Communication and Broadcast Engineering

VOL. 3 NO. 6

JUNE, 1936

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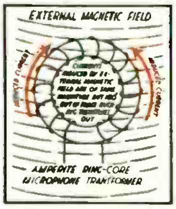

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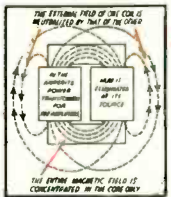

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Associate Editor

VOLUME 3 | JUNE, 1936 | NUMBER 6

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THE TRANSMITTERS AND POWER BOARD ON THE QUEEN MARY. THESE TRANSMITTERS ARE CONTROLLED FROM A ROOM SOME 400 FEET AWAY. SEE ARTICLE ON PAGE 8.

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EDITORIAL

RMA's 5-POINT TELEVISION PROGRAM

AT THE ENGINEERING CONFERENCE on the allocation of ultra-high-frequency waves in Washington, D. C., a 5-point program was recommended to the FCC by James M. Skinner, Chairman of the RMA's Television Committee, and President of the Philadelphia Storage Battery Co. Briefly the five points are as follows:

1. One single set of television standards for the United States, so that all receivers can receive the signals of all transmitters within range.

2. A high-definition picture approaching ultimately the definition obtainable in home movies.

3. A service giving as near nationwide coverage as possible.

4. A selection of programs; that is, simultaneous broadcasting of more than one television program in as many localities as possible.

5. The lowest possible receiver cost and the easiest possible receiver tuning, both of which are best achieved by allocating for television as nearly a continuous band in the radio spectrum as possible.

According to Mr. Skinner, in order to obtain television pictures that will compare favorably with home movies, a definition of 440 or 450 lines will be required, necessitating a channel width of 6 megacycles.

The RMA's Television Committee report will request a television band extending from 42 to 90 mc; the 56 to 60 mc amateur band will not be requested by the RMA unless the Commission finds that this band is not urgently needed by the amateurs. Without the amateur band the space from 42 to 90 mc provides room for seven television broadcasting channels.

The RMA will also request an experimental band beginning at 120 mc. This is said to be required to provide space for television relaying and television pickup from the field to the transmitter . . . as well as for additional broadcasting channels in the future.

It is our opinion that the proposed allocation of the ultra-high frequencies to the various services is the most difficult as well as one of the most important problems that the FCC has had to face. The entire future of the radio industry depends upon the proper solution. It will indeed be interesting to follow the further developments of this hearing.

FACSIMILE

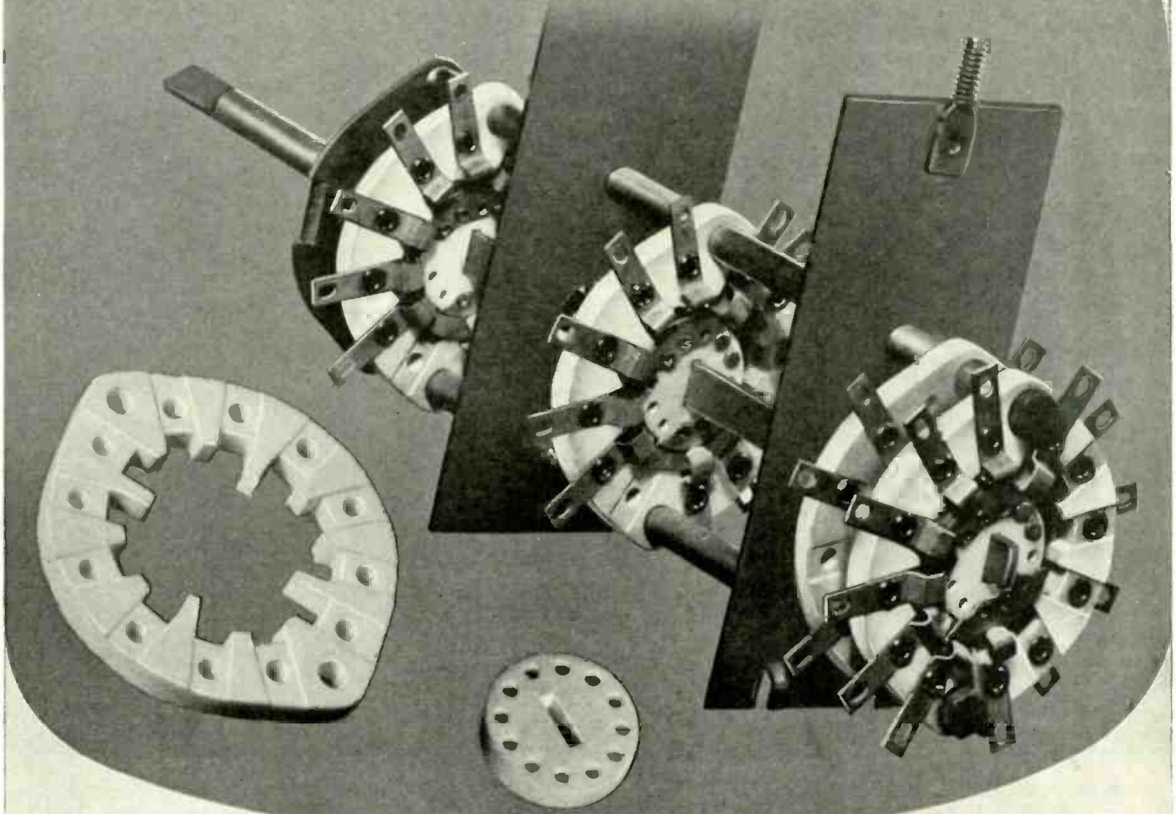
DURING RECENT YEARS much effort and money has been devoted to the development of facsimile transmissions. A transatlantic facsimile service was begun in 1924 and a telephoto service was started in 1925 by the American Telephone and Telegraph Company, the latter method now being used by the Associated Press for transmitting photographs to certain newspaper members. In November of 1935, after about a year and a half of research. Western Union opened a commercial facsimile-telegraph circuit between New York City and Buffalo, N. Y. (See page 21, December, 1935, COMMUNICATION AND BROADCAST ENGINEERING.) Further, considerable experimental work has been done during the last two years by RCA, especially in connection with the transmission of weather maps to ships at sea. On June 11 of this year, this latter organization gave a public demonstration of its facsimile radio circuit between New York City and Philadelphia; further data on this ultra-short-wave system appears elsewhere in this issue. Considerable work with facsimile systems has also been done by independent experimenters.

It is indeed interesting to consider some of the commercial possibilities of facsimile. In connection with business transactions. where time is of paramount importance, the value of facsimile for sending letters, maps, circuits, specifications, etc., is readily apparent. The desirability of incorporating facsimile receiving apparatus in radio receivers for use as "home printing presses" has often been pointed out. It would permit the owner of a radio receiver to have even more timely news in his morning paper than is now available.

It is probably not looking too far into the future to visualize facsimile playing an important role in police-radio communications systems. This would enable the various police departments throughout the country to exchange fingerprints, photographs, criminal records, and the like. Further, it would appear that such a system might be employed advantageously in police-radio patrol cars for the purpose of making permanent records of orders sent from the headquarters' station, thus reducing the possibility of errors at the receiving end.

Briefly, facsimile is adaptable to the transmission of nearly any type of visual material. While all of its possibilities cannot yet be fully appreciated, certainly its applications will be both numerous and important.

Another Contribution



ISOLANTITE has helped to improve many pieces of equipment and now makes another contribution to this CENTRALAB wave change switch.

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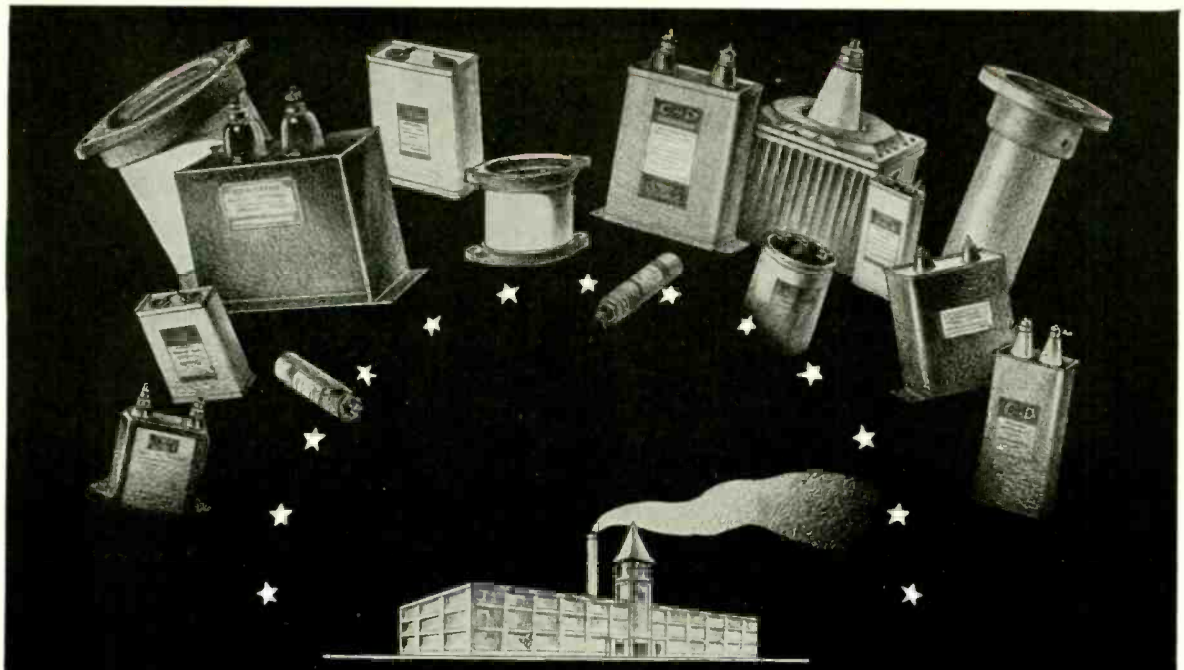

CITED FOR DISTINGUISHED PERFORMANCE IN THE RADIO INDUSTRY

NO citation could be more impressive than the acceptance of Cornell-Dubilier condensers by the radio engineering fraternity. In the electronic field and in the field of physio-therapy, in broadcasting and in high tension systems, in radio receivers and in special applications for the many phases of the radio engineering art, engineers have come to the realization that C-D condensers serve their purpose best.

Cornell-Dubilier high voltage Dykanol Transmitting Capacitors, utilized by leading broadcast and transmitting stations in the world, have established an unrivalled record for unfailing dependability.

Check these outstanding features of these highly efficient capacitors.

- Non-inflammable and non-explosive.
- Can be operated at 10% above voltage rating without damage to unit.
- Substantial reduction in size and weight made possible, due to the high dielectric strength and constant of Dykanol.
- Dykanol impregnated and filled, in hermetically sealed non-corrosive, welded, metal containers, supplied with high insulators and convenient mounting feet.

Cornell-Dubilier Mica Transmitting Capacitors will be found in broadcast installations the world over, where reliability of operation is important.

Investigate the features that make this C-D series famous!

- Assembled with only the finest imported India Ruby Mica.
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COMMUNICATION & BROADCAST ENGINEERING

FOR JUNE, 1936

NAB CONVENTION

To Be Held From July 5 to July 8
At The Stevens Hotel In Chicago

THE FOURTEENTH ANNUAL CONVENTION of the National Association of Broadcasters will be held at the Stevens Hotel, Chicago, on July 5, 6, 7 and 8, 1936. This gathering promises to be one of the most important conventions in the history of the NAB, and it is expected that considerable attention will be devoted to the copyright situation . . . as well as to the future of the broadcasting industry.

LEO J. FITZPATRICK, PRESIDENT OF THE NAB.

OFFICERS

The officers who have been serving the NAB for the last year are: President, Leo J. Fitzpatrick, WJR, Detroit, Michigan: First Vice-President, C. W. Myers, KOIN, Portland, Oregon; Second Vice-President, Edward A. Allen, WLVA, Lynchburg, Virginia; Treasurer, Isaac D. Levy, WCAU, Philadelphia, Pennsylvania; Managing Director, James W. Baldwin, Washington, D. C.

The members of the Board of Directors are as follows: Ralph R. Brunton, KJBS, San Francisco, California; Harry C. Butcher, WJSV, Washington, D. C.: H. K. Carpenter, WHK, Cleveland, Ohio; Arthur B. Church, KMBC, Kansas City, Missouri; Gardner Cowles, Jr., KSO, Des Moines, Iowa; Edwin W. Craig, WSM, Nashville. Tennessee: W. Wright Gedge, WMBC, Detroit. Michigan; John J. Gillin, Jr., WOW, Omaha, Nebraska; William S. Hedges, WEAF, New York City, New York: I. R. Lounsberry, WGR-WKBW, Buffalo, New York; Alfred J. McCosker, WOR, Newark. New Jersey: J. O. Maland, WHO, Des Moines, Iowa; Gordon Persons, WSFA, Montgomery, Alabama; Frank M. Russell, WRC, Washington, D. C.; T. W. Symons, Jr., KFPY, Spokane, Washington.

Managing Director, James W. Baldwin has appointed a Local Convention Committee. This group was selected from the NAB member stations in Chicago. Its members are: Glenn Snyder, Ralph L. Atlass, H. Leslie Atlass, H. C. Crowell, Gene T. Dyer, W. E. Hutchinson, Quin A. Ryan, F. A. Sanford, Niles Trammel and Clinton R. White. Glenn Snyder has been appointed Chairman of this Committee.

GENERAL INFORMATION

The registration desk will be open from 10:00 a. m. until 1:00 p. m. on Sunday, July 5, and from 8:30 a. m. until 5:00 p. m. on Monday, Tuesday and Wednesday. The registration fee is $10.00 per person: banquet tickets may be purchased at Registration Desk at $3.50 each.

All general sessions will start promptly at 9:30 a. m. All motions and resolutions offered by delegates must be in writing and handed to the presiding officer after presentation.

The Sixth Annual NAB Championship Golf Tournament, for the Broad-

ISAAC D. LEVY.
TREASURER, NAB.

CHARLES W. MYERS,
FIRST VICE-PRESIDENT, NAB.

EDWARD A. ALLEN,
SECOND VICE-PRESIDENT, NAB.

cast Advertising Magazine Trophy, will be held Sunday. The first foursome will tee off at 10:30 a. m.

PROGRAM

The tentative program for the convention follows:

Monday, July 6, 1936

9:30 a. m.—*Call to Order.*

Address of Welcome:
Hon. Edward J. Kelly, Mayor of Chicago.

Address of the President:
Mr. Leo J. Fitzpatrick, WJR, Detroit, Michigan.

Address of the Chairman, Broadcast Division, Federal Communications Commission:
Judge Eugene Octave Sykes, Washington, D. C.

Address of Treasurer:
Mr. Isaac D. Levy, WCAU, Philadelphia, Pennsylvania.

Report of the Managing Director:
Mr. James W. Baldwin, Washington, D. C.

Appointment of Committees.

Announcements.

Adjournment.

No Afternoon Sessions Scheduled.

Committee Meetings (at call of Chairman).
Nominating Committee, Private Dining Room 1 (3rd floor).
Commercial Committee. Private Dining Room 3 (3rd floor).
Engineering Committee, Private Dining Room 4 (3rd floor).
Resolutions Committee, Private Dining Room 5 (3rd floor).

Tuesday, July 7, 1936

9:30 a. m.: *Call to Order.*

Cooperative Bureau of Radio Research:
Mr. Arthur B. Church, Kansas City, Missouri.

Discussion.

What the Radio Business Census Means to the Radio Broadcasting Industry:
C. H. Sandage, Chief, Division of Transportation and Communications, Bureau of the Census, Philadelphia, Pennsylvania.

Discussion.

A Panel Discussion:
Organizing a station for selling Radio Advertising. Mr. H. K. Carpenter, Cleveland, Ohio.

Discussion.

2: p. m.—*Call to Order.*

Report of Nominating Committee.

Election of officers.

7:00 p. m.—*Annual NAB Banquet*:
Presentation of trophy to winner of Golf Tournament. Entertainment.

Wednesday, July 8, 1936

9:30 a. m.—*Call to Order.*

Report of Commercial Committee:
Mr. Arthur B. Church, Chairman, Kansas City, Missouri.

Report of Engineering Committee:
Mr. J. H. DeWitt, Chairman, WSM, Nashville, Tennessee.

Report of Resolutions Committee.

2:00 p. m.—*Call to Order.*

General Discussion.

Report of Elections Committee.

Installation of officers.

Adjournment.

TELEVISION DEMONSTRATION

CULMINATING several years of experimentation, a television receiver has been announced by Harry R. Lubcke, Director of Television, Don Lee Broadcasting System. Simultaneously with the announcement of the new instrument's completion came the word that the Don Lee experimental television station, W6XAO, would immediately assume the following regular daily (except Sunday) broadcast schedule: 3:00 to 5:00 p. m., and 6:30 to 8:30 p. m., pst. Television transmissions have gone out from W6XAO since December, 1931.

