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CONTENTS

FEATURES

DEPARTMENTS

COVER ILLUSTRATION

THE LAYOUT IN THE UNITED STATES COAST GUARD STINSON RADIO TEST PLANE. AT CENTER, TOP, IS THE CATHODE-RAY VISUAL INDICATING SCREEN (SEE ARTICLE ON PAGE 17). THE MAGNETIC COMPASS, ARTIFICIAL HORIZON, AND THE DIRECTIONAL GYRO FORM A VERTICAL LINE DIRECTLY BENEATH THE VISUAL INDICATING SCREEN.

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EDITORIAL

BROADCAST ALLOCATION HEARING

NOTICE HAS BEEN GIVEN of an informal hearing beginning October 5 before the Broadcast Division of the Federal Communications Commission in their offices at Washington, D. C. The purpose of this hearing is to determine what principles should guide the Commission in making allocations of frequencies and the prevention of interference in the 550-1600 kc band.

Briefly, the Broadcast Division will consider proposals and evidence for and against the following:

I. *Classification of Broadcast Stations.*

1. Desirability of establishing new classes, or abolishing any existing class.
2. Proper definition of each class with respect to purpose and character.
3. Frequencies to be allocated each class.
4. Suitability of various frequencies in the 550-1600 kc range.
5. Extent to which freedom from interference is to be secured and extent to which duplicated use, night or day, is to be permitted, including: number of stations to be permitted to operate simultaneously on frequencies of each class; mileage-frequency separation tables as a method for determining permissible duplications; advisability of establishing subclassifications of any of the principal classes; use of frequencies allocated to one class by stations of another class; possibility of duplicated use of a frequency by two 50-kw stations separated by a substantial distance; consideration of hour of sunset as the dividing line between daytime and nighttime permissible duplications, and location at which sunset or other hour should be taken as such dividing line; application of directional antennas, and synchronization.
6. Maximum and minimum power requirements with respect to each class, including: increases in power above 50 kw on any class of frequency; horizontal increases in power on frequencies on which nighttime duplicated operation is permitted; and differentiation in maximum power at day and at night.

II. *Standards to be applied in determining coverage and the presence or absence of objectionable interference.*

1. Propagation characteristics of the various frequencies, including comparison of east-west and north-south transmission, effect of intervening mountain ranges, and seasonal variations.
2. Attenuation in various parts of country.
3. Ratio of desired to undesired signal.
4. Signal intensity necessary to render satisfactory service in various types of communities (urban, residential, rural).
5. Relative electrical noise levels in various types of communities.
6. Frequency separation, including: the prescribed 10-kc separation between frequencies; the customary 50-kc separation between frequencies used by broadcast stations in the same community; mileage-frequency separation tables as a method for determining minimum geographical separation between stations using frequencies separated by from 10 to 40 kc; permissible disparity in power between stations on adjacent frequencies; practicable standards of receiver selectivity, and receiver fidelity.
7. Proper definition of blanketing signal.
8. Legitimate assumptions with respect to Heaviside layer and sunspot cycle.

III. *Geographical distribution of broadcast facilities.*

1. Weight to be given to such factors as area, population and economic support.
2. Desirability of establishing a system for evaluating facilities (a quota system) in order to comply with Sec. 307 (b) of the Communications Act of 1934.
3. Feasibility of allowing adherence to sound engineering principles automatically to effect the distribution required by Sec. 307 (b).

IV. *Standards and methods of measurement.*

1. Power.
2. Tolerance.
3. Field intensity.
4. Determination of service.
5. Determination of interference.

V. *Apparatus performance requirements for broadcast stations.*

1. Frequency stability.
2. Antenna efficiency.
3. Modulation.
4. Suppression of harmonics.
5. Fidelity of transmission.
6. Transmitter location.

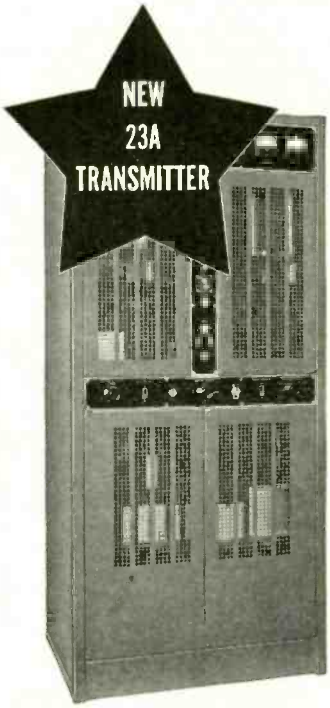
VI. *Effect of any proposals regarding the foregoing subjects.*

1. Socially and economically, upon the public and the industry.
2. Internationally, upon use of the 550-1600 kc band by other countries in North and Central America.
3. Upon possible future use of frequencies in the band 6000-30,000 kc and above 30,000 kc for broadcasting.

It is felt that this hearing will afford both the industry and the Commission the opportunity to cooperate in an open manner toward the logical solution of the many existing broadcast problems.

BRAND NEW EQUIPMENT

Low in first cost . . low in maintenance cost . . high in quality!



This new Western Electric 23A Transmitter gives high fidelity performance—at a minimum of expense. Because of its high overall efficiency and the smaller type of tubes used, the operating cost of this 100-250 Watt equipment is remarkably low. Other outstanding features are: stabilized feedback, grid bias modulation, complete AC operation, all tubes radiation cooled.

The 23A is *completely new*—designed by the Bell Telephone Laboratories to more than meet all the proposed high fidelity requirements of the Federal Communications Commission.

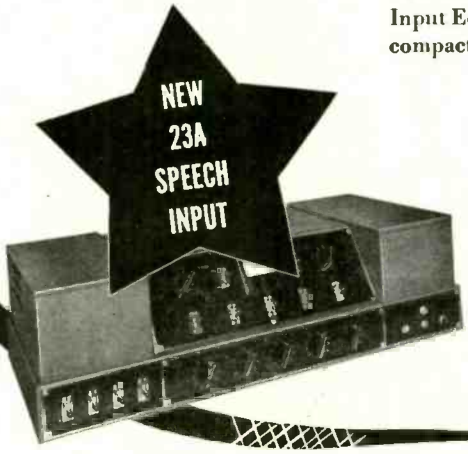
• • •

The new 23A single unit Speech Input Equipment—complete in a compact "organ console" cabinet—gives a rare combination of flexibility, simplicity of operation and high quality performance. It is especially suitable for studio installations and with the new 23A transmitter. It utilizes stabilized feedback.

• • •

For picking up programs *outside* the studio, Western Electric now offers the new 22A Portable Speech Input Equipment. Amplifier and control facilities are contained in a carrying case weighing only *25 lbs. complete.* Separate battery or AC power unit of like size and weight may be used. High fidelity performance is assured through use of stabilized feedback.

For full details, write Graybar Electric, Graybar Building, N.Y.



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Most Complete Transformer Line in the World

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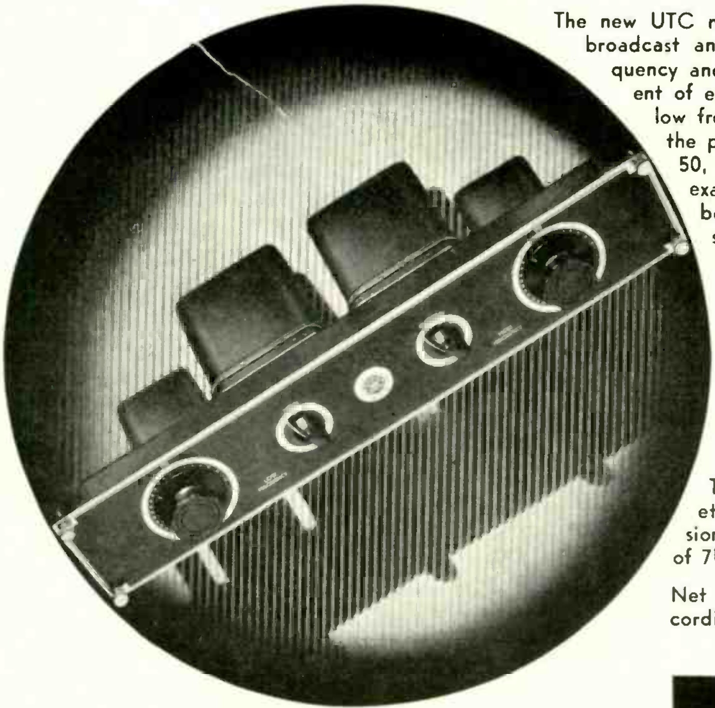
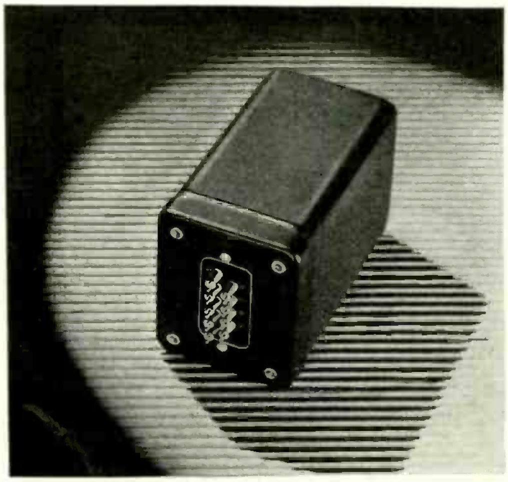


The new UTC model 3A equalizer is the ideal unit for every broadcast and recording purpose. It combines a low frequency and high frequency equalizer which are independent of each other and can be used simultaneously. The low frequency portion incorporates a switch by which the point of maximum equalization can be set as 25, 50, or 100 cycles and a calibrated T pad by which exact adjustment of the amount of equalization can be obtained. The high frequency section can be switched for maximum equalization at 4000, 6000, 8000, or 10000 cycles and a similar calibrated control is provided reading directly in DB. Where rapid changeover is required in service from one line to another, from recording to playback, or from one microphone to another, it is merely necessary to predetermine the required setting. The actual adjustment of the controls can be taken care of almost instantaneously.

This unit is constructed in the depressed chassis, etched panel manner for rack service. The dimensions of the panel are 3½" x 19" with a depth of 7½".

Net price to broadcast stations or recording studios .... **$85.**

The new UTC equalizer bulletin covers every type of equalizer and filter for communication service. Some of the subjects covered are dialogue equalizers, resonant equalizers, scratch filters, recording equalizers, universal equalizers, speaker divider networks, wave filters, harmonic analysis, high Q coils, etc. Limited number of copies will be available. Request yours now.



Two-section low frequency equalizer, model HE-811. Tapped for resonant frequencies (maximum equalization) of 25, 50 and 100 cycles. 25 DB equalization available. Net price to broadcast stations or recording studios **$22.50**

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COMMUNICATION & BROADCAST ENGINEERING

FOR AUGUST, 1936

THE SIMON RADIOGUIDE

By HENRY W. ROBERTS

THE SIMON RADIOGUIDE is a new instrument for radio navigation, which automatically indicates true direction of the transmitting station, its bearing in degrees off bow or off beam, approximate ratio of distance traveled toward or away from the station, position, and drift.

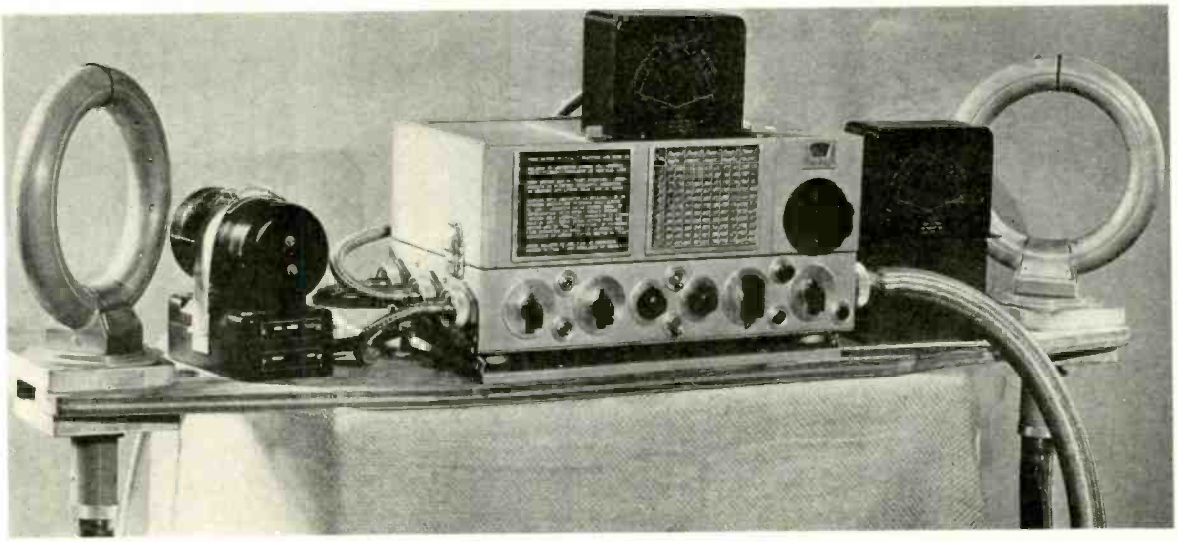
The capabilities of this instrument are made possible by the use of a unique principle of radio direction finding, developed by Emil J. Simon.

Physically, the Radioguide consists of two small electrostatically-shielded loops fixed mounted within the airplane, a special twin-channel superheterodyne receiver, and a course-indicating instrument. The weight of the entire apparatus, including connecting cables and dynamotor, is only forty pounds.

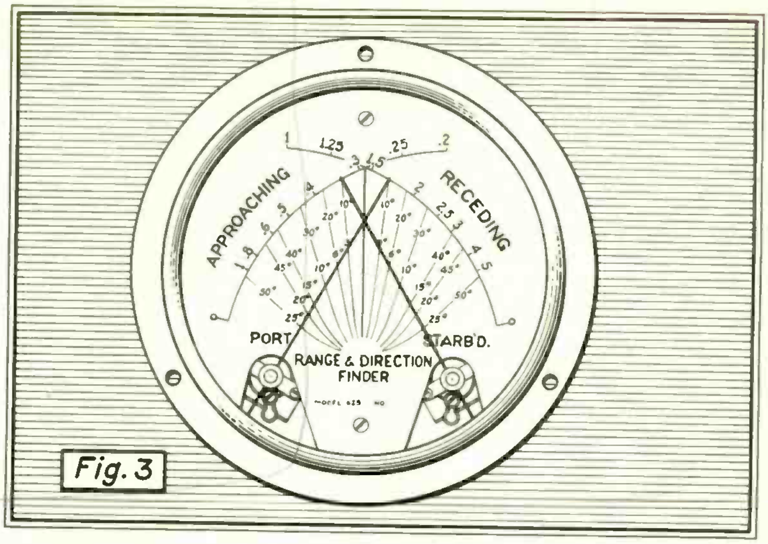
The loops are arranged in a "no-coupling" position, at an angle of 60 degrees to each other and to the transverse axis of the airplane. They are usually mounted completely within the airplane—in the fuselage or in one of the wings. In all-metal airplanes, the loops are carried in a small streamlined nacelle mounted above or below the fuselage.

The receiver is available with either direct or remote control. In large airplanes, where a radio operator is carried, the former model is used, and when necessary, a duplicate course-indicating instrument is provided for the radio-

COMPLETE RADIOGUIDE INSTALLATION, SHOWING THE TWIN LOOPS, THE TWIN-CHANNEL RECEIVER, DYNAMOTOR, AND COURSE-INDICATING INSTRUMENT.



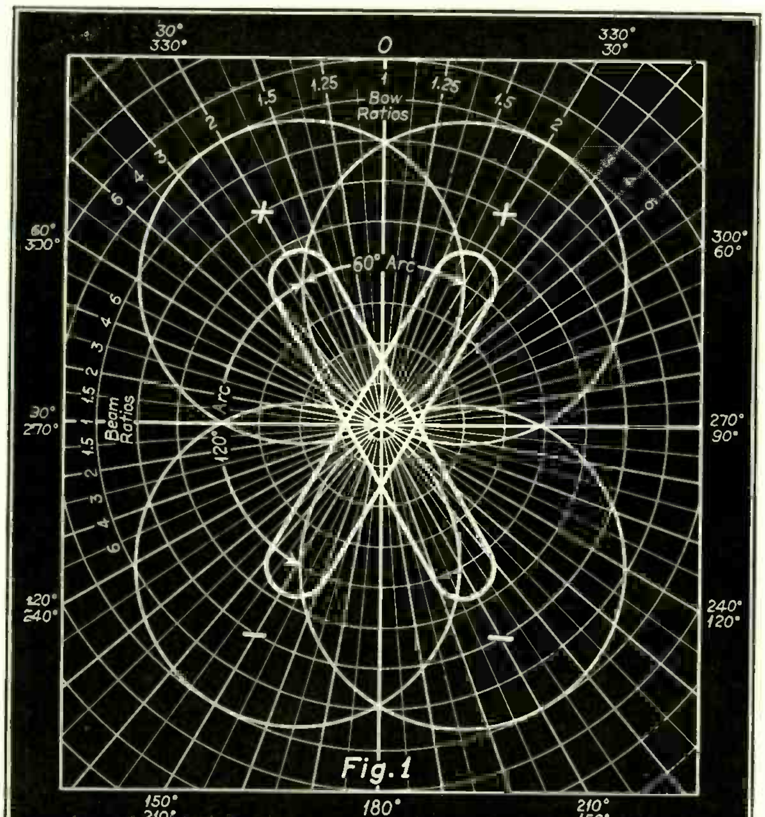
man, in addition to the one on the instrument board in front of the pilot. In airplanes where the pilot also acts as the radio operator, the remote-control model is usually more convenient: the receiver is then mounted out of the way, and the controls are compactly grouped in front of the pilot on the instrument board.



COURSE-INDICATING INSTRUMENT. BEARINGS OFF BOW ARE INDICATED ON 0°-50° SCALE; OFF BEAM ON 0°-25° SCALE. APPROACHING, RECEDING SCALES ARE FACTORS OF INITIAL DISTANCE FOR SAME VOLUME SETTING.

