 2. = 1.74$$

This means that in this direction 74% greater field strength will be obtained than if the same power is used in a single radiator alone. If the absolute theoretical field strength is desired it is found by determining the field strength of a single radiator alone and multiplying by the above factor. It can be found from the article[2] to which previous reference is made that the theoretical field strength of a quarter wave vertical grounded radiator is:

$$6.2 \text{ MV/m}/\sqrt{\text{watt}} \text{ at 1 mile.}$$

Multiplying this by the above factor gives the theoretical field strength of the array in this direction.

$$6.2 \times 1.74 = 10.8 \text{ MV/m}/\sqrt{\text{watt}} \text{ at 1 mi.}$$

If we square the above factor we obtain the power gain of the array.

$$E^2_{90} = 1.74^2 = 3.02$$

This indicates that using the array gives an increase of field strength in this direction equivalent to tripling the power in the single radiator. Incidently this figure checks with the figure given by P. S. Carter[5] for the power gain of two half wave dipoles in free space, which corresponds to two quarter wave grounded radiators.

It is only necessary to calculate the factor once for each complete pattern. Each radius of the pattern is multiplied by the factor. Fig .2 shows how the correction factor varies with spacing and phase angle for two quarter wave elements with equal currents. There are several points of interest on these curves. At very large spacings there is no appreciable coupling between the two elements and R_m approaches zero. If either R_m or $\cos \phi = 0$ then:

$$\left[\frac{I_1}{I}\right] = \sqrt{\frac{1}{1+k^2}}$$

and if $K = 1$

$$\left[\frac{I_1}{I}\right] = .707$$

Notice that all the curves are approaching this value at large spacings. At approximately .43λ spacing R_m also equals zero for the quarter wave elements. At this spacing the only coupling between the elements is purely reactive. Therefore all the curves pass thru the point .43λ, .707. The $\phi = 90$ degrees curve is constant at .707 since the two currents are in quadrature and there is

(*Continued on page 72*)

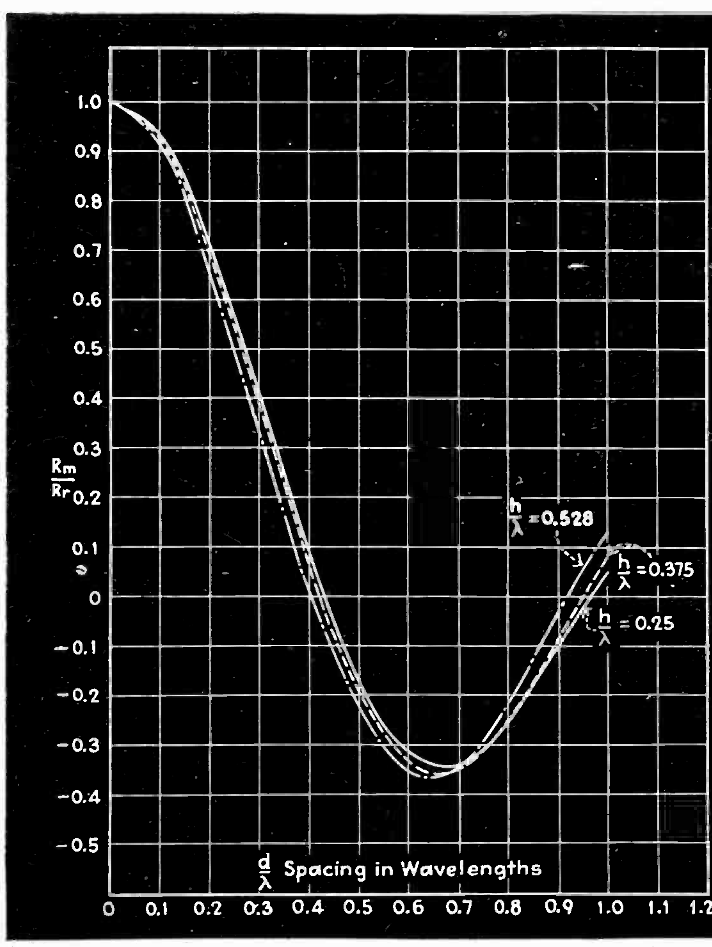


Fig. 1—Ratio of mutual resistance to self-resistance of two vertical grounded radiators

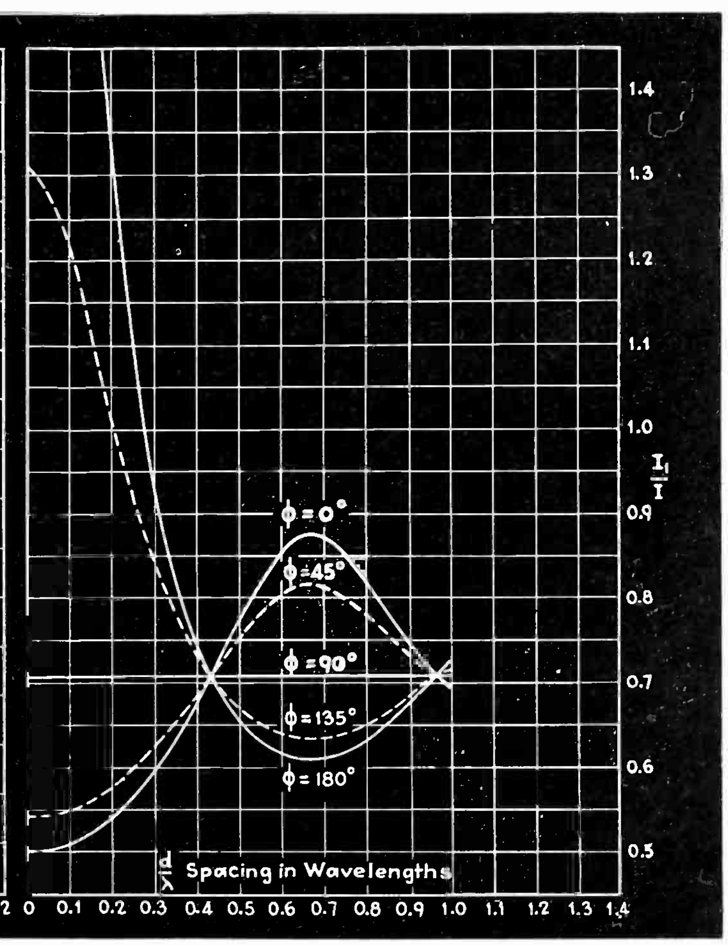


Fig. 2—Correction factor for two quarter-wave radiators

Tube Controlled Candy Wrapper

By FOSTER A. HALL
Westinghouse Electric & Mfg. Co., Grand Rapids, Mich.

A PHOTO-ELECTRIC control used by the automatic Packaging Machinery Company of Grand Rapids, Michigan, on a machine for automatically wrapping candy bars, has proven extremely practical and reliable.

The use of a photo-electric control on the machine has eliminated the necessity of closely supervising the cutting operation, and through the reliability of the apparatus it is not necessary to have an expensive technical man available at all times to service the machine.

Any automatic candy wrapping machine is in itself a complicated piece of apparatus. It is doubly complicated when it is necessary to install a mechanical means of accurately cutting the paper so that it will always have the trade-mark in the proper place after the candy bar is wrapped, and to be certain that this trade-mark is always in the same place during the thousands of operations of the machine.

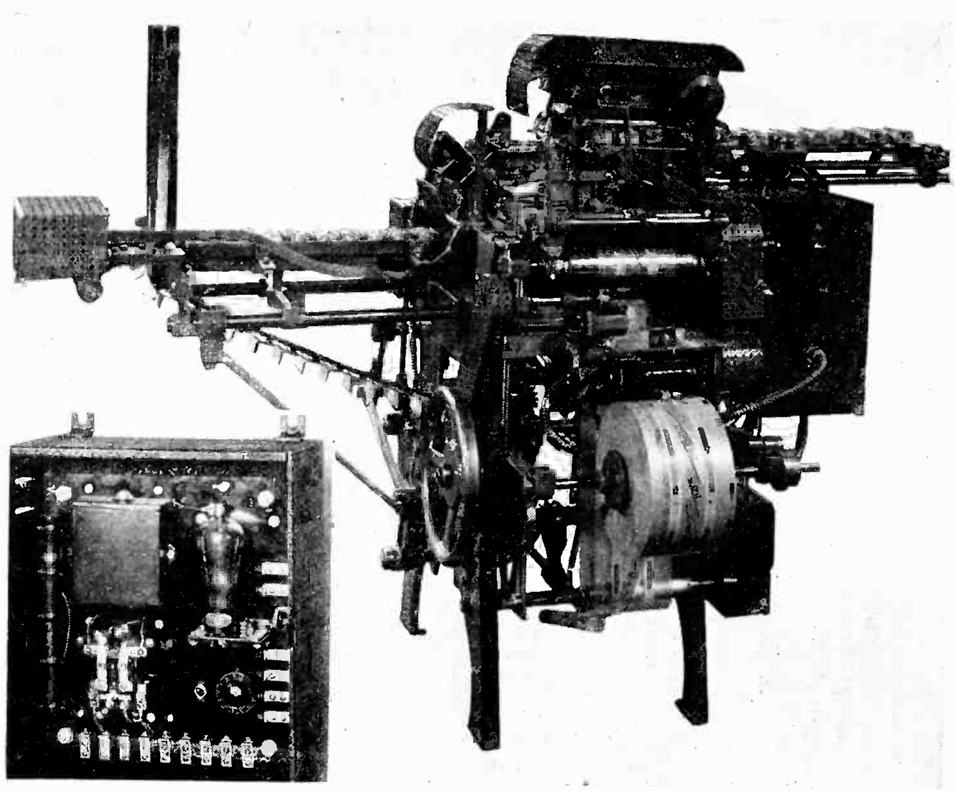
When designing the machine, the control was simplified by utilizing a light source actuated from a printed spot on the paper to time their cutter. A photo-troller with an electric eye and photo-tube and an electric solenoid furnished the basic elements. The candy wrapping machine has a maximum output of 120 candy bars per minute, and even under this severe test the photo-tube control operates perfectly and the overall operation of the machine as a whole, is such that the variation in paper lengths is less than 1/64 in.

An interesting feature is that, should the electric eye miss operation on the spot, the machine automatically cuts the paper about ½ inch longer than normal. However, in less than eight operations of the photo-troller the paper will again be back to the predetermined length with the trade-mark in the proper position.

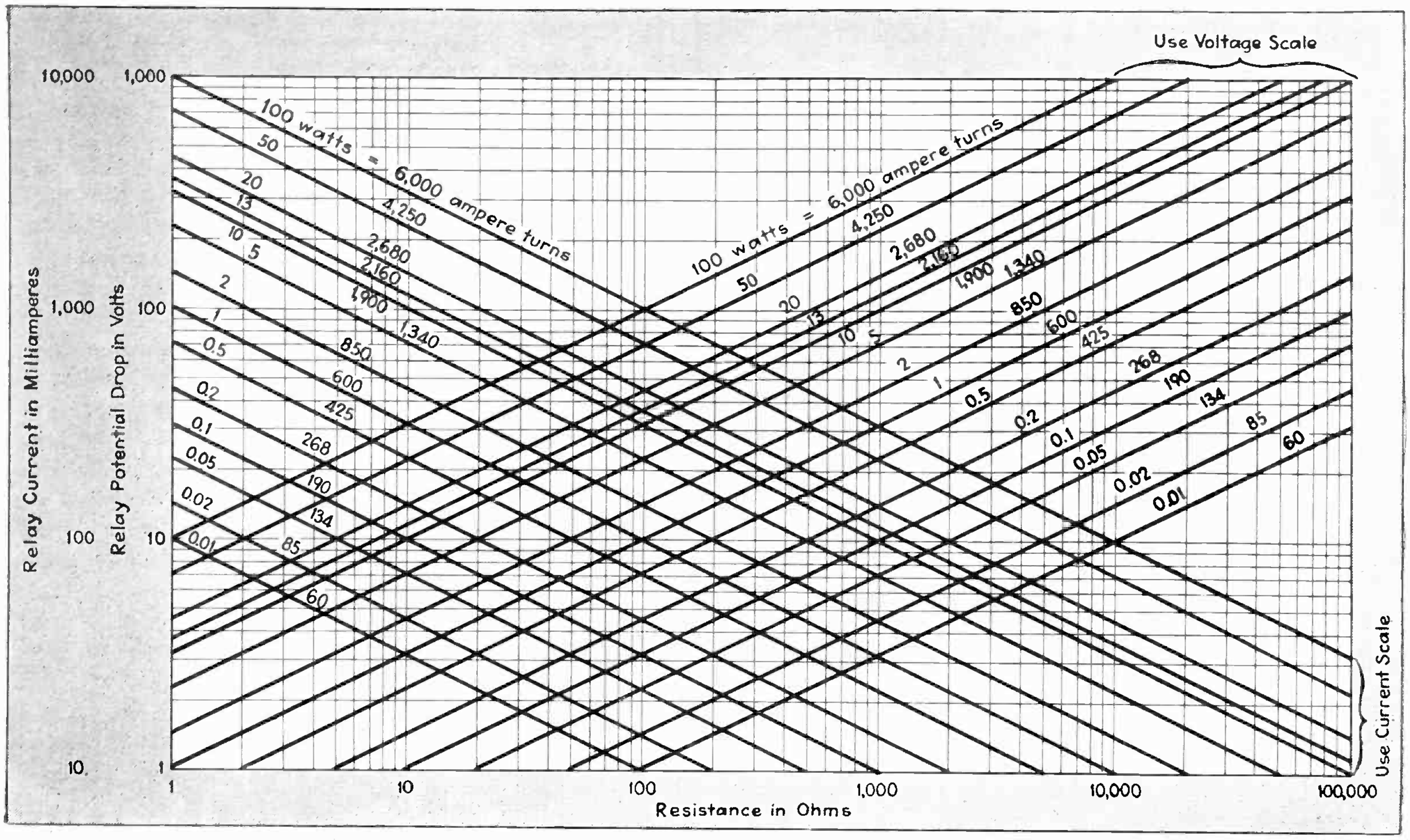
The photo-troller is mounted on the right-hand side of the machine in the black box directly below the discharge table for the candy bars, as illustrated. Two flexible conduits lead from this controller to the light source and the photo-tube. The light source is mounted directly above the paper and shows just above the roll of paper which feeds the machine; the photo-tube is mounted directly beneath the light source with about a quarter of an inch clearance through which the edge of the paper passes on which is printed the oblong black interrupter spot. This spot can be seen on the right-hand side of the paper roll.

The paper cutter on this machine is actuated by a black oblong spot printed on the paper which when passing between the light source and the photo-tube, causes an electrical impulse to trip the paper cutter. The spot is very dense to properly interrupt the light beam; and has a certain printed location with reference to the trade-mark on the paper so a satisfactory operating sequence could be obtained.

The operation of the photo-troller is based on the use of a grid glow tube, which breaks down at a certain grid voltage. Once the tube is excited it continues to pass current until the circuit is interrupted; for this reason it is necessary to have in the circuit some device which will open the circuit after the paper cutter has operated. This is accomplished by a switch operated directly from the shaft operating the paper cutter; after the knife cuts the paper the grid glow circuit is opened and is closed just before the knife is ready to make a new cut. Since the grid glow tube is only tripped on the impulse caused by the interruption of the light beam, the circuit, including the grid glow tube, is limited to approximately 35/100 of an ampere and is used to operate a solenoid which trips the cutting blade on the machine.



Under phototube control this machine wraps 120 candy bars a minute with less than 1/64 inch variation in paper length. The control unit is shown in the inset at the left



This combination chart relates five important parameters for standard telephone type relays: relay current, voltage, resistance, power consumption, and ampere-turns. These curves will be useful for design work or for preparing a chart like that shown in Fig. 2

Relays in Tube Output Circuits

Circuit conditions for developing optimum relay magnetomotive force rapidly determined by superimposing relay characteristic chart on tube static curves. Effect of variations of voltage or relay and tube characteristics easily seen

By E. E. GEORGE
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PRACTICALLY every type of vacuum tube application in the industrial field requires a relay in the plate circuit of the final tube. This article describes a method which permits a visual comparison of the tube and relay characteristics by superimposing the relay characteristics on the tube characteristics so that the origin of the relay characteristic corresponds to the plate supply voltage and zero plate current. If the tube characteristics are known it is immediately possible to determine by inspection the most suitable resistance for a standard telephone type relay coil to operate in the plate circuit and supply the maximum magnetomotive force for operating the relay. The method gives the same results as are obtained by the usual resistance load line characteristics, but by superimposing the two families of characteristics the effects of variations of either the tube or the relay parameters may be more easily visualized.

The curves presented in this article have been worked up for standard telephone type relays, since these are used more frequently than any other type in vacuum tube plate circuits. Fig. 1 shows the ratio of turns to the coil resistance for such relays. The data given is for Automatic Electric Company's relays of the AQA or similar type, assuming copper wire, enameled cotton insulation, no slugs or other accessories reducing the winding space, and coils full wound (except as noted) so as to get the maximum number of turns in the specified length and limiting outside diameter. Other makes of telephone type relays have similar characteristics. For example, this design of relay is similar to that used in much Western Electric telephone equipment. Very few standard designs have full windings where the resistance is less than 30 ohms, and the points shown to the left end of the curve are therefore for coils $\frac{3}{4}$ or $\frac{7}{8}$ of full wound, since these are the maximum available below 30 ohms.

When plotted on log-log paper, the

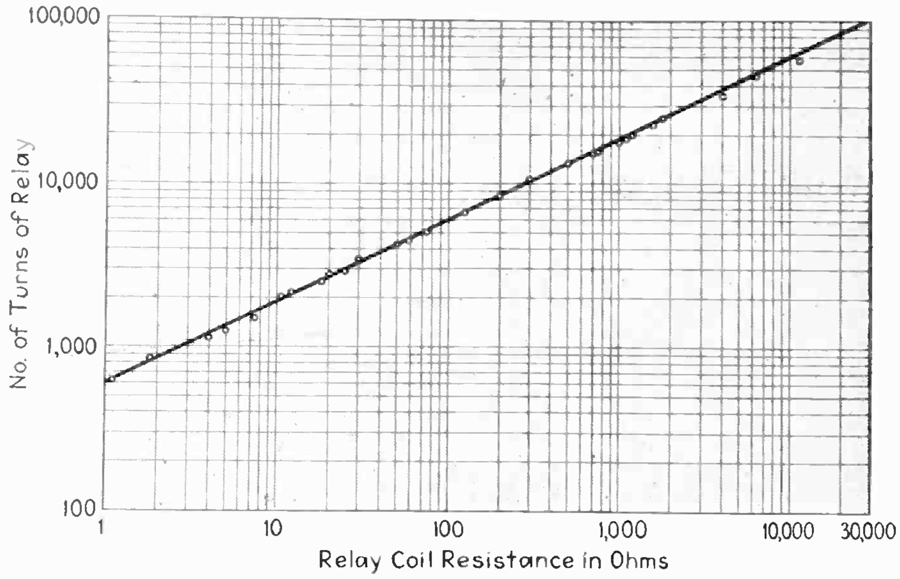

Fig. 1—Theoretical curve and observed points showing coil resistance and number of turns for standard telephone type relays

relation between the coil resistance and the number of turns in the relay may be represented by means of a straight line having a slope equal to one-half. This slope has been drawn in Fig. 1, together with the points justifying the assumption of the square root relation connecting the relay resistance with the number of turns in the relay coil. While this relation has been derived empirically it has a sound theoretical basis because of the relatively constant ratio of insulation to copper on modern enameled magnet wire and the large ratio of outside to inside coil diameter on commercial telephone type relays. The relays for which Fig. 1 applies have a winding length of $2\frac{11}{16}$ in., an outside diameter of 1 in., and an inside diameter of $\frac{3}{8}$ in.

In order to justify the graphical construction of Fig. 1 and determine the magnetic characteristics of the relay in terms of the operating voltages and current the following mathematical notations will be adopted: Let MMF = the magnetomotive force developed, T = the number of turns on the relay, R = resistance of the relay, P = the power consumed in the relay coil, I_r = the current through the relay, I_p = the plate current of the vacuum tube, E_r = the voltage across the relay coil, E_p = the voltage on the plate of the tube and E_b = the total plate supply voltage. Using this symbolic notation, we may derive from Fig. 1 the relations:

$$T = 600\, R^{\frac{1}{2}} \qquad (1)$$

$$P = E_r^2/R = I_r^2 R = E_r I_r \qquad (2)$$

$$MMF = I_r T = 600\, I_r R^{\frac{1}{2}} = 600\, P^{\frac{1}{2}} \qquad (3)$$

For a relay in the plate circuit of a vacuum tube we have the relations

$$I_r = I_p \qquad (4)$$

$$E_r + E_p = E_b \qquad (5)$$

so that the magnetomotive force produced, in terms of the tube voltage and current, is

$$MMF = I_r T = 600\, [(E_b - E_p)\, I_p]^{\frac{1}{2}} \qquad (6)$$

Equation (3) expresses the relation between the magnetomotive force in ampere-turns and the power consumption of the relay, and enables us to plot ampere-turn curves with voltage, current and resistance characteristics of the relay coil as coordinates. While the square root relation between resistance and ampere turns is true for all types of cylindrical windings meeting closely the above mentioned requirements of space factor and ratio of outside to inside winding diameter of the constant, 600, will vary for winding spaces of different size or shapes. Plotting data for full-wound coils of different size of wire on log-log paper, enables us to determine the proper coefficient for the square root relation given in Eq. (3) for windings of any size, shape, or type of material. The set of curves at the head of this article shows the family of ampere-turn characteristics plotted against relay coil resistance and relay current (or relay coil voltage) as well as the power consumption for standard telephone type relays. Since 13 watts is frequently considered a maximum continuous duty rating of telephone relays, this value is shown along with decimal and other values more convenient for graphic interpolation. Although the relay curves shown will be useful to any one employing standard telephone type relays in vacuum tube circuits, they are not used directly in the graphical method, which is the subject of this article.

The characteristic curves of a re-

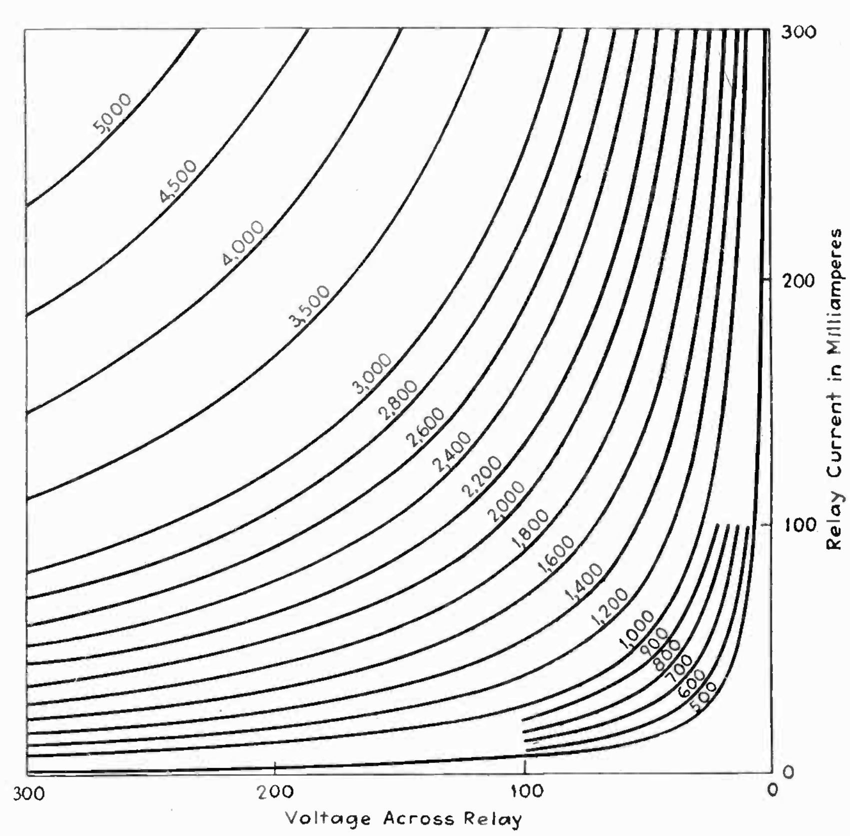

Fig. 2—Hyperbolic curves giving telephone relay ampere turns as a function of voltage and current

lay, showing the magnetomotive force plotted as a function of relay current and voltage on rectangular coordinates, are rectangular hyperbolas giving loci of equal ampere-turns. The characteristics of rectangular hyperbola* are such that a change of scale does not change their relative shapes, and it is this property which permits us to superimpose the relay and tube characteristics even though the scales may be dissimilar. By changing the scale of the hyperbolas of Fig. 2, using Eq. (3) for determining the conversion ratio, the same hyperbolic curves can be used to determine the power output of the tube under operating conditions.

The method of using Fig. 2 in connection with tube static characteristics depends upon having a copy of Fig. 2 to a scale suitable for use with tube characteristics, plotted on some transparent medium. It is essential that the voltage and current scales on this transparent scale be evident, since they must be compared with the equivalent scales of the tube characteristics in order to determine the proper multiplying factors. In using this chart it has been found useful to trim close to the axes so that the transparent chart may be superimposed on tube characteristics without removing these from their binders.

* See any book on analytical geometry or "Mathematics for Engineers" by Raymond W. Dull for properties of hyperbolas.

It will now be necessary to determine the scale ratio for Fig. 2 when used with any set of tube static characteristics. To do this compare the voltage scale on the relay characteristic with the voltage scale on the tube characteristics, and the current scale of the relay chart with the current scale on the tube characteristics. If the voltage change on the tube characteristics corresponding to a 100 volt change on the relay characteristic is E_t, and if I_t is the plate current variation of the tube characteristics corresponding to a relay current change of 100 milliamperes, then the scale multiplying factor will be

$$F = (F_v F_i)^{\frac{1}{2}} = (E_t I_t)^{\frac{1}{2}}/100 = 0.01\, P^{\frac{1}{2}} \quad (7)$$

where F_v and F_i are, respectively the voltage and current multiplying factors, and P is power in watts. An example will make this clear.

If, as shown in Fig. 3, 100 milliamperes on the relay characteristic corresponds to 196 milliamperes on the tube characteristic, the current scale factor will be $F_i = 196/100$ or 1.96. Similarly, if 198 volts on the tube characteristic corresponds to 100 volts on the relay characteristic, the voltage multiplying factor, F_v, is 1.98. The total multiplying factor will then be $(1.96 \times 1.98)^{\frac{1}{2}}$ or 1.972. Obviously, for a given set of relay hyperbolas, the scale factor will, in general, change with each new graph of tube characteristics.

Fig. 3 shows the application of the relay characteristics, applied to 6L6 tube. The origin of the relay characteristic curve is placed at the point on the tube characteristic corresponding to zero plate current and the operating plate voltage ($I_p = 0$, and $E_b = 400$ volts in this case) with the current and voltages axes of both characteristic curves parallel. The point at which the relay characteristic becomes tangent with the tube characteristic (for any grid voltage) gives the maximum magnetomotive force which can be developed under the assumed conditions. Connecting the point of tangency thus found with the origin of the relay characteristics will give the optimum load line. Conversely for given plate and grid bias voltages, we can determine the upper and lower limits of the magnetomotive force developed by the relay as soon

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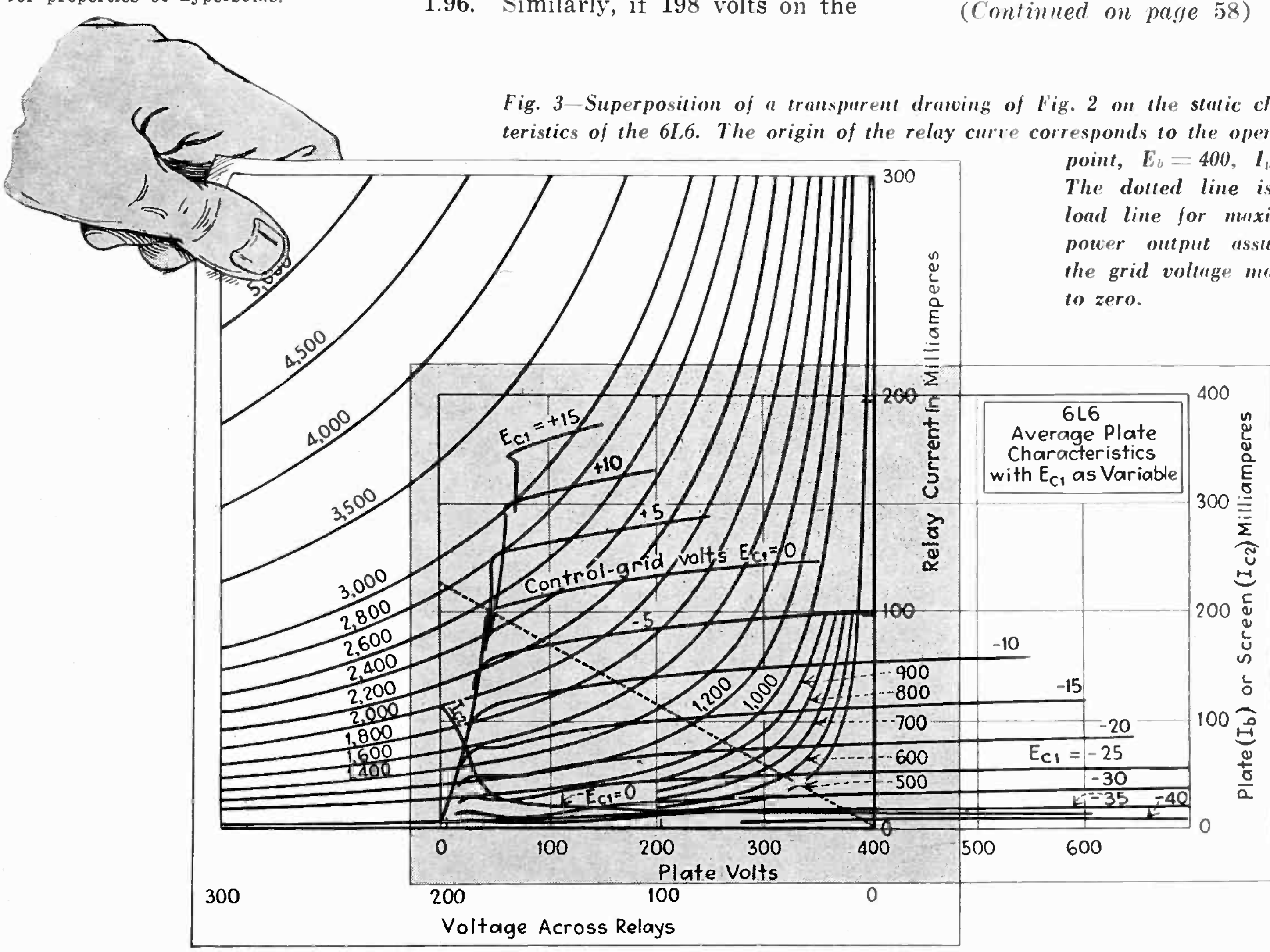

Fig. 3—Superposition of a transparent drawing of Fig. 2 on the static characteristics of the 6L6. The origin of the relay curve corresponds to the operating point, $E_b = 400$, $I_p = 0$. The dotted line is the load line for maximum power output assuming the grid voltage may go to zero.

Video Amplifier Design

Practical data, including an example, for the design of wide-band amplifier circuits, having the uniformity of frequency and phase response necessary for television receivers, transmitters, and studio equipment

By R. L. FREEMAN and
J. D. SCHANTZ

Farnsworth Television Inc. of Penna.

A VIDEO amplifier is one that is responsive to picture signals, and, therefore, is an extremely good audio as well as a very wide band radio frequency amplifier. It is used in the studio for amplification and for impedance matching purposes; in the transmitter for amplification and modulation; in the receiver for amplification, and often times in all three components of a television system as a polarity changer. In the design of such an amplifier the frequency response, phase shift and transient response must be considered.

Frequency Response

Although television in the United States is not yet commercialized it is practically certain that the standards[1] set down by the R.M.A. Committee on Television will be adopted permanently. These standards establish 441 lines, 30 c.p.s. frame frequency, 4 to 3 aspect ratio, odd-line interlacing, utilization factor of 0.8, and a 6.0 Mc. channel width for transmitters. With this set of standards the upper video frequency limit necessary to scan a pattern of vertical bars having a pitch equal to the line pitch would be 4.85 Mc. It has been found[2] that this upper limit is not necessary when equal resolution is to be obtained for both the horizontal and vertical directions. Equal horizontal and vertical resolution is obtained when the upper frequency limit is about two-thirds of that calculated from the bar pattern. This would require an upper limit of 3.1 Mc. However, the transmitter channel width of 6.0 Mc. would necessitate side bands of 2.5 Mc. since the audio channel and guard band must be considered. Hence, at present, 2.5 Mc. will be taken as the upper video limit. Observation has indicated that a maximum variation in response of about four to five db. for the whole system can be tolerated. This requires a very flat response for any one amplifier stage.

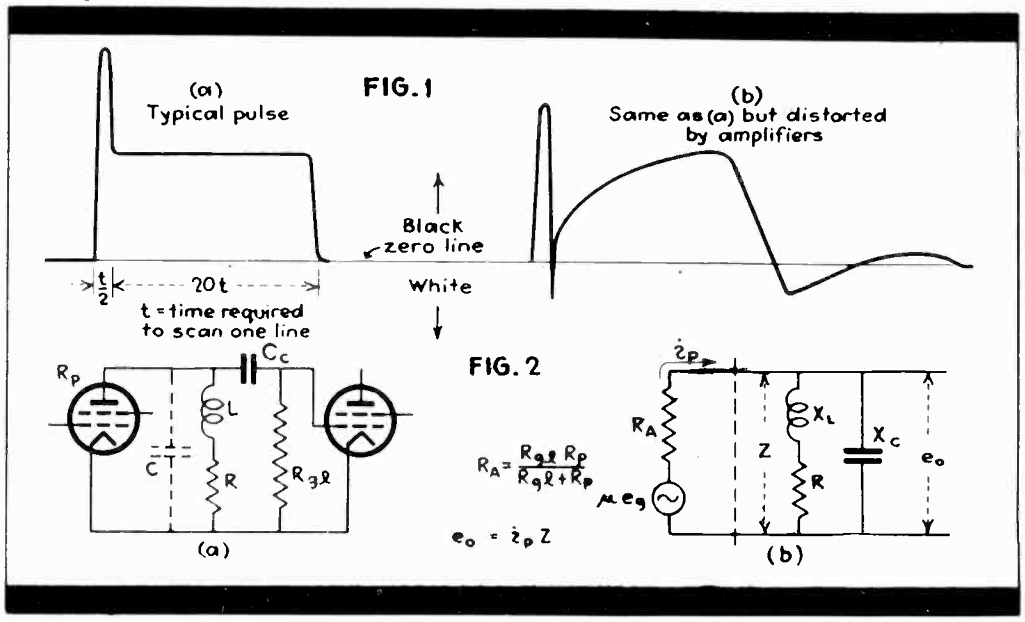

Fig. 1—Wave-form distortion results if both amplitude and phase response are not correct. Fig. 2—Actual and equivalent circuits of the video amplifier

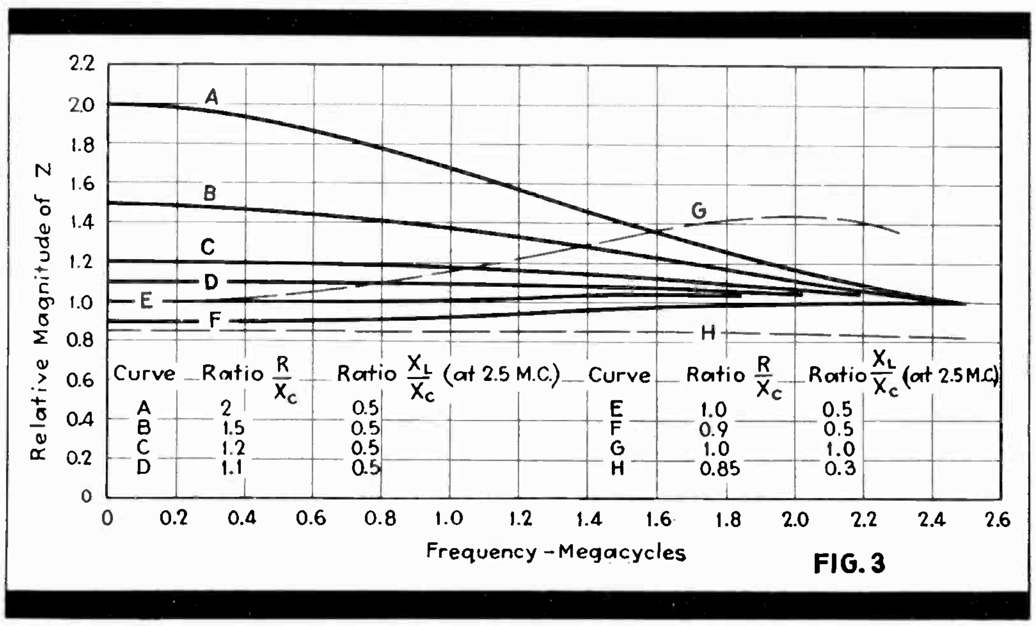

Fig. 3—High frequency response curves in terms of the relative impedance Z. To obtain the actual gain multiply Z by g_m and by X_c value at highest frequency (2.5 Mc.)

Phase Response

Television requires that the wave form of the camera signals, synchronizing pulses and blanking pulses, be preserved. It is known that the wave form will be preserved if the phase angle is proportional to frequency, or in other words, if there is a uniform phase delay for all frequencies. The phase delay T in terms of frequency f in megacycles and phase angle ϕ is:

$$T = \frac{\phi}{360 \times f} \text{ microseconds} \qquad (1)$$

The total phase delay probably is not important as long as all pulses and video signals are delayed the same, whether transmitted through the same or different channels. The permissable variation in phase delay over the video band is not accurately known. Usually any significant variations are accompanied by poor transient response. However, one may reason that picture detail necessitating frequency components up to 2.5 Mc. would lose resolution if the 2.5 Mc. component were shifted 90° greater than the tenth subharmonic component. This would limit the permissable variation in phase delay to 0.1 microsecond over a frequency band of ten to one. This is a most stringent requirement for an overall system, especially in r-f and i-f stages, but not difficult for a single video stage.

