VOLUME 11 APRIL, 1923 NUMBER 2

PROCEEDINGS
of
The Institute of Radio Engineers

EDITED BY
ALFRED N. GOLDSMITH, Ph.D.

PUBLISHED EVERY TWO MONTHS BY
THE INSTITUTE OF RADIO ENGINEERS
THE COLLEGE OF THE CITY OF NEW YORK
140th Street and Convent Avenue, New York, N. Y

Subscription $9.00 per Annum in the United States
$9.60 in all other Countries

GENERAL INFORMATION AND SUBSCRIPTION RATES ON PAGE 73

Entered as second-class matter, February 16, 1916, at the Post-Office, at New York, N. Y., under the Act of March 3, 1879.

Acceptance for mailing at special rate of postage provided for in Section 1103, Act of October 3, 1917, authorized October 7, 1918.

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PROCEEDINGS OF

The Institute of Radio Engineers

Volume 11 | APRIL, 1923 | Number 2

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GENERAL INFORMATION

The Proceedings of the Institute are published every two months and contain the papers and the discussions thereon as presented at the meetings in New York, Washington, Boston, Seattle, San Francisco, or Philadelphia.

Payment of the annual dues by a member entitles him to one copy of each number of the Proceedings issued during the period of his membership.

Subscriptions to the Proceedings are received from non-members at the rate of $1.50 per copy or $9.00 per year. To foreign countries the rates are $1.60 per copy or $9.60 per year. A discount of 25 per cent is allowed to libraries and booksellers.

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PUBLISHED BY

THE INSTITUTE OF RADIO ENGINEERS, Inc.

THE COLLEGE OF THE CITY OF NEW YORK

EDITED BY

ALFRED N. GOLDSMITH, Ph D.

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THE WORK OF THE INTERNATIONAL UNION OF SCIENTIFIC RADIO TELEGRAPHY*

By

J. H. Dellinger

(Chief of Radio Laboratory, United States Bureau of Standards, Washington, D.C.)

This organization is not, as the name might perhaps suggest, a radio telegraphers' union. It is the world organization for the promotion of radio research on an international scale. It was begun in July, 1919, under the auspices of the International Research Council. It is organized:

1. To promote the scientific study of radio communication.
2. To aid and organize researches requiring cooperation on an international scale and to encourage the discussion and publication of the results of such researches.
3. To facilitate agreement upon common methods of measurement and the standardization of measuring instruments.

The work is actually carried on thru the activities of the National Sections, which have been organized in the United States, Belgium, England, France, Italy, and Norway. Steps are being taken to create such Committees also in Australia, Holland, Japan and Spain.

The International Union itself is a rather simple organization framework for carrying on the international phases of the administrative work. It is similar to the various other international unions: of astronomy, geophysics, mathematics, chemistry, and so on. The officers are a president (General Ferrié, France), four vice-presidents (Dr. L. W. Austin, United States; Dr. W. H. Eccles, England; Dr. Vanni, Italy; Dr. Bjerknes, Norway), and a general secretary (Dr. R. B. Goldschmidt, Belgium). The office is located in Brussels. One of the principal duties of the international officers is the calling of a general meeting of the International Union every three years. Delegates from the several National Sections attend the general meeting. The second such meeting was held in Brussels in

*Published by permission of the Director of the Bureau of Standards of the United States Department of Commerce. Received by the Editor, March 8, 1923.

July, 1922. This meeting organized four international "commissions" for the purpose of correlating the work done by the several national committees on the corresponding subjects. The membership of the international commissions is as follows:

	President	United States	England	Belgium	France	Italy	Norway
Methods of measurement and standards	Abraham	Dellinger Goldsmith	Glazebrook Dye F. E. Smith E. Murray	Henrion Tricot Corteil	Abraham Jouaust Bethenod	Vanni Vallauri	Vegard Petersen
Radio wave transmission phenomena	Austin	Austin Alexanderson Taylor	Howe F. E. Smith	DeDonder Philippson	Mesny Perot	Artom Pession	Petersen Engset Cythfeldt
Atmospheric disturbances	Eccles	Austin Squier	Eccles	Wibier Jaumotte	Ferrié Rothe Marius Latour	Pession Sacco Le Dir. de l'Observatoire de Monte Cassino	Bjerknes Skolen Devik
"Liasons"	Vanni	Kennelly	Campbell Swinton	Goldsmith Pere Lucas	Jullien Brenot	Vanni Bardeloni	Not yet designated

The American Section was organized on October 26, 1920, under the auspices of the National Research Council, in Washington. The American Section is made up of an Executive Committee and six technical committees. The Executive Committee consists of: two officers of the National Research Council ex-officio, one member each from the Army, the Navy, the Department of Commerce, the Institute of Radio Engineers, four members at large appointed by the President of the National Academy of Sciences, and (ex-officio) officers of the International Union resident in the United States. The personnel, for 1922 to 1925, is:

L. W. Austin, *Chairman*

J. H. Dellinger, *Technical Secretary*

Chairman of Division of Physical Sciences, National Research Council, *Corresponding Secretary* (ex-officio)[1]

Chairman of Division of Engineering, National Research Council (ex-officio)[2]

E. F. W. Alexanderson

Alfred N. Goldsmith

F. B. Jewett

A. E. Kennelly

G. O. Squier

A. Hoyt Taylor

E. M. Terry

The technical committees are briefly described in the following. In every case, persons interested in participating in the work are invited to communicate with the Chairman of the Committee.

1. Radio Wave Transmission Phenomena.—Chairman, Dr. L. W. Austin, Naval Radio Research Laboratory, Bureau of Standards, Washington, D. C. One of the principal kinds of work is the measurement of radio wave field intensity at receiving stations, observing particularly diurnal and seasonal variations, and the comparison of observed values with formulas for the determination of the laws of transmission under various conditions by day and by night, over sea and various kinds of topography, sunset and sunrise effects, fading, aurora, local absorption phenomena, and so on. Comparison of results with different types measuring apparatus is another part of the work. Experiments indicate agreement between results obtained with the telephone signal comparator of Dr. Austin and

[1] W. Duane, in 1923.
[2] A. D. Flinn, in 1923.

the radio-frequency comparison method of the Western Electric Company. For the assistance of participants in this work, certain large stations send special signals daily. These signals give the letters URSI and a dash lasting two minutes. The letters URSI are the initials, arranged as in the French equivalent of International Union of Scientific Radiotelegraphy. Even for stations in the following list which are not transmitting these special signals, observations on the field strength of the waves are worth while, since great accuracy is not required.

Stations Now Transmitting U. R. S. I. Signals

	Greenwich Time	λ	Approximate Radiation Height	Approximate Antenna Current
Eiffel Tower	10 h.35 m.	2,600 m.	85 m.	85 amp. (spark)
Nantes....	14 h.15 m.	9,000 m.	135	180
Bordeaux..	19 h.55 m.	23,400 m.	170	480
Rome	16 h.	10,500 m.	120	100

The following American stations are expected to begin sending URSI signals in the near future.

	λ	Approximate Radiation Height	Approximate Antenna Current
New Brunswick, New Jersey	13,600 m.	66 m.	590 amp.
Radio Central (Long Island, New York).............	16,800	80	702
Marion, Massachusetts.....	11,620	66	600
Annapolis, Maryland.......	17,200	130	250
(Sends time signals at 16 h. 55 m.)..................			

The following British stations are expected to send URSI signals.

Leafield
Northolt
Horsea
Kidbrook
Constantinople
Clifden
Carnarvon

A large amount of work in the field of this committee has already been done by several observers in various parts of the world, particularly by Dr. Austin, chairman of the Committee. Results are published in the PROCEEDINGS OF THE INSTITUTE OF RADIO ENGINEERS, which has been designated as the official organ of publication of the American Section. There are various subordinate problems also within the purview of this committee, such as the angle of tilt of a wave front under various topographical conditions and for various types of waves.

1a. VARIATIONS OF RADIO WAVE DIRECTION.—Chairman, Commander A. H. Taylor, Naval Aircraft Radio Laboratory, Anacostia, D. C. This is a Subcommittee of Committee 1, Radio Wave Transmission Phenomena. The principal object of research is the variation of wave direction with time. Bending of the waves by topography or bodies of water is another object. The study of direction finder errors due to conditions at the receiving station is of collateral interest. The results of the observations taken to date indicate that the wave directions, for wave lengths above 4,000 meters, are subject to rapid and violent fluctuations; that the fluctuations are greater at night than by day; that the variations are probably greater at distances between 100 and 300 miles (160 and 480 km.) than for either shorter or longer distances; that the variations are less for damped than for undamped waves; that the variations are less over sea than over land. These conclusions are only preliminary, and more observational data on all these points are desirable. Further study in particular is desired on: (a) Short-wave direction variations of continuous wave and broadcasting stations; (b) damped wave variations; (c) night variations on wave length over 2,400 meters; (d) observations on all wave lengths at sea. Data may be taken either with or without compensation of minimum, that is, special means to reduce signal to zero at minimum position of direction finder; but the observer should always record the type of compensation used, if any.

2. ATMOSPHERIC DISTURBANCES.—Chairman, Commander

A. H. Taylor, Naval Aircraft Radio Laboratory, Anacostia, D. C. The work includes measurement of the intensity and direction of propagation of atmospherics ("strays", "static"), and daily and seasonal variations. The problem is complicated by the numerous types of atmospherics that occur. The rumbling type, which is the most important, seems to consist of a spectrum of strongly damped waves. It is frequently directive, that is, comes from a definite direction. Thus a considerable portion of the atmospherics in the United States appear to come from the region of Texas. The particular subjects on which work should be done are: (a) directivity of the various types of atmospherics; (b) the question whether the various types are single pulses or a spectrum; (c) systematic measurement of intensity at different wave frequencies at different times of day; (d) systematic daily measurement of direction of directive types; (e) comparison with other phenomena such as sun spots, temperature, earth currents, weather, and so on.

3. Methods of Measurement and Standards.—Chairman, Dr. J. H. Dellinger, Bureau of Standards, Washington, D. C. The work of this committee is the development of radio measurements and standards, in general and also with particular view to the work of the other U.R.S.I. committees. One of the first problems calling for extensive observations is comparison of the wave frequency standards in use by measurements of wave frequency of stations transmitting waves of known frequency. Standard signals of this kind are transmitted from the Bureau of Standards about once a month; announcements of exact date are given in the Radio Service Bulletin.[3]

Measurements on the wave frequency of the high-power stations listed under 1 above are of value when made simultaneously by two or more observers. Standard wave lengths are transmitted by the Eiffel Tower and Lyons stations in France on the first and fifteenth of each month. The transmissions are between 18:00 and 18:30 Greenwich time, on approximately 5,000, 7,000, 10,000, and 15,000 meters. Another part of the work is improvement and standardization of methods for measuring field intensity of received waves and atmospherics, including the relating of signal intensity to field intensity, and the development of recording apparatus for continuous measurement of intensity. Collateral problems are the measurement of

[3] A monthly publication of the Department of Commerce, obtainable for 25 cents per year from the Superintendent of Documents, Government Printing Office, Washington, D. C.

radiation resistance, current distribution, and effective height of antennas. The improvement of apparatus for routine observations of direction of waves and atmospherics is another line, including the study of "antenna effect," induction from surroundings, and use of balancing condensers. This committee also fosters progress on measurements and standards of capacity, inductance, resistance, current, and the like.

4. MEASUREMENT OF RADIATION CAUSING INTERFERENCE.—Chairman, Mr. E. F. W. Alexanderson, Radio Corporation of America, New York City. This committee has in view the measurement of what has been called "improper radiation" or "objectionable emissions." This involves the study of the distribution of wave field intensity with frequency. These measurements upon transmitted radio waves may be made in large part with the same apparatus used in the measurement of wave intensity, in work of committee on "Radio Wave Transmission Phenomena." The frequency breadth of a wave determines the interference it produces, whether such breadth is due to modulation, high signaling speed, spacing wave, actual decrement, harmonics, variation of generator frequency, and so on. Besides regular measurements on wave breadth, and perhaps prior to any extensive observations of that kind, there is need for: (a) devices to obtain resonance curve of wave form of a distant station modulated by speech or other arbitrary modulation; (b) simple analytic solution of problem of getting actual wave distribution from observed resonance curve, eliminating effect of measuring instrument; (c) mechanical device to replace analytic solution.

5. ELECTRON TUBES.—Chairman, Dr. F. B. Jewett, Western Electric Company, New York City. The character of this committee's work differs somewhat from those above. Research on electron tubes is necessarily of individual laboratory type. While there are many interesting and important research problems awaiting solution, the Committee's work as such has not yet been specifically outlined.

6. "LIAISON."—Chairman, Dr. A. E. Kennelly, Harvard University, Cambridge, Massachusetts. This is not strictly a technical committee. Its purpose is to facilitate the participation of operators, amateurs, and untrained observers in the recording of data of importance to the technical work of the International Union.

There is fruitful work for many years in the program as outlined above, which should have value not only for the better understanding and use of radio but also in the problems of geophysics, composition of the atmosphere, and other fields. Observers contemplating participation in the work should wherever possible plan to continue for at least a year, thus covering seasonal variations. Observations at sea are likely to be of particular value, as they have been fewest in the past, and because the radio phenomena are in general less complicated than on land.

It is believed that radio is unique among the few fields having special adaptability to a large-scale international research program. The phenomena that must be studied are world-wide in extent, and yet are in large measure subject to control of the experimenters. It is a field of work that has large possibilities for the future, and the surface only has been touched in the work done so far. Great progress can be made in the understanding of radio phenomena when widespread observations are taken, similar to the organized observational work on weather, earthquake, and terrestrial magnetic phenomena.

As previously stated, the chairman of each of these committees will be glad to receive communications from all persons who desire to co-operate in the work, and will furnish further information, data on methods of measuring, and so on. The American Section is especially desirous of gaining the co-operation of workers in universities and technical schools. The author of this article is Technical Secretary of the American Section, and will be glad to reply to general communications, requests for bibliographies or research suggestions, questions applying simultaneously to several of the Committees, and reports of work done.

Washington, D. C.

RECEIVING MEASUREMENTS AND ATMOSPHERIC DISTURBANCES AT THE UNITED STATES NAVAL RADIO RESEARCH LABORATORY, BUREAU OF STANDARDS, WASHINGTON, NOVEMBER AND DECEMBER, 1922*

By

L. W. Austin

(United States Naval Radio Research Laboratory, Washington, D.C.)

(Communication from the International Union for Scientific Radio Telegraphy)

The observations given were taken as before.

It is seen that the afternoon fading noted during the summer has entirely disappeared, the three o'clock signals being generally stronger than those of the forenoon, due to the approach of sunset. The disturbances have fallen to a low value, being generally weaker than the signals.

During a part of November, the antenna current at Nauen was reduced to about 280 amperes while changes were being made in the station. This explains in part the low observed values of the Nauen signals during that month.

Lafayette did not send regularly during the forenoon in November and was not observed at all before noon during December.

The calculated signal intensities, assuming 480 amperes at Lafayette and 380 amperes at Nauen, are

$$E \text{ (Lafayette)} = 31.5 \cdot 10^{-6} \text{ volts/meter}$$
$$E \text{ (Nauen)} = 15.3 \cdot 10^{-6} \text{ volts/meter}$$

*Received by the Editor, February 21, 1923.

RATIO OF AVERAGES

	Signal $\frac{\text{P. M.}}{\text{A. M.}}$	Disturbance $\frac{\text{P. M.}}{\text{A. M.}}$	A. M. $\frac{\text{Signal}}{\text{Disturbance}}$	P. M. $\frac{\text{Signal}}{\text{Disturbance}}$
		November		
$\lambda = 23{,}400$ m.	1.61	1.50	1.34	1.45
$\lambda = 12{,}500$ m.	1.55	1.48	1.02	1.07
		December		
$\lambda = 23{,}400$ m.	....	....	....	3.30
$\lambda = 12{,}500$ m.	1.01	1.21	1.83	1.52

FIELD INTENSITY OF LAFAYETTE AND OF DISTURBANCES ($\lambda = 23{,}400$ m.) IN NOVEMBER, 1922, IN MICRO-VOLTS PER METER

	10 A. M.		3 P. M.	
Date	Signal	Disturbances	Signal	Disturbances
1	*	85	50.0	130
2	*	62	70.0	30
3	*	15	70.0	60
4	*	80	60.0	80
6	*	15	75.0	20
7	*	30	40.0	61
8	*	55	50.0	50
9	30.0	42	95.0	30
10	*	30	46.5	48
11	*	30	55.0	200
13	45.0	20	60.0	50
14	50.0	22	*	38
15	33.0	30	75.0	32
16	40.0	15	45.0	20
17	75.0	22	60.0	22
18	*	..	80.0	30
20	36.5	35	130.0	62
21	....	..	105.0	15
22	*	45	100.0	15
23	*	31	85.0	40
24	*	60	115.0	60
25	*	30	130.0	30
27	75.0	30	130.0	60
28	55.0	43	90.0	150
29	50.0	10	80.0	30
Average	48.9	36.4	79.0	54.5

*Not heard.
....Not taken.

Field Intensity of Nauen and of Disturbances ($\lambda = 12{,}500$ m.) in November, 1922, in Micro-volts per Meter

	10 A. M.		3 P. M.	
Date	Signal	Dis-turbances	Signal	Dis-turbances
1	36.0	40	17.0	30
2	19.0	30	11.0	20
3	43.0	10	34.0	30
4	22.0	50	21.8	60
6	32.0	6	22.0	8
7	34.0	8	28.0	56
8	14.0	20	....	....
9	12.0	28	29.0	10
10	8.5	8	29.0	12
11	6.3	8	18.5	60
13	12.0	8	9.5	30
14	13.2	10	37.0	21
15	6.0	10	38.5	17
16	7.2	5.5	30.0	20
17	11.0	8	31.0	8
18	8.5	6	25.7	20
20	4.5	15	*	30
21	....	....	*	8
22	7.2	18	3.0	10
23	6.8	18	37.0	21
24	25.7	40	47.0	40
25	27.0	15	31.2	15
27	*	16	....	....
28	*	15	....	....
29	19.0	6	*	16
Average	17.0	16.6	26.3	24.6

*Not heard.
....Not taken.

FIELD INTENSITY OF LAFAYETTE AND OF DISTURBANCES ($\lambda = 23{,}400$ m.) IN DECEMBER, 1922, IN MICRO-VOLTS PER METER

	10 A. M.		3 P. M.	
Date	Signal	Dis-turbances	Signal	Dis-turbances
1	*	50	160.0	10
2	*	32	170.0	12
4	*	20	105.0	18
5	*	40	90.0	30
6	*	40	135.0	60
7	*	50	95.0	50
8	*	8	100.0	60
9	*	18	90.0	30
11	*	60	100.0	80
12	*	40	95.0	60
13	*	30	110.0	40
14	*	10	115.0	22
15	*	15	100.0	25
16	*	20	100.0	80
18	*	15	100.0	30
19	*	....	65.0	20
20	*	....	140.0	20
21	*	....	115.0	21
22	*	....	70.0	14
23	*	....	....	....
26	*	....	60.0	17
27	*	....	135.0	18
28	*	....	60.0	12
29	*	....	80.0	10
30	*	....	80.0	12
Average		29.0	103.0	31.3

*Not heard.
....Not taken.

Field Intensity of Nauen and of Disturbances ($\lambda = 12{,}500$ m.) in December, 1922, in Micro-volts per Meter

	10 A. M.		3 P. M.	
Date	Signal	Dis-turbances	Signal	Dis-turbances
1	*	22	47.0	6
2	27.0	15	47.0	8
4	35.0	12	34.0	9
5	30.4	20	29.5	18
6	27.0	20	25.0	32
7	29.0	20	21.5	30
8	18.4	5	19.0	25
9	16.2	10	21.5	19
11	13.7	40	21.5	40
12	20.5	20	*	32
13	*	10	21.5	12
14	29.5	5	27.0	10
15	18.4	10	29.5	12
16	15.0	15	21.5	15
18	21.3	10	17.4	15
19	15.0	15	17.0	15
20	26.7	10	21.5	15
21	19.2	15	17.0	10
22	25.7	15	14.7	8
23	27.8	10	....	....
26	19.2	5	27.8	12
27	25.7	7	17.0	12
28	8.5	4	17.0	10
29	13.0	7	25.7	8
30	17.0	6	17.0	8
Average	24.0	13.1	24.2	15.9

*Not heard.
....Not taken.

SUMMARY: Field intensities of the signals from the Lafayette and Nauen stations, together with the simultaneous strengths of the atmospheric disturbances, are given for November and December, 1922.

A COMBINED KENOTRON RECTIFIER AND PLIOTRON RECEIVER CAPABLE OF OPERATION BY ALTERNATING CURRENT POWER*

By

Albert W. Hull

(Research Laboratory, General Electric Company, Schenectady New York)

1—Introduction

The tube to be described is a combination of kenotron rectifier and pliotron with equipotential cathode. Equipotential cathodes, heated by radiation or bombardment from an internal filament, have long been in use in scientific investigations, and have frequently been suggested for pliotrons in order to obtain better amplifying and detecting characteristics.[1] It is obvious that a cathode of this kind in a pliotron could be heated by alternating current without producing appreciable alternating current hum in the output circuit.

The use of kenotron rectifiers for supplying plate voltage is also well known, and has become common practice in radio transmission. The combination of these two functions in a single four-element tube is new, so far as I know, and has interesting characteristics.

2—Principle

The principle of the combined kenotron and pliotron will be obvious from Figure 1, which shows a typical two-tube alternating current receiving equipment, with kenotron rectifier furnishing plate voltage for a pliotron detector. The heating battery for the pliotron cathode is omitted. The only point to be noted on this figure is the fact that the anode of the kenotron is connected directly to the cathode of the pliotron. It is evident that the operation would be the same if these two elements were combined into one, that is, if the kenotron were incorporated in the pliotron, and its anode used as pliotron cathode. The kenotron

*Received by the Editor, October 9, 1922. Presented before The Institute of Radio Engineers, New York, November 1, 1922.

[1] Nicolson, United States Patent, 1,169,182; Morecroft, "Principles of Radio Communication," page 379.

filament furnishes sufficient heat, by radiation, to enable this combined anode-cathode to emit electrons. The resulting tube and circuit is shown in Figure 2. The filament performs the

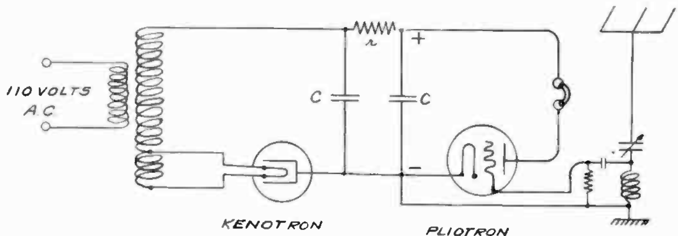

FIGURE 1—Diagram of ordinary pliotron receiving circuit, with kenotron rectifier supplying plate voltage

double function of cathode for a kenotron rectifier that provides plate voltage, and radiant heater for the pliotron cathode. The cylinder which surrounds the filament acts at the same time as pliotron cathode and as anode of the kenotron rectifier.

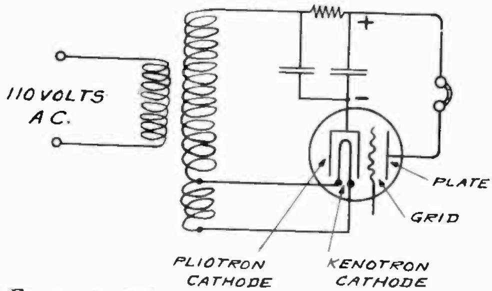

FIGURE 2—The same circuit as Figure 1, with kenotron incorporated in the pliotron

3—CONSTRUCTION

The essential construction can be seen in Figure 2. The structural features of one form of tube are shown in Figure 3. The filament is a helix of tungsten wire, maintained at approximately 2,300° K. by 2 amperes alternating current at 5 volts. At this temperature it has ample electron emission for its function as kenotron rectifier, and its radiation heats the surrounding cathode to a temperature at which it also has sufficient electron emission. The cathode is a nickel cylinder ⅛ inch (0.32 cm.) in diameter by 1⅛ inches (2.86 cm.) long, coated with barium oxide. Grid and plate are concentric cylinders surrounding the cathode, the grid being a helix 1 inch

(2.54 cm.) long by ¼ inch (0.64 cm.) diameter, consisting of 40 turns of 3 mil (0.008 cm.) molybdenum wire.