Demonstration of the transmitter and cathode-ray tube receiver was witnessed on Thursday, June 4, by press representatives of metropolitan Los Angeles.

Both the receiver and the system in general are said to be based upon patents of Mr. Lubcke, who declares that the equipment and principles involved are in radical departure from other systems. The receiver consists of a cathode-ray tube unit, two scanning sources, the television signal amplifier and the power supply. The images are composed of 300 lines and are repeated 24 times per second.

NEW AIRCRAFT RECEIVER

FRONT VIEW OF THE 20A RECEIVER.

IN A SINGLE, small and light-weight radio receiver for aircraft, Bell Telephone Laboratories have combined three important services for the private flyer. Now, in the limited space available aboard the smaller types of planes, this compact unit may be conveniently installed, bringing to the pilot efficient reception in the beacon and the broadcast bands as well as in the short-wave bands employed for communication with ground stations. This new three-purpose receiver is known as the Western Electric 20 type, and is supplied with or without a small remote-control unit, which may be mounted on or near the plane's instrument panel. A flexible cable connecting the remote-control unit with the receiver, permits installation in some out-of-the-way place.

The new receiver is a superheterodyne, with one stage of tuned-radio-frequency amplification, two stages of intermediate-frequency amplification and two stages of audio-frequency amplification. Four separate frequency bands are provided, the first band being 200 to 400 kilocycles, for beacon and weather stations. The second band is from 550 to 1500 kilocycles, for commercial broadcast stations. The third band is from 1500 to 4000 kilocycles for aircraft, police and amateur communications; and the fourth band is from 4000 to 10,000 kilocycles, for aircraft, amateur and foreign broadcast stations.

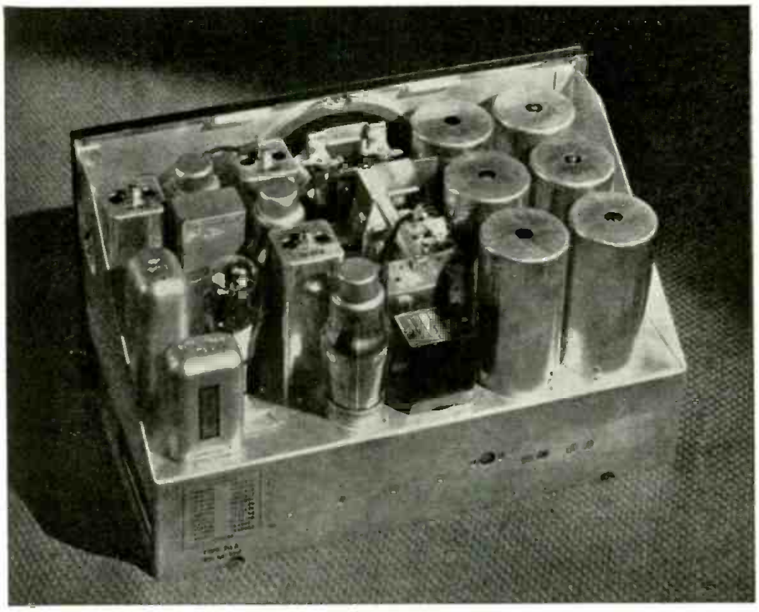
One form of the receiver has its controls mounted directly on the front panel and is intended for mounting within easy reach of the pilot, whereas the other is provided with a remote-control unit on a flexible cable. The diminutive control unit may be mounted flush on the plane's instrument panel, if desired, for convenience and accessibility.

The output of the receiver is 700 milliwatts, which is sufficient to operate as many as six pairs of headphones simultaneously if desired. It is so designed that crystal-controlled reception in either or both of the high-frequency bands may be employed, and for this purpose a two-frequency crystal-control unit is available to be incorporated in the receiver. One of the crystals may be used in each of the high-frequency bands, or both may be employed in the same band. The definite day and night frequencies for communications between commercial planes and ground stations make this a desirable feature.

A device known as the "varistor" reduces loud static crashes when receiving weak signals, and the automatic volume control is normally used except for beacon reception, where it might interfere with the performance of the receiver for course indication.

The convenient facilities for transferring from one to another of the four-frequency bands available, combined with its other features, make this receiver particularly well adapted for marine applications as well as for the use of police and other municipal, county, state and federal agencies. In aviation service, its utility is not confined to the privately operated plane, but it is also well suited for emergency service in transport and mail planes.

Including its compliment of vacuum tubes, the receiver weighs only 14¾ pounds and measures only 9 inches high, 14⅝ inches wide and 8¼ inches deep. The unit has been constructed to withstand the rigorous conditions of flying and includes a spot-welded chassis as well as special shock-absorbing rubber mountings.



REAR VIEW OF 20A AVIATION RADIO RECEIVER.

THE PASSENGERS' RADIO-ACCEPTING OFFICE.

THE QUEEN MARY'S

THE TRANSMITTING ROOM. ANOTHER VIEW OF THIS ROOM IS SHOWN ON THE FRONT COVER.

WHEN THE *Queen Mary* sailed, shipping was not the only industry which welcomed a magnificent new unit. Throughout her voyages this great ship will be within ready communication by telegraph and telephone with all parts of the civilized world.

Here are a few salient facts about her radio plant: four major transmitters and eight receivers, weight eleven tons; complete emergency unit comparable in power to the major transmitters of many ships; 31 wave bands; operating capacity of about 150 radiograms per hour simultaneously with telephone conversations to America and to Great Britain which may be passed from either switching point to any part of the world; 14 operators compared to the usual 4 on other large vessels; motor-driven lifeboats equipped with radiotelephone as well as telegraph.

The radio plant for the *Queen Mary* complete has been supplied and installed, and will be operated for the Cunard-White Star Line by the International Marine Radio Company, Ltd., of London, associated company of the International Telephone and Telegraph Corp.

The four main transmitters on the *Queen Mary* consist of one long-wave, continuous-wave transmitter; a medium-wave, continuous and modulated continuous-wave; and two short-wave transmitters capable of operating in either radio-telegraph or radiotelephone service. The long-wave transmitter covers all wavelengths between 1875 and 2725 meters with seven "spot" waves assigned: the medium wave unit covers 600-800 meters with four "spot" waves; and the short-wave radiotelephone and radiotelegraph transmitters cover all wavelengths in the marine bands between 17 and 96 meters and each of these units has ten crystal-controlled "spot" waves.

Wave changes from "spot" to "spot" may be made in from three to five seconds by remote control from the main radio-operating room of the ship. The operators have a dial apparatus for this purpose similar to that on the ordinary dial telephone.

The eight receivers are arranged in four operating positions, divided primarily into long-wave, medium-wave and two short-wave positions. These positions, however, are interchangeable inasmuch as all four provide for telegraph operation on long, medium and short waves. They are equipped with automatic telegraph transmitters and recorders for high-speed operating. There are also three spare receivers for use during extraordinary loads.

The room in which the receivers are situated is the main radio-operating room of the ship. The transmitters, 400 feet distant to avoid interference with reception, are operated from the receiving positions and all of the new devices for modulating and perfecting the telephone transmission and reception are in this general radio-operating room. Automatic control of the transmitters is duplicated throughout and the entire installation has been designed for multiplex operation, that is, each of the four transmitters can be operated independently or all can be operated simultaneously. The eight receivers can, of

THE FADIO CONTROL ROOM.

THE CONTROL ROOM SHOWING OPERATORS AT WORK.

course, be operated at the same time.

As mentioned previously, the radiotelephone service can be provided through either or both of the short-wave transmitters. Normally two radiotelephone calls can be handled simultaneously, one to America and one to Great Britain. This means that, switching through New York and London into the world radiotelephone network which interconnects about 93 percent of all the telephones in the world, a person in any of the 500 cabins on the ship is able to talk on the telephone with any part of the world. Special telephone booths for the radiotelephone service are also available at convenient locations on the ship.

Any possibility of eavesdropping on the radiotelephone conversations with the *Queen Mary* has been forestalled. The radiotelephone installation is equipped with a scrambling device which renders the conversations entirely unintelligible until they go through the receiving stations where they are unscrambled.

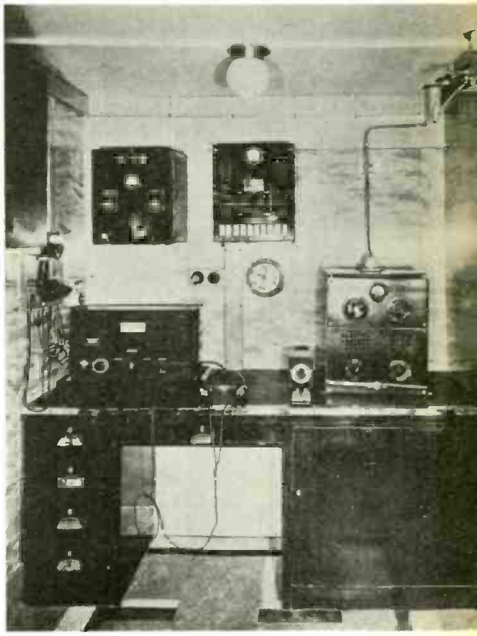
The radio direction finder is of brand new design. It has been thoroughly tested at sea. Its bearings under all conditions have been consistently sharp.

The main transmitting aerial of the *Queen Mary* consists of two parallel wires twelve feet apart extending 600 feet between the masts. There are eight other aerials, four transmitting and three receiving, and a special 600-meter transmitting and receiving aerial for the emergency equipment.

This emergency installation which is as powerful as the main radio on many other vessels is a completely self-contained unit for use in the event of trouble so major as to affect the main power supply. The radio power plant itself is duplicated throughout to forestall any possibility of mechanical failure. The emergency transmitter and receiver operate from a large accumulator battery which is, of course, entirely independent of the ship's power plant.

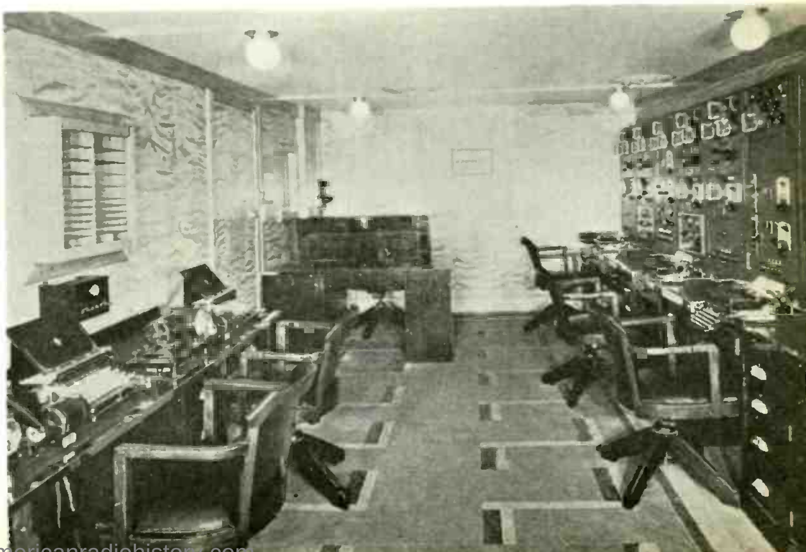
Two motor-driven lifeboats, in addition to being equipped with radiotelegraph sets, have a radiotelephone installation as well, which provides a second and alternate means of communication. This lifeboat-radiotelephone set is especially robust and it can be operated without difficulty by unskilled persons. It is substantially the same kind of equipment supplied to trawlers and other boats of similar size which do not carry a professional operator.

In its radiotelegraph communication with the United States the *Queen Mary* will operate, for the most part, with the coastal stations of the Mackay Radio and Telegraph Company. The service in the main will be conducted through the famous Mackay Radio station (WSL) at Sayville, L. I., and the new station (WSE) at Amagansett, Montauk Point, L. I. Both of these marine transmitters are operated by remote control from the Mackay Radio receiving center and concentrated operating department at Southampton, and Southampton is connected by a group of direct wires with the main operating center of Mackay Radio in the International Telephone and Telegraph Building at 67 Broad Street, New York City.



THE EMERGENCY EQUIPMENT COMPRISING TRANSMITTER, RECEIVER AND ACCUMULATOR BATTERY.

ANOTHER VIEW OF THE CONTROL ROOM SHOWING AUTOMATIC HIGH-SPEED EQUIPMENT (LEFT), AND PART OF THE RECEIVING EQUIPMENT (RIGHT).



FUNDAMENTALS IN THE APPLICATION OF MATRICES TO ELECTRICAL NETWORKS

Part I

By JOSEPH R. PERNICE

THE ANALYSIS of networks and the solution of network problems are, in many instances, facilitated by the use of matrices. The first publication on the subject appeared in Germany in 1929 in "Elektrische Nachrichten-Technik," in a paper by F. Strecker and R. Feldtkeller; in 1931 and 1932 other papers on the subject appeared written by E. Selache and H. G. Bearwald. In the United States the method was presented and utilized by Dr. E. A. Guillemin in his book "Communication Networks" (1935). At the Case School of Applied Science, Professor R. S. Burington has materially extended the theory. The present writer's introduction to the subject came in part from a course at Columbia University under Professor John B. Russell to whom he expresses his appreciation and gratitude.

The application of matrices to the solution of electrical network problems, however, has not spread beyond a limited number of pioneering engineers. Since the use of the matrix affords a new and rather novel insight into the analysis of networks, having striking advantages in certain applications, this subject no doubt will be of growing importance to the engineer engaged in transmission work. With the use of matrices the solution of tedious problems is in many cases made less fatiguing and it affords a substantial saving of time. Much practical value should be gained by the practicing engineer from an instructive presentation of the principles in the application of matrices to networks.

A series of three articles, therefore, will be presented in successive issues of this publication in which these principles will be developed and applied to illustrative problems.

In order to grasp the ideas to be discussed in these articles, familiarity with the operation of matrix algebra is necessary. Hence, we shall first present the fundamental theory of matrices which will enable us to understand how to "set-up" a matrix and how to perform the operations of multiplication and addition, the use of which is very important in the network theory.

FUNDAMENTALS IN MATRIX ALGEBRA

Let us consider the system of equations

$$a_{11} x_1 + a_{12} x_2 = y_1 \quad \ldots\ldots (1)$$
$$a_{21} x_1 + a_{22} x_2 = y_2 \quad \ldots\ldots (2)$$

and

$$b_{11} y_1 + b_{12} y_2 = d_1 \quad \ldots\ldots (3)$$
$$b_{21} y_1 + b_{22} y_2 = d_2 \quad \ldots\ldots (4)$$

Then it can be shown that

$$c_{11} x_1 + c_{12} x_2 = d_1 \quad \ldots\ldots (5)$$
$$c_{21} x_1 + c_{22} x_2 = d_2 \quad \ldots\ldots (6)$$

Substituting the value of y_1 and y_2 of equations (1) and (2) into equations (3) and (4) we obtain

$$d_1 = b_{11} y_1 + b_{12} y_2 = b_{11} (a_{11} x_1 + a_{12} x_2) + b_{12} (a_{21} x_1 + a_{22} x_2)$$
$$d_2 = b_{21} y_1 + b_{22} y_2 = b_{21} (a_{11} x_1 + a_{12} x_2) + b_{22} (a_{21} x_1 + a_{22} x_2)$$

or

$$d_1 = (b_{11} a_{11} + b_{12} a_{21}) x_1 + (b_{11} a_{12} + b_{12} a_{22}) x_2 \quad \ldots\ldots (7)$$
$$d_2 = (b_{21} a_{11} + b_{22} a_{21}) x_1 + (b_{21} a_{12} + b_{22} a_{22}) x_2 \quad \ldots\ldots (8)$$

This simple derivation forms the basis of Matrix Algebra. We will now proceed to define the "Matrix" and to show how the matrices of a system of equations are interrelated.

Consider the equations (1) and (2), (3) and (4), (5) and (6). Their respective "a," "b" and "c" matrices are as follows:

$$\|a\| = \begin{Vmatrix} a_{11} & a_{12} \\ a_{21} & a_{22} \end{Vmatrix}; \quad \|b\| = \begin{Vmatrix} b_{11} & b_{12} \\ b_{21} & b_{22} \end{Vmatrix}; \quad \|c\| = \begin{Vmatrix} c_{11} & c_{12} \\ c_{21} & c_{22} \end{Vmatrix}$$

Thus the "a," "b" and "c" matrices for these systems of equations are defined as arrangements in rows and columns of the coefficients of x and y, the elements being written between a set of vertical lines as shown.