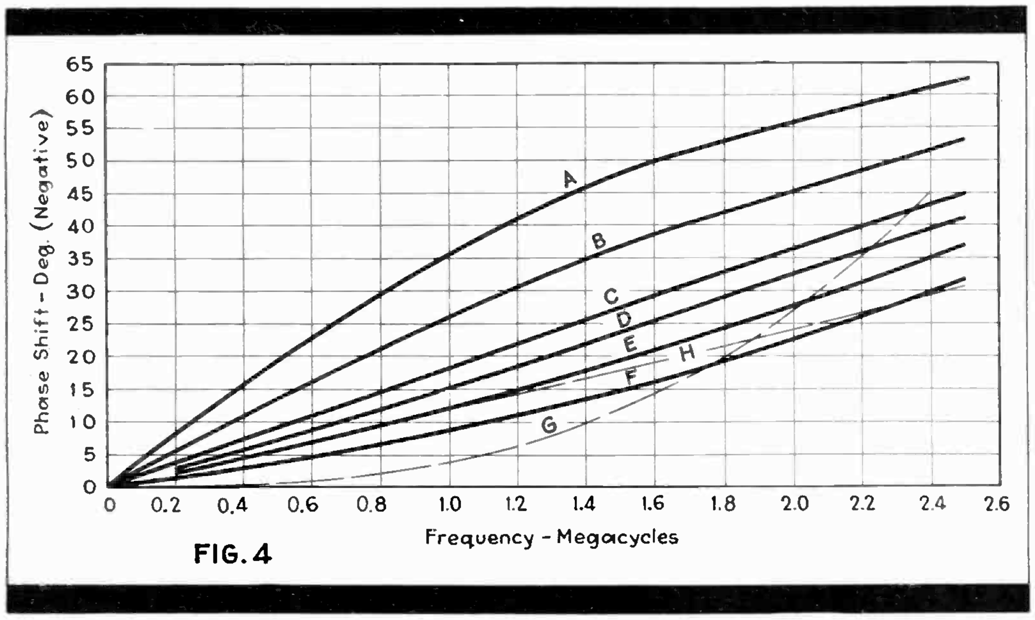

Fig. 4—Phase response curves corresponding to the amplitude response curves of Fig. 3. Curve C, being most linear, represents a desirable condition

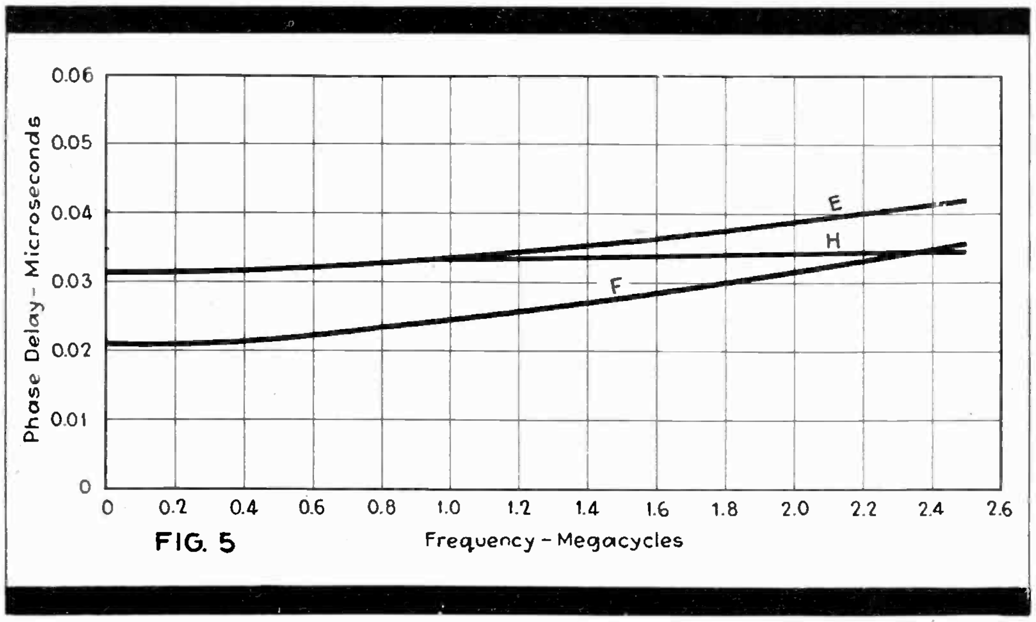

Fig. 5—Phase delay curves of Fig. 4 reduced from degrees to microseconds, showing that up to ten stages may be used without exceeding the 0.1 microsecond limit

Transient Response

Since preservation of wave form is so important in television, it follows that the response of components of a television system to impulse excitation is important. Poor transient response will give rise to two classes of effects,—loss of picture detail and annoying disturbances. The latter may be explained by a few examples which are usually most likely to occur. When a video amplifier is corrected for loss of high frequencies by haphazardly adding inductance, it is possible that this inductance may resonate with circuit capacities near the video band and give an appreciable circuit Q. Impulse excitation, caused by signal components, would then excite this resonant circuit. The picture would then show bands of white on the trailing edge for sudden changes of black to white or vice versa. If distortion of the synchronizing and blanking pulses occurs so that the resultant wave travels beyond the zero line, as shown in Fig. 1-b, white lines will occur in the picture since this is the region of picture signals and gives increasing brightness in the downward direction. Pulse distortion may also give poor return trace blanking, especially if the frame blanking pulse develops a tail. This would give an indefinite top border to the picture and also cause a vertical line to become skewed if the tail were long enough to allow the envelope of line sync pulses to deviate from a straight line.

High Frequency Response

There are several ways of designing an amplifier to give satisfactory response for video frequencies. The circuit shown in Fig. 2-a has the most advantages in simplicity and performance. It is merely the familiar resistance coupled amplifier with inductance L added to counteract the loss of higher frequencies because of the shunting capacity C. In Fig. 2-b the equivalent circuit for the high frequencies is shown. These frequencies cover the band from 10 kc. up to 2.5 Mc. The low frequency response and filtering will be considered later.

The capacity C represents stray, tube input, tube output, and feedback capacities. In using screen grid tubes of the r-f type the latter capacity is negligible; furthermore the plate resistance is more than $100 \times R$ and the circuit can be treated as one having a generator producing a current $i_p = g_m e_g$ and a voltage $e_o = i_p Z$.

The grid leak resistance R_{gl} is necessarily large compared to R and can, by Thevenin's theorem, be combined in parallel with the plate resistance R_p. The resultant, R_A, will still be large enough to allow the use of the current generator. The gain in the high frequency range will be $\frac{e_o}{e_g} = g_m Z$ when Z represents the parallel circuit of capacitive and inductive branches. The magnitude and phase angle of Z will consequently establish the frequency and phase response of the amplifier. In developing the expression for Z as a function of X_L, X_c, and R, one obtains for the magnitude of Z:

$$|Z| = \left(\frac{X_L^2 X_C^2 + R^2 X_c^2}{R^2 + (X_L - X_c)^2}\right)^{\frac{1}{2}} \qquad (2)$$

and for the phase angle of Z:

$$\phi = \tan^{-1}\frac{R}{X_L} - \tan^{-1}\frac{X_L - X_c}{R} \qquad (3)$$

It has been found that certain ratios of X_L and R to X_c (values taken at the highest frequency, namely, 2.5 Mc.) give flat frequency and linear phase responses.

The curves of Fig. 3 and Fig. 4 were computed from the above Equations for Z using as parameters the 2.5 Mc. values of X_L/X_c and R/X_c. The frequency axis represents the range up to 2.5 Mc., but may as well represent any range provided the ratio X_L to R to X_c is evaluated at the maximum frequency. For example, multiplying the abscissa by two and using the same reactance and resistance ratio would give the response of an amplifier passing up to 5 Mc.; naturally, L and C are then calculated from the 5 Mc. values of X_L and X_c. Since X_c would be half as much as at 2.5 Mc. R would be half as great to maintain the ratio, and the gain would be half that obtained for 2.5 Mc. design. It has been found that the ratio of $\frac{X_L}{X_c} = \frac{1}{2}$ gives the best compromise between gain and tolerable response distortion. Consequently, for this ratio there are several curves drawn for various values of the ratio of $\frac{R}{X_c}$ from 0.9 to 2.0. Any of this family gives a satisfactory transient response. It will be noted that for $\frac{X_L}{X_c} = \frac{1}{2}$ resonance occurs at $2.5\sqrt{2}$ Mc. and the Q is less than unity. It will be noted that the best frequency response is obtained for $\frac{R}{X_c} = 1$ or 0.9, the latter being desirable to compensate for r-f circuit side band attenuation. However, the most linear phase response is obtained when $\frac{R}{X_c} = 1.2$.

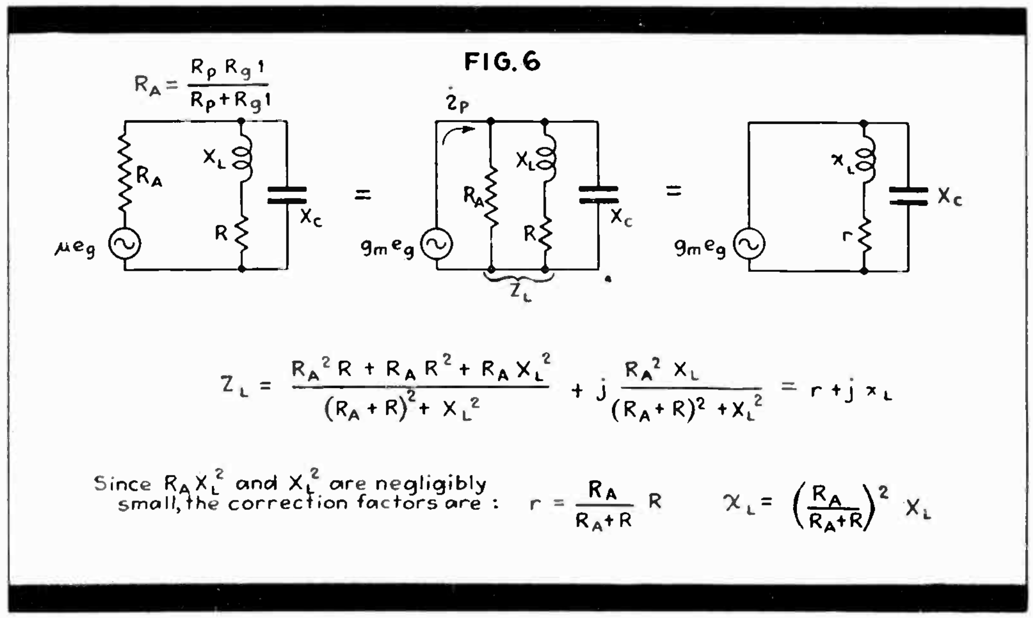

Fig. 6—Equivalent circuits when R_A is only 10 to 100 times as great as the load resistance, as in pentode and beam-power tubes

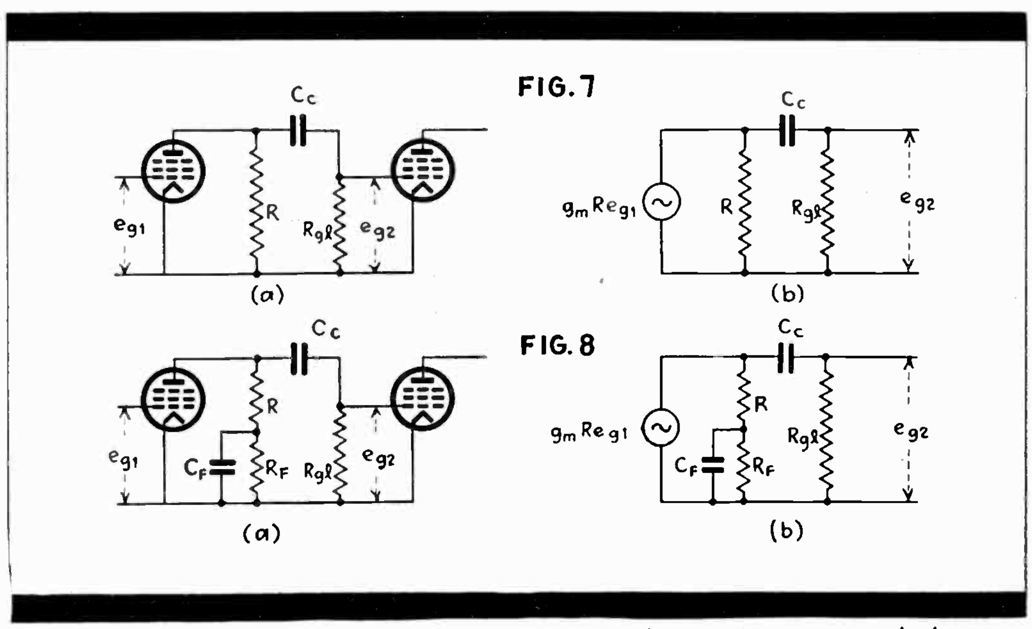

Fig. 7—Equivalent circuit parameters for low frequency response of the video amplifier. Fig. 8—Circuit including filter R_F C_F, to avoid coupling through the common plate supply

In Fig. 5 a few of the curves of Fig. 4 have been converted to phase delay as a function of frequency. From this figure we can see that up to 10 stages can be used without exceeding the previously established limit of 0.1 microsecond for variation of delay in a ten to one frequency band. The studio and transmitter amplifiers usually contain about sixteen stages for a 1 KW transmitter, taking into account line matching amplifiers. The receiver will have either zero or two stages; hence the variation in delay may become considerably greater than the stated limit. By using electron multipliers[8] much higher stage gains can be obtained with appreciable reduction in interstage networks and their attendant phase distortion.

The dotted curves of Fig. 3 indicate the performance that is obtained for $\frac{X_L}{X_c} = 1$ for one case that might be used inadvisably in trying to augment the highs. It represents a condition near the point where insufficiently damped resonance in the band might occur. One stage like this may not cause that type of trouble but several stages will certainly lessen the image resolution because of the poor phase shift response. The other dotted curve represents a condition of extremely good phase and frequency response for one set of values. However, this is obtained with a reduction in gain.

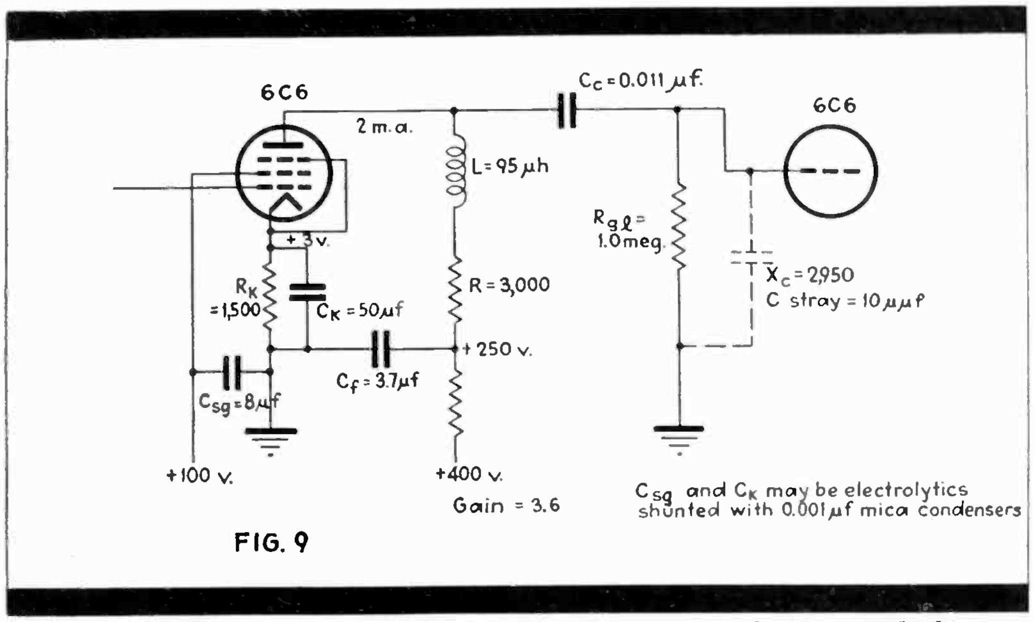

Fig. 9—A typical video stage employing a plate inductance and decoupling filter, designed from the methods presented in this article

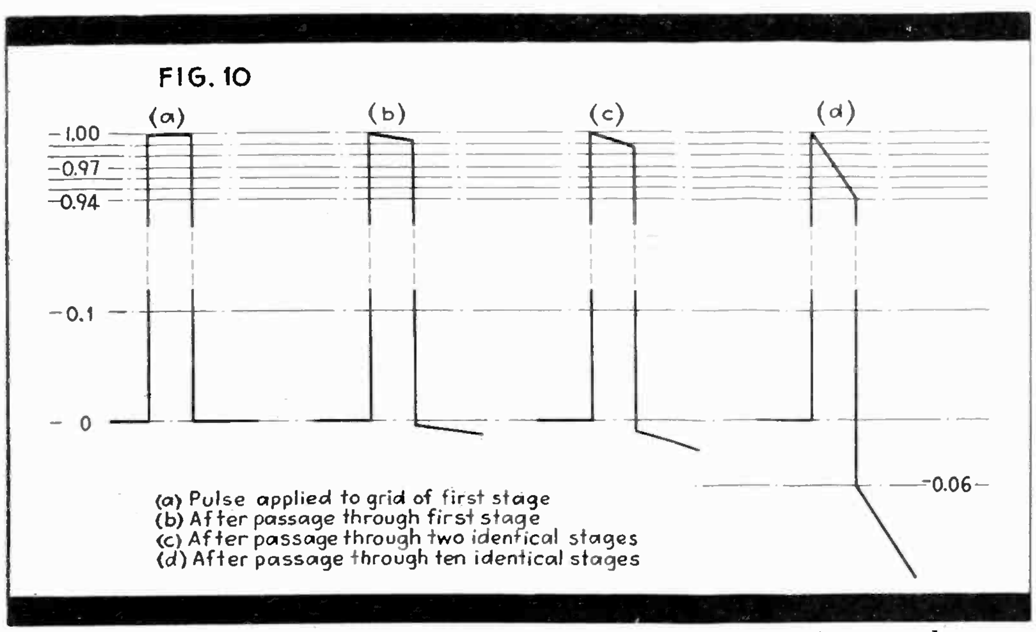

Fig. 10—Transient response to a blanking impulse lasting 0.0015 seconds

Inasmuch as the analysis so far only applies to the case where $R_A \gg R$ as in screen grid tubes, consideration may be given to other tubes. The pentode and beam power tubes are excellent video amplifiers. Here we have a condition where R_A is about 10 to 100 times R. An accurate analysis for the response in such cases is complicated. An approximate correction for the previous analysis can be used by formulating the expression for R_A in parallel with $R + jX_L$ and equating the real and imaginary components to a new pair of parameters $r + jx_L$. This is shown in Fig. 6. Hence, for $R_A = 10R$, or $r = .9R$ and for a choice of $R/X_c = 1$ we would actually use a circuit value of $R/X_c = 1.1$.

The expression for x_L would likewise follow: $x_L = 0.825\,X_L$ and for a choice of $\dfrac{X_L}{X_c} = 0.5$ we would use a circuit value of $X_L/X_c = 0.61$. This would give an error of less than 3%.

Since the gain of a video stage depends on the value of X_c at maximum frequency as well as the mutual conductance, it can be seen the figure of merit of a tube as a video amplifier is the ratio of mutual conductance to interelectrode capacities. The table (page 60) gives a few of the tubes having a high figure of merit. The acorn tubes are well suited for low level studio stages as they introduce less tube noise. For line matching amplifiers, several tubes in parallel are employed so as to prevent excessive loss because the plate resistor is placed at the far end of the line and equals the characteristic impedance of only 75-100 ohms. For parallel operation the g_m and tube capacities are multiplied by the number of tubes.

Low Frequency Response

A good video amplifier should have a low frequency gain characteristic which is flat and which is free from phase distortion at the lowest desired frequency. Since the picture repetition rate is thirty per second, it is obvious at once that it is necessary to have the amplifier pass frequencies as low as thirty cycles per second. If the response characteristic is flat at considerably lower frequencies, the contrast of the reproduced picture will be much improved.

The equivalent circuit of a conventional resistance-capacity coupled amplifier at low frequencies is shown in Fig. 7. The desirability of using multi-electrode tubes in video amplifiers is explained in the section on the high frequency response. An analysis of the equivalent circuit will show that the gain at low frequencies is:

$$G = \frac{e_{g2}}{e_{g1}} = g_m R \frac{\omega R_{gl} C_c}{\sqrt{1 + (\omega R_{gl} C_c)^2}} \qquad (4)$$

The phase characteristic will be seen to be:

$$\phi = \cot^{-1} \omega C_c R_{gl} \qquad (5)$$

It is usually advisable to filter the plate circuit of each stage of a resistance-capacity coupled amplifier in order to avoid trouble from coupling through the common plate-supply source. By properly proportioning this network, it can also be made to compensate for loss in low frequency response brought about by the increasing reactance of the coupling

(Continued on page 60)

Radio Tube Noise

Tubes make radio receivers possible. But in addition to their desired contributions of amplification, detection, rectification, they often add their quota to what the layman labels as "static"

By HUGH G. HAMILTON

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SINCE the commercialization of screen grid tubes, sensitivities of radio receivers have been greatly increased. Receivers of good quality are now designed for maximum sensitivities ranging in different types from 1 to 20 microvolts. However, the problem of background noise has been an undesirable accompaniment. A considerable amount of this noise is introduced by slight electrical fluctuations in the tubes. The effect of tube noise, due to the shot effect, gas ionization, x-rays and secondary emission on the ultimate sensitivity of an amplifier, has been considered elsewhere, [1,2,3]. In addition to these sources of noise, other electrical or mechanical variables in the tubes may, when present, set up disturbances of an even higher order of magnitude[4].

Tube noise of this type is similar in character to that occasioned by a microphonic connection or by atmospherics. The most common examples are intermittent crashes occurring when the tube undergoes vibration and sustained hissing, or squealing sounds ranging from mere audibility to an intensity sufficient to destroy reception from local broadcasters. Fortunately, due to intensive investigation of the causes of noise, manufacturers have been able to work out processing methods which have greatly reduced the earlier serious trouble.

The more important tube defects responsible for this class of noise are:

1. Variable electrical leakage deposits.

2. The presence of conducting threads of carbonaceous material lodged between elements.

3. Variable or sliding contact between metal parts, nominally at the same potential.

4. Poor welding of the elements to their lead wires and intermittent short circuits between elements.

5. Mechanical vibration of elements.

I. Variable Electrical Leakage Deposits

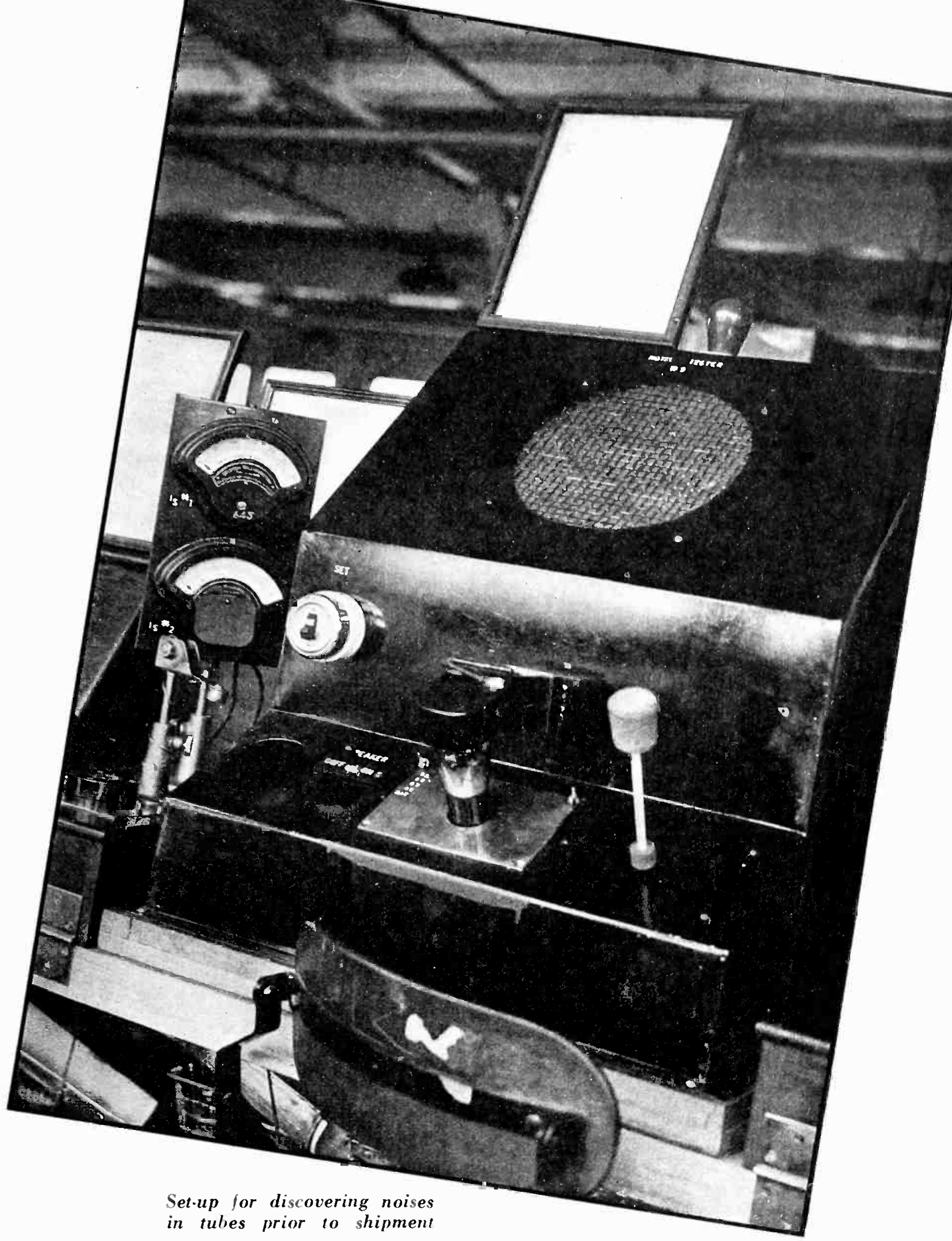
Variable electrical leakage is a prolific source of trouble and it is probably the most difficult to eliminate. The tube elements must, of course, be mechanically supported. Consideration of cost, ruggedness and uniformity have led to the adoption of insulating spacers, usually made of mica, or a ceramic material of high resistivity (Fig. 3). Calculations on a type 42 tube with mica spacers give values of 3.8×10^{6} ohms between cathode and control grid and 12×10^{9} ohms between the control and screen grids, considering the path through the mica at operating temperatures. Actual measurements on type 42 tube processed under conditions conducive to formation of leakage film give average values of the same order of magnitude as those calculated with the exception that an occasional tube may show an interelectrode conductance 1,000 or 10,000 times greater than normal. However, a test of these tubes with a group which have been normally processed shows nearly all of the former to be very noisy in comparison with the latter. This observed fact was puzzling because oscillographic observations on most tubes of the former type did not indicate the presence of any instantaneous leakage values which might cause noise yet not continue long enough to actuate a microammeter. Subsequent investigation resulted in two explanations for noise due to conductive deposits:

A. Noise may be caused by a measurable leakage path of fluctuating resistance between one or more elements in the tube. Since the elements are generally in series with high resistances, fluctuations in leakage will produce fluctuations in electrode voltages which are manifested as an audio disturbance. In addition, shock excited oscillations are evidently produced in the radio frequency circuits. The leakage must be rather severe, however, for this type of noise to become troublesome.

B. Noise may be caused by intermittent or fluctuating contact of tube elements against isolated patches of conductive deposits. These deposits are the same as those present when there is measurable leakage between elements, the only difference being that the direct path has been broken into sections so that no current flow can be observed. This class of leakage noise is particularly serious in radio frequency tubes and is more generally encountered than the class noted above. The mechanism of noise production is due to the phenomena to be described under "Variable Or Sliding Contact Between Metal Parts."

Figure 2 shows the result of passing high voltage sparks between elements over the insulator surface in tubes with high leakage. The sparks have broken up the extremely thin conducting film on the spacers. Fig. 1 shows an interesting relationship of leakage currents in an artificially applied thin film. The curve of leakage current versus applied voltage for a strip of clean mica is linear. A thin film of nickel evaporated on this mica caused the relationship to become exponential. The curve taken on a type 42 tube known to have electrical leakage is similar to that of the nickel film on mica.

It is of interest to summarize the more common causes of film formation. These are:



Set-up for discovering noises in tubes prior to shipment

(a) Distillation of nickel from the cathode, due to abnormal temperature during exhaust.

(b) Distillation of material from other metal parts in the tube which may have been raised to an abnormal temperature by the high frequency induction furnace during exhaust.

(c) Distillation of a conducting hydrocarbon residue left after partial decomposition of oils during exhaust. A small amount of oil may remain on metal parts after fabrication which may not be properly cleaned thereafter. Perspiration from the hands of the mounting operators sometimes causes trouble.

(d) Metallic deposits from condensation of the "getter" material (magnesium or barium) vaporized just before sealing off the tube.

(e) Distillation of impurities of relatively low vaporization temperatures from the metal parts.

(f) Deposit of conducting residue resulting from incomplete decomposition during exhaust of organic binder used in the cathode coating.

(g) Distillation of barium or strontium and barium and strontium oxides from cathode coating.

(h) Deposit of carbon or of a conducting hydrocarbon formed by distillation and decomposition of the carbonaceous material on the surface of a carbonized plate. A considerable amount of hydrocarbon compounds is mixed with the carbon on the plate. The high temperatures of exhaust probably crack them, the result of the reaction condensing as a conducting film.

(i) Sputtering off of easily removable oil contamination from the grids, during aging.

Leakage is largely controlled by exhaust and aging processes and by the preliminary processing of tube parts. It may be minimized most easily by suitable adjustments of these processes. The surface application to the insulating spacers of a finely divided ceramic such as aluminum oxide is also effective. In the case of mica spacers, mechanical scoring of the surface by means of a scratch brush is also helpful.

Noises due to electrical leakage are apparently created by radio frequency disturbances set up either in the film or more probably at the microphonic contact between the film and adjacent element supports. If such tubes are placed in the 1st r-f socket of a radio receiver, it is found that the application of a carrier signal causes relatively little increase in the noise. If the cause were due directly to modulation of the carrier by changes in leakage occurring at an audio rate, we would expect the noise to increase in proportion to the carrier voltage, up to the point where the carrier is modulated 100 per cent.

II. Conducting Carbonaceous Threads Between Elements

The next cause of noise is the presence of threadlike bits of conducting material in contact with one or more active tube elements. In a case of this kind, the conducting thread may carry sufficient current to be raised to incandescence by the applied voltages so that it glows like the filament in a carbon lamp. If the tube is jarred slightly the glow will often change in intensity with an accompanying change in the noise from the speaker. Incandescence becomes noticeable when a minimum of about 15 volts is applied to the elements contacted by the thread. The amount of current required to produce this effect generally lies between 10 and 50 milliamperes. If the current increases further the thread will burn out. In case the conducting material is lodged between the control grid and cathode, the high series resistors in the grid circuit will limit the current below the glow point but the production of noise will be just as serious.

Investigation has shown these threads to be bits of carbonized lint. The air circulating through the tube factory carries in suspension small quantities of light woolen, cotton or paper threads of which a large amount comes from the operators' clothing. To determine the source, glass plates coated with a thin oil film were placed in each department of a tube factory and the number of threads settling upon the oil were counted. The air outside the plant was found to be nearly free of lint, while the greatest concentration occurred in the mount department, where a large group of girl operatives work.

The longer of these threads occasionally catch between the grids of a mount during assembly. When the mount is exhausted, the intense heat carbonizes the material which then becomes a high resistance conductor.

Various means have been tried in attempting to eliminate this difficulty such as the use of air jets to blow the lint away, vacuum suction devices, or a tiny flame to burn it up, before the mount is exhausted. Probably the most successful, however, is the application of high voltage between tube elements, which fuses the carbonized lint. Another effective, although expensive, method of filtration is by circulating air in the mount department.

The presence of such carbonaceous material between elements in a radio tube gives rise to extremely loud and disagreeable frying or crashing sounds. If the resistance of the conducting path is sufficiently low, the tube may be rendered completely inoperative, and apparently dead, although this is seldom the case.

The microphonic nature of the contact between the light carbon filament and the grid wires may give rise to high frequency radiations which, in addition to the sizeable irregular voltages across the high series resistors in the radio set, account for the severity of this type of tube noise.

III. Variable or Sliding Contact Between Metal Parts

In this category is considered the production of noise by variable contact of metal parts or surfaces nominally at the same potential, or having no exterior connection. For example, one of the metal eyelets which would normally be welded to the plate support (Fig. 3) might become loosened. It will be noted that it is not intended that this eyelet carry any current and that its movement does not open or close any circuit associated with the tube. It is nominally at plate potential. Since it is still held in position by the mica spacer, a slight vibration will cause it to slide up and down on the support. On account of the microscopic surface irregularities of the eyelet and support wire, any current flowing between the two varies in strength at audio and at radio frequencies. If the eyelet gains a slight charge from stray electrons from the cathode for instance, then its discharge to the support wire will be interrupted by the variable contact, with resultant introduction of radio frequency impulses in the plate circuit, in this case. These discharges apparently occur in the form of a series of damped oscillations. It is improbable that the contact potentials of the two pieces of metal are responsible, since the effect is as pronounced with two pieces of metal cut from adjacent portions of a strip or wire.

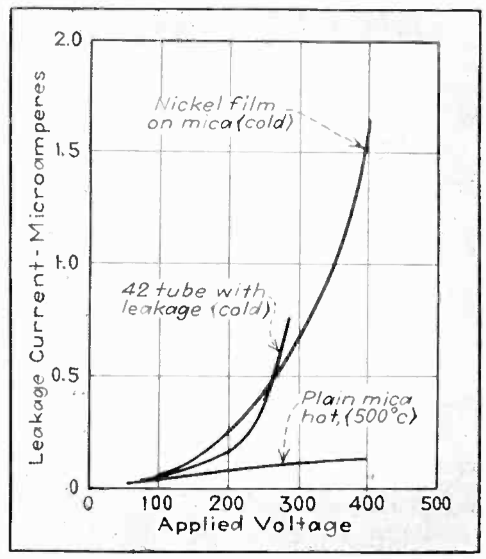


Fig. 1.—Leakage in artificially made films

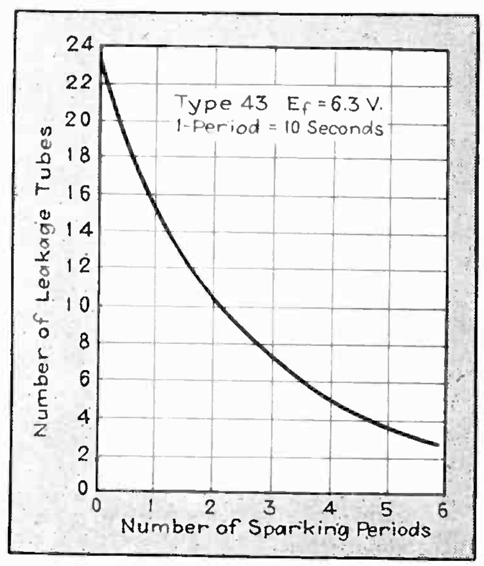


Fig. 2—Effective use of sparks to reduce leakage

In connection with an investigation of this phenomena, an experimental testing device has been made which permits, within limits, the localization of the tube element carrying the loose part, without opening the tube. This consists of a socket for the tube under test, wired to a series of low capacity switches which will connect each tube element independently either to a common ground bus or to the antenna post of a sensitive radio receiver. All wiring must be thoroughly shielded, or interwire pickup will result and it will be impossible to determine which element the fault is on. A noisy tube is inserted in the test socket and the tube jarred. If there is a loose part present, capable of causing noise in a radio receiver, the same noise will issue from the radio set to which the device is connected. By connecting each element in turn to the antenna post of the receiver, at the same time grounding all the remaining elements, the noise will in general appear only, or be much louder, in connection with the element with the loose part. Two exceptions are loose parts on either the plate or screen grid, and the case of a getter cup touching the flash. In the former case, the large area of the screen grid (with the outer cage often connected to it) and the adjacent plate gives rise to sufficient pickup within the tube so that a loose part on either one will cause about the same amount of noise to appear on both elements. The getter cup touching the flash causes noise to appear on all elements.

IV. Poor Welding of the Elements. Intermittent Short Circuits Between Elements

Nearly all parts used in the construction of a radio tube are spot welded in place. Inasmuch as an average of 25 welds are made in each tube, it is necessary to guard carefully against poor welding. If a poor or intermittent contact exists between any active tube element and its lead wire, the voltage on that element will be interrupted, and a

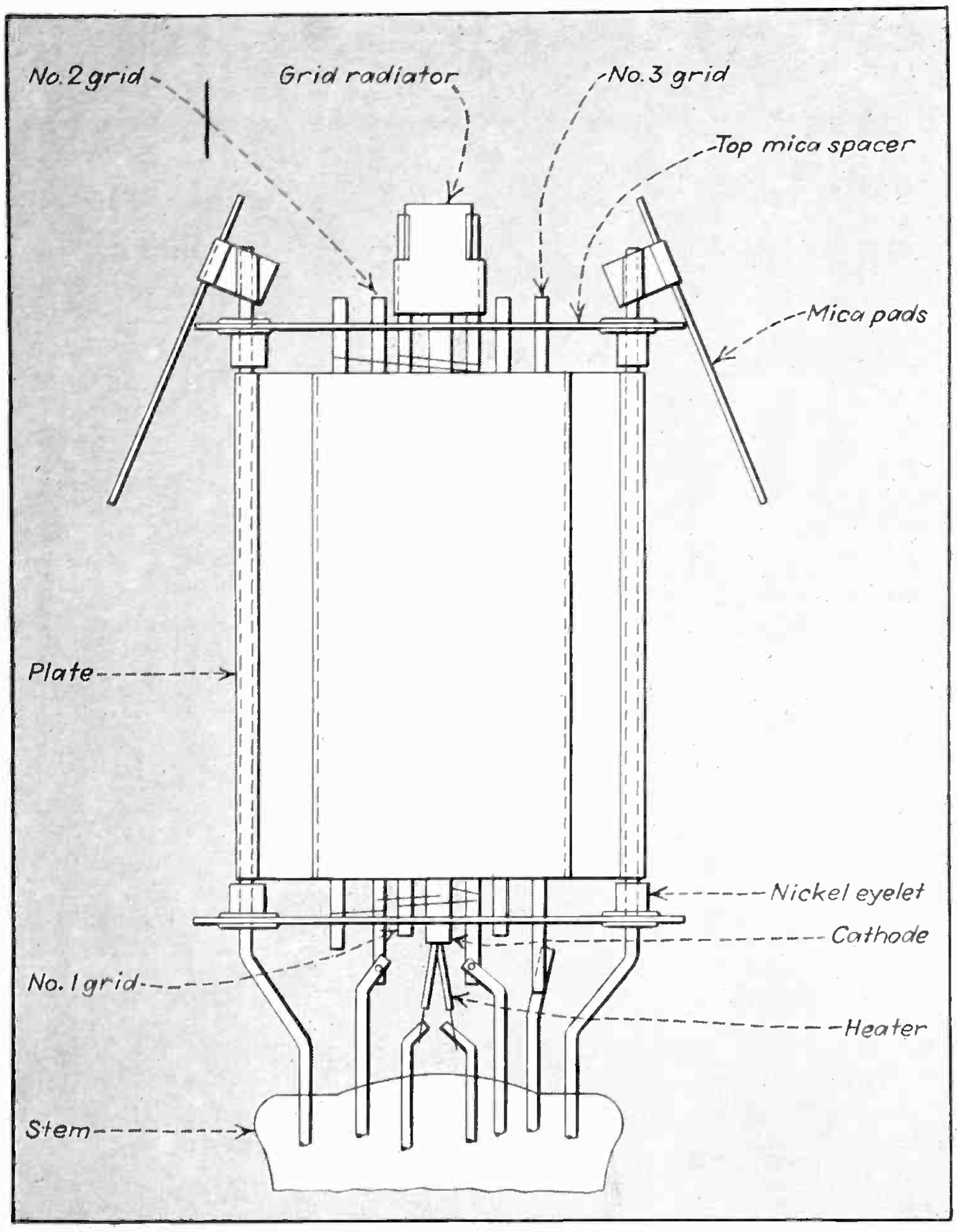


Fig. 3—Typical mount of vacuum tube showing supports

seriously noisy tube will result. In connection with this problem, thyratron, or other form of automatically timed welding is extremely helpful in eliminating as many as possible of the variable factors controlling the weld. The number of cycles through which the welding current flows, the strength of the current, and the pressure upon the weld should as far as possible be automatically controlled.

Usually, a poor connection of this nature or an intermittent short between elements is noted through flickering of the meters on the tube tester. However, the loose contact or short circuit may be present for such a brief interval that the inertia of the meter needle prevents it from following the current variation. Such tubes can generally be found with the use of a special short tester in which neon glow lamps are placed in series with each active element. Any defective tubes getting by this test are caught by a test for noise in a radio receiver (See photograph).

V. Mechanical Vibration of Elements

The effect of mechanical vibration of the elements with respect to one another, at a definite periodicity, produces what is known as "microphonic" noise. Vibration of the tubes in a receiving set by sound waves in the air, or in the chassis, may cause such elements as are not tightly locked in place to vibrate at their own natural frequency. During the changes in position, the tube characteristics change slightly in synchronism with the vibrating elements, with the result that an a-c component is introduced into the plate current. The usual sources of trouble are loose cathodes and grids in the case of heater type tubes, and filament vibration in the filament types. Early tubes were manufactured with a good deal of clearance between the holes in the insulating spacers and the element supports passing through them. In some cases, support was obtained by melting wires into a glass bead.

It has been found that the use of rigid supports, together with the reduction of clearances between spacer holes and element supports to 2 or 3 thousandths of an inch or less practically eliminates microphonism.

Detection of Noisy Tubes at Factory Inspection

It is probable that noisy radio tubes of the type discussed in this paper are the cause of more real annoyance to the consumer than any other tube defect. For this reason it is important to eliminate tubes showing any trace of noise.

A photograph of a typical factory noise tester is given here. The noise test is simply a sensitive radio set which has been adapted for production purposes. The automatic volume and tone controls have been eliminated, while provision has been made to include each tube element cross a load so that no matter how complicated the circuit may be in which the tube is ultimately used, the tube noise will have been inspected. The noise tester is thoroughly shielded by an iron case from interference by electrical equipment operating near it. The tube under test is put in a conveniently placed socket which has been wired by means of shielded leads to that part of the circuit where the tube under test would ordinarily be used. A movable shield is then dropped over the top of the tube, and the tube submitted to mechanical vibration. Any sign of noise is sufficient cause for rejection. In case the test set is installed on the manufacturing floor or other physically noisy location, a neon light is connected to the output in addition to the loud speaker for visual indication. The circuit is then adjusted so that both speaker and neon lamp operate at the slightest sign of noise from the tube under test. Input sensitivities are adjusted to 5 microvolts or less.

References:

[1] A Study of Noise in Vacuum Tubes and Attached Circuits, F. B. Llewellyn, *Proc. I.R.E.*, February 1930—page 243.

[2] Fluctuation Noise in Radio Receivers, Stuart Ballantine, *Proc. I.R.E.*, August 1930—page 1377.