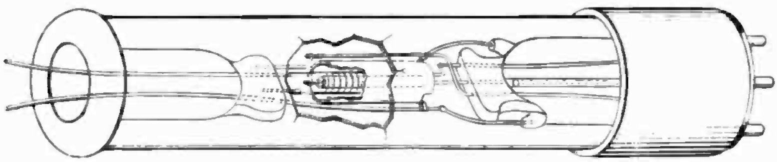

FIGURE 3—Drawing of a laboratory model of new tube

Figure 4 gives a cross-section view of a tube suitable for operation from a lamp socket, without transformers. The filament is a standard tungsten helix, such as is used in gas-filled tungsten lamps, and the cathode a nickel cylinder ½ inch (1.27 cm.) in diameter by 1½ inches (3.81 cm.) long.

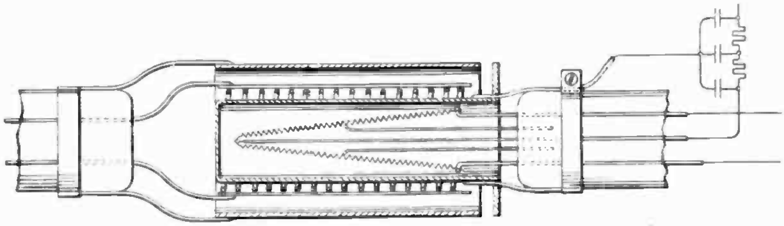

FIGURE 4—Cross-section drawing of a tube with 110-volt filament

4—CIRCUIT

A typical receiving circuit, using a single tube of the type shown in Figure 3, is sketched in Figure 5. Filament voltage is obtained from a small step-down transformer. One side of the 110-volt alternating current power line is connected to the filament, the other side to the plate terminal, so that the filament swings up and down ± 110 volts with respect to the plate terminal. On the negative swing it feeds current to the cathode, which current is stored by the first condenser, C_1, and further smoothed by the combined action of the second condenser, C_2, and resistance r.

Figure 6 shows a single tube with 110 volt filament acting as radio detector, using the alternating current power line as antenna. In this case the only accessory apparatus is the tele phones, filter, and tuning unit.

5—RECTIFICATION

With a single tube used as half-wave rectifier, as shown in Figures 2 and 5, it is necessary that the outside surface of the cathode should have a higher electron emissivity than the inside in order that rectification may result. This may easily be accomplished by covering the outside of the cathode with an oxide

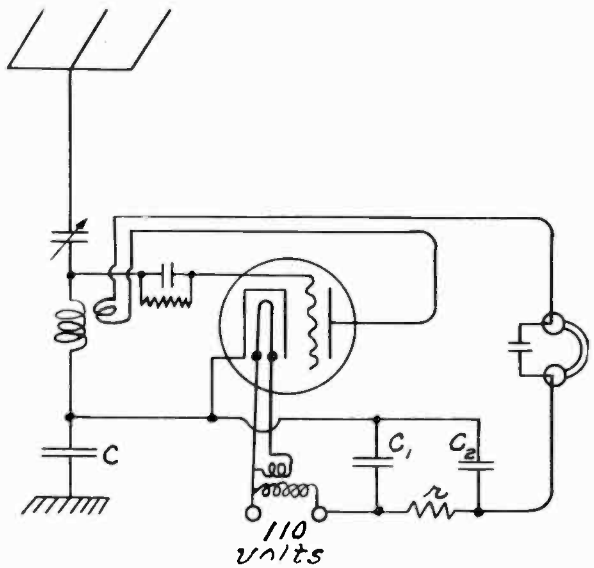

FIGURE 5—Simple receiving circuit, using new tube

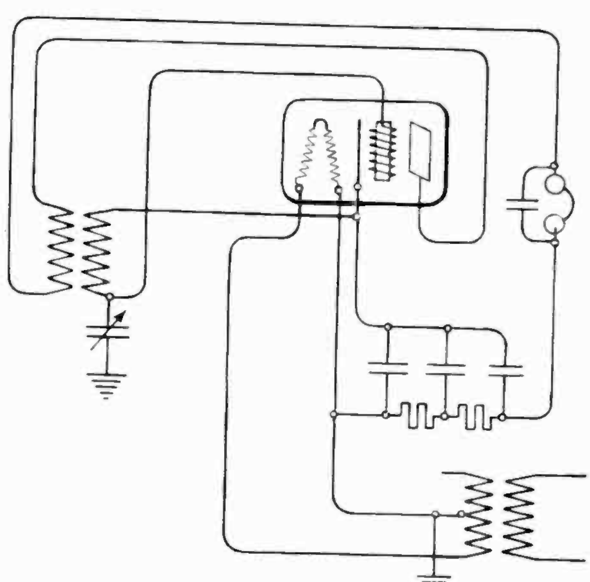

FIGURE 6—Receiving circuit for 110-volt tube, using power line as antenna

coating. The necessity for unilateral electron emissivity is removed when full wave rectification is used. If a single tube with 110 volt filament is used a sfull-wave rectifier, as shown in Figure 4, the electron emission from the inside of the cathode may be the same as from the outside, provided it is less than that of the filament. For in this case the cathode is always receiving electrons from one end of the filament at the same time that it is emitting them to the other end, and it is only necessary that the number received should be in excess.

6—Filter

A resistance-capacity filter gives satisfactory operation, and is lighter and cheaper than the usual inductance-capacity filter. The filter shown diagrammatically in Figure 6, which consists of three 2-microfarad condensers and two 4,000-ohm resistances, is capable of furnishing 5 milliamperes at 60 volts with half-wave rectification. A ground connection is generally not necessary, as the alternating current line is sufficiently grounded. No harm can be done, however, by grounding the circuit at any point, except as it may interfere with operation or introduce alternating current hum. It is preferable to ground thru a condenser, as shown in Figure 5.

7—Characteristics

The volt-ampere characteristics of a tube similar to that sketched in Figure 3 are shown in Figures 7 and 8. For comparison, the characteristics of a standard UV-201 amplifier tube, at the same plate voltage, are shown on the same plot. It will be noted that the characteristics of the new tube are much steeper than those of the UV-201, as might be expected from its large cathode area and equipotential surface. The values of mutual conductance, plate resistance, and amplification constant for the equipotential-cathode tube shown are 1.50×10^{-3}, 18,000, and 27, respectively, as compared with 0.28, 20,000, and 6.0 for the UV-201. It will also be noted that the grid current characteristic is much steeper than that of the UV-201, so that a higher detection co-efficient may be expected.

8—Operation

The tube here described is in an ordinary pliotron in every respect except the method of supplying power to the plate and cathode. Hence its operating characteristics are identical with those of standard pliotrons, and the only points of interest are

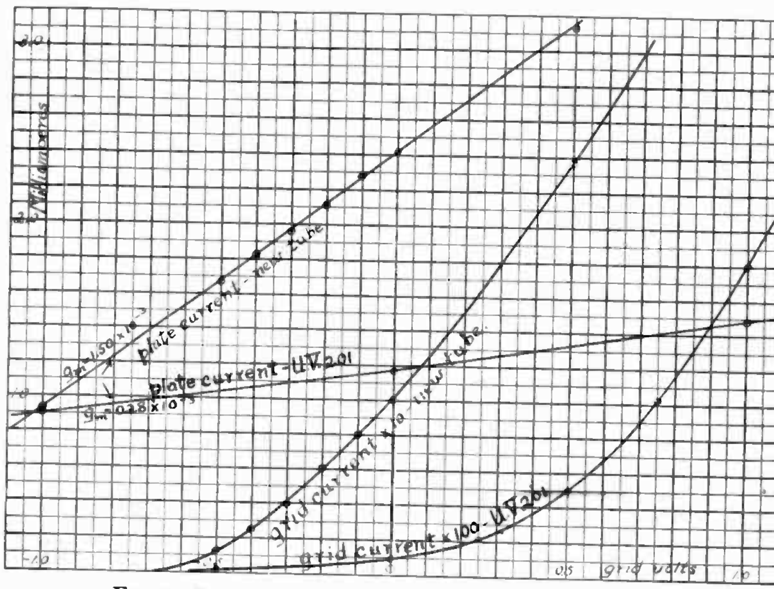

FIGURE 7—Static characteristics of new tube and UV-201

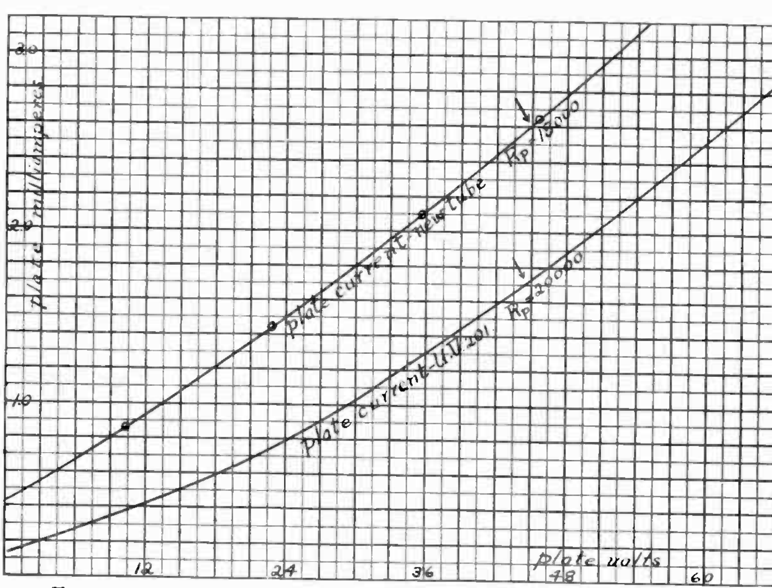

FIGURE 8—Plate-resistance characteristics of new tube and UV-201

the degree of amplification and detection, and the amount of alternating current hum introduced by the 60-cycle current.

The voltage amplification per tube is about four times that of the UV-201, at both radio and audio frequencies. This is especially significant in the case of radio frequency. At 300 meters, a resistance coupled UV-201 amplifier gives a voltage amplification of 2.0 per tube. The equipotential cathode tubes that have been measured average 7-fold voltage amplification with resistance coupling. A single tube is thus nearly the equivalent of 3 UV-201 tubes.

Under normal circuit conditions alternating current hum cannot be heard when a single tube is used as amplifier or detector. With two tubes in series, the hum can be heard only when the telephones are pressed tightly on the head. With three tubes in series the hum is quite noticeable, but not objectionable. A large part of this hum is probably due to circuit induction, and can be eliminated by shielding.

An important operating feature of this type of receiving equipment is its safety. Nothing that the operator can do can harm either himself, the receiving tube, or the lighting circuit. The alternating current power terminals are made inaccessible by the use of standard lamp receptacles and plugs, and all exposed terminals are protected by high resistances. No injury can be done to the tube by short-circuiting either the pliotron or the kenotron part.

9—Comparison With Other Methods

The only other method that has been tried for receiving with alternating current power is the use of standard pliotrons with a mid-point connection to the filament transformer. Plate voltage is furnished by kenotrons and filter. With symmetrical tubes and a perfectly linear plate current-grid voltage characteristic, this method should be applicable to audio frequency amplification without alternating current disturbance. Under practical conditions, even with a very high impedance load in the plate circuit, the hum is considerable. Under the very best conditions it is many times louder than in the equipotential cathode tubes. For radio frequency amplification this method would be satisfactory if such amplification were large enough to be of interest. For radio detection, either with or without grid condenser, this method cannot be used at all.

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SUMMARY: A new type of four-element tube is described, which combines the functions of kenotron rectifier and pliotron, and can be operated from an alternating current source of power without either "A" or "B" battery.

The cathode is an equipotential surface so that alternating current hum is inappreciable even with three stages in series.

The combination of equipotential cathode and large cathode area results in unusually high amplification and detection constants, making the tube a practical radio-frequency amplifier.

A NEW NON-INTERFERING DETECTOR*

By

Harold P. Donle

(Chief Engineer, Connecticut Telephone and Electric Company, Meriden, Connecticut)

One of the least efficient elements of modern radio is, despite the large amount of development since coherer days, the detecting system. Our best detectors are insensitive things when compared to galvanometers or telephones, and there appears room for considerable advance in increasing detector effectiveness. The present paper describes a radically new way of securing dependable detectors having high sensitiveness, which, it is hoped, will be considered to mark a step forward.

The ordinary three-element tube as a simple detector is not nearly sensitive enough to satisfy the present demands. Many attempts have been made to increase this sensitivity by including within the tube a gaseous atmosphere and while extremely effective detectors have been thus produced, they have required very delicate adjustment and in the majority of cases were not stable and required constant attention. Furthermore, it has been found practically impossible to reproduce in quantity tubes of uniformly maximum sensitivity.

The three-element electron tube and regenerative circuit is largely used at present for reception of radio signals. While it gives excellent results and certainly far exceeds in response any other method disclosed to date, nevertheless it has certain disadvantages and its widespread use has created a situation which is bound to retard the popular use of radio.

By using the three-element detector in a regenerative circuit greatly increased sensitivity is secured, but if regeneration is carried far enough to give worth-while response, there is produced considerable signal distortion. Furthermore, adjustments are critical, the slightest variation in capacity destroying the operating adjustment. What is still more important, the radiation

*Received by the Editor, November 24, 1922. Presented before the Boston Section, November 10, 1922, and before The Institute of Radio Engineers, New York, December 20, 1922.

from many regenerative circuits, particularly in the hands of inexperienced operators, creates an alarming amount of interference which if continued will seriously hamper reception of the present broadcasting programs.

There seems to be a definite need for a receiving tube which under no condition can radiate any energy from the antenna to produce interference, which can be easily adjusted, which is not affected by the body capacity while the circuit is being tuned, and yet which secures all this at no sacrifice of sensitivity and loudness of response.

For several years we have conducted experiments on many different forms of detectors, and particularly upon detectors employing ionization of metallic atoms. This was a most promising field of development since such ionization was found to be readily controlled and stable. As one of the results of this work we have developed the present tube which is the logical result of experimental work which we have done along these lines. This new tube has none of the disadvantages of regenerative and gaseous detector systems above mentioned. Its method of operation seems to involve many interesting phenomena, which are radically different from those occurring in other tubes.

The construction of one form of this tube is illustrated diagrammatically in Figure 1 where *F* is the filament, *A* is the anode, which may be of metallic sodium in the bottom of the tube, and *H* is the heater which is a short length of resistance wire cemented to the outside of the glass directly underneath the anode. This heater maintains the anode at proper operating temperature. *C* is the "collector" electrode of sheet metal bent

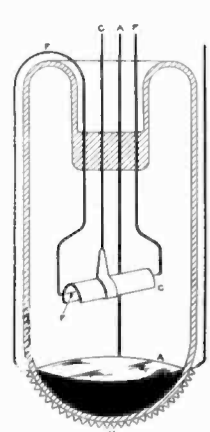

FIGURE 1

into a "U" and positioned above the filament with its open side toward the anode.

Figure 2 shows these various parts before assembly and Figure 3 a finished tube.

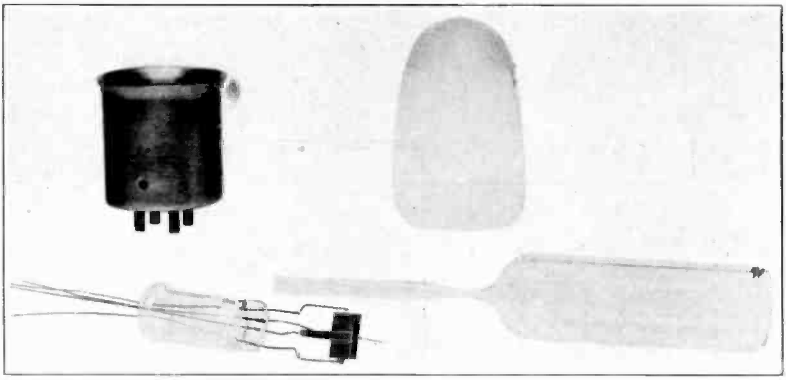

FIGURE 2

FIGURE 3

In operation the tube may be connected to the circuit, shown in Figure 4, which is simply a two-circuit tuner with one terminal of the secondary connected to the collector electrode of the tube and the other to a contact operating on a resistance connected directly across the filament battery terminals. The remainder of the circuit is as used with any simple detector.

The adjustment of collector potential is the only one necessary for efficient operation other than the usual variation of capacity and coupling of the tuning circuit. The potential of the "B" battery is not at all critical and usually may be varied between ten and thirty volts without much effect on response.

As a detector this tube is remarkably sensitive, its adjustment is simple, and it is absolutely stable in operation. This extreme sensitivity is readily reproducable and permanent.

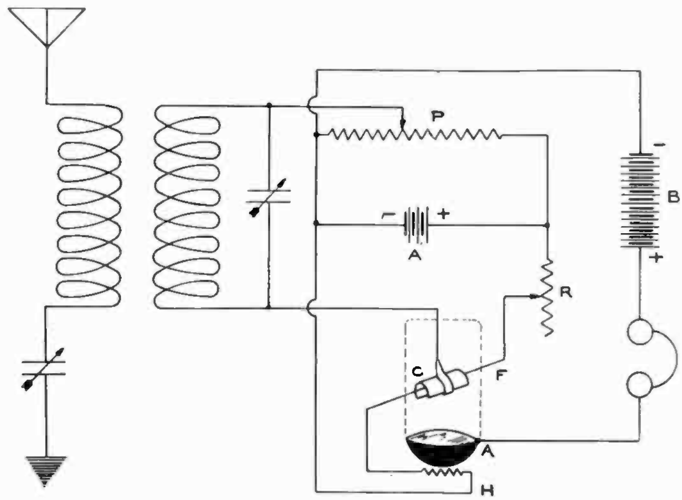

FIGURE 4

The response secured with this tube in a plain circuit equals in magnitude the response from a regenerator, using maximum non-oscillating regeneration. A regenerative circuit under this condition of critical adjustment will give very considerable distortion, which is particularly objectionable when receiving voice or music and which can only be eliminated by a reduction of regeneration and consequent reduction of signal strength.

On the other hand, the new detector creates no noticeable distortion, and, as it does not oscillate over its useful range, it cannot create any interference with other receivers. Furthermore, it is unaffected by small capacity changes, such as those produced by the operator's hand in tuning.

The response of the tube is greatly improved by very weak coupling between the circuits. This is due to its very low input impedance which also makes the proportion of capacity and inductance of secondary circuit for maximum results quite different from those for other tubes. Altho the new detector can be used successfully in an ordinary two-circuit tuner, results will fall short of the maximum unless means are available for selecting the best value of secondary inductance.

In this tube there is an electron flow from the filament to the collector, the magnitude of this current being due in part to the relatively large area of the collector and to its close proximity to the filament. It, therefore, receives an equivalent of large electron flow when it is at the same potential as the negative end of the filament. In order to reduce this flow an opposing potential (which may be taken from the "A" battery) is introduced into the circuit between collector and filament. This potential is called the neutralizing potential and is used as abcissas of curves shown in Figure 5, which show the variation in anode and collector currents I_a and I_c with variation of neutralizing potential E_n, and also the collector current when the anode circuit is open I_c'. The curve labelled $I_c - I_c'$ is the difference between the collector current with the anode circuit completed and opened. This last curve is interesting in that it apparently takes into consideration various phenomena concerned in the operation, and its slope is practically a direct index of the merit of the tube as a detector.

These curves show some of the fundamental characteristics of the tube. The abrupt bend in the collector current at $E_n = -1.8$ is a point at which maximum detection would be expected to take place, according to the usual conception of detection as being due to rectification over a section of the characteristic slope where the rate of change is large. One would also gather from this curve that the effect of a signal impressed would be to increase the average value of the collector and anode currents. Altho some detection takes place on this part of the curve, in magnitude it is not comparable to that secured over the sensitive portion of the slope. The point of maximum sensitivity for these curves is at $E_n = -1.4$ volts, which is at a relatively flat portion of the collector current curve and considerably above the lower bend. Furthermore, a signal impressed on the collector circuit always gives a decrease in collector current regardless of whether the characteristic curve at the sensitive point is concave or convex, many examples of both types having been observed. It should also be noted that this point of maximum sensitivity occurs somewhat above the center of the $I_c - I_c'$ curve. Another point of interest in connection with these curves is the values at operating potentials of collector and anode currents, the collector current usually being two to four times that of the anode. Special attention should be given also to the large changes of current produced by small changes of neutralizing potential.

Figure 6 shows the collector and anode currents at various values of anode potential E_a, but is of little interest in the present discussion except to show the very slight variation in collector current and the slow slope of anode current as a function of anode voltage. Considerable amplification might be expected from a superficial examination of these two anode current curves, Figures 5 and 6. However, the tube is not in fact an amplifier, probably on account of the comparatively high input power required for operation. It nevertheless has a high so-called voltage amplification, which in some cases runs as high as 400.

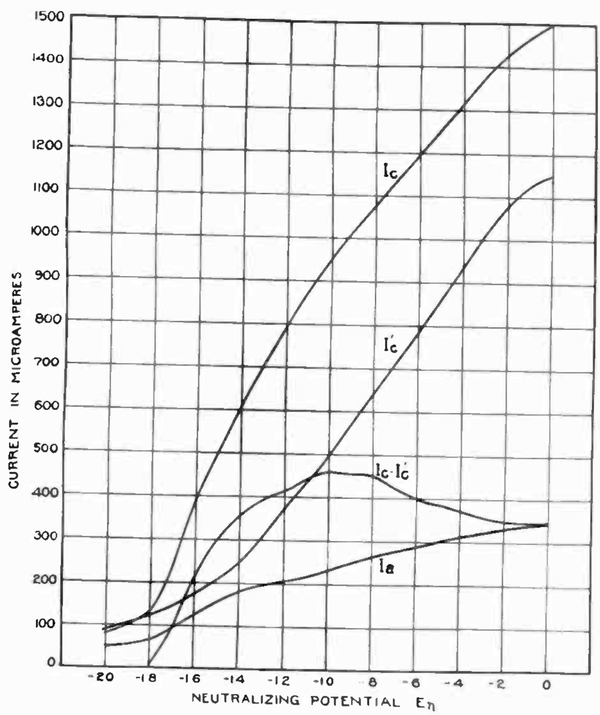

FIGURE 5

To determine some of the predominant features of the new tube in comparison with older types, a special tube was built, having filament and collector structure exactly as in Figure 1. but with the sodium anode replaced by a molybdenum plate, This special tube, like the usual new type, was evacuated to a high degree so as to preclude gas ionization. Since it contained no ionization metal, it operated on the pure electron basis. In

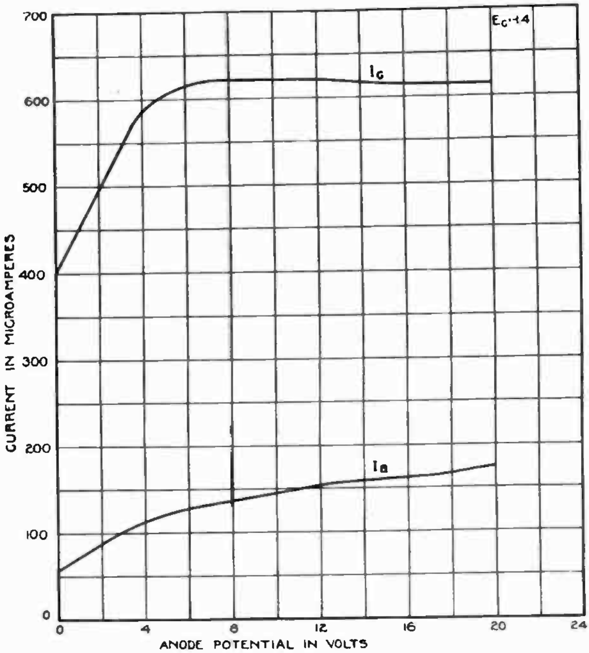

FIGURE 6

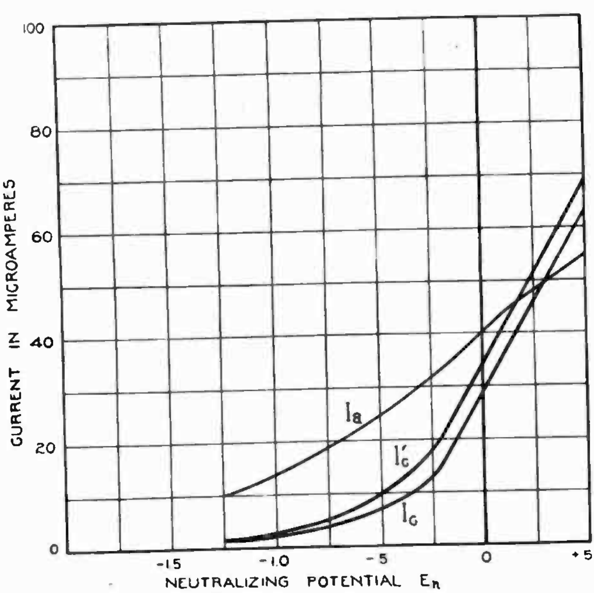

FIGURE 7

the circuit of Figure 4 it showed none of the sensitive response which was had with the sodium tube. Characteristic curves for the special pure electron tube are shown in Figure 7; these were taken under conditions identical with those for curves of Figure 5. The effect of the new ionization phenomena on the form of these curves can be readily seen.