The principle of operation of the Radioguide is very simple. As is well known, a vertical loop is most responsive to signals emanating from points lying within its plane, and least responsive to those at right angles to it. Between these two positions, the responsiveness of the loop varies as the cosine of the angle between the plane of the loop and the source of signal. With the two loops fixed mounted as described, the responsiveness of both loops remains equal as long as the airplane is headed directly toward or away from the station. If the airplane veers away from this heading, there is an increase in responsiveness in one of the loops, and a corresponding decrease in the other loop. The *ratio* of responsiveness of the two loops remains constant for any given bearing, irrespective of the signal strength or distance from the station. This permits calibrating the instrument dial in degrees—an important feature unobtainable with a single-loop arangement. The receptivity pattern of the twin-loop arrangement is shown in Fig. 1.

POLAR DIAGRAM OF THE COMBINED LOOP PATTERN OF THE TWIN LOOPS.

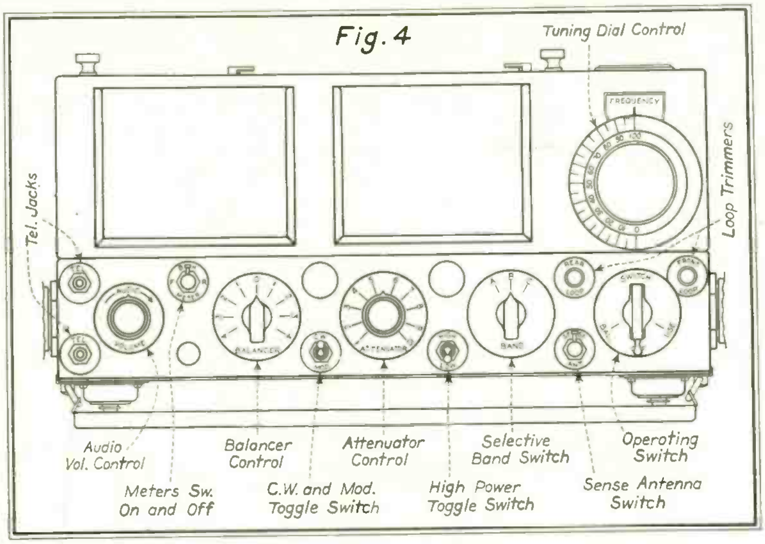


Mounting the two loops in restricted quarters without mutual electrical interference is made possible by the discovery that a "no-coupling" position between the loops will be obtained when the center of one of the two loops coincides with a certain generated curve symmetrical about the line bisecting the angle between the loops (see Fig 2).

The twin-channel superheterodyne receiver employs a common oscillator. For the purpose of balancing the gain of the two channels, means are provided for temporarily dividing the combined voltage induced in the two loops and applying it equally to the two amplifying channels. Thus it is possible to equalize the gain in the two channels and attenuate it to any desired volume. In this manner, any inherent or incidental differences in the gain of the two channels may be detected and corrected at any time. After the gain in the two channels has been balanced, the voltage divider is cut out of the circuit, and each channel then amplifies the signal induced in its corresponding loop.

The ratio of the output of the two channels is measured by the course-indicating instrument (Fig. 3), which consists of two crossed pointers moving over a common scale. Each pointer is deflected in proportion to the signal strength in its corresponding loop and channel, and their intersection shows the bearing of the transmitting station, read in degrees directly from the scale.

When the set is switched on, the operating switch is automatically in the



THE CONTROL ARRANGEMENT OF THE SIMON RADIOGUIDE. IN REMOTELY-CONTROLLED RECEIVERS, ALL CONTROLS ARE MOUNTED ON A SMALL PANEL LOCATED ON THE AIRPLANE'S INSTRUMENT BOARD.

"balancing" position (see Fig. 4). The desired station is then tuned in, the gain in the two channels equalized by means of a single differential balancer, and the volume adjusted to the desired level. The operating switch is then turned to "use" position, cutting the voltage divider out of the circuit. Each pointer is now deflected in proportion to the signal strength in its corresponding loop and channel, and the apparatus functions directionally.

Perusal of Fig. 1 will show that the responsiveness of the two loops is equal when the station lies directly ahead, or directly behind, or directly on either beam. This quadrantal ambiguity is quickly resolved as follows: if the station is in the fore-and-aft direction, there is no appreciable change in the elevation of the pointers when the operating switch is brought to the "use" position. If the station is abeam, there is a pronounced drop of the pointers. The fore-and-aft ambiguity is resolved by momentarily turning the sense switch: the pointers rise if the station is ahead, and fall if it is behind.

The distance indication is obtained by observing the movement of the pointer tips against the outer scale, which is calibrated to show factorially the rate of approach or recession. At the beginning of the trip, the pointers are set at the zero mark on the appropriate distance scale: "approaching" or "receding." When flying toward the station, the gradual rise in signal intensity causes the pointers to rise in proportion to the distance traveled. The rate of recession is similarly indicated on the "receding" scale.

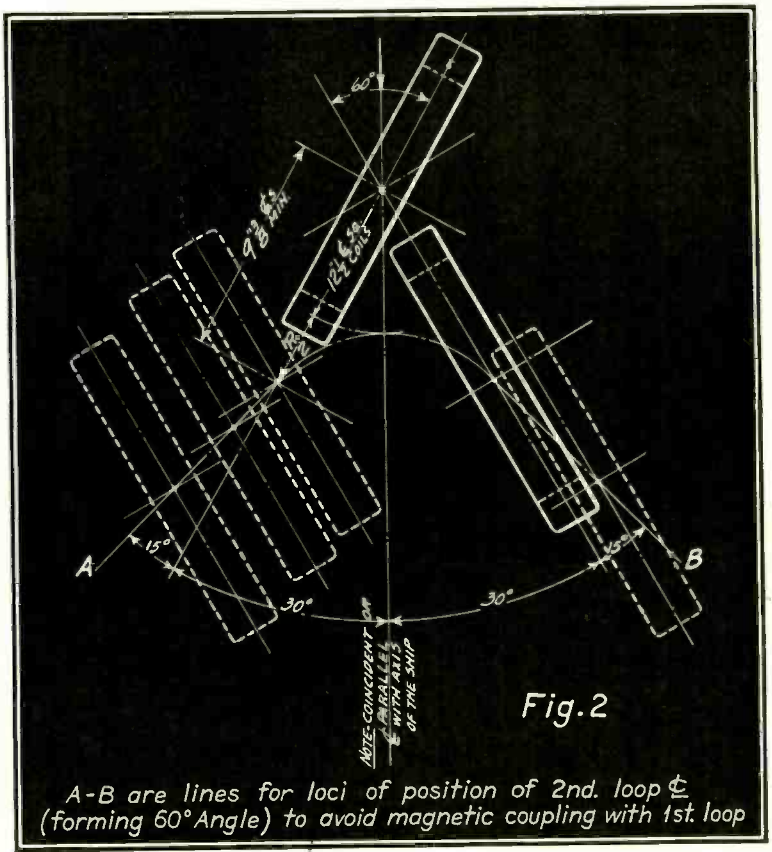
With the direction and distance of the transmitting station shown on the dial, the position of the airplane is always known. The position of the airplane may be further checked and a definite "fix" obtained without changing the course, by tuning in on two or more stations and plotting their bearings on a map. The operation takes but a few seconds, and can be accomplished by the pilot without relinquishing controls.

Drift indication is constantly available by observing any divergence between the Radioguide course and the directional gyro. By steering a course off the direct heading, where no divergence occurs, the pilot is able to fly a direct Great Circle route towards or away from the station, at the correct drift angle and irrespective of visibility or wind conditions. Any change in wind direction or velocity is instantly shown, and the necessary correction can be made promptly. The amount of drift, if needed, can be easily computed.

In addition to providing complete navigational information, the Radioguide also embodies many valuable features, the most important of which is its freedom from night error. Inasmuch as the Radioguide employs two loops operating at 60 percent to 85 percent of their maximum receptivity, the volt-

(*Continued on page* 20)

DETERMINATION OF "NO-COUPLING" POSITIONS FOR CLOSELY MOUNTED LOOPS.



REDIFFUSION IN GREAT BRITAIN

PART II

By PAUL ADORJAN
Technical Director
Rediffusion, Limited, London, England

THE GENERAL PRINCIPLES and the conditions under which Rediffusion is being operated in Great Britain were described in the September, 1935, issue of COMMUNICATION AND BROADCAST ENGINEERING. In the present article it is intended to deal with certain technical details in connection with power-amplifier design for Rediffusion services.

All power amplifiers used are of the Class AB push-pull type and general design principles have been dealt with by the author in an article entitled "Power-Amplifier Design" published in June, 1936, issue of *Radio Engineering*.

EFFECT OF VARYING LOAD

The design of power amplifiers for Rediffusion purposes, however, has its special problem inasmuch as the load is not a constant but a varying one. The first difficulty that is encountered is the variation of voltage gain due to variation of load. This variation may be as much as 6 db from no load to full load, but this is taken care of by a central control operator, who with the aid of the necessary monitoring and control gear can regulate the level of the outgoing programs at each station. Methods are also being developed for keeping amplifier gains constant automatically.

At first it may be thought that the varying load would introduce considerable distortion owing to "mismatching." This is not the case, and if the amplifier is designed for a definite percentage of harmonic distortion when working into the lowest load resistance (corresponding to the maximum output), then with any lighter load there will be the same or less harmonic distortion.

Various methods, that have been suggested from time to time, for keeping the amplifier load constant, do not give any advantages and are uneconomical, as it is necessary to run all equipments under all load conditions if such methods are employed; whereas at present a smaller number of amplifiers can be used under light load conditions than on heavy load conditions and this results in considerable saving in current and tube cost.

The maximum rms output voltage each amplifier must deliver under normal service conditions has been fixed at 45 volts where amplifiers operate directly into service feeders. If the output of the amplifier that can be obtained with 5 percent total voltage harmonic distortion is W and the optimum plate-to-plate load impedance of the amplifier is R_{pp}, then the maximum load (that is, the minimum value of load resistance that can be connected to the

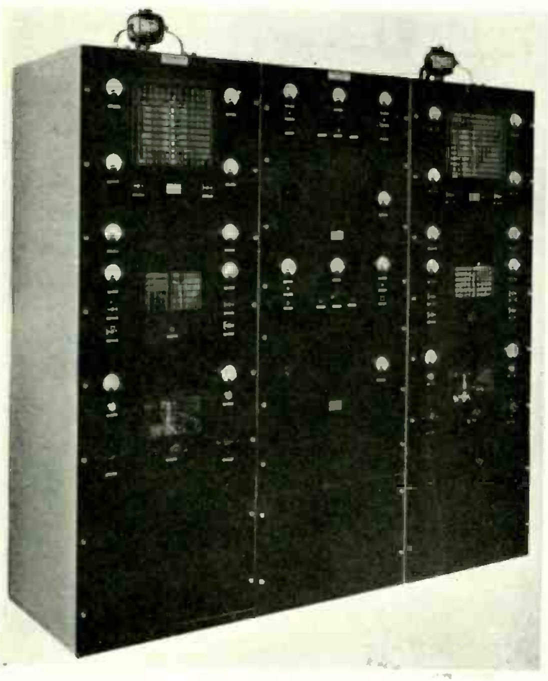


FIG. 3. (LEFT) THE NEW TYPE OF REDIFFUSION EQUIPMENT. TWO OUTSIDE BAYS CONTAIN 300-WATT POWER AMPLIFIERS, WHILE CENTER BAY CONTAINS TWO LINE AMPLIFIERS.

FIG. 4. (BELOW) THE SMALLER TYPE OF REDIFFUSION AMPLIFYING EQUIPMENT.

amplifier output terminals without excessive distortion) is

$$r = \frac{45^2}{W}$$

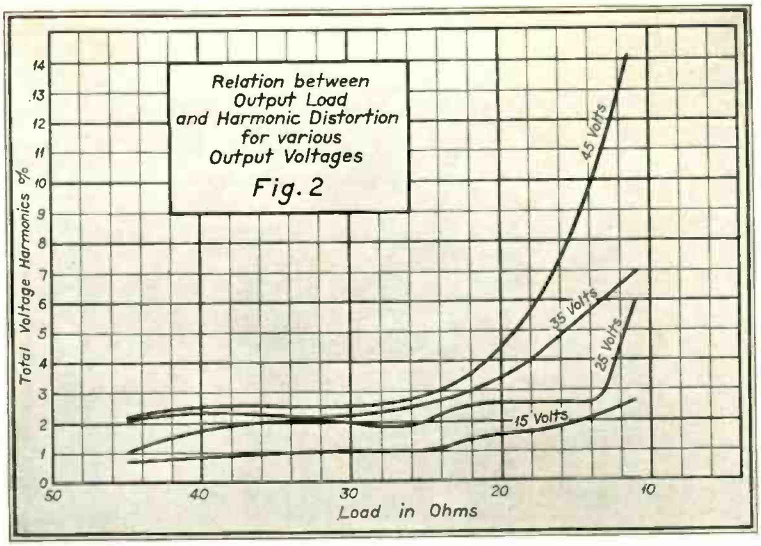
If the amplifier is required to operate into a special high-voltage distributing line, as described in the first article, the load r that the amplifier can take will be given by substituting the required transmission voltage in place of the 45-volt level mentioned above. Transformer turns ratio, of course, will be given by

$$T = \left(\frac{R_{pp}}{r} \right)^{1/2}$$

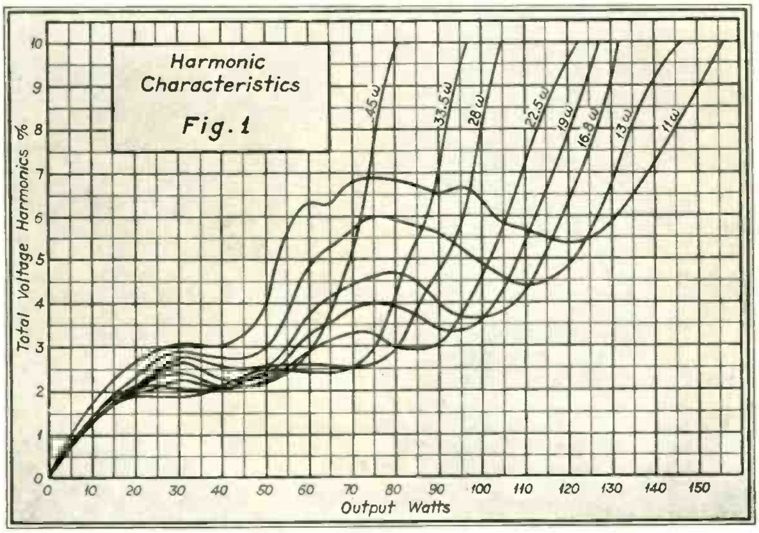
Fig. 1 shows curves for an amplifier that is rated at 100 watts output. The total voltage harmonic percentages are plotted against output watts for various output loads varying from 11 to 45 ohms at the output terminals of the equipment.

The nominal output load of the particular amplifier is taken as 19 ohms and if the curve corresponding to 19 ohms is considered it will be seen that the total voltage harmonic distortion does not exceed 5 percent at any point up to 109 watts. The 17-ohm load could have been adopted as the optimum load and would have given another four watts but on account of the hump in the harmonic curve between 70 and 80 watts, which is particularly noticeable on the lower load resistances (i.e., heavier load conditions), it is not advisable to let this hump reach more than 4 percent. This will give a safety margin to take care of additional distortion introduced by aging of tubes, etc.

Fig. 2 is obtained from Fig. 1 and gives the relation between output load and harmonic distortion for various output voltages up to 45 volts. It can be seen that the maximum harmonic distortion experienced at any output level not exceeding 45 volts falls off with increasing value of load resistance (that is, light load).



Provided that the performance of amplifiers used for a Rediffusion service is similar to the above illustration, no serious distortion will occur at any loads up to the full rated load of the amplifier. When this load is exceeded (the value of the load resistance becomes lower owing to more subscribers switching on) a second amplifier can be switched in parallel. Provided that the second amplifier is identical and the gains are adjusted to equal values, each will take half the load and the condition is equivalent to each amplifier operating into a load resistance equal to twice the value of the actual load resistance. In this manner up to four amplifiers can be used satisfactorily.



As stated in the first part of this article, two programs are supplied. It is obvious that if one program is heavily loaded, the other one must be lightly loaded. It is thus possible to transfer amplifiers from one program to the other according to the load conditions. In unattended sub-stations this can be done automatically from a central control station. An experienced operator can easily judge when additional amplifiers have to be brought into service not only from the audible distortion but from the drop in gain of the amplifier—when the gain falls below a certain level, an additional amplifier or amplifiers are brought into service.

The frequency characteristic of amplifiers is within ± 1.0 db from 50-10,000 cycles, including line amplifiers. A certain amount of departure from these limits is unavoidable owing to the reactive component of the load varying on various lines and under various load conditions.

The older type equipments were built on standard 19-inch relay racks but the later type equipments are built in bays. Fig. 3 shows three such bays, the center bay carrying two line amplifiers and the two outside bays each consisting of a 300-watt power amplifier. These larger types of equipments were originally designed for 300 watts output but are now being modified to give 450 watts undistorted output. The h-t voltage is of the order of 2000 volts and gate switches are included as a safety device against electric shock. Electric ventilating fans can be seen on top of the power-amplifier bays.