[3] *Electronics*, September 1930.

[4] The investigation described in this paper was carried out at the Hygrade Sylvania Corporation, Salem, Mass.

Tubes at Work

A photocell headlight analyzer, stroboscopic studies of loudspeaker diaphragm oscillations, an a-c voltage regulator using 874 tubes on the line side of the transformer, are among this month's tube applications

Self-Generating Photocell used In Auto Headlight Testers

A COMPACT INSTRUMENT for measuring the output of automobile headlight lamps has recently been developed by a midwest manufacturer. The device consists of a funnel-shaped reflector which is placed against the lens of the headlight and a self-generating photocell which receives the light. The output of the cell is directed to a sensitive microammeter whose dial is divided into three sections indicating poor, medium and good illumination. This device checks not only the illumination of the lamp itself, but also the loss of illumination due to dust on the reflector and on the lens surfaces, both of which reduce lighting efficiency by as much as 50 per cent.

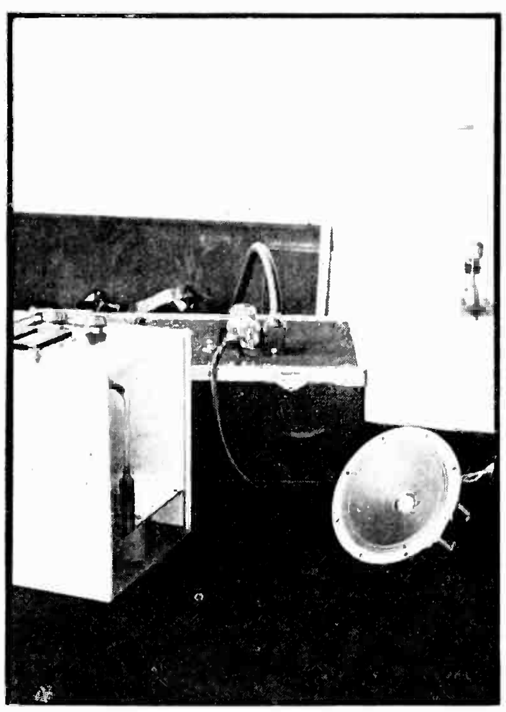
• • •

Stroboscope Aids Dynamic Speaker Design

By W. O. Rogers

Central Station Div. Westinghouse Elec. & Mfg. Co., New York

THE STROBOSCOPE has long been recognized as an aid in studying the cycle of high speed re-occurrent phenomena. To date, the principle field of application has been in the study of rotating bodies, and reciprocating motions. Recently, interesting applications have been made in the study of vibrating bodies such as diaphragms of horns and cones and diaphragms of moving coil microphones and dynamic speakers.



Studying the front surface of a speaker cone in action by means of a portable Stroboglow

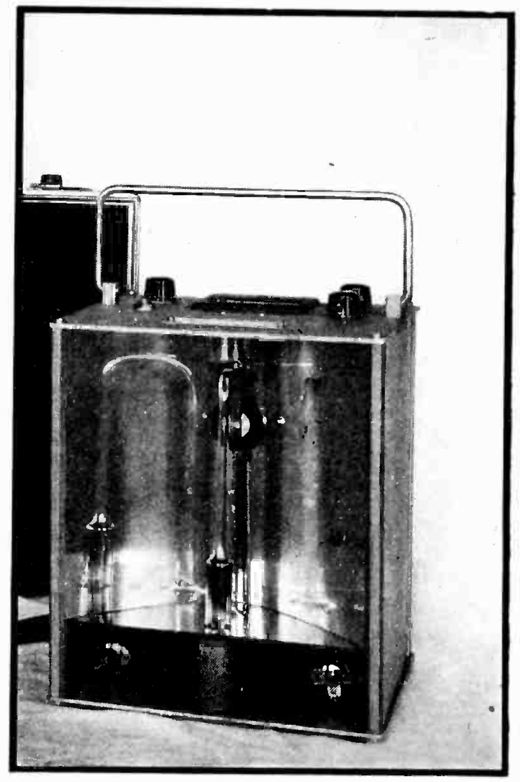
Coincident with refinements in radio transmitting and receiving equipment and circuits, manufacturers of dynamic speakers are deep in research to insure their product doing its part toward the production of high fidelity reproduction.

In this research, it has been demonstrated that dynamic speaker diaphragms do not follow a sine wave displacement when fed with a sine wave signal unless the speaker is perfect in design, manufacture and assembly. In carrying on this research, a portable stroboglow unit (see Figure) has proven an indispensable tool. The buzz which is noticed in a poor quality dynamic speaker is the result of distortion of the reproducing surface. The cause of this distortion can be one of many which may be revealed by a stroboscopic inspection. Non-uniform construction of the cone material results in a distorted cone surface which in turn results in a distorted phase-displacement curve. Such construction if extreme in character might result in rubbing of the voice coil ring on the pole of the field electro magnetic if the cone is constructed without the use of a cone spider.

Cracks in the cone surface are revealed under the stroboscopic inspection which otherwise could not be detected as the cone surface appears perfect when at rest. Loose parts, such as dust cups, voice coil loops, spiders, etc., can be observed and steps taken to remedy the conditions causing these defects. Short voice coil leads restrict the full travel of the cone while long loops may cause vibration. Either of these conditions are immediately identified as a possible cause of distortion.

The frequency of the applied sine wave signal depends on the point of maximum amplitude of cone travel. In large speakers, this is about 40 cycles per second while in smaller speakers, this frequency may be as high as 200 cycles. Since the particular stroboglow used has a speed of flashing ranging between 500 and 10,000 per minute, it was readily adjusted to give a clear image of the vibrating cone either in a stationary position or slowly moving through its cycle of motion. Such adjustments instantly reveal the presence of any mechanical defects which interfere with the ultimate performance of the unit.

Quality control in manufacture may be attained by demonstrating, before



View of the Stroboglow used in tests described

groups of the factory employees, the results of these defects and how their individual operations influence the operation of the completed product.

By the addition of a suitable phase shifting device and a calibrated high powered microscope, curves showing distortion and harmonic content may be plotted. Such research can have but one result, a larger demand because of a more perfect product.

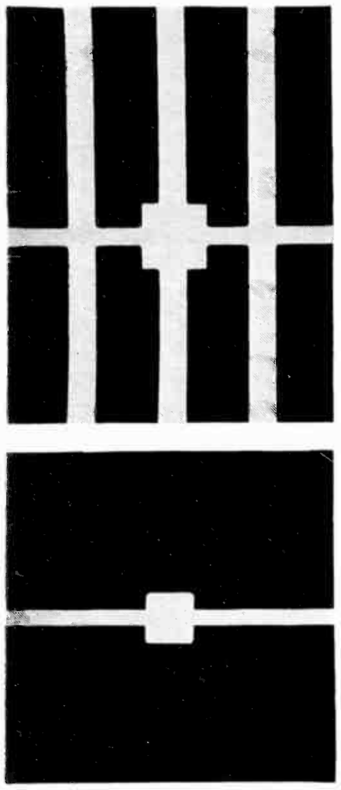
• • •

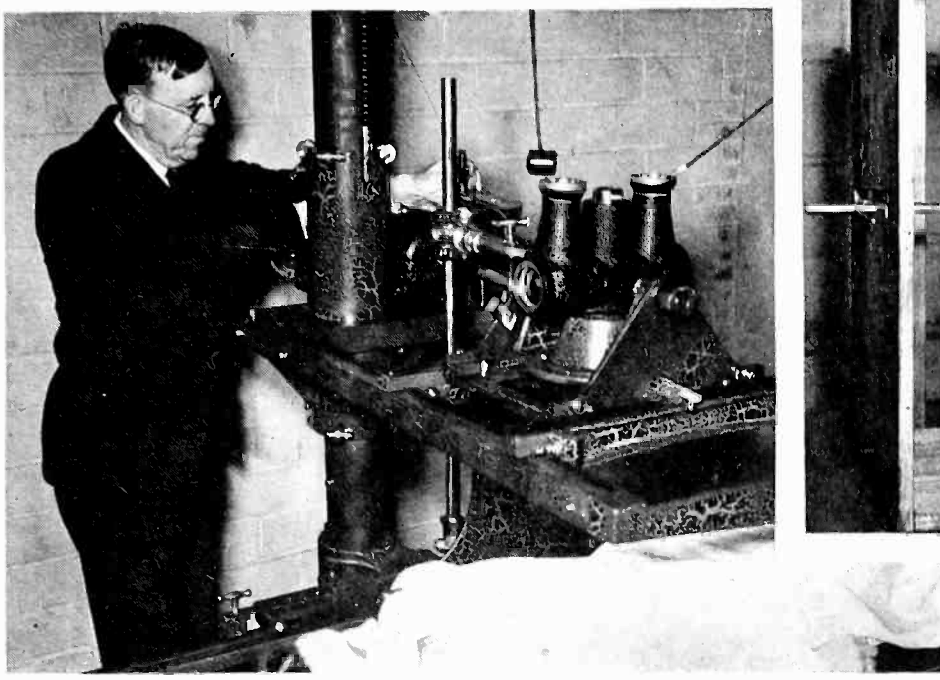
A Simple A-C Voltage Regulator

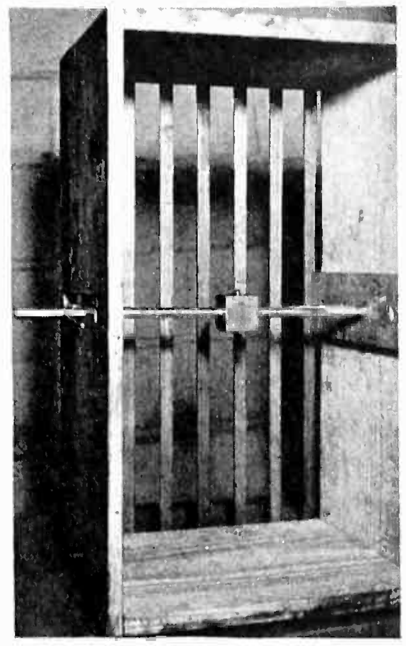
By G. F. Lampkin

THE TREND TOWARD full a-c operation of radio equipment has been very definite since the introduction of the 226 and 227-type tubes years ago. Laboratory and test equipment have, as a rule, lagged behind the general trend because their operating requirements are

STEREOSCOPIC X-RAY "SEES AROUND" OBSTRUCTIONS







By moving an x-ray tube and the photographic film in opposite directions during the exposure, Jean Kieffer of the Connecticut State Tuberculosis Hospital has succeeded in recording objects in one plane only. The box at the right when photographed ordinarily shows the image both of the bars and the cube (left, above), but with the new apparatus, only the cube is recorded. By this means it is possible to photograph parts of the body normally obscured by bones, etc., which have never been seen except in post-mortem dissection

much more stringent. In the case of the vacuum-tube voltmeter, for instance, full a-c operation is attended with difficulties due to line voltage fluctuations. This difficulty applies equally well to other classes of equipment such as precision oscillators, frequency meters, signal generators, analyzers, and so on.

The regulating scheme detailed herein is applicable to power units which are a source of plate current, or of both plate current and filament current. Plate powers upwards of 30 ma. at 200 volts d-c, plus filament loads of five watts, may be controlled. The method utilizes two neon regulator tubes of the 874 type, connected back to back across the power transformer

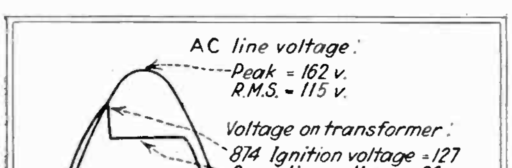


Fig. 1—Approximate waveform of voltage applied to transformer, using 874 tubes as regulators

primary. A regulating resistance is connected in the a-c supply ahead of the neon tubes. The idea is outlined in the circuit diagram shown on Fig. 2. The spread of line voltage over which the method is effective depends on the total load connected to the transformer. A light load can be regulated over a wider range of a-c supply voltage than can a heavy one, the limiting factor being the safe, rated, current on the 874 type tubes.

The theory of operation of the neon regulator tubes on d-c is rather well known. The bulb has a very flat voltage characteristic. The voltage across its terminals does not vary more than one or two volts from an average of 90, as the current changes from a low value up to the rated maximum of 50 ma. When placed across the output of a B-eliminator the tube simply soaks up any excess current which might tend to flow, either because of a higher line voltage or an easier external load on the d-c side. By drawing the excess current through the resistances of rectifier and filter, the impressed voltage is dropped to the nearly constant value of 90 volts at the regulator tube.

The regulator tubes may be operated in series across the d-c output of the eliminator to control the voltage at multiples of 90; i.e., two tubes for 180 volts, three tubes for 270 volts, etc. An advantage of regulating with the tubes on the a-c side is that the d-c voltage is not limited to multiples of 90, but may be any desired intermediate value; and, with only two tubes, d-c potentials as high as 400 or 500 volts may be stabilized. Another advantage of the a-c regulation method is that the filament supply as well as the B supply is smoothed of fluctuations.

The system is simple to put in operation, and for parts requires only standard items readily available on the market. The resultant r-m-s voltage

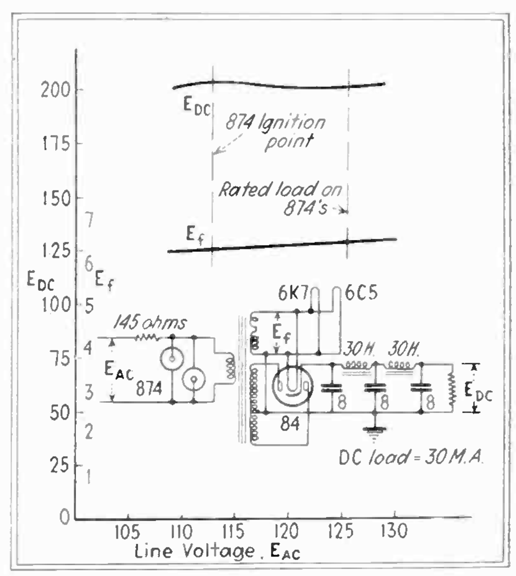


Fig. 2—Diagram and performance characteristics of power pack

on the transformer is such that the usual 5-volt and 2.5-volt filament windings, connected in series, will give close to 6.3 volts. It is advisable to use the 6.3-volt tubes because of the lower power requirements for their heaters. The same filament source of 6.3 volts will suffice to light the rectifier tube and the radio tubes in the laboratory or test equipment. This is

(Continued on page 36)

NEW BOOKS

Fundamentals of Vacuum Tubes

BY AUSTIN V. EASTMAN, Assistant Professor of Electrical Engineering, University of Washington. *McGraw-Hill Book Co., New York, 1937. (438 pages, illustrated, price $4.00)*

UNLESS ONE IS ACCUSTOMED to use the words "vacuum tubes" as a generic term for vacuum and gas filled diodes, triodes, tetrodes, pentodes, photosensitive devices, as well as for cathode ray tubes and magnetrons, there is likely to be a feeling that the title selected by Prof. Eastman is not sufficiently broad and inclusive to do justice to this new text on tubes. The book is much more than a text on *vacuum tube* fundamentals and fulfills in an excellent manner the author's intent of combining in "a single text the basic theory underlying the operation of all types of modern tubes, both radio and industrial, together with their more common applications." The industrial and communication applications are presented in an unusually well balanced selection of material. Thus the industrial engineer will find as much material for his use as the communication engineer, and this one volume should find a place in the libraries of those who desire a general background on tube matters without specializing too much in either field.

The book is a serious work, and an excellent geometrical mean between the elementary tube books and the extensive reference works such as that by Chaffee. The text is designed especially for senior students in electrical engineering, but will, no doubt, also prove useful to the practicing engineer. Bessel functions are mentioned but not discussed and little calculus (limited usually to the maximization of one quantity with respect to another) is used. Therefore as far as mathematical difficulty is concerned any senior electrical student should be able to read 95% of the book at sight with only mental checks on the equations employed. At the same time lack of extensive use of higher mathematics has not resulted in lack of rigor, for the author has managed to present the essential concepts in a straightforward and unusually clear manner. In a considerable number of cases the concepts are developed in a manner different from the usual treatment, and it appears that the final results have been obtained more directly and with less labor than with the more usual methods of approach. The essential assumptions, limitations, and concepts are clearly stated, the more important equations are indicated by means of an asterisk, and a number of very practical problems are given without answers. These pedagogical tricks of the trade are likely to be appreciated by the student and will save the time of those using the book for reference work.

Unfortunately, it is necessary to report that a number of errors exist, such as the statement on page 170 that periodic changes of 10 to 15 per second represent direct currents, the incorrect labelling of grid voltage on a diagram purporting to represent diode operation on page 313, and a number of inaccurate current wave forms in some of the high vacuum rectifier circuits of Chapter IV. In a few cases the text might have been made more rigorous by a more precise choice of words. It is only fair to say, however, that although possibly confusing to one obtaining his introduction to tubes from Prof. Eastman's book, these matters are not sufficiently serious as to cause confusion to those even only fairly familiar with tubes and their circuits. Certainly these errors and ambiguities can be corrected easily in the second edition.

Portions of the book which struck this reviewer as being unusually well done include the practical data on design of filters for rectifiers in Chap. IV, discussion of distortion in push-pull circuits on page 174, the short but concise treatment of the input impedance of triodes on page 198, and the design data for oscillators and amplifiers of the Class B and Class C variety, all of which will appeal immediately to the practical engineer.

All in all, "Fundamentals of Vacuum Tubes" can be considered an excellent job of textbook writing in the electron tube field—B.D.

Short-Wave Diathermy

BY TIBOR DE CHOLNOKY. *Columbia University Press, New York, N. Y. (310 pages, 38 illustrations. Price, $4.00).*

THIS BOOK is offered to the medical profession as an outline of short wave diathermy in its present state of development and as a survey of the laboratory and clinical work which has been carried on to date. It deals with a historical outline of the subject, diathermy equipment of both spark and tube varieties (briefly), experimentation with, technic of, and clinical applications of short wave diathermy. It summarizes with a critical yet tolerant attitude the results of some 750 books and articles listed in the bibliography. It is evident that the author has a realization of the possibilities of the beneficial effects of short wave diathermy as well as of some exaggerated claims which have been made as to the therapeutic value of short waves, but it is for the medical profession to pass on the merits of this volume as a contribution to medical science.

Most writings on diathermy appear to be lamentably weak in the field of electricity and ordinary college physics to which M.D.'s are exposed in their undergraduate courses. This book is no exception in that respect. If it is unreasonable to expect a physician to know the circuit intricacies of spark and tube equipment which he may be called on to operate, the chapter on physical principles and equipment might have been written in collaboration with a physicist or engineer with considerable improvement. The author uses such terms as "a current of one million frequency" leaving it to the reader to judge for himself whether results are to be expressed in cycles, kilocycles, or megacycles per second—a matter of some importance, especially when the specific effects of certain wave lengths are under discussion.—B.D.

Measurement of Radiant Energy

EDITED BY W. E. FORSYTHE. *McGraw-Hill Book Co., New York, N. Y. (452 pages, 224 illustrations. Price, $5.00).*

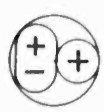
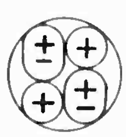
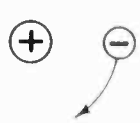
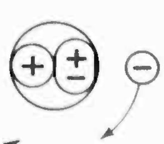
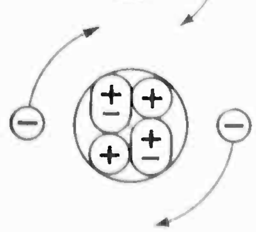
PREPARED UNDER THE DIRECTION of A. C. Hardy, H. E. Ives, and W. E. Forsythe, and written by a staff of twenty-one specialists, this volume is a compilation of modern data pertaining to radiant energy and methods of measuring it. The treatment covers radiation laws, radiation constants, care that should be exercised in radiation measurements, selective and non-selective detectors, methods of separating the radiation into wavelength intervals, and the various methods of measuring radiant energy including precautions for precise work.

Of special interest to readers of *Electronics* is Chapter VII on the "Measurement of Spectral Radiation by means of the Photoelectric Tube" prepared by Dr. L. R. Koller. This chapter deals, in a somewhat elementary manner, with the characteristics and operation of phototubes, mostly of the emissive type, rather than with photoelectric effects and theories. Emphasis is placed on the phototube as a selective device for measuring electromagnetic energy; suitable amplifying circuits are shown and suggestions for using the phototube most effectively in various portions of the spectrum are given.

Although an advanced reference book, "Measurement of Radiant Energy" is easily readible, practical, and devoid of unnecessarily lengthy descriptions. A valuable feature is the inclusion of numerous references to current literature at the end of each chapter.—B.D.

Nuclear Physics Chart

By DR. CHARLES M. LACK
Westinghouse Electric and Manufacturing Co.

Name	Picture Representation	Probable Composition	Charge	Approximate Mass	Remarks
Neutrino *	(±)	Unknown	Zero	1/2000 Unit	Undiscovered but theoretically necessary for conservation of mass energy in many nuclear transformations.
Electron	(−)	Elementary	1 Unit Neg.	1/2000 Unit	Carrier of electricity in wire conduction and vacuum tubes.
Positron **	(+)	Elementary	1 Unit Pos.	1/2000 Unit	Discovered recently. Very unstable. Probably unites with electron and both disappear. ** Particle ejected during breakdown of a large number of artificially prepared radio-active substances.
Proton	(+)	Elementary	1 Unit Pos.	1 Unit	Ordinary hydrogen nucleus or ionized hydrogen atom.
Neutron		Proton Electron	Zero	1 Unit	Discovered recently. Electron and proton are closely bound so there is no external electric charge. This enables it to penetrate matter easily until it unties with a nucleus forming an isotope usually radio-active.
Deuteron Heavy Hydrogen Nucleus Diplon		Neutron Proton	1 Unit Pos.	2 Units	Discovered recently.
Alpha Particle Helium Neucleus		2 Neutrons 2 Protons	2 units	4 Units	Given off in ordinary radioactivity.
Protium Hydrogen Atom		Proton Electron	Zero	1 Unit	Electron is separated from proton and loosely bound to it. May be ionized in discharges to form proton and free electron.
Deuterium *** Heavy Hydrogen Atom Diplogen Hydrogen Isotope		Proton Neutron Electron	Zero	2 Units	Discovered recently. Occurs one part in ten thousand of ordinary hydrogen. May be easily ionized to form a deuteron.
Helium Atom		2 Protons 2 Neutrons 2 Electrons	Zero	4 Units	Electrons loosely bound. May be ionized in discharges to form alpha particles and two free electrons.

* In certain nuclear transformations it is necessary to postulate the ejection of small chargeless particles of two varieties or else abandon the laws of conservation of mass energy. One of these particles (neutrino) has a variable mass usually less than that of the electron and the other (anti-neutrino) a negative mass of the same amount.

** Modern physics believes mass and energy are different forms of the same thing and under certain conditions can be directly transformed one into the other. The mass of an electron, for instance, is equal to the energy of an electron or proton after being accelerated through 500 KV. When an electron and positron combine and disappear, two gamma rays are produced by the 500 KV type.

*** An isotope of an element is a form of the element having the same chemical properties but different mass. The chemical properties of all elements are determined by the number of outer loosely bound electrons. Thus to form an isotope it is necessary to increase or decrease the number of neutrons in the nucleus.

Television Terms

An alphabetical glossary of words and phrases commonly used to describe the operation of television equipment, supplementary to those given in "Television Terminology", *Electronics,* June 1937

By FRANK J. SOMERS
Farnsworth Television, Inc., of Penna.

Aperture distortion:
A loss of image definition due to the finite width of the scanning aperture, the height of the aperture being equivalent to the height of one scanning line.

Aspect Ratio:
The numerical ratio of the width to the height of the picture frame area.

Automatic Background Control:
A method of automatically adjusting the background illumination of the cathode-ray reproducer by modulating the cathode-ray intensity with the d-c component of the video signal.

Black Control:
A name sometimes used for Automatic Background Control.

Composite Television Signal (R.M.A.):
By a composite television signal is meant a signal in which the combined video, blanking, and synchronizing signals are present.

Consecutive Scanning:
A method of television image scanning in which the field-frequency and the frame-frequency are identical.

D-C Video Component:
The part of the video signal due to the average steady back-ground illumination of the scene being transmitted is called the d-c Component of the video signal.

Direct Pickup:
The process of televising scenes or objects directly from life as contrasted with the transmission of film subjects.

Electron Multiplier:
A video amplifier tube in which amplification of the original electron emission (either photo-electric or thermionic) is obtained by bombarding the emitted electrons against one or more secondary-emissive surfaces.

Even-line Interlace:
An interlaced scanning field in which the number of lines scanned during each frame is an even integer.

Field Frequency (R.M.A.):
The field frequency is the number of times per second the field area is fractionally scanned in interlaced scanning.

Field Frequency Blanking Impulse:
A square topped impulse transmitted at the end of each vertical scansion of the picture field for the purpose of erasing the retrace path of the cathode ray spot at the television receiver.

Field Distortion:
Distortion of the shape of proportions of objects in the television image due to non-uniform velocity of the scanning spot, or departure from a rectilinear shape of scanning field.

Field Frequency Synchronizing Impulse:
A square topped impulse transmitted at the end of each vertical scansion of the picture field for the purpose of keeping the vertical scanning generator at the receiver in step with the transmitter.

Frame Frequency (R.M.A.):
The frame frequency is the number of times per second the frame area is completely scanned in interlaced scanning.

Frame:
A single complete picture.

Horizontal Scanning Frequency:
Synonym for "Line Frequency."

Horizontal Synchronizing Impulse:
Synonym for "Line Frequency Synchronizing Impulse."

Horizontal Blanking Impulse:
Synonym for "Line Frequency Blanking Impulse."

Ghost Image:
A spurious image usually displaced in phase from the main image and having the same or opposite polarity as the main image. (E.g. The signals generated during the retrace time of the television camera scanning produce a ghost image signal which is subsequently erased by the blanking signals.)

Iconoscope:
An electronic television camera tube in which an insulated photo-electric mosaic plate is scanned with a cathode ray beam so that the positive charges thereon are neutralized and the resulting discharge currents constitute a video signal.

Image Dissector:
A television camera tube in which an electron image which corresponds to the optical image of the scene being televised is made to move with respect to a fixed scanning aperture in such a way that the electrons so collected constitute a video signal current.

Interlaced Scanning Field:
A unidirectional rectilinear scanning field in which the field frequency is an integral multiple of the frame frequency and in which the lines traced on each fractional scansion of the picture area are made to fall evenly between those of each previous fractional scansion so as to completely scan each picture frame.

Interlace Ratio:
The numerical ratio of the field frequency to the frame frequency is called the interlace ratio.

Keystone Distortion:
An optical or electrical distortion whereby the picture field assumes a trapezoidal rather than rectangular shape.

Kinescope:
An electrostatically focused cathode ray television receiver tube.

Line Frequency (R.M.A.):
The line frequency is the frequency of the sawtooth wave used for scanning in the horizontal direction and is numerically equal to the number of lines scanned per second.

Line Frequency Synchronizing Impulse:
A square topped impulse transmitted at the end of each scanning line to keep the horizontal scanning generator at the receiver in step with the horizontal generator at the transmitter.

Line Frequency Blanking Impulse:
A square-topped impulse transmitted at the end of each scanning line for the purpose of erasing the return trace of the cathode-ray spot on the television receiver tube.

Master Pulse Generator:
A central unit used at the television studio to provide all blanking and synchronizing signals both for the transmitter and the receiver.

Magnetic Deflection:
The method of imparting lateral or vertical motion to the cathode-ray spot by means of the field produced by a coil through which the sawtooth scanning current is made to flow.

Magnetic Focus Coil:
A D-C solenoid placed over the neck of an oscillight tube for the purpose of concentrating the stream of electrons emitted by the cathode-ray gun into a fine spot on the cathode-ray screen.

Multipactor:
A cold-cathode secondary-emission multiplier tube.

Negative Polarity of Transmission:
The polarity of transmission is said to be negative when a decrease in initial light intensity results in an increase in the radiated r-f power.

Negative Picture:
The image produced when a video signal of reversed polarity is applied to the grid of the cathode-ray receiver tube.

Odd-Line Interlace:
An interlaced scanning field in which an odd number of lines is scanned during each picture frame.

Optical Focus:
The focussing of the optical image on the light sensitive cathode of an image dissector as distinguished from the electrical focussing of the electron image produced within the tube.

Oscillight:
A magnetically-focussed cathode-ray television reproducer tube.

"Pairing-Off":
Expression used to describe the condition of an interlaced scanning field when the lines traced on succeeding fractional scansions are not evenly spaced but are distributed in pairs.

Positive Polarity of Transmission:
The polarity of transmission is said to be positive when an increase in initial light intensity results in an increase in the radiated r-f power.

Picture Element:
A picture element is the smallest subdivision of the picture area defined in the process of scanning.

"Rain":
Expression used to describe the effect on the television image of a poor signal-to-noise-ratio. Under such conditions thermal agitation and shot-noise produce on effect similar to the appearance of "rain" on the television image.

Retrace Time:
The time which elapses between the end of one vertical scansion of the picture field and the start of the next vertical scansion or the time elapsing between the ending of one scanning line and the starting of the next consecutive line.

R. F. Television Signal:
The signal resulting from modulation of the r-f picture carrier by the composite television signal.

Scanning:
The process of analyzing in a predetermined manner an optical image having the dimensions width, height, and intensity for the purpose of obtaining an electrical amplitude-time function representative of the illumination intensity of each elemetary area of the original image. The amplitude-time function thus obtained constitutes a video signal.

Scanning Interference:
The effect produced on the television image by cross-talk between the video and scanning circuits.

Scanning Field:
The area traversed by the scanning spot either in dissecting or reproducing the television image.

Synchronization:
The process of keeping the scanning generators at the receiver in step with the scanning generators feeding the television camera.

Scanning Generator:
A vacuum tube circuit used to generate the sawtooth waves used for the electrical scanning of a television camera tube or a cathode-ray reproducer tube.

Telecine Transmission:
The process of transmitting motion-picture film subjects by television.

Vertical Blanking Impulse:
Synonym for "Field Frequency Synchronizing Impulse."

Vertical Synchronizing Impulse:
Synonym for "Field Freouency Synchronizing Impulse."

Vertical Scanning Generator:
Synonym for "Field Frequency Scanning Generator."

Video Signal:
The video signal is the signal generated by the television camera in the process of scanning the image being transmitted.

Tubes at Work

(*Continued from page 31*)

accomplished by grounding the heater circuit at one point, and using a 1-v or 84 type rectifier having high-potential rating between heater and cathode.

Although the operating voltage of the neon regulator approximates 90, some 120 to 130 volts are required to ignite the tube. Further, at the peak inverse voltages encountered on a 115 or 120-volt line, the tube passes current only in one direction. Therefore the form of voltage across the tube, and correspondingly across the transformer primary, is as shown in Fig. 1. On each half cycle the potential increases to the ignition voltage for the particular tube, the tube then lights, and for the remainder of the half cycle consumes enough current through the regulating resistance to maintain approximately 90 volts across itself. The action is repeated on the succeeding

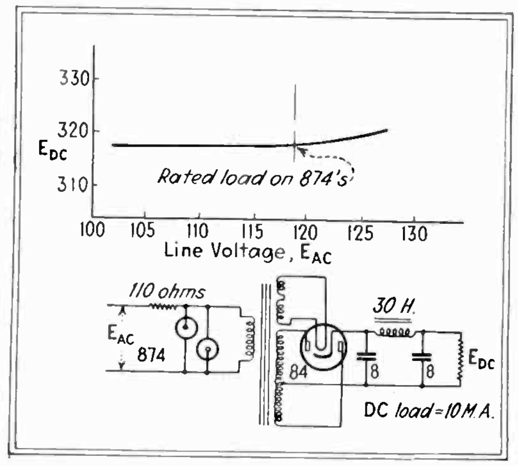
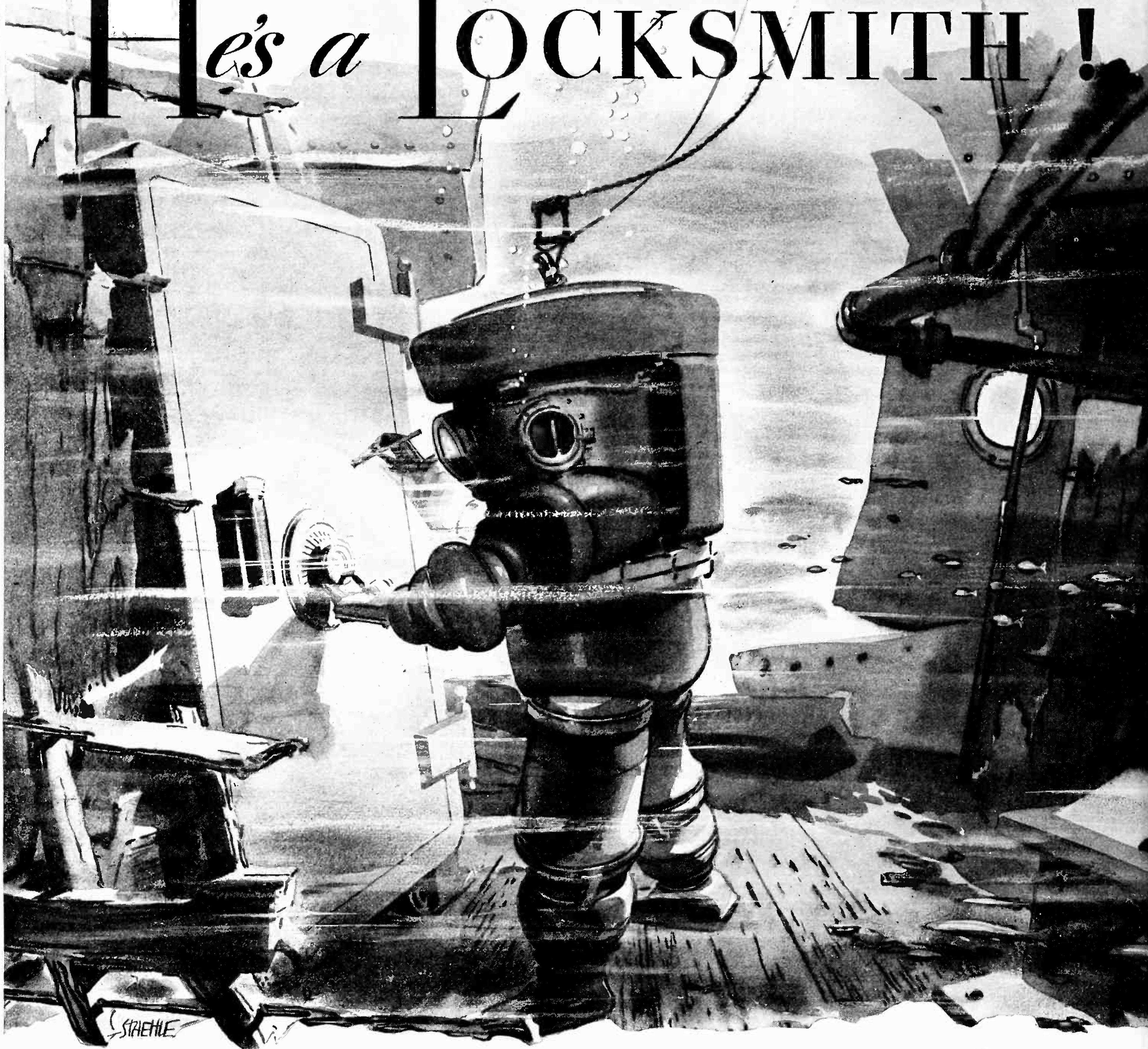


Fig. 3—Typical performance on light load

half cycle by the other tube. Since the primary current on typical transformers lags the supply voltage, the instantaneous current is at or near zero as the ignition point is approached. The instantaneous drop in the regulating resistor is respectively at or near zero, so that the full value of the a-c supply can act to boost the neon tube over the top.

It is important that condenser input be used on the filter. The stabilization of the d-c voltage will not be good if choke input is used. It is preferable to use 874 tubes having nearly equal characteristics so that they will approach their maximum current ratings at the same level of input voltage. The optimum method of design, or adjustment, is to set a minimum value of a-c line voltage, then increase the regulating resistance until the 874 tubes nearly reach extinction. The tubes then will take care of all higher line voltages up to their overload point. A 200-ohm, 50-watt, adjustable wire-wound resistor is suitable for use in the a-c line. The leveling action becomes better as

He's a LOCKSMITH!



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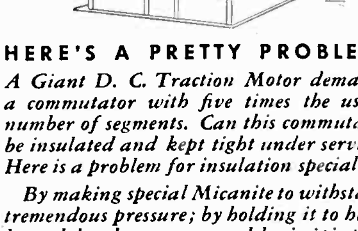

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the regulating resistance goes up; or, stated in another way, a range of 110 to 130 line volts can be controlled more satisfactorily than can 100 to 120 volts.

In Figs. 2, 3, and 4 are operating data on different layouts, showing what may be expected from the method. The first curve in Fig. 2 shows regulation for a fairly heavy load. The d-c side supplied 30 milliamperes at 200 volts, while the filament windings lighted two 0.3 ampere tubes in addition to the 84 rectifier tube. For a spread of 16

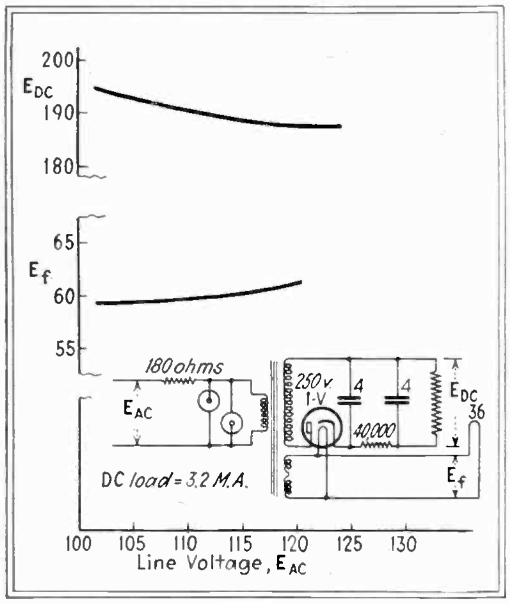


Fig. 4—Unit which displays negative characteristic

per cent on the line voltage from 110 to 128 volts, the filament voltage varied a total of 3.2 per cent. The plate voltage did not depart more than 0.75 per cent from the average, over the same range. The filter was a two-section type using iron-core chokes. The 874 tubes came into action at the point noted, having been extinguished at the lower a-c voltages. The rated load point on the 874 tubes also is shown.

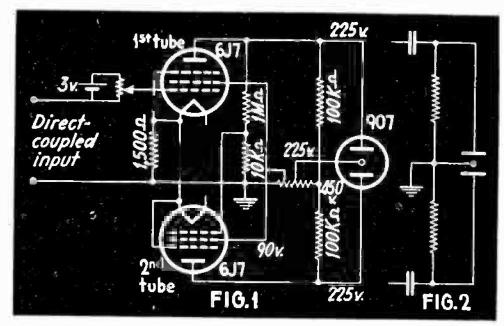
In Fig. 3 a relatively light load obtained. The transformer of the preceding diagram was the so-called four-tube midget type, which pulled some 150 milliamperes no-load exciting current at 115 volt, 60 cycles. The transformer of Fig. 3 was a similar type, but of different make, and required 260 milliamperes under the stated conditions. The presentation shows better performance characteristics than the preceding run, chiefly because of the lighter load. For a 16 per cent variation of input voltage the d-c output remained constant to better than 0.2 per cent.

The curve of Fig. 4 is presented to show that under very light loading the voltage actually may decrease as the input increases. This phenomenon probably is due to changing phase conditions, but occurs rather consistently at light loads. It offers interesting possibilities in the way of compensating effects for radio apparatus, either taken alone or in conjunction with the filament voltage characteristic. In the particular run, while the input was varied over a 21 per cent range, the filament voltage increased 4.2 per cent and the d-c voltage decreased 4.0 per cent.

Direct-Coupled Push-pull Oscillograph Driver Stage

THE EDITORS HAVE RECEIVED an interesting amplifier circuit intended for use with high voltage cathode-ray oscillographs, designed by Mr. S. A. Talbot, biophysicist at the Johns Hopkins Hospital in Baltimore. Biologically produced signals, for which the amplifier is designed, change slowly, so that a-c amplification cannot be used. A direct-coupled d-c amplifier is accordingly used, the total gain being 4×10^6 and the output signal voltage (maximum) 700 volts. The diagram shows the output direct-coupled driver stage, which amplifies the output of previous stages. The output stage is arranged in push-pull, which gives a high output signal without the necessity of using a high plate supply voltage. A 450 volt plate supply in this circuit will produce a 700 volt undistorted swing in the output. Another advantage of the push-pull connection is the fact that the sum of the plate currents is constant, so that a plate supply of poor regulation may be used. Because the total plate current does not change a single plate supply may be used to feed two amplifiers (one for each set of deflecting plates) without interaction between the circuits. Freedom from degeneration in the biassing resistor is also obtained.