A most interesting point in comparison of these characteristic curves of Figures 5 and 7 is that in Figure 5 the collector current is increased by the completion of the anode circuit, while with Figure 7 the collector current decreases when the anode is connected, this last being similar to the effect on grid current when the anode circuit is opened in the ordinary three electrode tube. As shown in Figure 5, when the operating phenomena of the sodium tube are broken up by too high a neutralizing potential, we also secure the same result, that is, an increase in collector current when the anode is disconnected.

Figure 8 shows the change in collector current of the sodium tube for impressed signals of different wave lengths. The ordinates of this curve show in micro-amperes the actual decrease in collector current caused by a signal of variable frequency, but of constant amplitude. This curve shows that the response for the particular tube on which this data was taken becomes small above the wave length of 1,000 meters, and that below this wave length detection increases rapidly. This might seem to indicate a limited wave length band of operation for this type of tube, but the entire shape and position of this curve depends upon the relative potentials of the tube electrodes and upon their proportions and relative positions. It is possible radically to change this curve by a simple variation of the neutralizing potential. It is also possible by a proper selection of values to secure a serrated form of this curve of which Figure 9 is a typical example.

The possibilities indicated by this curve in the elimination of interference are obvious.

Figure 10 shows the variation in collector current at various values of E_n due to an impressed signal of constant frequency on the collector circuit. Thus it represents the range of the neutralizing potential for a signal, and gives some idea of the ease of adjustment of this variable for maximum signal. This adjustment is obviously broad and allows a relatively wide variation of neutralizing potential for an audible signal, making it simple and easy to locate the point of maximum sensitivity.

It might be of interest to state that the data for this curve was obtained while the tube was functioning on an antenna and that the ordinates represent the change in collector current produced by a signal from WOR (Newark, New Jersey) as received in Meriden, Connecticut, 100 miles (160 km.) away.

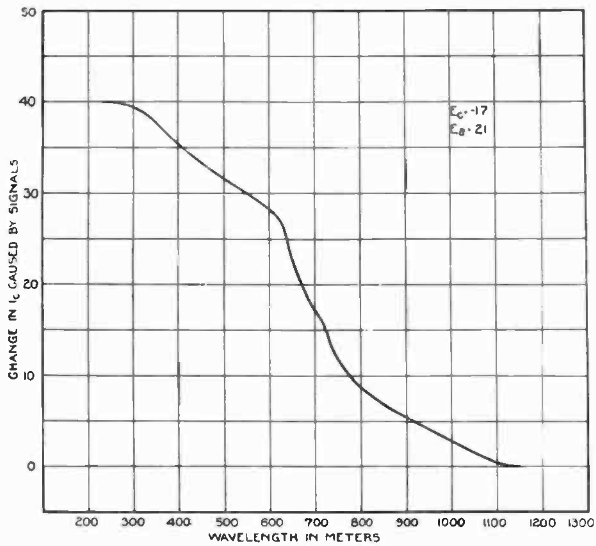

FIGURE 8

The effect shown in Figure 8 of signal frequency on response given by the tube, a most interesting phenomenon, is a consequence of a constant pulsation of collector current, the time period of which is controlled in part by relative electrode potentials and the position of the electrodes. This frequency of pulsation is low compared with the lowest frequency at which the tube is a sensitive detector. Furthermore, this pulsation of collector current at low radio frequencies is in no way affected by a capacity-inductance circuit associated with the tube. For example, if the collector electrode is connected directly to the contact on the potentiometer, with no periodic circuit interposed, the circuit will oscillate at a low radio frequency, the value of which is determined by the various factors set forth as above. Furthermore, when the tube is oscillating at a particular frequency, inserting a closed capacity-inductance circuit in series with the collector will have little effect on the oscillation of the tube.

The fundamental frequency of collector current pulsation for curve of Figure 8 was 74,300 cycles per second and it was possible to detect by use of an amplifier the first and second harmonics, both of which were obviously at frequencies well below the sensitive range.

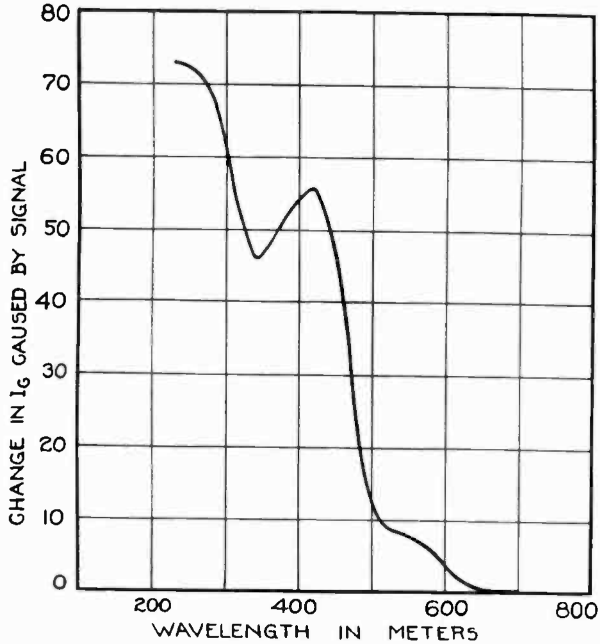

FIGURE 9

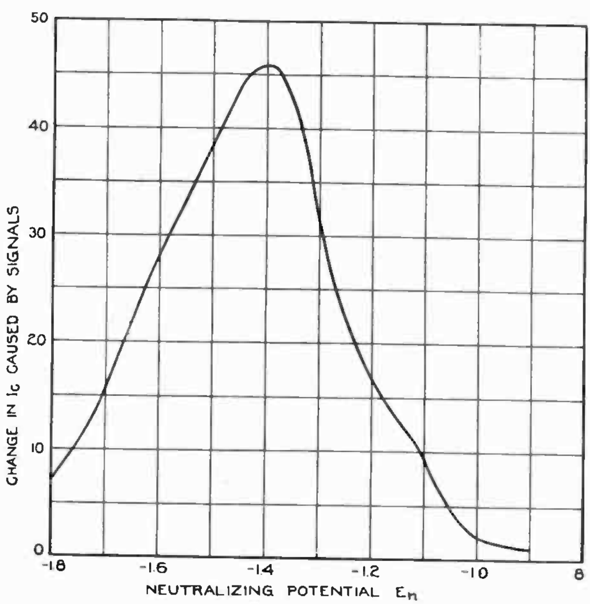

FIGURE 10

Altho the collector current pulsates at low frequencies, the tube is entirely ineffective as a heterodyne receiver due to the almost negligible detection at this frequency. As can be observed by an examination of Figure 8, no appreciable detection takes place until the signal frequency is at least four or five times the fundamental pulsation frequency.

The fact that the collector current pulsates and that this pulsation is not affected by a capacity-inductance circuit demonstrates that there is within the tube a mechanism, necessarily connected with ionization, which causes an alternate build-up and break of current in the collector circuit.

When the alternating potential of a signal is applied to the collector circuit, the pulsation is impeded to a greater or less extent depending upon the amplitude and frequency of this potential. Furthermore, since the pulsation causes a build-up of average collector current, the effect of a signal in this circuit is invariably to reduce the average value of this current.

Since slow changes in the collector circuit current are reflected in the anode circuit, a decrease of the average value of the collector current will result in a like decrease in the anode current, but this occurs without any appreciable amplification. By experiment on large number of tubes the ratio of change of power in collector circuit to resulting power change in anode circuit was found to be approximately unity.

This lack of amplification accompanying the detection effects, makes it feasible to operate the tube with an indicating device, such as a telephone receiver, placed directly in the collector circuit instead of in the anode circuit as shown in Figure 4. This is of interest, altho results are not quite as good as with the normal circuit (Figure 4), due to the fact that in the low impedance circuit, the high resistance of the receivers interferes with proper functioning. The anode circuit impedance is well suited to the standard telephones and transformers on the market.

With the telephones in the collector circuit the device might seem to be more or less the equivalent of a two-element tube, but the contrary is true, however, for with this connection, if the anode circuit is opened, no operation whatever will be secured, thus demonstrating that satisfactory operation depends upon the presence of this new anode circuit.

The action of this tube depends upon ionization produced by electrons emitted from the filament. It is, however, not the purpose of this brief paper to go into detail beyond a description of some of the most interesting characteristics.

The use of an easily vaporized anode metal allows great possibilities in the way of controlling ionization, in part because it becomes possible to secure a very sharp density gradient of atoms available for ionization, and to supply these atoms continuously at the proper rate required for operation, thus leaving unrestricted the mean free path beyond the zones of ionization.

Sodium is a convenient metal of this type, but similar useful effects have already been secured from a variety of differently composed anode materials. The present paper describes only one of the structures used with the sodium anode in this tube, the supply of atoms being regulated by the temperature of the anode and this varied by the external heater. In practice the heater is connected in series with the filament, and the two are thus controlled simultaneously.

At first thought it would seem necessary to allow a considerable time after lighting the tube filament before the anode would become sufficiently hot. That is, however, not the case on account of the following most interesting phenomenon. When the filament is first lighted the anode receives a small amount of heat by direct radiation from the filament and there will be, even at this relatively low temperature, a considerable emission of particles from this anode. This emission will, however, decay with time, and in a period of possibly one hour it will have reached a small fraction of its initial value. However, with the external heater connected in series with the filament, as described above, when the filament is lighted the anode will commence to receive heat from this heater. Its effect in raising the anode temperature will be necessarily slow on account of the interposition of the glass wall of the tube, but the temperature of the anode will be increased by this heater at a rate approximately correct to compensate for the decay of the initial emission, and thus the emission of particles from the anode will become fairly constant within a few seconds after the tube is first lighted. The result of this combination of affairs is that when the tube is lighted it is almost immediately in operative condition, altho in some cases a slight re-adjustment of neutralizing potential is later necessary to maintain a maximum sensitivity.

Ionization controlled in this way is extremely stable and these tubes may be maintained in their most sensitive adjustment for long periods of time. This is an impossibility with a gaseous detector. Also, with this type of ionization, it is possible to manufacture in quantity tubes with little if any variation of sensitivity. The tubes will remain substantially constant in sensitiveness thruout their life.

It is felt that the unique characteristics of this device and its inherent advantages over prior detectors should offer a new avenue of approach to the problem of detection. By replacing, without loss of sensitiveness, many of the regenerators now in use the new tube should further help to eliminate much of the present disagreeable interference.

Research Laboratory of
the Connecticut Telephone and Electric Company,
Meriden, Connecticut,
November 8, 1922.

SUMMARY: A new detector of high sensitivity is described which to the stimuli of weak impulses gives a response at least equal to a regenerator with the most critical regeneration. This high sensitivity is secured with the use of metallic ionization and a new electrode termed the "collector." Ionization of this type is readily controlled and stable and makes it possible to secure uniform characteristics on production tubes.

Static characteristics are given and show some points of particular interest such as, for example, the high value of current to collector as compared with the anode current. Curves are also given showing the effect of frequency on response, indicating great possibilities in the elimination of interference. The effect of a signal is shown to always decrease the steady value of the collector and anode currents irrespective of the shape of the characteristic curve.

As this detector does not oscillate thruout its sensitive range it obviously cannot radiate any energy and, therefore, interfere with broadcast reception by neighboring receivers.

A HIGH VOLTAGE MECHANICAL RECTIFIER*

By

S. T. Woodhull

Engineering Manager, (American Radio and Research Corporation' Medford Hillside, Massachusetts)

The conventional type of direct current generator of small power is limited to about 1,000 volts per commutator, because of the difficulty of insulating the commutator segments and armature windings in the small space. In generators for operation of radio transmitting equipment, insulation troubles are more pronounced because of the possibility of radio frequency surges getting back into the winding. The voltages of these surges are not equally distributed thruout the winding, but builds up in the first few turns of the armature coils. Altho surge voltages in themselves seldom exceed twice normal voltage, the voltage will subject the outer turns of the coil to many times normal voltage.

Many devices are in service to provide a generator for direct current, such as thermionic tubes, gaseous conduction, mechanical rectifiers and, of course, many well-insulated, direct-current generators of the conventional type.

The purpose of this paper is to describe a direct-current generator of the mechanical rectifier type, using transformer action for the generation of the high voltage and a synchronous commutator for its rectification.

The generating equipment comprises a polyphase alternating current generator with an extension shaft, on which is mounted the rectifying commutator, having segments corresponding to the phases of the generator. A single phase transformer is provided for each phase for stepping up the voltage before rectification. In practice nine phases are found suitable for transmitter operation.

The schematic wiring diagram (Figure 1) shows the connections for a two-pole, three-phase machine. *A* represents the generator, *B* the single-phase transformer, and *C* the commutator segments. Slip rings *D* are provided for collecting the direct current.

* Received by the Editor, December 1, 1922.

It will be noticed in this circuit that, differing from the common type of mechanical rectifiers, the secondaries of the transformers are connected in series. The commutator segments are shown displaced 120 degrees to correspond to the phase rotation of the generator. The series connection of the transformer in a nine-phase machine reduces the voltage commutated per pair of brushes to approximately 25 per cent. of line voltage. This connection, therefore, very naturally reduces commutator insulation. The ripple of the delivered current is the same as that encountered in commutating line voltage per pair of brushes, which is approximately 5 per cent. of delivered voltage.

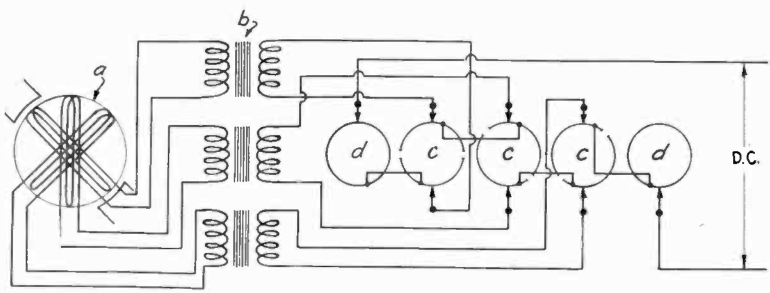

FIGURE 1

The generator should be wound with one slot per phase per pole in order to provide a wave having a long zero potential, so that the point oi commutation is not critical. Since the point of commutation depends upon the power factor, the generator synchronous impedance should be as small as possible.

The transformer design is of the closed core type, having a primary and secondary winding on each leg. Switching mechanism can be provided for throwing the secondaries in series or parallel to give wide variation of voltage. Following the same design as the generator, the leakage of the transformer should be kept to a minimum. Insulation of the transformers should be suitable for full line potential, both between primary and secondary and secondary and core. It is preferable to double space the first few turns of the secondary winding to more equally distribute surge potentials.

The commutator offers most of the difficulties in design. It is best solved by the use of an air brake type in which all insulating materials are kept from the commutation surface. The commutator segments may be cast and turned true after assembly. Insulation between segments is provided by discs of smaller diameter than the commutator segments. These discs also insulate the segments from the shaft. The brushes must, of course, be wide enough to span the break, so that the circuit is continuous. The sparking which accompanies this type of commutator can be decreased to a negligible amount by the addition of a one microfarad condenser across each pair of brushes. Provision is made for rotating the brushes with respect to the commutator to find the best point of commutation. Since the zero potential point changes with load, it is necessary to adjust this for each change in load. In machines of small power, that is, of 0.5 kilowatt capacity or less, the commutator may be adjusted for full load without injurious effects of sparking at no-load.

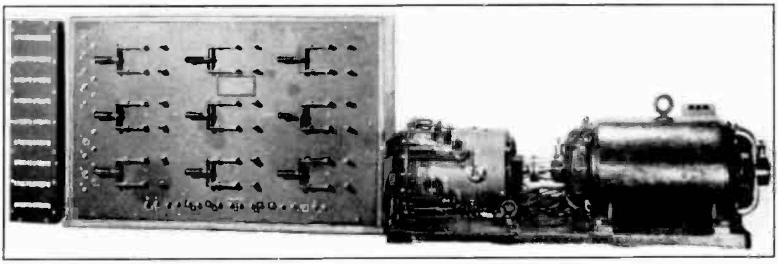

FIGURE 2

Figure 2 illustrates the general form of a 0.5 kilowatt, 20,000-volt generator. The generator proper is nine-phase, four-pole, 1,800 revolutions per minute. Nine single phase transformers are mounted in the cabinet. The double-pole, double-throw switches on the front of the cabinet throw the secondaries in series or parallel. The addition of a field rheostat for the generator provides a range of voltage from 5,000 to 20,000. Because of the size of the commutator required for this voltage, separate mountings are necessary.

The advantage of a machine of this type is in its ease of insulation. The high voltage is limited to the transformer and commutator, both of which can be readily designed.

SUMMARY: A mechanical power rectifier for high voltage direct current production is described, and its design and operation discussed.

RADIO TRANSMISSION MEASUREMENTS*

By

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(American Telephone and Telegraph Company, New York)

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(Western Electric Company, New York)

Almost from the beginning of the radio art there has been sought a suitable way of measuring and expressing the strength of received signals and the effect of static on their readability. It is not until very recent years, however, that any really effective progress directed toward this goal has been made. This has been not so much due to any lack of diligence on the part of radio engineers as to a lack of adequate experimental tools. In recent months the technical press has reflected an increasing and world-wide interest in this subject. Our paper, as is indicated by its title, deals with such experimental measurements, but before going into the details of apparatus and methods we wish to give a few paragraphs to the fundamental background against which the subject should be viewed. For this reason we have started our presentation below with a very brief transmission analysis of the generalized radio "circuit" or system. Following this analysis there are given brief descriptions of the methods and apparatus which we have been developing in the last two years for measuring experimentally two things of fundamental importance, namely—absolute values of the electric field strength of radio waves and effective values of radio noise. To give the descriptions greater interest and to demonstrate the practicability of the methods and apparatus, illustrative results have been included showing cases where the apparatus has already been successfully used to advantage. These results are given, however, only as illustrations and no attempt is made to adequately discuss them as results. It is hoped that this may be done in later papers.

* Received by the Editor, March 9, 1923. Presented before The Institute of Radio Engineers, New York, March 21, 1923.

Transmission Analysis of Radio Circuit

A radio system viewed from the transmission standpoint splits naturally into three distinct parts as indicated in Figure 1. First is the transmitting end of the system in which the radio frequency signal power is produced and radiated. Second is the

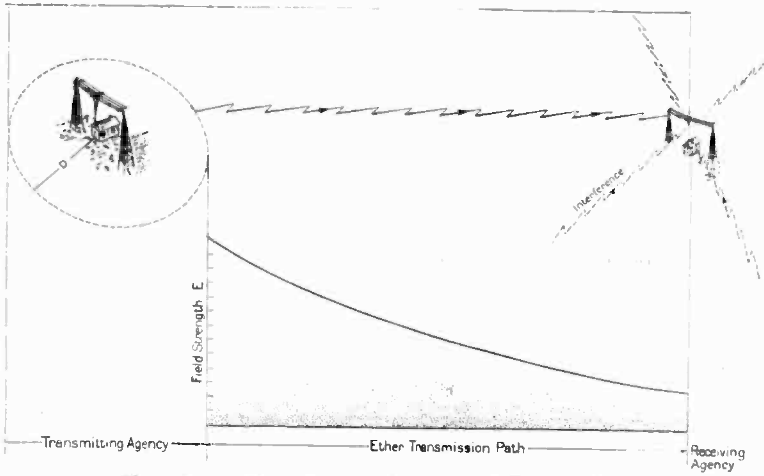


Figure 1—Transmission Analysis of Radio Circuit

ether transmission path, and third is the receiving antenna and its associated receiving apparatus. In all three of these portions the signal-bearing currents or waves are subject to losses. In the first, and usually the third, they receive gains due to some form of amplification. The radio transmission engineer must so distribute the gains in the system that the minimum cost and the desired service efficiency are achieved. The gains are produced in terminal apparatus while the losses occur in the transmitting and receiving antenna structures and in the ether path between them. Before the transmitting and receiving apparatus can be chosen to give the most suitable partitioning of the gain, the losses must be isolated and evaluated. It is with this part of the problem that the present paper is concerned.

In the transmitting end of the system the important element from the present standpoint is the radiation efficiency of the transmitting antenna structure. This efficiency is defined as the ratio between power input to the antenna and power actually radiated, expressed as a percentage. The input is readily determined as the product of the total antenna resistance and the square of the antenna current, both of which may be measured by well known methods. The radiated power is the product of the radiation resistance and the square of the antenna current. The radiation resistance is in accordance with the usual theory,

$R = 1600 \frac{h^2}{\lambda^2}$ ohms where h and λ are in the same units. The wave length being known, it remains to determine the effective height h. Now

$h = \frac{E \lambda d}{377 I}$ meters, where λ and I are the sending wave length and antenna current respectively in kilometers and amperes, and E is the effective or root mean square value of the electric field strength of the radiated waves in micro-voits per meter at a distance d kilometers from the antenna. All of these quantities are readily found except the field strength E. If E is measured, all the data are available for figuring out h and the radiated power.

It is worth while to consider some of the assumptions this method of evaluating the radiated power involves. It assumes first of all that the antenna has no directional effect. This is not usually the case and unless interest is confined to one direction, measurements of E must be made in a number of directions and the results properly averaged. It assumes also that the field surrounding the antenna is the ideal one for which the formula is derived. This assumption is probably a safe one if the distance d is sufficiently large. Another assumption is that all losses occurring between the antenna and the point at which E is measured are antenna losses. This is really a matter of definition and it is, at least for present purposes, quite reasonable to consider as transmitting station losses those occurring out to the point where the waves have gotten well started on their way. E must be measured not closer than several wave lengths from the antenna to have these conditions obtain.

For a knowledge of the performance of the ether transmission portion of the system, measurements of E, the electric field intensity of the waves, are needed at a number of places along their route of travel beginning at a point suitably near the transmitting station as discussed above and continuing to the receiving station.

At the receiving station, which forms the third portion of the system, another factor enters into consideration. Interfering electric waves from static, other stations, local electric power systems and so on, are usually present and the incoming experimental problems in the construction of a field strength measuring set is to keep the oscillator which produces the local signal power from affecting the antenna directly. The success of the method depends on having all the power fed to the antenna thru the circuits designed to meter and control it and on having no external "pick up." It is found that this requirement can be met sufficiently if the oscillator power is kept to the lowest workable value, the oscillator is given a reasonable separation from the antenna and the whole input circuit is carefully and systematically shielded.

LONG WAVE FIELD STRENGTH MEASUREMENTS

In a note published recently in the PROCEEDINGS,[1] Mr. Englund has described the initial form of our field strength measuring sets for very long waves. For completeness and as illustrative of the method in its simplest form it will be briefly reviewed here. The apparatus was designed to measure signals in the neighborhood of 23,500 cycles per second. From the diagram of Figure 2, it will be seen that it consists of three main parts, namely, the local signal input apparatus, the loop antenna, and the receiving set.