Fig. 4 shows a smaller equipment

(Continued on page 29)

Rule 127 The approved power ratings of vacuum tubes for operation in the last radio stage of broadcast transmitters are fixed as set out in the following tables:

TABLE A*

Power Rating of Vacuum Tubes for High-Level Modulation or Plate Modulation in the Last Radio Stage

POWER RATING (Watts)	Amperex	Collins	De Forest	Eitel McCullough	Federal Telegraph	Heintz & Kaufman	Hygrade Sylvania	RCA Mfg. Co.	United Electronics	Western Electric
50	–	–	–	50T	–	–	–			211D 211E 248A 276A
75	203-A 211 852 860	C-203A C-211	503-A 511 552 560	–	F-303-A F-311-A F-352-A		203-A 211 852 860	838 203-A 211 850 852 860	303A 311 938 952 361A	242A 242B 242C 260A 261A 284A 295A
100	HF-200	–	–	–	F-102-A F-108-A	–	–	–		
125	–	C-200 C-201 C-211D	–	150T	–	–	–	803 805	905	
250	204-A HF-300	C-204A C-300	504-A 561 571	–	F-204-A F-212-E F-331-A	354	204-A 212-D 831 861	204-A 831 861	304-A 312-E	212D 212E
350	849	–	549	300T	F-100-A F-349-A		849	849	949	270A
500	–	–	–	–	–	255	–	–	–	251A
750	851	–	551	500T	F-351-A		851	851	951	279A
1000	–	–	–	–	F-346-A	1554	846	846	–	–
2500	–	–	520-B 520-M	–	F-328-A F-3652-A	3054	820-B	1652	–	228A
5000	–	–	507 548 563	–	F-307-A F-320-A F-320-B F-348-A F-363-A		207 848 863	207 848 863 891 892	–	220-B
10,000	–	–	–	–	F-110-A F-110-X F-116-A F-332-A F-332-C F-358-A F-101-B	–	–	858	–	232A 232B
40,000	–	–	–	–	–	–	–	862	–	–

TABLE B*

Power Rating of Vacuum Tubes for Low-Level Modulation or Last Radio Stage Operating as Linear Power Amplifier

POWER RATING (Watts)	Amperex	Collins	De Forest	Eitel McCullough	Federal Telegraph	Heintz & Kaufman	Hygrade Sylvania	RCA Mfg. Co.	United Electronics	Western Electric
25	–	–	–	–	–	–	–	203-A	–	–
50	HF-200	–	–	150-T	–	354	–	803	–	242-B 242-C
75	HF-300	–	504-A	–	F-304-A F-312-A	–	204-A 212-D	204-A	304-A 312-E	212D 212E
125	–	–	549	300-T	F-100-A F-349-A	–	849	849	949	270A
250	–	–	551	500-T	F-351-A	255 1554	851	851	951	251A
500	–	–	–	–	F-346-A	3054	846	846	–	279A
1000	–	–	520-B 520-M	–	F-328-A F-3652-A	–	820-B	1652	–	228A
2500	–	–	507 569	–	F-307-A F-320-A F-320-B F-363-A	–	207 863	207 863 892	–	220B
5000	–	–	–	–	F-358-A	–	–	858	–	–
8500	–	–	–	–	F-101-B F-110-A F-116-A F-110-X F-332-A F-332-C	–	–	–	–	232A 232B
25,000	–	–	–	–	–	–	–	862 898	–	

TABLE C*

Power Rating of Vacuum Tubes for Grid Bias Modulation in the Last Radio Stage

POWER RATING (Watts)	Amperex	Collins	De Forest	Eitel McCullough	Federal Telegraph	Heintz & Kaufman	Hygrade Sylvania	RCA Mfg. Co.	United Electronics	Western Electric
50	–	–	–	–	–	354	–	–	–	212E 270A
100	–	–	–	300T	–	–	–	–	–	–
125	–	–	–	500T	–	255	–	–	–	–
250	–	–	–	–	–	1554	–	–	–	–
500	–	–	–	–	–	3054	–	–	–	–

* These tables apply only to tube ratings for use in the last radio stage of broadcast transmitters and may not be applicable to any other service.

If in an application to the Commission a vacuum tube of a type number and power rating not given in the foregoing tables is specified for operation in the last radio stage, it may be accepted provided there is also submitted to and approved by the Commission the manufacturer's rating of the vacuum tube for the system of modulation or class of service contemplated. These data must be supplied by the manufacturer.

FUNDAMENTALS IN THE APPLICATION OF MATRICES TO ELECTRICAL NETWORKS

Part III

By JOSEPH R. PERNICE

IN THE SUBSEQUENT SECTIONS are presented the proofs and methods of obtaining the resultant matrices of three types of combinations of networks. These are given for the cascade, parallel, and the series connection of networks. For each type of combination is given a simple example of its application. The chart, published in the July, 1936, issue, to which reference should be made, also gives the general expressions for the matrices of these combinations which can be expediently applied in specific problems.

CASCADE CONNECTION OF NETWORKS

When two four-terminal networks are connected in cascade, the general circuit matrix for the combination is given by the product of the individual general circuit matrices of the two networks. Having found the matrix for the combination it is possible to find the impedance and admittance matrices of the combination by equations (17) and (18).

We will now show that

$$\begin{Vmatrix} A_o & B_o \\ C_o & D_o \end{Vmatrix} = \begin{Vmatrix} A & B \\ C & D \end{Vmatrix} \cdot \begin{Vmatrix} A' & B' \\ C' & D' \end{Vmatrix}$$

Referring to Fig. 8 we can write for the first network

$$\begin{Vmatrix} E_1 \\ I_1 \end{Vmatrix} = \begin{Vmatrix} A & B \\ C & D \end{Vmatrix} \cdot \begin{Vmatrix} E_2 \\ -I_2 \end{Vmatrix} = \begin{Vmatrix} (AE_2 - BI_2) & 0 \\ (CE_2 - DI_2) & 0 \end{Vmatrix}$$

For the second network

$$\begin{Vmatrix} E_1' \\ I_1' \end{Vmatrix} = \begin{Vmatrix} A' & B' \\ C' & D' \end{Vmatrix} \cdot \begin{Vmatrix} E_2' \\ -I_2' \end{Vmatrix} \quad \begin{Vmatrix} (A'E_2' - B'I_2') & 0 \\ (C'E_2' - D'I_2') & 0 \end{Vmatrix}$$

Suppose we let

$$\begin{Vmatrix} E_2 \\ -I_2 \end{Vmatrix} = \begin{Vmatrix} E_1' \\ I_1' \end{Vmatrix}$$

so that

$$E_2 = E_1' \text{ and } -I_2 = I_1'$$

Then

$$\begin{Vmatrix} E_2 \\ -I_1 \end{Vmatrix} = \begin{Vmatrix} A' & B' \\ C' & D' \end{Vmatrix} \cdot \begin{Vmatrix} E_2' \\ -I_2' \end{Vmatrix}$$

Since

$$\begin{Vmatrix} E_2 \\ -I_2 \end{Vmatrix} = \begin{Vmatrix} A' & B' \\ C' & D' \end{Vmatrix} \cdot \begin{Vmatrix} E_2' \\ -I_2' \end{Vmatrix}$$

Then by substitution

$$\begin{Vmatrix} E_1 \\ I_1 \end{Vmatrix} = \begin{Vmatrix} A & B \\ C & D \end{Vmatrix} \cdot \begin{Vmatrix} A' & B' \\ C' & D' \end{Vmatrix} \cdot \begin{Vmatrix} E_2' \\ -I_2' \end{Vmatrix} = \begin{Vmatrix} A_o & B_o \\ C_o & D_o \end{Vmatrix} \begin{Vmatrix} E_2' \\ -I_2' \end{Vmatrix}$$

Thus the general circuit matrix for the combination of networks shown in Fig. 8 is given as follows:

$$\begin{Vmatrix} A_o & B_o \\ C_o & D_o \end{Vmatrix} = \begin{Vmatrix} A & B \\ C & D \end{Vmatrix} \cdot \begin{Vmatrix} A' & B' \\ C' & D' \end{Vmatrix}$$

where

$$A_o = AA' + BC' \qquad C_o = CA' + DC'$$
$$B_o = AB' + BD' \qquad D_o = CB' + DD'$$

An interesting example of the cascade connections is shown in Fig. 9. Here we have a four-terminal network connected to an ideal transformer.

The general circuit matrix for the network is given by $\begin{Vmatrix} A & B \\ C & D \end{Vmatrix}$ and the ideal transformer has a turns ratio of 1:N. Thus we could write that

$$\begin{Vmatrix} E_1 \\ I_1 \end{Vmatrix} = \begin{Vmatrix} A & B \\ C & D \end{Vmatrix} \cdot \begin{Vmatrix} A' & B' \\ C' & D' \end{Vmatrix} \cdot \begin{Vmatrix} E_2' \\ -I_2' \end{Vmatrix}$$
$$= \begin{Vmatrix} A & B \\ C & D \end{Vmatrix} \cdot \begin{Vmatrix} 1/N & 0 \\ 0 & N \end{Vmatrix} \cdot \begin{Vmatrix} E_2' \\ -I_2' \end{Vmatrix}$$
$$= \begin{Vmatrix} A/N & NB \\ C/N & ND \end{Vmatrix} \cdot \begin{Vmatrix} E_2' \\ -I_2' \end{Vmatrix} = \begin{Vmatrix} (A/N\ E_2' - NBI_2') & 0 \\ (C/N\ E_2' - NDI_2') & 0 \end{Vmatrix}$$

From this we note that

$$E_1 = A/N\ E_2' - NBI_2'$$
$$I_1 = C/N\ E_2' - NDI_2'$$

and that

$$\begin{Vmatrix} A_o & B_o \\ C_o & D_o \end{Vmatrix} = \begin{Vmatrix} A/N & NB \\ C/N & ND \end{Vmatrix}$$

By relations shown in equations (17) and (18) we can find the admittance and impedance matrices for the cascade connection of Fig. 9 as follows:

$$Y^{o}_{12} = \frac{D_o}{B_o} = \frac{ND}{NB} = \frac{D}{B} = Y_{11}$$

$$Y^{o}_{12} = Y^{o}_{21} = -\frac{1}{B_o} = -\frac{1}{NB} = \left(-\frac{1}{B}\right)\left(\frac{1}{N}\right)$$
$$= Y_{12}\frac{1}{N} = \frac{Y_{12}}{N} = \frac{Y_{21}}{N}$$

$$Y^{o}_{22} = \frac{A_o}{B_o} = \frac{A/N}{NB} = \frac{A}{N^2B} = \left(\frac{A}{B}\right)\frac{1}{N^2} = Y_{22} \cdot \frac{1}{N^2} = \frac{Y_{22}}{N^2}$$

$$Z^{o}_{11} = \frac{A_o}{C_o} = \frac{A/N}{C/N} = \frac{A}{N} \cdot \frac{N}{C} = \frac{A}{C} = Z_{11}$$

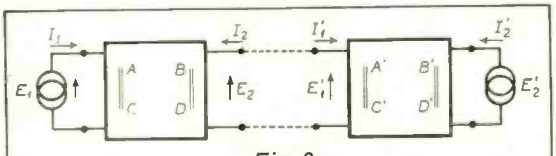


Fig. 8

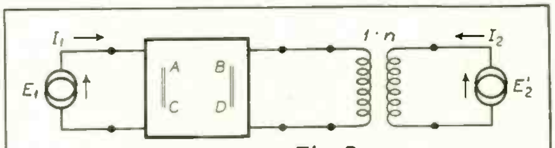


Fig. 9

$$Z_{o_{12}} = Z_{o_{21}} = \frac{1}{C_o} = \frac{1}{C/N} = \frac{1}{C} \cdot N = NZ_{12} = NZ_{21}$$

$$Z_{o_{22}} = \frac{D_o}{C_o} = \frac{ND}{C/N} = \frac{D}{C} N^2 = Z_{22} N^2$$

Thus

$$\|Y_o\| = \begin{Vmatrix} Y_{11} & Y_{12}/N \\ \dfrac{Y_{21}}{N} & \dfrac{Y_{22}}{N^2} \end{Vmatrix} \quad \text{and} \quad \|Z_o\| = \begin{Vmatrix} Z_{11} & NZ_{12} \\ NZ_{21} & N^2 Z_{22} \end{Vmatrix}$$

The procedure just outlined can be applied to any number of four-terminal networks connected in cascade. However, for two networks so connected the results can be obtained directly from the expressions given in the chart, thus materially reducing the time required for solution of a given problem.

The advantages of employing matrices to the solution of network problems are strikingly illustrated by the problem of Fig. 10. Here we have two lattice networks connected in cascade working into a resistive load of 10 ohms. It is required to find the load current.

We will find the resultant general circuit matrix for the two networks in cascade and solve for the load current I_2' by the use of equation (13).

$$\begin{Vmatrix} A_o & B_o \\ C_o & D_o \end{Vmatrix} = \begin{Vmatrix} \dfrac{30}{10} & \dfrac{400}{10} \\ \dfrac{2}{10} & \dfrac{30}{10} \end{Vmatrix} \cdot \begin{Vmatrix} \dfrac{50}{30} & \dfrac{800}{30} \\ \dfrac{2}{30} & \dfrac{50}{30} \end{Vmatrix}$$

$$= \begin{Vmatrix} \left(\dfrac{150}{30} + \dfrac{80}{30}\right) & \left(\dfrac{2{,}400}{30} + \dfrac{2{,}000}{30}\right) \\ \left(\dfrac{10}{30} + \dfrac{6}{30}\right) & \left(\dfrac{160}{30} + \dfrac{150}{30}\right) \end{Vmatrix} = \begin{Vmatrix} \dfrac{23}{3} & \dfrac{440}{3} \\ \dfrac{1.6}{3} & \dfrac{31}{3} \end{Vmatrix}$$

$$E_1 = A_o E_2' - B_o I_2' = A_o (-I_2' Z_2) - B_o I_2' = (-A_o Z_2 - B_o) I_2'$$

$$\therefore I_2' = \frac{E_1}{-A_o Z_2 - B_o} = \frac{100}{-\dfrac{23}{3} \times 10 - \dfrac{440}{3}} = \frac{100}{\dfrac{-670}{3}} = -\frac{300}{670} = -0.447 \text{ ampere}$$

The load current is calculated to be 0.447 ampere, the minus sign indicating that I_2' flows in the opposite direction than shown in Fig. 10. Just a couple of minutes were required to solve the problem by this method; however, a much greater length of time would be required to obtain the solution by the more complicated and laborious classical method.

Suppose now we desire to find the insertion loss of the second lattice when used in the circuit of Fig. 10.

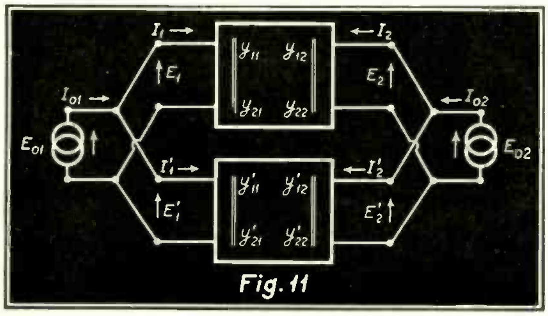


Fig. 11

Let us remove the second lattice from circuit and find the current I_2 in the load resistance when it is connected to the output terminals of the first lattice.

$$E_1 = AE_2 - BI_2 = A(-I_2 Z_2) - BI_2$$

$$\therefore I_2 = \frac{E_1}{-AZ_2 - B} = \frac{100}{-3 \times 10 - 40} = \frac{100}{-70} = -1.43 \text{ amperes}$$

Thus the insertion loss of the second lattice is

$$\text{db} = 20 \log \frac{I_2}{I_2'} = 20 \log \frac{1.43}{.447}$$

$$= 20 \log 3.2 = 20 \times .505 = 10.1 \text{ db.}$$

PARALLEL CONNECTION OF NETWORKS

When two four-terminal networks of the balanced type or two of the unbalanced type having a common side are connected in parallel, the admittance matrix of the combination is given by the sum of the individual admittance matrices of the two networks. Then by the use of equations (18) and (19) we can find the impedance and general circuit matrices for the combination.

NOTE: In the fundamental derivation of matrices of the basic networks the currents entering and leaving the input are equal in magnitude and those entering and leaving the output are similarly equal. Operations with these matrices could not be validly employed if these

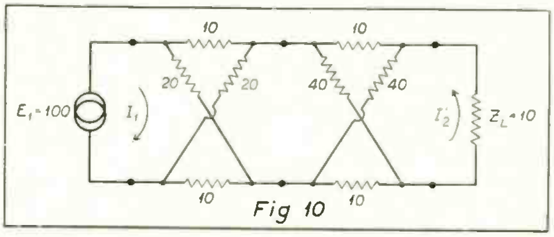


Fig 10

conditions were violated when making the parallel combination. Hence, the theorem is necessarily restricted to the combination of two balanced-type networks or two unbalanced types having a common side. The matrix operation could not be used in cases of the parallel combination of any two unbalanced networks not having a common side; and the combination of a balanced and an unbalanced network.

It will now be proven that

$$\begin{Vmatrix} Y_{o_{11}} & Y_{o_{12}} \\ Y_{o_{21}} & Y_{o_{22}} \end{Vmatrix} = \begin{Vmatrix} Y_{11} & Y_{12} \\ Y_{21} & Y_{22} \end{Vmatrix} + \begin{Vmatrix} Y_{11}' & Y_{12}' \\ Y_{21}' & Y_{22}' \end{Vmatrix}$$

For the upper network of Fig. 11

$$\begin{Vmatrix} I_1 \\ I_2 \end{Vmatrix} = \begin{Vmatrix} Y_{11} & Y_{12} \\ Y_{21} & Y_{22} \end{Vmatrix} \cdot \begin{Vmatrix} E_1 \\ E_2 \end{Vmatrix} = \begin{Vmatrix} (Y_{11} E_1 + Y_{12} E_2) & 0 \\ (Y_{21} E_1 + Y_{22} E_2) & 0 \end{Vmatrix}$$

For the lower network

$$\begin{Vmatrix} I_1' \\ I_2' \end{Vmatrix} = \begin{Vmatrix} Y_{11}' & Y_{12}' \\ Y_{21}' & Y_{22}' \end{Vmatrix} \cdot \begin{Vmatrix} E_1' \\ E_2' \end{Vmatrix} = \begin{Vmatrix} (Y_{11}' E_1' + Y_{12}' E_2') & 0 \\ (Y_{21}' E_1' + Y_{22}' E_2') & 0 \end{Vmatrix}$$

Let

$$\begin{Vmatrix} I_{01} \\ I_{02} \end{Vmatrix} = \begin{Vmatrix} (I_1 + I_1') \\ (I_2 + I_2') \end{Vmatrix} \quad \text{and} \quad \begin{Vmatrix} E_1 \\ E_2 \end{Vmatrix} = \begin{Vmatrix} E_1' \\ E_2' \end{Vmatrix}$$

so that

$$I_{01} = I_1 + I_1' \qquad \text{and} \qquad E_1 = E_1'$$
$$I_{02} = I_2 + I_2' \qquad \qquad \qquad E_2 = E_2'$$

Hence

$$\begin{Vmatrix} I_{01} \\ I_{02} \end{Vmatrix} = \begin{Vmatrix} I_1 + I_1' \\ I_2 + I_2' \end{Vmatrix} = \begin{Vmatrix} I_1 \\ I_2 \end{Vmatrix} + \begin{Vmatrix} I_1' \\ I_2' \end{Vmatrix}$$

$$= \begin{Vmatrix} Y_{11} & Y_{12} \\ Y_{21} & Y_{22} \end{Vmatrix} \cdot \begin{Vmatrix} E_1 \\ E_2 \end{Vmatrix} + \begin{Vmatrix} Y_{11}' & Y_{12}' \\ Y_{21}' & Y_{22}' \end{Vmatrix} \cdot \begin{Vmatrix} E_1' \\ E_2' \end{Vmatrix}$$

and since

$$E_1 = E_1' \quad \text{and} \quad E_2 = E_2'$$

$$\begin{Vmatrix} I_{01} \\ I_{02} \end{Vmatrix} = \left[\begin{Vmatrix} Y_{11} & Y_{12} \\ Y_{21} & Y_{22} \end{Vmatrix} + \begin{Vmatrix} Y_{11}' & Y_{12}' \\ Y_{21}' & Y_{22}' \end{Vmatrix} \right] \cdot \begin{Vmatrix} E_1 \\ E_2 \end{Vmatrix}$$

$$= \begin{Vmatrix} (Y_{11} + Y_{11}') & (Y_{12} + Y_{12}') \\ (Y_{21} + Y_{21}') & (Y_{22} + Y_{22}') \end{Vmatrix} \cdot \begin{Vmatrix} E_1 \\ E_2 \end{Vmatrix}$$

$$= \begin{Vmatrix} Y_{\underset{11}{o}} & Y_{\underset{12}{o}} \\ Y_{\underset{21}{o}} & Y_{\underset{22}{o}} \end{Vmatrix} \cdot \begin{Vmatrix} E_1 \\ E_2 \end{Vmatrix}$$

$$= \begin{Vmatrix} [(Y_{11} + Y_{11}')\, E_1 + (Y_{12} + Y_{12}')\, E_2] & 0 \\ [(Y_{21} + Y_{21}')\, E_1 + (Y_{22} + Y_{22}')\, E_2] & 0 \end{Vmatrix}$$

$$= \begin{Vmatrix} (Y_{\underset{11}{o}} E_1 + Y_{\underset{12}{o}} E_2) & 0 \\ (Y_{\underset{21}{o}} E_1 + Y_{\underset{22}{o}} E_2) & 0 \end{Vmatrix}$$

From whence

$$I_{01} = (Y_{11} + Y_{11}')\, E_1 + (Y_{12} + Y_{12}')\, E_2 = Y_{\underset{11}{o}}\, E_1 + Y_{\underset{12}{o}}\, E_2$$

$$I_{02} = (Y_{21} + Y_{21}')\, E_1 + (Y_{22} + Y_{22}')\, E_2 = Y_{\underset{21}{o}}\, E_1 + Y_{\underset{22}{o}}\, E_2$$

MATRICES OF THE BRIDGE T

The bridge T can be considered as a parallel connection of a series network and a T network the admittance matrices of which are known. This is illustrated in Fig. 12.