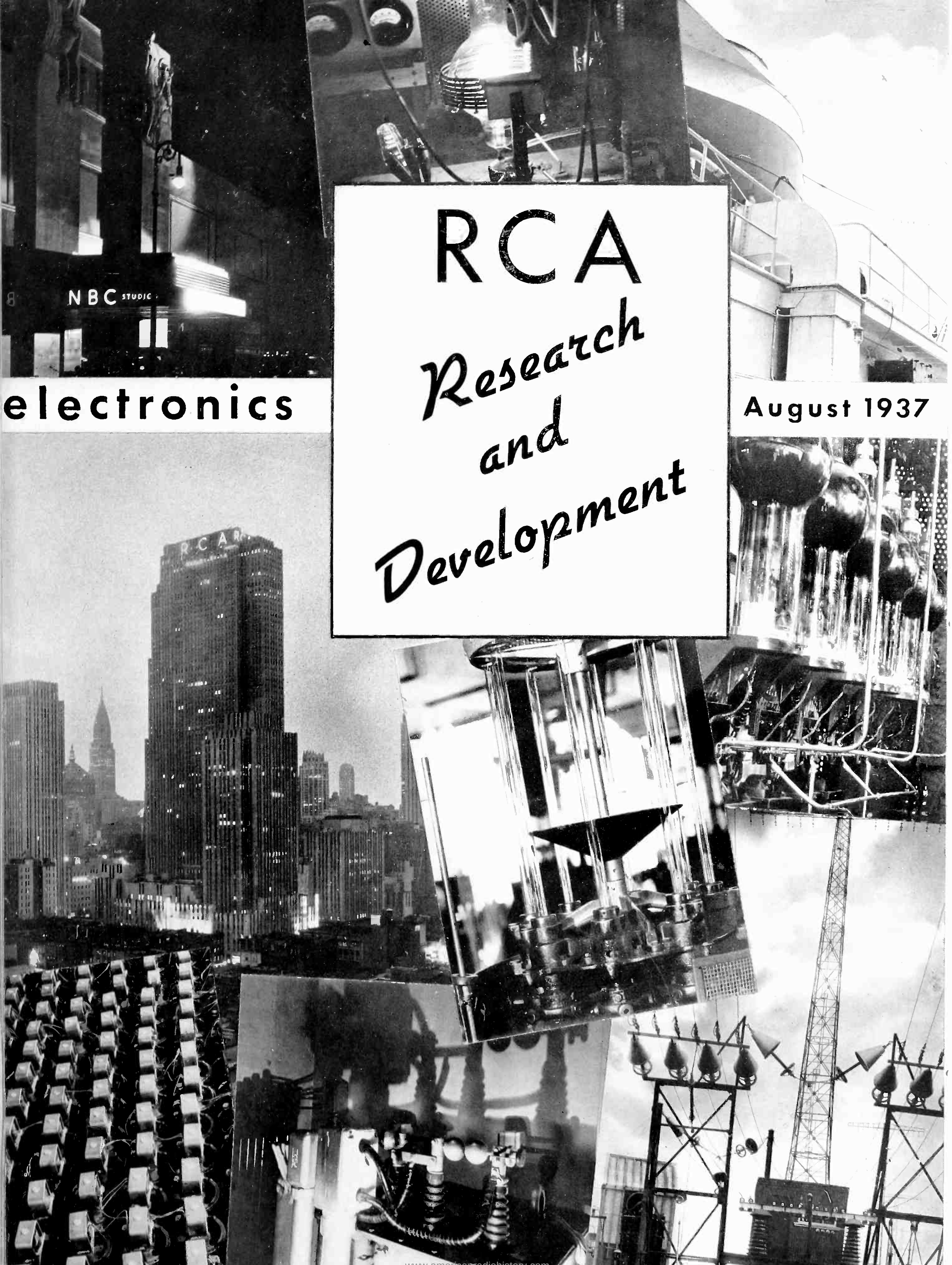
If the stage preceding the output stage contains but one tube, the reversal of phase required between the push-pull inputs is usually obtained by taking part of the output signal of one of the push-pull tubes as grid signal for the other. In the circuit shown, however, a direct-coupled grid for the second tube is used, with a compensating bias voltage of two volts. The overall sensitivity displayed by the circuit is 10 mv/mm with 2000 volts anode voltage on the cathode ray tube.



Direct-coupled amplifier stage capable of delivering an undistorted output swing of 700 volts, from a 450 volt supply electronics

August 1937

RCA Research and Development



RCA

Research and Development

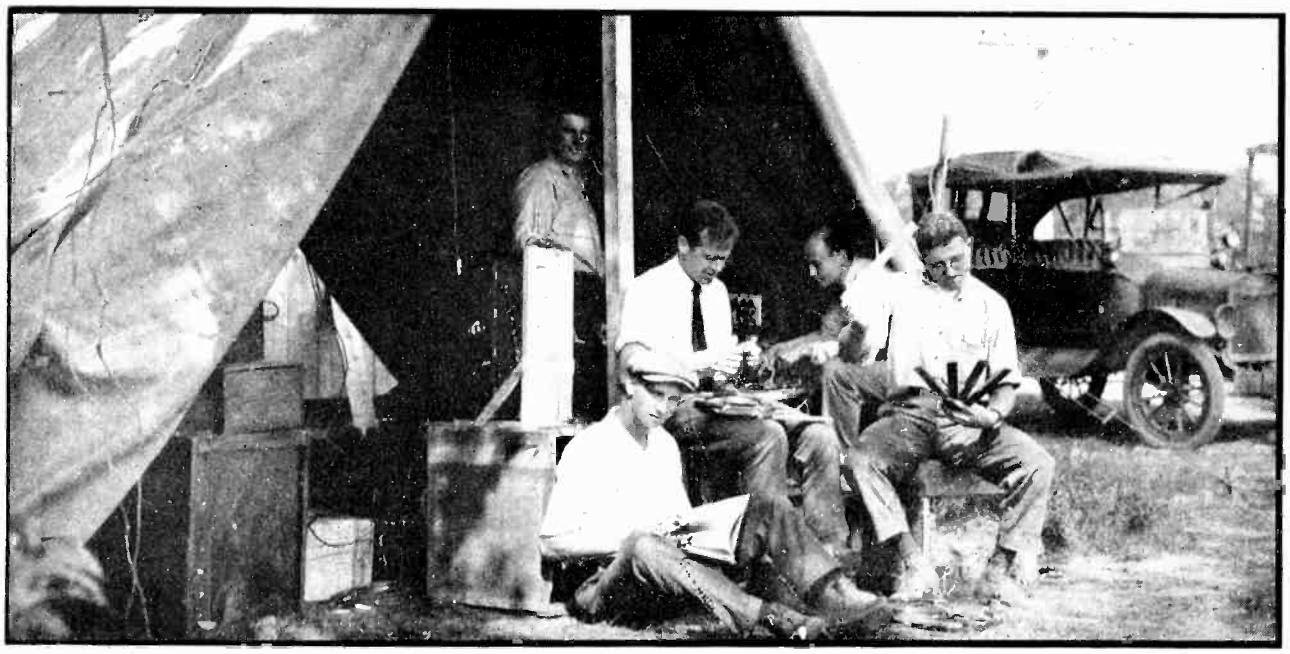
Communication—broadcast or directed, by voice or music or code or sight, on film, or by facsimile—is an art based on and maintained by research, by exploration into new methods, new processes, new materials, new mathematics, new concepts. The millions of words that cross the seas in code, the thousands of hours of entertainment and education for millions of listeners, the ship-to-shore system, communication between land and aircraft or with land vehicles—all hinge upon continued research. Radio Corporation of America plays a major role in this dramatic art of communication; its research and development activities are told in the following pages by the editors of *Electronics*.

It is romantic but true, that the Radio Corporation of America, the outstanding example of private enterprise in the radio and electronic arts, was formed at the suggestion—even persuasive insistence—of officials of the United States Government. At the end of the Great War overseas communication with the United States was largely dominated by foreign capital. The only facilities bearing any semblance to a commercial international system were owned by the Marconi Company. The Navy Department, with an eye to a possible future situation in which this foreign control might place commercial opportunity above public welfare, saw the chance to develop an American system.

The opportunity that presented itself was the proposed sale of the Alexanderson alternator to the British Marconi Company by the General Electric Company, which had developed it. General Electric had practically no other purchaser—certainly no American buyer. And yet, at that time, it was the most promising single piece of apparatus which would make possible transoceanic communication through space, and could thus offer a service in competition with, and independent of, underwater cables.

So, on April 4, 1919, the Acting Secretary of the Navy, requested the General Electric Company to hold up its negotiations for the sale of the alternator until a conference with the Navy might take place. Out of this round table discussion came the Radio Corporation of America. The new company thus formed had for its premises that the United States should possess its own communication system, and that this should be realized from the practical opportunity the Alexanderson alternator, together with the multiple tuned antenna, offered. The entire history of RCA since that time has been based on the same two premises—to perform a service, and to develop technical equipment to improve and expand that service.

The commercial side of this picture has been told many times. The early history of the company has been cited as an early instance of governmental participation in business, because for a while representatives of the Government sat in on meetings of the Board of Directors. The financial background of the company has been told at length in an article in the September, 1932, issue of *Fortune*. But the real background of the company is not finance, nor the commercial give-and-take of business, but *technical organization*. The story of this part of the company's activity has not been told, except in fragmentary form. *Electronics* presents, therefore, this story of the research and development activities of RCA. The laboratories and their products, the men who man them, the achievements that have been pro-



First RCA laboratory, Spring 1920. H. H. Beverage, H. L. Olsen, Chester Rice, E. W. Kellogg, R. D. Greenman

Remotely controlled swivel antenna at Riverhead, used in ultra-high frequency studies

duced—all fit into that early vision of an American communication system, but in a fascinating and composite way that could not be foreseen by those who were in at the start.

HISTORY

When RCA "took over" the assets of the Marconi Wireless Telegraph Company of America existing in this country, it inherited a factory at Roselle Park, N. J., where marine communication apparatus was made. It also inherited some good men with the factory; men whose jobs were research and development. Among them were H. Shoemaker, Roy Weagant and F. H. Kroger, the last of whom pioneered in engineering then, and has been in the forefront of radio experimentation since 1902. Today he uses his days and his imagination at Rocky Point, Long Island, working on projects 2 to 5 years in advance of their practical application. He makes no secret of the fact that at present his time is being spent on schemes involving wavelengths of fractions of a centimeter.

The Roselle Park plant was closed in 1920, and the men who experimented there moved, some to the site of RCA's projected trans-atlantic station on Long Island, and some to quarters at 326 Broadway, New York, where marine commercial and technical activities were continued. C. H. Taylor, from the Marion, Mass., station of the Marconi Company joined the group on Long Island. Mr. Taylor had come to this country in 1902, to participate in the struggle to send radio signals across the Atlantic with reliability. None has a better right to look with satisfaction upon present achievements than he, because he has had an active part in forcing stubborn space to yield before relentless investigation. And yet if you call upon him at his office today you may find him poring over reports of the effects of recent sun spots on short wave transmission. It is not enough that continuous communication is now an assured fact; today the job is to insure that nothing shall interfere with communication at accustomed speeds.

The first laboratory set up by RCA was housed in a tent, erected late in 1919 at Riverhead, Long Island, the site of the company's projected receiving center. Under this canvas H. H. Beverage, now Chief Research Engineer of R.C.A. Communications (1937 President of the Institute of Radio Engineers) inaugurated a program of field research in radio reception. Beverage had served with Alexanderson in General Electric. In 1920, activities were transferred to a little white shack, fifteen feet square. This was later enlarged, and the work here was augmented by another laboratory established at Belmar, N. J., in one of the buildings acquired from the predecessor Marconi Company.

During the World War, the best reception point was located in Maine. It was decided therefore to explore possibilities of this location for commercial operation. The company proposed to relay transatlantic signals received in Maine to New York by radio rather than by wire. Transmission was to be accomplished on wavelengths of about 1600 meters.

H. O. Petersen and H. H. Beverage with field strength measuring set, a Radiola and the first h-f signal generator in a wash boiler

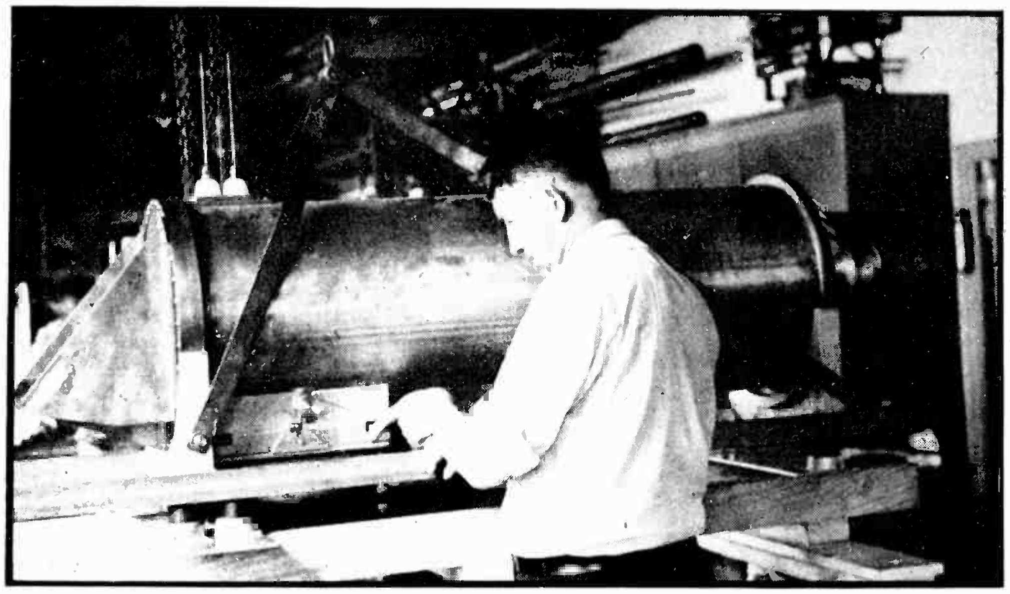
It probably is remembered only by those who were actively engaged in this work that Belfast, Maine, was the station at which automatic radio relay and multiplex radio transmission were first achieved. On a single carrier, five separate channels carrying signals received from Europe were imposed, to be unscrambled at Riverhead into their original components. At about this time, C. W. Hansell took the fundamental work with crystals of W. G. Cady, of Wesleyan University, and G. W. Pierce of Harvard, and applied it to create the first crystal-controlled radio transmitter. The staff at Belfast found time, between jobs, to accomplish the first successful international program, which was received from London and automatically relayed by radio to New York, for broadcast over station WJZ. This occurred in December of 1924.

After many months of commercial operation at Belfast it was concluded that it would be more effective to work with longer transatlantic circuits, to gain the convenience of having the point of reception close to the operating terminal at New York City. Accordingly, activities in transatlantic communication were consolidated at Long Island. Here H. H. Beverage, H. O. Peterson, C. W. Hansell, J. L. Finch, P. S. Carter and N. E. Lindenblad continued their feud with 2,000 miles of ocean, under the veteran C. H. Taylor.

Evidence of the effectiveness of this organized approach to a commercial, international radiotelegraph service is that, at the end of 1920, the first year of RCA operations, radio circuits had been established with England, France Germany, Norway, Hawaii and Japan. These facilities included 300 KW stations, 400 foot towers and other gargantuan items. Today, the complete RCA international system is comprised of 55 circuits which link the United States, its insular territories and the Philippines directly with 45 countries. Nowadays the bulk of the traffic is carried on short-wave channels, using much less bulky, and more effective transmitters and antennas.

Transoceanic radio circuits were not the sole interest of RCA. The assets of the American Marconi Company acquired by RCA upon its organization included ship stations of American registry and shore stations on American mainland. It was the most profitable part of the company's business. It deserved technical attention. Therefore the benefits of continued engineering in long distance communication spread into this field, and ships began to receive better equipment. Crystal detectors gave way to vacuum tubes, and spark and arc transmitters gave way to tube equipment. Efforts in this latter direction were met with some resistance from potential users, however, because vacuum tubes were things of glass, with delicate internal elements, and therefore too fragile to be trusted to operate satisfactorily when subjected to a ship's vibration, or to the possibility of breakage when they might be most needed, in emergency. Despite these objections the last RCA spark transmitters were made in 1922.

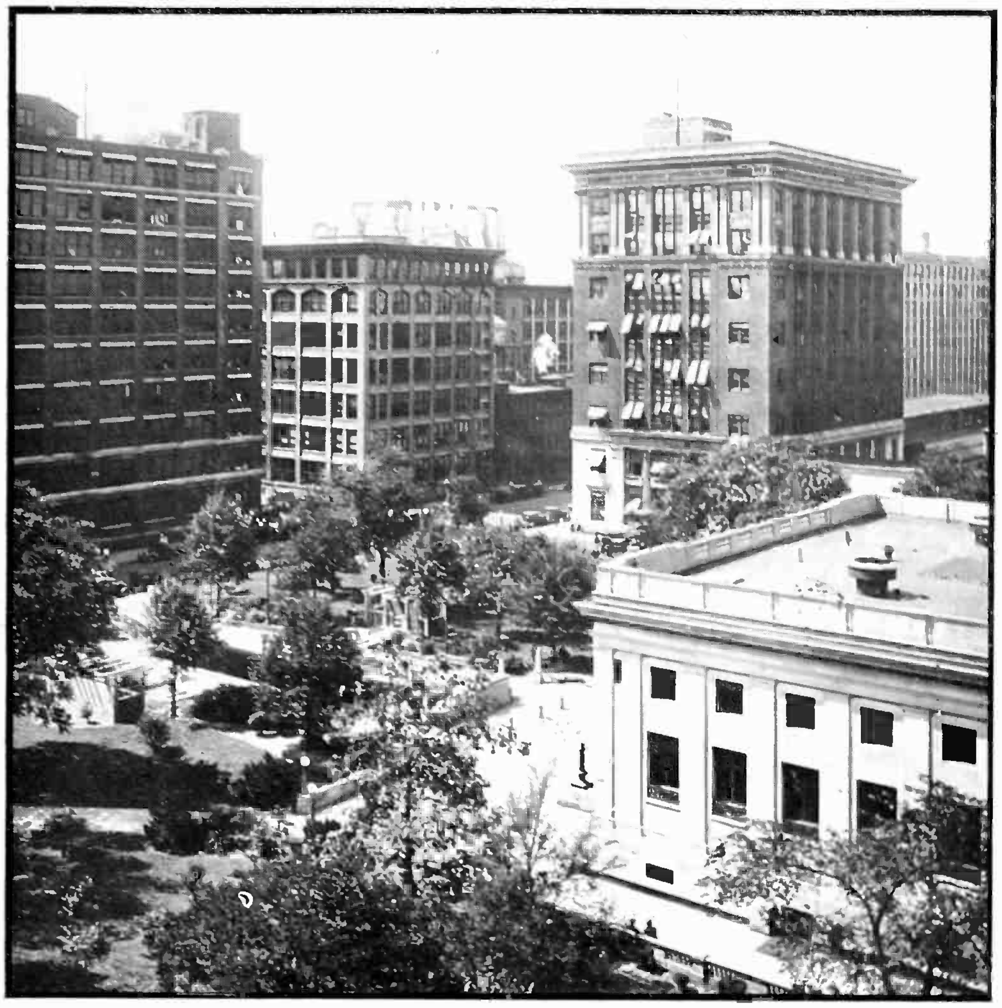
In 1924 engineers of the company produced the first practical, commercial, rotating-loop type, radio direction finder. This important aid to navigation has since been under continued improvement.



90 megacycle "boiler" transmitter under construction at Rocky Point. At full load the shield gets hot, so air-cooling is used

Prior to 1920 efforts toward radio development were for the most part directed to improvement of point-to-point and marine communication. But in that year something happened in Pittsburgh. Frank Conrad of Westinghouse put the baseball scores on the air by voice, discovered that thousands of people would listen on home made receivers,—and broadcasting was born. Later that same year C. W. Horn joined in this new field, becoming manager of radio operations, and technical boss of famous KDKA. Mr. Horn (Charlie to most people) is now Director of Research and Development of NBC.

The beginnings of broadcasting in America (1920) presented problems in the design of transmitting equipment which were far different from those of long-range, point-to-point radiotelegraph communication. For a time, RCA's requirements in laboratory work relating to this new field were met by Dr. A. N. Goldsmith and his assistants, at the College of the City of New York. Dr. Goldsmith had been retained since the Marconi Company days, as consultant, and his laboratory staff



RCA-Victor plant at Camden. Ground space, 82 acres, floor space 480 acres, 14,000 employees maximum, power plant, 41,500 kw., 50,000 tons coal consumed annually.

had originated many important advances in the communications field. Among these was the development of the centralized high-speed ink recorder system, in 1921, which replaced the aural recording system inaugurated by the British Marconi Company. In this system the signals are recorded on a paper tape and transcribed on typewriters by groups of operators.

By 1924 it was apparent, however, that the full time of this staff would be required, in quarters specially prepared for their needs. In that year the company set up a new laboratory at the edge of Van Cortlandt Park, in New York City, to which the group moved.

The laboratory's activities in two groups were under Dr. Goldsmith. One, the Research Division, was headed by Julius Weinberger, and the other, the Engineering Division, was headed by Arthur F. Van Dyck; both now of the License Laboratory. These groups supplied specifications for broadcast transmitters and receivers, conducted field surveys for the buyers of broadcasting equipment, and supervised the design and construction of the first broadcasting stations, and carried on continuous quality control testing of all sets and tubes sold by RCA. From their work came many devices which were important in advancing the art, including the first electric phonographs, many fundamental acoustical developments, the velocity microphone, centralized radio, the first low-priced a-c receivers using the 226 tube, measurement methods, early sound motion picture devices and a television system giving theatre-size pictures.

The years 1929 and 1930 were important times, for it was then that the company acquired manufacturing rights and manufacturing facilities. With the purchase of the Victor Talking Machine Company in 1929, it was set up to manufacture home receivers and radio equipment of all types. In 1930 the purchase of a plant of the General Electric Company at Harrison, N. J., equipped it to enter the tube manufacturing field. This plant was an outgrowth of the first incandescent lamp factory of Thomas A. Edison.

Beyond the attainment of these objectives, RCA gained also a large complement of additional laboratory man-power. It was logical that future laboratory activities be concentrated at the Camden and Harrison plants. Accordingly the Van Cortlandt Park Laboratory was closed, and its staff moved to one of the locations in New Jersey.

In 1930 there was established a laboratory maintained as a service to licensees. RCA has been rendering such service since 1928 from the laboratories which were also doing the company's other research work. By 1930, this license service had grown to an activity requiring a separate technical group, organized to render engineering service on a more comprehensive scale to its patent users. The License Laboratory was first established at 75 Varick Street, but later, in the spring of 1935, was moved to its present quarters at 711 Fifth Avenue, New York.

RCA's laboratory facilities have grown as adjuncts to the various services of the company. For this reason they are not consolidated at any one place, but are located convenient to the various activities. These services may be divided into four general classifications: Communication, Manufacturing, Broadcasting and Licensing.

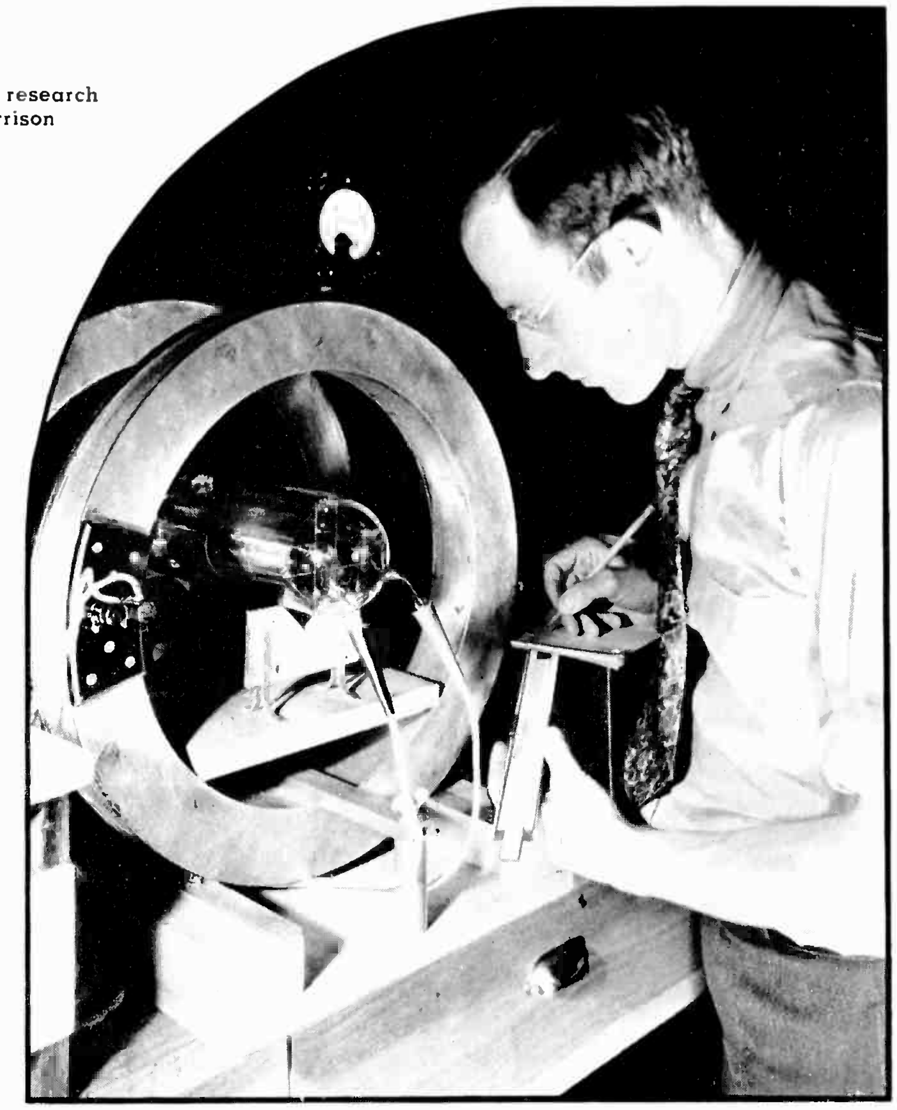
RCA COMMUNICATIONS LABORATORIES

Communications, from which the radio industry sprang, is overshadowed by broadcasting in public interest, but it has never ceased to be the vital factor in pressing engineers and research men on toward greater knowledge. Not only must apparatus be developed, but Nature herself must be investigated to know best how to circumvent and to take advantage of the vagaries of weather, and such seemingly unrelated phenomena as the spots on the sun, and the ionization of the upper air.

Communications research activities divide broadly into three divisions, Transmission, Reception and Terminal Equipment. The work of these groups is co-ordinated under H. H. Beverage, Chief Research Engineer, who in turn reports to C. H. Taylor, Vice President in Charge of Engineering.

Transmission

The transmission laboratory, under C. W. Hansell, is located at Rocky Point, L. I., adjoining the commercial-transoceanic radio facilities. Its function is to develop new and more efficient types of transmitters and antennas for frequencies used in transoceanic communication and for frequencies higher than those employed in such work and for the study of propagation in portions of the radio spectrum not now in general use.



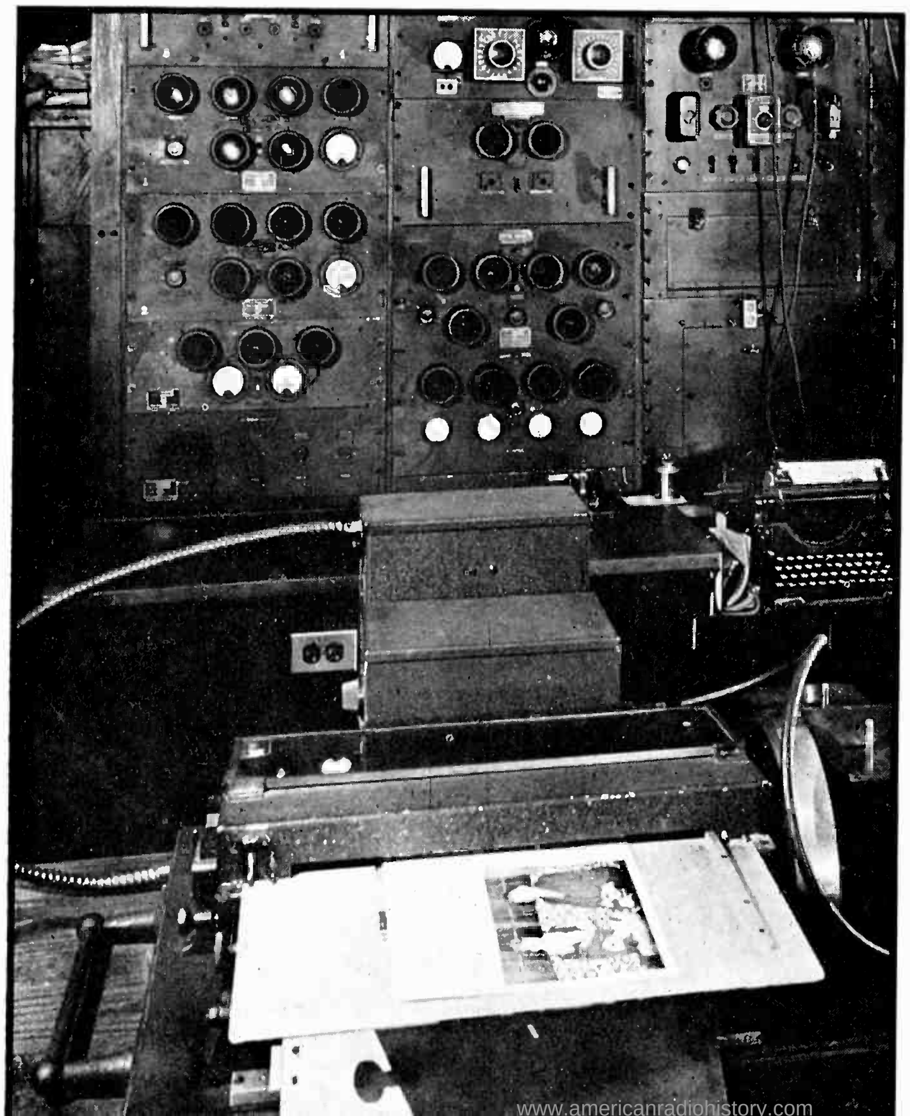
Magnetron research at Harrison

There is continual search for transmitters of greater stability and power, in the simplest and most economical designs. In the early attempts at creating short wave transmitters of considerable power great difficulty was encountered in preventing self oscillation between the various stages. This problem was solved by making the successively higher powered stages multiply the frequency, in addition to amplifying power. The arrangement was so successful that it was rapidly adopted for use in short wave communication throughout the world.

In 1927 the Transmitting Division developed the first four-tube power amplifier, which held the world's record for the highest high-frequency power on a given frequency for several years. In 1927, also the first quick wave change device was developed, almost doubling the value of the individual transmitter by fitting it for day or night service. More recently, the same principles, employing newer tubes and associated components, have been applied to create a transmitter with an output of 200 kilowatts—the highest unit output in short waves today.

Frequently it is found that principles and equipment successfully employed in one radio band hold little promise of adaption to even experimental work in another. An example of this is in crystal control of transmitters. Experimental work with ultra-short waves soon demonstrated that as the frequency was increased the crystal method of controlling transmitters became more and more cumbersome and expensive. Crystals have definite, practical, upper frequency limits, beyond which an excessive number of multiplier stages becomes necessary in ultra-short wave work. To obviate this necessity the transmission laboratory developed the principle of resonant line control. This consists, basically, of a concentric transmission line a quarter wavelength long—a device of extremely low loss, comparable to a crystal and yet capable of controlling the transmitter directly, without use of crystal or multipliers.

Harking back to the reason for



Facsimile equipment control board at 66 Broad Street, New York founding the company—so that America could have its own radio communication system—it is interesting to note how antenna development made its contribution to this end. In fact, improvements in antenna design made the system possible economically. Commencing with complicated and expensive arrays, it was seen that a multiplicity of such antennas, for simultaneous communication with several countries, would result in prohibitive plant and maintenance cost. The necessity for more economical antenna designs, of simpler mechanisms, was obvious. Subsequent mathematical and theoretical exploration pointed to the possibilities of obtaining desired performance from antennas of radically different design. Thus the Transmitting Division came to develop various types of "long wire" radiators, each successive type representing an advance both in efficiency and economy of construction and maintenance over preceding efforts. Today's antennas produce a concentration of power in the desired direction equal to that of the older arrays at the cost of about five to ten per cent of the earlier method.

The application of directive transmission is illustrated by an incident during the course of Admiral Byrd's last voyage to the Antarctic, when it was desired to send a special radio program to his ship by way of Rocky Point. According to the itinerary, the *Jacob Ruppert* should have been off the coast of Ecuador, so transmission was attempted with an antenna directed on South America. When it was found that the vessel was in mid-Pacific instead, and outside that antenna's beam, the engineers hastily went into conference with a terrestrial globe.

The difficulty was solved by reversing the Moscow antenna electrically, and the radio waves from Rocky Point played upon the ship like the searchlight of a passing vessel. Today's directional transmission is a far cry from the splash of energy sent off in all directions in the ethereal mill-pond by the early spark transmitters.

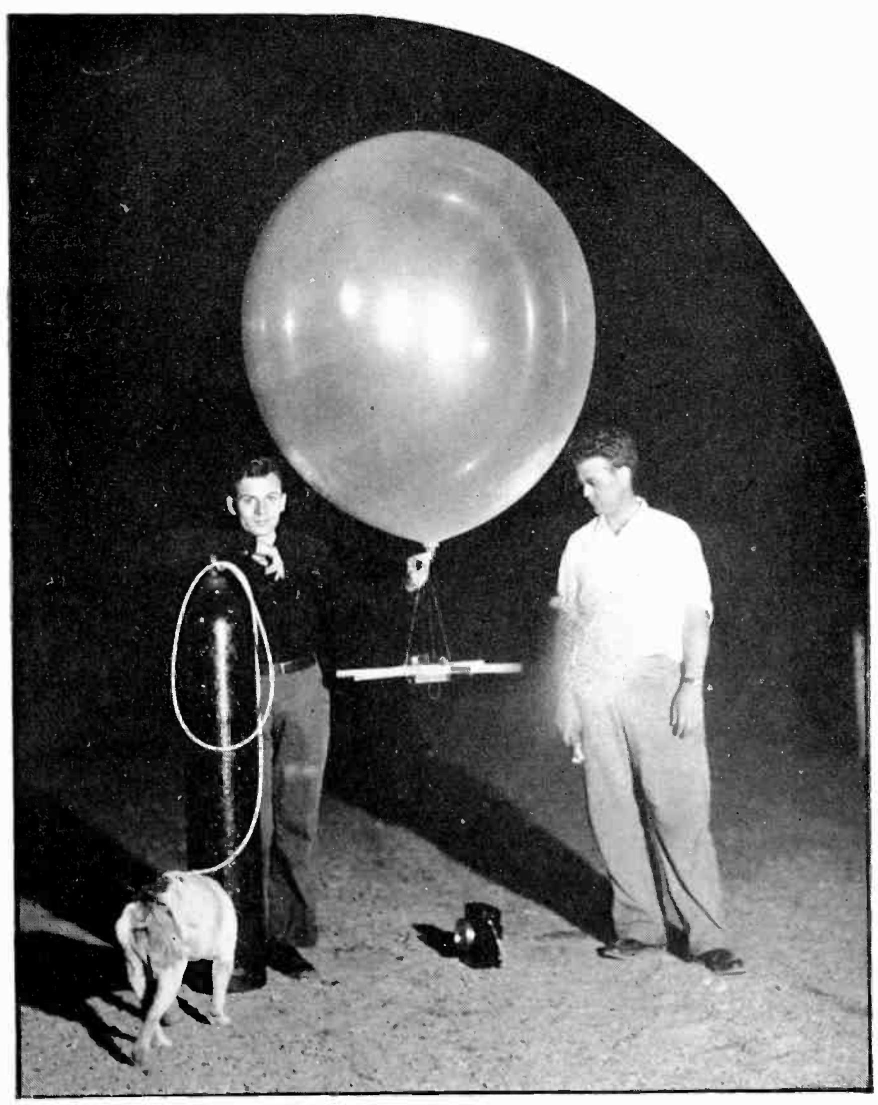
Reception Division

The Reception Division is located at the main receiving center, at Riverhead, L. I., under the direction of H. O. Peterson. It is engaged in the development of transoceanic receiving facilities which involves not only the improvement of receiving equipment but also the continuous study of the propagation of electrical energy through space. The work is not confined to the frequencies utilized for transoceanic communications but extends also into the ultra-high frequency domain.

The most important early contribution of this receiving laboratory was the "wave antenna" for long wave reception developed by Beverage, Rice and Kellogg. This was the first time the aperiodic principle was used in reception by which an antenna of fixed dimensions receives a wide band of frequencies with equal efficiency. Nothing looked less like the antennas then existing. The wave antenna was strung on telephone poles, not over 20 feet from the ground. This line of poles was aimed in the general direction of the countries from which signals were to be received—and the wires on these poles were actually grounded at the remote end. Later, when the laboratory became active in investigation of short wave phenomena, H. O. Peterson designed the "fish-bone" type, which is standard in RCA communications practice at present.

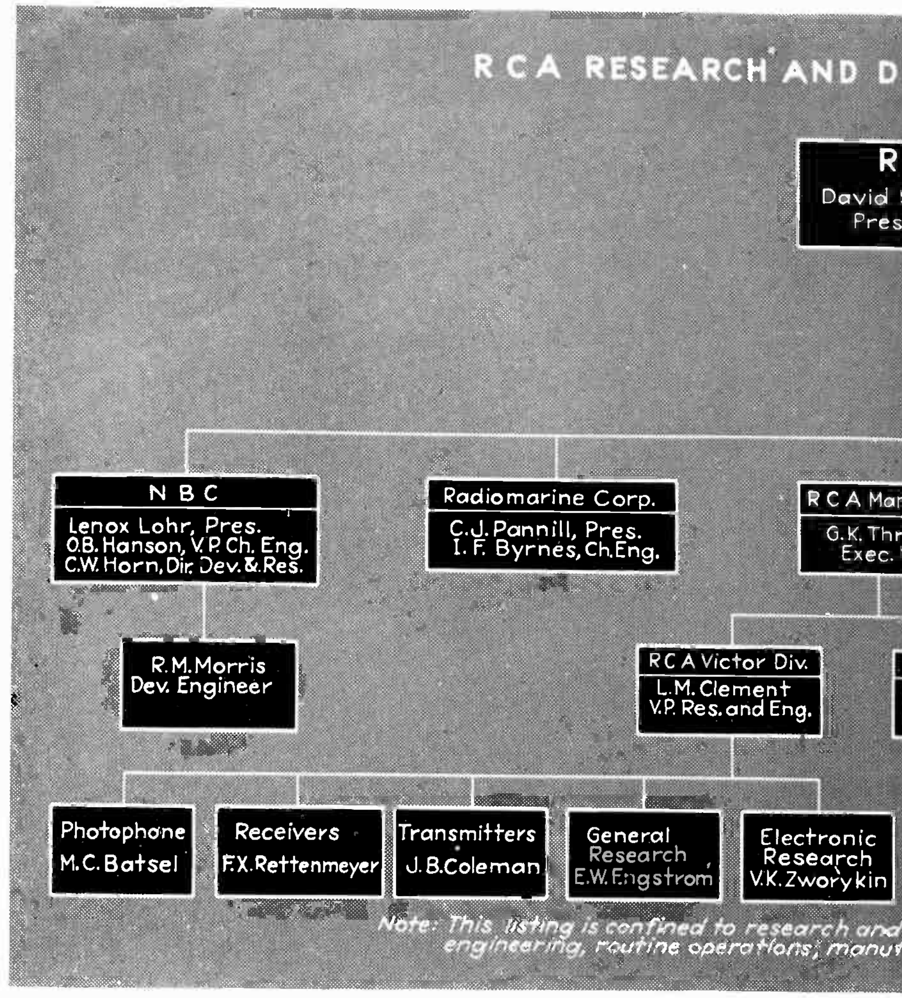
Propagation studies with "fading" on short waves led to experiments in combining the products of signals received at different frequencies, as well as the products of horizontally and vertically polarized waves. Still another method, known as "spaced diversity" reception, utilized three antennas in triangular formation spaced about a thousand feet apart. These were of the "fish-bone" type, for reception of horizontally polarized waves, the energy from each being fed to its own receiver. The combination of the products of the receivers provides signals unusually free from fading difficulties. However, there remained problems of mutual interference between receivers, which necessitated the development of tuned radio frequency amplifiers for operation on much

Balloon ascensions at Riverhead determine "angle of arrival" of radio waves



higher frequencies than had previously been employed. The diversity receiving system was subsequently adopted as standard at all RCA transoceanic radiotelegraph stations, and the same principles extended to include telephonic operation. The latter makes possible the present standards of the RCA addressed program service, by which programs are received from foreign countries for connection to American broadcasting networks.