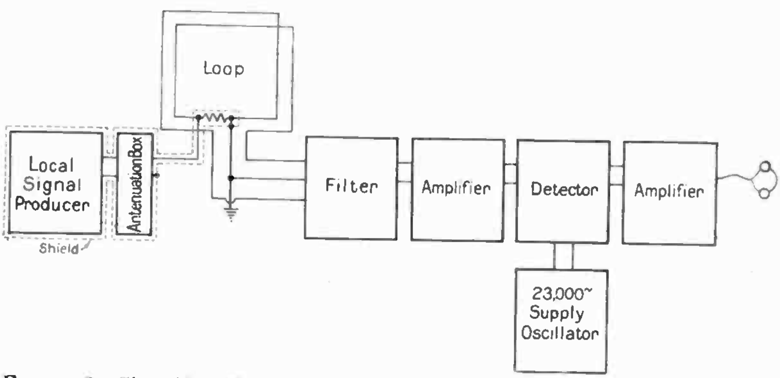


FIGURE 2—Simplified Diagram of Long Wave Field Strength Measuring Set No. 1

There is nothing out of the ordinary in the loop antenna and the receiving set except the use of a band filter between them to give very high selectivity. The input apparatus consists of an oscillator circuit complete with its own "A" and "B" batteries, which generates 23,500 cycle current. This current passes thru a thermocouple type of milliameter into a 600-ohm adjustable

[1] PROCEEDINGS OF THE INSTITUTE OF RADIO ENGINEERS, volume 11, number 1, February, 1923, page 26.

artificial line designed for radio frequency use. The output end feeds thru a 599-ohm resistance into a one-ohm resistance shunt which is included in the loop circuit. The whole input system is covered by a copper shield. This will be seen by reference to Figure 3 which is a photograph of a set up using this same input equipment. The large copper box at the extreme

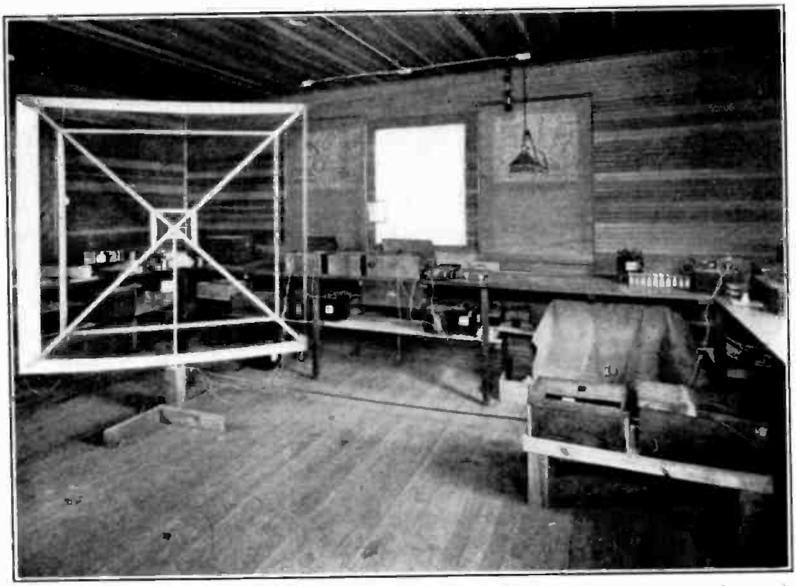


FIGURE 3—Long Wave Field Strength Measuring Set Showing Shielding of Local Signal Input System

right on the low bench contains the oscillator with its "A" and "B" batteries The next copper box, which is joined to the first by a short length of copper pipe, contains the thermocouple instrument, artificial line, and 599-ohm resistance From this box a copper pipe extends over to a small copper box on the loop base. This pipe contains the single wire leading to the one-ohm shunt in the copper box. The return circuit is thru the copper pipe.

The operation of the set when measuring signals from a co-operating transmitting station sending dashes separated by spaces is as follows. The loop is oriented to receive maximum signals. The signals are tuned in properly thru the filter and received as a tone by the aid of the heterodyne oscillator in the receiving set so that they may be listened to or, if static permits, read on a microammeter. The local signal oscillator is then turned on and its frequency adjusted to be exactly the same as that of the incoming signals. Then by means of a key the local signal is cut on and off during spaces in the incoming signals so that the two signals (incoming and local) are heard alternately. When the local signal oscillator is adjusted to the proper frequency the two will have the same tone pitch. It only remains then to adjust the local signal by means of the artificial line to have the same loudness as the incoming signal and to read the setting of the artificial line and the value of the current flowing into it.

Since the artificial line, when properly terminated, is a current attenuator, the current flowing into the line multiplied by the attenuation factor for which the line is set gives the much reduced current which flows out to the shunt in the loop circuit. A small portion of this current goes thru the loop itself, which forms a series resonance circuit in parallel with the shunt, so that the current thru the shunt is less than that coming from the artificial line by an amount equal to the ratio of the shunt and loop resistances. This ratio is usually too small to warrant the correction.

The shunt current in amperes multiplied by the shunt resistance in ohms (one ohm in this case) gives the voltage introduced into the loop, which is in turn equal to the voltage induced in the loop by the incoming signal waves. The voltage V induced in the loop by incoming waves, the effective field strength of which is E micro-volts per meter is

$$V = \frac{2}{3} \pi f\, A\, N\, E \times 10^{-18} \text{ volts}$$

where f = frequency in cycles per second, A = loop area in square centimeters, and N the number of turns. Substituting for V its value $V = I_L F R_s$, where I_L = current into the artificial line in amperes, F the current attenuation ratio setting of the line, and R_s the resistance of the shunt in ohms, we have

$$E = \frac{3\, I_L\, F\, R_s}{2\pi f\, A\, N} \times 10^{18} \text{ micro-volts per meter.}$$

It should be noted that this calculation requires no accurate knowledge of the loop resistance, inductance or capacity, since the measurement matches voltages directly and the resulting current is of no import. There is, to be sure, some error due to the fact that the incoming signal voltage is induced in a distributed manner and the local signal voltage is introduced at a fixed point in the circuit, but our calculations lead us to believe that this error is too small to warrant any correction.

Setting up an outfit of this kind is fraught with many experimental difficulties which we unfortunately have not space to consider here in detail. The shielding must be effectively and carefully bonded into a continuous conducting sheath. Multiple grounds must be avoided. The final test is to short-circuit the shunt with a heavy copper conductor of substantially zero resistance and so to set the oscillator output and the attenuation box that a relatively large current flows thru this conductor. If the receiving set is then unable to detect a voltage in the loop which is appreciable in comparison with signals of the intensity which it it desired to measure, the set is free from spurious effects.

The second type of long wave measuring set which we have used was made up for measuring signals in London in connection with the recent transoceanic telephone experiments carried out by the American Telephone and Telegraph Company and the Radio Corporation of America in co-operation. The wave length is somewhat shorter (5,300 meters, 57,000 cycles), but the local signal input system is practically identical with that of the initial set except for the constants of the oscillator. A further difference is that a double detection type of receiving set was used. The entire outfit is diagrammed in Figure 4. The loop antenna has a very loose capacity coupling to a secondary circuit which feeds into the radio frequency detector. This detector also has impressed on its grid a 91,000 cycle voltage from the radio frequency beating oscillator. The incoming signal frequency is 57,000 cycles, so these two beating together produce 34,000 cycles in the detector output. This is selected by the filter circuit which permits the passage of a 2,000 cycle band from 33,500 to 35,500 cycles and greatly attenuates all other frequencies. The signal is then amplified to the desired degree and impressed on the audio frequency detector together with a 35,500 cycle voltage from the carrier supply oscillator. In case the incoming signal is the 57,000 pure continuous wave which is used for measurement transmission, it comes out as a 1,500 cycle tone in the telephone receivers. The operation of the outfit, except for the tuning of the receiving set, is exactly the same as with the simpler set. Rocky Point transmits dashes and in between these the local signal is turned on for matching of tone pitch and intensity.

In Figure 5 is shown the set up of the apparatus in London where it has been in use for the past few months measuring the special test signals from Rocky Point. At the left of the picture is the local signal input apparatus with the copper shielding

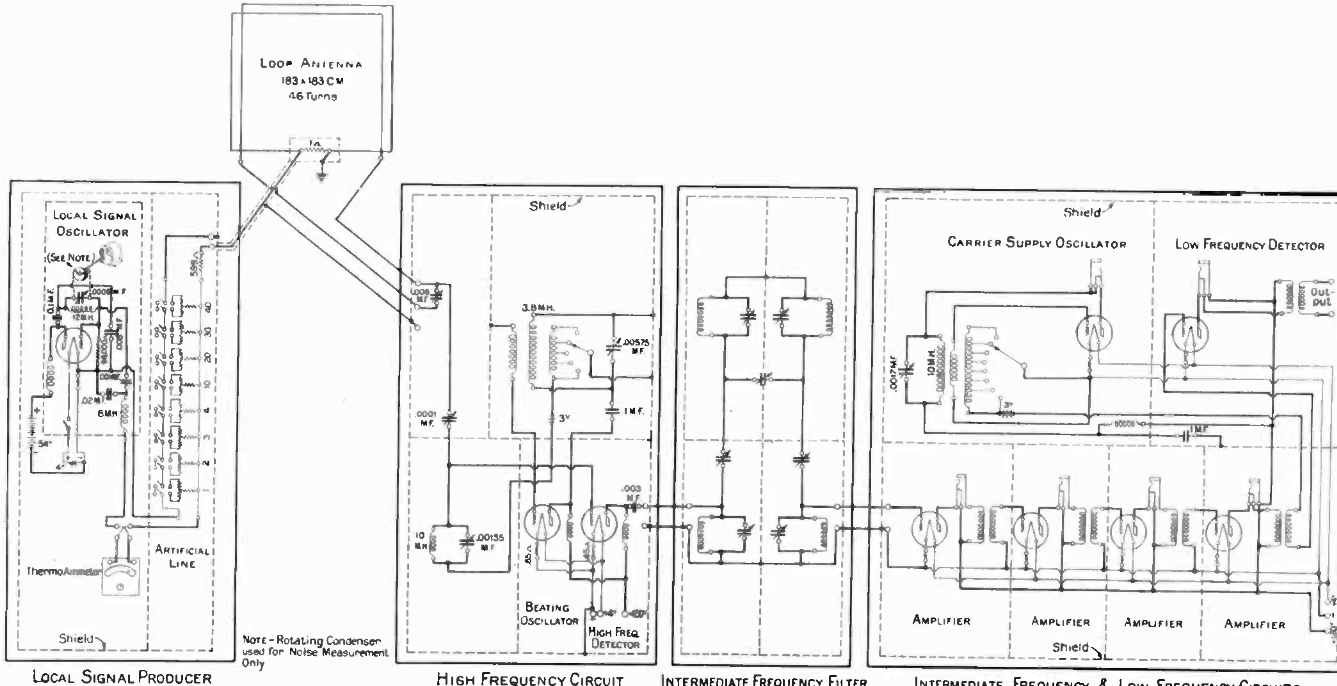


Figure 4—Long Wave Field Strength Measuring Set Number 2

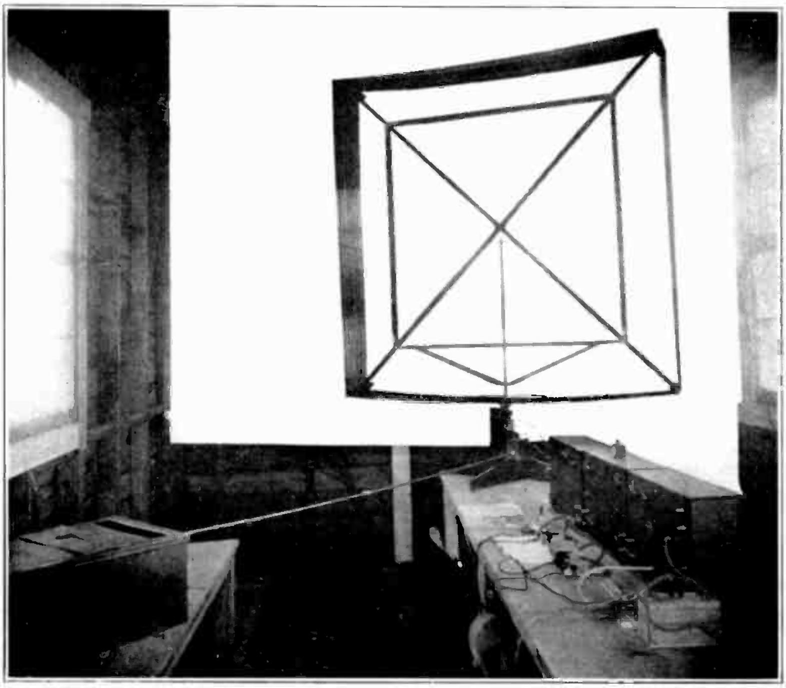


FIGURE 5—Long Wave Field Strength Measuring Installation in London

pipe leading from it to the loop. The three boxes on the bench contain the receiver portion of the measuring set. An illustrative example of the data being taken is given in Figure 6. This shows the hourly field strength readings made during a 52-hour run on February 11, 12, and 13, 1923. A considerable amount of such data is being obtained, but until the tests are completed any general discussion of the results would be premature. The method of interpreting the field strength curves in combination with noise measurements is taken up in later paragraphs.

SHORT WAVE FIELD STRENGTH MEASUREMENTS

In measuring short wave signals, as from radio broadcasting stations, it was anticipated that the direct method of comparing the voltage induced in the loop antenna by the incoming carrier wave with that introduced by a local oscillator at the same frequency would be difficult. The higher frequency makes the "pick up" from the local signal oscillator harder to reduce to satisfactory values. In getting around this trouble we employ a modified method devised by Mr. Friis which is believed to be entirely new. A detail circuit diagram of a measuring set of this type is shown as Figure 7.

The loop antenna is provided with a tuning condenser across its terminals in the usual way, but its central point is grounded and connection to the receiving set is from ground to one side of the loop. This is great measure preserves the directional balance of the loop and minimizes the damping due to the receiving set. The receiving set itself is of the double detection type and has intermediate frequency amplifying and selecting circuits designed for 45,000 cycles. As will be seen by reference

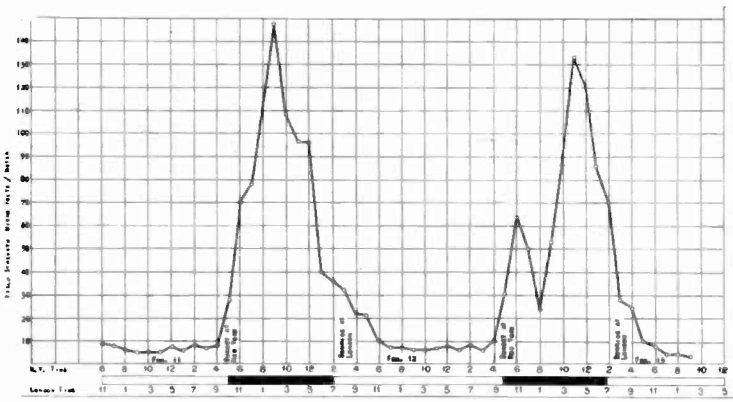


FIGURE 6—Field Strength Measurement. Transatlantic Signals from Rocky Point, Long Island, United States of America. Measured in London, England, (Distance 5,000 km.) (3,200 miles), February 11, 12, 13, 1923

to Figure 8, if the incoming signal has a frequency of 750,000 cycles, the loop is tuned to 750,000 cycles, but the radio frequency beating oscillator is set to produce a frequency of either 705,000 or 795,000 cycles, so that, beating with the 750,000 cycle signal in the radio frequency detector, it will produce the 45,000 cycles, necessary for further amplification and selection. The local signal oscillator is not set at 750,000 cycles, but at a frequency which is just 45,000 cycles the other side of the beating oscillator so that it also will produce 45,000 cycles at the output of the radio frequency detector. This means that if the beating oscillator is below the loop tune, at 705,000 cycles, the local signal oscillator will be 45,000 cycles still lower, or at 660,000 cycles. Or if the upper position has been selected, the two will be at 795,000 cycles and 840,000 cycles respectively. In either case, insofar as the intermediate frequency and audio frequency output circuits are concerned, the incoming and local signals are

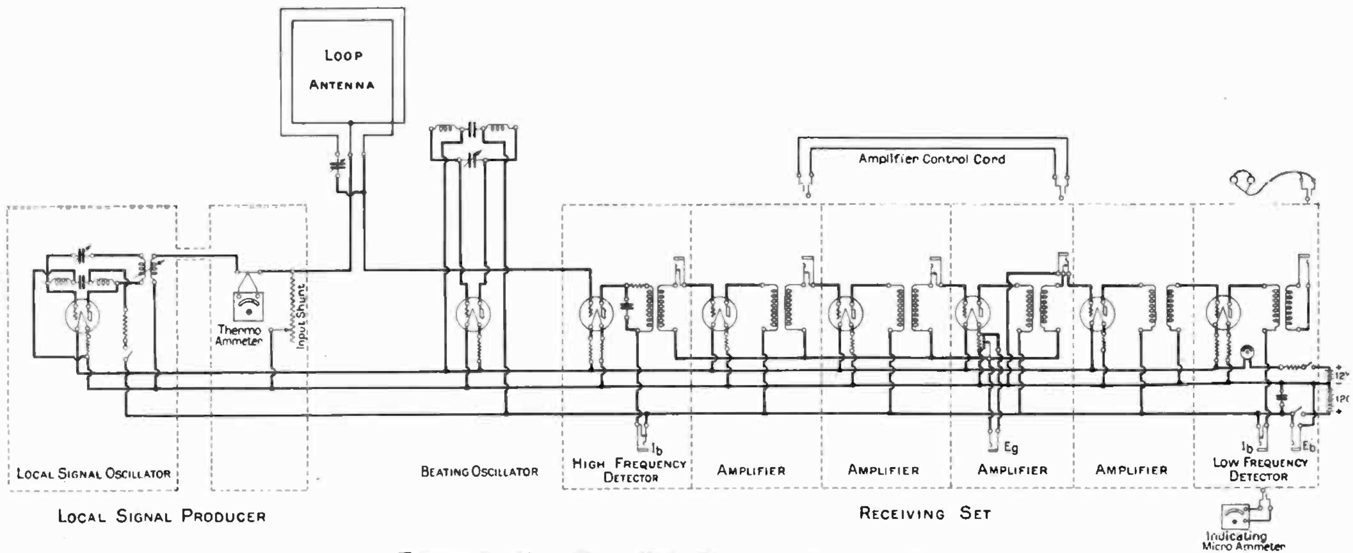


Figure 7—Short Wave Field Strength Measuring Set

delivered to them at exactly the same frequency. At the same time, the original frequency of the local signal is well off the loop tune, and induction in to the loop is so reduced that only a moderate amount of shielding is required.

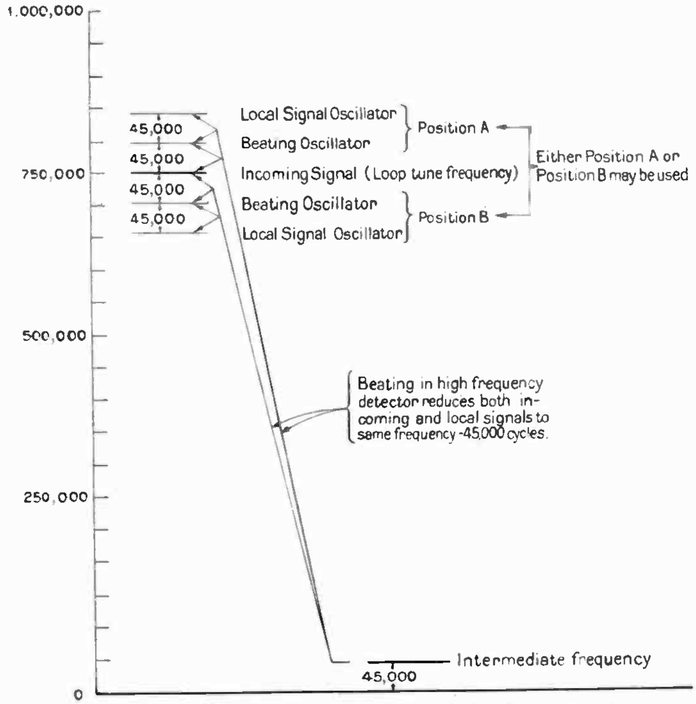


FIGURE 8—Frequency Diagram—Short Wave Field Strength Measuring Set

The resistance shunt thru which the local signal is introduced is placed in the ground lead of the loop. Thus the shunt is not in the loop circuit proper, but, viewed from the input terminals of the receiving set, is in series with the parallel resonance circuit formed by the loop and its tuning condenser. Since the local signal voltage impressed on the receiving set comes directly from the shunt and is not increased by resonance, the current thru the shunt is larger than in the case of the direct method used in the long wave sets, and no attenuation net work is needed. In effect the voltage across the shunt is compared by the receiving set with the voltage set up by the incoming signal across one half of the loop. The two voltage sources are in series in a very high impedance circuit. The low impedance shunt has, therefore, no appreciable effect on the interaction of the loop and the receiving set. On the other hand, the loop, acting as a trap circuit, has sufficient impedance, even at the off-tune frequency of the local signal, to require that a simple experimental correction be made for it. The correction factor is determined as a part of the calibration of the set by taking the ratio of the voltage impressed on the receiving set from the shunt with the loop cut out of the circuit, to that impressed when the loop is in the circuit. Figure 9 gives curves of the correction factor α for a representative set for different frequencies of operation and for the two possible frequency relations between the incoming and local signals. The voltage applied to the receiving set by the

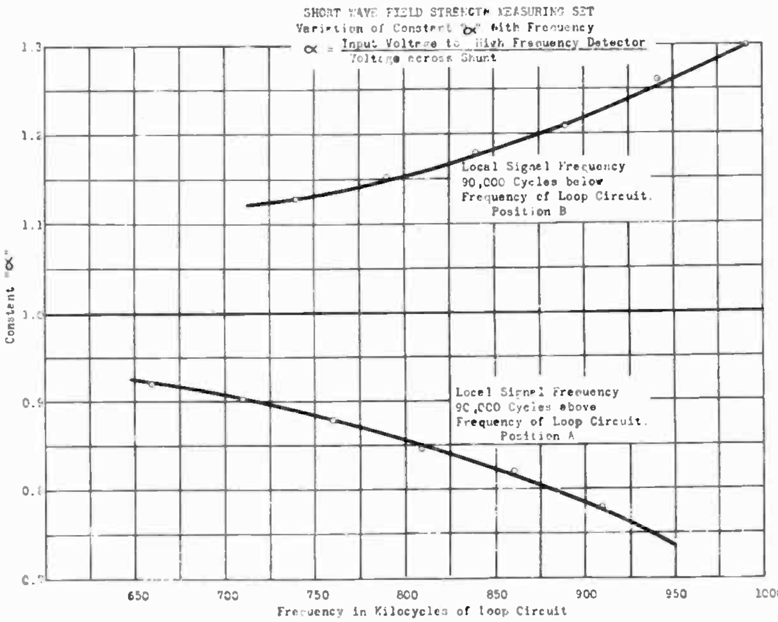


FIGURE 9

local signal input system is then: V (in millivolts) $= I_L \alpha R_s$, where I_L is the current in the shunt in milliamperes measured directly by a series thermocouple as indicated in the circuit diagrams, α is the correction factor, and R_s is the resistance of the shunt in ohms.

The potential applied to the receiving set as a result of the action of incoming waves of field intensity E micro-volts per meter is one-half that across the loop terminals or,

$$V = \frac{1}{2}\,\frac{4\pi^2 f^2 LANE \times 10^{-15}}{3R} \text{ millivolts.}$$

Transposing: $E = VK$ micro-volts per meter

$$\text{where } K = \frac{0.152\, R}{f^2\, L A N} \times 10^{15}.$$

In the above.

f = frequency in cycles per second.

L = Inductance of loop in henrys.

A = Area of loop in square centimeters.

N = Number of turns in whole loop.

R = Total radio frequency loss resistance of loop circuit in ohms.

V is measured by comparison with the voltage across the shunt. E is derived from it thru the agency of the factor K, which is a calibration constant of the set. The short wave measuring set thus differs from the long wave set in that the inductance and resistance of the loop must be accurately known as well as its turns-area.

The distributed capacity of the loop and its connecting leads are determined by the well-known method of finding the values of the calibrated tuning condenser required to give resonance at various wave lengths, plotting these capacities against the corresponding wave length squared, and extrapolating the straight line thus obtained to its intercept on the capacity axis. Figure 10 shows the data thus plotted for a representative loop in which the distributed capacity was found to be 25 micro-micro-farads. Adding this to the capacity of the tuning condenser at resonance for some particular frequency, the inductance of the loop may be calculated by the usual method. In the loop mentioned the inductance is 156 micro-henrys.

After trying out several methods it was found that the resistance of the loop circuit could be best determined from the resonance curve by the capacity variation method. Each measuring set has permanently installed in parallel with the main tuning condenser a calibrated single plate variable condenser for the carrying out of this method. The radio frequency detector tube is one in which the change in plate current is proportional to the square of the radio frequency voltage impressed on its grid. In other words, it may be used as a vacuum tube voltmeter. The beating oscillator, with reduced coupling to the loop, serves as a source of constant radio frequency power. Thus the resonance curve of the system may be run at any desired frequency by means of the single plate tuning condenser and a micro-ammeter plugged into the plate circuit of the radio frequency detector tube. The conditions of calibration are thus those of operation and the resistance derived from the resonance curve by the usual methods includes all losses in the radio frequency circuit. The accuracy of the set is dependent on the accuracy with which R is determined, and R sometimes varies appreciably with climatic conditions. The method of

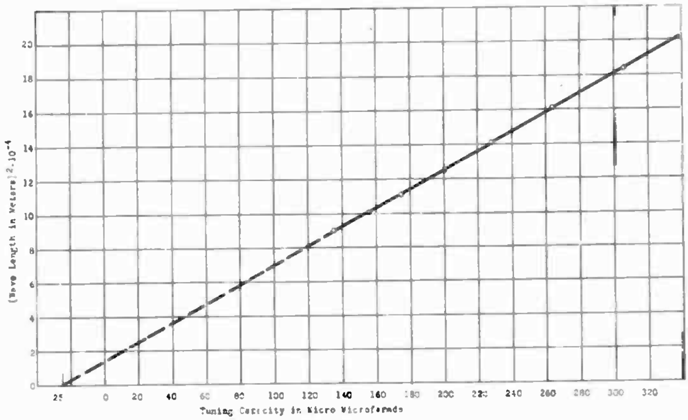


FIGURE 10—Short Wave Field Strength Measuring Set—Determination of Distributed Capacity of Loop

calibration is fortunate, therefore, in that no extra apparatus is needed, and it may be carried out in a few minutes wherever the set is in use. For the particular loop mentioned above, the variation of R with frequency is given in Figure 11. This loop has six turns and is a square 154 centimeters (59.7 inches) on a side. From these data, the factor K may be evaluated. It is given for the frequency range covered by the set in Figure 12.