We know that the admittance matrix for the bridge T is equal to the sum of the admittance matrices of the series and the T networks.

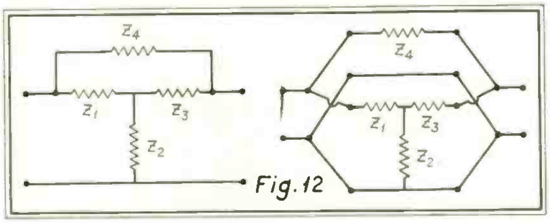


Fig. 12

$$\| Y_o \|_{BT} = \| Y \|_s + \| Y \|_T = \begin{Vmatrix} 1/Z_4 & -1/Z_4 \\ -1/Z_4 & 1/Z_4 \end{Vmatrix} + \begin{Vmatrix} \dfrac{(Z_2 + Z_3)}{d} & -Z_2/d \\ -Z_2/d & \dfrac{(Z_1 + Z_2)}{d} \end{Vmatrix}$$

where $d = Z_1 Z_2 + Z_2 Z_3 + Z_1 Z_3$

Then

$$Y_{\underset{11}{o}} = \frac{1}{Z_4} + \frac{Z_2 + Z_3}{d} = \frac{d + (Z_2 + Z_3)\, Z_4}{d\, Z_4}$$

$$Y_{\underset{12}{o}} = Y_{\underset{21}{o}} = -\frac{1}{Z_4} - \frac{Z_2}{d} = -\frac{(d + Z_2 Z_4)}{d\, Z_4}$$

$$Y_{\underset{22}{o}} = \frac{1}{Z_4} + \frac{Z_1 + Z_2}{d} = \frac{d + (Z_1 + Z_2)\, Z_4}{d\, Z_4}$$

Therefore the admittance matrix is

$$\| Y_o \|_{BT} = \begin{Vmatrix} Y_{\underset{11}{o}} & Y_{\underset{12}{o}} \\ Y_{\underset{21}{o}} & Y_{\underset{22}{o}} \end{Vmatrix}$$

$$= \frac{\begin{Vmatrix} [d + (Z_2 + Z_3)\, Z_4] & -(d + Z_2 Z_4) \\ -(d + Z_2 Z_4) & [d + (Z_1 + Z_2)\, Z_4] \end{Vmatrix}}{d\, Z_4}$$

The general circuit and impedance matrices are found from equations (19) and (18).

$$A_o = -\frac{Y_{\underset{22}{o}}}{Y_{\underset{12}{o}}} = \frac{-[d + (Z_1 + Z_2)\, Z_4]}{d\, Z_4} \cdot \frac{-d Z_4}{(d + Z_2 Z_4)}$$

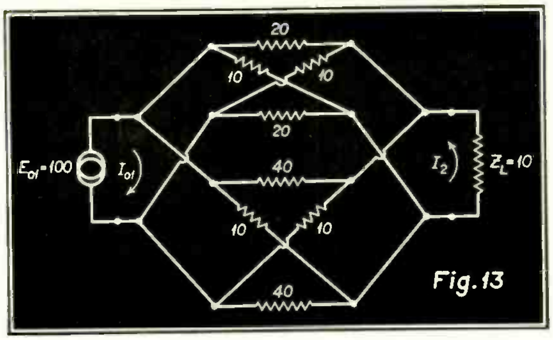


Fig. 13

$$= \frac{(d + Z_2 Z_4) + Z_1 Z_4}{(d + Z_2 Z_4)} = 1 + \frac{Z_1 Z_4}{(d + Z_2 Z_4)}$$

$$B_o = -\frac{1}{Y_{\underset{12}{o}}} = \frac{d\, Z_4}{(d + Z_2 Z_4)}$$

$$D_o = -\frac{Y_{\underset{11}{o}}}{Y_{\underset{12}{o}}} = \frac{-[d + (Z_2 + Z_3)\, Z_4]}{d\, Z_4} \cdot \frac{-d\, Z_4}{(d + Z_2 Z_4)}$$

$$= \frac{(d + Z_2 Z_4)\ Z_3 Z_4}{(d + Z_2 Z_4)} = 1 + \frac{Z_3 Z_4}{(d + Z_2 Z_4)}$$

$$C_o = -\frac{|Y_o|}{Y_{\underset{12}{o}}} = -\frac{\begin{vmatrix} Y_{\underset{11}{o}} & Y_{\underset{12}{o}} \\ Y_{\underset{21}{o}} & Y_{\underset{22}{o}} \end{vmatrix}}{Y_{\underset{12}{o}}} = -\frac{Y_{\underset{11}{o}} Y_{\underset{22}{o}} - Y_{\underset{12}{o}} Y_{\underset{21}{o}}}{Y_{\underset{12}{o}}}$$

$$= Y_{\underset{12}{o}} - \frac{Y_{\underset{11}{o}} Y_{\underset{22}{o}}}{Y_{\underset{12}{o}}}$$

$$= -\frac{(d + Z_2 Z_4)}{d\, Z_4} - \frac{(d + Z_2 Z_4 + Z_3 Z_4)}{d\, Z_4} \cdot \frac{(d + Z_1 Z_4 + Z_2 Z_4)}{d\, Z_4} \cdot \frac{d\, Z_4}{-(d + Z_2 Z_4)}$$

$$= \frac{(d + Z_2 Z_4 + Z_3 Z_4)\quad (d + Z_1 Z_4 + Z_2 Z_4)}{d\, Z_4\, (d + Z_2 Z_4)} - \frac{(d + Z_2 Z_4)}{d\, Z_4}$$

$$= \frac{(d + Z_2 Z_4 + Z_3 Z_4)\ (d + Z_1 Z_4 + Z_2 Z_4) - (d + Z_2 Z_4)^2}{d\, Z_4\, (d + Z_2 Z_4)}$$

$$= \frac{d\, Z_4\, (Z_3 + Z_1) + (Z_1 Z_2 + Z_1 Z_3 + Z_2 Z_3)\, Z_4^2}{d\, Z_4\, (d + Z_2 Z_4)}$$

$$= \frac{d\, Z_4\, (Z_3 + Z_1)}{d\, Z_4\, (d + Z_2 Z_4)} + \frac{d\, Z_4^2}{d\, Z_4\, (d + Z_2 Z_4)}$$

$$= \frac{(Z_3 + Z_1)}{(d + Z_2 Z_4)} + \frac{Z_4}{(d + Z_2 Z_4)} = \frac{Z_1 + Z_3 + Z_4}{d + Z_2 Z_4}$$

Thus

$$\begin{Vmatrix} A_o & B_o \\ C_o & D_o \end{Vmatrix}_{BT} = \begin{Vmatrix} \left[1 + \dfrac{Z_1 Z_4}{(d + Z_2 Z_4)}\right] & \dfrac{d\, Z_4}{(d + Z_2 Z_4)} \\ \dfrac{Z_1 + Z_3 + Z_4}{(d + Z_2 Z_4)} & \left[1 + \dfrac{Z_3 Z_4}{(d + Z_2 Z_4)}\right] \end{Vmatrix}$$

$$Z_{\underset{11}{o}} = \frac{A_o}{C_o} = \frac{(d + Z_1 Z_4 + Z_2 Z_4)}{(d + Z_2 Z_4)} \cdot \frac{(d + Z_2 Z_4)}{(Z_1 + Z_3 + Z_4)}$$

$$= \frac{d + Z_1 Z_4 + Z_2 Z_4}{Z_1 + Z_3 + Z_4} = \frac{d + (Z_1 + Z_2)\, Z_4}{Z_1 + Z_3 + Z_4}$$

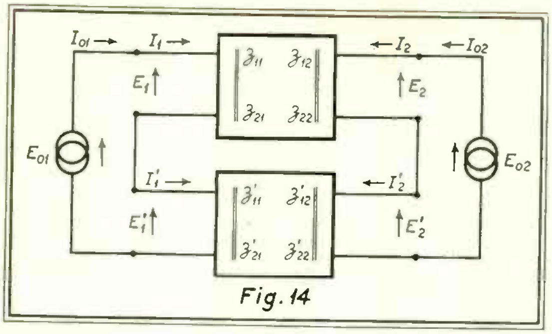


Fig. 14

$$Z^{o}_{12} = Z^{o}_{21} = \frac{1}{C_o} = \frac{(d + Z_2 Z_4)}{Z_1 + Z_3 + Z_4}$$

$$Z^{o}_{22} = \frac{D_o}{C_o} = \frac{(d + Z_2 Z_4 + Z_3 Z_4)}{(d + Z_2 Z_4)} \cdot \frac{(d + Z_2 Z_4)}{Z_1 + Z_3 + Z_4}$$

$$= \frac{d + (Z_2 + Z_3) Z_4}{Z_1 + Z_3 + Z_4}$$

The impedance matrix for the bridge T is

$$\begin{Vmatrix} Z^{o}_{11} & Z^{o}_{12} \\ Z^{o}_{21} & Z^{o}_{22} \end{Vmatrix}_{BT} = \frac{\begin{Vmatrix} [d + (Z_1 + Z_2) Z_4] & [d + Z_2 Z_4] \\ [d + Z_2 Z_4] & [d + (Z_2 + Z_3) Z_4] \end{Vmatrix}}{Z_1 + Z_3 + Z_4}$$

As an example of a numerical problem, let us find the load current when the two lattices shown in Fig. 13 are connected in parallel.

The admittances matrix for the two networks in parallel is

$$\begin{Vmatrix} Y^{o}_{11} & Y^{o}_{12} \\ Y^{o}_{21} & Y^{o}_{22} \end{Vmatrix} = \begin{Vmatrix} \frac{30}{400} & \frac{10}{400} \\ \frac{10}{400} & \frac{30}{400} \end{Vmatrix} + \begin{Vmatrix} \frac{50}{800} & \frac{30}{800} \\ \frac{30}{800} & \frac{50}{800} \end{Vmatrix} = \begin{Vmatrix} \frac{11}{80} & \frac{5}{80} \\ \frac{5}{80} & \frac{11}{80} \end{Vmatrix}$$

The load current can be computed from equation (10).

$$I_{02} = Y^{o}_{21} E_{01} + Y^{o}_{22} E_{02} = Y^{o}_{21} E_{01} + (Y^{o}_{22}) \; (-I_{02} Z_{02})$$

$$I_{02} + Y^{o}_{22} I_{02} Z_{02} = Y^{o}_{21} E_{01}$$

$$I_{02} (1 + Y^{o}_{22} Z_{02}) = Y^{o}_{21} E_{01}$$

$$I_{02} = \frac{Y^{o}_{21} E_{01}}{1 + Y^{o}_{22} Z_{02}} = \frac{\frac{5}{80} \times 100}{1 + \frac{11}{80} \times 10} = \frac{\frac{500}{80}}{\frac{80 + 110}{80}}$$

$$= \frac{50}{8} \times \frac{8}{19} = \frac{50}{19} = 2.63 \text{ amps}$$

We can arrive at the same answer if A_o and B_o are found and then solving for the load current by equation (13).

$$A_o = -\frac{Y^{o}_{22}}{Y^{o}_{12}} = -\frac{11}{80} \times \frac{80}{5} = -\frac{11}{5}$$

$$B_o = -\frac{1}{Y^{o}_{12}} = -\frac{80}{5}$$

But

$$E_{01} = A_o E_{02} - B_o I_{02} = (A_o) \; (-I_{02} Z_{02}) - B_o I_{02}$$

$$E_{01} = -I_{02} (A_o Z_{02} + B_o)$$

$$I_{02} = -\frac{E_{01}}{A_o Z_{02} + B_o} = -\frac{100}{\left(-\frac{11}{5}\right) 10 - \frac{80}{5}}$$

$$= -\frac{100}{-\frac{110}{5} - \frac{80}{5}} = -\frac{100}{-\frac{190}{5}} = \frac{500}{190} = 2.63 \text{ amps}$$

Now let us assume that the load normally works from the output of the two lattices when connected in parallel as shown in Fig. 13. Let us find the insertion loss due to removing the upper lattice so that the load works from the output of the lower lattice alone.

We have already found the load current to be 2.63 amperes when both lattices are in circuit in parallel connection. Now let us find the current in the load with just the lower lattice in circuit.

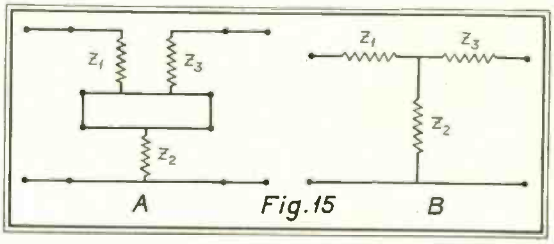


Fig. 15

$$A = -\frac{Y_{22}}{Y_{12}} = -\frac{\frac{5}{80}}{\frac{3}{80}} = -\frac{5}{80} \cdot \frac{80}{3} = -\frac{5}{3}$$

$$B = -\frac{1}{Y_{12}} = -\frac{80}{3}$$

$$E_1 = AE_2 - BI_2 = -AI_2 Z_2 - BI_2 = -I_2 (AZ_2 + B)$$

$$I_2 = -\frac{E_1}{AZ_2 + B} = -\frac{100}{-\frac{5}{3} \times 10 - \frac{80}{3}} = -\frac{100}{-\frac{50}{3} - \frac{80}{3}}$$

$$= -\frac{100}{-\frac{130}{3}} = \frac{300}{130} = 2.31 \text{ amps}$$

Thus the loss due to the removal of the upper lattice from the circuit of Fig. 13 is

$$\text{db} = 20 \log \frac{I_{02}}{I_2} = 20 \log \frac{2.63}{2.31} = 20 \log 1.14$$

$$= 20 \times .057 = 1.14 \text{ db}$$

SERIES CONNECTION OF NETWORKS

When connecting two unbalanced networks having a common side in series, the impedance matrix of the

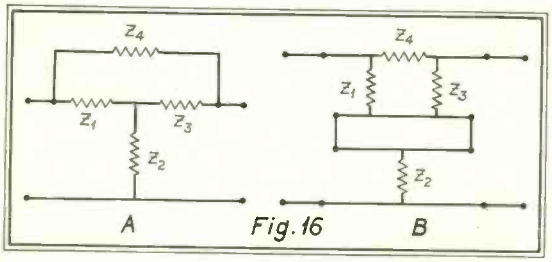


Fig. 16

network resulting from the combination is given by the sum of the impedance matrices of the individual networks. The admittance and the general circuit matrices can then be obtained from the relations of equations (17) and (19).

NOTE: This theorem is necessarily restricted to unbalanced networks having a common side since these are the only types of networks where the entering and leaving currents at the input of the combination are equal . . . and the entering and leaving currents at the output are equal.