Extension of propagation studies into the realm of ultra-short waves, and the development of suitable transmitters and receivers for investigating this new domain led to cooperative program with the Mutual Telephone Company of Honolulu, which gave five islands of Hawaii a telephone system devoid of connecting wires. This was of particularly practical value, since cable connections between the islands had proved unusable because of great ocean depths, and long wave signals had been found to be too mutilated by static. The ultra-short wave system has been in continuous and automatic operation since it was installed, in 1931.



Rube Goldberg in Radio

Today's organized research is not without its ingenious short-cuts. It will be recalled that Edison, as a telegrapher, contrived a combination of clock and automatic telegraphic keying device which "reported" for him to a dispatcher at regular intervals, leaving his mind free for experimental work.

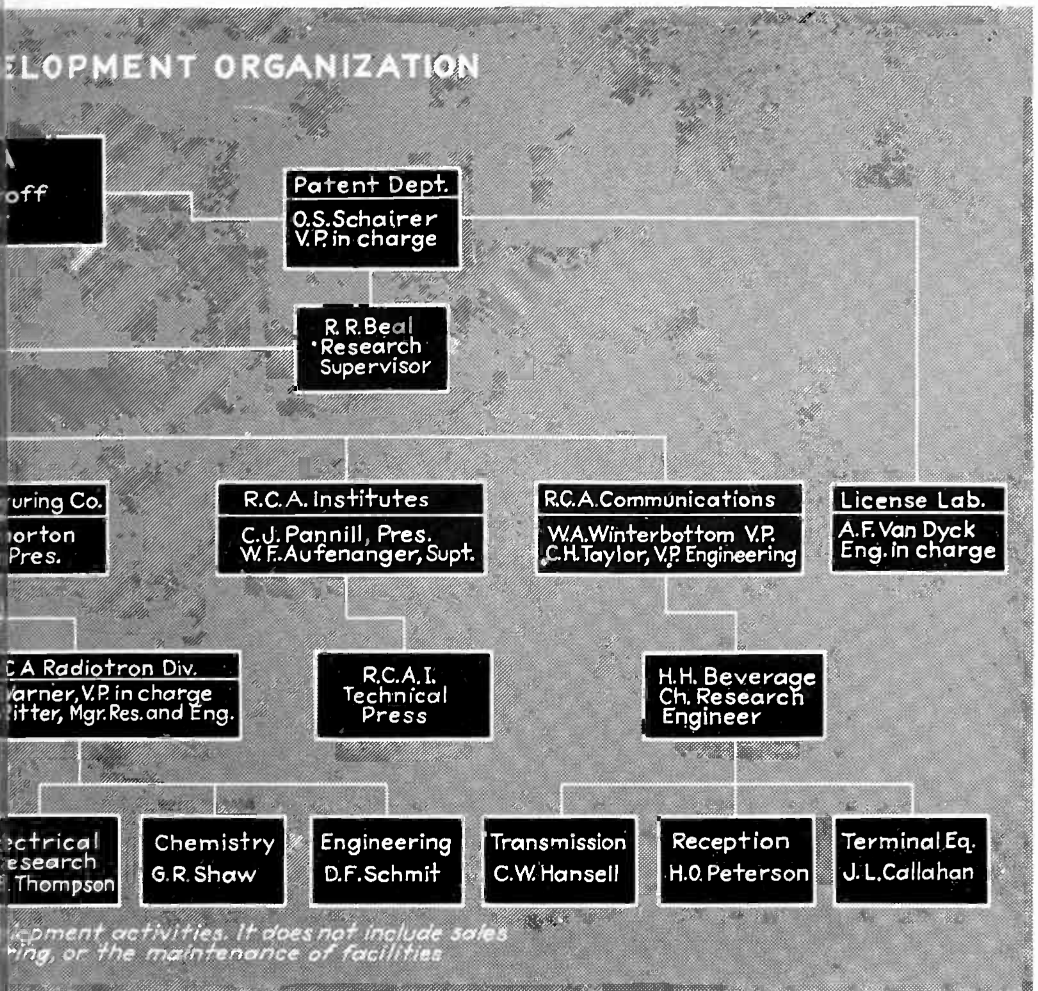
One of today's counterparts is a young engineer at the Riverhead station, whose assignment was to study the angle of arrival of short wave signals. A transmitter attached to a captive balloon was employed in the tests, but it was soon found that any appreciable degree of wind caused the balloon to "bounce," thereby rendering worthless measurements at a given length of cord. Tiring of rising during the best sleeping hours of the night and driving to "location" only to find a defeating breeze, this engineer devised a pendulum with a five-gallon oil can suspended on a ten-foot string. A spike fastened to the bottom of the can was utilized as one contact, and a ring of metal, in the center of which it normally rested, was the other. Wind from any direction would sway the can and close the circuit.

In operation, the complete rig worked like this: On being awakened by his alarm clock, the engineer reached for his telephone and called Riverhead 2576. At the laboratory, the microphone and other apparatus translated the ringing bell into the action of lifting the receiver off the hook for one minute. During this time, contacts of the wind measuring device outdoors actuated a buzzer near the telephone transmitter. By the frequency and duration of the buzzes thus caused, the engineer could determine whether the wind would accommodate his balloon measurements.

Terminal Equipment Division

The function of the Terminal Equipment Division, headed by J. L. Callahan, is to improve the terminal apparatus incident to all phases of central office operation. This includes

Meeting of the Board of Editors, RCA Institutes Technical Press. Front row, left to right: R. S. Burnap, Radiotron; I. F. Byrnes, Radiomarine; Dr. A. N. Goldsmith, Consulting Engineer; C. J. Pannill, Radiomarine and RCAI; L. M. Clement, RCA Victor; C. W. Horn, NBC. Standing, C. S. Anderson, Production; E. S. Colling, RCA Review Manager; R. M. Morris, NBC;



F. E. Mullen, Director of Information, RCA; H. H. Beverage, RCA Communications; J. C. Warner, Radiotron; W. S. Fitzpatrick, Secretary to the Board; and A. F. Van Dyck, License Lab. Members not present: (above, left to right), C. H. Taylor, RCA Communications, R. R. Beal, Research Supervisor, RCA; O. B. Hanson, NBC; C. B. Joliffe, RCA Frequency Bureau.

the preparation of messages for actual transmission, i.e., transcribing or converting printed text into time codes or the equivalent thereof, and on the receiving end to transcribe electrical pulses into a form of language message for delivery to the addressee.

This general activity divides into three classes: Research and advanced engineering, application engineering and construction engineering. The principal projects of this group are with general radiotelegraph control apparatus, which includes automatic tape transmitters, tape perforators, tone sources, tone keyers, line filters and equalizers, line amplifiers and ink recorders. Upon this fundamental system advanced radiotelegraph applications are based, such as time division multiplex, time code printers and code converters.

Time division multiplex appears to hold great future possibilities in radiotelegraphy because of new horizons of operating efficiency and flexibility which it has already brought into view. It makes possible multiplex transmission at no increase over power necessary for simplex operation and it operates through conventional simplex transmitting and receiving facilities. It offers greatly increased flexibility at the operating terminal by enabling the simultaneous operation of several different classes of radiotelegraph service.

Thus, as the Transmission and Reception Divisions continue to provide better and better radio circuits, the Terminal Equipment Division is constantly developing ways and means for making the most efficient use of the improved facilities.

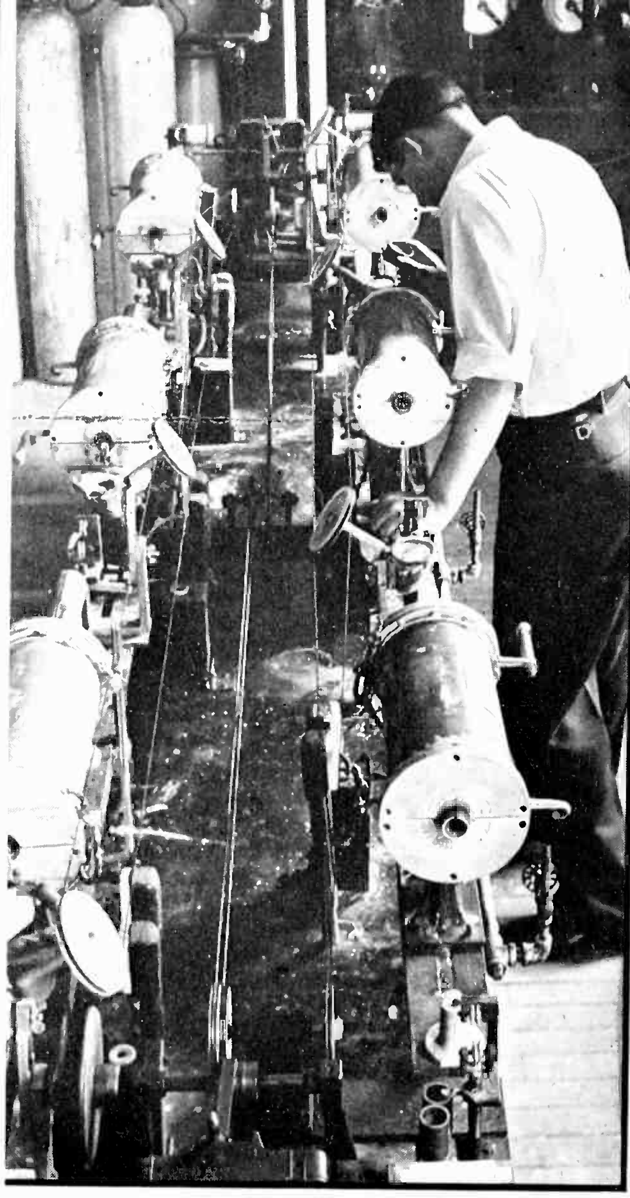
Other special applications which also employ fundamental telegraphic technique in the operation of facilities for transmitting and receiving intelligence in different forms are picture sending and recording apparatus termed by RCA "Photoradio," and facsimile equipment. The term facsimile is here used to differentiate between the transmission of pictures and sketches and the transmission of written or printed matter.

RCA VICTOR

In 1927 RCA began to license other companies to make radio sets under its patents. In this year the Victor Talking Machine Company acquired the Orthophonic phonograph developed by the Bell Telephone Laboratories and began to believe there might be a revival of its business. There was a flurry of public interest, but in a short time business was again "not so good." Radio was taking hold in a big way, cutting seriously into phonograph sales.

At this same time RCA was looking for an opportunity for getting into manufacturing. Logically Radio and Victor should join, in producing instruments for home entertainment —which was the first objective in RCA's manufacturing project. This they did in 1929, and at the beginning of the depression RCA found itself in possession of a large plant.[1] It found itself with men from RCA, from Victor, from General Electric and from Westinghouse. It was overstaffed, in a depression, and entering

[1] In gathering material for this article, the Editors asked E. T. Dickey (one of the original City College men) how much floor space there was at the Victor plant. His reply was "If you walk through all the floors of all the buildings, you get damn tired."



Coating and baking filament wire at Radiotron plant, Harrison, N. J.

a new field with a luxury item as its immediate mainstay. Plans for expansion into the manufacture of radio equipment for every field of application had to wait.

One of the big problems was to weld one unitary force from these men; to get the RCA Victor idea going. It had to compete with many companies, longer in the set business, smaller and more flexible, none with the technical staff of Victor—and none with the overhead to support.

To shake down this big plant, to hammer out of it a going concern, ultimately producing many products, fell to the lot of W. R. G. Baker who had one additional factor designed to make any chief engineer's hair turn gray—a deep depression. Yet the Victor Division of RCA Manufacturing has not only converted its heritage, a dying phonograph concern, into a successful radio set company, but it supplies other RCA subsidiaries, and the radio industry generally, with research and with products. From the broad point of view Victor is not just a set-making plant. It is a broad-gauge plant making many individual products used very widely in and out of the communication art.

Victor, at Camden, naturally divides itself into certain major divisions. All Engineering, under Lewis M. Clement (who was in Hawaii in 1915 with American Marconi) breaks down into the Receiver Division, Photophone and Test Equipment Division, General Research Division, Electronic Research and Transmitter Engineering.

The Receiver, Transmitter and Photophone Divisions each possess an advance development group, which handles work of an exploratory and experimental nature, with respect to the basic principles of the products of each division.

Receiver Design Division

F. X. Rettenmeyer's Division is responsible for the development and design of all radio receivers, whether quantity production or limited production items, as well as the "systems" work in connection with police and aviation systems—a full time job.

The Advance Development Section of this Division is the "idea factory," producing improvements which are later incorporated in the product. In so far as home receivers are concerned, advanced development is customarily looking one or two years ahead. Circuits and other arrangements now engaging the attention of this group should, in that time, be ready for incorporation into products. Examples of some of the components which have recently come from Camden are magnetite i-f transformers, concentric air trimmers, viscalloid damping of phonograph pick-ups, the "inertia" tone arm, the double voice coil loud speaker, compound horns for theaters, and r-f coils which need no adjustment.

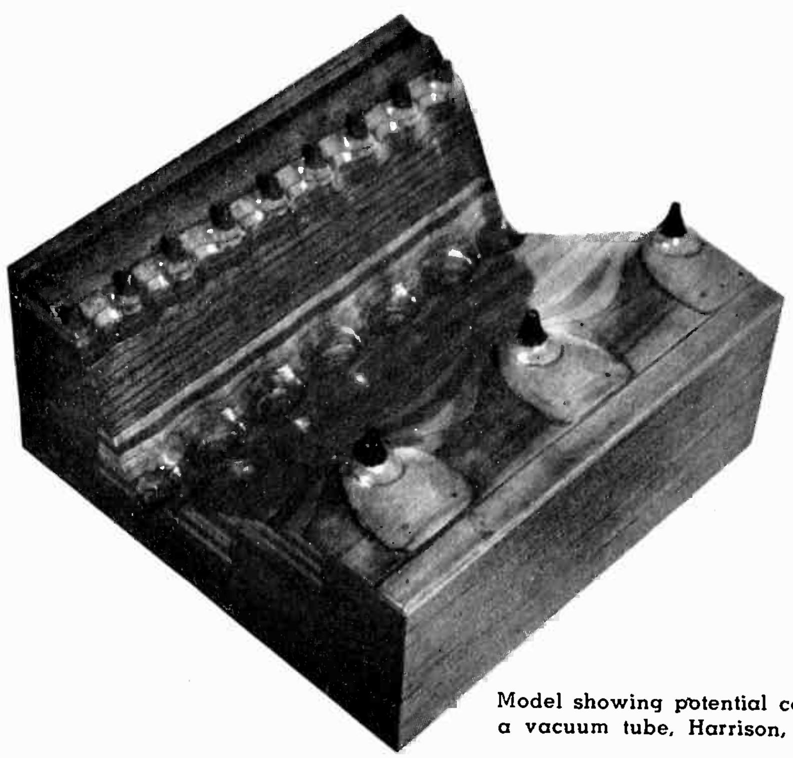
Transmitter Division

The transmitter division, under J. B. Coleman, has five sections. Since transmission is the egg which must invariably precede the chicken of reception, the responsibilities of this Division are a large order.

The first section handles commercial aircraft, police and communications transmitters; the second, special transmitters for Government service; the third, television transmitters; the fourth, transmitters for RCA. Communications and the Radiomarine Corporation of America, and other special equipment such as amateur transmitters, portable equipment and equipment of special designs; the fifth section serves the entire division on standardization and factory contact work.

Photophone Division

Although it entered the sound motion picture field later than other factors serving that industry, Photophone is today in a leading position.



Model showing potential contours in a vacuum tube, Harrison, N. J.

This group is now headed by Max Batsel, one of Dr. Goldsmith's men in his original group.

The work of this Division consists of the development and design of apparatus of the following classes:

1. Photophone sound picture reproducers for use in theatres, schools, etc., for both domestic and export fields, and special designs for the Navy.
2. Sound pictures recording systems. This equipment is leased to motion picture producers, both domestic and foreign.
3. Speech input equipment, for sales to broadcasting companies, in both domestic and foreign fields.
4. Sound systems, consisting of public address, sound reinforcing systems, paging systems, etc. Such equipment is for use in theatres, schools, hotels, factories, etc., and, in special designs by the Navy.
5. Test equipment for manufacturers, service organizations, research laboratories, and operating companies, such as broadcasting stations.

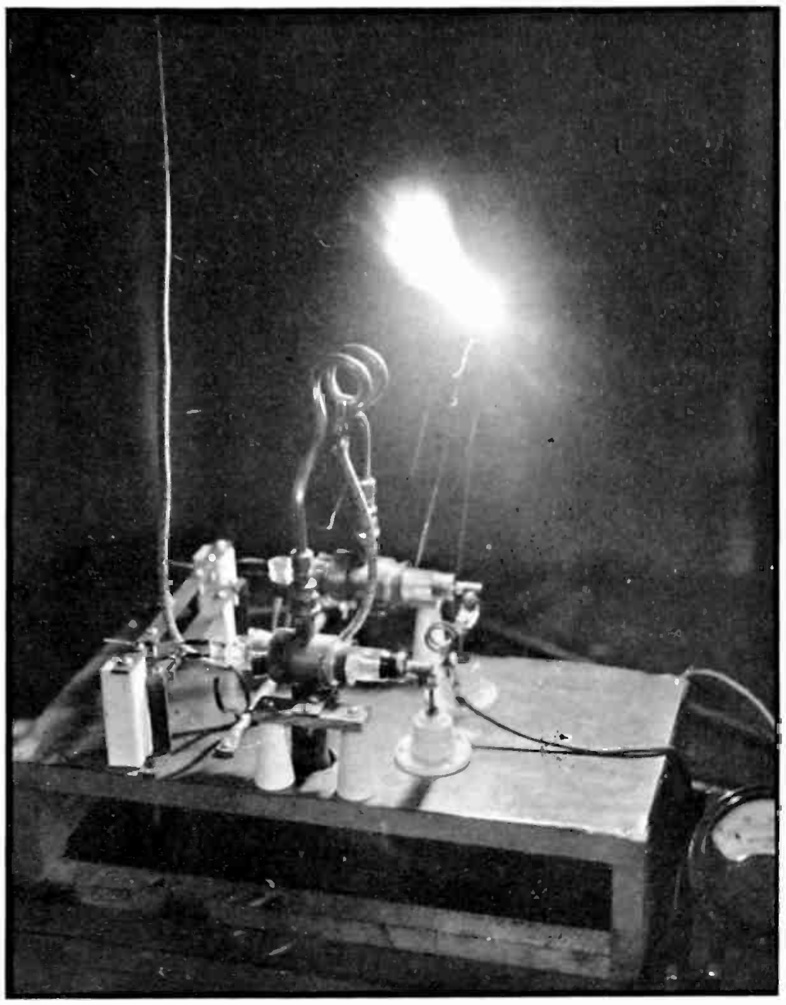
Recent developments of Photophone are the use of ultra-violet recording and the push-pull sound track.

Electronic Research

Very broad indeed is the scope of electronic research. Very broad and widely known, also, are the contributions of V. K. Zworykin. In fact, the basic devices of electronic television and the name of Zworykin are so inseparably linked in technical radio literature that no introduction to his earlier research work is here offered.

Sources of electrons, thermionic emission, photoelectricity, gaseous conduction, electron control, electron optics, electron paths, luminescence—all are studied first from the standpoint of finding new fundamentals and secondly from the standpoint of practical application.

Three projects which are currently receiving much attention in this laboratory section are the secondary emission electron multiplier, the electron image tube and the "Iconoscope." They are not unrelated.



Standing arc drawn from 3.3 meter, 1.5 kw. oscillator, using water cooled 888 tubes. Will operate at 115 centimeters

The secondary emission multiplier is the outcome of research in secondary emission and in electron optics. Although this work has been in progress for only a few years, the multipliers are beginning to be recognized as a commercial possibility. Such tubes are at present in use by astronomers to aid in guiding their telescopes and by others interested in using very low or very high intensities. As development continues, the fields of usefulness of these tubes will increase.

The image tube is another practical use of electron optics. It makes visible images which cannot be seen by the eye except by its use.

General Research

Work along the entire front of the company's activities is carried out by General Research. E. W. Engstrom heads this activity. This Division is no ivory tower of abstract contemplation, as is proved by the mention of two words: Facsimile and Television. The fundamental fields embraced include: radio circuits, and investigations with short waves, radio radiation and propagation, acoustics, physics, recording and reproduction.

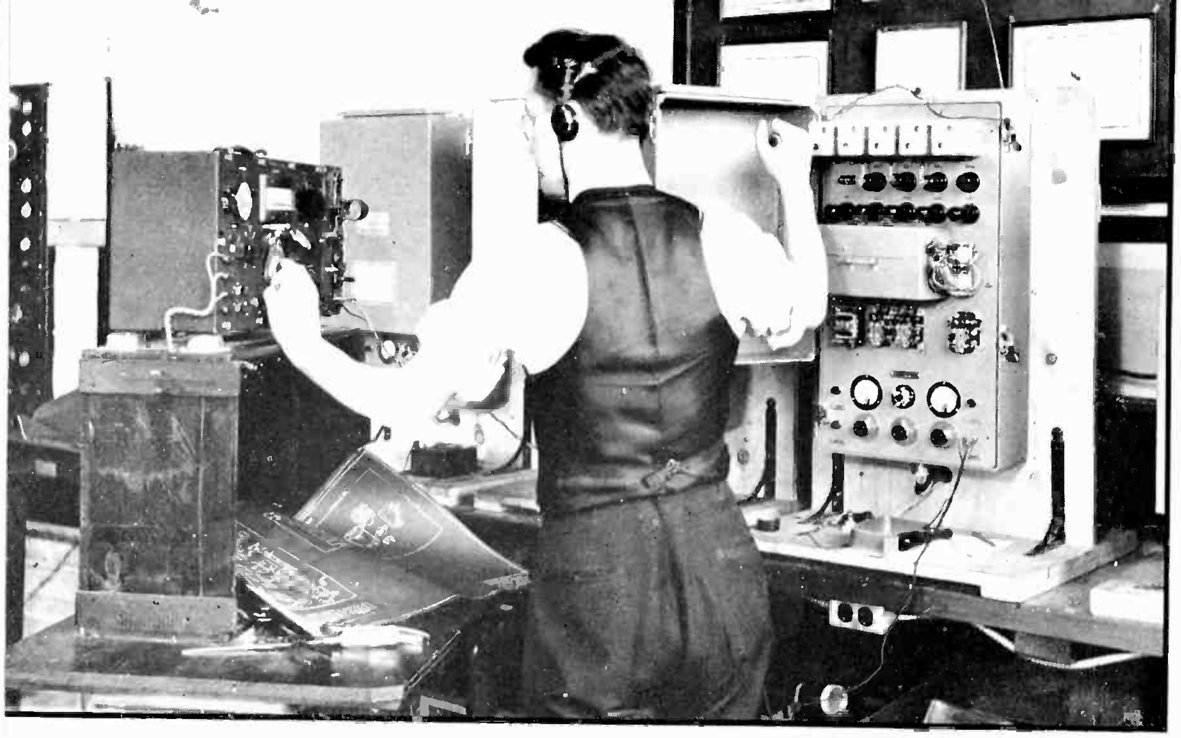
Transmitter antennas, to extend the service range by reducing selective fading, directive antenna structures for ultra-short waves, facsimile, television are but a few of the subjects under constant study.

"V" cut quartz crystals are another development of the laboratories at Camden. These crystals have low temperature coefficients and contribute toward keeping broadcasting and other of the nation's stations on their assigned frequencies.

One of the interesting by-products of General Research is the "automatic snitch" or metal detector used at Alcatraz Penitentiary to detect knives, guns or files concealed on prisoners. There have been produced, also, sources of 60 cycle power very accurately controlled by tuning forks, to provide constant feed drive for facsimile and chronograph devices.

Facsimile

And while on the subject of facsimile; this is a development whose movement so far has been uni-directional. It has become highly successful in transferring news pictures



Adjusting intermediate frequency amplifier on an automatic SOS alarm, at Radiomarine

across oceans. It has proved out in other point-to-point applications. And it has even been successfully applied to a service comparable to broadcasting, in sending weather maps to ships at sea, for simultaneous reception. But facsimile service to the home remains the "watched pot" of radio.

Yet, although the saying persists that a watched pot never boils, physicists relegated this notion long ago to the category of old wives superstitions. Facsimile, like many another laboratory development, is on the fire, and will "boil" into home service whenever a complete set-up, in which programs, service and apparatus are integrated into a complete industrial organization.

C. J. Young, of the Camden laboratory, believes in the possibilities of facsimile. Why, otherwise, would he have given the time to developing a facsimile instrument no larger than an average console broadcast receiver, a device which records lettersize pages of type and pictures, and slices completed sheets neatly into a collated stack for the owner to pick out of a tray for his permanent record? Young has other ideas, also, some of which, like the "tick analyser," are already in valuable service. The device mentioned is used by watch manufacturers to make adjustments in a few minutes that might otherwise require days or weeks. Proving that it is not too wise for practical business to wave aside the new gadgets of engineers because customers' names are not on existing lists.

Television is one of the projects which General Research has under its wing. It is an expensive project, but the social possibilities and economic return are very great. Because of the wide scope of the subject, only a brief review can be presented here.

RCA's television project has been in progress for some years. From time to time, laboratory development has been augmented by field tests, that new advances might be tested in a complete system under actual operating conditions. RCA is at present in the midst of such a field test, more ambitious and complete than any previously attempted. From this test it is expected to learn the answers to many problems and to determine the next steps in apparatus, programs and commercial studies.

Television must be approached as a systems problem in which all the components fit accurately. It is essential to establish standards for universal operation and of lasting value. Translated into general terms these standards determine picture detail, picture quality and entertainment value. RCA has been active in the evolution of these considerations and in establishing recommended practice and standards. In the work so far, the research and engineering groups have made practically all the studies and have carried all the burdens from research to commercial planning.

The degree of success of the "shaking down" at RCA Victor may be judged from the fact that this year complete *factory* models (not laboratory models) of all receivers were shown to the trade in May and at the same time carload lots were on the way to distributors. Under the continued program of coordination red tape has been cut, and the required time between an engineer's conception of a receiver model and its final appearance in production has been reduced by a factor of three.

RCA RADIOTRON

Radio would be helpless without tubes. And tubes are the job of the men at Harrison, New Jersey, the Radiotron Division of the Manufacturing Company, headed by J. C. Warner. Tens of millions of tubes are produced here every year.

The Research and Engineering Department, under the management of E. W. Ritter is organized in three divisions. Since the activities of these divisions deal with a common product, their organization is largely on a functional basis. Thus all divisions may be working on different phases of the same problem. For example, this is particularly true of work on television, which represents a major project. The Chemical Research and Engineering Division is working on television in connection with emitters, materials for bulb coatings and materials for cathode ray tube screens; the Electrical Research Division is at present devoting its major effects to investigations of pick-up and reproduction devices for television purposes; the Development and Engineering Division, in its various section activities, is working on transmitting and receiving tubes for television application, cathode ray tubes for pick-up and reproduction purposes and television circuits to accommodate such tubes.

In the following descriptions given under division headings, it should, therefore, be kept in mind that many of the problems are being attacked from different angles by all three groups.

Electrical Research Division

The Electrical Research Section, concerns itself principally with investigation in the field of thermionics. This group is headed by B. J. Thompson, whose personal contributions are frequently described in the technical literature. Electrical research, in this sense, is defined as the search for new kinds of electron devices and the study of the phenomena involved in these devices. It is not concerned with the *production* (i.e., source) of electrons in a vacuous space, but with the *use* of the electrons.

It has already been stated that this group is concerned with investigating pick-up and reproduction devices for television. It is, in addition, studying high frequency, electronic phenomena, together with basic design principles of tubes for use in short wave transmitting and receiving applications. This latter work is, of course, of importance in the development of television.

Micro wave transmitters, amplifiers and receivers are studied in this group with an eye to the future. The characteristics and uses of electron beams are investigated, the possibilities of gaseous discharge devices are explored and the effects of electron transit time in tubes, together with fluctuation phenomena are studied extensively.

Chemical Research Division

The Chemical Section is organized to carry on investigations in the physical and chemical research fields and to care for those problems naturally referred to them by the engineering departments. G. R. Shaw, who directs this group, has no dull moments.

An important phase of the work of this section is the study of the production of electron emission and of the conditions necessary for its maintenance. This includes the various possible sources of electrons, such as thermionic, photoelectric, impact, gaseous discharges, etc. It also involves study of the materials used for the production of cathodes, such as base metal, carbonates, alkalis, etc., and their processing in tube manufacture.

A continuous study of insulation is carried on, the field of investigation including materials fulfilling the high temperature requirements of heater-cathode insulation, the medium temperature resisting materials for mount supports such as mica and glass, and the low temperature tube components such as bases and basing cements.

Glass, being an important part of the tube, is studied to make it more effective as an insulator and to facilitate its use as an integral part for the support of the other members.

Because of the wide nature of metallic materials entering into tube construction, metallurgy is also important. The metallurgical study of base metals for filaments and cathodes, the metals constituting the grids, anodes, supports, sealing in wire, and even the "getter" is a necessary feature for tube progress.

Development and Engineering Division

This group covers a lot of territory. It is close to the "firing line" of tube usage, and therefore D. F. Schmit, who looks after its manifold functions uses his desk principally for a telephone address. His activities have to do with matters of tube development, application engineering, standardization, and commercial engineering.

The development of new types of receiving, transmitting, photoelectric and cathode-ray tubes is carried on by sections within this group. This is true, not only for tubes for sound broadcast use, but also for tubes for television developmental activities, and tubes for specialized transmitting fields such as aviation, amateur, police, and general commercial service.

Working hand-in-hand with the development group, the application engineering group is concerned with the development of new circuits to employ these new tubes to best advantage. Information gained in this way is supplied as a service to companies engaged in the manufacture of equipment. Through this group, also, special tubes are made available to experimenters and laboratories.

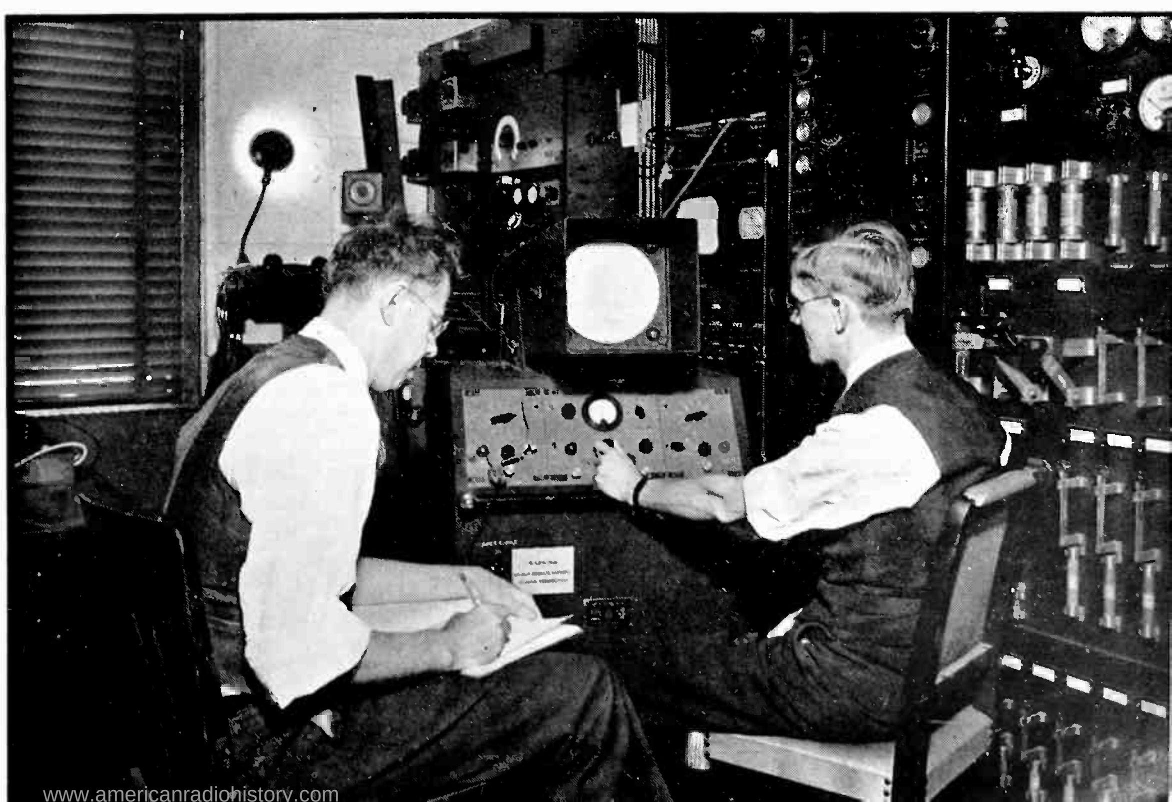
The standardization section has the duty of preparing specifications covering the construction, the processes and the materials used in all radio tubes produced at Harrison. It is also responsible for the design of bulbs and metal shells, bases, and tube cartons.

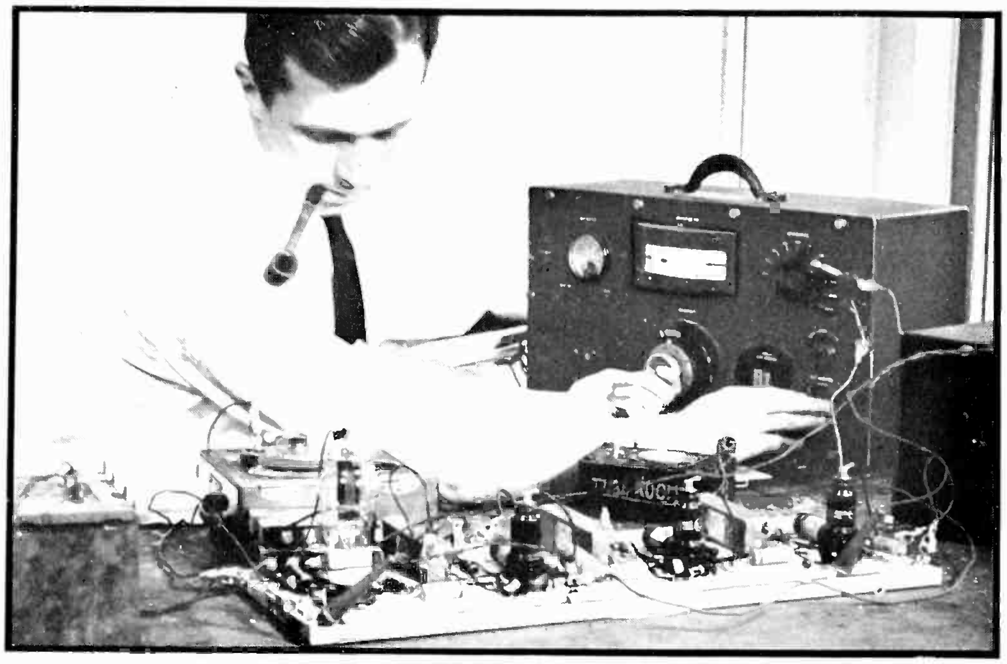
The commercial engineering section is busied with contact through correspondence and the regular channels of publication and supplies technical information on radio tubes in published form to manufacturers, the trade, amateurs and experimenters, and the public generally. This activity includes the publication of application notes, various manuals on receiving transmitting and cathode ray tubes, and the RCA tube handbooks.

RADIOMARINE

The laboratory facilities of Radiomarine are located at 75 Varick Street, New York. Here various types of marine radio equipment, both receiving and transmitting, are developed for use within the RCA organization and for sale to American shipowners generally. Some of the later developments have included a small direction-finding receiver and loop (*Electronics*, April, 1937, page 9), useful in all manner of small craft, and an Auto Alarm (*Electronics*, April, 1937, page 20), a device for receiving distress signals when the operator is off watch. A distinguishing feature of the Radiomarine Lab set-up is the close contact between the laboratory and the production line, both being located on the same floor, almost within calling distance. In charge of the laboratory is I. F. Byrnes, whose

Checking modulation wave-form of the NBC experimental television transmitter, Empire State Building, New York





Measurements with signal generator at License Laboratory

background includes service with G.E. and RCA Victor, under whose direction the careful design and production necessary in marine equipment has proceeded since 1930.

The problems encountered in the design of marine radio equipment are more severe in certain respects and certainly more changeable than most branches of radio. Apparatus must be made efficient, reliable and as simple as possible. It must be capable of quick installation and be constructed to allow easy and rapid servicing.

Methods of coupling transmitters to antennas must be ingenious as well as practical, since antenna constants vary widely and ordinarily the same "sky-hook" is used for both low and high frequency transmission. Frequency stability is more of a problem than in fixed station transmitters for several reasons; the equipment is subject to vibration and abnormal derises of temperature and must be capable of quick change from calling to working frequency with a minimum error due to human manipulation of dials and controls. Circuit design is influenced by spare parts and spare tube requirements. "Break-in" operation must usually be provided to expedite the handling of traffic.

THE BROADCASTING LABORATORY

The Engineering Department of the National Broadcasting Company has the job of providing facilities for program transmission and of operating them on the high plane of efficiency which modern broadcasting demands. While all of these facilities constitute a "field laboratory" from which much data is obtained during routine operation, strictly speaking, the technical investigations of NBC are carried out in a group of development laboratories, housed in the Radio City plant. The primary function of these development groups is to adapt the engineering advances in other scientific fields to the particular needs of broadcasting, and in so doing to act as a liason officers between NBC and the manufacturing organizations of RCA.

With the rapid growth of broadcasting, the activities of this group have expanded to include the handling of all engineering matters of an experimental nature pertaining to broadcasting, the testing and approval of broadcast equipment, the development of new equipment for special purposes or where suitable equipment is not available, the testing of acoustical and sound isolation materials, the preparation of specifications for acoustic treatment and sound isolation of studios, and the conduct of acoustical absorption, transmission, and vibration measurements, as well as television in its many aspects.

To carry on these activities there are radio, audio, acoustical and television laboratories located in the NBC section of the RCA Building in New York City. R. M. Morris, Development Engineer, is in charge of this group with W. A. R. Brown as assistant. The Development Engineer reports directly to O. B. Hanson, Chief Engineer of NBC.

The most important experimental development in progress at present is television. NBC has been actively engaged in this field for over six years and is now occupied with the technical operating problems of the RCA television field test. Two studios are being operated at Radio City while at the Empire State Building operation of the experimental high power television transmitters associated with the project is carried on. In addition to experimental operation for the RCA field test an operating technique is being developed which will fit smoothly with existing broadcast operational practice when television passes from the experimental stage to regular operation.

An example of operational development is the short wave relay broadcast equipment used extensively in field operations. Since much of this development can be carried out most effectively by the NBC, because it is in intimate contact with the problems involved, the Development Group designs and constructs models of various types of equipment to meet the demands of the Operating Groups. These models are then turned over to the RCA Manufacturing Company where they are produced in quantities sufficient to meet the requirements of all NBC divisions.

Studio acoustics and the related problems of sound transmission and vibration isolation are other phases of broadcasting in which the NBC laboratory is active. Determination of the acoustical absorption coefficients of acoustic treatment materials is made by the reverberation chamber method and the data is applied in the design of studios.

A more complete presentation of the many activities of the NBC Engineering Department, of which the Development Group is only a part, is given in the November, 1936, issue of *Electronics*.

THE RCA LICENSE LABORATORY

The License Division Laboratory was established early in 1930, under the direction of A. F. Van Dyck, in response to a definite need for a centralized technical service to perform certain important functions. The activities of this laboratory are determined by the condition that RCA patents are available to about seventy other companies in the radio industry. All these companies are engaged in highly technical businesses, subject to rapid and continual change. For best operation of this complex structure, therefore, it is required that a centralized technical service act as a general coordinating agency, and a "clearing house" in matters of common interest.