In using this type of set, our practice is to dispense with ear comparisons and employ a micro-ammeter in the plate circuit of the audio frequency detector as the indicating means. The audio frequency detector then acts as a vacuum tube voltmeter to measure the amplitude of the carrier of the incoming radio telephone signals. Unless the transmitting station is badly over-modulating, the micro-ammeter is unaffected by the speech or music being sent. It is the carrier field strength which is measured, without reference to the degree or nature of the modulation.

The operation of the set is as follows: The desired signal is picked up by the loop and receiving set and brought to a volume which gives a satisfactory reading on the indicating instrument.

By means of the fine adjustment condensers, and by watching the indicating instrument, the loop is tuned to exact resonance and the beating oscillator is set to place the intermediate frequency in exact resonance with the 45,000 cycle selective circuit of the amplifier. The loop is also oriented to give maximum response.

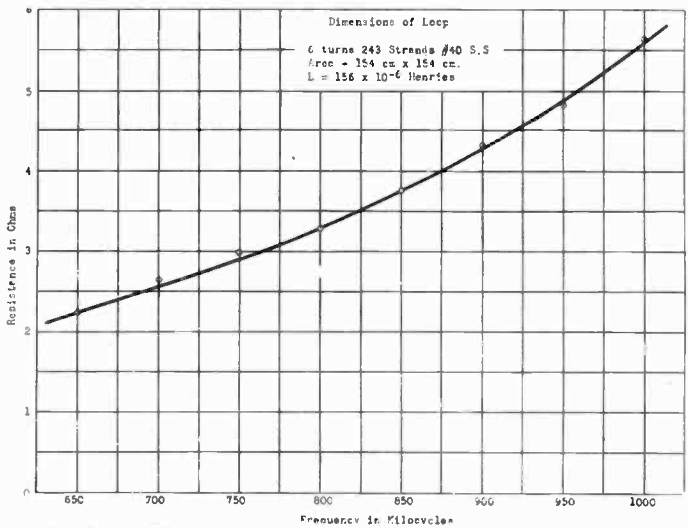


FIGURE 11—Short Wave Field Strength Measuring Set—Variation of Loop Circuit Resistance with Frequency

The instrument reading is then recorded. Since the vacuum tube voltmeter indicates by virtue of the change in its plate current produced by the input voltage, a reading must also be

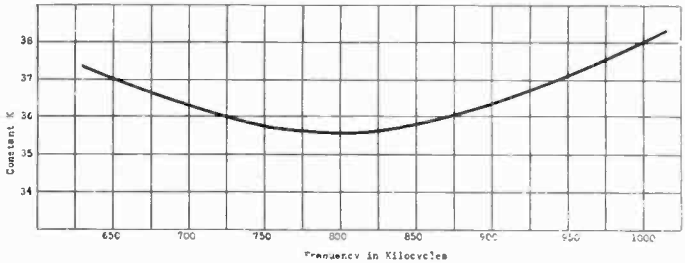


FIGURE 12—Short Wave Field Strength Measuring Set—Variation of Constant "K" with Frequency

$$K = \frac{\text{Voltage across half of loop (Millivolts)}}{\text{Field Strength } (\mu V/M)} = \frac{0.152\, R}{f^2 L A N} \cdot 10^{15}$$

Based on loop:

6 turns 243 strands No. 40SS.

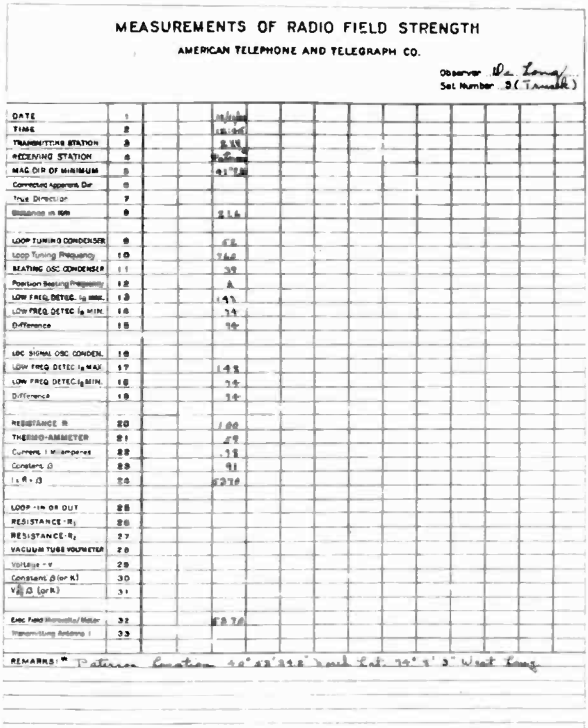
154 cm.×154 cm. (59.7 in.×59.7 in.)

$L = 156 \times 10^{-6}$ henrys

taken with the incoming signal cutoff. This is accomplished by shutting off the beating oscillator for a moment and recording the instrument reading, which is lower than with the signal on. The local signal oscillator is then started, set approximately to its proper frequency and the shunt adjusted to give a suitable value of input. A beat note is now heard between the 45,000 cycles due to the incoming signal and that due to the local signal. When this beat note is reduced to zero by means of the local signal oscillator frequency control, the local signal has been set exactly to its proper frequency position. If the transmitting station is co-operating it is then shut down, or if not co-operating, the loop is turned 90° to balance its signals out. Following this, the input shunt is adjusted to give a *difference reading* on the indicating instrument, due to the local signal, exactly the same as that which was given by the incoming signal. The measurement is now completed except for recording the various settings. The whole process takes 3 to 5 minutes, depending on the skill of the operator, and strength of signal, amount of interference, and so on.

A sample data sheet for use with this type of set is illustrated in Figure 13. Items 1 to 8 give general information relating to the test. Items 9, 11, and 16 are the condenser settings of the loop and oscillators. From Item 9 and a calibration curve, the frequency of the incoming signal (Item 10) is recorded in kilocycles. From Items 9, 11, and 16 one knows whether the signal is above or below the oscillators in frequency (Item 12) and the proper branch of the calibration curve is selected for the reading of the correction factor α. Items 13—14 and 17—18 are the "signal on" and "signal off" readings of the indicating micro-ammeter for the incoming and locally produced signals respectively. Their two differences (Items 15 and 19) should be equal.

Item 20 is the resistance of the local signal input shunt, Item 21 the series thermo-ammeter reading in scale divisions, and Item 22 the same in milliamperes. $I \times R$ (Item 20 times Item 22) gives the potential in millivolts impressed on the receiving set which, when multiplied by α the correction factor, is equal to the voltage impressed by the loop. The loop voltage times the factor K equals the field strength of the incoming signal in micro-volts per meter. Since α and K are thus ultimately multiplied together, it is a convenience to do this once for all and a combined factor $\beta = \alpha K$, is usually plotted up for use in reducing data. Such a curve is shown in Fig. 14. β is entered as Item 23. Item 24 $\times IR \times \beta$ is the field strength in microvolts per meter. Items 25 to 31 are for use with a slightly modified type of set. Item 32 is provided for collecting results at the bottom of the sheet. Item 33, the transmitting antenna, current is recorded when known.



MEASUREMENTS OF RADIO FIELD STRENGTH

AMERICAN TELEPHONE AND TELEGRAPH CO.

Observer [illegible]
Set Number 3 ([illegible])

DATE	1	[illegible]
TIME	2	[illegible]
TRANSMITTING STATION	3	[illegible]
RECEIVING STATION	4	[illegible]
MAG DIR OF MINIMUM	5	[illegible]
Corrected Apparent Dir	6	
True Direction	7	
Distance in Km	8	[illegible]
LOOP TUNING CONDENSER	9	[illegible]
Loop Tuning Frequency	10	[illegible]
BEATING OSC CONDENSER	11	39
Position Beating Frequency	12	A
LOW FREQ. DETEC. I_g MAX.	13	[illegible]
LOW FREQ. DETEC. I_g MIN.	14	[illegible]
Difference	15	[illegible]
LOC SIGNAL OSC CONDEN.	16	
LOW FREQ DETEC I_g MAX	17	[illegible]
LOW FREQ DETEC I_g MIN.	18	[illegible]
Difference	19	[illegible]
RESISTANCE R	20	[illegible]
THERMO-AMMETER	21	[illegible]
Current I Milliamperes	22	[illegible]
Constant β	23	91
$I \times R \times \beta$	24	[illegible]
LOOP - IN OR OUT	25	
RESISTANCE - R_1	26	
RESISTANCE - R_2	27	
VACUUM TUBE VOLTMETER	28	
Voltage - V	29	
Constant β (or K)	30	
V $\times$ β (or K)	31	
Elec Field Microvolts/Meter	32	[illegible]
Transmitting Antenna I	33	

REMARKS: * Paterson Location [illegible] North Lat. [illegible] West Long.

FIGURE 13—Data Sheet used for Recording and Reducing Data

Each measurement requires one column on the data sheet. The sample column shown is data taken on December 11, 1922 at a point near Paterson, New Jersey, while measuring transmission from Station 2XY. The auto truck measuring set described in subsequent paragraphs was used.

The photograph Figure 15 illustrates the original laboratory set up of the first short wave measuring set. It was with this apparatus that the first measurements of the field strength received from the S. S. *America* were made in February and March, 1922. One of the best sets of data obtained is reproduced in Figure 16 as illustrative of the utility of such measure-

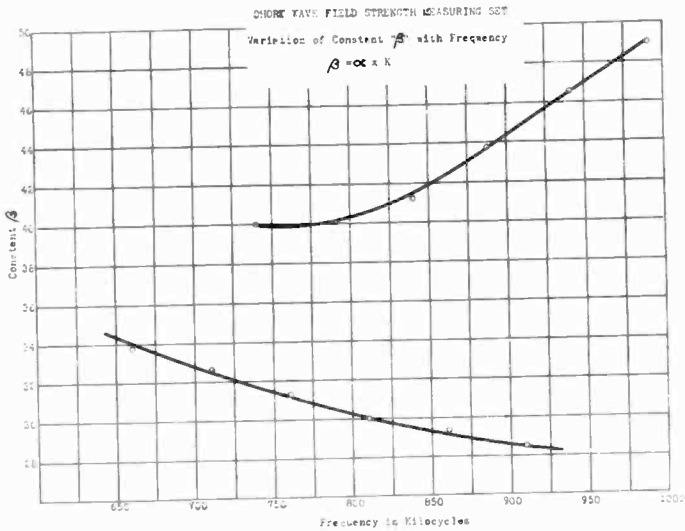


FIGURE 14

ments in studying the law of short wave transmission over water and of giving a quantitative insight into the phenomena of night and day transmission, fading and the like.

Following the success of this original measuring set, models were made up for more general field use. These were more compact, rugged, and transportable in physical form, but electrically were so similar to the original set that the circuit diagram of Figure 7 represents their circuits almost exactly. One of them is shown set up in a small shack in Figure 17. The two boxes mounted on the loop contain the beating oscillator and the loop tuning condensers. On the bench the large box in the foreground contains "B" batteries and filament controls. The long box in the rear is the receiving set. The two boxes at the front edge are the local signal oscillator and input shunt with its thermocouple milliammeter. Between them is the output indicating instrument. A twelve-volt storage battery completes the outfit. Cords and plugs are provided for all connections between boxes. The loop folds up into a special packing case for shipment. The boxes may be shipped in a padded trunk. The battery rack under the bench is used with the permanent set up illustrated, the "B" batteries in the set being too small for long continued service. It will be noted from Figure 17 that all wiring and metal net works (except for a short piece of insulated stove pipe) have been eliminated from the neighborhood of the set.

One of these sets with a different form of loop antenna has been installed in a small motor truck for mobile field use. It is illustrated in Figure 18. An interior view looking from the rear

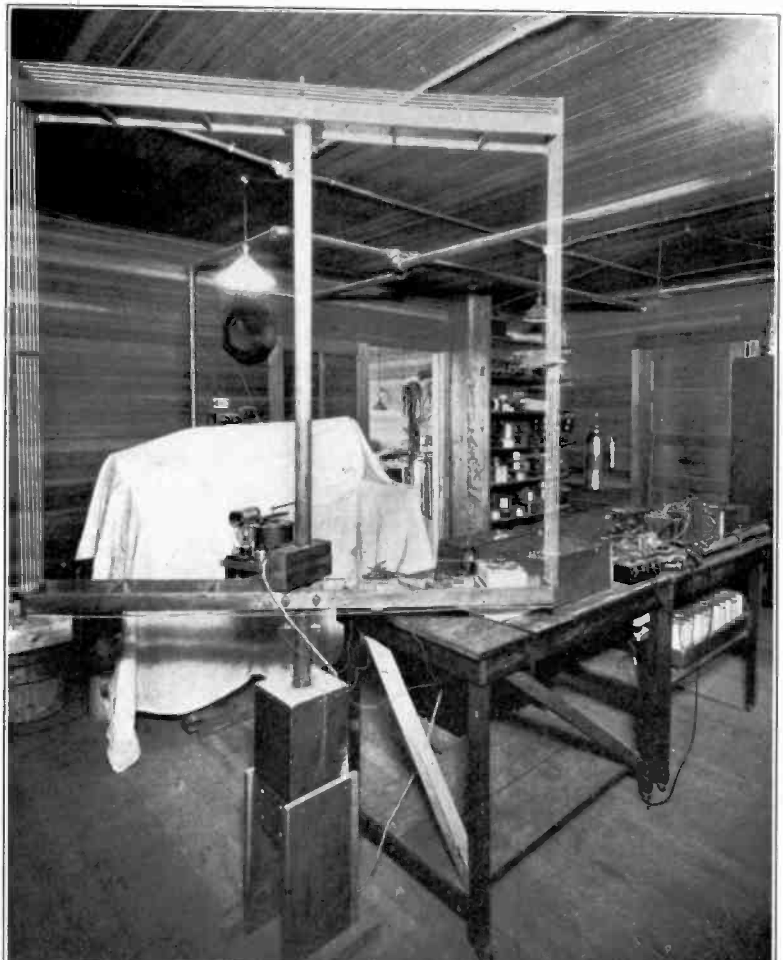


Figure 15—Original Short Wave Field Strength Measuring Set

is given in Figure 19. The truck set has for the past few months been engaged in an investigation of transmitting conditions for radio broadcasting in and around New York City. One of the interesting things shown by the investigation is that the transmitting efficiency of a broadcasting antenna erected on the roof of a steel building may be very much affected by the height of that building. For instance, with station 2XY, located on the top of the 24-story telephone building at 24 Walker Street, New York, it was found that the field strength received at a fixed measuring point varied with the wave length in the manner indicated in Figure 20. The general nature of this characteristic could have been determined qualitatively by means of ordinary listening tests, but a satisfactory study of the phenomena was possible only with the aid of absolute and quantitative measurements of radiated field. This study has been very useful in

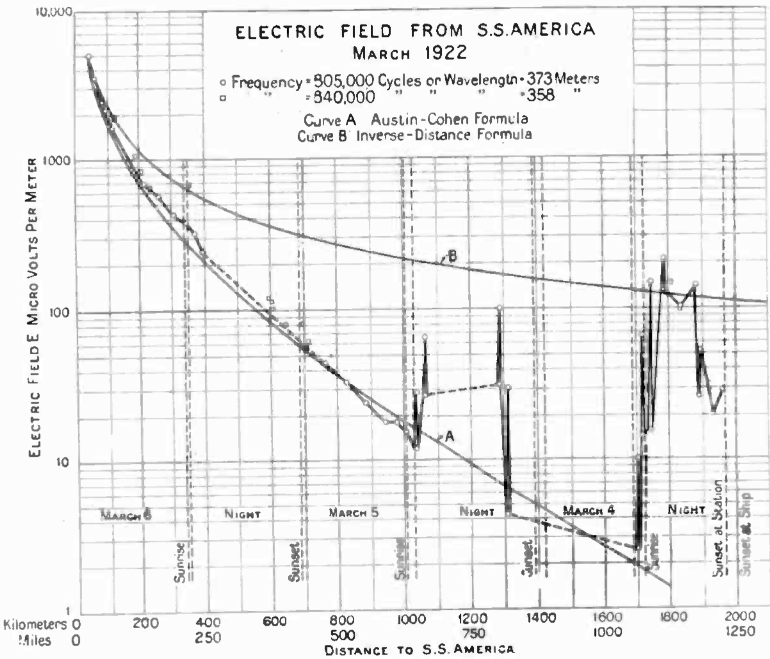


FIGURE 16

enabling us to predict with a fair degree of certainty the results to be expected from any particular building, as was the case with the proposal to locate a city broadcasting station on the Municipal Building. Later the tests were extended to mapping the transmission distribution of stations in lower Manhattan. Three stations were mapped: 2XB (WEAF), 2XY (WBAY), and 2XW (Municipal Building experimental antenna). The results of the series of tests are plotted in Figure 21. It will be seen that at 400 meters these stations are handicapped in transmitting northward thru the maze of steel structures of the island. Also it is apparent that the two high buildings are less favorable sites than the 14-story building at 2XB.

The results so far obtained demonstrate that field strength measuring sets are valuable experimental tools. For this reason it has seemed worth while to us to develop the short wave set into a form as compact and portable as possible. Figure 22 shows such a set. This outfit is self contained within the parts shown in the picture. It is intended to be enclosed entirely in two bags or suit cases of the kind used by salesmen for carrying samples. Thus it can be easily transported in an automobile or even carried by hand for reasonable distances. The loop

FIGURE 17—Short Wave Field Strength Measuring Set as Installed in the Measurement Shack at Cliffwood, New Jersey

collapses compactly. The upper box contains the receiving set complete including "A" and "B" batteries, which are dry cells. The lower box contains the local signal input apparatus

FIGURE 18—Truck Installation of Short Wave Field Strength Measuring Set

together with all its batteries. The alternating current voltmeter shown alongside enables the vacuum tube voltmeter in the set to be calibrated anywhere that an alternating current lighting circuit is available. This is not essential since several spare calibrated tubes may be carried inside the set. Back panel views of the receiving set and local signal producer are shown respectively in Figures 23 and 24. A circuit diagram is given in Figure 25. In order to simplify the diagram, several jacks, amplification control, and battery switches have been omitted from it. Western Electric type N tubes (popularly known as "peanut tubes") are used thruout, which accounts for the compactness of the batteries. The arrangement differs from the earlier sets essentially only in the local signal input unit. The oscillator feeds into the shunt thru an amplifier to give stability. The current in the shunt is measured by means of a vacuum tube voltmeter rather than a thermo-ammeter. There is also a minor difference in that the beating oscillator feeds into a small pick-up coil rather than into the loop directly. This outfit has not as yet been given a sufficiently thoro tryout to enable us to say with assurance that it is successful. It is with-

FIGURE 19—Interior View of Truck Installation

out doubt, however, capable of success, and we may look forward confidently to the time when the field strength measuring set will be almost as convenient and usable as the wavemeter is today.

Very little has been said above about the range and sensitiveness of our short wave measuring sets. It has not been found desirable to cover a wave length range much wider than two to one in a particular set. The short wave sets have been designed for a nominal range of 300 to 600 meters (1,000,000 to 500,000 cycles). Some of them have been used as high as 1,000 meters by adding loading condensers. This makes the calibration less determinate, and it is preferable to provide new loops and oscillator coils where radical shifts in range are desired. The later sets have been made with interchangeable socket mounted coils for this reason.

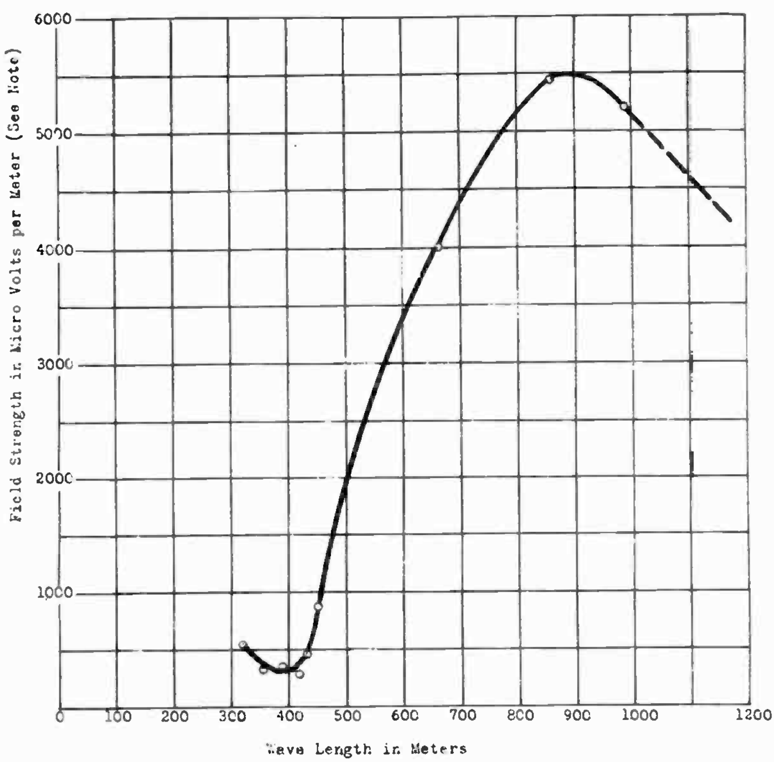


FIGURE 20—Variation of Field Strength with Wave Length. Measurements taken on 2XY (24 Walker St., New York City) at Cliffwood, New Jersey. NOTE: Field Strengths Corrected to 5 amps. Antenna Current at all Wave Lengths. Normal Antenna Current at 400 Meters is 10 amps.