It shall now be proven that for the circuit connections of Fig. 14

$$\begin{Vmatrix} Z_{o_{11}} & Z_{o_{12}} \\ Z_{o_{21}} & Z_{o_{22}} \end{Vmatrix} = \begin{Vmatrix} Z_{11} & Z_{12} \\ Z_{21} & Z_{22} \end{Vmatrix} + \begin{Vmatrix} Z_{11}' & Z_{12}' \\ Z_{21}' & Z_{22}' \end{Vmatrix}$$

For the first network

$$\begin{Vmatrix} E_1 \\ E_2 \end{Vmatrix} = \begin{Vmatrix} Z_{11} & Z_{12} \\ Z_{21} & Z_{22} \end{Vmatrix} \cdot \begin{Vmatrix} I_1 \\ I_2 \end{Vmatrix} = \begin{Vmatrix} (Z_{11} I_1 + Z_{12} I_2) & 0 \\ (Z_{21} I_1 + Z_{22} I_2) & 0 \end{Vmatrix}$$

For second network

$$\begin{Vmatrix} E_1' \\ E_2' \end{Vmatrix} = \begin{Vmatrix} Z_{11}' & Z_{12}' \\ Z_{21}' & Z_{22}' \end{Vmatrix} \cdot \begin{Vmatrix} I_1' \\ I_2' \end{Vmatrix} = \begin{Vmatrix} (Z_{11}' I_1' + Z_{12}' I_2') & 0 \\ (Z_{21}' I_1' + Z_{22}' I_2') & 0 \end{Vmatrix}$$

But

$$E_{01} = E_1 + E_1' \text{ and } E_{02} = E_2 + E_2'$$
$$I_{01} = I_1 + I_1' \quad \text{and} \quad I_{02} = I_2 + I_2'$$

Thus

$$\begin{Vmatrix} E_{01} \\ E_{02} \end{Vmatrix} = \begin{Vmatrix} E_1 \\ E_2 \end{Vmatrix} + \begin{Vmatrix} E_1' \\ E_2' \end{Vmatrix} = \begin{Vmatrix} Z_{11} & Z_{12} \\ Z_{21} & Z_{22} \end{Vmatrix} \cdot \begin{Vmatrix} I_1 \\ I_2 \end{Vmatrix} + \begin{Vmatrix} Z_{11}' & Z_{12}' \\ Z_{21}' & Z_{22}' \end{Vmatrix} \cdot \begin{Vmatrix} I_1' \\ I_2' \end{Vmatrix}$$

$$= \left[\begin{Vmatrix} Z_{11} & Z_{12} \\ Z_{21} & Z_{22} \end{Vmatrix} + \begin{Vmatrix} Z_{11}' & Z_{12}' \\ Z_{21}' & Z_{22}' \end{Vmatrix} \right] \cdot \left[\begin{Vmatrix} I_1 \\ I_2 \end{Vmatrix} + \begin{Vmatrix} I_1' \\ I_2' \end{Vmatrix} \right]$$

$$= \begin{Vmatrix} (Z_{11} + Z_{11}') & (Z_{12} + Z_{12}') \\ (Z_{21} + Z_{21}') & (Z_{22} + Z_{22}') \end{Vmatrix} \cdot \begin{Vmatrix} I_{01} \\ I_{02} \end{Vmatrix}$$

$$= \begin{Vmatrix} Z_{o_{11}} & Z_{o_{12}} \\ Z_{o_{21}} & Z_{o_{22}} \end{Vmatrix} \cdot \begin{Vmatrix} I_{01} \\ I_{02} \end{Vmatrix} = \begin{Vmatrix} (Z_{o_{11}} I_{01} + Z_{o_{12}} I_{02}) & 0 \\ (Z_{o_{21}} I_{01} + Z_{o_{22}} I_{02}) & 0 \end{Vmatrix}$$

From which we can write

$$E_{01} = Z_{o_{11}} I_{01} + Z_{o_{12}} I_{02}$$
$$E_{02} = Z_{o_{21}} I_{01} + Z_{o_{22}} I_{02}$$

As a simple example of the application of this principle, we can regard the T network as made up of the series connection of the double shunt and the single shunt networks shown in Fig. 15.

By referring to the chart, the impedance matrix for the double shunt is

$$\| Z \|_{DS} = \begin{Vmatrix} Z_1 & 0 \\ 0 & Z_3 \end{Vmatrix}$$

The impedance matrix for the single shunt is

$$\| Z \|_{S} = \begin{Vmatrix} Z_2 & Z_2 \\ Z_2 & Z_2 \end{Vmatrix}$$

Therefore

$$\| Z_o \|_T = \begin{Vmatrix} Z_1 & 0 \\ 0 & Z_3 \end{Vmatrix} + \begin{Vmatrix} Z_2 & Z_2 \\ Z_2 & Z_2 \end{Vmatrix} = \begin{Vmatrix} (Z_1 + Z_2) & Z_2 \\ Z_2 & (Z_2 + Z_3) \end{Vmatrix}$$

which we know to be true.

In a similar manner the bridge T can be considered as a series connection of a π network and a single shunt as shown in Fig. 16.

$$\| Z_o \|_{BT} = \| Z \|_\pi + \| Z \|_S$$

$$= \frac{\begin{Vmatrix} Z_1 (Z_3 + Z_4) & Z_1 Z_3 \\ Z_1 Z_3 & Z_3 (Z_1 + Z_4) \end{Vmatrix}}{Z_1 + Z_3 + Z_4} + \begin{Vmatrix} Z_2 & Z_2 \\ Z_2 & Z_2 \end{Vmatrix}$$

Thus

$$Z_{o_{11}} = Z_2 + \frac{Z_1 Z_3 + Z_1 Z_4}{Z_1 + Z_3 + Z_4} = \frac{Z_1 Z_2 + Z_2 Z_3 + Z_2 Z_4 + Z_1 Z_3 + Z_1 Z_4}{Z_1 + Z_3 + Z_4}$$

$$= \frac{d + Z_2 Z_4 + Z_1 Z_4}{Z_1 + Z_3 + Z_4} = \frac{d + (Z_1 + Z_2) Z_4}{Z_1 + Z_3 + Z_4}$$

$$Z_{o_{12}} = Z_{o_{21}} = Z_2 + \frac{Z_1 Z_3}{Z_1 + Z_3 + Z_4} = \frac{Z_1 Z_2 + Z_2 Z_3 + Z_2 Z_4 + Z_1 Z_3}{Z_1 + Z_3 + Z_4}$$

$$= \frac{d + Z_2 Z_4}{Z_1 + Z_3 + Z_4}$$

$$Z_{o_{22}} = Z_2 + \frac{Z_1 Z_3 + Z_3 Z_4}{Z_1 + Z_3 + Z_4} = \frac{Z_1 Z_2 + Z_2 Z_3 + Z_2 Z_4 + Z_1 Z_3 + Z_3 Z_4}{Z_1 + Z_3 + Z_4}$$

$$= \frac{d + Z_2 Z_4 + Z_3 Z_4}{Z_1 + Z_3 + Z_4} = \frac{d + (Z_2 + Z_3) Z_4}{Z_1 + Z_3 + Z_4}$$

Therefore the impedance matrix for the bridge T is

$$\begin{Vmatrix} Z_{o_{11}} & Z_{o_{12}} \\ Z_{o_{21}} & Z_{o_{22}} \end{Vmatrix} = \frac{\begin{Vmatrix} [d + (Z_1 + Z_2) Z_4] & [d + Z_2 Z_4] \\ [d + Z_2 Z_4] & [d + (Z_2 + Z_3) Z_4] \end{Vmatrix}}{Z_1 + Z_3 + Z_4}$$

By referring to the chart published in the July issue we can recognize this to be correct.

FACSIMILE DEMONSTRATION

THE VISUAL BROADCAST of facsimile matter on a regular commercial basis was forecast recently, following experiments which have just been conducted in the East.

Captain O. Fulton announced that mass production of automatic home-set facsimile receivers can be expected in the near future. Captain Fulton's announcement was made on the occasion of the NAB Convention at Chicago, at which a model of one of the Fultograph facsimile receivers was displayed in the newsroom of Transradio Press Service.

The Fultograph system, according to its inventor, has successfully sent facsimile matter from London to Sydney, Australia, a distance of 12,000 miles, over wireless "beam" channels.

Other recent achievements claimed by the inventor of the Fultograph were:

1. Successful transmission of facsimile material from 2,500 to 3,000 miles from an Atlantic coastal station to ships at sea.
2. Weather charts to airplanes flying between New York and Miami.
3. Facsimile photographs and printed matter to speeding trains and to automobiles moving through Central Park, New York City.

The statement by Captain Fulton stressed the great simplicity and low cost of facsimile equipment developed in his laboratory. He claimed that his transmitter-scanner can be attached to any regular broadcast transmitter, regardless of wavelength. The whole transmitting unit weighs 60 pounds.

THE FERRIS MICROVOLTER

ONE OF THE greatest difficulties encountered in high-frequency measurements is that of connecting together the units under test. Even at frequencies as low as 20 megacycles, leads 2 or 3 feet long used to connect a receiver to a microvolter may cause considerable error due to resonant step-up. Errors as large as 10-to-1 have been measured in the 20-30 mc region in typical setups. When the frequency is increased to 50 or 60 mc even the shortest leads may cause large errors.

If a unit were built so that the output terminals, across which the measured voltage appears, could be brought up to the point at which this voltage is applied such errors could be eliminated. In the Model 18B Microvolter (Fig. 1), recently announced by the Ferris Instrument Corporation, this is accomplished by placing the output terminals at the end of a 3-foot flexible cable. They are mounted in a small box that can be conveniently inserted into any setup, and connected directly to the desired point with leads only an inch or so long . . . in some cases direct connections may be made.

The 3-foot flexible cable is said to be a true transmission line when properly terminated with resistors at both ends,

FIG. 1. FRONT VIEW OF THE MODEL 18B MICROVOLTER.

and its transmission loss has been corrected for in the design of the entire output system so that the voltage appearing at the output terminals is correct. This transmission line is a permanent part of the unit.

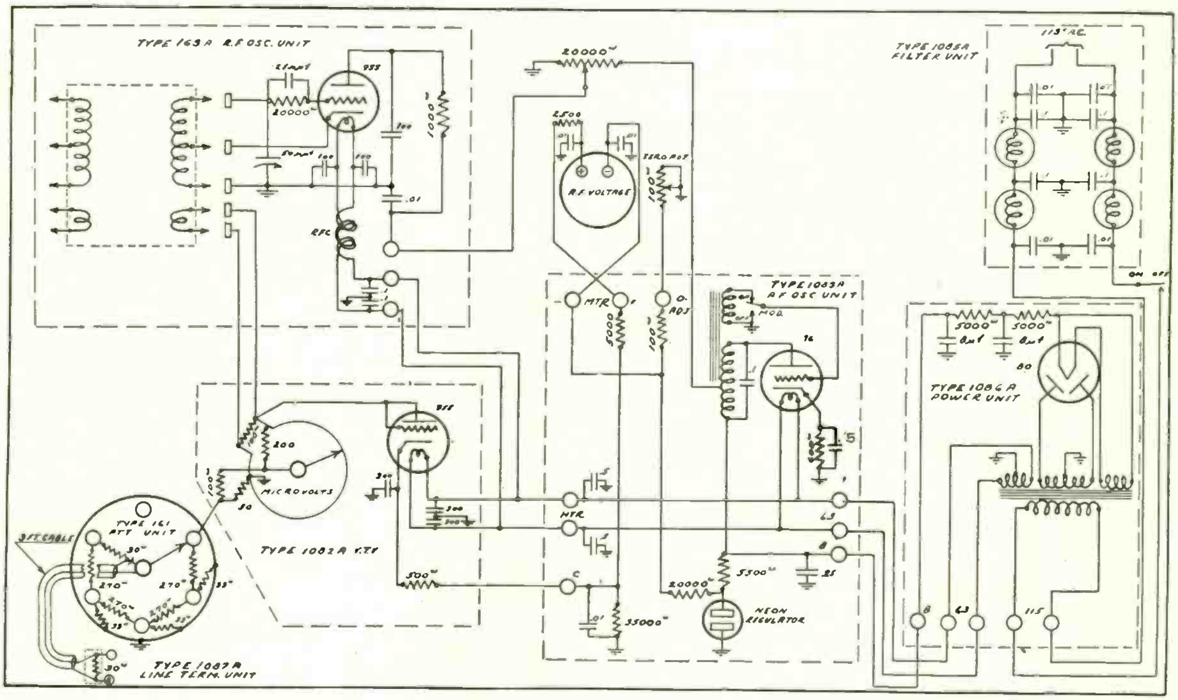
Except for the transmission line and terminating unit, and the modification necessary to permit their use, the attenuator is a normal resistance type; careful choice of parts and arrangements makes possible satisfactory operation in the 20-to-100 megacycle region. Attenuator includes four 10-to-1 ratios.

An inductive potentiometer is used at the input of the attenuator instead of the resistive potentiometer frequently used for this purpose. The dial fitted to the inductive potentiometer shaft is calibrated directly in microvolts input.

As may be seen from the accompanying diagram (Fig. 2), a filter unit is placed in series with the supply-line cord to prevent r-f voltage from reaching the power line. The power unit uses resistors instead of chokes for the series elements of the smoothing filter, thus saving space and weight, and providing protection in case of accidental short circuit of the B-supply line.

(*Continued on page* 18)

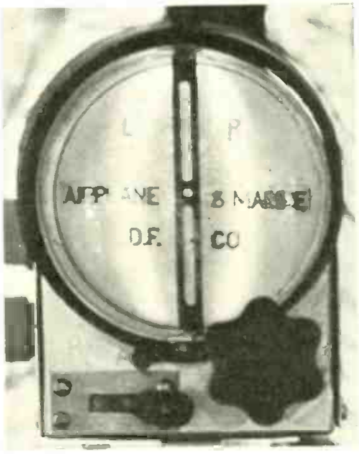
FIG. 2. SCHEMATIC DIAGRAM OF THE NEW FERRIS MICROVOLTER.



CATHODE-RAY DIRECTION FINDER

ENCOURAGING RESULTS have been obtained during recent tests conducted by the Coast Guard of a cathode-ray radio direction finder which was submitted for test by the Airplane and Marine Direction Finder Corporation. This indicator, which utilizes a cathode-ray projector is the invention of Mr. Edward Hefele, Chief Engineer of that company.

The tests included more than one hundred and fifty hours' actual flying, forty hours of which were conducted during the hours of darkness. These tests were carried out over mountainous, flat and rolling country, as well as over water and along a coast line of various configurations. These tests were directly supervised by Chief Radio Electrician C. T. Solt of the Communications Division, U. S. Coast Guard Headquarters, in the Coast Guard radio test plane (see front cover) which was piloted by C. G. pilots J. R. Orndorff and W. R. Durham.



Rudy Arnold photos

FIG. 1. ELLIPTICAL PATTERN ON SCREEN OF CATHODE-RAY TUBE INDICATING THAT PLANE IS APPROACHING STATION.

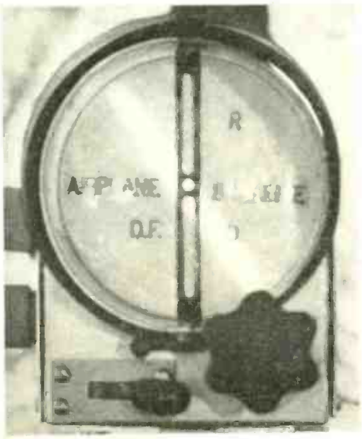


FIG. 3. THIS INDICATES THAT PLANE IS TO LEFT OF COURSE.

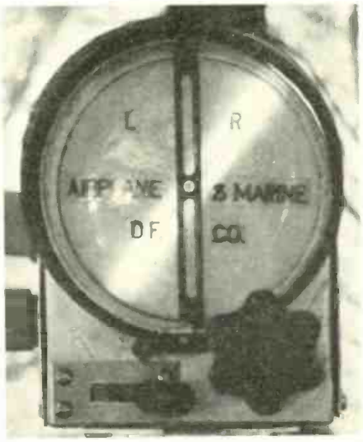


FIG. 4. THIS INDICATES THAT PLANE IS TO RIGHT OF COURSE.

FIG. 2. CIRCULAR PATTERN ON VISUAL SCREEN. INDICATING THAT PLANE IS DIRECTLY OVER STATION.

The performance of this instrument during the tests indicated that reliable bearings could be consistently obtained through heavy intermittent atmospheric disturbances, as well as interference from other radio signals on the same frequency of the observed signal. Performance of this equipment was impressive during night flying and, while so-called "night effect" was frequently noted, the directional qualities of the observed bearings were not affected.

On approaching a station being used for radio guidance, the cathode-ray pattern gradually opens out from a vertical line beam into an ellipse (Fig. 1), until, finally, when directly over the station, an almost perfect circle is obtained (Fig. 2) or the elliptical pattern goes completely off the circle giving a very definite indication of the location of the station. The directional "sense" characteristic was found to be entirely automatic. The approach and departure of the aircraft, with regard to any broadcasting or radio-range station being employed for radio guidance is at all times apparent. The sensing of the equipment installed in the Coast Guard plane was arranged so that when utilizing the device for homing purposes and approaching a station the vertical beam would incline to the left (Fig. 3) indicating that the plane was swinging to the right of the observed station. With this arrangement, if the beam inclines to the right (Fig. 4) of the vertical guide lines on the cathode screen, it is an indication that the observed station is to the right of the course flown by the airplane.

The indication of line bearing and directional sense was found to be satisfactory with A-1, A-2 and A-3 classes of radio signals. Telegraphic signals are readable by means of the cathode indicator, which is responsive to keyed telegraphic signals of any speed. In addition to functioning as a radio direction finder, homing device, right and left indicator and non-directional receiver, the Hefele cathode-ray direction finder tested was found to give accurate line of bearing and directional indication of electric storms.

The directional indication obtained with this equipment and the accuracy of the radio bearings is not dependent on parallel balanced and/or bridge circuits or delicate phasing of any sort. The equipment employs two separate amplifying channels, one utilizing the energy from a simple vertical antenna and the other amplifying the radio-frequency signal picked up by a rotatable loop antenna. The visual indication obtained with the cathode projector is a resultant of the vertical and loop antenna signal. Consequently, the accuracy of this equipment can only be destroyed by some accident to the rotatable loop. If the vertical antenna is disconnected, satisfactory null indications are still obtainable by means of the rotatable loop as this equipment operates as a null-type direction finder.

The total weight of the equipment is approximately 75 pounds, which compares favorably with the various standard types of aural—null direction finders in use today. The power necessary to operate the equipment is derived from the 12-volt storage battery installed in the airplane for starting and lighting purposes.

During the tests conducted with the direction finder by the Coast Guard, it was found that a consistently satisfactory distance range of 125 to 200 miles could be obtained on the 50-kilowatt class of broadcasting station. It is expected that this range will be extended in an improved model which will be tested by the Coast Guard in the near future.

By means of the directional sensitivity control incorporated as part of this equipment, the observer, may, at his wish, make the directive response as critical or as sluggish as he desires. This sensitivity control is apparent to the observer in the amount of inclination of the beam to the right and left of its vertical alignment. The control may be set so that deviating one degree from the course (or rotating the loop one degree from the null point) will cause deviation of the vertical beam to be anything from one to fifteen or twenty degrees, depending upon the directional sensitivity desired. This is a distinct advantage when flying in rough weather as the ballistic properties of the beam may be adjusted to suit the movement of the aircraft.

Mr. Solt reports that it was determined that during the test described herein that the cathode-ray direction finder afforded a means for constantly checking the drift of the airplane due to wind. Wind-drift check is accomplished by coordinating the cathode indication with the setting of the directional gyro, the latter constituting standard equipment on all modern planes.

It was noted that during these tests, that while the presence of interfering signals and electrical atmospheric disturbances were indicated on the cathode screen, these types of disturbances did not deter from the accuracy of the indicator. On several occasions bearings were obtained on electrical storms quite as readily as they were obtained on radio stations.