Now if we carefully examine equations (7) and (8) it is found that we have actually derived by algebraic methods the "c" matrix of equations (5) and (6). However, the "c" matrix could be obtained by taking the product of the "b" and "a" matrices. This product is defined as follows:

$$\|c\| = \|b\| \cdot \|a\| = \begin{Vmatrix} b_{11} & b_{12} \\ b_{21} & b_{22} \end{Vmatrix} \cdot \begin{Vmatrix} a_{11} & a_{12} \\ a_{21} & a_{22} \end{Vmatrix} = \begin{Vmatrix} c_{11} & c_{12} \\ c_{21} & c_{22} \end{Vmatrix} =$$
$$\begin{Vmatrix} (b_{11} a_{11} + b_{12} a_{21}) & (b_{11} a_{12} + b_{12} a_{22}) \\ (b_{21} a_{11} + b_{22} a_{21}) & (b_{21} a_{12} + b_{22} a_{22}) \end{Vmatrix}$$

Thus $c_{11} = b_{11} a_{11} + b_{12} a_{21}$; $\quad c_{12} = b_{11} a_{12} + b_{12} a_{22}$;
$c_{21} = b_{21} a_{11} + b_{22} a_{21}$; $\quad c_{22} = b_{21} a_{12} + b_{22} a_{22}$;

In taking the product of two matrices the row by column method is used. The process is illustrated in the above example. It should be noted that the "c_{11}" element is obtained by taking the product of the first "b" element in the first *row* and the first "a" element in the first *column* plus the product of the second "b" element in the first *row* and the second "a" element of the first *column*. The "c_{12}" element is obtained by the product of the first "b" element in the first *row* and the first "a" element in the second *column* plus the product of the second "b" element of the first *row*, and the second "a" element of the second *column*. A similar method is used in finding the "c_{21}" and "c_{22}" elements. As multiplication is frequently used a mental picture should be made of how the elements are grouped when taking the product.

In the original system of equations we may wish to consider the "x," "y" and "d" matrices. These are respectively written as follows:

$$\|x\| = \begin{Vmatrix} x_1 & 0 \\ x_2 & 0 \end{Vmatrix} = \begin{Vmatrix} x_1 \\ x_2 \end{Vmatrix}$$

$$\|y\| = \begin{Vmatrix} y_1 & 0 \\ y_2 & 0 \end{Vmatrix} = \begin{Vmatrix} y_1 \\ y_2 \end{Vmatrix}$$

$$\|d\| = \begin{Vmatrix} d_1 & 0 \\ d_2 & 0 \end{Vmatrix} = \begin{Vmatrix} d_1 \\ d_2 \end{Vmatrix}$$

It should be noted that the elements of the second column of these matrices happen to be equal to zero; otherwise the arrangement of the elements is the same as those of the "a," "b" and "c" matrices.

Let us now derive the inter-relationship of the various matrices.

$$\text{Thus } \|y\| = \begin{Vmatrix} y_1 & 0 \\ y_2 & 0 \end{Vmatrix} = \|a\| \cdot \|x\| = \begin{Vmatrix} a_{11} & a_{12} \\ a_{21} & a_{22} \end{Vmatrix} \cdot \begin{Vmatrix} x_1 & 0 \\ x_2 & 0 \end{Vmatrix} = \begin{Vmatrix} (a_{11} x_1 + a_{12} x_2) & 0 \\ (a_{21} x_1 + a_{22} x_2) & 0 \end{Vmatrix}$$

From which it is recognized that $y_1 = a_{11} x_1 + a_{12} x_2$ and $y_2 = a_{21} x_1 + a_{22} x_2$

since like terms in equal matrices are equal.

Similarly

$$\|d\| = \begin{Vmatrix} d_1 & 0 \\ d_2 & 0 \end{Vmatrix} = \|b\| \cdot \|y\| = \|c\| \cdot \|x\| = \|b\| \cdot \|a\| \cdot \|x\|$$

$$\text{Thus} \quad \|d\| = \begin{Vmatrix} b_{11} & b_{12} \\ b_{21} & b_{22} \end{Vmatrix} \cdot \begin{Vmatrix} y_1 & 0 \\ y_2 & 0 \end{Vmatrix} = \begin{Vmatrix} (b_{11} y_1 + b_{12} y_2) & 0 \\ (b_{21} y_1 + b_{22} y_2) & 0 \end{Vmatrix}$$

From which it is recognized that $d_1 = b_{11} y_1 + b_{12} y_2$ and $d_2 = b_{21} y_1 + b_{22} y_2$

We may consider also that

$$\|d\| = \begin{Vmatrix} b_{11} & b_{12} \\ b_{21} & b_{22} \end{Vmatrix} \cdot \begin{Vmatrix} a_{11} & a_{12} \\ a_{21} & a_{22} \end{Vmatrix} \cdot \begin{Vmatrix} x_1 & 0 \\ x_2 & 0 \end{Vmatrix} =$$

$$\begin{Vmatrix} (b_{11} a_{11} + b_{12} a_{21}) & (b_{11} a_{12} + b_{12} a_{22}) \\ (b_{21} a_{11} + b_{22} a_{21}) & (b_{21} a_{12} + b_{22} a_{22}) \end{Vmatrix} \cdot \begin{Vmatrix} x_1 & 0 \\ x_2 & 0 \end{Vmatrix}$$

$$= \begin{Vmatrix} [(b_{11} a_{11} + b_{12} a_{21}) x_1 + (b_{11} a_{12} + b_{12} a_{22}) x_2] & 0 \\ [(b_{21} a_{11} + b_{22} a_{21}) x_1 + (b_{21} a_{12} + b_{22} a_{22}) x_2] & 0 \end{Vmatrix}$$

and now we obtain

$$d_1 = (b_{11} a_{11} + b_{12} a_{21}) x_1 + (b_{11} a_{12} + b_{12} a_{22}) x_2 = c_{11} x_1 + c_{12} x_2$$
$$d_2 = (b_{21} a_{11} + b_{22} a_{21}) x_1 + (b_{21} a_{12} + b_{22} a_{22}) x_2 = c_{21} x_1 + c_{22} x_2$$

It is of interest to note that we have derived the original systems of equations merely from a manipulation of matrices of these equations. Furthermore, the interrelations of these matrices are defined by the operations just described which should be kept in mind.

In performing operations with matrices the following rules must be observed.

1. Multiplication of two matrices is not *commutative.*

$$\|p\| \cdot \|q\| \neq \|q\| \cdot \|p\|$$

2. Matrices are distributive in the sense that if two matrices are equal their respective elements are equal. If $\|a\| = \|b\|$, then $a_{11} = b_{11}$, $a_{12} = b_{12}$, $a_{21} = b_{21}$, and $a_{22} = b_{22}$.

3. Matrices have associative properties in the sense that the sum of two matrices is given by the sum of their respective terms.

$$\|a\| + \|b\| = \begin{Vmatrix} a_{11} a_{12} \\ a_{21} a_{22} \end{Vmatrix} + \begin{Vmatrix} b_{11} b_{12} \\ b_{21} b_{22} \end{Vmatrix} = \begin{Vmatrix} (a_{11} + b_{11}) & (a_{12} + b_{12}) \\ (a_{21} + b_{21}) & (a_{22} + b_{22}) \end{Vmatrix}$$

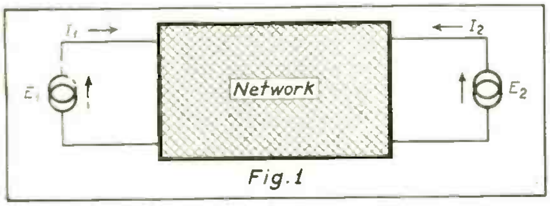


Fig. 1

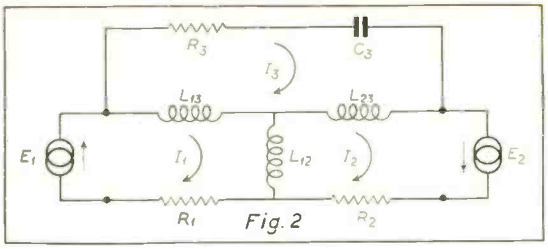


Fig. 2

4. A common factor can be factored out of its associated matrix.

$$\begin{Vmatrix} ha_{11} & ha_{12} \\ ha_{21} & ha_{22} \end{Vmatrix} = h \begin{Vmatrix} a_{11} & a_{12} \\ a_{21} & a_{22} \end{Vmatrix} = h \|a\|$$

SYSTEM OF GENERAL EQUATIONS FOR FOUR-TERMINAL NETWORKS

For any four-terminal network such as is shown in Fig. 1 we can express the sending voltage and current and the receiving voltage and current by the following system of general equations:

$$I_1 = y_{11} E_1 + y_{12} E_2 \quad \text{(9)}$$
$$I_2 = y_{21} E_1 + y_{22} E_2 \quad \text{(10)}$$
$$E_1 = z_{11} I_1 + z_{12} I_2 \quad \text{(11)}$$
$$E_2 = z_{21} I_1 + z_{22} I_2 \quad \text{(12)}$$
$$E_1 = AE_2 - BI_2 \quad \text{(13)}$$
$$I_1 = CE_2 - \mathit{D}I_2 \quad \text{(14)}$$
$$E_2 = \mathit{D}E_1 - BI_1 \quad \text{(15)}$$
$$I_2 = CE_1 - AI_1 \quad \text{(16)}$$

The general network equations (9 to 16) were expressly set up in terms of the functions shown so that the independent and dependent variables would conform with the requirements of the system of equations which allows the use of matrix algebra in computing network combinations.

In these equations the "y" and "z" are respectively admittance and impedance functions of the network. The letters "A," "B," "C" and "*D*" represent the general circuit functions of the network. "A" and "*D*" are merely ratios of two admittances or two impedances and hence are constants for a given network. But "B" is the reciprocal of an admittance and it represents an impedance while "C" is the reciprocal of an impedance and thus it is an admittance. All of these functions will be later explicitly defined in terms of the network parameters.

In Fig. 1 the voltages and currents are assumed in the directions shown. The voltage E_1 is across the input terminals of the network while the voltage E_2 appears across the output terminals of the network. E_2 may be a voltage source or it may exist by virtue of the impedance drop across the receiving load.

The network equations (9 to 16) are perfectly general for any four-terminal network regardless of the number or type of meshes or the configuration of the parameters. It is of interest to note that in these equations only the terminal voltages and currents are taken into account.

We shall now derive the general network system of equations (9 to 16) and define the terms used in these equations. For simplicity let us consider some network such as is shown in Fig. 2. Let I_1, I_2, I_3 and E_1, E_2 and E_3 be the mesh currents and voltages of the first, second and third meshes, respectively. Then by Kirchhoff's Law we can write the mesh voltages as follows:

$$[j\omega(L_{12} + L_{13}) + R_1] I_1 - (j\omega L_{12}) I_2 - (j\omega L_{13}) I_3 = E_1$$
$$-(j\omega L_{12}) I_1 + [j\omega (L_{12} + L_{23}) + R_2] I_2 - (j\omega L_{23}) I_3 = E_2$$

$$-(j\omega L_{13})\ I_1 - (j\omega L_{23})\ I_2 +$$

$$\left[j\omega\ (L_{13} + L_{23}) + R_3 + \frac{1}{j\omega c_3} \right] I_3 = E_3 = 0$$

Let us rewrite these equations in terms of the corresponding self-impedances and transfer impedances. Thus we have that

$$Z_{11} I_1 - Z_{12} I_2 - Z_{13} I_3 = E_1$$
$$-Z_{21} I_1 + Z_{22} I_2 - Z_{23} I_3 = E_2$$
$$-Z_{31} I_1 - Z_{32} I_2 + Z_{33} I_3 = E_3 = 0$$

For reasons which will be subsequently obvious we shall solve these equations for the mesh currents I_1, I_2, and I_3 by the use of determinants.

The determinant is

$$D = \begin{vmatrix} Z_{11} & -Z_{12} & -Z_{13} \\ -Z_{21} & Z_{22} & -Z_{23} \\ -Z_{31} & -Z_{32} & Z_{33} \end{vmatrix} = Z_{11} \begin{vmatrix} Z_{22} & -Z_{23} \\ -Z_{32} & Z_{33} \end{vmatrix}$$

$$(-1)^{1+1} + Z_{21} \begin{vmatrix} -Z_{12} & -Z_{13} \\ -Z_{32} & Z_{33} \end{vmatrix} (-1)^{2+1} + Z_{31} \begin{vmatrix} -Z_{12} & -Z_{13} \\ Z_{22} & -Z_{23} \end{vmatrix} (-1)^{3+1}$$

or $D = Z_{11} M_{11} (-1)^{1+1} + Z_{21} M_{21} (-1)^{2+1} + Z_{31} M_{31} (-1)^{3+1}$

Thus

$$I_1 = \frac{\begin{vmatrix} E_1 & -Z_{12} & -Z_{13} \\ E_2 & Z_{22} & -Z_{23} \\ E_3 & -Z_{32} & Z_{33} \end{vmatrix}}{D}$$

$$= \frac{E_1 M_{11} (-1)^{1+1} + E_2 M_{21} (-1)^{2+1} + E_3 M_{31} (-1)^{3+1}}{D}$$

or $I_1 = E_1 \dfrac{M_{11}}{D} (-1)^{1+1} + E_2 \dfrac{M_{21}}{D} (-1)^{2+1} + E_3 \dfrac{M_{31}}{D} (-1)^{3+1}$

and similarly

$$I_2 = E_1 \frac{M_{12}}{D} (-1)^{1+2} + E_2 \frac{M_{22}}{D} (-1)^{2+2} + E_3 \frac{M_{32}}{D} (-1)^{3+2}$$

and

$$I_3 = E_1 \frac{M_{13}}{D} (-1)^{1+3} + E_2 \frac{M_{23}}{D} (-1)^{2+3} + E_3 \frac{M_{33}}{D} (-1)^{3+3}$$

Examining the equation for the current I_1 it is of interest to observe that the first term of this equation represents the current in the first mesh due to the voltage in the first mesh. The second term represents the current in the first mesh due to the voltage in the second mesh and, similarly, the third term gives the current in the first mesh due to the voltage in the third mesh. Incidentally, we have actually proven the "Superposition Theorem" for the case where the voltages E_1, E_2 and E_3 are all of the same frequency.

We have considered a network of only three meshes. But the theory developed can be applied to any network consisting of any number of meshes made up of lumped inductances, capacitances and resistances. Thus, in general, the current in the first mesh would be expressed as follows:

$$I_1 = E_1 \frac{M_{11}}{D} (-1)^{1+1} + E_2 \frac{M_{21}}{D} (-1)^{2+1}$$

$$+ \ldots + E_j \frac{M_{j1}}{D} (-1)^{j+1} + \ldots + E_n \frac{M_{n1}}{D} (-1)^{n+1}$$

or

$$I_1 = \sum_{j=1}^{j=n} E_j \frac{M_{j1}}{D} (-1)^{j+1}$$

and similarly the current in the second mesh

$$I_2 = E_1 \frac{M_{12}}{D} (-1)^{1+2} + E_2 \frac{M_{22}}{D} (-1)^{2+2}$$

$$+ \ldots + E_j \frac{M_{j2}}{D} (-1)^{j+2} + \ldots + E_n \frac{M_{n2}}{D} (-1)^{n+2}$$

or

$$I_2 = \sum_{j=1}^{j=n} E_j \frac{M_{j2}}{D} (-1)^{j+2}$$

In the general equation for the mesh currents it is of importance to notice that in the expression M_{jk}/D, the M_{jk} is the minor of the "j" row and "k" column of the determinant D. The term M_{jk}/D represents an admittance or, in other words, a current per unit voltage and it is expressed in terms of the impedances of the network.

Now in any network such as represented by Figs. 1 and 2, all mesh voltages except the sending voltage E_1 and the receiving voltage E_2 are zero. Hence, in the general current equations just derived all terms drop out except those associated with E_1 and E_2. Consequently, we have that in any four terminal network

$$I_1 = E_1 \frac{M_{11}}{D} (-1)^2 + (-E_2) \frac{M_{12}}{D} (-1)^3$$

and $\quad (-I_2) = E_1 \dfrac{M_{12}}{D} (-1)^3 + (-E_2) \dfrac{M_{22}}{D} (-1)^4$

but let us define $\quad y_{11} = \dfrac{M_{11}}{D}$

and $\quad y_{12} = \dfrac{M_{12}}{D} = y_{21} = \dfrac{M_{21}}{D}$

and $\quad y_{22} = \dfrac{M_{22}}{D}$

Thus it follows that $I_1 = y_{11} E_1 + y_{12} E_2$ and
$I_2 = y_{21} E_1 + y_{22} E_2$

thereby establishing equations (9) and (10).