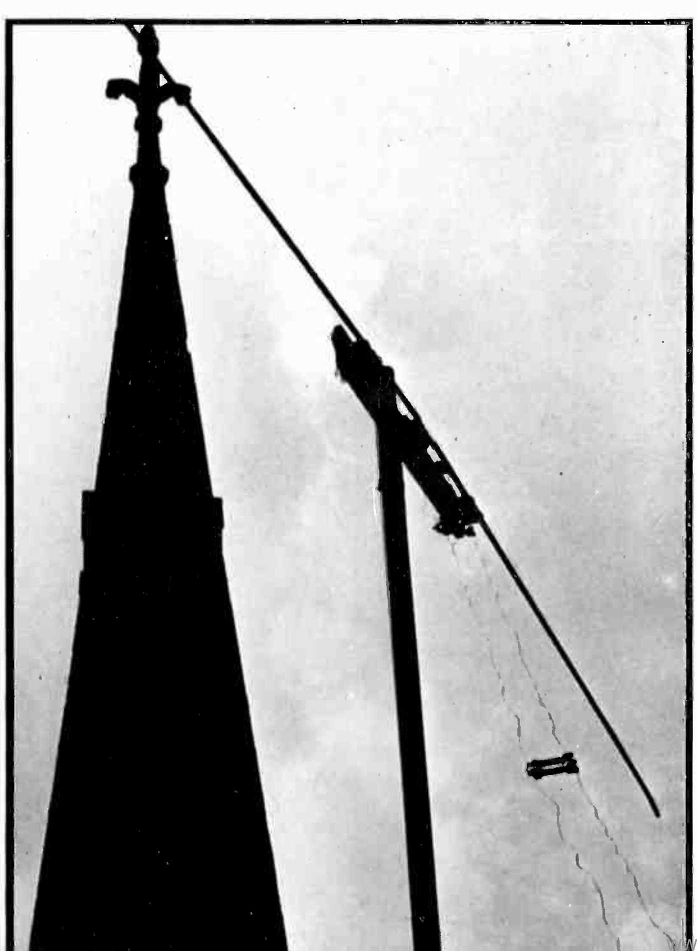
The radio industry not only draws upon and uses freely the results of the continuing research and development work of the groups previously described, but utilizes for radio purposes the circuits and devices described by more than five thousand patents owned by RCA, General Electric, Westinghouse, the American Telephone and Telegraph Company and many foreign companies with which RCA has patent license agreements. The RCA patents under which the industry is licensed are increasing at the rate of about 500 annually. Under RCA licenses during the period 1927-1936 there have been produced forty million radio receivers and over half a billion vacuum tubes.

Through the Laboratory, information has been transmitted to the licensees on the application of patented RCA circuits for such important advances in the art as the superheterodyne, automatic volume control, automatic frequency control, class B amplification, high fidelity receivers, automobile receivers and all-wave reception. Numerous surveys of industry technical practices have been carried out, resulting in valuable information for the guidance of design. Close contact is maintained with the Radio Manufacturers Association, the National Association of Broadcasters, the Institute of Radio Engineers and the Society of Automotive Engineers.

The functions of the laboratory are carried out by several groups. D. E. Foster heads a group which renders engineering assistance to licensees, makes all receiver tests and measurements, conducts industry technical surveys and does field work at licensee receiver plants. S. W. Seeley's group takes charge of tube problems submitted by licensees, field work at licensee tube plants and various special studies of industry-wide importance relating to tubes and sets. E. W. Wilby's group attends to the issuance of patent bulletins, RMA tube standardization, RMA and other committee activities, and general laboratory services such as model shop and maintenance. J. Weinberger carries on economic research relating to the radio industry.

By rendering a consulting engineering service the Laboratory is able to help licensees when they encounter difficulty in the early stages of production of new circuits, parts, etc. The Laboratory can solve such difficulties quickly, because it usually happens that many manufacturers will be introducing a new development at the same time. Finding the solution to the problem of one enables quick service to subsequent inquiries from others.

Ultra short wave antenna at RCA License Laboratory



In the case of certain licensees, every laboratory model of receivers intended for production by them is first submitted to the Laboratory for test and criticism.

Automatic Tuning: The Laboratory's most recent contribution to the industry along these lines, and one which has received widespread usage during the past two years is the development of automatic tuning.

This has been introduced by radio manufacturers in various forms, such as "dial tuning", "push button control", and "automatic frequency control." In this instance, a problem arose when "all-wave reception" first made its appearance. Superheterodyne oscillators were required to maintain a higher degree of frequency stability when receiving short waves than had ever before been the case. Starting with devices for compensating oscillator drift through temperature control, the Laboratory's engineers finally were led to various circuit devices for automatic frequency control.

Measurements and Standardization: The Laboratory's measuring equipment serves in some cases as a standard against which calibrations of licensee measuring equipment may be checked, thus insuring uniformity of measurements throughout the industry. Many of the smaller licensees do not have adequate measuring equipment for testing the performance of tubes or receivers and welcome the opportunity for making such tests at the Laboratory.

The work carried on under this heading includes:

(a) The study of technical trends in the industry.

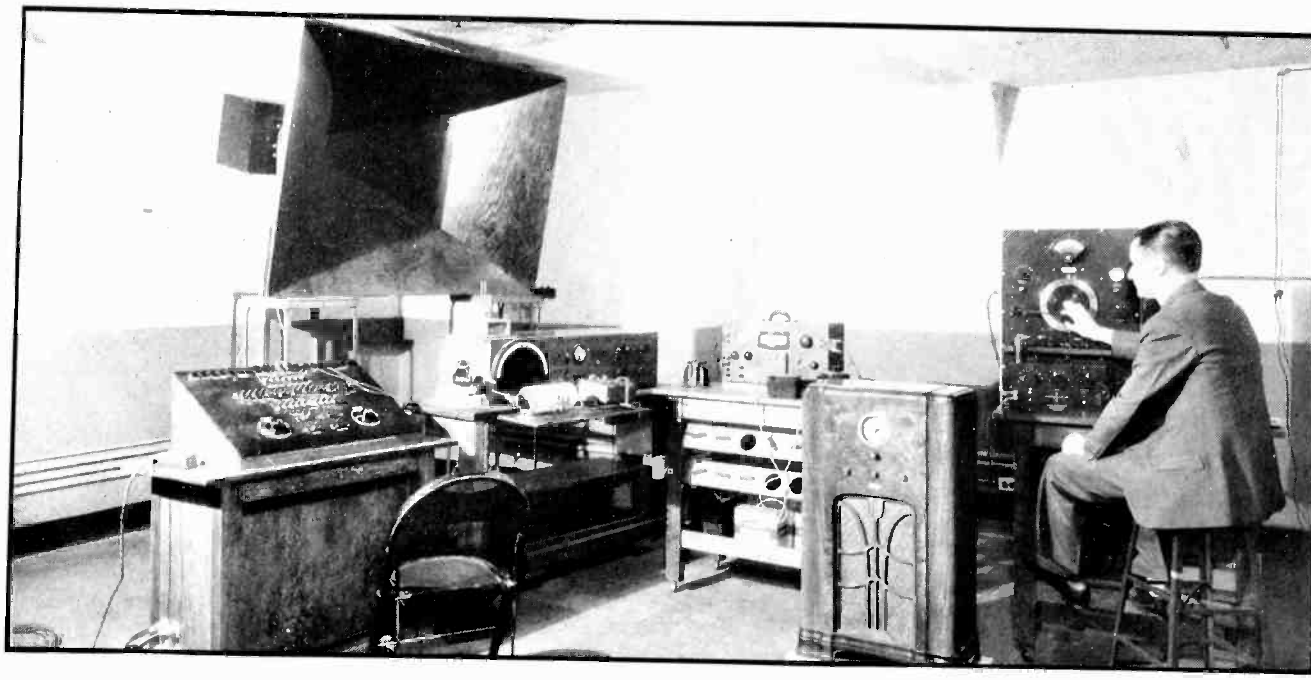
(b) Advance study in the Laboratory of technical factors or new fields having prospective importance to the industry.

The results of these studies are circulated to all licensees in the form of technical bulletins.

These bulletins are supplemented by meetings called by the Laboratory, and attended by engineers of practically all of the licensees, at which discussions of these subjects are held.

At the present time this group is principally concerned with technical studies embracing television, which will lead to the initiation of licensees into the factors of importance in television receiver design.

One of the important continuing activities of the Laboratory is the accumulation and distribution of data relating to the industry-wide characteristics of broadcast receivers. This information is issued annually in the form of a summary of broadcast receiver trends. However, during 1936, an especially comprehensive report was issued, based on the Laboratory's data of the preceding five years, on the subject of "Receiver Characteristics in American Homes." This report was pre-



Portion of License Laboratory where acoustics measurements are made. Lines to NBC studios (16,000 cycles wide) provide high quality material for test (and entertainment) purposes

pared for presentation to the Federal Communications Commission, and forms a set of fundamental data which they may utilize in determining future broadcast allocations.

Standardization Activities

The Laboratory functions as the official agency for tube numbering and standardization of the Radio Manufacturers' Association, as well as for the standardization of related matters such as tube factory test limits. This work was extended recently to include not only standardization of tubes made in the United States, but also those made in Canada, Australia and American type tubes made in Italy. The standard RMA tube data sheets are prepared and issued by the Laboratory.

COORDINATION

All these varied functions of the RCA laboratories, whose field of interest extends to every phase of radio, are coordinated through the central, parent organization, the Radio Corporation of America. Information originating in each of the units flows through the office of R. R. Beal, Supervisor of Research, for distribution to others who may find it useful to their particular problems.

Here, also at RCA, rests the ultimate control of all research activities, as well as the apportionment of appropriations for the various projects. It is a very broad control, which assigns projects to the various laboratory units, thereafter permitting the greatest possible freedom and flexibility of action.

No appraisal of the research activities of RCA would be complete without an acquaintance with the company's guiding hand. Two characteristics distinguish David Sarnoff in his relation to the technical organization of RCA; experience in practical operation and an incisive mind which quickly grasps and evaluates new facts which the specialists in every department of research and development bring to light.

Coming to the new company from American Marconi as Commercial Manager, Mr. Sarnoff had served in every post of the predecessor company. As ship radio operator he knew the importance—and the difficulties—of clearing the hook of messages. All through his career he has been able to gauge what could be done with existing facilities, and what might be done with more effort and investigation directed to this or that end. Always he has appreciated the dimensions of the job ahead, but this has never reduced his impatience at obstacles, natural or otherwise.

At all stages of his career, men came to David Sarnoff's desk wanting to know "the answers." Frequently he could give them out of personal experience. There were many that he could not supply; but every man who went away temporarily unanswered knew that someone would soon be assigned to the job of finding out.

In a recent address before the American Physical Society, David Sarnoff revealed some of the thoughts which enable him to inspire technical groups on to new frontiers. "In our knowledge of the atom," he said, "We first discovered and utilized the negative electron—the outermost and most easily accessible structural element, and the one which, in a sense is nearest to us. Some day we shall know more about and doubtless utilize some of the other elementary nuclear particles which have been discovered in recent years—protons, neutrons, positrons, deuterons and their various combinations. These new discoveries in turn may give us new sources of power, new modes of travel and communication, new manufacturing processes, new forms of illumination, new cures for dreaded diseases, new highways to health."

Research thrives in such an atmosphere.

1938 Radio Receivers

(*Continued from page* 15)

As for the audio output circuit, the most popular type of output tube seems to be one of the several suitable varieties of pentode, with the beam power tube running a close second. For the utmost in quality reproduction, and especially where price is a secondary consideration, triode power output tubes are still holding their own very well.

Glass Versus Metal Tubes

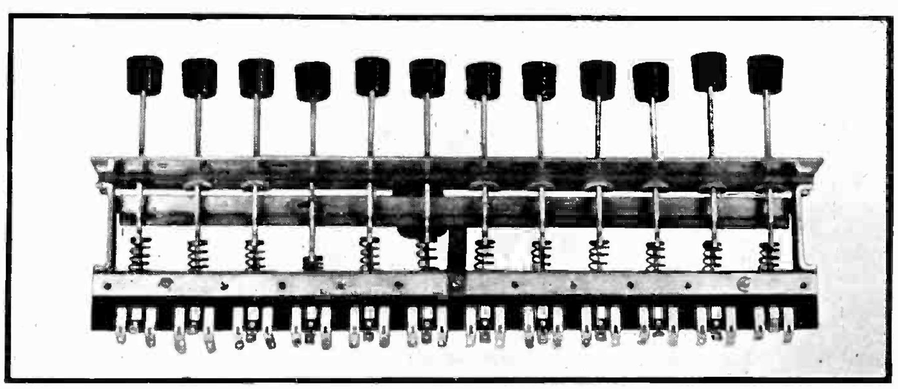
The feud of the glass versus metal tubes seems to be simmering down somewhat with the G type out in front. Most receivers use a combination of glass and metal tubes, although there are some sets using all glass, and a few using all metal tubes, if we except the rectifier and of course the tuning indicator. Although metal tubes are used extensively for low level amplification, detection, and oscillation, glass envelope tubes are invariably used for the rectifier and final audio output stage. It is interesting to observe that General Electric, pioneer proponents of the metal tube, have discontinued the use of the 5Z4, 6J7, 6L6, and have almost entirely dropped the 5W4 for reasons of cost or poor performance as compared with equivalent glass envelope tubes. GE still retains the use of the 6A8, 6C5, 6F5, 6F6, 6H6, 6K7, and 6L7 metal tubes in this year's sets. On top of that comes information that one of the tube manufacturers is making approximately 20% of the tube line in metal and 80% in glass. However, since the glass variety includes replacement of old models, these figures do not give an accurate comparison of the popularity of glass and metal tubes as used in modern receivers. Another tube manufacturer has written off $45,000 worth of metal tube equipment which has been junked.

Although it cannot be said that there is a very decided trend toward the use of single purpose tubes (as contrasted with a tube in a single envelope performing various functions simultaneously) there does appear to be a trend on the part of some manufacturers to put a greater part of the cost of the receiver in the number of tubes rather than in the perfection of other components.

In the field of tuning indicators, the electron ray tubes have almost a clean sweep, although the flash tuning arrangement of Sears Roebuck and Sentinal Radio Co., which are retained this year prevent a complete landslide for the "magic eye."

"No Squat, No Stoop, No Squint"

Convenience in operation is carried out in a good many cabinet designs. The lazybones or armchair receiver introduced a few years ago by Philco, is making headway this year with a number of manufacturers announcing this type of cabinet. The introduction of a number of models of armchair type has led to the cabinets of rather odd shapes and designs, but the console, high boy, and low boy models which have been in evidence in previous years are to be found in this year's models, especially among the higher price sets. Other improvements in cabinets which have been made by the manufacturers include a sloping control panel, featured especially in the higher price sets made by Philco. Although a sloping panel has some advantages from the standpoint of ease of adjustments, broadcast receivers of more than a decade ago featured sloping panels.



Typical of the high quality components going into modern receivers is this Mallory switch. The photograph was taken of an experimental model after it had completed 15,000 cycles of operation on a life test

No increase in the use of the 20 to 60 Mc. band is evident; if anything the number of receivers having this band seems to have decreased since last year. At the same time, through the use of better tuning arrangements, the operation on the high frequency bands has been greatly simplified and made more satisfactory to the ordinary user. In a good many sets the higher frequency band contains provision for much easier tuning. For example, some of the receivers have split up the high frequency band into four band spread sections so that high frequency tuning is actually easier to accomplish than tuning in the 500 to 1,500 kc. band. It is estimated that some of the broadcast sets are equal to high priced communications receivers in their performance at the high frequencies.

In the lower frequency bands, there is no apparent increase in the use of the 150 to 350 kc. band for the reception of weather signals, airplane reports and the like. In the lower priced sets using only two bands, the 6 to 18 Mc. is the second band.

While in general the prices of sets are somewhat advanced from what they were last year, a distinct trend indicates greater values than ever before; values which are made possible only because of fairly stiff competition and considerable study and research on the part of the manufacturers. Many receivers are available in the medium price range, but there seems to be some doubt as to the proper place in the sun which the cheapest and most expensive sets are to occupy. The Kadette receiver, manufactured by the International Radio Corp. of Ann Arbor, Mich. is making a bid for outstanding value in the low price field. The Kadette is a table model, 10 tube, a-c operated, superheterodyne receiver selling at a list price of $19.95. It is anticipated that this receiver will be quite a sensation in the low price field, but it remains to be proven as to what can be expected from sets selling at $2 per tube, complete and ready to go.—B.D.

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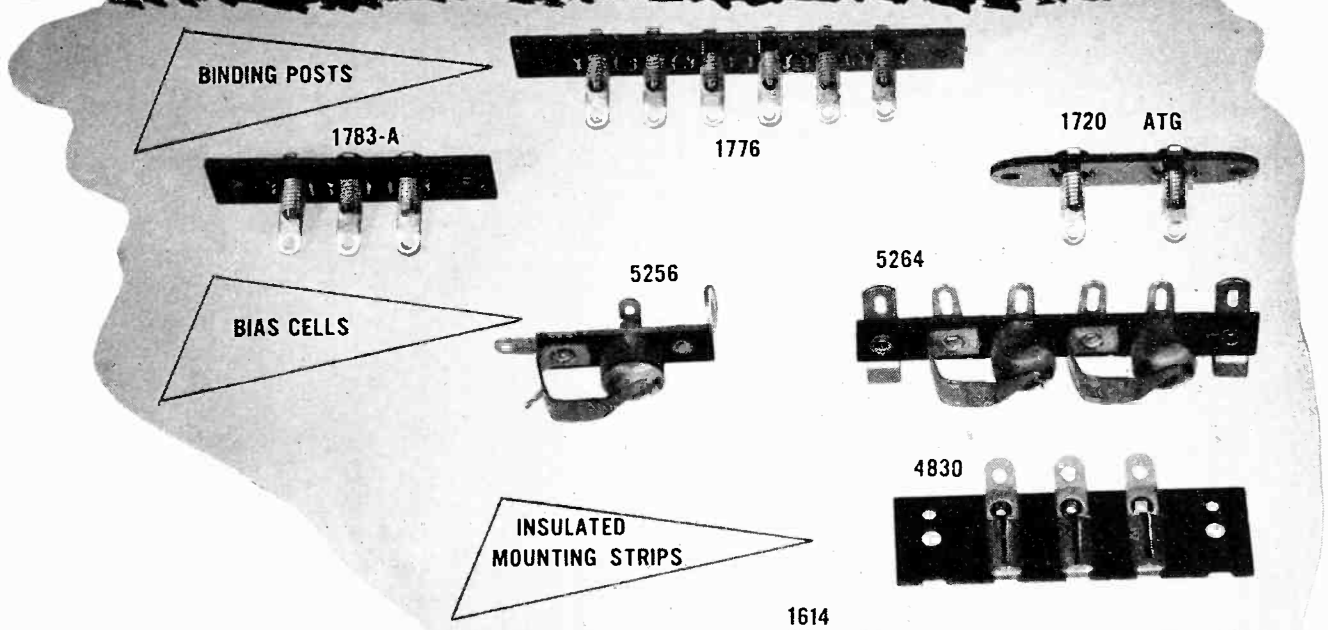

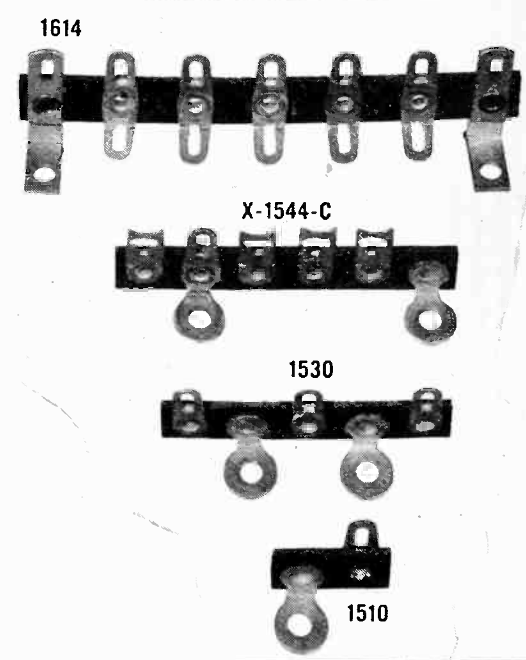

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THE ELECTRON ART

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

History and Application Of Piezoelectricity

An article under the above title by M. Tournier appears on pages 312-327 of the April issue of *Electrical Communication*, issued by the International Standard Electric Corp. The article covers, in an interesting manner, the important developments in piezoelectricity since 1881, when the theoretical studies of Pierre Curie on pyroelectricity led him to foresee before he was able to observe it, the phenomenon of piezoelectricity. The theory of piezoelectric properties of crystals, developed by Voigt in the last decade of the nineteenth century are discussed and the main conclusions given.

The first application which is mentioned is that of Langevine in 1914 in the field of ultra-sonics for the detection of submarine bodies; the application of ultra-sonic waves for marine depth sounding and for marine signalling purposes is also briefly reviewed.

A large portion of this paper deals with piezoelectric quartz plates for the stabilization of frequency in vacuum tube oscillators. The use of quartz plates for the measurement of pressure, in sharply tuned filters, and several applications in acoustics are given in conclusion.

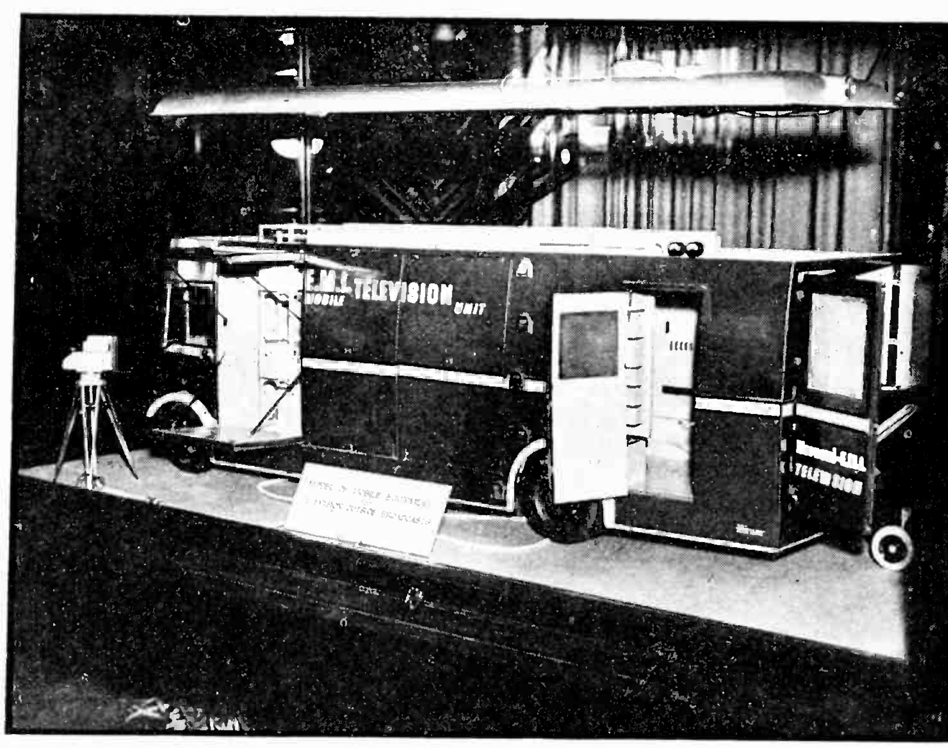
Bridge Type Flux Meter

A satisfactory method of obtaining a direct and continuous reading of the flux density of magnetic fields, either steady or slowly varying, is described in the article "A New Magnetic Flux Meter," by G. F. Smith in the April issue of *Electrical Engineering*. This new flux meter depends for its operating principle upon the change in resistance exhibited by a bismuth wire when placed in a magnetic field. The application of this physical phenomenon to engineering was accomplished by using a bismuth resistor in each of the two diagonally opposite arms of a Wheatstone bridge and placing both of the bismuth elements in the magnetic field to be measured.

In the design and construction of this bridge a number of problems arose which required solution before the bridge could be put into service. The high thermoelectric effect which appears when bismuth is joined to most other metals, was overcome by so designing the arms of the bridge as to minimize temperature variations. All junctions were made as near each other as possible so that very little difference in their temperatures could exist. It is reported that no errors from this source have been detected. The shift in the zero position of the flux meter when the temperature of the bridge varied was overcome by using a metal of higher temperature coefficient of resistant than bismuth, and using only enough so that its resistance change would always be equal to the corresponding resistance change in the bismuth. The third problem presents itself when the temperature of the bridge varies any considerable amount from that at which the bridge is calibrated. In this case it has been found possible to provide a calibration curve corresponding to the normal temperature at which the bridge is operated, together with supplementary curves or data which permit corrections to be made for other temperatures at which the bridge is operated.

A summary of the advantages and disadvantages of the meter makes evident that by the use of two bismuth elements instead of one, the indication for a given flux density value is very greatly increased and that the change in resistance of bismuth arrives at its final value almost as soon as the element is placed in the magnetic field, remains constant if the field is constant, or varies with the field if the change is not too rapid for the meters to follow. If the various arms of the bridge are so constructed that changes due to temperature are similar in each, small temperature changes, so troublesome with the single bismuth spiral arm, are entirely or almost entirely obviated. A simple bridge and meter may be calibrated for a very wide range of flux densities from the lowest the bridge will give to the highest desired. By including more than one bridge with the same meter, the combination can be adopted to measurements of very small magnetic areas, as well as for the larger areas of comparatively low density. Probably the greatest disadvantage of the meter is the change in the indication for a given flux density when the bismuth temperature is changed either above or below that at which the meter is calibrated. Where great accuracy is desired, readings must be corrected by means of calibration curves. Another slight disadvantage is that for all measurements the current applied to the bridge must be maintained constant.

MOBILE TELEVISION PICK-UP UNIT



At the television exhibit in the Science Museum, London, is displayed this model of the Marconi-E.M.I. equipment for outside television broadcasts. Note the "Emitron" camera at the left

LITTLE THING, isn't it?

Not much more than an inch long and only .050 inches in diameter, but its job as a Cathode Sleeve is a big one. So important, in fact, that many electronic engineers insist on the kind of precision for which Superior Tubing is noted . . . metals of proven characteristics, extremely close tolerances in wall thickness, diameter and length, and unfailing uniformity throughout every shipment—year after year. . . . A request for quotations on your requirements will receive prompt and intelligent attention.

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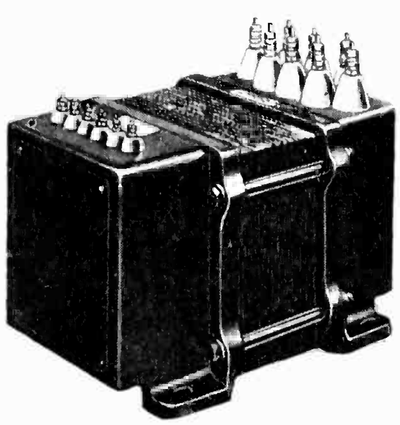
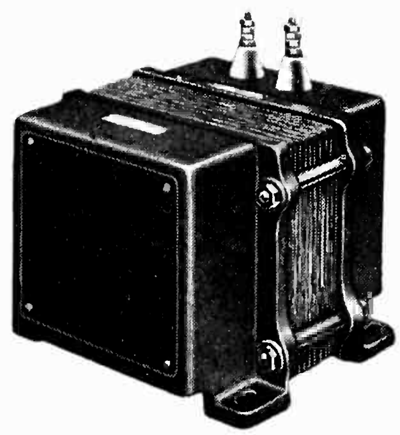
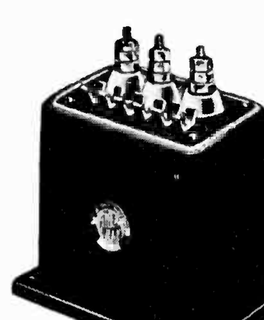




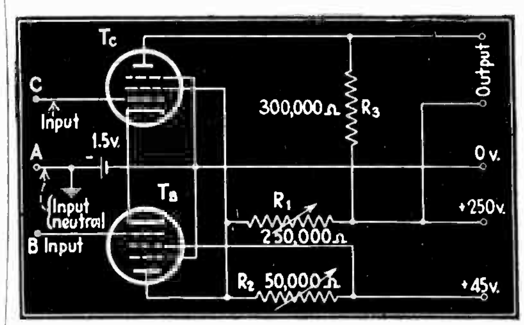


Power Tube Rating

PERHAPS RADIO AMATEURS are the most notorious overload addicts as far as vacuum tubes are concerned. For this reason the article "Frank Talks About This Business of Transmitting Tube Ratings," by E. C. Hughes in the June issue of *QST* should find a receptive audience. However, amateurs are not the only ones that can profit by this article, and we should think a number of readers of *Electronics* would classify this article as one they must read in the near future.

Simple Differential Amplifier

A SIMPLE TWO TUBE differential amplifier having a voltage amplification of about 160, and independent of frequencies up to about 20 kc. per second, which is suitable for amplifying the voltage between two electrodes, each having a high impedance with respect to ground, is described by Otto H. Schmidt, in an article entitled "A Simple Differential Amplifier," in the *Review of Scientific Instruments* for April 1937. The amplifier is simple to build and adjust and is quite inexpensive since only two tubes, two rheostats, and a resistor enter into its construction.



In the schematic wiring diagram, the tube T_c functions as a normal high gain amplifier, its plate circuit furnishing the output of the device. The tube T_b serves both as a high gain amplifier and as a phase converter. Both tubes are identical high mu pentodes, such as the 6B6, 57, or 6J7.

For a differential amplifier it is essential that the input circuits be symmetrical and that the output should be independent of the mean voltage of the two control grids within reasonable operating limits. The first of these conditions demands that the screen and grid potentials of both tubes be equal. This is obtained by varying the resistor R_1 until the plate current of the tube T_c does not vary when R_2 is changed. For this adjustment it is necessary that the input terminals *B* and *C* be connected to *A*. Independence of the output upon the mean grid potential is assured by adjusting the rheostat R_2 until the output is zero, when a small alternating voltage is applied between *A* and the two grids *B* and *C*. Neither of these adjustments is critical and in practice they need be made only infrequently.

July 20th, 1937

For the Bulletin Board

TO ALL EMPLOYEES

Here is a paragraph of a letter received today from another customer who seems to think well of this organization:

> " .... and I can sign myself 'yours sincerely' when I say that the service and cooperation you wrap up along with our orders for Stackpole products has materially aided us in keeping quantity production on a quality basis ...."

Customers' comments on the work we do here are of vital interest to us all, and praise such as the above should be as gratifying to you as it is to the management.

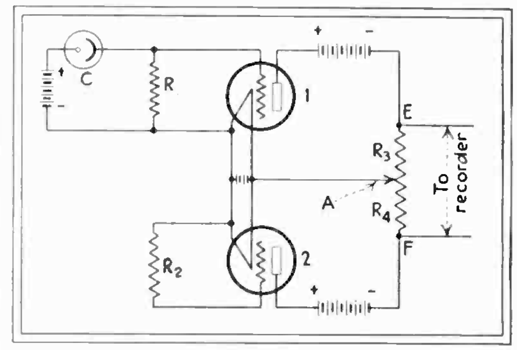
H. C. Stackpole

P. S. This is no reason for swelled heads in any department.

Recording Microphotometer

A NEW RECORDING microphotometer employing a phototube, two high μ triodes, three resistors and suitable batteries is described by H. V. Knorr and V. M. Albers in the June issue of the *Review of Scientific Instruments*, pp. 183-184. The advantages claimed for this system, a schematic wiring diagram of which is shown in these columns, include obtaining of an inked tracing, stability and freedom from mechanical vibrations, very constant zero, large deflection compared with other instruments performing the same function, and ability to make readings while the inked tracing is being made. A linear relation between deflection of the recorder and the transmission of the material is obtained.

The photographic plate to be analyzed is moved between a fixed beam of light and an emission type of phototube. The light falling on the phototube causes a phototube current to be



established which varies the grid voltage on tube No. 1. The amplified voltage appears across the resistor R_3; the output voltage across R_3 and R_4 is fed to a Leeds and Northrup Speedomax recorder. The resistance of R_1 and R_2 are equal and the two triodes should have identical characteristics, although this is not imperative since slight variations can be taken care of by the position of the tap, *A*. This amplifier circuit may be looked at as a push-pull d-c amplifier in which the grid voltage variations occur for only one of the tubes.

WWV Standard Frequency Transmissions

LETTER CIRCULAR LC 498, issued May 12 by the National Bureau of Standards, Department of Commerce, Washington, D. C., is a mimeographed circular of 31 pages on "Methods of Using Standard Frequency Radio Emissions." In addition to outlining various practices in utilizing emitted radiations of constant frequency, LC 498 contains a lengthy bibliography on this general subject.

Letter Circular LC 499, dated May 15, outlines the services made available through WWV at Beltsville, Md., particularly as regards the studies of the ionosphere and radio transmission conditions.

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. **Battery Chargers.** Descriptive folders of wind-operated battery chargers are available from the Windcharger Corp., Sioux City, Iowa.

2. **Cathode Ray Photograph.** Data on photographic exposures for use with cathode ray tubes is contained in the May issue of the "Oscillographer", house organ of Allen B. DuMont Laboratories, Upper Montclair, N. J.

3. **Test Equipment.** Bulletins on test equipment and component parts for radio construction are available in a booklet from the Boonton Radio Corp., Boonton, N. J.

4. **Tube Electrodes.** A 16-page bulletin on Speer graphite anodes for transmitting and rectifying tubes recently published by the Speer Carbon Co., St. Mary, Pa.

5. **Radio Components.** Catalog No. 38 of the J. W. Miller Co., 5917 South Main St., Los Angeles, lists a wide variety of coils and other radio component parts.

6. **Electrical Steel.** Published under the title "USS Electrical Steel Sheet" a new booklet embodying the latest factual information on this specialty product has been released by the Carnegie-Illinois Steel Corp., 434 Fifth Ave., Pittsburgh, Pa.

7. **Electrical Instrument.** A 10-page folder briefly describing various types of electrical instruments such as potentiometers, galvonometers, and resistance factors, is available from the Rubicon Co., 29 North Sixth St., Philadelphia. Bulletins describing specific types of instruments in greater detail are also available.

8. **Radio and Industrial Tubes.** A 56-page technical manual covering information on United transmitting tubes, mercury rectifiers, and diathermy oscillators, in loose-leaf folder, has just come from the United Electronics Co., 42 Spring St., Newark, N. J.

9. **Recording Equipment.** Booklets entitled "Presto Disc and Needle" and "Presto Instantaneous Sound Recording Equipment" which give the specifications and prices of recording equipment for radio use are available from the Presto Recording Corp., 139 West 19th St., New York City.

10. **R.C.A. Tubes.** R.C.A. Technical Bulletins have recently been released by the RCA Manufacturing Co., Harrison, N. J., on the 1608 transmitting triode, the 1609 low microphonic pentode amplifier and the 1610 crystal oscillator pentode.

11. **Microphones.** The 1938 catalog of microphones of Shure Bros., 225 West Huron St., Chicago, is now off the press and available for distribution.

12. **Rectifier Tubes.** A loose-leaf booklet giving technical data sheets on the various types of gas discharge rectifier and control tubes, together with other pertinent technical information is available from Electrons, Inc., 127 Sussex Ave., Newark, N. J.

13. **Class B Amplifier.** Technical data sheet on the 6Z7G class B power amplifier is available from the Hygrade Sylvania Corp., Emporium, Pa.

14. **Tube Data.** An up-to-date index of all broadcast receiving tubes as well as a large wall chart of tube characteristics is obtainable from the Arcturus Radio Tube Co., of Newark, N. J.

15. **Flexible Finishes.** Two folders describing flexible lacquer finishes may be obtained from the Roxalin Flexible Lacquer Co., Inc., of Elizabeth, N. J.

16. **Portable Radio Equipment.** A portable communication outfit operating from a 12-volt storage battery or gasoline-operated generator unit and weighing but 40 lb. is described in a 6-page folder bulletin of Lear Developments, Inc., 121 West 17th St., New York City.

17. **Raytheon Tubes.** Permanent data sheets for the Raytheon type 6U7G, 5T4, 5W4, 5W4G, 6Z8G and 6W5G tubes may be had from the Raytheon Production Corp., Newton, Mass.

18. **Condensers.** A 16-page bulletin of technical information on condensers and their uses is available for distribution from the Cornell-Dubilier Corp., Hamilton Blvd., North Plainfield, N. J.

19. **Weston Service Equipment.** Copies of an illustrated bulletin, No. R-15-A give details of the model 773 tube checker, model 775 test set, model 771 and 772 analyzers manufactured by the Weston Electrical Instrument Corp., Newark, N. J.

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20. Peri-Dynamic Principle. A twelve page booklet, "The Guide to a New Day," covers all phases of use, operation, and installation of peri-dynamic speakers manufactured by the Jensen Radio Manufacturing Co., 6601 S. Laramie Ave., Chicago.

21. Fibre Sheets. A four page folder gives data on characteristics of fibre sheets manufactured by the Spaulding Fibre Co., Tonawanda, N. Y.

22. Neoprene. An illustrated booklet available from the E. I. duPont de Nemours & Co., Wilmington, Del., describes the physical, chemical and electrical properties of a synthetic rubber-like compound commercially known as "Neoprene."

23. Service Catalog. A new catalog showing complete line of service equipment made by the Clough-Brengle Co., 2815 W. 19th St., Chicago, has just been released.

24. High Frequency Triode. Bulletin No. 11 gives a description and brief technical details of the WL-461 high frequency power oscillator and amplifier manufactured by the Lamp Division, Westinghouse Electric & Mfg. Co., Bloomfield, N. J.

25. Receiving Tubes. Technical data has been released by the Radiotron Division of RCA Mfg. Co., Harrison, N. J., on the 6J5 triode, 6U5 indicator electron ray tube, and the 25L6-G beam power amplifier.

26. Microphone. A four page bulletin of Epiphone, Inc., 142 W. 14th St., New York City, describes the Electar bullet microphone.

27. Plastics. Two folders illustrating the use of resinox molding material and giving the properties of various forms of this plastic are available from the Resinox Corp., 230 Park Ave., New York. A twenty-four page illustrated folder shows numerous applications and uses of this material. A spiral bound booklet gives technical information which will be useful to the manufacturer or the molder of this material.

28. Electrical Measuring Instruments. Catalog No. 40 of the Sensitive Research Instrument Corp., 4545 Bronx Blvd., New York, N. Y., is a 144-page letterhead size book dealing with precise laboratory electrical measuring equipment. Dynamometer, d'Arsonval, and thermo-couple types of movements are available for a wide variety of voltage, current, and power scales, and for frequencies from zero up to and including radio frequencies. In addition to the regular line of portable and panel mounting instruments, a number of instrument accessories and components are listed. Those having need for accurate meters will be interested in looking through "Electrical Measuring Instruments."

29. Sound Products. An 8-page loose-leaf technical bulletin on sound equipment has recently been made available by Sound Products, 704 N. Curson Ave., Hollywood, Calif.

30. Radio Parts. Folder describing a multiple crystal holder as well as newly designed sockets for vacuum tubes are available from the National Co., Malden, Mass.

31. Bakelite. An 18-page folder "What Is Bakelite?" has been issued by the Bakelite Corp., 247 Park Ave., New York City.

32. Lacquer Finish. Buffing Lacquer No. 950 and Blue Knight BA-Flex are the titles of two bulletins which have been issued by the Roxalin Flexible Lacquer Co., of Elizabeth, N. J.

33. Condensers. The "C-D Condenser" is the title of a newly issued house organ published by the Cornell-Dubilier Corp., South Plainfield, N. J.

34. Silent Gears. An 8-page folder, "Celeron Gears" is a rather complete treatment of the subject with gear specifications. Available from the Continental Diamond Fibre Co., Newark, Del.

35. Microscope. Catalog D-177 gives technical data and illustrates a wide variety of microscopes for medical and industrial uses, which are made by the Bausch & Lomb Optical Co., Rochester, N. Y.

36. Broadcast Station Equipment. Three new bulletins have been issued recently by the Western Electric Co., 195 Broadway, New York City, describing broadcast equipment. The first of these describes the No. 104-A, 105-A and 106-A amplifiers. The second describes the 110-A program amplifier and the third deals with the 23-B speech input equipment.

37. Sylvania Tube. Technical data bulletin has recently been issued by the Hygrade Sylvania Corp., Emporium, Pa., on the 6U5 tuning indicator.

38. Automobile Antennas. A single page folder describing six new automobile antennas has recently been published by the Insuline Corp. of America, New York City, as their bulletin No. 192.

39. Vacuum Tube Switch. The mark-time vacuum tube switch, series 1300, manufactured by M. H. Rhodes, Inc., Rockefeller Center, New York City, may be used to close the plate voltage on a tube circuit a predetermined time after the filament voltage has been applied. These switches are described in a single-page bulletin, 37 B-4.

40. Insulating Varnish. A 4-page cardboard folder from the Irvington Varnish & Insulator Co., Irvington, N. J., gives data on their Harbel 512 C varnish for insulating coil windings.

41. Washers. The Wrought Washer Manufacturing Co., Milwaukee, Wis., has announced the publication of a special washer data chart, available to radio and sound equipment manufacturers upon request.

42. Tubing. "Aircraft Tubing" by Summerill is the title of a single page folder available from the Summerill Tubing Co., Bridgeport, Pa.

43. Cathode Ray Tube. Specifications of a new 2″ cathode ray tube, in which is included a wiring diagram of oscillograph circuit suitable for use with the tube has been published as a separate page bulletin by the Allen B. DuMont Laboratories, Upper Montclair, N. J.

44. Insulation Test Set. Catalog E-54 (1) published by the Leeds and Northrup Co., 4902 Stenton Ave., Philadelphia, Pa., is a four page bulletin in which is described an insulation resistance test set for research, teaching and testing. Using a guarded circuit, this test set is free from the effects of leakage currents.