TELEVISION DEMONSTRATION

ON AUGUST 11, a special television demonstration was given by the Philco Radio and Television Corporation of Philadelphia, Pa. The equipment used in this demonstration represented the results of over 5 years of research work by this organization and preceded the beginning of experimental work to obtain a higher definition picture (between 440 and 450 lines) to conform with the Television Standards as outlined by the RMA (see page 9, July, 1936, COMMUNICATION AND BROADCAST ENGINEERING).

The apparatus used consisted of the transmitter, W3XE, operating on a power of approximately 1 kw, located in the Philco Laboratories at Ontario and C Streets in Philadelphia. The signals of W3XE were picked up at the receiving point some 7 miles distant.

Broadcasts first began from W3XE on December 23, 1935, and regular nightly programs have been put on the air since June 18, 1936. Receivers have been distributed in Philadelphia and field tests have been carried on for quite some time.

The television apparatus conforms to the standards set forth by the RMA, with the exception of the number of lines and the synchronizing signal. The Philco system is of 345-line type and a narrow vertical synchronizing signal is used. The carrier frequency of the picture transmitter is 51 mc while the carrier frequency for sound is 54.25 mc. According to Philco engineers, W3XE is using a new type of modulation. The pictures are approximately 10 by 12 inches, and are black and white rather than the usual greenish or yellow type.

THE FERRIS MICROVOLTER

(*Continued from page* 16)

The audio oscillator is of the conventional type, and is so arranged that it can be turned off if unmodulated output is desired. The modulation is not adjustable but is set at approximately 30 percent at 400 cycles. The r-f oscillator uses a type 955 acorn tube, and the structure of the unit is arranged to keep connections between the tube, coil and condenser extremely short. Control of the oscillator output is obtained by varying the plate voltage, and the circuit is arranged so that this can be done without changing the percentage of modulation.

The output of the oscillator connects to the inductive potentiometer, and the vacuum-tube voltmeter is connected at this point so that this voltage can be maintained at the required value.

A unit type of construction is employed in the 18B, and each of the following units constitutes a separate sub-assembly, separately secured to the case: line filter, power supply, audio oscillator, radio oscillator, vacuum-tube voltmeter and inductive potentiometer, attenuator and output cable.

The coils supplied with the instrument cover the following ranges:

Coil A—18-to-35 mc
Coil B—32-to-60 mc
Coil C—55-to-100 mc

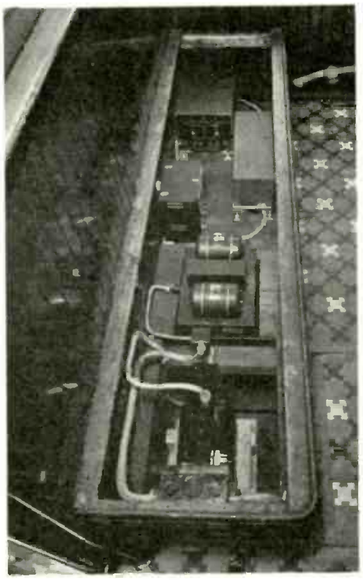
Space is provided for a fourth coil, and if desired a special experimental coil covering approximately 100-to-150 mc may be used.

NEW TWO-WAY RADIO-TELEPHONE SERVICE

PREPARATORY to establishing regular two-way radio-telephone service for commercial craft in New York Harbor and nearby waters, the New York Telephone Company has been conducting an operating trial of equipment on seven boats engaged in freight transportation in the harbor. The tests are being made under experimental licenses issued by the Federal Government. Five of the boats are tugs owned and operated by the Pennsylvania Railroad. One of the other two is operated by the Oil Transfer Corporation and the other by the Socony Vacuum Company.

When the service is opened to the public, after the trials conducted jointly by the telephone company and the transportation enterprises, it is expected to be widely used by various classes of harbor vessels. It might also be used by certain vessels operating in Long Island Sound and on the Hudson River.

The period of trial operation of the harbor radio-telephone system is now drawing to a close and has resulted in many improvements and advances in the art which will make it possible to offer a high-speed efficient service for the towing companies in New York Harbor, so that two-way conversations can be carried on between harbor vessels and their dispatchers quickly and easily at any time during the day or night. Connections, when desired, can also be made to any land telephone. The new Western Electric radiophone equipment, said to be one of the most up-to-date and efficient developed, has been tested thoroughly and adjusted to meet the needs of customers for this service. The complete system is now working smoothly in connection with the normal operation of the towing companies.



THE APPARATUS USED TO PROVIDE TELEPHONE SERVICE FOR TUG BOATS. THIS PHOTOGRAPH WAS TAKEN ON BOARD THE "LANCASTER."

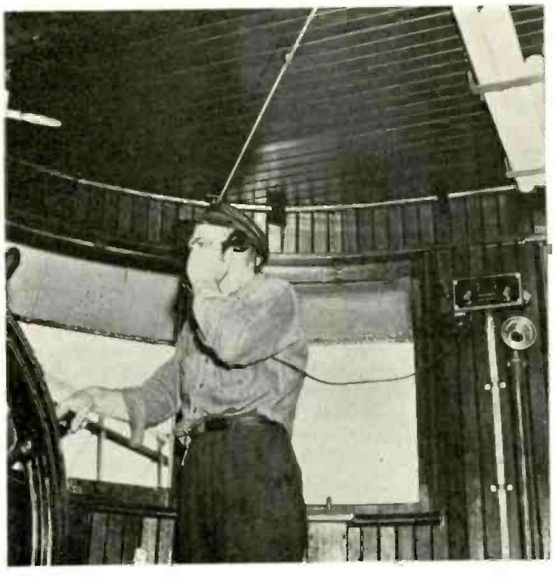
Radio shore equipment installed by the telephone company includes a 400-watt short-wave transmitting station atop the building at 25 Hyatt Street, St. George, Staten Island. A receiving station is located nearby on the island with facilities for interconnecting the radio voice ways with the telephone company's regular land wires.

During the trial the seven harbor boats are communicating to designated points ashore under the direction of the telephone company. These tests supplement earlier ones made by the telephone company with its own cable-laying boat and have provided further necessary operating experience.

Ship-shore radiophone equipment and service have been developed steadily during the past five years, meeting a growing demand for two-way voice communication with ships. A score of transatlantic liners have adopted the service since the first installation was made aboard the steamship Leviathan.

THE TRANSMITTING EQUIPMENT AT ST. GEORGE, STATEN ISLAND. OPERATION IS BY REMOTE CONTROL FROM THE RECEIVING STATION AT ROSEBANK, S. I.

ACTING-CAPTAIN OLE WALEN, OF THE TUGBOAT "SAMPSON," USING HIS RADIO TELEPHONE TO CALL THE OFFICE FOR INSTRUCTIONS.



Plans for radio-telephone service for the nation's greatest seaport and water transportation center—New York City—have been under way for several years. Upon the authority of the Federal Communications Commission, the New York Telephone Company completed the transmitting station. Development and improvements in the equipment, however, continued. Special effort was made to produce ship equipment which could be operated effectively and more economically than was possible with existing sets. The result was a low-powered five-watt set which has been installed on the seven boats.

An improved method of calling the boats by means of selective signaling apparatus also is being utilized.

Under the old system of loudspeaker monitoring, the ship crew had to listen constantly for the ship's particular call. But with selective signaling, a regular telephone bell rings on the ship being called, obviating any confusion. The manipulation of the ship telephone is nearly the same as that of the ordinary telephone, thereby making unnecessary the employment of skilled operators on the boats.

The trial which has been carried on over a period of about two months has resulted in changes and adjustments which have developed a smooth working and speedy system of communication. Further tests are in progress in connection with the handling of large numbers of messages which might arise in the future under emergent conditions, such as in foggy weather, when many of the boats would have urgent need of communication. This portion of the trial has thus far shown very remarkable results. In the last test of this sort the messages handled were about twice the record number handled in any previous test. Further tests along these lines are continuing.

BROADCASTING THE OLYMPIC GAMES

EXTENSIVE PREPARATIONS were made in Berlin to broadcast the Olympic Games to all parts of the globe, so that millions of listeners might enjoy the descriptions of the stirring events which were of world interest from August 1 to 16.

In the main stadium, near the stands for the guests of honor, an underground radio station was built from which 30 direct broadcasts can be made at a time and also 42 transcriptions on record discs. The main switchboard in this radio station measures 65 feet and has room for 10,000 switches, whose location is indicated by 4,000 small signal lights. In addition to the main switchboard there will be 30 auxiliary boards with about 350 microphone connections.

In order to take care of the enormous volume of transmissions during the Olympics, radio experts from all over Germany were summoned. Of these, 400 sound engineers worked on the international programs, 80 on the short-wave senders, and 100 on the broadcasts to all parts of Germany.

Arrangements were made for the closest cooperation with international broadcasting systems.

THE SIMON RADIOGUIDE

(*Continued from page 7*)

ages induced in the two loops by the vertical wave component are equal (when heading directly toward or away from the transmitting station), consequently, when the signal fades at night, the two pointers of the course-indicating instrument rise and fall equally and simultaneously, and maintain their intersection on the central, or 0 degree, line. Under similar conditions, a single loop operating on the null principle is rendered entirely inoperative. When the transmitting station is off the airplane's course, the accuracy of the off-course bearings progressively decreases, yet at all times remains fully comparable to the heavier Adcock system, which is universally recognized to have the greatest freedom from night error. Even under the most severe night-effect conditions, bearings up to 20 degrees off course are sufficiently accurate for practical navigation purposes.

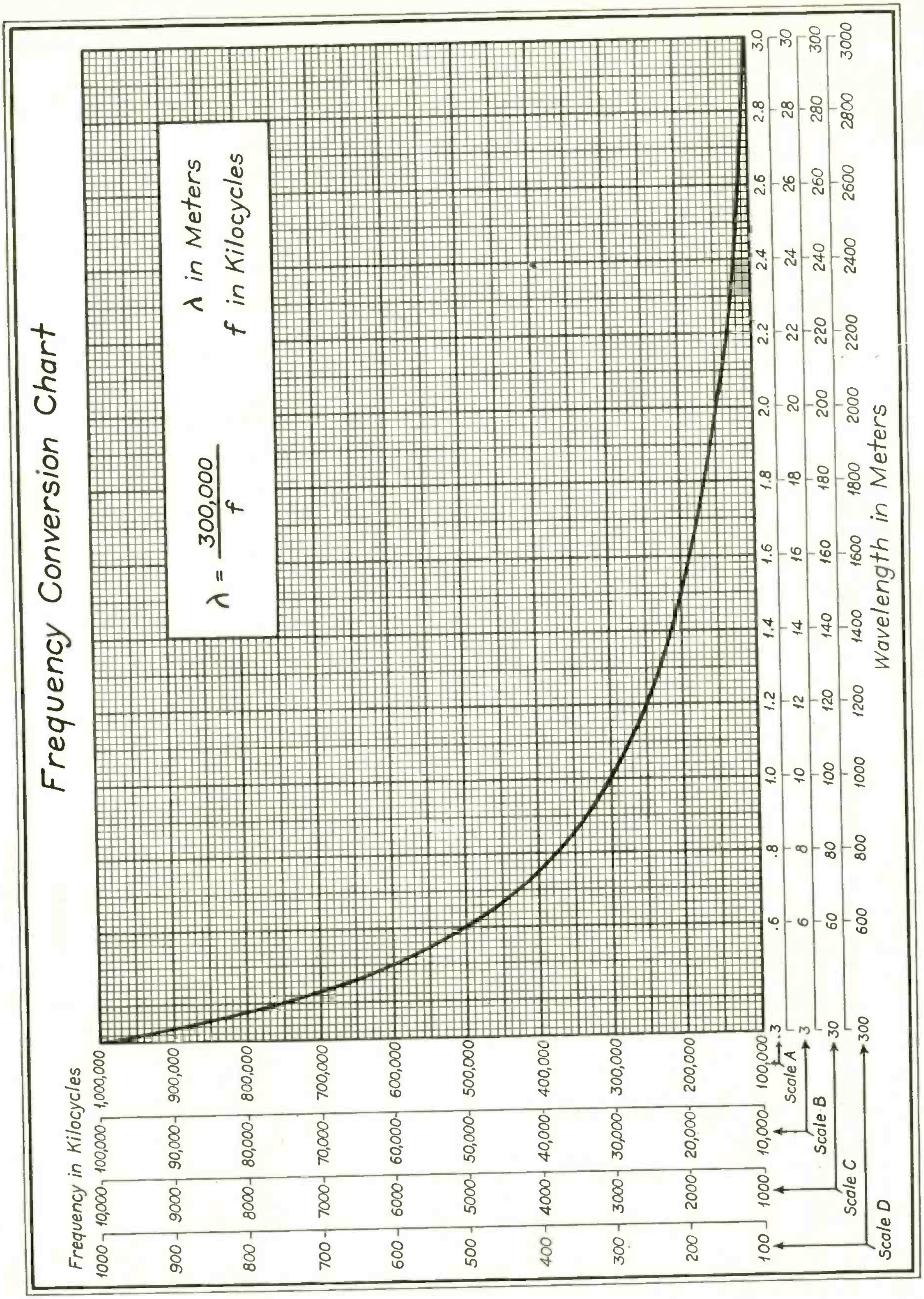
Another important consideration is the immunity of this instrument to rain and snow static. The two loops used for reception of signal are electrostatically shielded and operate without the use of an antenna, except momentarily when the sense switch is turned to resolve the fore-and-aft ambiguity.

In making instrument approaches to the airport for landings under low- or zero-ceiling conditions, the instrument is extremely valuable because of its ability to indicate to the pilot when he passes over the exact center of the transmitting antenna. As the "cone of silence" above the transmitting antenna is reached, the two pointers momentarily fall to non-operating position; first one, then the other, depending to which side of the precise electrical center of the transmitting antenna the airplane passed. By observing the interval between the fall of the two pointers, the pilot can judge his position with respect to the exact center of the antenna.

Another important feature is that should the radio be off or "dead," both pointers instantly drop to non-operating position, warning the pilot, instead of continuing to read "on course."

The range of the instrument embraces all long-wave radio range beacons of the Federal airways system, all American broadcasting stations, and many short-wave stations, down to as low as 50 meters. Since the instrument operates from the rectified carrier wave, a steady reading is obtained from a steady carrier, and is not affected by modulation of the carrier. Aural reception is also provided, and may be used separately or simultaneously with the visual course indication.

The Simon Radioguide is a product of the Radio Navigational Instrument Company of New York City, N. Y., and is rapidly gaining favor among private, commercial and government users.


Frequency Conversion Chart
λ = 300,000 / f
λ in Meters
f in Kilocycles
Wavelength in Meters
Frequency in Kilocycles
Scale A
Scale B
Scale C
Scale D
.3 .6 .8 1.0 1.2 1.4 1.6 1.8 2.0 2.2 2.4 2.6 2.8 3.0
3 6 8 10 12 14 16 18 20 22 24 26 28 30
30 60 80 100 120 140 160 180 200 220 240 260 280 300
300 600 800 1000 1200 1400 1600 1800 2000 2200 2400 2600 2800 3000
1,000,000 900,000 800,000 700,000 600,000 500,000 400,000 300,000 200,000 100,000
100,000 90,000 80,000 70,000 60,000 50,000 40,000 30,000 20,000 10,000
10,000 9000 8000 7000 6000 5000 4000 3000 2000 1000
1000 900 800 700 600 500 400 300 200 100

TELECOMMUNICATION

PANORAMA OF PROGRESS IN THE FIELDS OF COMMUNICATION AND BROADCASTING

AIRCRAFT ANTENNA

THE DEVELOPMENT of an auxiliary radio antenna to supplement the standard trailing antenna for simultaneous or independent use and which is shot out into space at the will of the pilots, has been completed in the Maintenance Department of Transcontinental and Western Air, Inc.

If the regular antenna is not giving the desired reception or transmission, the auxiliary unit can be released for simultaneous use. The switch throws the auxiliary antenna in parallel with the regular antenna and it may be used in this manner without affecting the signal strength of the transmitter or the reception of the two-way receiver. In fact, while operating on day frequency, it actually increases the signal from the transmitter.

To permit the installation of this auxiliary antenna, a new casting was designed in order to house the portable unit directly beneath the regular unit, slightly altering shape of tail cone.

The portable auxiliary unit consists of a cylinder having a compression spring and trigger. There also is an electrical switching mechanism, which, when loaded with the antenna cartridge and released by an Arens control, shoots out the cartridge and closes the electric switch putting the auxiliary antenna into immediate use. When the control is released, a compression spring forces a paper cylinder out into space—upon this cylinder is wrapped 35 feet of No. 16 steel control cable which serves as the antenna wire. The antenna wire ravels and discards the cardboard tube upon which it is packed in the cylinder. The paper cartridge is approximately 1¾ inches in diameter and is held in place against the compression spring by a trigger. The entire unit is covered over by a wax paper cover which is torn open when the trigger is released.

A special loading tool is used to reload the cylinder with a new antenna cartridge when the unit is repacked.

RADIO STATION KGEZ

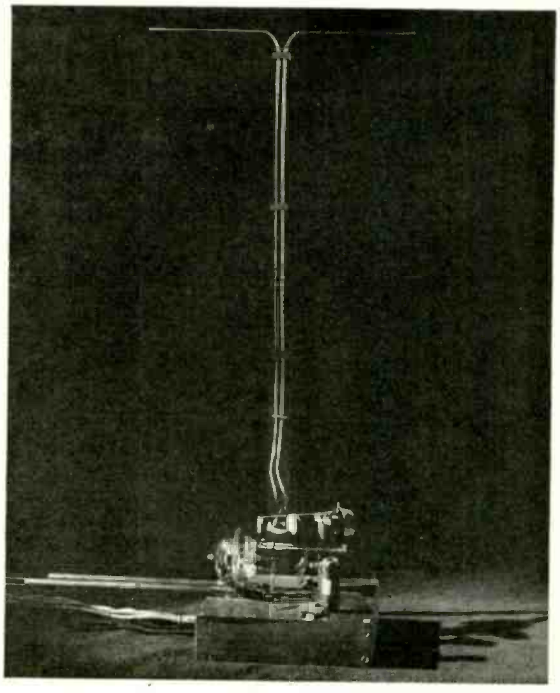
AMONG THE MORE interesting small station installations is that of KGEZ in Kalispell, Montana. This station, which was designed and built by the author, is believed to be sufficiently interesting to warrant the following brief description.