In order to establish equations (11) and (12), let us solve by the use of determinants for E_1 and E_2 in the equations just derived.

$$E_1 = \frac{\begin{vmatrix} I_1 & y_{12} \\ I_2 & y_{22} \end{vmatrix}}{\begin{vmatrix} y_{11} & y_{12} \\ y_{21} & y_{22} \end{vmatrix}} = \frac{y_{22} I_1 - y_{12} I_2}{|y|} = \frac{y_{22}}{|y|} I_1 - \frac{y_{12}}{|y|} I_2$$

Let $\quad z_{11} = \dfrac{y_{22}}{|y|}$ and $z_{12} = -\dfrac{y_{12}}{|y|}$

Then $\quad E_1 = z_{11} I_1 + z_{12} I_2$

Similarly

$$E_2 = \frac{\begin{vmatrix} y_{11} & I_1 \\ y_{21} & I_2 \end{vmatrix}}{\begin{vmatrix} y_{11} & y_{12} \\ y_{21} & y_{22} \end{vmatrix}} = \frac{y_{11} I_2 - y_{21} I_1}{|y|} = \frac{y_{11}}{|y|} I_2 - \frac{y_{21}}{|y|} I_1$$

Let $\quad z_{21} = -\dfrac{y_{21}}{|y|}$ and $z_{22} = \dfrac{y_{11}}{|y|}$

Then $\quad E_2 = z_{21} I_1 + z_{22} I_2$

To prove equations (13) and (14) let us consider the equation previously derived: $I_2 = y_{21} E_1 + y_{22} E_2$

This can be written $\quad y_{21} E_1 = I_2 - y_{22} E_2$

or $\quad E_1 = \dfrac{1}{y_{21}} I_2 - \dfrac{y_{22}}{y_{21}} E_2$

If $\quad A = -\dfrac{y_{22}}{y_{21}}$ and $B = -\dfrac{1}{y_{21}}$

then $$E_1 = AE_2 - BI_2$$

It has been shown that $I_1 = y_{11}E_1 + y_{12}E_2$ and that

$$E_1 = \frac{I_2}{y_{21}} - \frac{y_{22}}{y_{21}}E_2$$

Thus
$$I_1 = y_{11}\left[\frac{I_2}{y_{21}} - \frac{y_{22}}{y_{21}}E_2\right] + y_{12}E_2$$
$$= \frac{y_{11}}{y_{21}}I_2 - \frac{y_{11}y_{22}}{y_{21}}E_2 + y_{12}E_2$$
$$= \left[y_{12} - \frac{y_{11}y_{22}}{y_{21}}\right]E_2 + \frac{y_{11}}{y_{21}}I_2$$
$$= \frac{y_{12}^2 - y_{11}y_{22}}{y_{21}}E_2 + \frac{y_{11}}{y_{21}}I_2$$

Defining $C = \dfrac{y_{12}^2 - y_{11}y_{22}}{y_{21}}$ and $D = -\dfrac{y_{11}}{y_{21}}$

Then $$I_1 = CE_2 - DI_2$$

It now remains to establish equations (15) and (16). This shall be done by solving for E_2 and I_2 in the equations last derived.

$$E_1 = AE_2 - BI_2$$
$$I_1 = CE_2 - DI_2$$

Thus

$$E_2 = \frac{\begin{vmatrix}E_1 & -B\\ I_1 & -D\end{vmatrix}}{\begin{vmatrix}A & -B\\ C & -D\end{vmatrix}} = \frac{-DE_1 + BI_1}{-\begin{vmatrix}A & B\\ C & D\end{vmatrix}} = \frac{-DE_1 + BI_1}{-1} = DE_1 - BI_1$$

and

$$I_2 = \frac{\begin{vmatrix}A & E_1\\ C & I_1\end{vmatrix}}{\begin{vmatrix}A & -B\\ C & -D\end{vmatrix}} = \frac{AI_1 - CE_1}{-\begin{vmatrix}A & B\\ C & D\end{vmatrix}} = \frac{AI_1 - CE_1}{-1} = CE_1 - AI_1$$

Hence
$$E_2 = DE_1 - BI_1$$
$$I_2 = CE_1 - AI_1$$

In this proof the value of the determinant $\begin{vmatrix}A & B\\ C & D\end{vmatrix}$ is assumed to be equal to unity. This is not obvious; however it can be proven as follows:

$$\begin{vmatrix}A & B\\ C & D\end{vmatrix} = AD - CB = \frac{M_{22}}{M_{12}} \times \frac{M_{11}}{M_{12}} - \frac{|M|}{M_{12}D} \times \frac{D}{M_{12}}$$
$$= \frac{M_{11}M_{22}}{M_{12}^2} - \frac{|M|}{M_{12}^2} = \frac{M_{11}M_{22} - |M|}{M_{12}^2}$$

But $|M| = \begin{vmatrix}M_{11} & M_{12}\\ M_{21} & M_{22}\end{vmatrix} = M_{11}M_{22}(-1)^2 + M_{21}M_{12}(-1)^3$
$= M_{11}M_{22} - M_{12}^2$ since $M_{21} = M_{12}$

Therefore

$$\begin{vmatrix}A & B\\ C & D\end{vmatrix} = \frac{M_{11}M_{22} - (M_{11}M_{22} - M_{12}^2)}{M_{12}^2} = \frac{M_{12}^2}{M_{12}^2} = 1$$

The admittances "y"$_{nm}$ and the impedances "z"$_{nm}$ and also the general circuit functions "A," "B," "C," "D" are fundamentally expressed in terms of the parameters of the network. The determinate "D" and its minor M_{jk} are also expressed in terms of these parameters. However, there are certain relations here between these terms which are more or less obvious and which are given here for the purpose of future reference.

$$y_{11} = \frac{M_{11}}{D} = \frac{z_{22}}{|z|} = \frac{D}{B} \quad \text{(17A)}$$

$$y_{12} = y_{21} = \frac{M_{12}}{D} = -\frac{z_{12}}{|z|} = -\frac{1}{B} \quad \text{(17B)}$$

$$y_{22} = \frac{M_{22}}{D} = \frac{z_{11}}{|z|} = \frac{A}{B} \quad \text{(17C)}$$

$$z_{11} = \frac{M_{22}}{|M|}D = \frac{y_{22}}{|y|} = \frac{A}{C} \quad \text{(18A)}$$

$$z_{12} = z_{21} = -\frac{M_{12}}{|M|}D = -\frac{y_{12}}{|y|} = \frac{1}{C} \quad \text{(18B)}$$

$$z_{22} = \frac{M_{11}}{|M|}D = \frac{y_{11}}{|y|} = \frac{D}{C} \quad \text{(18C)}$$

$$A = \frac{M_{22}}{M_{12}} = -\frac{y_{22}}{y_{12}} = \frac{z_{11}}{z_{12}} \quad \text{(19A)}$$

$$B = \frac{D}{M_{12}} = -\frac{1}{y_{12}} = \frac{|z|}{z_{12}} \quad \text{(19B)}$$

$$C = \frac{|M|}{M_{12}D} = -\frac{|y|}{y_{12}} = \frac{1}{z_{12}} \quad \text{(19C)}$$

$$D = \frac{M_{11}}{M_{12}} = -\frac{y_{11}}{y_{12}} = \frac{z_{22}}{z_{12}} \quad \text{(19D)}$$

The validity of the fundamental system of equations (9 to 16) has been proven and we have defined the terms used in these equations and have also shown their interrelationship. We are now at liberty to use these equations in order to establish the matrices of four-terminal networks.

With few exceptions every four-terminal network has associated with it an admittance, an impedance and a general circuit matrix. These are respectively designated $\|y\|$, $\|z\|$ and $\begin{Vmatrix}A & B\\ C & D\end{Vmatrix}$. In order to illustrate the method of obtaining these matrices, we shall actually derive the matrices of the T, the π and the lattice network, in the following article.

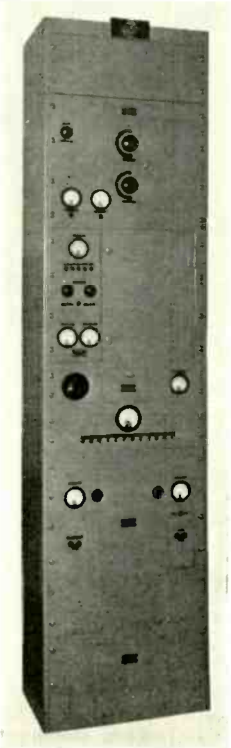
AMBULANCE WITH TWO-WAY RADIO SYSTEM

A NEW USE for radio-communication facilities was inaugurated in Evanston, Ill., last spring, when one of the city's ambulances was equipped with ultra-short-wave transmitting and receiving apparatus. The ambulance equipment, enabling doctors to keep in close touch with police and hospital officials, is part of a two-way radio system which engineers of the General Electric Company installed also on ten of the Evanston police prowl cars.

If, during either a police chase or an emergency in which the ambulance is used, the driver of one of the eleven radio-equipped cars desires to communicate with the police station or hospital, he merely lifts a telephone from a hook on the car's instrument panel, and a 15-watt transmitter mounted in the car goes on the air.

ABOVE: THREE-METER TRANSMITTER USED IN NEW ULTRA-SHORT-WAVE RADIO CIRCUIT CONNECTING NEW YORK AND PHILADELPHIA. RESONANT LINES ARE USED IN BOTH TRANSMITTERS AND RECEIVERS TO ELIMINATE NECESSITY FOR CRYSTAL CONTROL. RIGHT: FRONT VIEW OF ULTRA-SHORT-WAVE RECEIVER.

ULTRA - HIGH - FREQUENCY



ON THURSDAY, June 11, RCA Communications gave the first public demonstration of their new ultra-short-wave radio circuit connecting New York and Philadelphia. The circuit is unique in that it employs ultra-short waves with automatic relay stations and enables the transmission of drawings, type matter, handwriting and other visual material in facsimile, along with simultaneous operation of automatic typewriter and telegraph channels. A schematic diagram of the setup is shown on page 32. This diagram was transmitted from Philadelphia to New York by facsimile over the ultra-high-frequency circuit, our reproduction being made from the received facsimile copy.

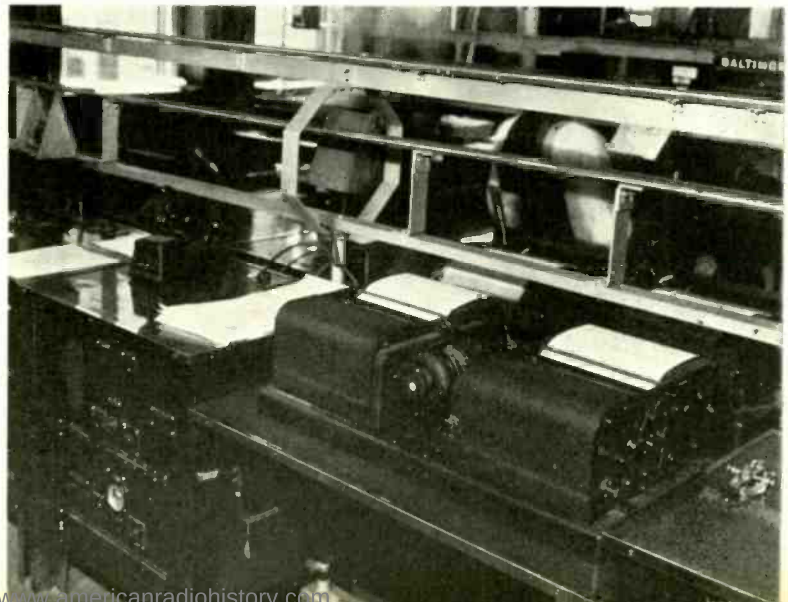
The automatic repeater stations are located at New Brunswick, New Jersey, and Arney's Mount, near Trenton, New Jersey. Since the range of three-meter radio waves is virtually limited to line-of-sight, the points of reception and transmission for each of the stations were selected to provide the most distant optical horizon. In New York and Philadelphia, therefore, the antennas are located atop tall office buildings, whereas the intermediate points of New Brunswick and Arney's Mount were chosen for their favorable terrain.

Each of the repeater stations employs two different transmitting wavelengths, or one for each direction. The two terminal stations each use one sending wave, making a total of six wavelengths, or frequencies, for the complete circuit. If it should be desired to extend the circuit beyond either terminal point, those waves could be used over and over again in the same sequence. Thus, two waves of the same length would be generated at points about one hundred miles apart, and would not interfere with each other, because of the line-of-sight limitation to their range.

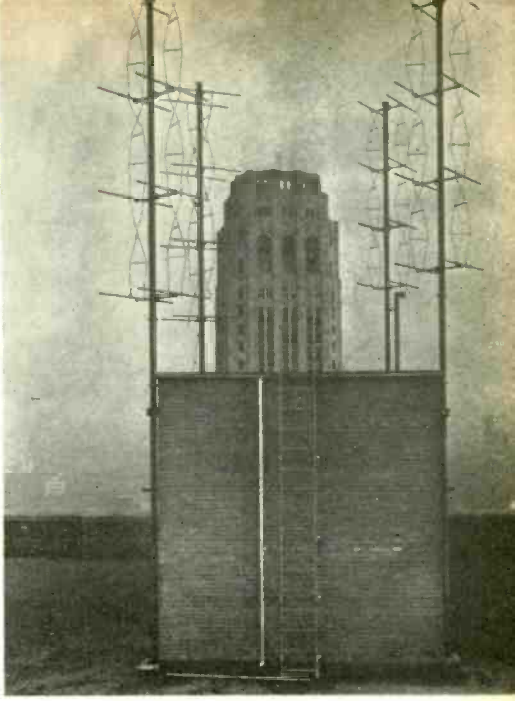
One of the most interesting engineering features of the new circuit is the method by which the unattended relay stations may be turned on or off from either one of the terminal stations by radio. The receivers at each of the four stations are always alive and ready to catch impulses from their assigned transmitters. When it is desired to make the circuit ready for traffic, New York or Philadelphia starts up its transmitter and sends a certain musical note which the receiving circuits are pre-set to "recognize." At the unattended receiver at New Brunswick the tone passes through electrical filters which accept the tone. In turn, relays are actuated, turning on the power for the "south" transmitter, which, when in operation, passes the tone on by radio to the Arney's Mount station. There the operation is repeated.

When the tone signal reaches the Philadelphia station, the transmitter at that city is also automatically turned on, and the tone starts on its return journey, back to New York. Operators in New York know

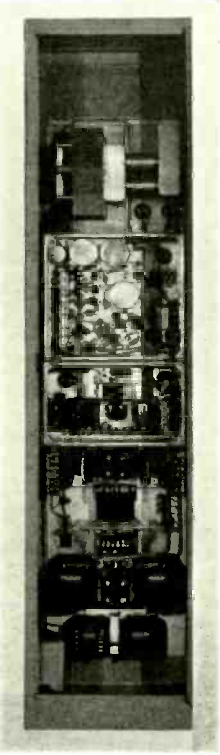
FACSIMILE SCANNER.



MULTI - CHANNEL CIRCUIT



ABOVE: THE TURNSTILE TRANSMITTING ANTENNAS AT THE NEW YORK END OF CIRCUIT. THE RECEIVING ANTENNA IS LOCATED ON TOP OF THE BUILDING IN THE BACKGROUND. LEFT: REAR VIEW OF THE ULTRA-SHORT-WAVE RECEIVER.



that when the tone comes back to them from the transmitter at New Brunswick the entire circuit is in full operation and ready for traffic. The constant presence of the tone keeps the relays closed, and the circuit in an operating condition. When the tone is withdrawn from the circuit, relays click in the same succession over the round trip to Philadelphia, and one by one the transmitters are automatically turned off. Philadelphia has the same control over the circuit as New York.

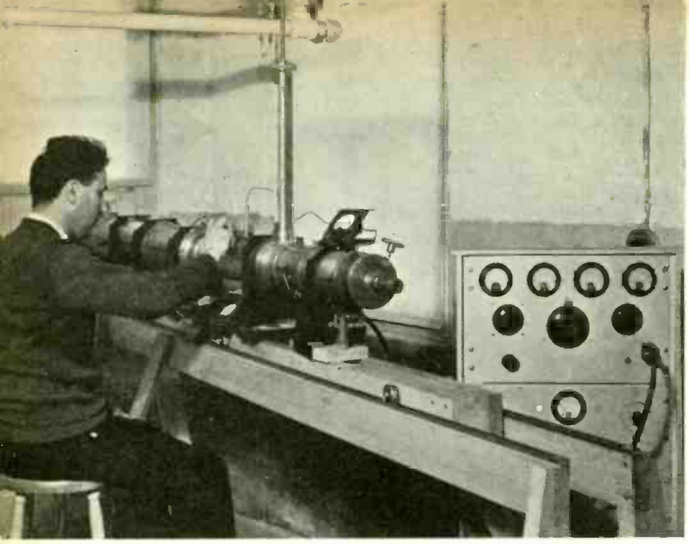
The new circuit is described by RCA officials as an outstanding example of the value of coordinated research and engineering in many special phases of the radio art. There being no precedent for building commercial apparatus for commercial operation on three meters, the equipment developed is unique. Antennas, because of their curious form, are characterized as "turnstiles." Certain parts of the receivers look like small steam engines and the transmitters might be taken for hot-water boilers, as may be seen from the accompanying illustrations. The odd shapes result from the application of resonant lines to both transmitters and receivers. The resonant lines eliminate crystal control and are said to provide an economical and efficient means of maintaining radio equipment in steady tune at extremely short wavelengths.

The heart of the receiver is the acorn tube; in the transmitters there are new power tubes specially designed for microwave service. These special tubes, along with the antenna, transmitter, receiver, facsimile and terminal control apparatus were all developed in a group of RCA laboratories.