By using the radio frequency detector directly as a vacuum tube voltmeter and dispensing with the rest of the receiving set, field strengths as high as 100,000 micro-volts per meter or more may be measured. The range is continuous from such values down to a minimum of about 10 micro-volts per meter, at which point the accuracy becomes questionable. Even lower field strengths may be measured approximately, however. Two

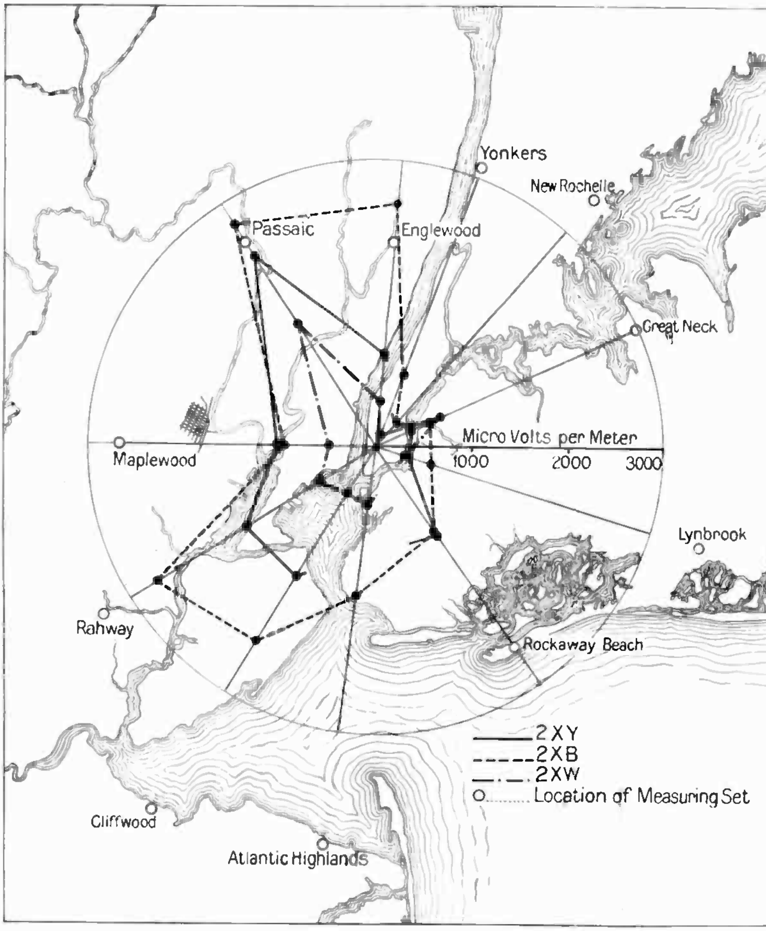


FIGURE 21—Polar Diagram of Field Strength Produced by Stations 2XB, 2XW, and 2XY. Corrected to 100 Watts in Antenna and a distance of 25 km. (16 miles)

or three hundred micro-volts per meter is about as low a radio telephone signal strength as can be received on the average high class radio receiver with any satisfaction under present day conditions of interference, so that the sensitiveness of the measuring sets seems adequate for any ordinary purpose. As was mentioned in a previous paragraph, only the carrier component of the transmission is measured, and ordinary modulation has no effect on the indicating instrument. Also static, which gives serious interference to reception of the speech or music, leaves the instrument practically unaffected. Even during summer, static

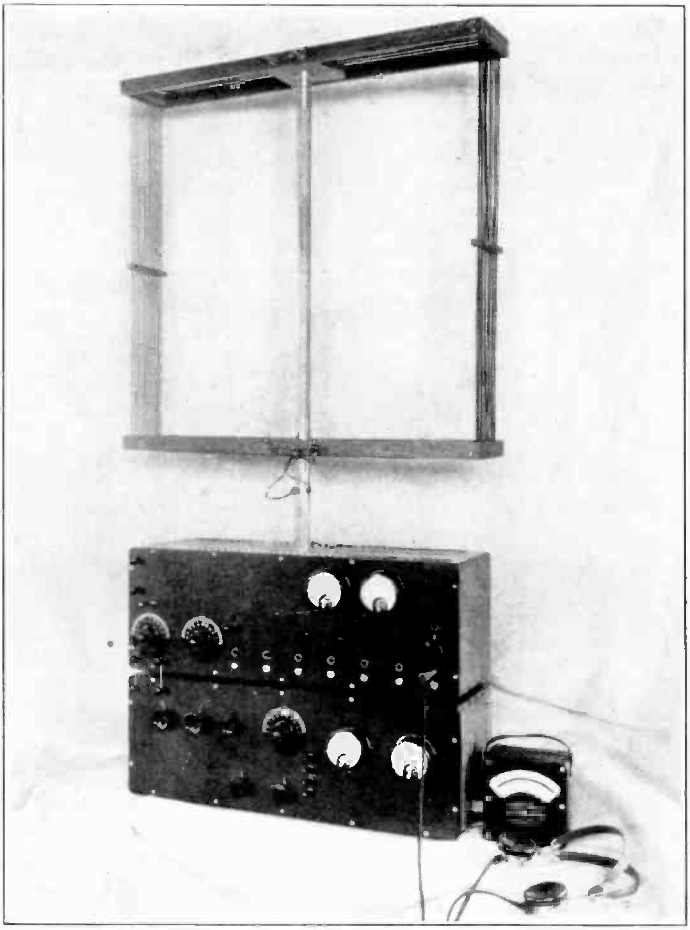


FIGURE 22—Portable Short Wave Field Strength Measuring Set

measurements can be made down to about 100 micro-volts per meter when a thousand micro-volts per meter or more would be required for satisfactory reception. The principal reason for this is that the direct current indicating instrument does not respond to alternating speech or noise currents in the output of the audio frequency detector. Interference from other radio telephone stations transmitting carriers of their own is obviously a different matter and may be very troublesome.

For comparing various incoming signals at or near the same frequency, the precision of the sets might almost be said to be limited only by the skill of the operator and the stability of the signals. When the results are expressed in absolute terms (micro-volts per meter) we do not believe that they are to be trusted closer than ±5 percent under the best operating conditions. Better calibration of sets may be expected to improve this, but it is quite sufficient for ordinary purposes. Where the signals are unstable in frequency or amplitude, interference is bad, or the operator unskilled, the results will be correspondingly less reliable.

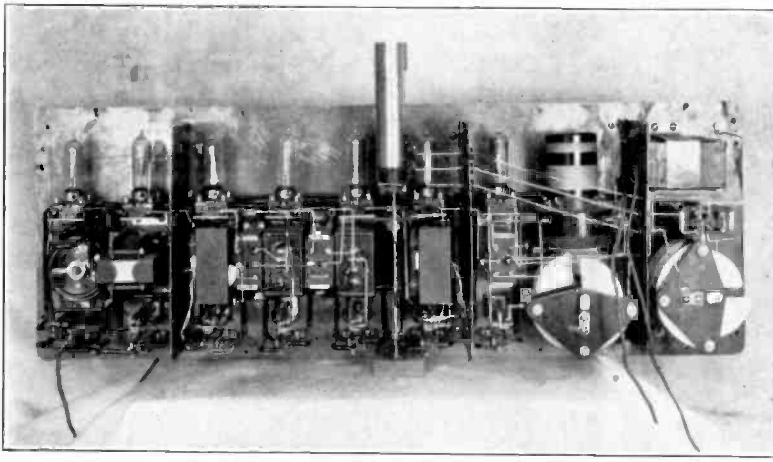


FIGURE 23—Interior View of Receiving Set Portion of Portable Short Wave Field Strength Measuring Set

MEASUREMENT OF RADIO NOISE

The problem of measuring radio noise is a considerably more puzzling matter than that of measuring the field strength of signals. First of all, the amount of noise received is dependent upon the directional and selectivity characteristics of the receiving system. In the present paper we will not enter into a consideration of these two factors, but will treat only the measurement of noise as received on apparatus we have used in experimental work. It should be noted, however, that the method of measuring noise described below may be used for comparing and evaluating the noise-reducing merits of receiving systems having various directional and selectivity attributes.

We have naturally approached noise from the telephone standpoint, since our primary interest is in radio telephony. Radio noise results in audio noise which comes to the ear of the listener and interferes with the understanding of sppech on the circuit. Within upper and lower limits set by the capabilities of the ear, the absolute volumes of speech and noise are not important as long as their relative volumes, that is, the ratio between their volumes, remains constant. This is a matter of common experience—changing the amplification of a receiving set to raise or lower the volume of received speech does not materially affect the interfering effect of static, because it is also raised or lowered in the same amount. It follows, therefore, that a good way of measuring noise should be to express it in terms of a volume of speech upon which it produces a certain

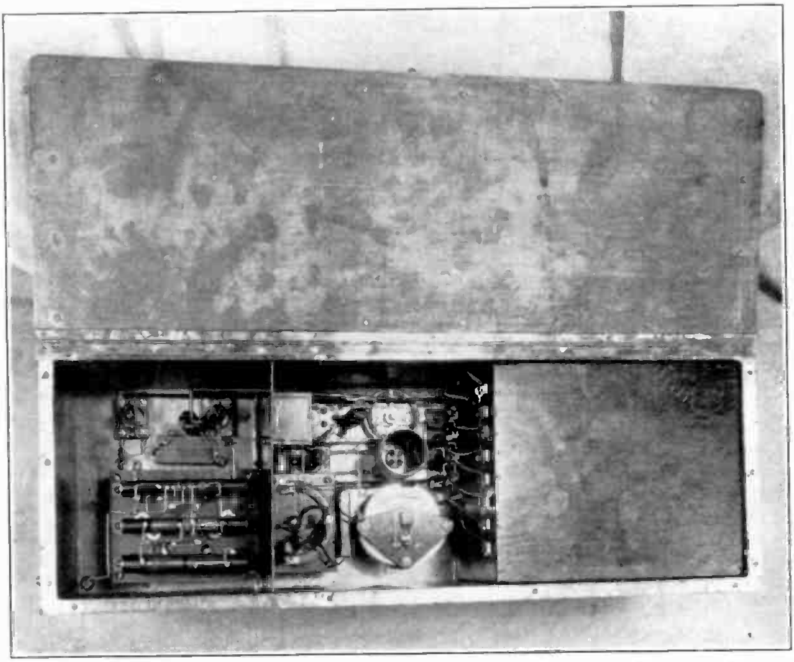


FIGURE 24—Interior View of Local Signal Producer Portion of Portable Short Wave Field Strength Measuring Set

standard interfering effect. Now, speech is a difficult thing to standardize, so that it is preferable to use some constant artificial source of sound which approximates speech in its effect on the ear and its reaction to the interfering effects of noise. For practical purposes it is found that an audio frequency tone, which flutters or varies back and forth uniformly in pitch between 600 and 1,400 cycles at a rate of about ten times per second, is a satisfactory form of artificial speech for the purpose. For the standard degree of interference produced on the artificial speech by noise, there are obvious reasons for selecting some sort of "end point." Such a suitable point is the one at which the

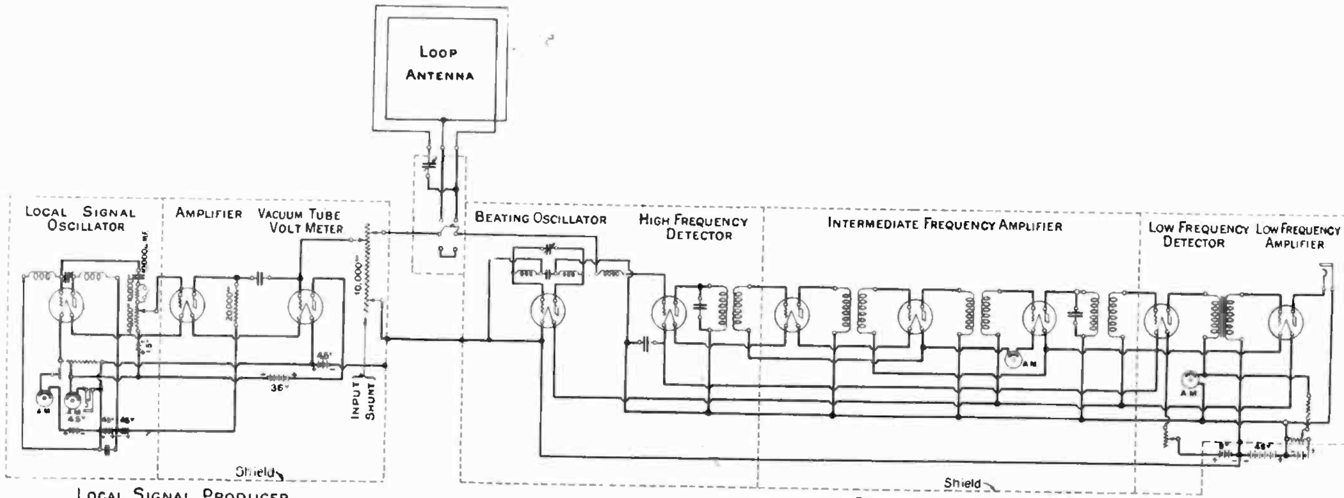


FIGURE 25—Portable Short Wave Field Strength Measuring Set. Circuit Diagram Simplified in Regard to Jacks, Amplification Controls, and Switches

presence of the artificial speech is just discernable thru the noise. The method, then, involves the introduction into the noisy circuit being measured of a controllable measured volume of the artificial speech and the setting of this volume to the point at which the ear is just able to recognize its presence. This point can be located by different observers who have but little skill in the use of the method, with a variation among observers of less than about 50 percent. To the ear 50 percent is a small change. The radio noise itself goes thru variations within a season and occasionally within a few days which are several hundred times as large, so that the precision of measurement is quite sufficient for the purpose.

If measurements of this kind are to be comparable and of permanent value, the volume of the artificial speech must be ex pressed in suitable absolute terms. Since it is radio noise with which we are concerned, the artificial speech should be expressed in the fundamental unit of radio transmission, which is electric field strength and of which the accepted practical base is one micro-volt per meter.

If the artificial speech is introduced into the antenna of a field strength measuring set as a radio signal in the same way that the local signal is introduced for field strength measurement purposes, the receiving set becomes merely an electrical extension of the ear and the evaluation of incoming noise in terms of the amount of local artificial radio telephone speech which it all but extinguishes, is made directly at the radio frequency. The conditions are those which would obtain if the artificial speech signal were in fact received from a distant station the power of which is under control by the measuring operator and the field strength of which at the measuring station is known for various power settings. To apply this method to a short wave measuring set, the local signal-producing oscillator must be modulated a fixed standard amount (say 1C0 percent) by the artificial speech flutter tone. We have not as yet been concerned with noise measurements at short waves, but have carried out our work in the long wave lengths.

Since in our long wave telephone work we are chiefly interested in the type of transmission which suppresses the carrier and one side band in the early stages of the transmitting amplifier and transmits but a single side band, our noise measurements have been carried out in such a way as to make the results most directly applicable to this kind of system.

The artificial speech is introduced into the calibrated receiving antenna in the form of a single radio frequency side band, and thus simulates incoming speech signals. Take, for instance, the case of artificial speech modulated onto a 56,000 cycle carrier. The upper side band when isolated by itself is a single continuous wave which varies in frequency from 56,600 to 57,400 cycles at a rate of about ten times per second. In practice this is a simple thing to produce. It merely requires a 57,000 cycle signal producing oscillator having a small motor-driven rotating condenser in parallel with its main tuning condenser, so as to cause the oscillator frequency to vary about 400 cycles each way from a mean of 57,000 cycles during each revolution of the rotating condenser, the rate of rotation being about ten times per second. A field strength measuring set may thus be readily adapted to measuring noise.

During the development and study of this method of measuring noise, data were taken at Cliffwood, New Jersey, nearly every hour during working days over a period of several months. An ordinary open antenna was used, the constants of which have been measured only approximately, so that the data are only approximately correct when referred to their absolute scale. For this reason we have not considered it desirable to give any of them in this paper.

The most interesting samples of data we have in the way of noise measurements are those being made in London contemporaneously with the measurement of field strengths received from Rocky Point.

In Figure 26 are plotted the noise measurements at London for the same 52-hour test period as the field strength values given in Figure 6. For making the noise measurements the field strength measuring set was modified along the lines discussed above and as indicated in Figure 4. The abscissas of the curves are hours of the day and the ordinates are the minimum values of single side band artificial speech in micro-volts per meter which could be heard thru the noise.

Since the noise measurement gives the minimum field strength audible thru the noise, satisfactory speech transmission of course requires a field strength many times larger. The factor of increase needed depends upon the quality of speech received, that is, upon the ease with which the speech could be followed if no noise at all were present. The nature of this factor of increase is brought out by the plot or diagram in Figure 27. The abscissas are ratios of received field strength and measured noise for the Rocky Point-London tests of February 11, 12, and

13, 1923, the field strength and noise values of which have been given in Figures 6 and 26. The ordinates are the corresponding percentage of words estimated as satisfactorily received in London during the part of each hourly test period in which speech was transmitted. The speech consisted simply of geographical names such as cities, states, rivers, and the like spoken slowly and distinctly, but quite disconnected and without context.

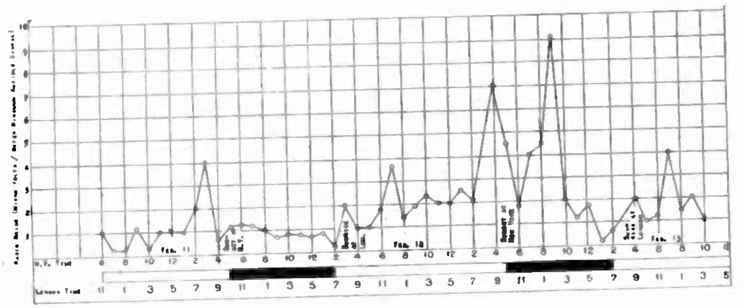


FIGURE 26—Noise Measurements taken in London, England, February 11, 12, 13, 1923. Frequency 57,000 Cycles

It will be seen that a field strength-noise ratio of about 30 marks a fairly definite division line. Above this value, good reception of the speech predominates, while below it the reception rapidly declines. The data shown are too meagre to warrant the drawing of a curve, but the general form which the curve would take may be visualized from the scatter of points shown. A considerable portion of the scattering in this set of data, which was selected at random, is due to the fact that the field strength and noise measurements were not simultaneous, but separated by ten or fifteen minutes. They are shown as simultaneous in Figures 6 and 26 because they are there referred to the beginning time of the hourly test periods, each of which had a duration of about 25 minutes.

It should not be inferred that the value 30 for the factor of increase has any general significance. It represents, for the speech quality being transmitted from Rocky Point during the tests, what might be termed the lower limit of speech reception. For such a grade of transmission as is given on good wire lines the ratio is several times this value. The principle illustrated is, however, of fundamental importance—noise measurements taken by this method, when multiplied by a suitable factor, give directly the field strength which is required to produce a grade of reception corresponding to the factor chosen. There is every reason to believe that the principle applies as well to telegraph reception as to telephone, provided a properly evaluated factor of increase is chosen. The two cases are parallel, since the process of receiving single side band speech transmission is the same as that of receiving continuous wave telegraph signals by the heterodyne method.

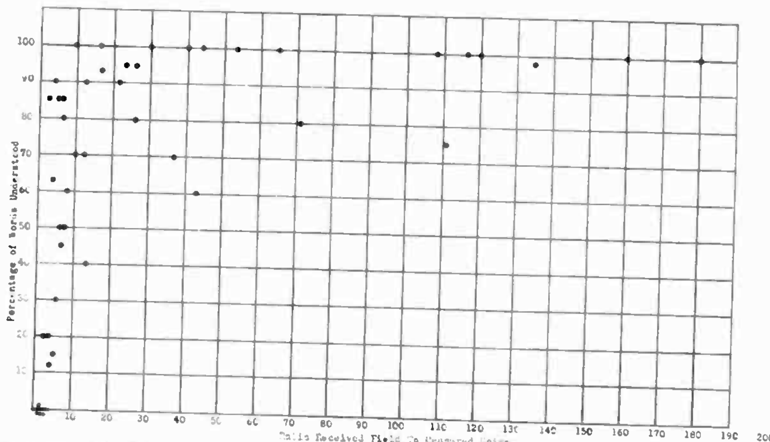


FIGURE 27—Relation Between Speech Reception and Signal to Noise Ratio. Transatlantic Radio Telephone Tests, February 11, 12, 13, 1923

In taking and interpreting the noise data several things have to be respected. To begin with, the receiving set itself must be free of appreciable noise. This can be tested by replacing the antenna with an equivalent impedance such as a dummy antenna having no noise pick-up. The room noises must be small enough so as not to be appreciable to the operator in comparison with the radio noise in the head receivers. The radio noise in the receivers should be adjusted by means of the receiving set amplification, to a comfortable volume which is kept about the same from test to test irrespective of whether the radio noise, in absolute terms, goes thru wide variations. This allows the ear to work under substantially constant conditions. At this point it might be well to distinguish clearly between the practice and philosophy of this method of measuring noise and that of the method of measuring "signal audibility" by the shunted telephone receiver, which has now outlived its usefulness. In the latter method no noise measurement is involved. The signal and radio noise are reduced together to the point where they are lost in the room noise or, if the room be quiet, to the limit of sensitiveness of the operator's ears. In the former method, noise only is measured (tho in terms of signal). The noise is kept substantially constant at a comfortable volume thruout the measurement, so that the ear is under a normal condition. The artificial speech is independently reduced until the noise all but blots it out. Room noise and the absolute sensitiveness of the operators' ears are not direct factors. The physiological and psychological aspects of the two schemes are indeed as different as are their purposes.

For the benefit of those who may wish to try this method of measuring radio noise we would, in the interest of uniformity in interpretation of results, suggest the following specifications for the artificial speech used. As listened to in the telephone receiver, the tone should traverse back and forth from 600 cycles to 1,400 cycles at a rate of ten complete round trips per second. At the radio frequency input the amplitude should be substantially constant over the band of frequencies traversed. The frequency variation should not be a sine function of time but more nearly linear, the resulting audio frequency increasing uniformly from 600 cycles to 1,400 cycles, abruptly reversing and going uniformly back to 600 cycles where it abruptly starts up again. This, combined with the constant amplitude, spreads the energy evenly over the frequency range covered. A small semi-circular-plate rotating condenser, in parallel with the tuning condenser of the local signal-producing oscillator, can be adjusted to meet these requirements properly.

Taking readings when the radio noise is the steady drum-fire type of static is relatively easy. When it is a steady background with occasional heavy crashes, the crashes must, perforce, be neglected and the background measured. When the crashes are loud and frequent enough to be of real importance, they have the effect of partially deadening the ear so that they produce somewhat the same effect on the hearing of the artificial speech in between times as they would have on the understanding of speech. Making the setting is more difficult, however, and the method is no doubt least accurate in measuring this type of noise.

SUMMARY: The paper divides naturally into three sections. The first section briefly analyses the radio transmission circuit into (a) the sending or radiating portion, (b) the transmitting portion consisting of the ether path thru which the radiated waves travel, and (c) the receiving portion. The relation of these from the standpoint of the radio transmission engineer is discussed, pointing out the need of quantitative data as to electric field

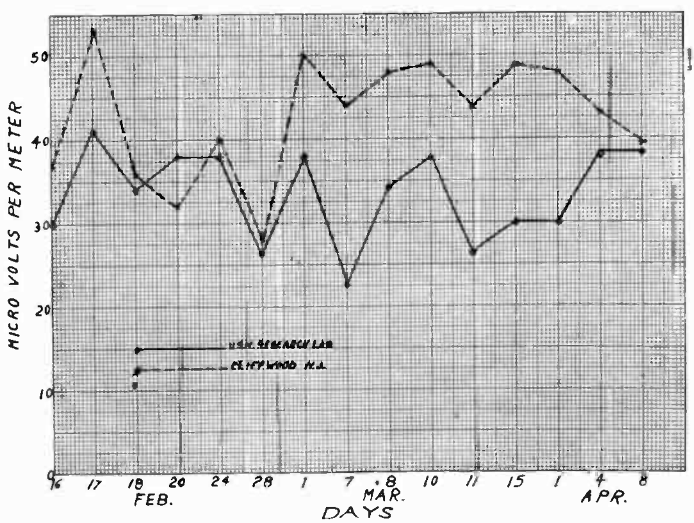
strengths of waves and of radio noise conditions to allow of rational design of radio systems. The second section is devoted to descriptions of apparatus which has been developed for measuring electric field strengths of radio waves, its theory and method of use. Illustrative data are given showing useful practical results already obtained at both short and long wave lengths. The third section deals with the measurement of radio noise. A useful method is described and is illustrated by examples of data from recent transatlantic telephone tests.

Discussion on
"NOTE ON THE MEASUREMENT OF RADIO SIGNALS"*

By

C. R. Englund

L. W. Austin (by letter†): The observations taken by Mr. Englund on Nauen have given an opportunity for comparing his radio frequency comparison method of measuring signals with the method used at the United States Naval Radio Research Laboratory, in which a telephone comparator is employed. In this



comparator, the telephones are thrown from the receiving circuit into a circuit supplied with known audio frequency current supplied by a General Radio tuning fork generator and potentiometer which is adjusted to give the same loudness of sound in the telephones as the signal.

The Table and curves give the observations taken on the corresponding days by the two methods. The average of Mr.

* Proceedings of The Institute of Radio Engineers, February, 1923, volume 2, number 1, page 26.

† Received by the Editor, February 10, 1923

Englund's observations is about twenty-four percent. higher than the Washington observations. About half of this difference is to be explained by the difference in distance of the transmitting station from the two receiving points, which brings the agreement within the probable accuracy of the methods.

The two curves are remarkably alike in form except for the observations on February 20, and those on April 4 and 8. On the last two dates the Cliffwood observations were taken about two hours later than those in Washington.

SOME IMPROVEMENTS IN THE POULSEN ARC*†

Part II

By

P. O. Pedersen

(Professor in the Royal Technical College, Copenhagen, Denmark)

The Efficiency of the Arc

The efficiency of the arc depends upon the shape of the arc voltage curve. For the sake of simplicity, we shall only consider those cases where the choke coils are of such a value that the supply current, I_o, may be considered constant. The total energy supplied to the arc and the oscillating circuit during each period is then determined by

$$W_o = \int_t^{t+\tau} I_o e_1 \, d\, t, \tag{1}$$

where e_1 is the arc-voltage and τ the period.

We will further confine our consideration to the case in which the arc-voltage is equal to E_b for any value of the arc current greater than $I°$, where $I°$ is very small compared with I_0 (see Figure 1 A and B). Most of the supply current will—under these circumstances—whether the arc voltage has one or two peaks—pass thru the arc while the arc voltage has the value E_b; the energy consumed in the arc is, therefore, approximately given by

$$W_a = I_o E_b \tau \tag{2}$$

The amount of energy, P, delivered to the oscillating circuit in each period is consequently determined by

$$P = W_o - W_a = \int_t^{t+\tau} I_o (e_1 - E_b) d\, t = I_o U, \tag{3}$$

*Received by the Editor, November 28, 1922.

†(a) "On the Poulsen Arc and Its Theory," Proceedings of The Institute of Radio Engineers, volume 5, pages 255-316, 1917.

(b) "Supplementary Note," volume 7, pages 293-297, 1919.

(c) "Some Improvements in the Poulsen Arc, Part 1," volume 9, pages 434-441, 1921.