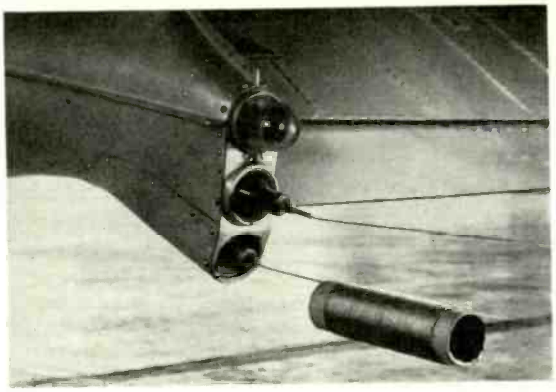
KGEZ, operating on a frequency of 1310 kc and at a power of 100 watts, is completely a-c operated with the exception of the program relays which are d-c operated. This was the first Prime A modulated broadcast transmitter in the state of Montana . . . or for that matter in any of the northwestern states. Prime A modulation is used because of the low tube upkeep expense and also because it is possible to obtain high-fidelity response with a minimum of distortion.

The mixer panel on the operator's desk is a four-channel job and can be remotely operated. All channels are interchangeable and each channel will perform any of the following functions:

THE NEW 154-FOOT, TYPE CK, BLAW-KNOX VERTICAL RADIATOR OF RADIO STATION WWSW, PITTSBURGH, PA.

A 500-MEGACYCLE (60-CENTIMETER) TRANSMITTER USING THE NEW WESTERN ELECTRIC NO. 316 A VACUUM TUBE.





THE AUXILIARY AIRCRAFT ANTENNA DESCRIBED ON THE OPPOSITE PAGE.

STUDIO CONTROL ROOM OF RADIO STATION WKY, OKLAHOMA CITY, OKLAHOMA.

1. Turn on the studio microphone, studio quiet light and turn off the studio monitor speaker.

2. Turn on the downtown studio microphone and turn off its monitor speaker, audio monitor signal being supplied from the station.

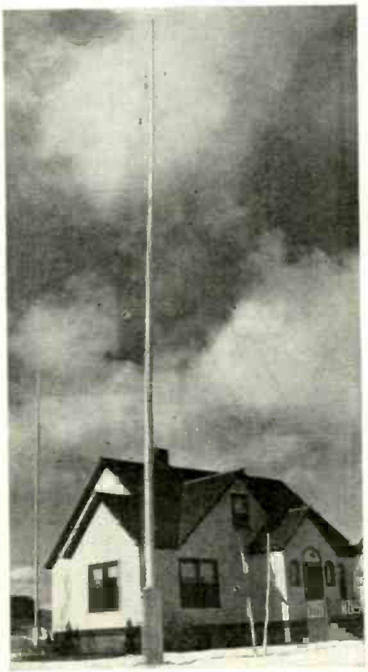
3. Turn on the control-room microphone and turn off monitor speaker.

4. Turn the phonograph line into program amplifier.

The circuit switching operations are performed entirely by relays operated by push buttons on the mixer panel. Lights indicate channel in service.

The speech panel carries extra amplifiers and an auxiliary power supply. The latter may be put into immediate operation.

The patch panel makes it possible to: interchange any one channel for another, to monitor one studio program while broadcasting another, to monitor one recorded program with another on the air, to monitor all programs going to the transmitter, or to give each phonograph pickup a channel of its own. Signal lights on this panel indicate which channel is in operation, a light being on only when the particular circuit is being used by the mixer.



RADIO STATION KGEZ, KALISPELL, MONTANA

One master switch opens all circuits with the exception of the electric clock, heater circuits of the quartz crystals and the overhead light. If manual operation is desired each circuit of the transmitter and speech circuits has its own off and on switch. A time relay allows all tubes to reach operating temperatures before the plate voltage is applied and in case of an overload, the plate voltage is automatically removed. The grid excitation from the right-hand panel (see accompanying illustrations) operates the relay that completes the connection from the high-voltage circuit to the station.

A Weston DB VI meter is arranged so that it will read either from the output of the program amplifiers or from the r-f linear rectifier.

The tube line up of the transmitter only is as follows: one 210, crystal oscillator; two 865, first and second buffers; one 830, r-f driver or final buffer; two 203A's, modulated high-level Class "C" amplifier; two 2A3's, Class "A" audio drivers; two 845's, Prime "A" modulators.

DONALD GORMAN, *Chief Engineer.*

VETERAN WIRELESS OPERATORS ASSOCIATION NEWS

W. J. McGonigle, Secretary, 112 Willoughby Avenue, Brooklyn, N. Y.

NAVY'S NUMBER ONE PIONEER

THE "WASHINGTON POST" of Friday, July 31, 1936, carried a half-column story of the life of Navy's No. 1 Pioneer, who has long been a veteran member of our association.

John W. Scanlin was born in South Ardmore, Pa., on July 29, 1874, and enlisted in the Navy in 1891. When the Spanish-American War broke out and the then unprecedented extent of the United States Navy maneuvers demanded improved systems of communication, Scanlin was one of the men chosen as chief electrician—the first in the history of the Navy. In 1902 when the office of naval communications was established. Scanlin was brought in from the fleet to serve in the newly-organized office. For a year following he journeyed between Washington and Annapolis testing the various types of apparatus that were submitted by American and European wireless equipment manufacturers. At the completion of these tests, Scanlin, because of his detailed experience and comprehensive knowledge of wireless apparatus, was chosen to make the first permanent installation on board a battleship.

He continued as one of the Navy's pioneers in the radio field in charge of the testing of wireless equipment. In 1911 he was assigned to the Bureau of Engineering for duty in the Naval Laboratory of the Bureau of Standards. The following year he assumed the position of electrician in charge of naval radio station being built at Arlington.

Scanlin carried on all the tests at the station until regular schedules were established. At that time the Arlington radio station was the only high-powered station in this country. In addition to his varied radio career ashore, he installed the first permanent electrical system on board a battleship, the first Arc apparatus to be used by the Navy, and set up the equipment that enabled the Army to maintain communication with United States ships in Vera Cruz during the Mexican Punative Expedition in 1916.

During the war Mr. Scanlin assumed the role of lieutenant in the communications branch of the Navy and after the Armistice reverted back to his previous rating of chief radio man. Some time later, after passing a most difficult civil-service examination he transferred to the office of the D. N. C. in Washington.

On July 30, 1936, sixty-two year old John W. Scanlin retired officially from the Navy, after completing 45 years of service. Rear Admiral Charles E. Courtney, head of naval communications, commended him very highly for his enviable record, and expressed his regret and that of the Navy at the loss of their No. 1 radio man.

We, his associates, in the Veteran Wireless Operators Association, congratulate him upon achieving such a place in the estimation of all who knew him in the naval communications service, and extend to him our heartiest wishes for continued success and the best of health in retirement.

HONOLULU

GEORGE STREET and Arthur Enderlin continue as chairman and secretary respectively of the Shredded Wheat Skirt Chapter in the paradise of the Pacific, at least until the first of 1937.

George rushes along a draft on New York covering membership dues for W. H. B. Cowan, who he says was pushing a spark gap around in 1908 on the Tub named *Enterprise,* which used to splash water with a paddle wheel in Long Island Sound. George says, however, that upon questioning WHB maintains that he did not attempt to use the blades of the paddle wheel as revolving electrodes for his spark gap. Mr. Cowan later was in the Navy, coming out after the war as a lieutenant, and also served with Telefunken Company. At present WHB is an immigration inspector for the United States Government stationed at Honolulu.

George mentions that, at a recent meeting in Honolulu, the Grandpa of member Warren Clark of Mackay Radio told an interesting story about learning to telegraph in the good old days—about 1873. Grandpa Clark (not our own George) sent the first message across—as operator—on the Commercial Pacific Cable.

Among the recent additions to the membership of the Surf Board Chapter are Angelo M. Da Vico of Aiea, Oahu, Hawaii. He first saw the light as operator for the Inter-Island Wireless Telegraph Co. (now Mutual Wireless); Philip H. Levey served aboard the S. S. *Enterprise* way back in May 1911 (we wonder whether that was the same *Enterprise* that the aforementioned member Cowan served on in 1908). Mr. Levey left the wireless field in 1915 and is at present established with the Bishop Trust Co., Ltd., in Honolulu; Val Arbogast, Jr., who has seen service aboard several vessels of the U. S. Navy since 1933—now attached to the U. S. S. *Beaver* at Pearl Harbor, T. H.

Arthur Enderlin, secretary, renders a report of the most recent meeting of the Honolulu Chapter. "We had 39 members and guests representing Mackay Radio, RCAC, FCC, Press Wireless, Honolulu Police, Globe Wireless, Commercial Pacific Cables, Army Signal Corps, Navy Radio, Inter-Island Airways, Coast Guard, Pan American Airways, Amateurs, and reformed (sic) operators, on July 1, 1936, at Waikiki Tavern, Waikiki, to do honor to our member Lt. Col. Leland Stanford of the U. S. Army Signal Corps, who was leaving for duty at the Presidio of San Francisco, and likewise to welcome Lt. Cmdr. Poindexter, who recently arrived as the D. C. O. of the 14th Naval District.

Among the many interesting anecdotes related was one by Mr. John R. Clark, who was a veteran telegrapher when most of the rest of us were in rompers. Mr. Clark was in charge of the Postal Delivery Department in San Francisco when the cable to Honolulu opened, and among the first messages was one addressed to Queen Liliuokalani of Hawaii, who was at the time in San Francisco. Mr. Clark personally delivered this message.

Col. Stanford, who is an enthusiastic VWOA booster is, unfortunately for us, en route to his new station at the Presidio of San Francisco. We earnestly recommend to the San Francisco Chapter that they miss no opportunity to have Col. Stanford at meetings. He generally arranges to find time to attend meetings and is a most entertaining speaker and an engaging personality.

We have an application coming up from one of the early operators of the Mutual Wireless Co., who operated in 1900. We confidently expect to produce operators before long, who can prove they were veteran wireless operators before Marconi sent the "S" across the Atlantic. How about our member S. B. Maddams, district manager for Mackay Radio, who was a telegraph operator in the Central Post Office in London way back, who was sent down to the south of England somewhere to punch the key for Marconi when Marconi was trying to prove to the British Government that wireless would actually work. That was some time in the 1890's, I think.

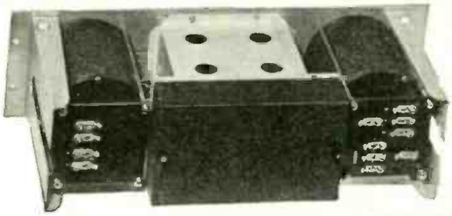
Capt. Roberts of the U. S. Army Signal Corps valiantly responded to numerous requests and rendered numerous selections on the grand piano, including, for the benefit of the Navy personnel present, "Anchors Aweigh" to the tune of "Aloha."

Our member, G. Paul Gray, RCAC is going to Detroit to pick up his new Packard at the factory. He left here July 25th on the *Lurline* and flew from San Francisco to Detroit. He is a good fellow, and members of San Francisco, Chicago and Detroit will find him a welcome visitor."

RENEWED ACTIVITY

PRESENT INDICATIONS are that we will have an extremely interesting and varied group of activities among the members of each of our chapters in numerous cities throughout the United States. Several of the chapter secretaries have requested large numbers of application blanks, and in some cases have taken the initiative and thus devised their own, and that which pleases us most is that they have had them signed by prospective members and forwarded to headquarters with the necessary. Plans will soon be formulated by committees in the various cities for a bang up nation-wide cruise to take place on February 11, 1937. We will warrant that the officers of the various chapters will welcome any suggestions you may wish to offer concerning the fall and winter program for your local organization.

Newly Designed REMLER



AR-69

• Preamplifier for VELOCITY or DYNAMIC MICROPHONES

Circuit: Two stage, resistance coupled. Highest quality, self-shielded transformers. Input transformer cushioned in rubber. Output transformer parallel fed. 2 Type 77 tubes, triode connected. Gain 42 db. Response: plus 1/4 to minus 1 3/4 db. from 1000 cycle reference over the range 40 to 12,000 cycles. Also available at 36 db. gain with rising high frequency response (plus 4 db. at 10,000 cycles) to compensate for other apparatus.

Input: 30 Ohms standard, 250 Ohms on special order. Input is balanced to center tap. Output: 200 Ohms. (May be paralleled for 50 Ohms.)

Power Required: 180 to 250 volts plate (less than 2 mils drain) and 6 volts A.C. or D.C. (at .6 amperes drain.) Plate current jacks on front panel. Tubes accessible from front.

May be had in Dural or Black finish Panel. Dimensions: 19" x 5 1/4". Depth, including Dust Cover, 11 3/4". Very moderately priced. Write for details.

Remler Company, Ltd. ● 2101 Bryant St., San Francisco

REMLER—THE RADIO FIRM AS OLD AS RADIO

BRUSH *General Purpose* MICROPHONE

The Brush G2S2P sound cell microphone—an all around general purpose microphone for program—remote pickup and announcing work. Widely used in high grade public address installations. A typical sound cell microphone built to Brush's traditionally high mechanical and electrical standards. Non-directional. No diaphragms. No distortion from close speaking. Trouble-free operation. No button current or input transformer to cause hum.

Beautifully finished in dull chromium. Output level minus 70 D.B. Size 3 inches by 1 1/4x1 1/8 inches. Furnished complete, at no extra cost, with a Brush S-1 socket that facilitates easy installation. Full details will be found in Data Sheet No. 4 Free. Send for one.

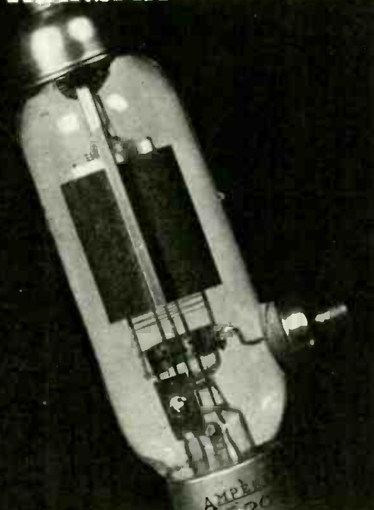
BRUSH *Headphones*

Meet every headphone requirement. Response 60 to 10,000 cycles. No magnets to cause diaphragm chatter. Specially designed cases minimize breakage. Light in weight. Only 6 oz., complete with headband and cords. A quality product at a low price. Details, Data Sheet No. 10. Copies on request. Send for one.

The BRUSH DEVELOPMENT COMPANY
PIEZO ELECTRIC
1898 E. 40th St. CLEVELAND, O.

MICROPHONES • MIKE STANDS • TWEETERS • HEAD PHONES • LOUD SPEAKERS

AMPEREX CARBON ANODE TRANSMITTING TUBES



AMPEREX
ELECTRONIC PRODUCTS, Inc.
79 WASHINGTON ST., BROOKLYN, N. Y.

DYKANOL

Transmitting Condensers

Making Condensers has been Our Business for More Than 26 Years . . . . .

Cornell - Dubilier Capacitors are being used in the majority of broadcasting stations the world over—*proof* that they must be good!

Send for Catalog No. 127 describing in complete detail the new DYKANOL Type TJ transmitting capacitors. The latest development in the broadcast field . . . these capacitors are winning wide acclaim because of their inherent reliable characteristics.

CORNELL-DUBILIER CORP. ● 4340 Bronx Blvd., New York

CORNELL DUBILIER

THE MARKET PLACE

NEW PRODUCTS FOR THE COMMUNICATION AND BROADCAST FIELDS

TECHNA PREAMPLIFIER

The "Techna" AR-83 preamplifier is a two-stage, resistance-coupled, fixed-gain, low-level line amplifier which has been designed for use with velocity and dynamic types of microphones, or may be connected to accommodate crystal types of microphones. A special equalizer is provided for use with velocity microphones.

The input transformer of the amplifier operates from a 30- or 250-ohm microphone line. Output impedances of 50, 200, or 250 ohms are provided by a parallel-fed output transformer. The frequency response is uniform within ±1 db, 30 to 12,000 cycles, with less than 1 percent total harmonics introduced into the circuit at zero level (0.006 watt). The overall gain of the amplifier is 44 db.

Further information may be secured from Techna Corporation, 926 Howard Street, San Francisco, California.

STEEL CUTTING STYLI

Universal Microphone Co., Inglewood, California, has added to its recording accessory line professional steel cutting styli to be used in conjunction with its professional blanks, Silveroid discs and all nitrate or acetate records. It is said to be the closest approach to sapphire yet produced commercially. The styli are not mass machine production items, but are entirely hand finished of special alloy steel.

SOUND RECORDS

The Masque Sound and Recording Corp., 285 Madison Avenue, New York City, New York, have recently announced the first releases of the Silver Masque Sound Records. Literature covering these releases is available. The Masque Sound and Recording Corp. are producers of sound-effect recordings.

SHURE CRYSTAL MICROPHONES

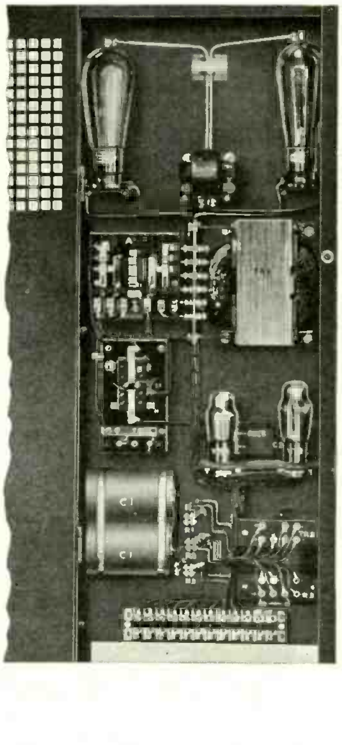
Three new crystal microphones with response curves closely approaching true high-fidelity performance have been announced by Shure Brothers, 215 W. Huron St., Chicago. All three models are licensed under patents of the Brush Development Co.

AUTOMATIC VOLTAGE REGULATOR

The Ward Leonard Electric Company, Mount Vernon, New York, have announced their Type EF electronic automatic alternator voltage regulator. This unit is shown in the accompanying illustration.

All Ward Leonard Type EF regulators perform the same functions as do the other and older types, but the method by which regulation is effected is entirely different. Instead of relying upon mechanical movements to close contacts or change pressure, an inertialess stream of electrons controls the regulating action. The vacuum tubes used function much as do tubes in a radio receiver, in that an extremely small signal (the change in a-c generator voltage) is greatly amplified. In the case of a radio receiver, the power tubes operate a loudspeaker, while in this case their output is used to keep the a-c generator voltage constant.