It was revealed that even before the completion of the new circuit, the development of improvements which promise to simplify design of future installations was already under way. These improvements also contemplate increasing both the speed and the number of communication channels which can be handled simultaneously on a single radio wave.

The two institutions which were first to recognize the importance of the electric telegraph of Samuel F. B. Morse a century ago celebrated this new era in communications by exchanging greetings. In 1836 Professor Morse gave the first demonstration of his new instrument to his colleagues at New York University. He gave the next demonstration outside New York City before the membership of Franklin Institute, in Philadelphia. At the demonstration on June 11, Chancellor Harry Woodburn Chase, of New York University, and Vice-President W. Chattin Wetherill, of the Franklin Institute, Philadelphia, exchanged pictures and greetings by radio facsimile. Models of the first Morse apparatus were connected to the circuit and operated simultaneously.

FACSIMILE RECEIVER.



THE SENDING END OF THE EXPERIMENTAL WAVE GUIDE AT HOLMDEL. THE TWO TRANSMISSION LINES ARE SHOWN BELOW.

HIGH-FREQUENCY

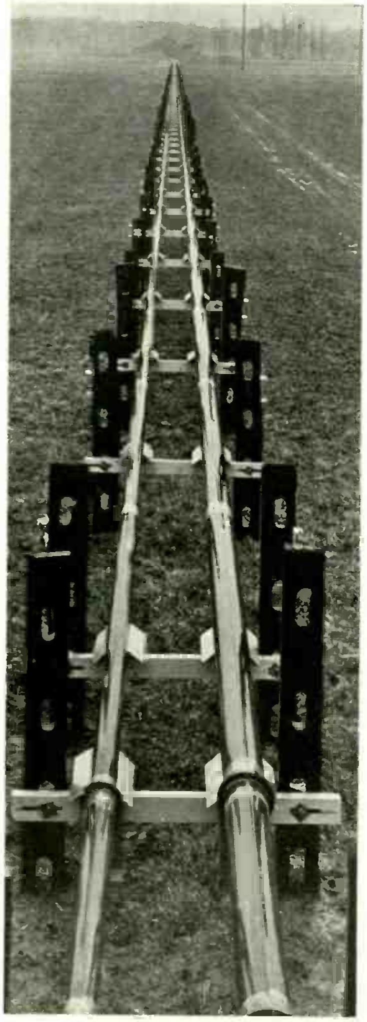
By G. C. SOUTHWORTH

RESEARCH in Bell Telephone Laboratories has disclosed a new form of transmission for high frequencies. It is unlike radio because the waves are not broadcast through space, but follow a physical guide comparable to a wire. With an ordinary concentric conductor, such as is used for feeding a radio antenna, the outer tube forms one side of the circuit and the central conductor the other. If, however, instead of operating such a structure at a frequency of about a million cycles, a frequency of two-thousand million cycles were employed, it would be found that the central conductor could then be completely withdrawn and still the structures would be able to transmit power.

In this example the pipe would have had to be at least 4½ inches in diameter, but if the pipe had been filled with an insulating material having a dielectric constant of 4, a 2¼-inch pipe could have been used, while if the dielectric constant had been 9, a 1⅛-inch pipe could have been used. As a matter of fact, the outer pipe itself may also be done away with, and the transmission will take place along a wire or rod of insulating material, and the attenuation will be least when the resistivity of the insulator, acting as a guide, is the greatest.

Incredible as these phenomena may seem at first sight, they are readily explicable on mathematical principles that have been known for many years.

In 1931 the author resumed some experimental work on wave guides, which he had started in 1920. This has now been expanded slightly and moved to



the Holmdel Radio Laboratory where long wave guides may be constructed. Some details have been given in the April, 1936, issue of the *Bell System Technical Journal*. Throughout this experimental research there has been considerable work done by members of the mathematical groups, notably by J. R. Carson, Sally P. Mead, and S. A. Schelkunoff, who have a paper in April *Bell System Technical Journal*.

The analytical work of Rayleigh and others has now been greatly amplified. The extensions which have been added to the theory include calculations of characteristic impedance, attenuation, and inductive effects into neighboring wave guides, and particularly the discovery that, theoretically at least, one of the many waves that may be transmitted through a hollow pipe becomes progressively less attenuated as its frequency is raised.

These electric waves that are guided through hollow pipes and dielectric rods are moving configurations of electric and magnetic fields. Mathematical theory indicates that in cylindrical guides these two fields may be associated in many different ways to provide a wide range of types of waves. Four of these are shown in Fig. 1. They may be generated by any source of sufficiently high frequency, such as a Barkhausen or a magnetron oscillator. To set up any particular type of wave it is necessary,

* An abstract of an article appearing in the May, 1936, *Bell Laboratories Record*.

WAVE GUIDES*

SOME OF THE EXPERIMENTAL APPARATUS EMPLOYED FOR WAVE-GUIDE TRANSMISSION

BELL TELEPHONE LABORATORIES

of course, to provide an appropriate launching mechanism. If the E_0 wave is desired, the source may be connected between the outside shell of the guide and a rather large central disc perpendicular to the principal axis. For H_1 waves the source is connected between diametrically opposite points on the inside of the pipe.

Wave guides behave somewhat like wire lines in that they have a definite characteristic impedance and a definite attenuation. Also waves travel through them with a velocity that may be predicted with considerable accuracy. The calculated attenuations of the four principal waves are of particular interest. They are shown in Fig. 2 for the special case of a five-inch hollow copper pipe.

It will be noted that all waves suffer infinite attenuation at or below certain critical frequencies, and that with an increase in frequency this attenuation decreases very rapidly. For three of the types of waves it approaches a minimum, and then increases for higher frequencies. For the wave that has been designated as H_0 this attenuation appears to decrease indefinitely with increase of frequency.

In much the same way that a pair of wires may resonate to waves traveling along their length, or an air column may resonate to certain sound waves, so may a short section of wave guide be made to resonate electrically to the frequencies which it is able to propagate. In its role as a resonator it behaves as if it were a coil and condenser, sometimes in series with an electromotive force, and sometimes in parallel. These resonance effects are very pronounced.

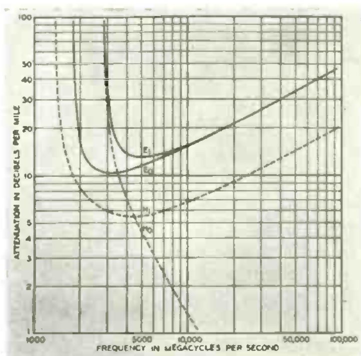
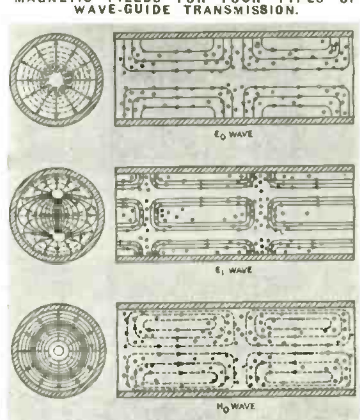


FIG. 2. ATTENUATION CHARACTERISTIC FOR TYPES OF WAVE-GUIDE TRANSMISSION GIVEN IN FIG. 1.

FIG. 1. REPRESENTATION OF ELECTRIC AND MAGNETIC FIELDS FOR FOUR TYPES OF WAVE-GUIDE TRANSMISSION.



The open end of a guide may be made to radiate wave power much the same as sound waves issue from a pipe. To enhance this effect the pipe may be expanded into a cone, thus producing an electrical horn. Tests show that it may function much the same as an acoustical horn, and accordingly may be used as an efficient radiating load for the generator to which it is connected.

Wave guides have definite limitations. The diameter of the hollow pipe that may be used is directly proportional to the wavelength. For a pipe that is at all convenient in size, the frequencies are the highest that have yet been tried out for radio. It is true that the diameter of pipe might be reduced if it could be filled with a suitable insulator. At this point we are met with a conflicting difficulty of producing at reasonable cost the necessary medium that will incorporate high dielectric constant with sufficiently low losses. It is true, too, that low attenuation could probably be had with much smaller pipes by the use of H_0 waves, but this calls for an even higher range of frequencies. For long-distance transmission, the situation is that the art at these extreme frequencies is not yet at a point which permits a satisfactory evaluation of practical use. For transmission over very short distances, however, or for use as projectors of electric waves, or as selective elements under certain conditions, the use of wave guides has definite possibilities.

TRANSMISSION-LINE CALCULATIONS

PART II

By J. G. SPERLING

CAUSES OF ATTENUATION

IN A PREVIOUS installment (April, 1936), the general impedance formula was derived and a means of graphically determining the line impedance was obtained. Upon erecting such a line it will be found that the efficiency is less than 100 percent, or that there is some power loss in the transmission line, whether parallel wire or concentric.

This attenuation or power loss is the sum of two separate losses: the r-f resistance loss, and the dielectric loss.

The r-f resistance loss ("skin effect") is an electrical phenomena in high-frequency lines whereby a high-frequency current tends to travel on a thin outer surface of the conductor. This tendency increases with frequency, and therefore the effective resistance will also increase.

When a transmission line is connected to a power source the voltage subjects the dielectric to a bending or stress and strain movement. If the dielectric were perfect, all the voltage energy stored during the first half-cycle would be released during the second half-cycle, or negative portion. However, the electrical elasticity of the dielectric is not perfect and the incoming voltage has to overcome this opposition or dielectric friction. This electrostatic loss is very similar in some respects to the eddy-current loss in electromagnetic circuits.

RADIO-FREQUENCY LOSSES

The radio-frequency resistances of parallel-wire and concentric transmission lines have been computed[1] and are listed here.

Parallel-wire Line:

$$R_{r-f} = \frac{5.08\,(\rho\mu f)^{1/2}}{10^9\, r} \text{ ohms per inch length} \qquad (25)$$

Concentric Line:

$$R_{r-f} = \frac{2.54\,(\rho\mu f)^{1/2}\left(\frac{1}{r_1}+\frac{1}{r_2}\right)}{10^9} \text{ ohms per inch length} \qquad (26)$$

ρ = Resistivity of conductor.
μ = Conductor's magnetic permeability.
f = Frequency in cps.
r_1 = Radius of inner surface of outer conductor.
r_2 = Radius of inner conductor.
r = Radius of one conductor.

In Fig. 5 is shown graphically the loss-in-watts versus frequency for various commonly-used wire sizes in parallel-wire transmission lines. This chart takes into account the resistance loss only since the dielectric loss due to spacing insulators is so negligible that it need not be considered. In addition this chart is universal in use

[1] A. Russell, *Alternating Currents*, Vol. 1; *Phil. Magazine*, April, 1909.

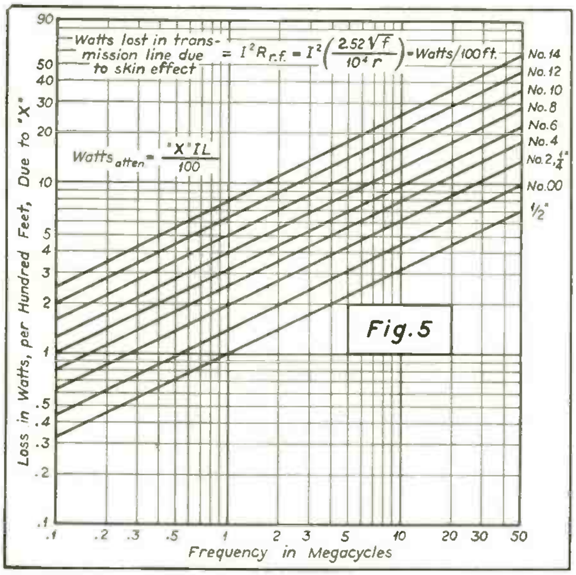


Fig. 5

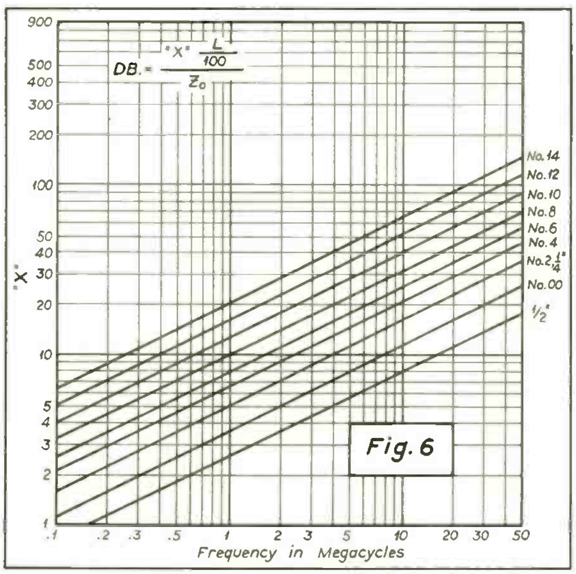
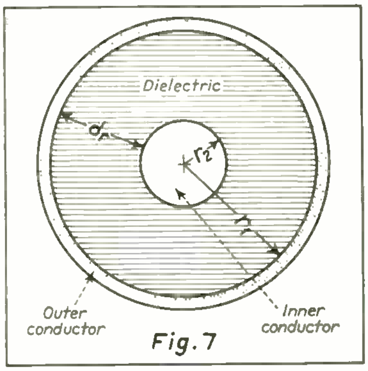
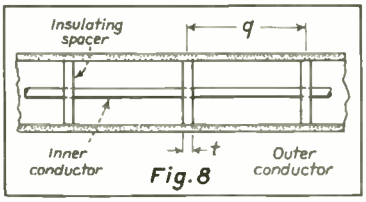


Fig. 6

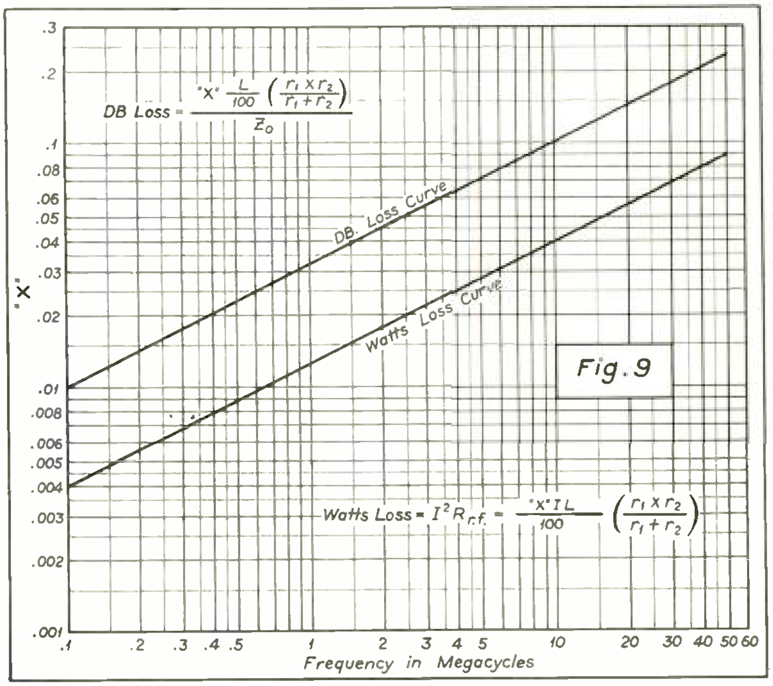
THESE CHARTS ARE FOR PARALLEL-WIRE LINES.



A CROSS-SECTIONAL VIEW OF A CONCENTRIC LINE.



ANOTHER VIEW OF A CONCENTRIC LINE.



THIS CHART IS FOR CONCENTRIC LINES.

as it is computed against a transmission-line current of one ampere. To find the actual loss in the line, merely multiply by the ratio of the actual current to one.

From alternating-current theory we know that the attenuation constant of any transmission line is

$$\alpha = [\tfrac{1}{2}([(R^2 - \omega^2 L^2)(G^2 - \omega^2 C^2)]^{1/2} - [\omega^2 LC - RG])]^{1/2} \quad (27)$$

At radio frequencies it is found that

$$\omega^2 L^2 << R^2$$

and that

$$\omega^2 C^2 << G^2,$$

hence

$$\alpha = \frac{R}{2}\left(\frac{C}{L}\right)^{1/2} + \frac{G}{2}\left(\frac{L}{C}\right)^{1/2} \quad (28)$$

If the transmission line is properly terminated in a complex impedance $\left(\frac{L}{C}\right)^{1/2}$ or its effective resistance, we can obtain from (28)

$$\alpha = \frac{R}{2}\cdot\frac{1}{Z_o} + \frac{G}{2}\cdot\frac{Z_o}{1} \quad (29)$$

If we neglect the loss due to leakage,

$$\alpha = \frac{R}{2 Z_o} \quad (30)$$

The value of voltage at the load or antenna end of the line bears a definite relation to the input voltage.

$$E_L = E_I\, e^{-\alpha l} \quad (31)$$

E_L = Voltage at load.
E_I = Input voltage.
l = Length of line in inches.