These papers are referred to above as (a), (b), and (c). For list of symbols see reference (a), pages 315, 316. (In the list of symbols and in the first part of paper (a), E_b is by mistake called E_c.)

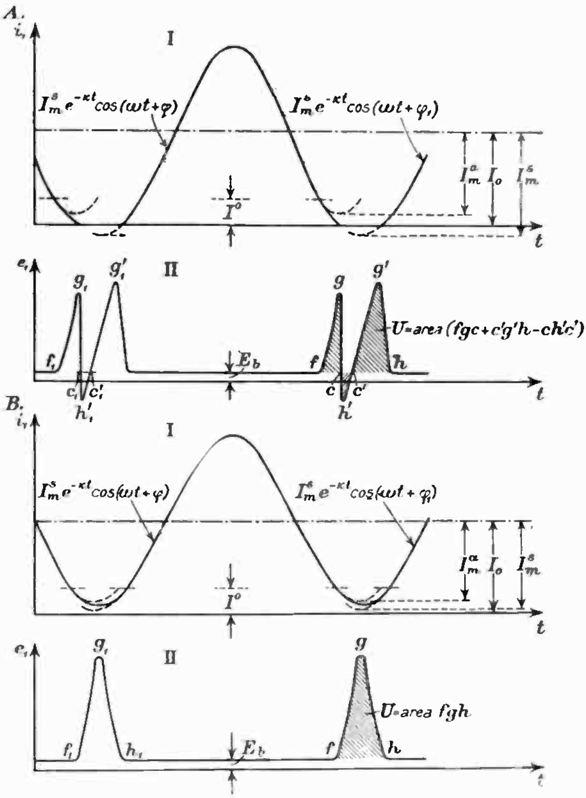


FIGURE 1—Arc Current i_1 and Arc Voltages e_1. A for double-peak operation. B for single-peak operation

where U is the area of the voltage peaks shown in Figure 1 A or B.

The efficiency, η, is therefore, determined by

$$\eta = \frac{P}{W_o} = \frac{U}{E_b \tau + U} = \frac{1}{1 + \frac{E_b \tau}{U}} \tag{4}$$

The efficiency will, for large arcs, often be about 50 per cent. L. F. Fuller[1] states that 50 per cent. is a theoretical limit for the efficiency, which limit normally is reached, but which cannot be passed. This is a mistake. There is no such theoretical limit. It will not violate any physical principle to have arc generators with 90 per cent efficiency, for instance. As shown above in equation (4) the efficiency for a given period depends solely on

[1] L. F. Fuller, PROCEEDINGS OF THE INSTITUTE OF RADIO ENGINEERS, volume 7, page 461, 1919.

the ratio of the voltage E_b of the arc when burning to the peak area U, and there is absolutely no theoretical lower limit to this ratio.

As the idea about the 50 per cent limit is rather generally entertained it may be worth while to calculate the efficiency in some simple cases.

For the sake of simplicity we take the form of arc voltage curve (e_1) shown in Figure 2, where the peaks are of a rectangular

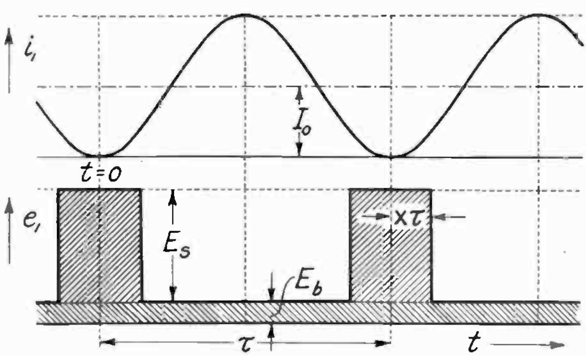


FIGURE 2—Diagrammatic Representation of Arc Current i_1 and Arc Voltage e_1

shape and where the arc current (i_1) is taken as a pure sine curve

$$i_1 = I_o \left(1 - \cos 2\pi \frac{t}{\tau}\right)$$

With the symbols used in the figure we have—(comparing equations (1)—(4)):

$$W_o = \int_o^\tau I_o e_1 \, d\,t = \tau I_o \,(2\,x\,E_s + E_b), \qquad (1')$$

$$W_a = \int_o^\tau i_1 \cdot e_1 \, d\,t = \tau I_o \left[(2\,x - \frac{1}{\pi} \sin 2\,\pi\,x)\; E_s + E_b \right] \qquad (2')$$

and

$$P = W_o - W_a = \tau I_o \frac{\sin 2\,\pi\,x}{\pi} E_s \qquad (3')$$

Accordingly, the efficiency is determined by

$$\eta = \frac{P}{W_o} = \frac{\sin 2\,\pi\,x \cdot E_s}{\pi\,(2x\,E_s + E_b)} = \frac{\sin 2\,\pi\,x}{2\,\pi\,x + \pi\,\beta}, \qquad (4')$$

where

$$\beta = \frac{E_b}{E_s}.$$

This efficiency is a maximum for the value of x_o determined by

$$\tan 2\pi x_o = 2\pi x_o + \pi\beta, \tag{5}$$

and the corresponding value of η is

$$\eta_{max} = \frac{1}{\sqrt{1 + (2\pi x_o + \pi\beta)^2}} \tag{5'}$$

Corresponding values of η_{max} and x_o are shown in Figure 3 as functions of β. It appears from this figure, that $\eta_{max} = 1$ for $\beta = 0$ and is above 50 per cent for values of β smaller than 0.2.

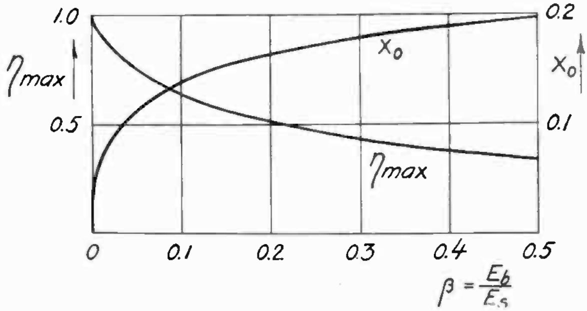


FIGURE 3—Diagrammatic Representation of Maximum Efficiency as depending upon the Ratio of the "Burning Voltage" E_b to the "Ignition Voltage" E_s

NON-HOMOGENEOUS MAGNETIC FIELD

In consequence of the preceding considerations, as shown in Figures 1 and 3, the best efficiency of the arc is obtained when the voltage E_b across the arc in the central portion of the period is kept as low as possible while the area of the peaks themselves should be as large as possible. This conclusion, combined with the knowledge of the working manner of the arc obtained thru the investigations described in the papers referred to above, may lead to new ideas in the design of arc-generators which may considerably increase the efficiency. We shall, in the following, consider one such suggestion.

In all investigations referred to above, the arc always burned in a fairly homogeneous and symmetrical field so that the arc was exposed to the same field intensity along its entire path. If there was any variation, then the strongest field would be located where the arc is struck. The consequence of this is that the arc is accelerated quite rapidly immediately after it has been struck. The arc therefore only remains a very short time in the innermost position. This is a disadvantage insofar as the arc is shortest and would burn at the lowest possible voltage in this position. It is therefore desirable that this first part of the cycle be prolonged as much as possible. The arc voltage will then be very low during a considerable part of the period, during which interval a considerable part of the supply current is passing thru it. On the other hand, the arc must acquire the necessary speed toward the end of the period in order to develop the necessary extinction voltage or, in other words, the necessary peak-area.

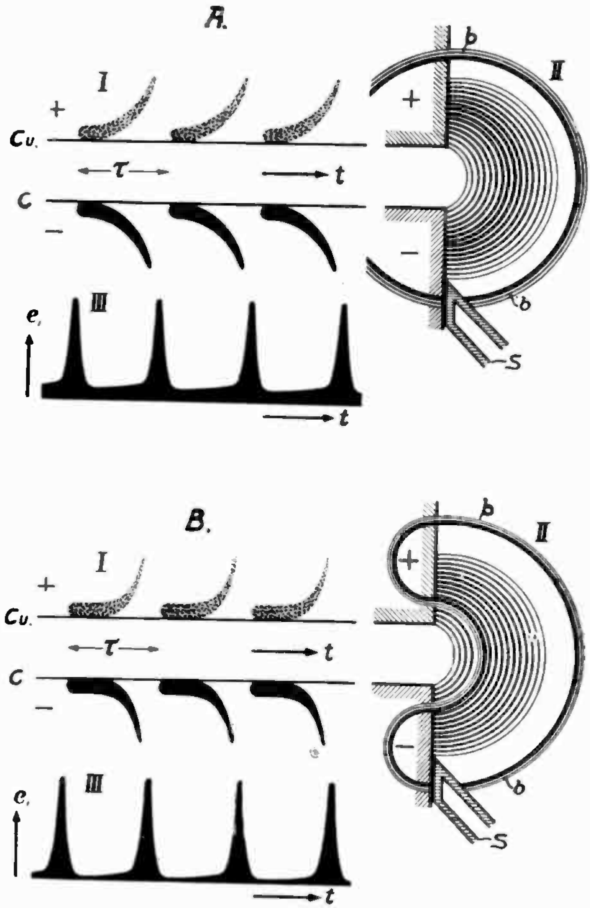


FIGURE 4—Schematic Representation of the Operation of the Arc:—*A* in a Homogeneous, and *B* in an Non-homogeneous Field. (The lines marked *b b* represent the boundary of the strongest part of the field.)

The consequence of these considerations is that the field should not be homogeneous, but weaker near the ignition position of the arc and stronger near the position of extinction. This is shown schematically in Figure 4-B, while Figure 4-A shows a homogeneous field. Under the conditions shown in part *B*, the arc burns a comparatively long time near the starting point so that the arc voltage in a comparatively long time—as follows from what is set forth above—will be very low, and will not, until the end of the period, rise to the extinction value or develop the necessary peak-area (see part *B* III). The result is a low value of the burning voltage, and consequently also a low value of the supply voltage V_o, and therefore a high efficiency.

Even with ordinary circular pole pieces, this effect may be shown by placing the arc in the outskirts of the field, either as shown in Figure 5-A with the pole piece *P* over the cathode, in which case the cathode end of the arc is ignited in a comparatively weak magnetic field and extinguished in a comparatively strong field, or, as in Figure 5-B, with the pole piece over the anode,

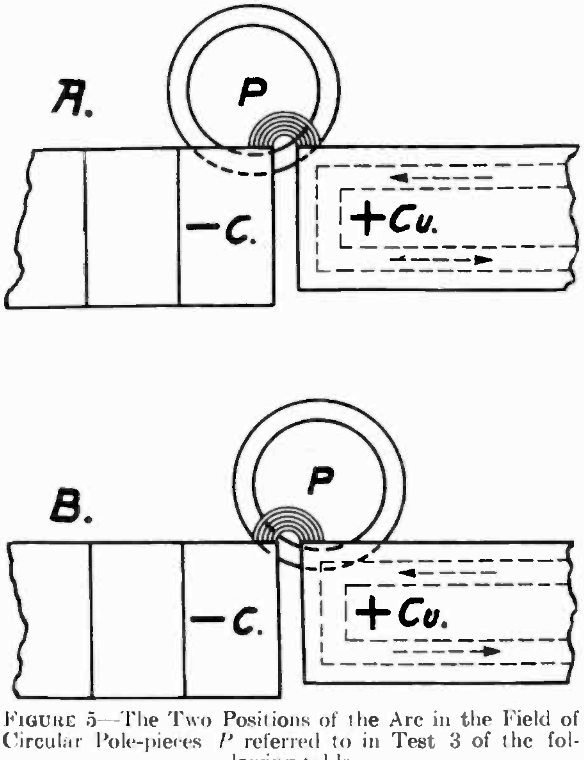


FIGURE 5—The Two Positions of the Arc in the Field of Circular Pole-pieces *P* referred to in Test 3 of the following table

in which latter case it is the anode end of the arc which is ignited in the weaker and extinguished in the stronger field.

TABLE

WAVE LENGTH = 9,800 m. V_0 = ARC VOLTAGE

I_o = SUPPLY CURRENT I = RADIO FREQUENCY CURRENT = $\sqrt{\frac{1}{2}}\, I_o$

I_m = CURRENT THRU MAGNETIC COILS

Test	V_o	I_o	I_m	$H_{Gausses}$	Cooling Shoe[2]	Form of Field
1	280	56	0.5	790*	With Shoe	Non-homogeneous
	320	49	1.8	1,990	Without Shoe	Homogeneous
	296	58	0.5	790*	With Shoe	Non-homogeneous
2	284	56	0.5	790*	With Shoe	Non-homogeneous
	382	56	1.0	1,720	Without Shoe	Homogeneous
	284	56	0.5	790*	With Shoe	Non-homogeneous
3	270	56	0.75	970*	With Shoe	Non-homogeneous†
	270	56	0.5	870*	With Shoe	Non-homogeneous††
	360	56	1.85	1,700**	Without Shoe	Homogeneous

* Mean value of a field over the area covered by the arc.
** Shape of pole pieces different from that used in tests 1 and 2.
† Taken with arrangement B, Figure 5.
†† Taken with arrangement A, Figure 5.

The results of some tests made with the arrangements shown in Figure 5-A and B are recorded in the table. In order to eliminate any uncertainty with regard to the radio frequency losses, the value of the radio frequency current was in all measurements —except in test 1—adjusted to 40 amperes. (The ratio between I_o and I is always constant and equal to 0.71). With this method the efficiency in the various tests is simply inversely proportional to the applied voltages V_o. (Compare, for instance, paper (a), equation (2), page 263.)

In order to get the greatest possible efficiency, the position of the arc in the non-homogeneous field has to be rather exactly adjusted.

It appears that in both the cases presented in Figure 5, the efficiency can be increased from η to $1.25\,\eta$, η being the maximum efficiency obtainable in a homogeneous field. The maximum increase of η thru a practical application of the idea set forth in Figure 4-B has not yet been ascertained on large

[2] See paper (c).

arcs, but must at all events be higher than the one stated above.[3]

In conclusion, I wish to acknowledge my indebtedness to Mr. J. P. Christensen for the excellent help he has given me in this work.

Royal Technical College, Copenhagen.

October, 1922.

SUMMARY: The possibility of increasing the efficiency of the Poulsen arc by burning it in a non-homogenous magnetic field is mathematically investigated, and experimentally verified.

[3] The correct distribution of the field intensity is of great importance in other ways, for instance, with regard to the regulation of the wear on the cathode carbon. In very large generators, this wear is often greatest at a certain distance from the edge of the carbon, and less at the edge itself. The reason for this is that the arc is not burning long enough at the edge, and when burning at that position is carrying too small a current. By making the field intensity smaller at the starting position of the arc, this irregularity may be eliminated. By suitable distribution of the field intensity any desired shape of the carbon tip may, no doubt, be obtained.

All these considerations make it desirable to have those parts of the pole pieces which cause the non-homogeneities in the field adjustable in such a way that the field distribution may be altered from outside the arc chamber.

DISTORTION-FREE TELEPHONE RECEIVERS*

By

J. F. J. Bethenod

(Paris, France)

For many purposes, and in particular for radio telephonic reception, it is advantageous to obtain a distortion-free reproduction of speech and various sounds.

As is well known, the sensitiveness of telephone apparatus varies appreciably with the frequency of the current, that is, with the pitch of the sound being reproduced. The theory of this phenomenon has been set forth in the previous papers of Rayleigh, Kennelly, and others, and is based upon resonance between the impressed current frequency and the natural frequency of the diafram.

The object of the following article is to show how it is theoretically possible to realize a receiving system having a uniform sensitiveness over any range of frequencies required.

When a current i circulates thru the magnetizing coil, the centre of the diafram is displaced by an amount x which is determined by the equation:

$$A\,i = S\,x + R\frac{dx}{dt} + M\frac{d^2x}{dt^2}, \qquad (1)$$

in which A is the magnetic pull on the centre of the diafram for unit current, S, R, and M the stiffness, mechanical resistance, and equivalent mass of the diafram, respectively.[1]

In order to solve this equation, it is first necessary to obtain a second relation between i and x. Two cases are to be distinguished, depending on the manner in which is constituted the electric circuit comprising the magnetizing coil of the receiver.

1. The Electromotive Force Impressed on the Electric Circuit Has a Definite Value e

One may then write

$$e = Z\,i + A\frac{dx}{dt}, \qquad (2)$$

*Received by the Editor, January 17, 1923.

[1] See the above-mentioned works.

in which Z is the impedance operator of the circuit. We will now ascertain the conditions which must be fulfilled in order to obtain a constant proportionality between x and e for a telephonic current of any frequency whatever. If we design the operation $\frac{d}{dt}$ by the symbol p, and introduce the abbreviation

$$P = S + p\,R + p^2 M \tag{3}$$

we obtain, from (1) and (2)

$$e = \frac{Z\,P\,x}{A} + p\,A\,x.$$

In order to solve the actual problem, the condition

$$x = \frac{e}{\lambda}, \tag{5}$$

must be satisfied, λ being a constant, positive or negative, which is quite independent of the current frequency. We thus obtain the relation

$$Z = \frac{\lambda A - p A^2}{P}. \tag{6}$$

Also, it must be remembered that the use of triodes, as proposed by Mr. Marius Latour in his French patent, number 501,472, of December, 1918, gives us the possibility of realizing artificial negative impedance, that is, not only negative resistances, but also negative inductances or capacities out of positive ones. Mr. L. B. Turner has since developed a negative resistance device by means of triode arrangements (Kallirotron). By means of these devices, it is therefore theoretically possible to neutralize the impedance z of the receiver winding (with diafram damped) and this for any current frequency. (Figure 1).

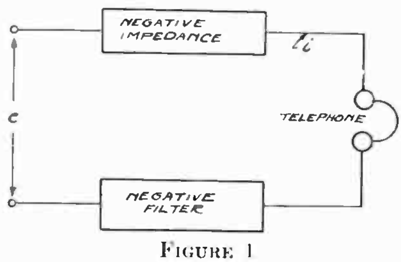


FIGURE 1

Furthermore, if we connect an inductance coil and a capacity in parallel, there results a joint impedance which is expressed by the well-known equation

$$Z' = \frac{r + p\,l}{1 + p\,r\,c + p^2 l\,c}, \tag{7}$$

in which l and r denote the inductance and ohmic resistance of the coil respectively, c, the capacity of the condenser (assumed without losses).

Now, if we make use of the device referred to above in order to reverse the sign of Z', that is, to constitute a "negative filter" which is inserted in the circuit, we obtain

$$Z = -g\,\frac{r + p\,l}{1 + p\,r\,c + p^2 l\,c}, \tag{8}$$

the numerical factor g being positive.

A comparison of (6) and (8) gives the conditional relations

$$-\frac{\lambda A}{g\,r} = \frac{A^2 p}{g\,l\,p} = \frac{S}{1} = \frac{M\,p^2}{l\,c\,p^2} = \frac{R\,p}{r\,c\,p}, \tag{9}$$

from which it follows that

$$l = \frac{A^2}{g\,S}, \quad c = \frac{g\,M}{A^2}, \quad r = \frac{R\,A^2}{g\,M\,S}, \quad \lambda = -\frac{RA}{M}. \tag{10}$$

This method determines the quantities l, c, r, and λ.

Moreover, the equation (5) becomes

$$x = -\frac{M}{RA}e, \tag{11}$$

and the problem is theoretically solved.

2. The Telephonic Current Has a Definite Value I

From (1) we get, for a magnetizing current equal to i

$$x = \frac{Ai}{P}, \tag{12}$$

and the ratio $\frac{i}{I}$ will be chosen so that the new condition

$$x = \frac{I}{\mu}, \tag{13}$$

is fulfilled, μ being a constant, positive or negative, which is independent of the current frequency.

In order to arrive at this result, it is sufficient to shunt the receiver winding by means of a "negative resonator," utilizing the triode device previously referred to. (Figure 2.) The negative sign is thereby obtained and we may then put down

$$z\,i = -h\left(r + l\,p + \frac{1}{c\,p}\right)(I - i), \tag{14}$$

wherein h is a positive numerical factor.

The condition to be fulfilled thus becomes

$$\frac{Px}{A} = \frac{h\left(r+lp+\frac{1}{cp}\right)}{z-h\left(r+lp+\frac{1}{cp}\right)},$$

or

$$\frac{P}{A} = -\frac{\mu h\left(r+lp+\frac{1}{cp}\right)}{z-h\left(r+lp+\frac{1}{cp}\right)}. \qquad (15)$$

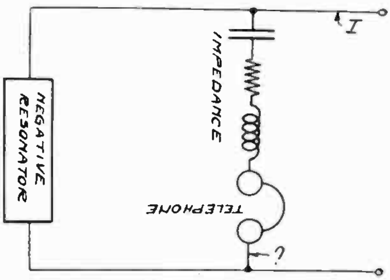


FIGURE 2

Furthermore, when connecting a positive resonator in series with the telephone winding (see Figure 2), we can always reduce the artificial impedance $z-h\left(r+lp+\frac{1}{cp}\right)$ to a pure capacitance $\frac{1}{kp}$. Consequently, the conditional equality (15) becomes

$$\frac{P}{A} = -\frac{\mu h k (1+prc+p^2 lc)}{c},$$

or $$c(S+pR+p^2M) = -\mu h A k (1+prc+p^2lc),$$

whence follow

$$lc = \frac{M}{S}, \quad \frac{r}{c} = \frac{R}{M}, \quad \mu = -\frac{c}{k} \times \frac{S}{hA}, \text{ and so on.} \qquad (16)$$

Therefore, for any case, the natural frequency and the time constant of the diafram will be equal to the natural frequency and the time constant of the filter or resonator.

The above statements show sufficiently how it is theoretically possible to realize a telephone receiver the sensitiveness of which is independent of the impressed current frequency.

It is interesting to remark that, by means of the same arrangements, we may solve the theoretical problem of the distortion-free oscillographic or radio telegraphic recording apparatus.

SUMMARY: The possibilities of a distortion-free telephone receiver are discussed. By means of triode devices, it is theoretically possible to realize such apparatus having uniform sensitiveness over any range of frequency required. The same devices may be applied to oscillographic or radiotelegraphic apparatus.

DIGESTS OF UNITED STATES PATENTS RELATING TO RADIO TELEGRAPHY AND TELEPHONY*

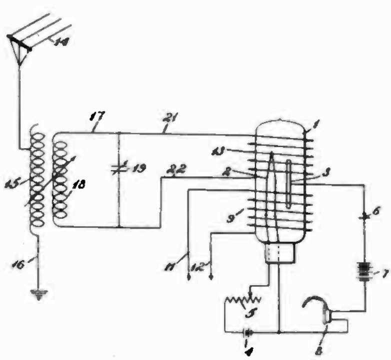
ISSUED DECEMBER 26, 1922—FEBRUARY 20, 1923

BY

JOHN B. BRADY

(PATENT LAWYER, OURAY BUILDING, WASHINGTON, D.C.)

1,440,432—C. T. Allcutt, filed June 25, 1921, issued January 2, 1923. Assigned to Westinghouse Electric and Manufacturing Company.

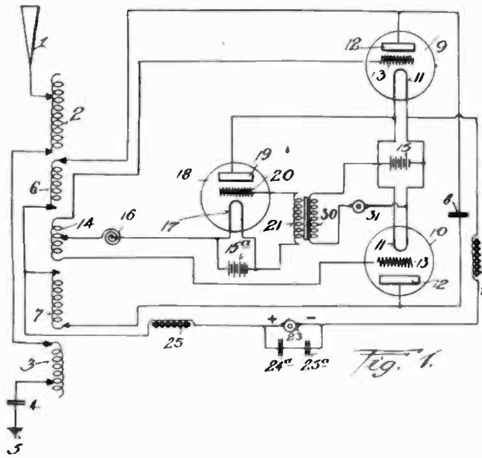


NUMBER 1,440,432—Radio Receiving System

RADIO RECEIVING SYSTEM, employing a two-electrode tube and a circuit arrangement for securing an interacting varying magnetic field produced by the interaction of the incoming signaling frequency and that of a local generator. The resultant magnetic field is transverse to the space current flow of the tube which is thereby controlled in accordance with the magnetic beat frequency to operate a telephone receiver.

1,440,834—C. V. Logwood, filed July 2, 1921, issued January 2, 1923. Assigned to De Forest Radio Telephone and Telegraph Company.

* Received by the Editor, March 7, 1923.



NUMBER 1,440,834—Electron Tube Transmitter

ELECTRON TUBE TRANSMITTER circuit having a plurality of electron tubes with their plate circuits connected with an antenna system. An additional tube is connected between the grid circuits of these tubes serving as an effective resistance in the first mentioned tube circuits. This effective resistance is varied in accordance with signals to control the output of the first mentioned tubes into the antenna system.

1,441,087—J. W. Hill, filed April 6, 1921, issued January 2, 1923.