45. Cable. Publication No. C-27, entitled "Anaconda Duraseal Cable" is a 20 page booklet describing non-metallic sheathed cable for direct burial in the ground. Available from the Anaconda Wire and Cable Co., 25 Broadway, New York, N. Y.

46. Drilling Machine. A single page folder describes the high speed drilling machine manufactured by the High Speed Hammer Co., 313 North Street, Rochester, N. Y.

ELECTRONICS **August**

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										

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

COMPANY ....

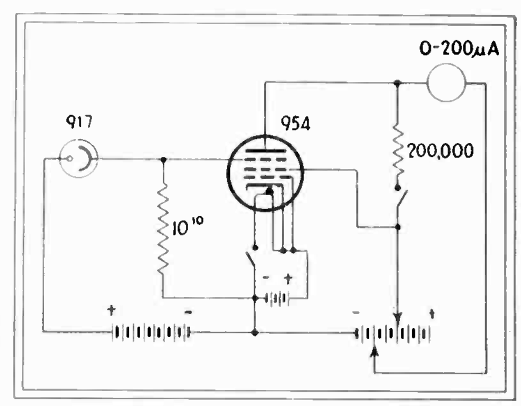
ADDRESS ....

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

Portable Phototube Amplifier With High Input Resistance

UNDER THE TITLE of, "A Portable Phototube Unit Using an RCA 954 Tube" appearing in the June issue of the *Review of Scientific Instruments*, G. H. Gabus and M. L. Pool discuss the problem of amplifying minute currents produced by a phototube and show an arrangement in which standard radio parts may be used to provide an amplifier which is not only portable but has unusually high input resistance.

The factors making for only moderately high input resistance in the ordinary vacuum tube are electron, ion, and leakage conductance. The ordinary radio tubes operated at rated voltages may be expected to have an input resistance of 10^8 to 10^9 ohms; in the arrangement used by these authors the input resistance has been increased to 10^{12} to 10^{13} ohms. This has been accomplished by reducing the voltages on the various elements so as to greatly reduce the possibility of ionization and by using the electrode connections shown in the schematic wiring diagram, as well as through the use of the 954 acorn pentode which has input resistance somewhat higher than the ordinary radio tubes.



In the diagram shown, the filament voltage is 4½ volts; the plate is operated at 6 volts and the screen at from 13 to 18 volts. No. 1 grid is connected to the cathode, No. 2 grid is the screen, and No. 3 grid is the control element. The number of ions reaching the No. 3 grid from the vicinity of the cathode is greatly reduced because they are repelled by the positive voltages applied to the No. 2 grid and the plate.

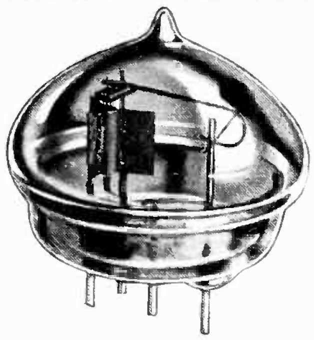
Increase in Motion Picture Theaters

Increase in the use of electron tubes in the motion picture industry is indicated in a report from the Bureau of Foreign and Domestic Commerce which reports that on January 1, 1937, there were 95,379 motion picture theaters throughout the world of which 55,563 were wired for sound. A year ago there were 87,229 motion picture houses of which 51,697 were wired for sound. Theaters of Soviet Russia accounted for 52.5% of the increase of 8,150.

For Modern High Frequency Jobs

...4 outstanding tubes by WESTERN ELECTRIC

316A

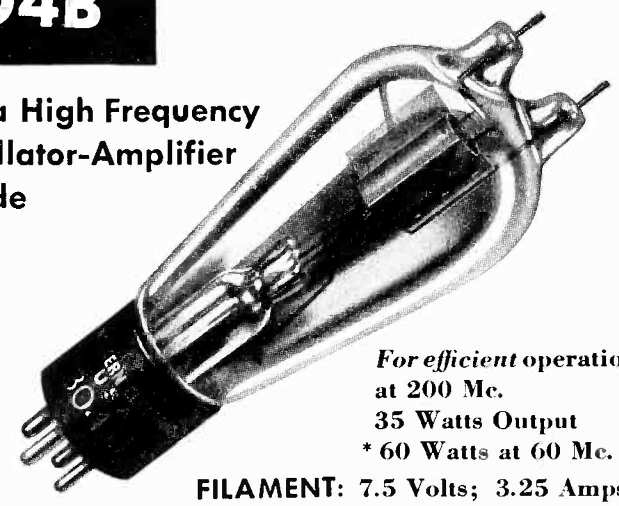


Ultra High Frequency Oscillator-Amplifier Triode

The tube that works below 1 Meter!
* 6.5 watts at 500 Mc. (60 cm.)
FILAMENT: 2.0 Volts; 3.65 Amps.
PLATE: 450 Volts. Max.; 80 Mils.; 30 Watts Dissipation
μ = 6.5

304B

Ultra High Frequency Oscillator-Amplifier Triode



For efficient operation at 200 Mc.
35 Watts Output
* 60 Watts at 60 Mc.
FILAMENT: 7.5 Volts; 3.25 Amps.
PLATE: 1250 Volts Max.; 100 Mils.; 50 Watts Dissipation
μ = 11

305A

Ultra High Frequency Screen Grid Amplifier

An *efficient* Screen Grid Amplifier at 100 Mc.
* 55 Watts at 60 Mc.
FILAMENT: 10 Volts; 3.1 Amps.
PLATE: 1000 Volts. Max.; 125 Mils.; 60 Watts Dissipation
SCREEN GRID: 200 Volts Max.; 6 Watts

312A

Suppressor Grid Pentode

1 Watt drives it!
* 65 Watts Output
Excellent Suppressor Grid Modulation with less than 1 Watt of Audio Power!
FILAMENT: 10 Volts; 2.8 Amps.
PLATE: 1250 Volts Max.; 100 Mils.; 50 Watts Dissipation
SCREEN GRID: 500 Volts Max.; 20 Watts

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RADIO TELEPHONE BROADCASTING EQUIPMENT

Organic Tissues at Short Waves

WHEN PLACED in a high frequency field a biological tissue behaves in the same way as a leaky condenser, according to Kurt Osswald, Siemens Research Laboratory, Berlin. Losses in a leaky condenser traversed by a given current are largest when the ohmic component is equal to the capacitive component of the current. This condition may be shown to agree with the equation expressing that the product frequency times conductivity (in electrostatic units) is equal to twice the dielectric constant. A maximum amount of heat is therefore set free in the condenser at a certain frequency which is determined by conductivity k and dielectric constant e as was shown experimentally by Patzold. Providing that k and e differ markedly from tissue to tissue selective heating should be possible if the frequencies are properly adjusted.

In order to find these frequencies it is necessary to measure k and e on the same sample and at the same time. The use of the "barrating bridge" has been proved by Wien to suit the purpose.

In the barrating method an audio or radio frequency current is induced in the measuring circuit containing L and C in series and made to flow through two branches. One branch contains the condenser C_{11} with the substance to be studied between the plates and a variable condenser c in parallel, the whole in series with L_1 and a variable C_1, the other branch is formed of calibrated parts L^2, C^2, R^2. The two branches are connected, directly or inductively, to two arms of a bridge and if the two branches produce the same heating effect in the two arms (lamps or filaments H of vacuum tubes) the indicating instrument is not deflected. When the frequency f is such that $4\pi^2 f_2 LC = 1$, and R and X designate the resistance and the reactance in the two branches the condition for no deflection in the bridge circuit is $R_1^2 + X_1^2 = R_2^2 + X_2^2$. The deflection is proportional to the difference between the two sides of the equation. By varying the setting of the condenser in the first branch the position at which X_1 disappears is ascertained; the deflection is a minimum at this point. The settings in the second branch are then adjusted until $X_2 = 0$; according to the formula this condition correspond to maximum deflection. The resistance R_2 is then changed until the deflection vanishes, when $R_2 = R_1$. The leakage and the dielectric constant of the condenser C_{11} are therefore known.

The material (muscles, liver, kidney, etc.) was removed from freshly killed pigs and calves, and carried in warm vacuum jackets to the laboratory. It was cautiously cut into sizes to fit the condenser. Tissues from the same organ but different animals gave about the same result. The conductivity is

RADIO engineers choose Alsimag 196 as the most advanced insulating medium of the day for high frequency work, because it achieves the combination of very low dielectric loss, mechanical strength, density and versatility of sizes and shapes.

By constant Laboratory development, American Lava seeks to lead in producing new steatite ceramic materials of outstanding merit.

There is now available, a table of characteristics, giving facts about Alsimag in useful data. If you do not have a copy, let us have your request.

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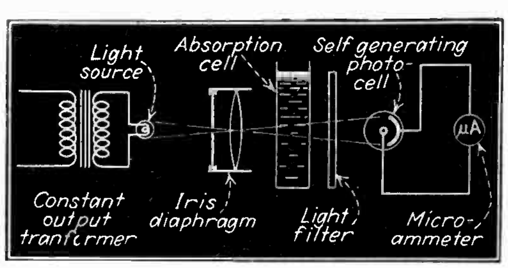
up to ten times higher at these high frequencies than at audio frequencies, and in the case of liver, spleen and brain continues to increase with increasing frequency at 3 meters, whereas with blood the main rise takes place in the range of broadcast frequencies. The dielectric constant decreases with increasing frequency between 3 and 12 meters. At 12 meters the dielectric constant of the kidney equals 200.

When the wave-lengths that would produce the largest amount of heating are computed from e and k, all the results are below 1 meter. There appears to be little difference between various organs of the body. All that can be hoped for is that blood and muscles may be more strongly heated than fat by using for fat a 4 meter wave, and for the muscles 1.5 meters. Schaefer, however finds the opposite behavior. Gall, urine and blood may be considered as electrolytes; it appears possible to heat them more strongly than the tissues by using waves of 0.76, 0.37 and 1 m. respectively. *(Hf. Tech. El. Ak.* 49: 40–47. 1937.)

Photoelectric Photometer

A PHOTOELECTRIC photometer, having as its principal applications the accurate determination of amounts of substance in solution and chemical analysis by a rapid, simple technique based upon special photometric methods has been developed for commercial use by the Central Scientific Co., and is known as its "photelometer." The essential features of the photelometer are the optical system, the carrier for the absorption cell in which particles may be suspended in a liquid, and the electrical measuring system. The optical system consists of a 6-volt incandescent lamp operated by a transformer of constant power output, a precision iris diaphragm, and a light filter of suitable transmission characteristics for the work at hand. A small glass rectangular cell is used for holding the liquid in which particles may be suspended. The electrical measuring system consists of a self-generating type photoelectric cell, connected to a low resistance microammeter of high sensitivity. The schematic wiring diagram of the photelometer is shown in the attached diagram.



Transparent substances absorb some of the incident light, and transmit the remainder. The ratio of intensities of transmitted to incident light is the transmission factor for that substance,

and is given by the equation

$$T = t^{cl}$$

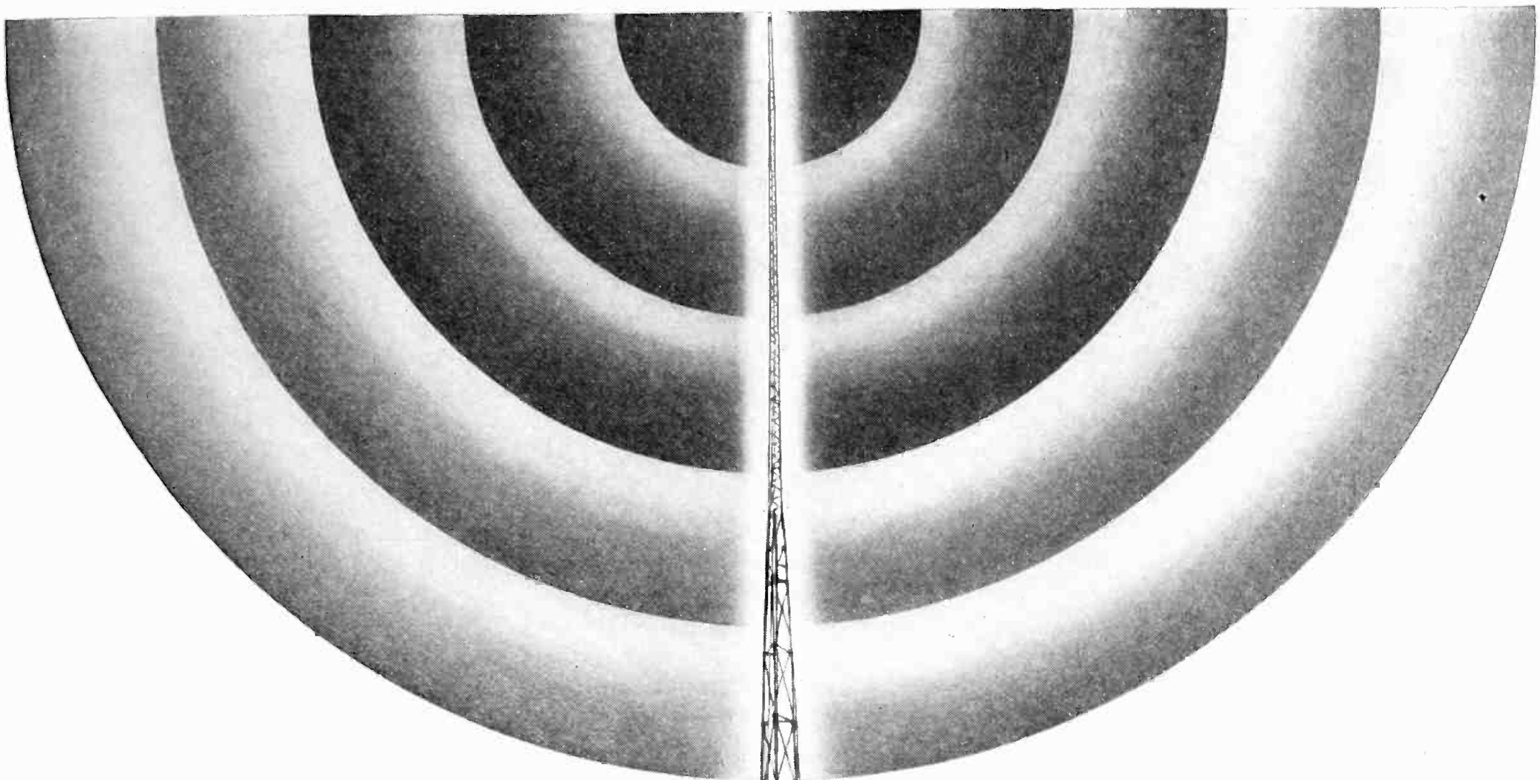
In this equation T is the transmission factor of a solution of concentration c and of thickness l, and t is the transmission factor for the solution of unit concentration and unit thickness. From this equation the concentration of the solution, c, may be determined by measuring T when the factors l and t are known. In practice the thickness of the solution, l, is determined by the size of the cell used so that there are only three variables in the above equation for a given series of measurements. The reading of the microammeter of the photelometer may therefore be calibrated to show the concentration of a given solution.

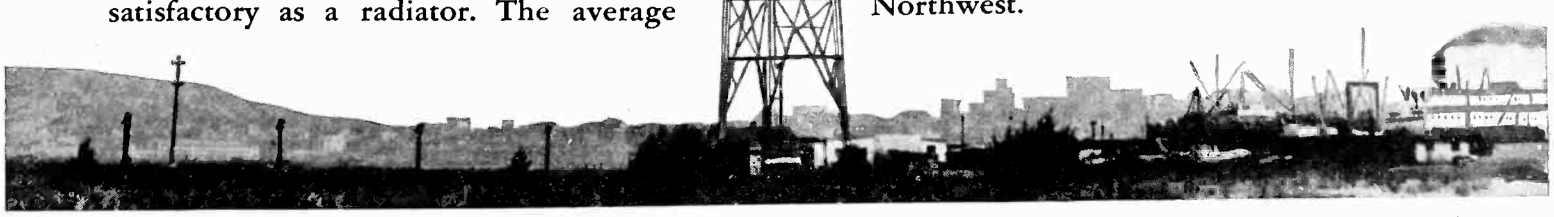
The photelometer has also been used to determine particle distribution and the specific surface area of particles in suspension. In making these measurements the particles are dispersed in a suitable medium and observations are made on the transmission of light through the cell containing the dispersed material, as the particles settle. The particles are assumed to obey Stokes' law of fall, and it is assumed that the surface area of all the particles having diameters less than d microns is proportional to the negative logarithm of the transmission factor of the sample at a fixed point below the surface of the liquid. Based on these assumptions the particle distribution and specific surface area may be determined for a given sample by taking observations of the photelometer microammeter reading over various intervals of time.

Electromagnet

A NEW TYPE of electromagnet composed entirely of iron or steel and insulation, without the use of copper or other non-ferrous metals, is described by Harvey Allison in the May issue of the *Review of Scientific Instruments*.

The magnet consists of a roll of thin sheet iron or steel, each turn of which is insulated from the other. Electrical contact is made to the inner turn as well as to the outermost turn and a current is passed through this iron coil which then becomes an electromagnet. For convenience in construction, the author suggests that it is desirable to attach an iron rod to the inner end of the sheet steel by soldering or other convenient method. The thin sheet steel may then be rolled on the rod which can be used for the electrical connection. The electrical resistance of such a magnet is greater than of the conventional type of electromagnet but can be considerably reduced by plating a thin coat of copper on the sheet iron. An interesting magnetic property of the rolled magnet is that the magnetism is strongest at the center of the pole, and diminishes steadily as the edge of the roll is approached.





Relays in Tube Circuits

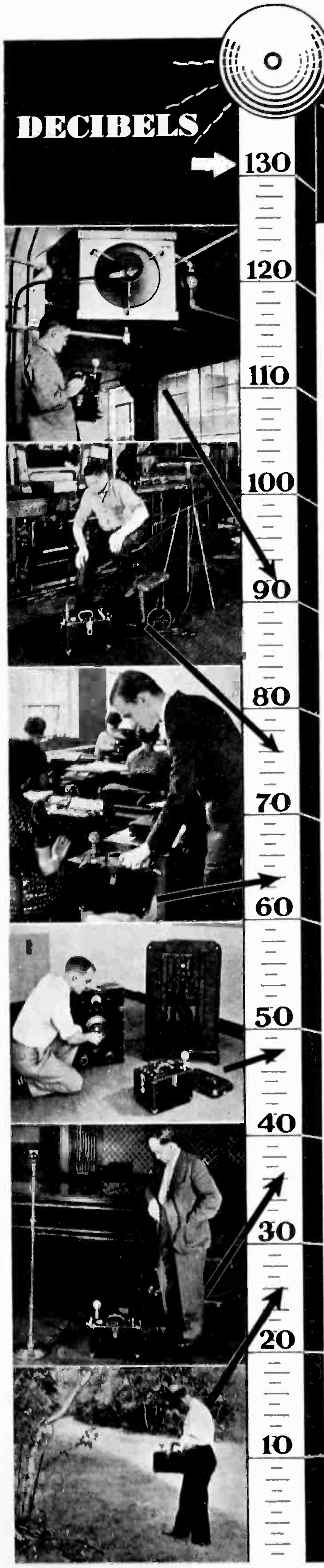
(Continued from page 21)

as we know the signal variations of the grid voltage.

For example, with 6L6 operating at 400 volts, the maximum magnetomotive force will be developed (assuming the grid may go to 0 but not positive) when the load line connects the point of tangency of the tube and relay characteristics with the point $E_b = 400$, $I_p = 0$. This gives a load resistance $R_L = E_b/I_p = 400/0.225 = 1780$ ohms. The magnetomotive force developed by the relay at zero grid voltage will be 2500 ampere turns times the scale factor of 1.972 or 4935 ampere turns. If the grid bias is —15 volts and we superimpose a signal of 10 volts (peak) on the grid, the quiescent *MMF* will be 1250×1.972 or 2460 ampere turns whereas the maximum and minimum *MMF* will be, respectively, 2120×1.972 or 4170 ampere turns, and 600×1.972 or 1180 ampere turns. The values for these latter cases are determined from the points where the relay characteristics coincide with the load line and grid voltage curves. For the load line plate voltage, grid bias, and signal voltage we have assumed, the magnetomotive force in the relay coil will vary between 1180 and 4170 ampere turns, peak values.

In the interests of stability and good design it is desirable to make allowances for the normal variations of tube and relay characteristics as well as for voltage variations which may arise in practice. It is also desirable to operate the tube at the right of knee of the tube characteristics for greatest stability.

It should be noted that the optimum condition for the case under consideration does not take into account any distortion in the plate circuit of the tube, so that load lines as determined by the method described may differ from those determined where high quality audio frequency reproduction is a consideration. The fact that the relay characteristic can be used with other forms of tube characteristics (such as plate voltage plate current curves for given grid bias with screen voltage as parameter) should not be overlooked. The method of operation is similar to that outlined above.



RIGHT ON THE NOSE WITH
THE NEW G-R SOUND LEVEL METER

NO herculean feat of strength is required to ring the bell every time in any sort of noise measurement with the new General Radio Type 759-A Sound-Level Meter. It is portable, light in weight, self-contained, can be operated by anyone with a few minutes practice and supplies the correct answer under all conditions.

AMONG ITS MANY FEATURES:

PIEZO-ELECTRIC MICROPHONE: Non-directional . . . uniform frequency characteristic . . . not affected by ordinary changes in temperature or humidity or mechanical vibrations.

STANDARDIZED READINGS: Meets standards of engineering societies.

UNUSUAL SENSITIVITY: Extends to 24 db above a zero level of 10^{-16} watts per cq. cm. Calibrated from +24 db to +130 db.

STABLE CALIBRATION: Remains constant throughout life of batteries. Can be checked easily by the user.

SELF-CONTAINED: Weighs only 23½ pounds with batteries . . . convenient carrying handles on lid of case and on instrument itself.

REQUIRES NO BATTERY ADJUSTMENTS: Ballast tube eliminates all battery adjustments.

NON-MICROPHONIC: Special construction eliminates microphonic noises and resulting serious errors.

NON-MAGNETIC PICK-UP: No inductance coils or transformers to introduce serious errors from electrical pick-up.

***THREE* WEIGHTING NETWORKS:** Over-all frequency characteristic corresponds to that of human ear no matter what the sound level is.

MODERATE PRICE: Many noise meters costing two or three times as much do not have all the features of the G-R Type 759-A Sound Level Meter. Its price is only $195.00 complete with all tubes and batteries and ready for immediate operation.

Write for Bulletin 160-E
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GENERAL RADIO CO.
Cambridge, Massachusetts

New York   Los Angeles   San Francisco

VIDEO AMPLIFIER DESIGN

(*Continued from page* 25)

condenser as the frequency is lowered. An analysis of the equivalent circuit for low frequencies, including this filter (Fig. 9), yields the following expression for the gain of a single stage:

$$G = g_m \omega R_{g1} C_c \left(\frac{(R+R_F)^2 + \omega^2 R^2 R_F^2 C_F^2}{(1+\omega^2 R_F^2 C_F^2)(1+\omega^2 R_{gl}^2 C_c^2)} \right)^{\frac{1}{2}} \quad (6)$$

If the circuit is so proportioned that $RC_F = R_{gl}C_c$ and $R_F \gg R$ this expression reduces to:

$$G = g_m R \frac{\omega R_F C_F}{\sqrt{1+(\omega R_F C_F)^2}} \quad (7)$$

with a phase characteristic

$$\phi = \cot^{-1} \omega R_F C_F \quad (8)$$

Using equations (8) and (1) we can determine the product $C_F R_F$ necessary to give a variation of phase delay T in microseconds for a single stage over a frequency band of ten to one:

$$\frac{100}{T} = \omega^2 C_F R_F \quad (9)$$

where ω is 2π times the lowest frequency to be transmitted. When this frequency is 30 cps and the permissable variation in phase delay for ten stages is 0.01 microsecond per stage we have

$$R_F C_F = 0.28 \quad (10)$$

The same reasoning can be applied to Eq. (5) in the case where no plate filter is used; thus

$$R_{gl} C_c = 0.28 \quad (11)$$

When equations (9), (10), or (11) are fulfilled the gain as calculated by Eq. (6) or (4) will be more than satisfactory as to uniformity. It is interesting to note that for a value of the isolating resistor approaching infinity, the gain reduces to $g_m R$ and is independent of the frequency. This, of course, is an unattainable ideal condition.

Another factor affecting the frequency characteristic is the method of obtaining the bias for the amplifier tubes. The ideal way to obtain the necessary bias voltage would be to use separate bias batteries for each stage, but this is not an economical method. The usual method of obtaining bias by means of a resistor in the cathode circuit is satisfactory, provided that the resistor is by-passed by a sufficiently large condenser. If the by-pass condenser is not sufficiently large, degeneration will result, affecting the response characteristic of the amplifier. Experience indicates that a ratio of by-pass reactance to cathode resistor of less than one-tenth for the lowest frequency to be transmitted is necessary.

A transient solution of the amplifier, including the plate circuit filter, is extremely cumbersome and beyond the scope of this paper. If the plate circuit filter is neglected, the transient solution is fairly straight forward but quite mathematical. The reader who is interested in the details of the solution is referred to a paper by H. M. Lane[4], published several years ago. It is sufficient to note here the results of a similar analysis and the interpretation of these results. If a unit voltage is suddenly impressed upon the grid of a tube, the shape of the voltage wave impressed upon the grid of the following tube will be given by the expression:

$$e_{g2} = k\varepsilon^{-bt}$$

where $k = \dfrac{RR_{g1}\mu}{RR_p + R_{gl}R_p + RR_{gl}}$

and $b = \dfrac{R + R_p}{C_c(RR_p + R_{gl}R_p + RR_{gl})}$

$\cong \dfrac{1}{R_{gl}C_c}$

and the shape of the voltage wave impressed upon the grid of the third tube is of the form:

$$e_{g3} = k^2 \varepsilon^{-bt}(1 - bt)$$

For a large number of stages the expression becomes more involved. Thus, for a five-stage amplifier, the voltage wave at the output is of the form:

$$e_o = k^5 \varepsilon^{-bt}(1 - 4bt + 3b^2t^2 - 4/3\, b^3t^3 + \tfrac{1}{4} b^4 t^4)$$

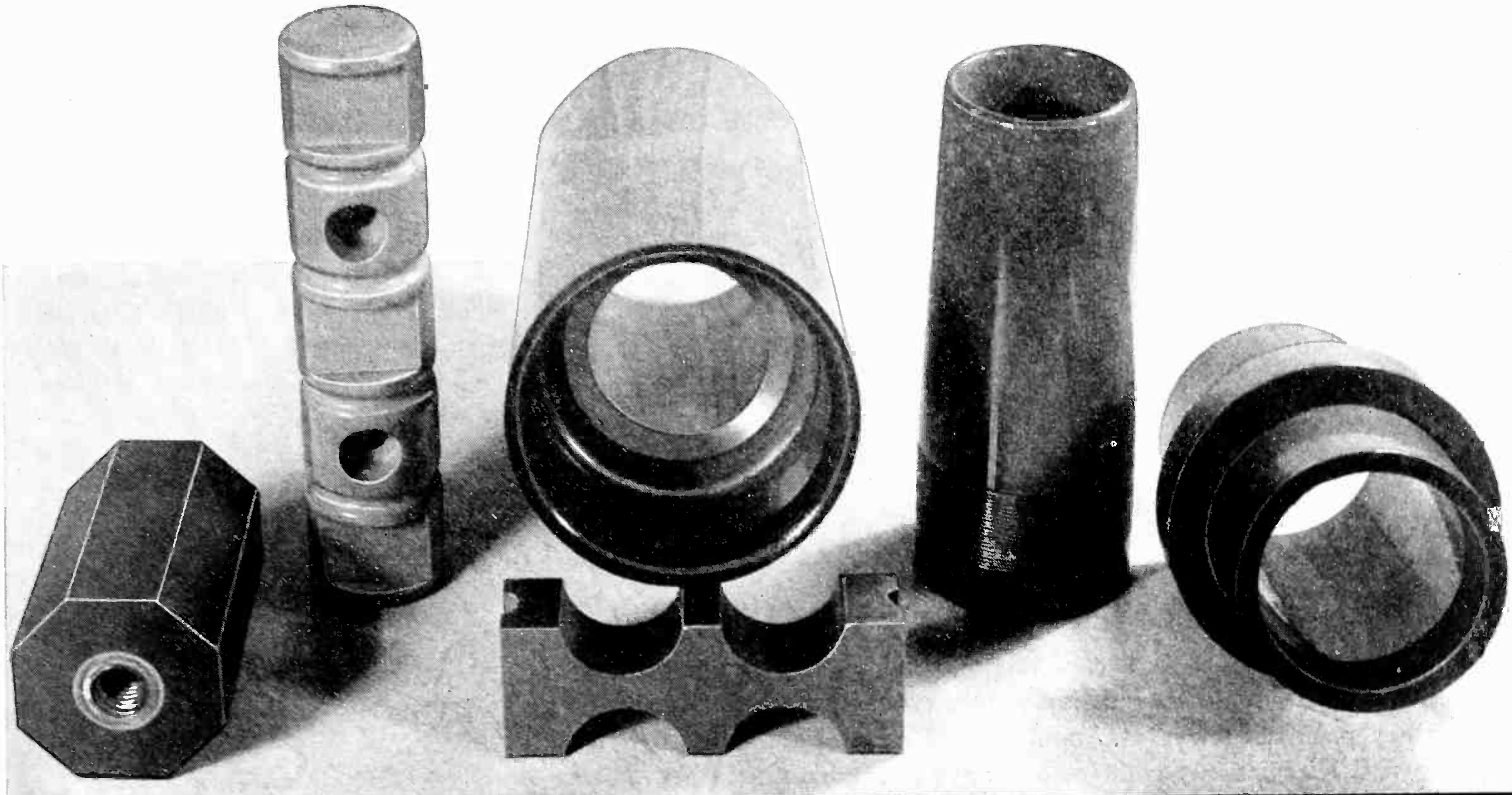
It is readily seen from these equa-

TABLE OF TUBES SUITABLE FOR VIDEO AMPLIFICATION

Triodes	Cgk	Cpk	Cgp	C[1] total	X_c @2.5MC	G_m	Gain[2]	Remarks
955	1.0	0.6	1.4	21.4	3,000	2,000	6.	High gain for low power supply demand
76	3.5	2.5	2.8	28.	2,270	1,450	3.3	6C5 not as good because metal shell causes high C_{pk}
800	2.75	2.75	2.5	32.	2,000	2,800	5.6	Used for large voltage swing
Screen grid tubes	**C Input**	**C Output**	**C[3] Total**		**X_c @ 2.5MC**	**G_m**	**Gain[2]**	**Remarks**
954	3	3	16		4,000	1,400	5.6	High gain for low power supply demand
6C6	5	6.5	21.5		2,950	1,225	3.6	6D6, 6K7G, 6J7G about equivalent
807	11.6	5.6	27.2		2,350	6,000	14.1	6L6G has slightly higher capacities. 6L6 metal inferior to 6L6G

[1] $C_{TOTAL} = C_{gk} + C_{pk} + (1 + \text{Gain})C_{gp} + 10\mu\mu f (= C_{STRAY})$
[2] $\text{Gain} = G_m X_c$, $X_l = .5X_c$, R_a neglected
[3] $C_{TOTAL} = C_{Input} + C_{Output} + 10\mu\mu F\ (= C_{STRAY})$

Note: Calculations based on tube working into a stage having same constants.



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tions that the response of a multi-stage amplifier to the unit impressed voltage is of an oscillatory nature. If the duration of the first positive swing for unit impressed voltage is long compared to the duration of the actual signal impulse, the amplifier response will be good. This requirement is satisfied by making b small, i.e., by making the time constant $R_{g1}C_c$ large. It is also evident that the time constant must be increased as the number of stages of amplification is increased. Although the impulses contained in a television signal do not have perpendicular sides, it can be shown that the conditions given here are valid. The curves of Fig. 10 illustrate the nature of the transient response to a pulse similar to a low frequency blanking pulse of unit amplitude and duration of 0.0015 seconds. The value $b = 4$ corresponds closely to Eq. (11) where $R_{g1}C_c = 0.28$.

Conclusions

The design procedure formulated in the foregoing paragraphs was used to calculate the constants in the circuit of Fig. 11 which shows a 6C6 stage working into a similar stage. The response of this stage would be entirely satisfactory in a television system.

Some points about construction may be mentioned. The condenser C_c should be non-inductive up to 2.5 Mc. and should be mounted some distance from the chassis to reduce stray capacity. All leads should be short as in usual r-f amplifier practice, and wire of the minimum size in keeping with mechanical considerations should be used to reduce stray capacity.

The resistance R should be non-inductive. A carbon resistor may be used here, or a wire wound resistor may be used which is so designed that its inductance equals L thus doing away with the extra component part.

[1] "Latest Television Standards as Proposed by R.M.A.", R.M.A. Engineer, p. 9, November 1936.

[2] Kell, Bedford, Trainer, "An Experimental Television System", I.R.E., p. 1246, November 1934.

[3] Slepian, Patent No. 1,450,265; Farnsworth, Patent Nos. 1,941,344; 1,969,399; 2,071,515; 2,071,516; 2,071,517; 2,075,378.

[4] Proc. I.R.E., Vol. 20, No. 4, p. 722.

MANUFACTURING REVIEW

News

✦ Dr. George H. Brown, formerly of the Research Division, RCA Manufacturing Co., Camden, N. J., has become associated with Paul Godley with the formation of Godley and Brown, consulting radio engineers. Offices of this new engineering partnership will be at Montclair, N. J.

✦ The first degree of doctor of engineering ever conferred by the Lewis Institute, at Chicago, was bestowed upon Dr. Lee DeForest, on June 23. Dr. DeForest was honored for his extensive research work in the radio field and particularly for his invention of the vacuum tube, without which radio could not exist in its present form today.

✦ C. R. Ogle, recently secretary and sales manager of the B-L Electric Manufacturing Co., has joined the sales organization of P. R. Mallory & Co., Inc., manufacturers of rectifiers, battery chargers, radio and electrical and metallurgy products.

✦ United States Rubber Products, Inc., has appointed Dr. Earl E. Sturdevant as consulting engineer of its electrical wire and cable department. Since 1920 when he took his doctorate at the University of Michigan, Dr. Sturdevant has been connected with many scientific developments in the rubber field. After a two-year interval of teaching at the University of Western Ontario, he joined the technical staff of Western Electric and in 1929 joined the staff of the United States Rubber Products, Inc. In his capacity as consulting engineer, Dr. Sturdevant will apply his extensive technical knowledge to the perfection of United States Rubber's wire and cable products, and to the rubber company's many developments in the rubber field to insulated wires and cables.

✦ Royal D. Mailey, vice-president in charge of engineering and manufacturing, General Electric Vapor Lamp Co., Hoboken, N. J., was awarded an honorary degree of doctor of science on June 12 by the Stevens Institute of Technology.

✦ At a meeting of the directors of the Western Electric Co. held June 8, a dividend of 75 cents per share on its common stock was declared. The dividend was payable on June 30 to stock of record at the close of business on June 25, 1937.

✦ Mackay Radio operations on the Atlantic seaboard have been placed in charge of H. L. Rodman as general manager, according to an announcement made by Luke McNamee, President of the Mackay Radio & Telegraph Co. Mr. Rodman was formerly general superintendent at San Francisco and will have charge of domestic radio telegraph service involving eastern cities, service with ships in the Atlantic region, and a direct radio telegraph circuit to points in Europe and Latin America.

✦ A statement of the income for the three months ended March 31, 1937, which was released on June 10 shows a net income for the International Telephone & Telegraph Corp. and subsidiaries of $1,658,437.82.

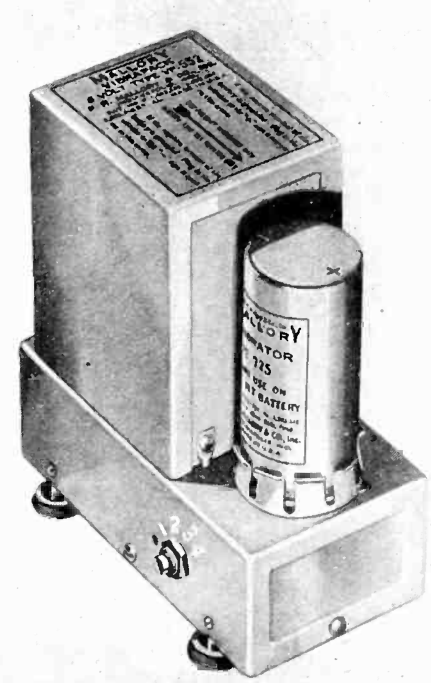
New Products

Sensitive Meters

The Sensitive Research Instrument Corp., of 4545 Bronx Blvd., New York City announces the introduction of a new line of medium size, portable, measuring instruments. In line with most of their other instruments, these new meters are flexible as regards ranges, all are switch controlled for the various ranges, and may be obtained in sensitivities down to 5 microamperes, full scale, in direct current meters. Dynamometer instruments are also available down to 5 milliamperes full scale range in the same design of case voltage.

Vibrator Power Pack

To provide portable power for radio transmitters, public address systems, and similar apparatus, P. R. Mallory & Co., Indianapolis, Ind., has introduced a line of 6-volt power supplies known as Vibrapacks.

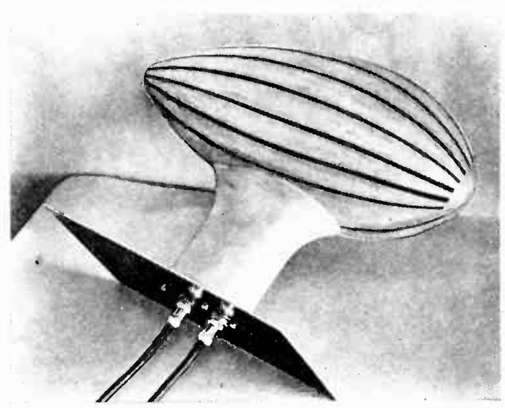


50-Watt Amplifier

A COMPLETELY NEW AMPLIFIER using 6L6 tubes in the output, has been announced by the Radolek Co., 601 West Randolph St., Chicago. The unit incorporates four individual high gain input channels for microphones and one input channel for a phonograph head. Each channel is controlled separately, and a master volume control is employed to vary the overall volume. A dual type control of tone permits the suppression of either the treble or bass notes. A voltmeter type volume indicator, mounted on attractive chromium finished control panel, permits easy monitoring of the equipment connected to four or less loudspeakers may be made by means of polarized plugs and sockets, impedances for line matching transformers of 200, 500 and 1,000 ohms being available. It is claimed that the response characteristic is flat to within 1 db. from 40 cycles to 9,000 cycles per second.

Shielded Loop Antenna

Lear Developments, Inc., 121 West 17th St., New York City announce the development of a shielded loop antenna for radio direction finders. The complete shielded loop weighs 7¾ lb. and has two loop antennas inside of the shell, placed at right angles to each other. One is used for "homing" or



direction finding; the other for reception from stations directly ahead or behind. The loop works in combination with the three-band receiver and reception and direction finding are obtainable over the following frequency ranges: 200 to 400 kc.; 550 to 1500 kc.; and 2400 to 6500 kc.

World Clock

AN A-C operated clock having an auxiliary dial in addition to the regular clock face which may be used to determine the time in all parts of the world has recently been released under the name "Globe trotter." The hand of this new Telechron model tells the time in the zone in which the clock is installed, while the revolving disk indicates the time in other sections of the world.

Wave Trap

A NEW WAVE TRAP announced by the Technical Appliance Corp., 17 East 16th St., New York City is available in three frequency ranges from 450 to 750 kc., from 750 to 1150 kc. and from 1150 to 1550 kc., covering the complete

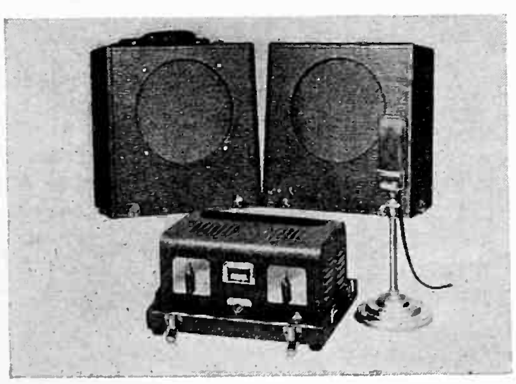
broadcast band. The unit of the particular frequency range in which the interfering station falls, is selected for installation. A setscrew adjustment then permits the tuning of the trap to the precise frequency to eliminate the undesired signal.

Filter

UNITED TRANSFORMER CORP., 72 Spring St., New York, N. Y. announces the release of their model BA-189 filter for commercial aircraft service. It consists of a combination band pass and band rejection unit which permits simultaneous voice and beam reception on aircraft receivers.