The loss in decibels is

$$db = 20 \log_{10} \frac{E_I}{E_L} = 20 \log_{10} e^{\alpha l}$$

$$= 20\,(0.434)\,\alpha l = 8.68\,\alpha l = 8.68 \frac{Rl}{2 Z_o}$$

$$\text{Attenuation in decibels per inch} = \frac{4.34\, R\, l}{Z_o} \quad (32)$$

The attenuation in decibels for commonly used sizes of parallel-wire feeders is given in Fig. 6.

In the previous installment, in the discussion of concentric transmission lines, we assumed that the dielectric constant between the outer and inner conductors was unity. In other words, air was used as the insulating medium. If the line is much over two or three feet in length it is necessary that the inner conductor be rigidly supported equidistant from the outer coaxial conductor. In commercial usage, the inner conductor is supported by insulating spacers or beads. The presence of such dielectric will introduce a loss, as previously described.

The realm of radio literature is comparatively free of any method of determining the attenuation due to poor dielectric, but the following exposition is offered[2].

The dielectric attenuation in a unit section of the concentric transmission line employing a solid dielectric is:

$$dW_{atten.} = i^2 dR \quad (33)$$

A section of this line is shown in Fig. 7.

The current in this section is:

$$i = \frac{e}{X_c} = \frac{e\,\omega\, k}{18 \log_e \frac{r_1}{r_2}\, 10^{11}} \quad (34)$$

The equivalent resistance dR of the segment is

$$\frac{\rho}{\omega\,(dC)} \quad (35)$$

The elementary capacity dC is the same as a flat-plate condenser with length 6.28 r, width one inch, and thickness dr.

$$dC = \frac{.218\, k\, r}{dr\, 10^{13}} \quad (36)$$

[2]Reproduced by permission of Mr. R. J. Fugal, General Electric Co., from *Principles of Radio Engineering*, page 115, by R. B. Dome.

$$\therefore dr = \frac{\rho \, dr \, 10^{12}}{.218 \, k r \omega} \quad (37)$$

Substituting (34) and (37), formula (33) becomes

$$W_{atten.} = \frac{e^2 \omega k \rho}{70.6 \left(\log_e \frac{r_1}{r_2} \right)^2 10^{10}} \quad (38)$$

The loss from r_2 to r_1 is the integral of (38) between these limits, or

$$W_{atten.} = \frac{e^2 \omega k \rho \, 10^{-10}}{70.6 \left(\log_e \frac{r_1}{r_2} \right)^2} \int_{r_2}^{r_1} \frac{dr}{r} \quad (39)$$

Performing the integration

$$W_{atten.} = \frac{e^2 \omega k \rho}{70.6 \left(\log_e \frac{r_1}{r_2} \right)^2} \log_e r \Big/_{r_2}^{r_1} \quad (40)$$

$$W_{atten.} = \frac{e^2 \omega k \rho}{70.6 \left(\log_e \frac{r_1}{r_2} \right) 10^{10}} \quad (41)$$

The transmission line, in practice, uses insulating spacers and not a solid dielectric for insulation.

The dielectric loss per inch is given by (41) multiplied by the ratio of t to q (Fig. 8).

$$W_{atten.} = \frac{e^2 \omega k \rho t}{10^{10} q \, 70.6 \left(\log_e \frac{r_1}{r_2} \right)} \quad (42)$$

Substituting t and q into our fundamental formula for the capacity of a concentric transmission line, we find:

$$C = \left(\frac{tk + q - t}{q} \right) \left(\frac{10^{-11}}{7.08 \log_e \frac{r_1}{r_2}} \right) \quad (43)$$

The surge impedance becomes[3]

$$Z_o = 60 \left(\frac{q}{tk + q - t} \right)^{1/2} \left(\log_e \frac{r_1}{r_2} \right) \quad (44)$$

[3]A slightly different impedance formula has recently been presented by Greene, Leibe and Curtis in the *Bell System Technical Journal* for April, 1936.

Simplifying it is found that the loss in decibels per inch becomes

$$\frac{23.16 \, f \, k \, t}{10^{10} \, (kqt + q^2 - qt)^{1/2}} \quad (45)$$

In Fig. 9 is shown a curve for determining the power loss due to r-f resistance in a concentric transmission line. In the chart is also shown a curve for determining the db loss per hundred feet in a concentric transmission line.

A curve for readily determining the efficiency of any transmission line, either parallel-wire or concentric, is shown in Fig. 10. This curve was calculated from the formula, % Eff. ≑ (100-2L) where L is the length of the transmission line in wavelengths[4]. This curve is accurate to within one or two percent, as determined against measured transmission-line efficiencies.

All of the curves on power and decibel losses check very closely with measured calculations[5].

CORRECTIONS

In the previous installment of this article (see page 14, April, 1936, COMMUNICATION AND BROADCAST ENGINEERING) the following corrections should be made.

The sentence preceding equation (1) should read *The total impedance, or characteristic impedance, of any length of line terminated in a load impedance is.* Likewise the sentence preceding equation (3) should be *The current i through the load is.*

Equation (12) should appear as follows:

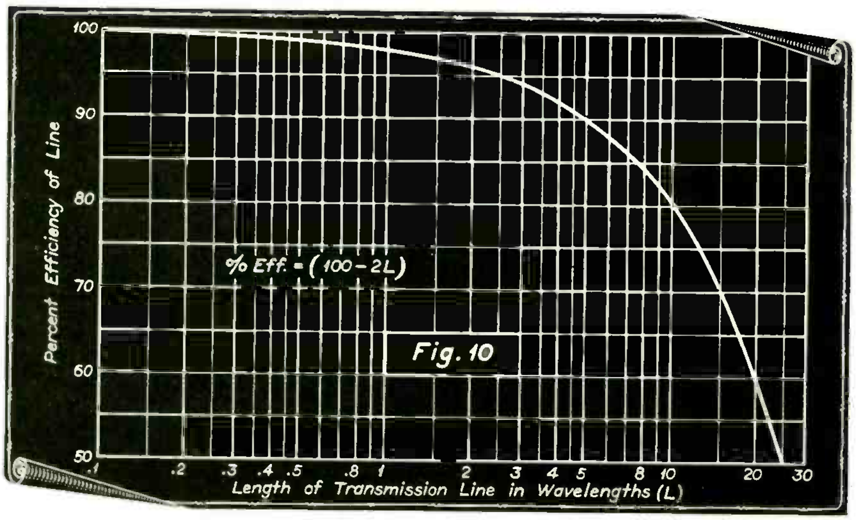
$$\frac{-jC}{2} (R + j\omega L)^{1/2} \frac{1}{((G + j\omega C)^3)^{1/2}} + \frac{jL}{2} (R + j\omega L)^{-1/2} (G + j\omega C)^{-1/2} = 0$$

while equation (13) should read

$$\frac{L}{C} = \frac{L}{C} \left(\frac{j\omega + \frac{R}{L}}{j\omega + \frac{G}{C}} \right)$$

—EDITOR.

[4]Lamerman, *Radio Engineering Handbook.*
[5]Sterba and Feldman, "Transmission Lines for Short-Wave Radio Systems," *Proc. IRE*, July, 1932.



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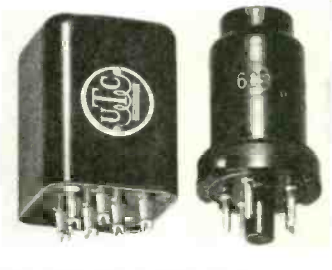
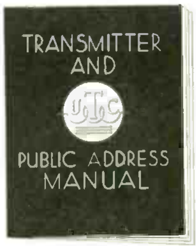


The actual size of these transformers can be visualized from this photograph which includes a small 6C5 tube for comparison.

Designed as companion units for acorn and metal type vacuum tubes. They measure up to good broadcast standards, having a response of plus or minus 2 db from 30 cycles to 20,000 cycles. The average weight is $6\frac{1}{2}$ ounces. and the overall dimensions are $1\frac{7}{16}$ x $1\frac{7}{16}$ x $1\frac{11}{16}$. These units are primarily intended for noise meter, aircraft and remote pickup work. Full description of these units is contained in the new U1100D bulletin.



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NOTES ON THE FCC ALLOCATION HEARING

By R. C. POWELL

THE NEED for careful study and cautious action was the keynote of every speech delivered at the opening of the informal hearing called by the Federal Communications Commission to discuss the allocation of high frequencies for communication services.

The hearing, which opened on June 15th at the Government Auditorium in Washington, D. C., was attended by about 300 engineers and executives of communication companies. Hearings are expected to continue for two weeks from that date.

The meeting was opened by Anning S. Prall, Chairman of the Commission, who stated that it was the purpose of the hearing to determine the allocation of frequencies above 30 mc, which have heretofore been classified as general-experimental bands, and to review the present medium-frequency allocations. In his talk Mr. Prall outlined future possibilities of radio including the allocations of bands for television, the possibility of aural-broadcasting assignments in the ultra-high-frequency bands, the use of facsimile transmission for printing newspapers in the home and other logical extensions of the present radio services which must be taken into consideration in formulating an allocation plan. By discussing these matters at the present time it is hoped that a well considered outline of frequency assignments may be ready for presentation at the Cairo Conference in 1938.

T. A. M. Craven, Chief Engineer of the FCC, reviewed the relationship of engineering progress and radio regulation during the past 23 years. Stating that radio communication was again at the "crossroads," he called attention to the events which lead up to the Radio Act of 1927, at which time inadequate legislative authority during the previous two years had made it necessary to fit engineering problems to an economic situation which already existed. At that time the public as well as set manufacturers and owners of broadcasting stations had a large investment in radio equipment which made broadcasting allocations on a purely engineering basis impossible. Now, it was stated, the radio-communication system is faced with extreme congestion in the frequency bands below 30,000 kc and it therefore becomes necessary to consider the bands between 30,000 kc and 200,000 kc.

In deciding upon the use of these bands there appears on the one hand the danger of making regulations and allocations on the basis of insufficient engineering knowledge which might retard development, and on the other hand the possibility of experimental users of these bands becoming intrenched through their financial investment which would hamper their proper distribution in the future.

Certain government departments now feel that they have enough information on the uses of the higher bands to warrant the investment of large sums of money for high-frequency equipment and these departments want bands assigned to them for their exclusive use. They desire to have these frequencies assigned with the cooperation of commercial organizations so that practical use may be made of them for the public benefit.

Following Mr. Craven's statement, J. H. Dellinger, of the National Bureau of Standards, discussed the uses which the government departments had made of the high frequencies and offered a tentative allocation plan in which approximately 60 percent of the band between 30 and 200 mc was reserved for government use. Several speakers following objected to the number of bands requested by the government on the basis that it would retard development and research. It was pointed out that the major portion of experiment in new fields was conducted through private enterprise rather than by the government.

David Sarnoff, President of the Radio Corp. of America, presented statistics on the development of radio under private initiative, discussed the developments which could be seen in the immediate future, and concluded his remarks with several specific recommendations for action. He did not favor advance assignments of frequencies except on an experimental basis, suggesting that definite assignments be made only after the allocations were proved to be needed for public service. He suggested that all bands be assigned for multiple use with precedence being given on the basis of importance as a public service. Limitations of exclusive assignments to the government were asked because they would not be needed except in the event of war and under such circumstances all radio facilities would be turned over to the government. Concluding, he asked for the continued independence of the U. S. radio system from government ownership and hoped for the further development of international radio communication by private concerns.

Dr. Frank B. Jewett, President of Bell Laboratories, pointed out the distinction between a communication service being ready for use and being ready for service. From his experience he stated his belief that, while a great many uses of radio had been developed which duplicated or superseded the use of wire lines, relatively few of them were ready to be offered to the public for dependable 24-hour service. The uncertainties of radio communication increase with the frequency used and he questioned whether the high-frequency transmission services were sufficiently perfected to warrant assigning them for public service.

Dr. J. W. Studebaker, U. S. Commissioner of Education, and William Green, President of the American Federation of Labor, asked that certain of the new frequencies be assigned for educational use.

James W. Baldwin, Managing Director of the National Association of Broadcasters, presented figures to show the importance of the broadcasting industry as it has developed to date. In a plea for an extension of radio broadcasting on the existing basis he discussed the economic limitations of the development of wired radio saying that wire service would cost the listener at least four times what his present service costs. He asked that consideration be given to facsimile transmission on the present broadcast band and that assignments in the 40-42 and 62-64 mc band be made available to broadcasting stations for television service. In connection with television he voiced the hope that patents would not be made the basis for monopoly of television services but rather that visual broadcasting would be permitted to develop on free competitive lines as had sound broadcasting.

Almost unanimously, representatives of the communication industries stated that it was not yet time to make fixed rules for the use of the ultra-high frequencies because of the lack of knowledge of their uses. What decisions are made will depend greatly upon engineering testimony to be presented during the remainder of the session.

RULE 377

THE BOARD OF DIRECTORS of the American Radio Relay League have requested that the Federal Communications Commission's Rule 377, providing for a suballocation of frequencies for Class A amateur radiotelephony operation (type A-3 emission), be amended to expand the present band of 3900 to 4000 kc to include the band 3850 to 4000 kc.

At a session of the Telegraph Division, held at its offices in Washington, D. C., on June 9, it appeared that many licensed amateur operators are opposed to any expansion of the existing radiotelephony bands.

It was therefore ordered that a public hearing be held before the Telegraph Division in the offices of the Commission at Washington, D. C., beginning at 10 a.m., on October 20, 1936.

All persons desiring to be heard at this gathering should file a notice with the Commission to this effect. This notice, which should be filed not later than ten days prior to the hearing, should state the reasons for the interest in the proceeding and, in a general way, the nature of the testimony to be presented.

TELECOMMUNICATION

PANORAMA OF PROGRESS IN THE FIELDS OF COMMUNICATION AND BROADCASTING

RADIO METEOROGRAPH

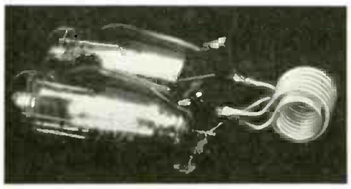
A RADIO "autograph"—an apparatus which automatically writes its own record of atmospheric pressure, temperature and humidity—is being developed jointly by the National Bureau of Standards and the Weather Bureau.

Formally known as a "radio meteorograph," this equipment finds immediate, practical application in testing wind velocity and other weather factors at upper levels of 25,000 to 30,000 feet. In this substratosphere, the Bureau of Air Commerce announced recently that it planned development of flying.

The self-registering radio meteorograph, installed in a manless balloon, functions automatically in sending radio signals while on its sky-climbing errand and these are picked up by receiving equipment on the ground and translated into terms of temperature, pressure, and humidity. Thus weather records at great heights are obtained directly without relying upon chance-recovered data, attached to a parachute, with a tag of identification requesting the finder of the parachute to forward to the Weather Bureau.

The radio meteorograph is simple in appearance. The visible part of the experimental equipment is a tail-like affair, designed in a point so as to keep the device in the path of the wind. The main part of it, protected by a light encasement, consists of two dry-cell radio tubes and oscillators, with a half-wave antenna, using as light a B battery as possible to provide the power necessary. The oscillators are arranged so they will operate only when signals are working so that even a smaller battery could be used to lessen the weight. A minimum weight (3 lbs.) is of primary importance since to increase the size of the contrivance may necessitate a corresponding increase in the size of the balloon and, of course, at a great increase of cost. Increased weight would also prevent the balloon from reaching heights it could otherwise attain.

In its final form, this device will give temperature, pressure, and humidity records and cosmic-ray impulses. Dr. Curtis showed this writer the record containing the message the radio meteorograph had transmitted. On an inch-wide tape were pin-point indentations at intervals of practically equal spacings. These points, of course, represented the contacts made by the little arm as it dragged across the insulated plate. The readings of the data, such as tempera-



THE BALLOON TRANSMITTER USES TWO 30 TUBES IN PUSH PULL.

ture, will be done by reckoning the relation between the marks made by the arm which merely reports that one revolution has been completed. The apparatus will be gaged so that such revolutions are at a constant timing.

The Weather Bureau pointed out how far-reaching may be the effects of this instrument. The present method of obtaining the temperature, pressure, and humidity records at altitudes is quite a heavy expense that is shared by the Weather Bureau and Army and Navy. From twenty-four observatories stationed throughout the country a plane leaves the ground at 4:30 a.m. each day and ascends to the height of 17,000 feet to get the desired information. At a rate of approximately $25 per trip this soon totals many thousands of dollars. The complete radio meteorograph costs from $10 to $20 and an arrangement is carried out whereby an automatic release will disengage the apparatus from the balloon (in case it bursts) so it can float to earth on the parachute fastened to it. Tags fixed to the instrument will instruct the finder to return it to the Weather Bureau at the latter's expense.