For complete information on these units write to the Ward Leonard Electric Company for Bulletin 5601-A.



PHOTOELECTRIC CELL

The Continental Electric Co., St. Charles, Illinois, announce a new photoelectric cell known as their Cetron Type CE-20. The cell has been designed especially for use with 16-mm projectors and other applications where a small but efficient photo cell is required.

The CE-20 is of the caesium-argon type. Its dimensions are as follows: 2 inches from bottom of base to top of bulb, width 11/16 inch. Cathode, concave 5/8 inch high, 1/2 inch wide; anode, rectangular, 1/2 inch square. Base is special 3 prong.

PORTABLE SPEECH-INPUT EQUIPMENT

The 22A speech-input equipment, shown in the accompanying illustration, has recently been announced by the Western Electric Company. It consists of combined amplifier and control facilities and a luggage-type carrying case. The equipment can be easily put into service or packed for carrying. The total weight, including the case, is approximately 25 pounds.

Harmonic distortion, under normal operating conditions, is said to be under one percent at normal output level. The amplifier is capable of delivering program levels as high as 6 db above 6 milliwatts (zero level).

Electrical noise introduced by the equipment is more than 50 db below the program level with amplification sufficient for Western Electric dynamic or other modern microphones under normal pickup conditions.

The 22A operates from either 110/120 volt, 50/60-cycle a-c supply, requiring approximately 32 watts, or from batteries, requiring 1.4 amperes at 6 volts and 21 milliamperes at 180 volts.

There are mixing circuits for 4 microphones. Provision has also been made for 2 output lines with keys for connecting either the amplifier or the order-wire telephone set to either line.

REMOTE AMPLIFIER

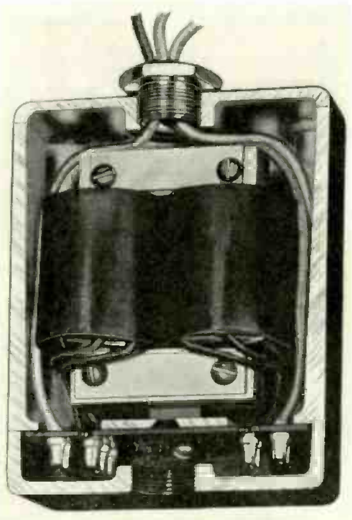
The Collins Type 12X remote amplifier is a compact, high-gain, three-channel amplifier for remote pickup service.

The complete assembly including amplifier, power supply, inter-connecting cables, spare tubes, monitor headphones and one or two microphones are all carried in a single case 10 inches x 15 inches x 19 inches.

The 12X amplifier incorporates a separate preamplifier stage ahead of each channel in the mixing circuit. A tapped input transformer in each channel allows any type of low-level, self-generating microphone to be used. The frequency response is essentially the same for all input impedance connections. Input impedance changes can be made while "on the job" without the use of tools.

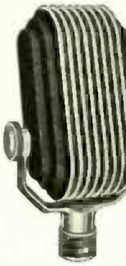
"TRU-FIDELITY"

Three years of laboratory and field work were culminated in the announcement this month of a new high-fidelity transformer by the Thordarson Electric Manufacturing Company, 500 West Huron Street, Chicago, Illinois. These units are known as "Tru-Fidelity" transformers and are said to feature the following: wide-range frequency response, high-permeability core, special coil construction for low distributed capacity and leakage reactance, maximum shielding from external fields, etc. Complete information is contained in Thordarson's Catalog No. 500.



VELOCITY MICROPHONES

The Electro-Voice Mfg. Company, Inc., 324 East Colfax Avenue, South Bend, In-



diana, announce the new "K" series velocity microphones. It is a low-priced companion line to the present "V" series. The housing is streamlined to give correct acoustic conditions and smart appearance. Each unit is furnished complete with 8-foot cable, dual shock-absorber and locking cradle. Standard output impedance is direct-to-grid.

CABLE CONNECTOR

To fill the need for a small positive and inexpensive cable connector, the Bruno Laboratories, Inc., 20 West 22 Street, New York City, announce the Bruno cable connector, Model CI. This is a small, all-metal coupling unit which permits instant connection or disconnection of two single-conductor shielded cables.

Its contact points are positive in action, self-wiping, and maintained under high pressures. Failure to hold contact is said to be a practical impossibility.

The unit cannot be damaged by being stepped upon. It cannot be accidentally disconnected. It is self-shielded and its diameter is only slightly greater than that of the cable, making its use inconspicuous.

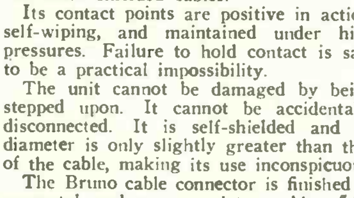
The Bruno cable connector is finished in gunmetal and accommodates cables 5/16 inch in diameter or less, and it is ¾ inch in diameter and 1½ inches long.

SPEECH-INPUT SYSTEM

Remler Company, Ltd., San Francisco, California, announces a new speech-input system, especially engineered to meet individual station requirements.

Modern, flexible and a-c operated, this new 70-A input system may be used with dynamic, velocity, crystal or condenser microphones. The equipment is said to be guaranteed to meet the requirements of the FCC.

Both single-channel and double-channel systems are available and include patch panel, combination line and bridging am-



plifier, speaker switch and signal-light relay panel, speaker-field and preamplifier

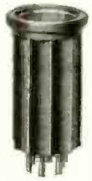
power supply and power supply for each line and bridging amplifier.

MICROPHONE VOLUME CONTROL

Among the products manufactured by Colortone, Inc., Sturgis, Mich., is the Type 20-C microphone volume control for crystal microphones. This unit features: capacity step control, offering eight positions of volume; toggle switch for On-Off position; and no tone control or frequency discrimination effects when used with crystal microphones. The aluminum housing is small and compact (5 x 2 x 2 inches) and attaches direct to microphone stand. Parts are sealed in against moisture.

TRANSMITTING COIL FORM

The Unit Development Division of the Hammarlund Manufacturing Co., Inc., has



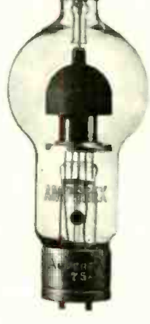
just developed a giant coil form for use in transmitters. It employs low-loss insulating material, SP-53 dielectric, the same substance that is used for the SWF coil forms. Its color is also natural with no artificial coloring to cause any losses. The forms are grooved ribbed to permit air-spaced windings for maximum efficiency.

Mounting flexibility is another feature of this coil form. The form may be permanently mounted by way of a special pair of brackets supplied with each form or temporarily mounted in the familiar plug-in coil fashion in the regulation socket. The form is 2¼ inches in diameter and 3⅞ inches long, exclusive of prongs. Two types are available—four and five prongs.

AMPEREX 575 A

Amperex Electronic Products, Inc., announces a new mercury-vapor rectifier tube, the 575 A. It is an intermediate rectifier planned to fill the gap between the 872 A and 869 A. Designed and proportioned along the lines of the 869 A with only slightly lower voltage-current characteristics.

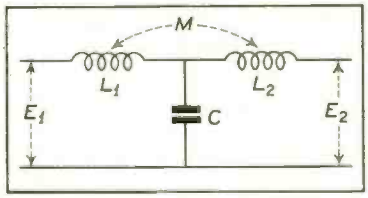
Rating and characteristics of the 575 A half-wave mercury-vapor rectifier follow. Filament: voltage, 5 volts a-c; current, 10 amperes; overall length, 10½ inches; maximum diameter, 3 3/16 inches; plate cap diameter, .500 inch; base, standard 50-watt. Maximum ratings—for operation at supply frequency up to 150 cycles and ambient temp. range of 15°-50° C.; peak inverse voltage, 15,000 volts; peak plate current, 6 amperes; average plate current.



1.5 amperes; average tube voltage drop, 10 volts.

NOTE ON THE CAMPBELL BALANCE

THE CAMPBELL BALANCE, long known and used in comparatively recent times



in power-supply circuits, measuring equipment, etc., is shown here.

Now

$$E_2 = J\left[\omega M - \frac{1}{\omega C}\right] I_1$$

If

$$\omega^2 MC = 1$$

then

$$E_2 = J\left[\omega \frac{1}{\omega^2 C} - \frac{1}{\omega C}\right] I_1$$

$$E_2 = 0$$

Thus the ripple of a-c voltage may be greatly reduced while d-c can flow.

BOOK REVIEW

HANDBOOK OF CHEMISTRY AND PHYSICS, twentieth edition, 1951 *pages, flexible covers. Published by the Chemical Rubber Publishing Co., Cleveland, Ohio. Price* $6.00.

There are any number of engineers, this reviewer among them, who would feel completely lost without the "Handbook" on their desks. Regardless of whether one's interest is in chemistry or mechanical or civil engineering, there is always something to be found in this publication.

It is hardly necessary to go into detail about the contents of the Handbook—it is familiar to everyone. However, new sections have been added; among these may be mentioned, Physical Constants of Organic Compounds, Formula Index of Organic Compounds, Pronunciation of Chemical Words (an idea which might profitably be extended to cover some other branches of sciences): X-ray Spectra, and Magneto-Optic Rotation.

It may be the height of something or other to use the expression again, but we do feel that if we were to be limited to one handbook, the volume being discussed would receive our vote.

REDIFFUSION

(Continued from page 9)

with an output of approximately 85 watts. These equipments are built in two units, the amplifier unit and the power unit. The frames of these units stand on top of one another and are localized by means of four pins. Up to six such units can be placed on top of one another to make a complete bay. Further, equipments can easily be installed and removed if necessary.

The usual practice when starting a new station is to install the smaller type equipments, increase the number of these as the number of subscribers increases and, when the number of subscribers exceed 1000-1200, the larger type of equipments replace the smaller amplifiers, which are then transferred for further use in other stations.

To facilitate servicing, the equipment is built in separate units which can easily be withdrawn from their frameworks. They slide in and out on rollers or ball bearings. Contacts between these units and the rest of the circuit are made by plug contacts at the back of the units. Any section of the amplifier equipment can, therefore, be placed on a service bench and attended to if necessary.

As a protection to the subscribers, the output transformers are tested at voltages equal to several times the h-t voltage of the equipment and the electrostatic screens, which are included between the primary and secondary windings of these transformers, are earthed.

Other constructional points of interest are separate meters in all anode circuits, h-t voltmeters, rectifier filament-current meters, and in some cases grid-current meters are used. Separate grid-bias adjustments for all tubes are included, and can clearly be seen under each of the anode-current meters in Fig. 4. Fixed bias is employed in all power-amplifier output stages and this is obtained from low-impedance metal-rectifier circuits.

The overall efficiency including driver stage, filament current and grid-bias supply, etc., of power amplifiers is of the order of 25 percent at full output, the plate efficiency of the output stage being over 70 percent.

The continuity of the service is one of the most important considerations when designing amplifiers for Rediffusion purposes and high safety factors are allowed in order to prevent breakdowns caused by faulty materials. As a result of this the percentage breakdown time due to equipment breakdown is almost negligible.

OVER THE TAPE . . .

NEWS OF THE RADIO, TELEGRAPH AND TELEPHONE INDUSTRIES

RADIO RESEARCH BOARD REPORTS

The Council for Scientific and Industrial Research, Radio Research Board, 314 Albert Street, East Melbourne, Victoria, Australia, have recently issued Reports No. 9 and No. 10.

Report No. 9, Bulletin No. 95, includes the following papers: *A Study of the Magneto-Ionic Theory of Wave Propagation by Means of Conformal Representation; Dispersion and Absorption Curves for Radio Wave Propagation in the Ionosphere According to the Magneto-Ionic Theory; A Temperature-Compensated Dynatron Oscillator of High Frequency Stability; The Amplification of Program Transients in Radio Receivers; A Multi-Range, Push-Pull, Thermionic Voltmeter; The Graphical Solution of Simple Parallel-Tuned Circuits;* and *An Electrical Harmonic Analyzer of the Fundamental Suppression Type.*

Report No. 10, Bulletin No. 100, consists of 4 papers of the following titles: *A Directional Recorder for Atmospherics; Observation of Atmospherics with a Narrow Sector Directional Recorder at Canberra; Characteristics and Distribution of Sources of Atmospherics; and Sources of Atmospherics over the Tasman Sea.*

RCA BULLETINS

A number of bulletins are now available from the RCA Manufacturing Company, Inc., Camden, N. J. These bulletins give technical information for all of the following equipment: monitoring equipment (Bulletin 39), Type 94-C monitoring amplifier, Type 62-A remote-pickup equipment, Type 74-A junior velocity microphone, collapsible microphone stand (Type 59-A), Type 44-B velocity microphone, RCA Type 58-A "Tri-Amplifier" (a novel unit which provides complete 3-channel preamplification, mixing and switching), Type 1-D broadcast transmitter (1,000 watts), the 100-F high-frequency transmitter (a commercial 100-watt broadcast transmitter for use in the 30-41 mc band), the Model AVR-11 general-purpose airport receiver, the Models AVR-7B and 7C aircraft radio receivers, and the type 77-A uni-directional microphone.

GENERAL RADIO BULLETIN

The General Radio Company, 30 State Street, Cambridge, Mass., have just published an interesting 4-page bulletin entitled "Variac Transformers for Voltage Control." The Variac is an autotransformer consisting of a single winding on a toroidally-shaped core. Contact between the winding and the load circuit is made through a carbon brush, the output voltages from the unit being continuously variable. This bulletin is available from the above organization.

SMPE FALL CONVENTION

The Fall Convention of the Society of Motion Picture Engineers will be held from October 12 to 15, inclusive, at the Sagamore Hotel in Rochester, New York.

An attractive program of technical papers and presentations is being arranged by the Papers Committee. Sessions and entertainment programs will be conducted at the Sagamore Hotel and at the plants of the Eastman Kodak Company and the Bausch and Lomb Optical Company.

There will be no general apparatus exhibit at this convention because of the limited display space. The Papers Committee, however, is arranging to hold the usual Apparatus Symposium, and would like to be notified of any papers for this session.

WESTERN ELECTRIC BULLETINS

The Western Electric Company, 195 Broadway, New York City, have available a number of new bulletins covering various equipments. These bulletins give rather complete technical information, including wiring diagrams, for the following: the 355 D-1 5-kw radio broadcast transmitter; the No. 22A portable speech-input equipment, the 272A program line panel, the 23A speech-input equipment, the 310A (100 watts) and 310B (100-250 watts) broadcast transmitting equipment. Also available is a complete and interesting bulletin on 100-1000 watt radio transmitting equipment.

COLLINS TUBES

The Collins line of mercury-vapor half-wave rectifiers and power tubes is described in a 4-page bulletin which has just been made available. Average characteristics are given for all the tubes. The Collins Radio Company is located in Cedar Rapids, Iowa.

BRUSH DATA SHEET

The Brush Development Company, East 40th Street at Perkins Avenue, Cleveland, Ohio, is distributing its newly revised Data Sheet No. 10. This is a two-page circular on Brush crystal-operated Type A headphones. It gives a clear and complete description of the construction of the headphone—is complete with prices, etc., of Brush Type A 2-phone head set, single-phone head set and Brush lorgnette handle ear phone for use by the hard of hearing. Copies will be sent postpaid upon request.

TURNER BULLETIN

The various Turner speech-relay systems for use in offices, factories, and the like, are described in a bulletin that has recently been released. Write to the Turner Company, Cedar Rapids, Iowa, for Bulltin No. 9.

WESTERN UNION APPOINTMENT

Appointment of Victor H. Rowland, Assistant Ocean Cable Engineer, to the office of Ocean Cable Engineer of the Western Union Telegraph Company, was announced recently by F. E. d'Humy, Vice-President in charge of the telegraph company's engineering department. The Ocean Cable Engineer and his staff supervise the manufacture, laying and maintenance of the 30,000-odd nautical miles of ocean cable in the Western Union system and direct the work of the cable ships *Lord Kelvin* and *Cyrus Field.*

RAWLPLUG DETROIT CO.

R. G. and T. C. Moeller have established the Rawlplug Detroit Co., 14415 Myers Road, Detroit, Michigan. They are to handle all the products of The Rawlplug Company, Inc., main plant and general offices, New York City. The Rawlplug Co., manufacture a complete line of anchoring devices for all types of material. They also manufacture a novel Lok-Crowner for locking and concealing bolt, rivet, and screw heads.

UTC BULLETIN

United Transformer Corporation has just announced the release of a new bulletin covering equalizers and filters for broadcast, recording and similar services. A complete analysis of various types of filters and their application is given along with schematics, frequency curves, and descriptions of the standard items they manufacture. Included in this leaflet is data on simple equalizers—resonant equalizers—universal equalizers—divider networks—application of equalizers—high Q coils—band-pass filters—band-elimination filters—low-pass filters—and high-pass filters.

A limited number of copies are available. Write to United Transformer Corp., at 72 Spring Street, New York City.

TAYLOR TUBES CATALOG

Taylor Tubes, Inc., 2341-43 Wabansia Ave., Chicago, Illinois, have available a combined catalog and handbook on their tubes. This transmitting-tube handbook is devoted particularly to the solution of the tube problems confronting the amateurs and experimenters. This 30-page booklet contains a great deal of information relative to tubes.

TECH CATALOG

A new catalog is now available from Tech Laboratories, 703 Newark Avenue, Jersey City, N. J. This catalog gives considerable information on the Tech line of attenuators, controls, faders, pads, impedance-matching and delay networks, filters, meters, switches, condensers, resistors, panels, and special instruments.

INDEX OF ADVERTISERS

The Modulation Monitor

1 INEXPENSIVE—$195.00 complete with tubes and accessories. Only a simple pick-up coil or coupling condenser required to place in immediate operation.

2 APPROVED—by the FCC as meeting all requirements of the Government for this type of equipment. In addition a marked improvement in reception in high-fidelity receivers can be expected.

3 COMPLETE UNIT—the General Radio monitor is a self-operated unit of the complete Class 730-A Transmission Monitoring Assembly, the two additional units of which may be added to the Modulation Monitor at any time. The complete assembly guarantees peak performance of the transmitter at all times.

4 LONG LIFE—is assured since the General Radio Monitor is correctly designed, carefully manufactured, accurately calibrated and rigidly inspected. Many years of low-upkeep performance are guaranteed.

Write for Bulletin 42-K for additional details.

GENERAL RADIO COMPANY

30 State Street, Cambridge, Massachusetts