WIRING SYSTEM, for improving sharpness in tuning in an electron tube transmitter. The tubes are all connected with equidistant leads from points in the circuits leading to similar elements of the tube whereby balancing of circuits is accurately obtained.

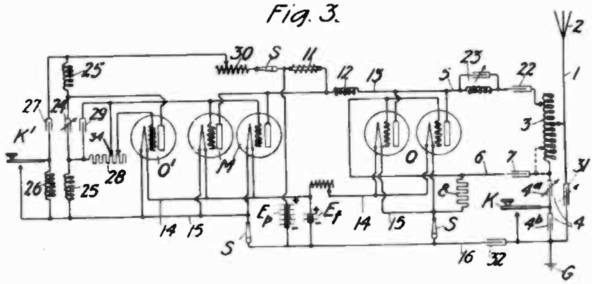
1,441,988—E. P. Lindner, filed December 18, 1920, issued January 9, 1923.

CRYSTAL DETECTOR construction wherein the crystal is supported in a cup mounted to rock about an axis to present the surface of the crystal to the rectifier contact point. A yieldable member is provided in the cup for maintaining the crystal in place.

1,442,146—R. A. Heising, filed April 13, 1918, issued January 16, 1923. Assigned to Western Electric Company, Incorporated.

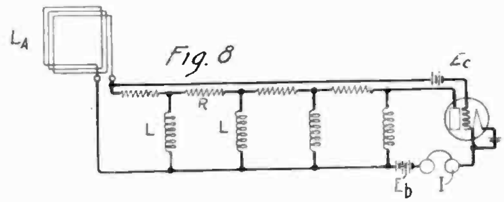
MODULATING AND TRANSMITTING SYSTEM, employing electron tubes in circuit with which a low frequency filter is located to prevent the radiation of low frequency hum with the modulated waves.

Fig. 3.



NUMBER 1,442,146—Modulating and Transmitting System

1,442,781—H. W. Nichols, filed July 7, 1921, issued January 16, 1923. Assigned to Western Electric Company, Incorporated.



NUMBER 1,442,781—Reamplifying System

REAMPLIFYING SYSTEM, in which an electron tube amplifier is provided with a feed-back connecting its output and input circuits, comprising a network having substantially capacitative reactance only. This arrangement selectivity amplifies energy of a particular frequency or range of frequencies without amplifying disturbing energy or other waves of considerably different frequency.

1,443,011—H. J. J. M. De R. De Bellescize, filed November 3, 1922, issued January 23, 1923.

ATMOSPHERIC DISTURBANCE REDUCING MEANS for a radio receiver comprising a resonant circuit with an amplifier connected to the circuit and a current limiting relay connected to the output amplifier with the detector and telephones connected to the output of the current limiting relay. The resonant circuit and the output of the current limiting relay are interconnected.

whereby an electromotive force derived from the current limiting relay is impressed upon the resonant circuit opposing the flow of currents having a frequency equal to the natural frequency of the resonant circuit.

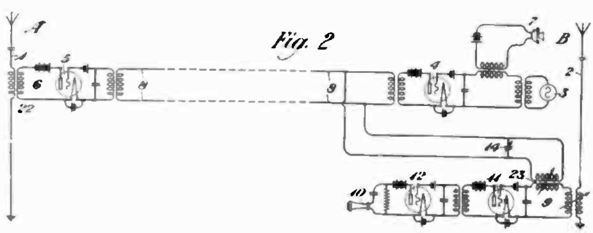
1,443,209—B. Bradbury, filed September 15, 1920, issued January 23, 1923. Assigned to General Electric Company, Incorporated.

Radio Receiving System, sharply tuned to eliminate the effects in the receiver of stations transmitting on closely adjacent wave lengths to the wave length desired to be received. A frequency trap is used in the telephone circuit. There are two portions to the frequency trap circuit, one of which is resonant to the signals of the frequency to be received and the other resonant to the frequency of interfering signals which it is desired to suppress.

1,443,361—J. H. Hammond, Jr., filed July 27, 1917, issued January 30, 1923.

System for the Transmission of Radiant Energy for secret communication. A set of rotatable commutators is provided at the transmitter in the keying circuit for impressing upon a source of oscillations periodic amplitude variations of relatively different frequencies with means for rendering either of said frequencies effective upon the oscillations. The receiver is provided with means for selectively receiving the modified signals.

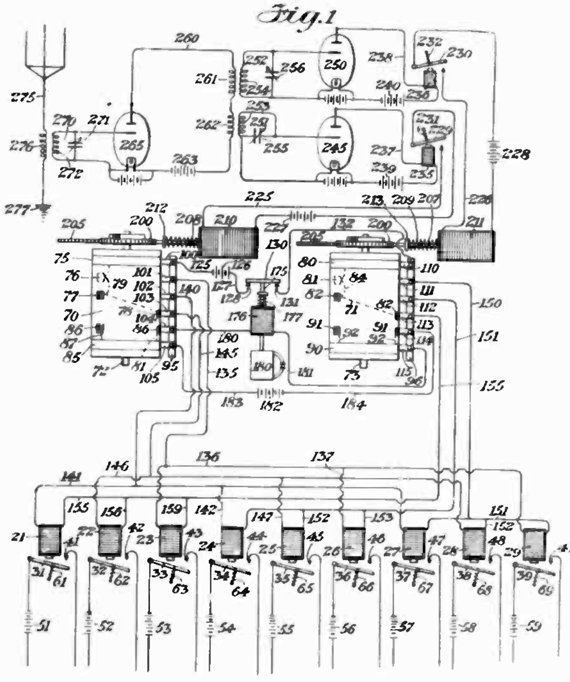
1,443,985—L. Espenschied, filed June 21, 1919, issued February 6, 1923. Assigned to American Telephone and Telegraph Company, Incorporated.



Number 1,443,985—Signaling System

Signaling System for duplex operation, having a circuit for eliminating "side tone" at the receiver. The system employs carrier waves of different frequency for transmission and reception by providing separate antennas for transmitting and receiving, the said antennas being located a considerable distance from each other, and by neutralizing the inductive action of the transmitting system proper on the receiving system by means of balancing circuits. A conductive transmission line extends from the transmitting apparatus to the receiving apparatus, and a circuit is connected between this line and the transmitting and receiving apparatus for nullifying the effect on said receiving apparatus of the waves from the transmitting apparatus.

1,444,417—J. H. Hammond, Jr., filed October 17, 1917, issued February 6, 1923.



NUMBER 1,444,417—Multiplex System in Teledynamic Control

MULTIPLEX SYSTEM IN TELEDYNAMIC CONTROL for manipulating a plurality of separately operable devices selectively from a distance in response to radiant energy, and in which each of the controlled devices is arranged to be controlled by the conjoint action of a plurality of separately movable commutators or controlling elements which are in turn separately controlled rotatable step by step.

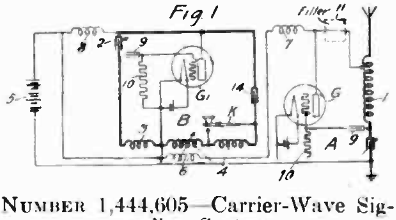
1,444,438—W. C. White, filed August 7, 1918, issued February 6, 1923. Assigned to General Electric Company, Incorporated.

GRID ELECTRODE STRUCTURE for an electron tube of the pliotron type. The difficulty of the grid wire turns becoming loose under conditions of unequal expansion and sliding down on the grid frame is prevented in this invention by a spiral wire coil on each side of the grid frame which space apart the turns of the grid and maintain the wires in spaced relation even under conditions of expansion.

1,444,534—B. Ames and P. J. Gilinson, filed February 15, 1918, issued February 6, 1923. Assigned to B. Ames.

ELECTRICAL CONDENSER, consisting of alternate layers of conducting material being somewhat longer than wide and the alternate layers of the conducting material disposed transversely of each other so as to project laterally on each side. A clamp for securing the condenser as a unit is held together at each corner of the device.

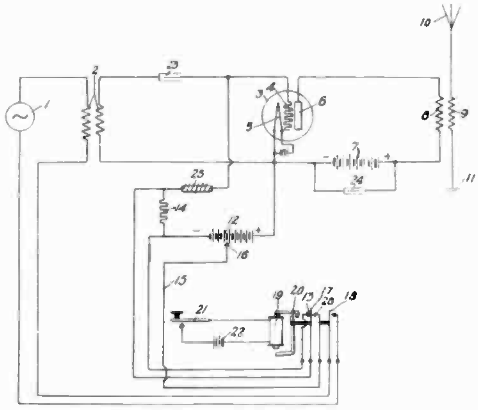
1,444,605—R. A. Heising, filed January 21, 1919, issued February 6, 1923. Assigned to Western Electric Company, Incorporated.



NUMBER 1,444,605—Carrier-Wave Signaling System

CARRIER-WAVE SIGNALING SYSTEM, comprising a high frequency generating system *A* and a low frequency generating system *B*. In system *A* high frequency oscillations are produced in the antenna circuit 1 by the action of the tube *G*. The frequency of the oscillations generated in the antenna is determined primarily by the tuning of the antenna. In system *B*, tube G_1 generates oscillations in a tuned circuit consisting of variable capacity 2 and inductances 3 and 4. Capacity 14 is included in the tuned circuit preventing the short circuiting of battery. A key *K* serves to short circuit a portion of inductance 4 for the purpose of changing the frequency generated in system *B*. By thus changing the frequency, signals may be transmitted. Current for the anode-cathode circuit of both tubes is furnished by the source 5. Coil 6 is variably coupled to coils 3 or 4, or both. Coil 7 constitutes a high impedance for currents of the frequency generated by the system *A*, and coil 8 constitutes a high impedance for currents of the frequency generated by the system *B*. The usual stopping condensers 9 and resistive leak paths 10 are provided. A filter or impedance device 11 of any suitable type, which may be a loop-resonant circuit tuned to the mean frequency of system *B*, prevents oscillations generated by the system *B* from being impressed upon the antenna circuit. During operation, the high frequency oscillations of the system *A* are modulated in accordance with the oscillations of the system *B*. This is caused by the intercoupling of coils 4 and 6, whereby a voltage corresponding to the low frequency oscillations is impressed upon the space between the anode and cathode of the tube *G*.

Re. 15,538—E. H. Colpitts, filed September 11, 1915, reissued February 13, 1923. Assigned to Western Electric Company, Incorporated.



Re. 15,538—Control Device for Radio Signaling

Control Device for Radio Signaling for modulating the output of an electron tube. The voltage of the battery in the input or grid circuit is made of such value that the space current, that is, the current in the output circuit, is made very small. Provision is made whereby the voltage applied to the grid or input circuit of the amplifier is changed at the instant of signaling from such a value as causes a minimum energy loss in the output circuit to a value which permits of normal flow of current in the said circuit whereby signal energy is radiated.

1,445,613—H. P. Donle, filed April 6, 1922, issued February 13, 1923. Assigned to The Connecticut Telephone and Electric Company, Incorporated.

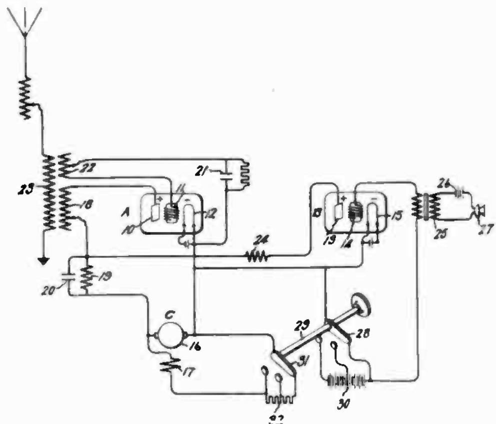
DETECTOR, in which a sensitive crystal is placed in an evacuated tube and a granular contact provided. The tube is evacuated to avoid the possibility of deleterious action upon the sensitive portions of the detector by moisture, dust or fumes and oxidation which tend to reduce sensitivity.

1,445,636—A. Meissner, filed May 3, 1922, issued February 20, 1923.

METHOD OF AND MEANS FOR INDICATING THE FREQUENCY VARIATIONS OF AN ALTERNATING CURRENT, consisting of a circuit arrangement including an antenna and an alternating current generator connected with the antenna, a circuit coupled with the antenna, and an indicator connected in the circuit. A second circuit is also coupled with the antenna and having the current therein differing in phase by 90° from the current in the antenna. A third circuit is provided having the current therein differing in phase by 90° from the current in the second circuit. The second and third circuits are tuned to the desired frequency of the generator and the third circuit is coupled to the first mentioned circuit so as to transmit current thereto at a difference in phase of 180° from the current transmitted to said circuit by the first mentioned coupling. This causes the currents in the indicating circuit to compensate each other when the generator is supplying energy of the desired frequency.

1,445,929—W. R. G. Baker, filed October 7, 1920, issued February 20, 1923. Assigned to General Electric Company, Incorporated.

ELECTRON TUBE TRANSMITTER, including an oscillator and a modulator. When it is desired to change the output of the oscillator to increase the transmission range a circuit is provided wherein a single switch control with a pair of independent arms moving over independent contacts will vary the potential applied both to the plate circuit of the oscillator and to the grid circuit thereof.



NUMBER 1,445,929—Electron Tube Transmitter

1,446,247—L. De Forest, filed March 16, 1921, issued February 20, 1923.

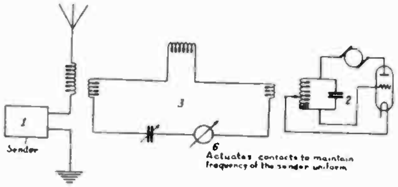
LIGHT CONTROLLING MEANS comprising a tube entitled the "luxion." The tube contains mercury vapor or the like and a thermonic electrode therein with an anode spaced at some distance therefrom and connected in an external modulation circuit by which the relative intensity of the light extending between the electrodes may be varied. The device finds application in photography wherein light intensity may be controlled by voice frequencies and projected upon a film.

1,446,425—A. Leib, filed August 3, 1922, issued February 20, 1923.

WAVE METER WITH CATHODE TUBE, arranged to be coupled with an antenna system in circuit with a receiver. The tube is arranged in a self oscillatory circuit with a buzzer connected in the anode circuit for interrupting the current generated by the wave meter whereby the receiver may be calibrated from known calibrations of the wave meter circuit.

1,446,433—W. Schaffer, filed August 3, 1922, issued February 20, 1923.

CIRCUIT ARRANGEMENT FOR INDICATING THE DEVIATION OF A SENDER FROM A DESIRED FREQUENCY. The theory of this device which indicates when the transmitting wave length shifts from a desired value as follows: If two transmitters operate jointly at the same frequency on an oscillating circuit, a phase displacement of 180° occurs between them. The weaker of the two transmitters is usually forced into or held in a 180° phase displacement by the more powerful transmitter. If the wave individual to the weaker sender is now slightly detuned with respect to the more powerful sender, the frequency of the oscillating wave does not vary, but apparently only the phase displacement of the two trasmitters with respect to each other is changed. Consequently, a measuring instrument provided in a circuit coupled with the two transmitters will register the variation. If, on the other hand, there is a variation in the wave of the more powerful sender, that is, the working sender, then this will have a corresponding effect on the auxiliary sender, the phase displacement being varied at the same time. The resulting variation in the current may then be used as a measure for the changes occurring in the wave, and the change in the output of the circuit may be used for correcting the occurring frequency variation. The present invention utilizes this theory by coupling an indicating device between a transmitting antenna system and a small oscillator and any deviation from the desired transmission wave is known by observing the indicator.



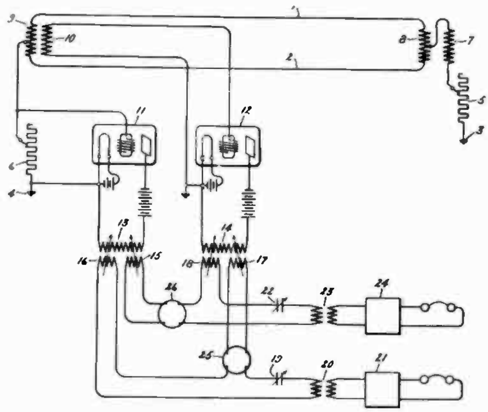
NUMBER 1,446,433—Circuit Arrangement for Indicating the Deviation of a Sender from a Desired Frequency

1,446,434—W. Schaffer and Dr. Fritz Kruschinsky, filed August 18, 1922, issued February 20, 1923.

CIRCUIT ARRANGEMENT FOR USE IN THE TRANSMISSION OF SIGNALS for supplying energy to electron tube circuits from an alternating current source for transmission. The invention relates to a particular combination of transformers, choke coil, and rectifier, connected to energize the tube circuits.

The following digests should be read in connection with those appearing in previous issues of THE PROCEEDINGS.

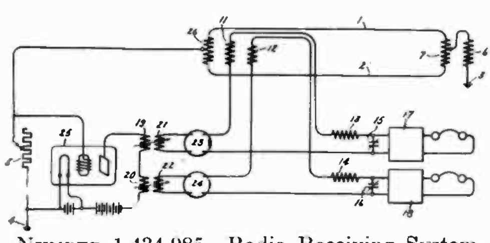
1,434,984—H. H. Beverage, filed May 3, 1921, issued November 7, 1922. Assigned to General Electric Company, Incorporated.



NUMBER 1,434,984—Radio Receiving System

RADIO RECEIVING SYSTEM for use with a Beverage antenna whereby signals may be simultaneously selectively received at the same receiving station from two different directions.

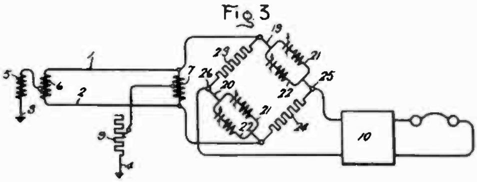
1,434,985—H. H. Beverage, filed May 3, 1921, issued November 7, 1922. Assigned to General Electric Company, Incorporated.



NUMBER 1,434,985—Radio Receiving System

RADIO RECEIVING SYSTEM, employing a Beverage antenna, for reception of a plurality of different wave lengths simultaneously. A plurality of receiving circuits which are resonant to the frequencies of the different signaling waves to be received are provided and the currents produced in the antenna at a selected point impressed upon these circuits. Each receiving circuit selects the particular signaling wave which it is desired to receive in that circuit without interfering with the selection of the desired waves by any of the other receiving circuits. In order to improve the reception, means are also provided for impressing upon each receiving circuit a current selected from another point in the antenna which will be of the proper intensity and phase to neutralize in each receiving circuit disturbing currents produced therein either by interference from undesired waves or by strays.

1,434,986—H. H. Beverage, filed May 25, 1921, issued November 7, 1922.



NUMBER 1,434,986—Radio Receiving System

RADIO RECEIVING SYSTEM, employing a Beverage antenna in which a balanced bridge circuit is provided for preventing interference in the system by waves of a wave length approximately the same as the wave length desired to be received and which are traveling in the same direction as the waves desired to be received.

LIST OF RADIO TRADE MARKS PUBLISHED BY PATENT OFFICE PRIOR TO REGISTRATION

The numbers given are serial numbers of pending applications:

159,955—"RADIOHOME" for radio apparatus. De Forest Radio Telephone and Telegraph Company, New York. Claims use since January 12, 1922. Published January 9, 1923.

168,098—"AUDIOPHONE" for loud speakers. The Bristol Company, Waterbury, Connecticut. Claims use since July, 1922. Published January 9, 1923.

170,131—"WAVOLA" for radio apparatus. The Fairmount Electric and Mfg. Co., Philadelphia, Pennsylvania. Claims use since about August 14, 1922. Published January 9, 1923.

170,478—Representation of head with ears of exaggerated size, for radio receiving apparatus. The Dyer Company, Cambridge, Massachusetts. Claims use since September 1, 1922. Published January 9, 1923.

170,969—"THE EAR OF THE WORLD"—design of world with ear in center of globe and receiving set in foreground—for radio apparatus. Chicago Radio Laboratory, Chicago, Illinois. Claims use since about February, 1922. Published January 9, 1923.

166,405—"Resco Radio" for radio receiving apparatus. The Radio Engineering and Sales Company, doing business as The Resco Radio Company, Cleveland, Ohio. Claims use since May 1, 1922. Published January 16, 1923.

168,000—"Go Skylarking with the Skylark" for radio receiving apparatus. The Perry, Desjardins and Temple Company, Cincinnati, Ohio, assigned to The Skylark Radio Company, Cincinnati, Ohio. Claims use since June 23, 1922. Published January 23, 1923.

169,572—"Areco" for radio sets and parts thereof. American Radio and Electric Company, New York, N. Y. Claims use since February 2, 1922. Published January 23, 1923.

171,109—"Tuska Radio" in ornamental arrangement, for radio apparatus. The C. D. Tuska Company, Hartford, Connecticut. Claims use since July 24, 1922. Published January 23, 1923.

168,093—"Radion" dials made of hard rubber for radio apparatus. American Hard Rubber Company, Hempstead and New York, N. Y. Claims use since April 14, 1922. Published January 23, 1923.

169,184—"Radiogem" for radio tuning coil. Radiogem Corporation, New York, N. Y. Claims use since August 21, 1922. Published January 30, 1923.

169,824—"RCA" in ornamental arrangement for radio receiving and transmitting apparatus. Radio Corporation of America, New York, N. Y. Claims use since August 15, 1922. Published January 30, 1923.

170,476—"Crosley" for radio receiving apparatus. The American Automobile Accessories Company, doing business as Crosley Mfg. Company, Cincinnati, Ohio. Claims use since July 15, 1922. Published January 30, 1923.

170,529—"Radio Rose" for radio receiving apparatus. Jackson and Finkenaur, New York, N. Y. Claims use since September 27, 1922. Published January 30, 1923.

170,894—"PHANTOM" for radio receiving sets. Oard Radio Laboratories, doing business as Atlantic-Pacific Radio Supplies Company, Stockton, California. Claims use since May 15, 1922. Published January 30, 1923.

171,110—"UDELL" in ornamental design, for radio cabinets. The Udell Works, Indianapolis, Indiana. Claims use since 1890. January 30, 1923.

167,999—"SKYLARK" for radio receiving apparatus. The Perry, Desjardines and Temple Company, Cincinnati, Ohio. Assigned to The Skylark Radio Co., Cincinnati, Ohio. Claims use since June 23, 1922. Published February 6, 1923.

169,208—"SENSORY" in ornamental design, for radio receiving apparatus. Heinemann Electric Company, Philadelphia, Pennsylvania. Published February 6, 1923.

169,855—"BESTONE" dials for tuning apparatus. Henry Hyman and Company, Incorporated, New York, N. Y. Claims use since April, 1922. Published February 6, 1923.

165,699—Mark represents an ear cap for a telephone receiver with the diafram colored in red and showing thru the cap. For head telephone receivers. Metropolitan Radio Corporation, Newark, New Jersey. Claims use since June 1, 1922. Published February 13, 1923.

169,134—Letter "M" upon a seal with ornamental lightning flash behind the seal. For radio and electrical apparatus. Manhattan Electrical Supply Company, Incorporated, New York, N. Y. Claims use since April 10, 1922. Published February 13, 1923.

171,797—"SIMPLE RADIO-PHONE" assembled with design of antenna ground system, for radio receiving apparatus. A. W. Hanington and Sons, New York, N. Y. Claims use since June 15, 1922. Published February 13, 1923.

165,533—"DIXIE" for radio receiving sets. Edwards and Company, Incorporated, New York, N. Y. Claims use since May 9, 1922. Published February 20, 1923.

165,968—"RADO" in ornamental design, for radio apparatus. The Ra-Do Corporation, Bay City, Michigan. Claims use since May 9, 1922. Published February 20, 1923.

169,869—"RASCO" for radio apparatus. Radio Specialty Company, New York, N. Y. Claims use since April, 1921. Published February 20, 1923.

169,909—"R. P. C." for radio receiving apparatus. Chas. M. Kemper, doing business as Radio Products Company, Westport, Connecticut. Claims use since September 8, 1922. Published February 20, 1923.

171,543—"CLAROPHONE" for loud speakers. Master Radio Corporation, Los Angeles, California. Claims use since August 10, 1922. Published February 20, 1923.

171,670—"MASTER" in shield design, for radio receiving and transmitting apparatus. Union Construction Company, San Francisco, California. Claims use since May 15, 1922. Published February 20, 1923.

171,671—"MASTROLA" in ornamental design, for radio receiving sets. Union Construction Company, San Francisco, California. Claims use since May 15, 1922. Published February 20, 1923.

172,137—"VICT-RA-PHONE" for radio receiving apparatus. Victor Radio Corporation, New York, N. Y. Claims use since May 1, 1922. Published February 20, 1923.

172,424—"DUOTROL" for rheostats. Malone-Lemmon Laboratories, New York, N. Y. Claims use since about May, 1922. Published February 20, 1923.


Brandes