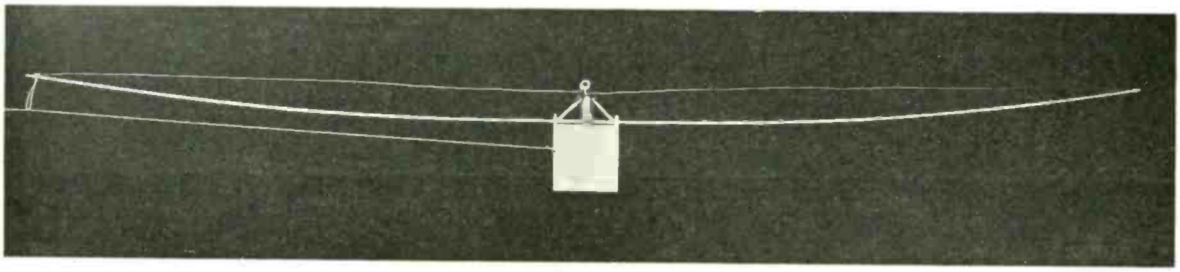
The radio meteorograph has the further advantage over plane flights in that it can go up in any kind of weather. It may even result in a marked improvement in the Bureau's ability to predict weather. D. M. Little of the Weather Bureau stated that since it would be able to go so high, it will be possible for observers to get the height of the stratosphere from day to day. He continued by explaining that stratosphere heights may change as much as 7 to 11 kilometers a day, and that this and other factors of stratosphere conditions may prove to have effects definite enough for making conclusions on future weather.

Aboard vessels this instrument will prove a great help. It is even thought that in the future it will be possible to measure the angle the balloon is traveling in, and then by computing from the pressure and temperature given by the radio signals, the elevation can be determined. Finally it will be possible to measure the wind direction and velocity inside and above cloud layers.

S. R. Winters.

RADIO-TOWER LIGHTING SYSTEM

A NEW SOLUTION to the problem of supplying power to lights on insulated

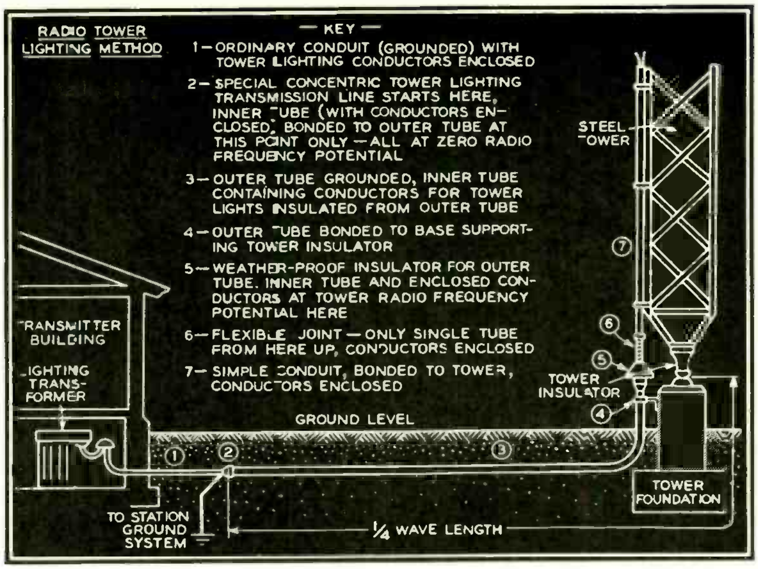


TRANSMITTER WITH ANTENNA AND BATTERY CASE AS SUSPENDED FROM THE BALLOON.

radio towers has been devised by engineers of Bell Telephone Laboratories for the Western Electric Company. It not only has technical advantages over existing methods but is also simpler and more economical. It has already been applied in the lighting system used on the antenna of WWJ, Detroit, Michigan.

Where the tower is itself the radiating antenna, it is of course electrically charged. Where it serves as a mast to support the real antenna, it lies in the immediate field of the radio-frequency energy emanating from the antenna. In either case power lines running up the tower to the lights would collect troublesome and dangerous radio-frequency voltage if special apparatus such as choke coils, motor-generators or other provisions were not employed to isolate the power line.

The new method, utilizing a specially-designed concentric cable which connects the tower with the light power supply, eliminates all other protective apparatus. This cable is composed of an outer metallic tube which is at ground potential over its entire length (see accompanying illustration), and an inner metallic tube insulated from the outer shell except at the end away from the tower where it is bonded to the outer sheath. The length of this line is designed to bear a direct relationship to the frequency at which the radio tower radiates (¼ wavelength). Within the inner tube are the two insulated conductors which carry the illuminating current.



MODERN RADIO STUDIOS IN HOLLAND

ONE OF THE MOST up-to-date, and at the same time architecturally beautiful, broadcasting studios in the world will be found in the small town of Hilversum, Holland.

The Algemeene Vereeniging voor Radio Omroep are building the new studios, and in order that they would be built in the latest and most efficient style for broadcasting, the company procured the services of two of the most capable architects and two of the leading authorities on physics and acoustics in that country. To enable the latter to make suitable experiments a temporary house was built on the grounds of the Technical University in Delft.

The principal problem which the architects and acoustical experts have had to solve has been that of the complete insulation of the studio so as to make them sound-proof. Experiments have shown that the best material for this purpose is the common white Dutch bricks, but even this material is not completely satisfactory. Hence the inner walls of the studios were built on pillars which go right down into the foundation, leaving a space of several inches between these pillars and the outer walls. Even with this system, however, the rooms would not be entirely sound-proof if the doors or lighting and ventilating systems admitted sound. Double iron doors were considered a necessity; the outer door must close before the inner door is opened and the steps on which the person enters or leaves the studio are attached only to the inner structure. There are no windows in the studios, the lighting being entirely artificial; while the "air-conditioning" is to be carried out by a specially-devised system in which an important feature is a series of expansion chambers fitted with a baffle—to which the name "suskamers" or rustic chambers, has been given—in which the air movement is silenced.

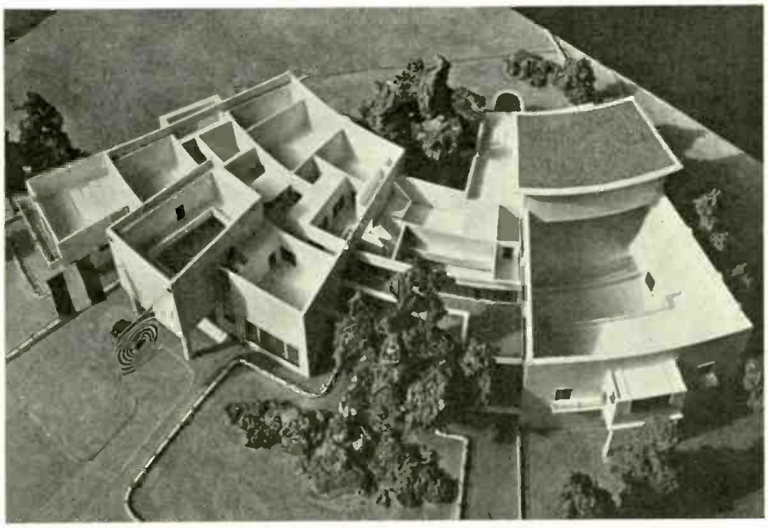
The largest studio is a combination of a theatre and concert hall which, with the necessary dressing-rooms, lobbies, etc., takes up the whole of one end of the building. This is fully equipped for opera as well as dramatic performances.

The center of the building is occupied by the restaurant and reception rooms, audition rooms, and large entrance hall. On the other side of the building are the smaller studios, nine in number. The two control rooms are in the middle of the fan-like part of the building, so that it is easy for the engineers to get to the studios quickly.

The formal opening of the new studios is expected to take place soon.

Hans Merx.

(*Continued on page* 29)



THE MODEL OF THE NEW BROADCASTING STUDIOS IN HILVERSUM, HOLLAND.

MARINE OBSTACLE DETECTORS

THE COMPAGNIE RADIO MARITIME have done considerable research work with the ultra-high frequencies, and it was this organization that installed the device on the *Normandie* for the detection of obstacles at sea.

The marine obstacle detector is based on the fact that ultra-short waves are easily defracted by objects, the character of the objects as electrical conductors having little if any effect on the results obtained. Hence, if a radio transmitter sends an ultra-short-wave beam that strikes an object, the beam will be defracted (see Fig. 1) and may be picked up. Further, the ultra-short waves are easily concentrated both at the transmitting and receiving end, so that the direction of the object can be obtained with the precision of the sharpness of the beam.

An obstacle detector should not only give the direction of the object but also the position. This result can be obtained in two ways:

1. With centimeter waves (approximately 16 cm) a very narrow beam can be produced. With an opening of only a few degrees, using small reflectors (for example, height 15 cm, opening 40 cm), the angles of transmitter and receiver will indicate the direction of the deflecting object within about 5 degrees. Concentration of the beam is, of course, necessary to obtain sufficient power to reach any useful distance. The zone common to both beams, transmitting and receiving, is thus rather limited and to be able to detect an unknown obstacle the zone under observation must be covered by a beam sweeping back and forth. For instance, if the zone under observation (see Fig. 2) is horizontal the beams must be concentrated in the zones, the sections of which are horizontal, e and r, and a sweeping system beam will depend upon the speed of the obstacle expected.

The more simple realization consists of placing the transmitting and receiving beams, e and r, in such a manner that their symmetrical vertical planes coincide and this can be realized by placing the reflectors on one common shaft. At least from a certain distance

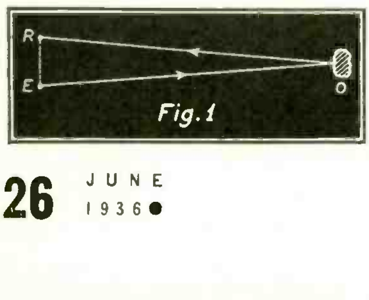


Fig. 1

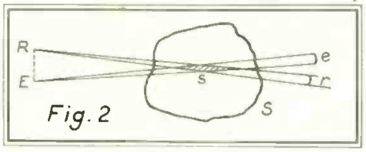


Fig. 2

the common zone will be represented as in Fig. 3 and the sweeping will simply be realized by the rotation of the common shaft support of the reflectors. An automatic system can bring about the stopping of the instrument as soon as an obstacle comes into the field.

2. The two essential operations to be accomplished should be carried by independent devices which make up the complete system. One will be used to detect the obstacle and will be continually sweeping the seas and will give the

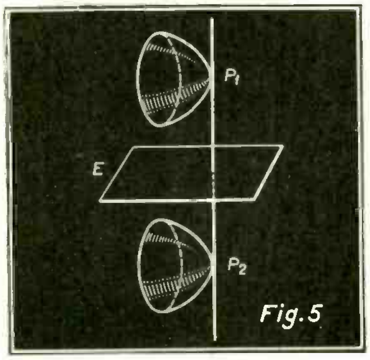


Fig. 5

approximate position of the object detected. The other will be put into action if it is needed in order to obtain a more accurate position. The operation of detection will be effected by ultra-short waves produced with sufficient power to permit a small directive effect according to the zone to be swept. The receiver will also be provided with an antenna of small directive effect.

The second operation to find the exact direction is effected by a system of ultra-short waves of 16 cm, which operation

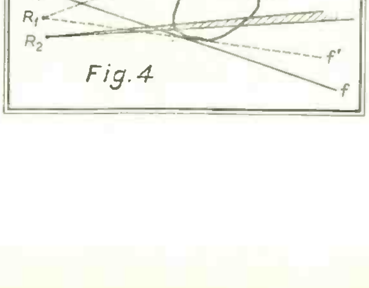


Fig. 4

takes place once the object has been detected by the above system with the use of waves of 80 cm to a meter.

Fig. 4 illustrates the principle as a whole. The transmitter of 80 cm sweeps over the zone S with a beam ff and with its associated receiver beams f'f' this sweeping is not limited and can be extended to all the space. When the transmitter with the aid of the receiver signals that there is an object in zone S, then the 16-cm set is put into operation and permits one to find the exact direction of the object.

In the case of ships, the space is limited, and the zone to be under surveillance is also limited by the installation on board. A system placed on the forward part of the ship can only successfully explore the space which is directly in front of it. In most cases it is efficient to explore an angular zone of 90 degrees situated in front of the ship and if the obstacle, supposedly stationary, is to be detected at 7 kilometers by an instrument located on a ship going at the rate of 55 kilometers an hour, the complete sweeping, that is, back and forth, could be accomplished in 2 minutes during which time the ship has gone forward 2 kilometers nearer the object to be detected. However, if the obstacle detected is another ship advancing at a similar speed, then the complete sweeping should last but 1 minute. If mirrors of small dimensions are used these measures of time can easily be realized.

The Compagnie Radio-Maritime is now experimenting with an apparatus which permits one to aim simultaneously two projectors towards the object detected. These two projectors are installed on one shaft which could turn on two bearings situated at each extremity (see Fig. 5). The two projectors are mounted on one shaft and a copper screen separates them to avoid any contact between the transmitting and receiving antennae. Due to this installation echoes were received from ships at a distance of 7 kilometers. At the height that these instruments were installed (approximately 8 meters above water) the waves do not produce echoes that disturb the measurements.

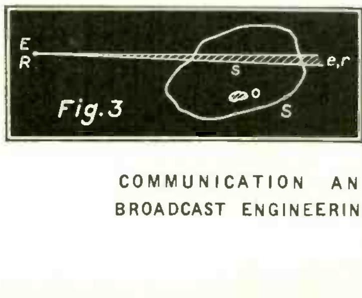
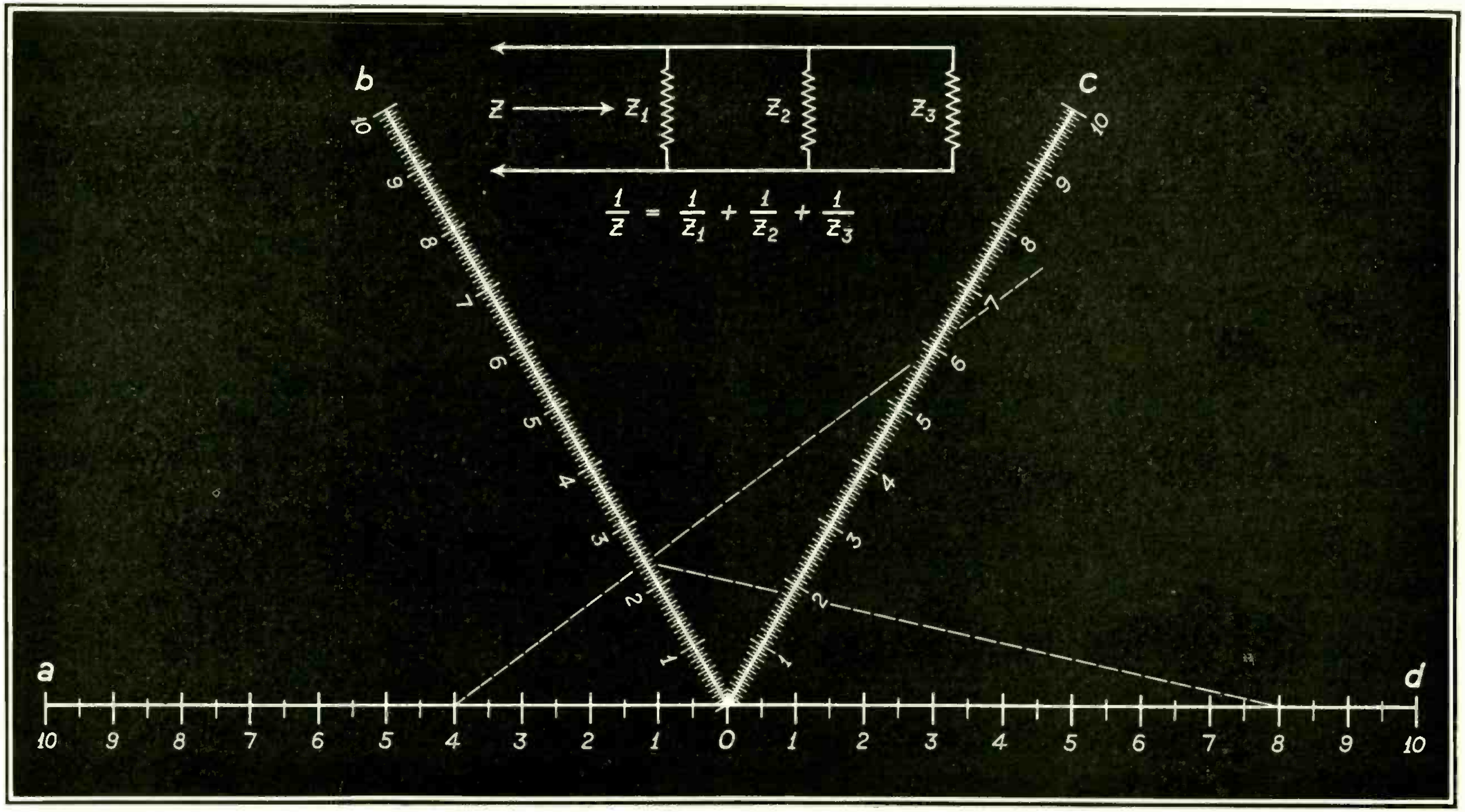


Fig. 3



PARALLEL RESISTANCE CHART

Shown above is a handy chart for finding resultant values of resistances in parallel. To use this chart lay a straight edge on two resistance values, say on scale (a) and scale (c), and read on scale (b) . . . or on (d) and (b) and read on (c). The dotted lines drawn in represent a calculated problem of three resistances of 4, 6 and 8 ohms in parallel. Thus 4 ohms on (a) is joined with 6 ohms on (c), indicating 2.4 ohms on (b). This value is in turn joined with 8 ohms on (d), giving the answer of 1.85 ohms on scale (c). This process may be repeated for any number of resistances.