Portable Sound System

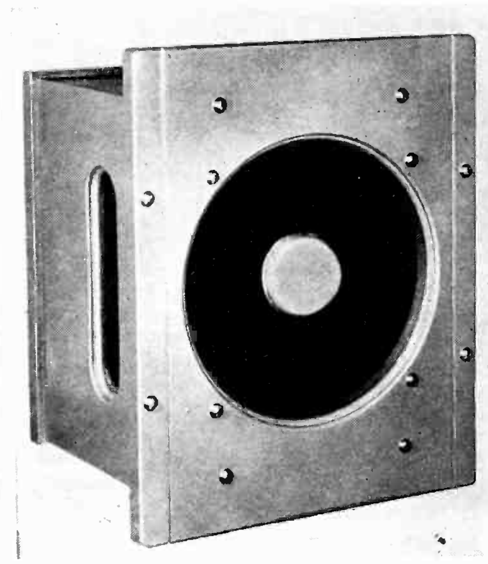
THE 12-WATT PORTABLE sound system model PA-712 announced by the Webster Co., 3825 West Lake St., Chicago, contains two speakers, microphone and amplifier packed in a single carrying case having a total weight of 44 lb.



The amplifier is a 4-stage high gain unit using beam power tubes. The two speakers are supplied in cases adaptable to either floor or wall mounting. A multiple outlet arrangement is provided for using additional speakers.

Peri-Dynamic Speakers

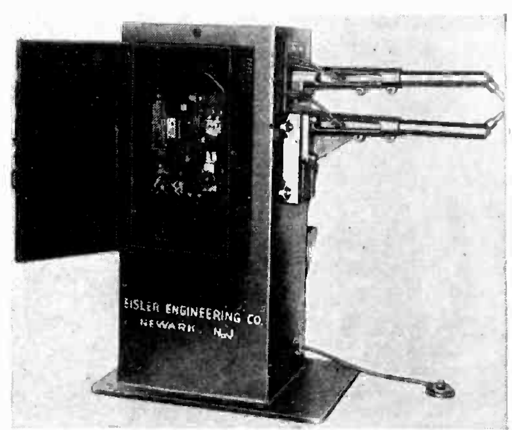
A new line of dynamic loud speakers available in kit form is announced by the Jenson Radio Manufacturing Co., 6601 South Laramie Ave., Chicago, Ill. The kit consists of speaker and knocked-down enclosure. All necessary



screws, bolts, grilles, brackets and other accessories for assembling are furnished. Enclosures in all cases are cut to size, drilled, and all necessary parts for assembling are enclosed.

Resistance Welder

An electric welder capable of making up to 100 spot welds per minute is announced by the Eisler Engineering Co., 740 South 13th St., Newark, N. J. An 8-point hand wheel regulates the heat regulation and the duration of the welding period is regulated by the automatic timer and contactor, assembled on the



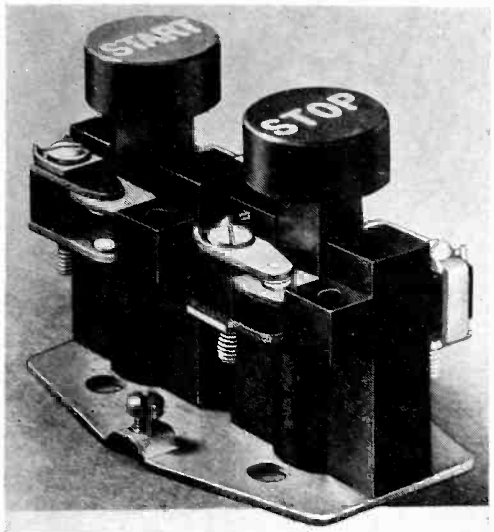
side of the fabricated frame. The timer is adjustable to regulate current from 2 to 60 cycles. An air-pressure valve on the machine is used to regulate the proper air pressure; this welder operates on an air pressure of 35 to 60 lb., depending on the nature of the work.

Amateur Microphones

Velocity microphones for amateur radio use is a recent development announced by the Amperite Corp., 561 Broadway, New York City.

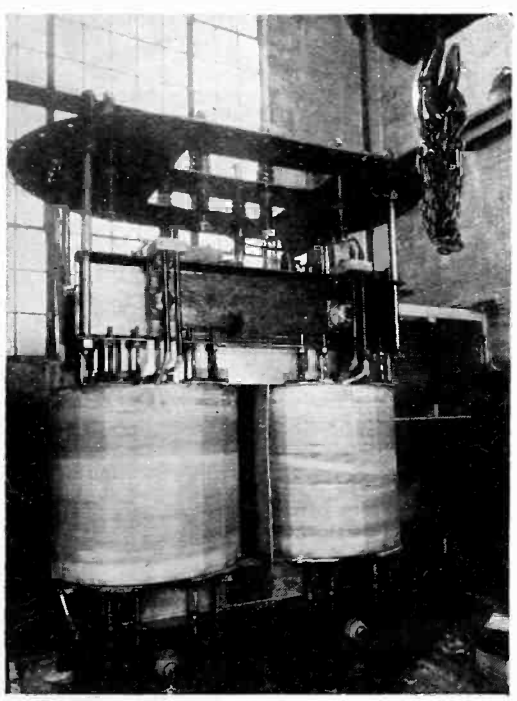
Push Button Control

THE MONITOR CONTROL Co., Baltimore, Md., have added one more push button control station to their long list of master control devices. This push button station is substantially built with liberal size silver contacts mounted on a molded bakelite base. Parts and cover are die cast. A wide number of contact arrangements is available with button markings suitable for almost every industrial purpose.

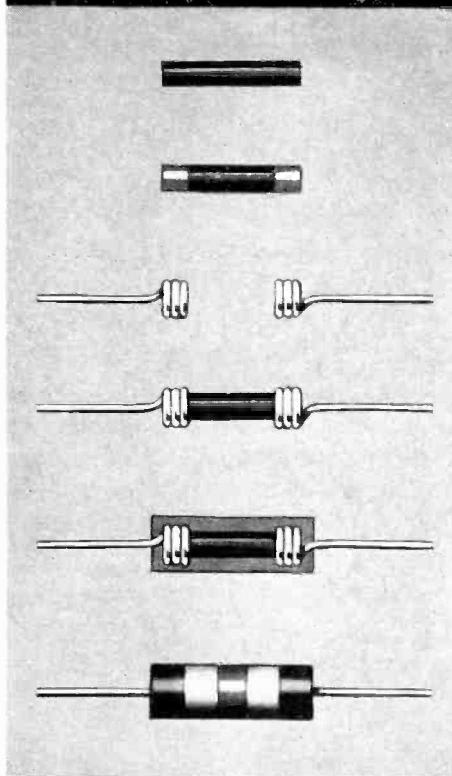


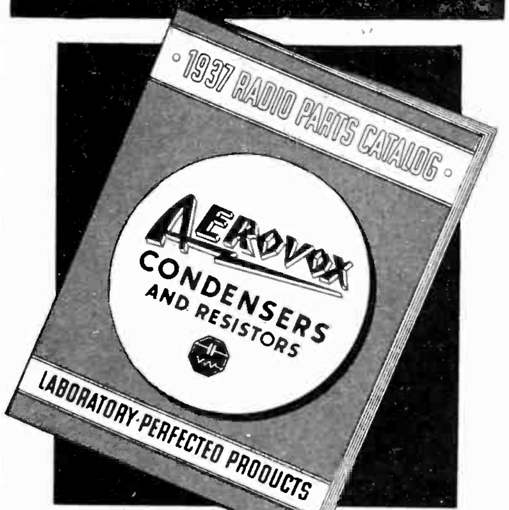
Signal Generator

CLOUGH-BRENGLE, Chicago, announces an accurate signal generator with a frequency range from 100 kc. to 31 mc. in five bands, with direct reading dial. R. f output is continuously variable up to 0.1 volt. Either internal or external modulation may be used at will. The tube complement is one 76 oscillator, one 6X5 rectifier, and one 6N7 modulator.



There aren't enough 50 kw. radiophone stations in the country for any manufacturer to carry a complete line of high power equipment on stock, but Amertran, makers of the modulating unit shown above, will manufacture to order



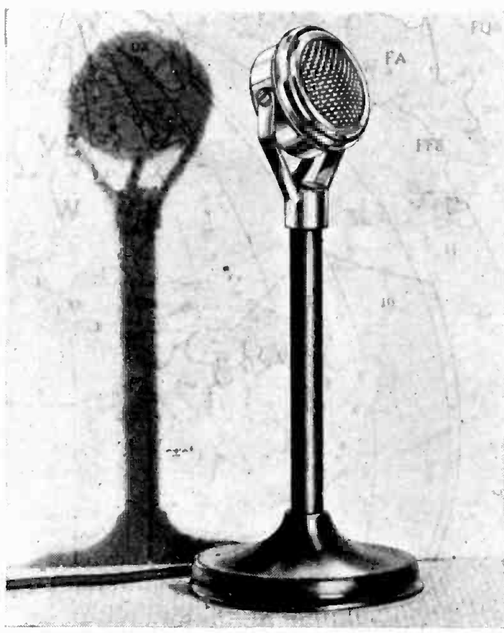


Analyzer

SIMPLIFICATION of radio servicing is the aim in introducing the model 100 analyzer made by the Simpson Electric Co., 5216 W. Kinzie St., Chicago. It is intended to be used with set tester, voltmeter or milliammeter. Through the use of machine punched cards placed over the jack switches, the connections of any type of tube are immediately evident and plainly marked for point to point testing. The system is flexible and may be expanded as future requirements dictate.

Crystal Microphone

A NEW TYPE of crystal which appreciably increases the output level is used in two new microphones recently announced by Shure Bros., 225 West Huron St., Chicago, Ill. The microphones are especially designed for communication in airway, police radio, commercial, and amateur radio telephone systems. These microphones have a frequency characteristic which discriminates against the lower audio



frequency and provides maximum output in the frequencies for which maximum intelligibility occurs. This frequency characteristic is especially advantageous in improving the output signal quality from highly selective receivers, since the rising characteristic of the microphone tends to compensate for receiver side-band cutting.

Chassis Cradle

AN AID to servicemen which will hold any make or model of radio chassis in the desired position for testing, aligning, or repairing, is the chassis cradle recently placed on the market by the Acro Tool & Die Works, 1401 Wilson Ave., Chicago, Ill. Special mechanical clamps hold the chassis without danger of breakage or damage and permit the serviceman to have both hands available for service work.

P. A. Amplifier

FEATURES OF THE model 855 amplifier manufactured by the Operadio Manufacturing Co., St. Charles, Ill., include the use of beam power tubes, four-channel input, electronically mixing of

three microphone channels simultaneously with phonograph or auxiliary input, volume expansion and compression, electronic visual overload indicator, master gain control and six stages of amplification using twelve tubes.

• • •

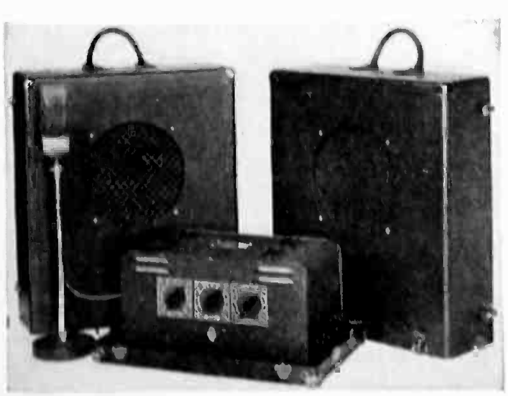
Spark Plug Alloy

A NEW SILICON-MANGANESE-NICKEL alloy called Sparkaloy has been developed by the Wilbur B. Driver Co., of Newark, N. J. for the rigorous requirements of spark plug use. It is especially resistant to the attacks of oxygen and sulphur and shows high resistance to mechanical disintegration at the operating temperatures encountered. It is claimed that the alloy is uniform in surface, thoroughly annealed and possessed of excellent welding properties.

• • •

Portable P.A. Unit

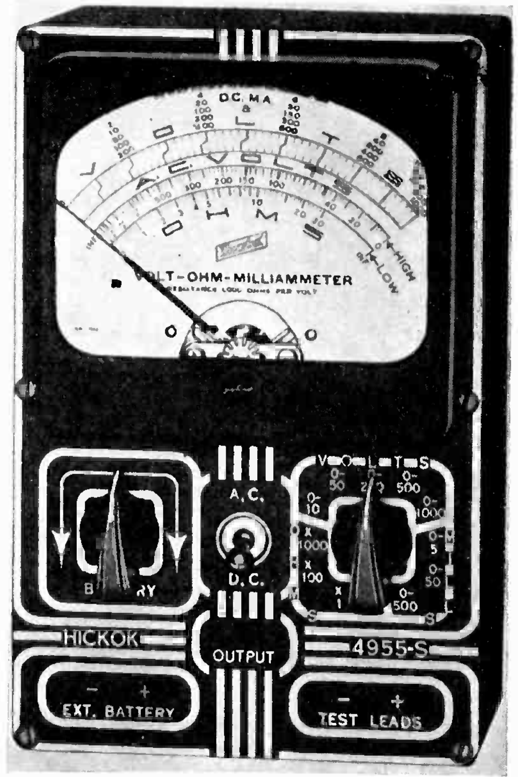
A PORTABLE microphone-amplifier-speaker system rated at 14-26 watts, and using beam power tubes is an-



nounced by the Operadio Manufacturing Co., St. Charles, Ill. Provision is made for mixing two microphones and one phonograph pick-up. Two 10 inch electrodynamic speakers are used.

Test Instrument

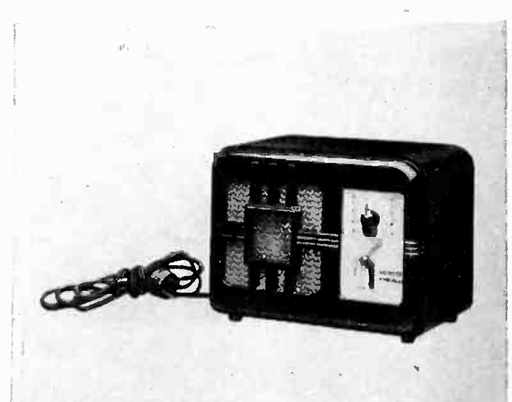
A TEST INSTRUMENT for general circuit testing on a.c. or d.c. and having a wide range of voltage, current, and resistance scales is the model 4955-S instrument manufactured by the Hickok Electrical Instrument Co., of



Cleveland, Ohio. The instrument is guaranteed accurate to within 2% of full scale on all ranges. A square meter with 4 inch scale is the foundation unit for this test equipment.

Intercommunicating System

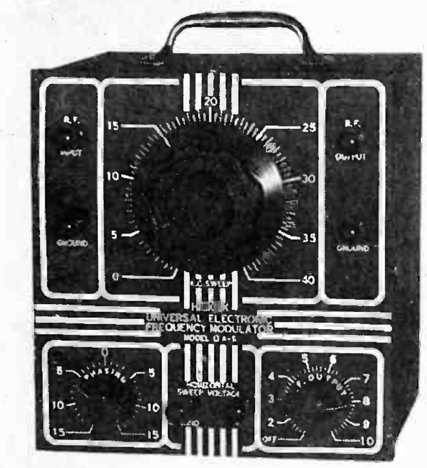
TWO NEW SYSTEMS have been added to the line of intercommunicating systems available from the Webster Co., 5622 Bloomingdale Ave., Chicago, Ill. for interoffice communication. The illustration shows one of the model OCM



units featuring a selector switch which is provided to contact the station calls. Each of these units can call each other unit in the system and as many as ten units can be accommodated; a total of five separate conversations may be held over the system from different points at the same time.

Electron Frequency Modulator

THE model OA-5 universal electronic frequency modulator, manufactured by the Hickok Electrical Instrument Co., Cleveland, Ohio operates with any oscillator or any size oscillograph to simplify a.f.c. alignment and to provide



a method of locating intermittent trouble. It supplies synchronized horizontal sweep voltage for oscillographs. It has a calibrated sweep, continuously variable from 5 to 40 kc. and calibrated phasing control. Output is continuously variable from 1 microvolt to more than 1 volt. The instrument has complete, self-contained power supply.

Two-Inch Cathode Ray Tube

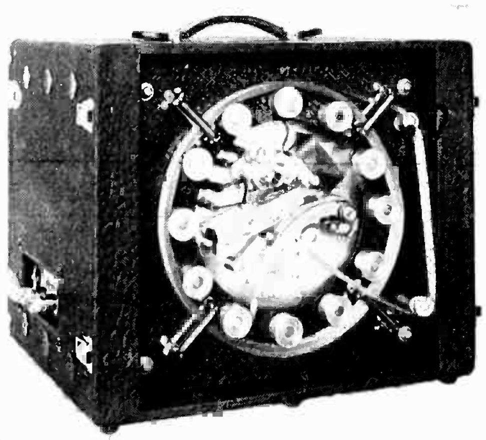
IN LINE WITH the recent trend of making available cathode ray tubes of small size and moderate price, the National Radio Union Radio Corp. announces the Type 2002 cathode ray tube with two-inch screen. It operates with a maximum plate voltage of 600 volts, has four deflecting plates, and a green screen of short persistence of image. The indirect heater operates at 0.6 ampere at 6.3 volts. Deflection sensitivity is approximately 0.15 mm/volt at the highest second anode voltage. At a second anode voltage of 400 volts, deflection sensitivity is about 0.22 mm/volt. Tube fits the standard octal sockets.

Station License Mounting

A MOUNTING which will permanently display as well as preserve the amateur operator and station licenses is available from the Gordon Specialty Co., 440 South Dearborn St., Chicago, Ill. A swivel type of mounting allows inspection of either operators' or stations' license. Made of steel and finished in black baked crackled finish to match other station equipment this unit is available in either panel mounting bracket or with heavy cast base for table mounting.

Film Recording System

A MODERN sound-on-film recording and reproducing machine, operating on an endless loop of 16 millimeter film varying in length to fit the recording time has been developed by the Fonda Sound Corporation, 117 West 63rd St., New York, N. Y. The recording head engraves a continuous spiral track on the film, using a special stylus. Immediate play-back is accomplished by simply placing the pick-up on the film. Elimination of changing of needles, low background and low recording costs are some of the advantages claimed for this new device.



2-inch Cathode Ray Tube

A new 2-inch high vacuum cathode ray tube with four electrostatic reflection plates is announced by the Allen B. DuMont Laboratories, Inc., Upper Montclair, N. J. A large octal base is used and heater voltage of 6.3 volts, a.c. or d.c., is used making this tube interchangeable with the 913. Second anode voltage is from 300 to 600 volts. List price $7.50.

Replacement Condensers

A RECENT announcement by the P. R. Mallory Co., Indianapolis, states that twenty-one new replacement condensers have been made available for radio receivers.

Directional Arrays

(*Continued from page 17*)

no real component of induced current, and as far as power radiation is concerned each element acts as tho the other were not present. Therefore for $\phi = 90$ degrees the correction factor depends only on k and is independent of the height and spacing. The correction factor gives direct comparisons between arrays of the same height. To compare systems of different heights it will be necessary to determine the actual theoretical field strength as explained previously. The principles here applied could be extended to arrays of more than two elements but the calculations would probably be rather laborious.

REFERENCES

1. Electronics April 1936 Page 22.
2. G. H. Brown *I.R.E. Proc.* Jan. 1936 Page 53 Fig. 5.
3. G. H. Brown and Ronold King. *I.R.E. Proc.* Apr. 1934 Eq. 7 and reference 2 above (Eq. 7).
4. Janke and Emde, "Funktionentafeln mit Formeln und Kurven."
5. *I.R.E. Proc.* June 1932 Page 1019 Fig. 14.

Permanent Magnet Speaker

A COMPLETE NEW LINE of permanent magnet speakers from 3 in. to 14 in. in diameter, under the trade name "Permag" is announced by the Oxford-Tartak Radio Corp., 915 West Van Buren St., Chicago. The 3-in. unit is claimed to be the world's smallest permanent magnet dynamic speaker and because of its desirable electric and acoustic characteristics, coupled with its small size, is being offered especially for interoffice communication systems.

Patent Suits

1,403,475 (*a*), 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., C. Div., Doc. E 894-S, *R. C. A. et al*, v. *E. Spigel et al.* Decree pro confesso Feb. 25, 1937. Doc. E 1082-J, *R. C. A. et al.* v. *F. Sage.* Decree pro confesso holding patents valid and infringed, injunction Feb. 25, 1937. Same, D. C., N. D. Calif. (San Francisco), Doc. E 4105-S, *R. C. A. et al.* v. *O. S. Grove.* Decree pro confesso holding patents valid and infringed as to certain claims, injunction Mar. 4, 1937.

1,403,475 (*b*), H. D. Arnold; 1,403,-932, R. H. Wilson; 1,507,017, L. de Forest; 1,507,016, same; 1,811,095, H. J. Round, D. C., S. D. Calif., C. Div., Doc. E 1080-S, *R. C. A. et al.* v. *O. J. Bates.* Decree pro confesso Feb. 25, 1937. Same, filed Feb. 26, 1937, D. D., S. D. Calif. (Los Angeles), Doc. E 1126-C, *R. C. A. et al.* v. *G. Deutch et al.* (*Radio Accessories Co.*).

1,403,475 (*c*), 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, D. C., S. D. Calif., C. Div. Doc. E 1078-M, *R. C. A. et al.* v. *J. Forbes.* Decree pro confesso for plaintiff for injunction Feb. 26, 1937.

1,403,475, (*d*) H. D. Arnold; 1,403,-932, R. H. Wilson; 1,518,017, F. Lowenstein; 1,936,162, R. A. Heising; Re. 18,579, Ballantine & Hull, D. C., S. D. N. Y., Doc. E 84/303, *R. C. A. et al.* v. *Amplex Radio Corp. et al.* Consent decree for plaintiff (notice Mar. 17, 1937).

U. S. PATENTS

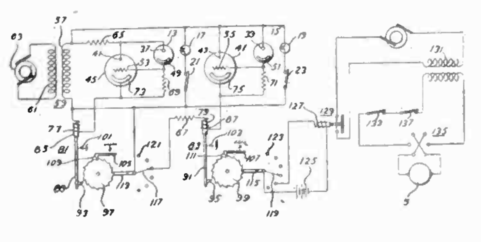
Timing Circuits, Etc.

Time recorder. No. 2,044,471, L. E. Dodd and W. W. Harper, Los Angeles, Cal. *Timing system.* No. 2,047,912, L. Theremin, New York. *Cycle timer.* No. 2,047,127, E. W. Huber, Crouse-Hinds Co. *Counting apparatus.* No. 2,047,665, J. E. Beggs, G.E. Co.

Watch timing. No. 2,055,231, Alfred Disteli, Ernst Leitz, Wetzlar, Germany. No. 2,064,559, 2,058,616, Ernst Norrman, Chicago, Ill. No. 2,063,184, time service system, D. H. Myers, Cincinnati. No. 2,050,866, Rudolf Tamm, Siemens & Halske, Germany.

Light Sensitive Applications

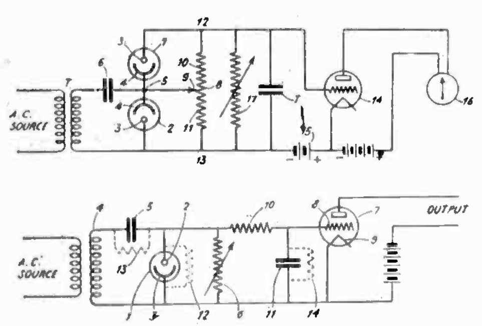
Relay. Circuit making use of polarized light, the tubes being in containers with light-polarizing windows with their



planes of polarization at angle to each other. F. W. Lyle, WE&M Co. No. 2,041,079.

Control circuit. A control system operated by moving objects, comprising a pair of photo tubes, directional relays, etc. H. H. Geffcken and H. R. Richter, RCA. No. 2,048,740. See also No. 2,058,011.

Light responsive device. A two tube photometer in which the photo tubes are supplied with a-c through a con-



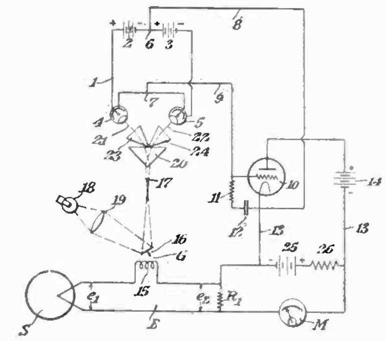
denser. Patent No. 2,054,836 and No. 2,065,758, to F. H. Shepard, Jr., RCA.

Lighting control. No. 2,078,677 to T. H. Long, WE&M Co. A system for display devices.

Relay. Combination of a source of a-c, a rectifier, a solenoid and light sensitive tube, differential relay, etc. A. H. Lamb, Weston. No. 2,057,384.

Engraving. Method of and means for producing printing plates by phototube apparatus. J. A. Bennett, Bloomington, Ind. No. 2,076,220.

Potentiometer. Photoelectric device responsive to a small voltage source.



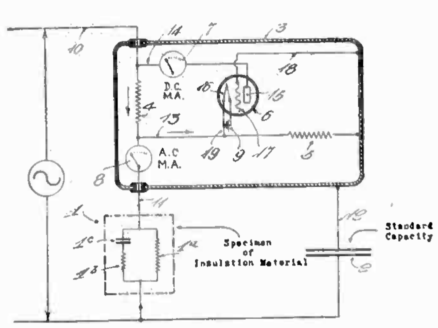
R. W. Gilbert, Gilbert Corp., East Orange, N. J. No. 2,059,786.

Light relay. Combination of phototube amplifier and voltage doubler rectifier. R. C. Hitchcock, WE&M Co. No. 2,060,500.

Safety device. Phototube safety control for punch press, etc. A. J. McMaster, G-M Lab., Inc. No. 2,082,210.

Photometer. No. 2,080,613 to Bruno Lange, Berlin, Germany, comprising a source of light, two blocking layer cells connected in series, both illuminated by a single source of light, a light filter between the source of light and one cell and a variable resistance in shunt with the galvanometer to regulate the sensitivity of the galvanometer and adjust the deflection of it to a scale of absolute values corresponding to the light absorption of the filter.

Insulation Testing. F. B. Doolittle, Glendale, Calif. No. 2,077,357. Apparatus for measuring the power factor



of the charging current of and watts loss in insulating materials.

Dust Measurement. Nos. 2,076,553 and 2,076,554. Philip Drinker and W. G. Hazard, Jamaica Plain, Mass. on apparatus for measuring, recording and controlling dilute dust concentrations.

Feedback circuit. Phototube feeds an amplifier with arrangements such a portion of the amplifier output feeds energy back to the input device. R. R. Haugh, G. E. Co. No. 2,082,627.

Alarm. A device for indicating illumination values. A. H. Lamb, Weston. No. 2,054,380.

Tabulating machine. J. W. Bryce, International Business Machines Corp. No. 2,063,482.

Exposure meter. Adjusting the diaphragm of a camera until the light permitted to go through it reaches some predetermined value indicated by a phototube. Odon Riszdorfer, Budapest. No. 2,059,032.

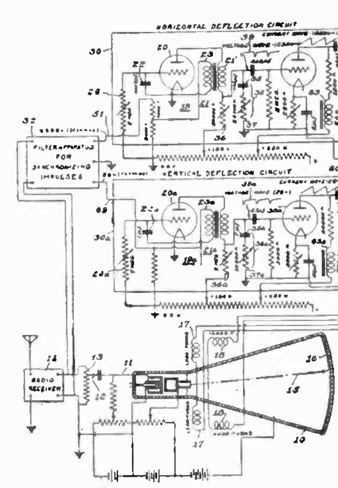
Photometer. Combination of a light meter comprising a photoelectric element, electric measuring instrument, etc. E. Reinhold, Photo Marketing Corp., New York. No. 2,064,987.

Elevator leveler. Means including photo-electric devices for furnishing several electric currents having relative magnitudes which vary in accordance with position of the elevator car. A. S. FitzGerald, Wynnewood, Pa. No. 2,074,835.

Register apparatus. Patents relating to machine operating on webs of material, etc. No. 2,075,111 to F. H. Gulliksen and S. A. Staege, Westinghouse. Localizer for web cutting machines. No. 2,082,705. J. J. Logan, Benjamin C. Betner Co., Devon, Pa. No. 2,075,095, cutter register control, to O. C. Cordes, WE&M Co. No. 2,050,315, paper cutting control, F. H. Gulliksen, Westinghouse E&M Co. Also No. 2,050,316. No. 2,052,256 to D. R. Shoults, G. E. Co. Also No. 2,052,263, A. L. Whiteley, G. E. Co. No. 2,078,661 to F. H. Gulliksen. No. 2,078,669, A. King, Narberth, Pa. No. 2,080,575, W. R. Perry, Reeves Pulley Co., Columbus, Ind.

Television

Television system. Means for developing a voltage wave comprising a

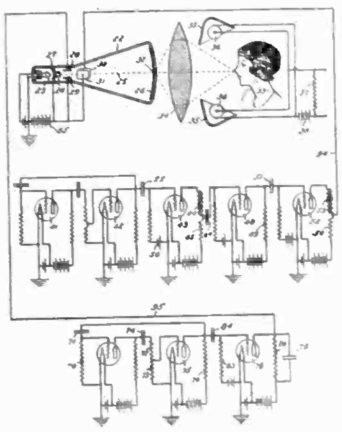


saw-tooth component and an impulse component and means for using them. W. A. Tolson, RCA, reissue No. 20,338.

Tilting oscillator. A device for producing relaxation oscillations of straight line wave form comprising a gas tube, an amplifier, etc. Kurt Schlesinger, Berlin, Germany. No. 2,075,140 to 2,075,142.

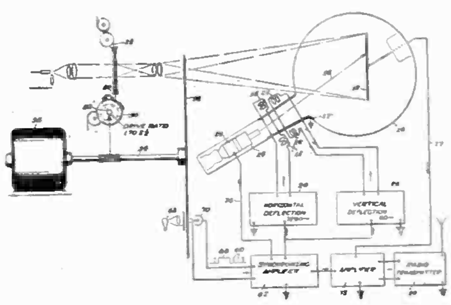
Charting system. Method and apparatus for observing bodies through opaque substances by means of cathode-ray tubes. R. A. Fliess, New York, N. Y. No. 2,075,808.

Saturating amplifier. H. R. Lubcke,



Los Angeles, Calif. No. 2,075,818. See also No. 2,055,748.

Transmission system. System for motion picture film providing that certain individual frames remain in position for scanning longer than other in-



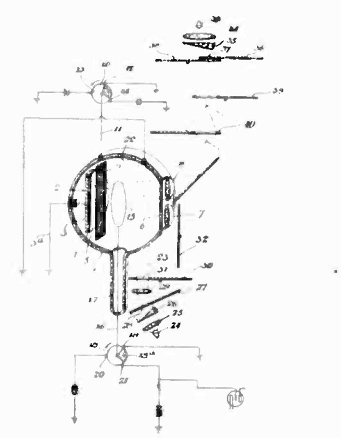
dividual frames and means for scanning these two sets of frames different numbers of times. A. V. Bedford, RCA. No. 2,082,093.

Rotating mirror. Means for mechanically printing characters on a tape member, means for feeding the tape from said device to a scanning member, means for scanning the tape and for converting the scanning results into electric current for reproducing record. R. A. Fessenden, Jan. 14, 1927. No. 2,059,222.

Oscillators, generators, etc. Patents to P. T. Farnsworth, of Farnsworth Television Incorporated, as follows: No. 2,059,683, scanning oscillator; No. 2,071,516, oscillation generator; No. 2,-071,517, multipactor phase control; No. 2,071,515, electron multiplying device; No. 2,059,219, slope wave generator. Also to R. H. Varian, No. 2,075,377, means and method for forming discrete areas; No. 2,075,380, means for modulating high frequency currents; No. 2,075,379, time delay oscillator; No. 2,075,378, means and method for collecting secondary electrons.

Impulse generator. No. 2,074,033, to W. A. Tolson and No. 2,062,198, system and method of operation for communication by television, both to RCA.

Screen system. Television process, the steps of which comprise projecting an image upon a photoelectric screen, then interrupting the light beam forming the image on the screen and then



scanning the screen. Original application May 29, 1929. Forty claims. F. C. P. Henroteau, the Electronic Television Co. Ltd., Ottawa, Canada. Reissue No. 20,187.

Television method. An arrangement for transmitting optical occurrences. M. von Ardenne, Berlin. No. 2,047,533.

Sound-television. Apparatus for receiving and projecting televised images in synchronism with sound. Lee de Forest, Los Angeles. No. 570.

Generator. Device for generating a current and voltage of saw tooth wave form. Tomomasa Nakashima and Kenjiro Takayanagi. No. 2,055,611.

Electron tubes

Inverter. A tube having a cathode and two anodes and means for moving the anodes alternatively adjacent to and away from the cathode. D. D. Knowles, Westinghouse E&M Co. No. 2,078,672. See also No. 2,078,671 to Knowles on a crystal starter rectifier and phase control tube.

Phototube. Patents to Bernard Salzberg, RCA. No. 2,077,810, and to A. J. McMaster, G-M Laboratories, No. 2,077,633 and No. 2,077,634.

Magnetron. An elongated U-shaped member, the legs of which have a comparatively large transverse cross section and are of comparatively large mass, the inner facing surfaces of said legs being closely spaced, flat and parallel, a pair of anode segments at the free ends of said legs on the inside surfaces thereof and having oppositely disposed semi-cylindrical surfaces providing a cylindrical chamber the axis of which is parallel to the flat surfaces of the legs of said U-shaped member, a straight thermionic cathode positioned axially of said cylindrical chamber and means for inducing a magnetic field longitudinally of said cathode. George R. Kilgore, RCA No. 2,075,855.

High Frequency Tubes. Several patents to the Bell Telephone Laboratories as follows: No. 2,063,341, A. L. Samuel; 2,063,342, A. L. Samuel; 2,062,892, J. P. Laico; 2,062,334, A. L. Samuel; 2,062,319, J. P. Laico and patents 2,062,301 and 2,062,302, C. E. Fay.

Measuring Equipment and Circuits

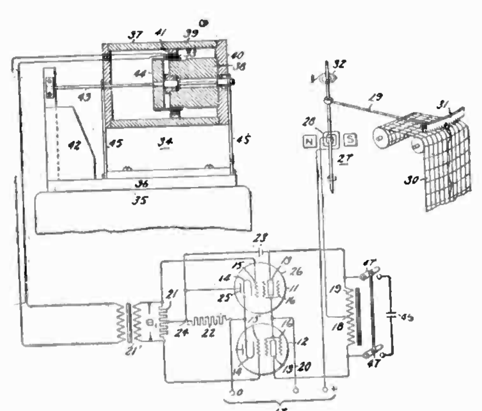
Sensitivity Meter. A method of measuring the selectance characteristics of a receiver by adjusting the receiver to a predetermined frequency, incrementally varying the frequency of the generated waves, utilizing the energy output of the amplifier associated with the receiver to automatically vary the amount of energy impressed upon the input of the receiver to such a value that the amount of output energy assumes a predetermined value at each of the increment points and measuring the amount of the input energy is varied from a predetermined value at each of the increment points. Walter Dissler, Telefunken, No. 2,081,739.

Radiation Measurement. An electrical circuit comprising an amplifier tube for detecting variations of relatively low order in an electric current. H. Kott, the Ion Corporation. No. 2,081,041.

Modulation Measurement. Patents No. 2,069,934, L. B. Arguimbau, General Radio Co. and No. 2,082,492, Henri Grumel, Paris, France.

Recording Circuit. A light-beam type instrument for recording transients in an electrical circuit. J. H. Hagenguth and W. A. McMorris, G.E. Co. No. 2,082,624.

Voltmeter. A tapered response voltmeter having its scale expanded at the



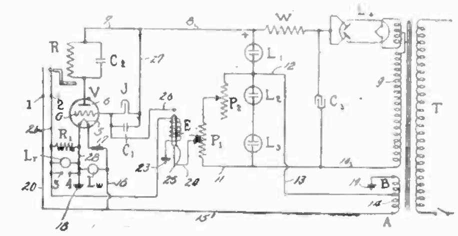
lower end. M. S. Mead, Jr., G.E. Co. No. 2,082,646.

Time Measurement. No. 2,080,825. Georg Keinath, Siemens & Halske, Germany.

Gravity Measurement. A geophysical gravitational prospecting apparatus. L. W. Blau, Standard Oil Development Co. No. 2,077,390 and No. 2,077,391.

Telemetering System. Apparatus for the continuous measurement and telemetering of mechanical power. No. 2,073,394. C. W. MacMillan.

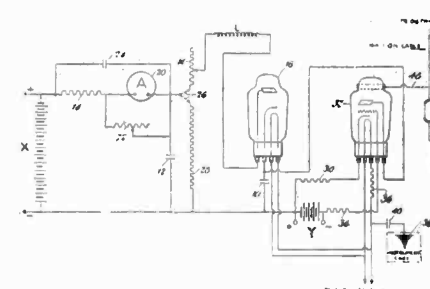
High Resistance Measurement. An amplifier and a circuit including a condenser for impressing a blocking charge on the grid and a third circuit to be closed upon current flow in first circuit comprising the amplifier and when so closed operating to close said second circuit. Siegmund Strauss, Vienna. No. 2,081,074.



Liquid Mixtures. The method of indicating the water content in liquid mixtures, measuring the flow of current between electrodes immersed in the liquid with a small voltage imposed upon the electrodes and again measuring the current between the electrodes with a higher voltage imposed upon the electrodes, this voltage being insufficient to cause disassociation of the water. J. L. O'Donnell, Long Beach, Calif. No. 2,082,213.

Remote Metering System. An impulse measuring system, comprising a transmitter which sends current impulses at a rate proportional to a quantity or condition affecting the transmitter. Carl Oman, Westinghouse E. & M. Co., No. 2,078,680.

Rate Meter. A circuit including a condenser with a means for discharging the condenser at a frequency proportional to the rate to be measured. Benjamin Miller, Doherty Research Co., New York. No. 2,068,147.



Pressure Measurement. Use of a cathode-ray tube in connection with an engine including a chamber in which a fluid undergoes rapid variations of pressure. Marcel Demontvignier, Suresnes and Andre Labarthe, Paris, France. No. 2,067,262. See also No. 2,054,787 R. J. Beavers and H. R. Laird, Western Electric Co. on a means to continuously measure and record both the magnitude and the variations in the pressure exerted between two elements by means of a piezoelectric crystal.

Universal Instruments. A universal multi-range alternating current meter for measuring either voltage, current or power. E. A. Massa, Jr., Haddon Heights, N. J. No. 2,059,594.

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Our work fully Guaranteed.

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REBUILT INSTRUMENTS of GUARANTEED ACCURACY

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Therefore

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INDEX TO ADVERTISERS

NOW!..Complete Distortion and Fidelity Measurements

EASILY... QUICKLY

New RCA Measuring Equipment Makes it Possible...

RCA announces the development of a set of new ac operated instruments with which the complete operating characteristics of amplifiers or transmitters may be easily and quickly determined with an unusually high degree of accuracy. This new equipment, consisting of an RCA Type 68A Beat Frequency Oscillator and RCA Type 69A Noise and Distortion Meter enables broadcast stations, laboratories, etc., to measure directly distortion percentage, noise level and frequency characteristics of equipment at frequencies in the audible range. Routine checks of fidelity require but a few minutes with this equipment.

The 6 important features shown here are proofs of the outstanding quality and usefulness of the equipment. Note these features. Consider how valuable this new equipment can be to you. Then write for free technical information. No obligation.

1. Enables broadcasting stations to maintain consistent high fidelity performance.

2. Measures complete operating characteristics — frequency response, distortion percentage and noise level.

3. Completely AC operated—small in size. Rack or cabinet mounting.

4. Operates over entire audio band of frequencies

5. Easy to adjust and indicates directly—no calculations or critical adjustments required.

6. Makes routine fidelity measurements a practical reality.

RCA Type 68A Beat Frequency Oscillator. Specifications: Frequency response: Is flat within plus or minus 1 db. over the range between 20 and 17,000 cycles. Instrument may be operated down to 5 cycles per second with good wave form. Output power: Maximum 120 mw. Output Impedances: 5,000, 500 and 250 ohms. Distortion: Total arithmetic sum below 100 cycles, 0.3%—Above 100 cycles 0.2% at 12½ mw. output. Hum (zero level output): Minus 60 db. Power supply: 110-120 volts, 25-60 cycles, 70 watts. →

RCA Type 69A Noise and Distortion Meter. Specifications: Frequency Range for Distortion Measurements: 50 to 7,000 cycles. Distortion Measurement Range: Full scale, 1% to 100%. Minimum reading .3 of 1%. Minimum Hum Measurement: 88 db. below a 12.5 mw. level on a 500 ohm line or below 100% modulation. Includes R.F. rectifier for transmitter measurements. Audio Input Impedance: 20,000 ohms bridging input balanced to ground and 250,000 ohms unbalanced to ground. →

RCA *Broadcast Equipment*

RCA Mfg. Co., Inc., Camden, N. J. · A Service of the Radio Corporation of America

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