TELECOMMUNICATION

(*Continued from page 25*)

A REMOTE-CONTROLLED LIGHTHOUSE

A FULLY-EQUIPPED radio-controlled lighthouse having a powerful light, an electrically-operated bell and a compressed-air fog signal will go into operation on Peshtigo Reef in Green Bay, Lake Michigan, at the opening of navigation, it was recently announced by the Bureau of Lighthouses, Department of Commerce.

The lighthouse is entirely automatic in that no person remains in attendance. The functions which must be exercised at irregular intervals such as the blowing of the fog signal and the changeover from one set of signals to the standby equipment are remotely controlled by radio, it was stated.

A lighthouse keeper located on shore 8 miles distant from the lighthouse operates the radio controls which start the fog signals. By the use of radiotelephone the keeper can determine if the orders which he transmits to the mechanical crew on the Reef have been received and executed.

In conformity with the policy of the Lighthouse Service to stress reliability in all of its aids to navigation, the introduction of radio control at the lighthouse was made only with adequate safeguards against breakdowns. Practically every piece of apparatus has been installed in duplicate, and provisions made for the quick substitution of one signal for another.

Keepers will visit the station at regular intervals to service the equipment and facilities are provided for stays at the station if required.

TELEPHONE SERVICE TO JAMAICA

RADIO-TELEPHONE CONVERSATIONS between New York City and the city of Kingston, on the island of Jamaica, on Friday, April 3, marked the further extension of Bell System overseas service to the West Indies. The speakers were in the Long Distance Building of the A. T. and T. Company, 32 Sixth Avenue, Manhattan, and the headquarter's building of the Jamaica Telephone Company, Kingston.

Short-wave radio-telephone stations of the Bell System at Miami, working with stations of the Direct West Indies Cable Company at Kingston, bridged the ocean between Jamaica and the mainland. At Miami the connection with New York was made over long-distance telephone wire lines and cables.

OVER THE TAPE . . .

NEWS OF THE RADIO, TELEGRAPH AND TELEPHONE INDUSTRIES

AIKEN RETAINED BY NAB

Dr. Charles B. Aiken, Assistant Professor in charge of communications, Purdue University, was retained to represent The National Association of Broadcasters at the hearing being held by the Federal Communications Commission.

Dr. Aiken was born in New Orleans in 1902. He has a B.S. degree from Tulane University and an M.A., M.S., and Ph.D. from Harvard. He has served as a radio marine operator, and as assistant operator of WAAB; and was engaged in the development of apparatus for geophysical exploration and in field work with Mason, Slichter and Hay at Madison, Wisconsin. Dr. Aiken was a member of the technical staff of the Bell Telephone Laboratories from 1928 to 1935. From 1930 to 1935 he was supervisor in charge of broadcast receiver development and was also engaged in work on aircraft communication, centralized radio systems, field-strength measuring, and common-frequency broadcasting.

ELECTRONIC TUBES

The many new and improved electronic tubes permitting wider industrial application has resulted in the preparation of a set of new data sheets covering tube ratings and characteristics. These sheets may be obtained by writing to the Special Products Department, Westinghouse Lamp Company, Bloomfield, N. J.

The new sheets describe ratings and operating characteristics of amplifier and oscillating tubes; grid-glow tubes and ignitrons; phototubes; rectifier tubes; and miscellaneous types, all of which are manufactured by the Westinghouse Lamp Company. The new data supersedes similar information included in the Engineering Catalog of July, 1934.

EASTERN MIKE-STAND CATALOG

The Eastern Mike-Stand Company, 56 Christopher Ave., Brooklyn, N. Y., manufacturers of "Eastern" microphone stands, have announced a new 6-page catalog describing their complete line. Among the new items are listed a short-circuiting switch-swivel unit and a shock-absorber coupling. A copy of this catalog may be obtained by writing to the above organization.

McCARTHY RECEIVES APPOINTMENT

Mr. Edward J. McCarthy has been appointed General Sales Manager of The Gamewell Company with headquarters at the general offices, Newton Upper Falls, Massachusetts. Mr. McCarthy has been in the employ of The Gamewell Company for over sixteen years.

SILVEROID RECORDS

Universal Microphone Company, Inglewood, California, has issued instruction sheets for recording on its Silveroid records. These records are one of the firm's instantaneous recording blank lines with a specially developed coating material.

HYGRADE SYLVANIA EXPANDS

Hygrade Sylvania's Electronics Division at Clifton, N. J., have recently enlarged their plant and installed new equipment. They are now completely equipped to manufacture high-quality electronic devices and components. The industry is invited to submit specifications on which quotations will gladly be made.

Mr. A. H. Hotopp is General Manager and Chief Engineer, while Mr. Burns is Sales Manager.

FAIRCHILD-PROCTOR

Expansion of its Recorder Division and refinement of its recording instruments through the acquisition of the manufacturing and sales rights of the B. A. Proctor Company, Inc., of 17 West 60th Street, New York, N. Y., is announced by the Fairchild Aerial Camera Corporation of Woodside, L. I., N. Y., which in recent years has been engaged in the development of high-fidelity recording apparatus, precision aerial cameras, aviation instruments, and the Kruesi type radio compass for aircraft.

The acquisition of these rights brings together two pioneers in the field of recording equipment as used by broadcasting stations, universities, recording studios, sales organizations, etc., where disc and cylinder records are employed.

The first public exhibition of the Fairchild-Proctor sound-recording equipment will be made at the annual convention of the National Association of Broadcasters at the Hotel Stevens, Chicago, Ill., July 5-8. The exhibition will include both the portable and the studio-type Fairchild-Proctor machines which are now in production at the Fairchild Camera Corporation's factory.

Officers of the Fairchild Aerial Camera Corporation are: James S. Ogsbury, President; Frederick W. Lutz, Vice-President and General Manager. Officers of the B. A. Proctor Company are: B. A. Proctor, President and Treasurer; and Fer. C. W. Thiede, Vice-President and Secretary.

TAYLOR TUBES EXPANDS

Taylor Tubes, Inc., are now increasing their production facilities and are launching a comprehensive merchandising program. Rex L. Munger has recently been appointed Sales Manager, and, in conjunction with Warren G. Taylor and Frank J. Hajek, owners and managers, is busily engaged in developing this new program. Several new tubes have been announced and literature will be available in the near future.

WALTERS RECEIVES APPOINTMENT

To cope with an increase in business, the Cornell-Dubilier Corporation has been rapidly expanding its engineering and production facilities. Announcement now is made of the appointment of Mr. Stanley Walters, in the engineering department.

TECHNA CORPORATION

The formation of Techna Corporation, 926 Howard Street, San Francisco, California, has recently been announced. This organization was formed to develop, manufacture, and install all types of broadcast, public-address, recording and laboratory equipment. Techna Corporation will be under the guidance of Robert B. Walder, President and Chief Engineer, Earl R. Jones, Factory Superintendent, and C. E. Downey, Broadcast Research Engineer. Techna invites inquiries.

LOWRY JOINS CONTINENTAL

The Continental Electric Company, St. Charles, Illinois, manufacturers of photo-cells, electronic and special vacuum devices, have announced that Dr. E. F. Lowry has become their Director of Research and Engineering. Dr. Lowry is recognized as one of the foremost authorities on cathode design.

ELECTROSTATIC INSTRUMENTS

A bulletin describing electrostatic instruments has recently been issued. It may be obtained by writing to the Sensitive Research Instrument Corporation, 4545 Bronx Boulevard, New York City, N. Y.

FCC MODIFIES RULE 229

The Commission on May 13 adopted the recommendation of its Engineering Department to modify its existing Rule 229.

The band 1500 to 1600 kc was assigned to broadcasting. This does not mean any immediate change in the existing policy of maintaining stations on the 1530, 1550 and 1570 kc frequencies in the experimental status.

Another change was the elimination of experimental visual broadcasting in the 2,000 to 3,000 kc band, on the basis that the consensus of engineering opinion and the inspection of reports submitted by visual-broadcast stations reveal that these frequencies are not particularly suited for television.

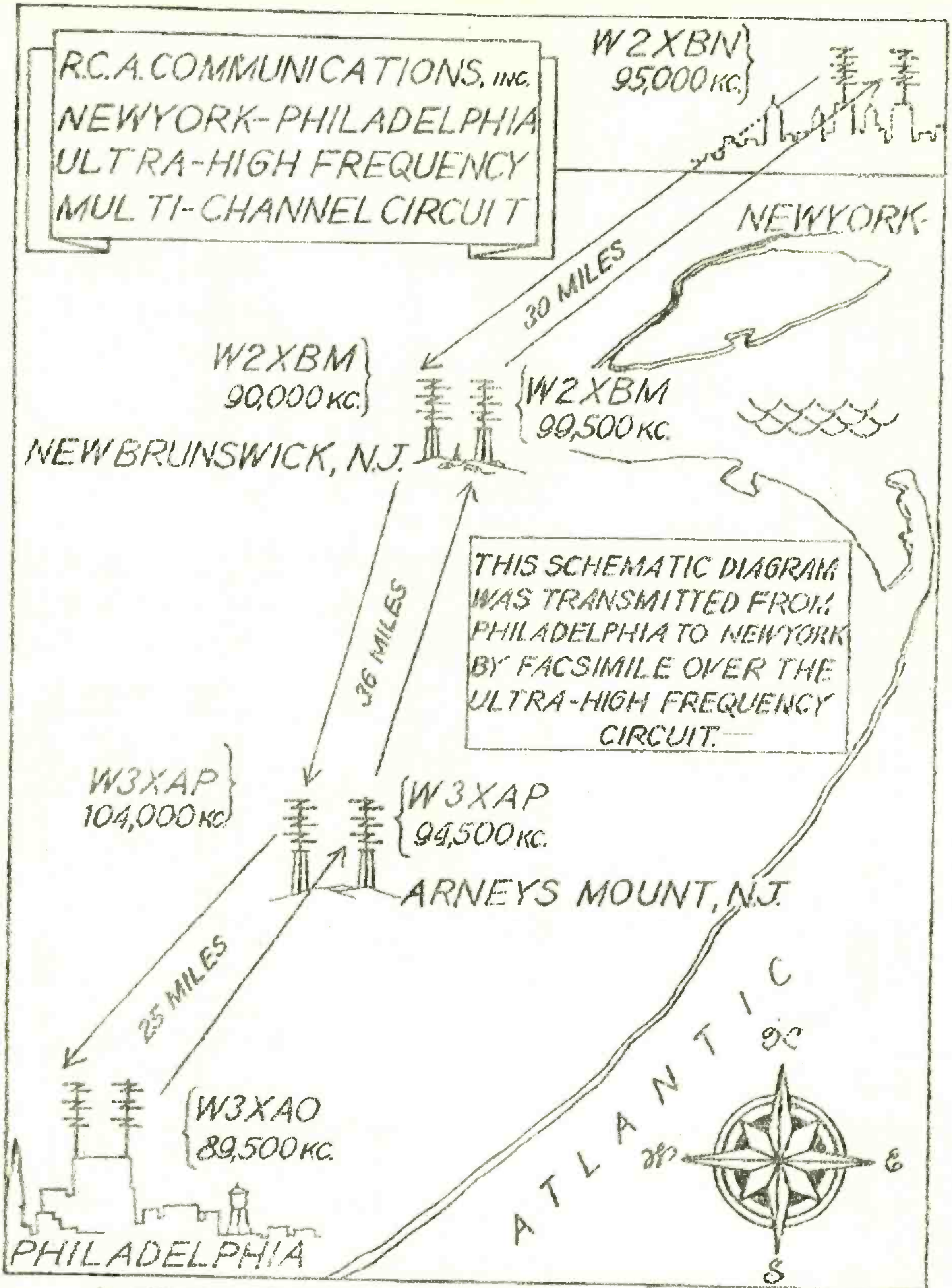
The frequencies thus released were made available to government departments, intercity police-communication services and point-to-point telegraph stations in the fixed public service.

The 25,600 to 26,600 kc band was assigned to broadcasting. No specific change in existing policy is involved in this assignment.

Four frequencies in the band 40,000 to 42,000 kc were assigned to experimental broadcasting, for the special purpose of ascertaining facts with respect to frequency modulation.

FERRANTI OFFICES

Ferranti Electric, Inc., manufacturers of transformers, instruments, surge absorbers, have just announced the removal of their executive and sales offices to larger quarters at 30 Rockefeller Plaza, New York City. Mr. W. R. Spittal, Manager, stated that this move was necessary due to increased sales of all Ferranti products.



MAP No. 19--New Ultra-High-Frequency Circuit.

(See page 14)

VETERAN WIRELESS OPERATORS ASSOCIATION NEWS

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

MEMORIAL SERVICES

THIS YEAR memorial services were held at noon on Friday, May 29th, instead of Saturday, May 30th, as it was deemed a more opportune time for members of the Association to be present.

A wreath was placed on the monument by President Clark and Secretary McGonigle. A plaque containing the name of Russell MacDonald was also placed on the monument.

Conversations with several of those present leads one to believe that there are many persons eligible for membership in our Association but, because they are not acquainted with membership requirements, remain outside the fold.

WHO TOLD US?

MANY OF YOU, undoubtedly, have wondered where the material concerning individual member's careers or present activities is gleaned from. It is unfortunate that little of it is received in the form of interesting items for use on this page. We have had to scan application blanks and every communication received to develop something about you, and *you* and YOU which will make interesting reading for the membership at large.

Now that Chapters have been organized in various cities throughout the country we believe that the increased activity among members in, heretofore, unorganized sections will provide material for many newsy items which will prove interesting to our membership and the many others who read this page.

We urge the chapter secretaries to forward at least once a month a resume of the activities of their membership either collective or individual in nature. We solicit items from individual members, geographically. separated from chapters.

It is not necessary that material submitted be in any particular form or that it deal directly with radio activities. Please send in those items you've been thinking of forwarding and let us be the judge of whether they should be used. Thank you.

PERSONALS

FROM THE *RCA Family Circle*—"Mr. Isbell's wireless career dates from 1902, when he joined the deForest Wireless Telegraph Company. During his career he has also worked for the National Electric Signaling Company, the Massie Wireless Telegraph Company, the Wireless Telegraph Company, Ltd., of Hawaii, the Marconi Wireless Telegraph Company of America, and is now in charge of the Commercial Department of RCA Communications and in addition handles the advertising done by RCA Communications.

"Mr. Isbell was the fourth American wireless operator, and the first commercial wireless operator on the Pacific Coast. He was expert radio aide in the Navy Department during the War and holds today the grade of Lieutenant Commander, USNR."

Charles J. Pannill, life member, President of Radiomarine Corp. of America, recently returned from an executive session of the CIRM, association of marine radio interests of the world, of which he is Executive Vice-President.

W. S. Fitzpatrick was recently appointed Secretary of the Board of Editors of the recently announced *RCA Review*. C. J. Pannill is Chairman of the Board of Editors and O. B. Hanson, Chief Engineer of the National Broadcasting Company and Arthur F. Van Dyck, Engineer-in-Charge, License Laboratory, Radio Corporation of America—both VWOA life members—are members of the Board of Editors.

George Martin, Chairman of the Chicago Chapter, head of the RCA Institutes in Chicago, gave a talk before the Chicago Radio Club and the senior graduating class at New Trier High School, Winnetka, Ill., on the subject "Radio as a Career."

Henri Jappe of the Boston Chapter has had a truly international radio career. Starting in 1912 as radio operator at OXA, Copenhagen, Denmark, he subsequently served with the Belgian Marconi Company, on the Belgian Congo Line, then with the Russian American Line and for some time with the Russian Government and the Shipowners Radio Service in the United States. During the War HJ served in the Radio Research Division of the Signal Corps, A. E. F. There is a story concerning Henri's work at the Eiffel Tower in France that we hope to receive in complete form. It sounds interesting.

Raymond F. Trop, Boston Chapter Treasurer, became actively interested in radio in the United States Navy in 1904. He was a participant in the "Fleet Round the World Cruise." After serving ten years in the Navy he spent four years with the Wireless Specialty Apparatus Company and then made his present connection with Guy R. Entwistle at the Massachusetts Radio and Telegraph School.

Charles C. Kolster, Boston Chairman, was with the Stone Telegraph and Telephone Company in 1905 and later became associated with the deForest Company, United Fruit Company, Bureau of Posts of the Philippine Islands, then the Department of Commerce, Radio Division, the Federal Radio Commission and now the Federal Communications Commission as Inspector in Charge of the Boston office.

Heartiest congratulations to Henry P. Kasner, member of the advertising staff of RCA Manufacturing Company, on completion of twenty-five years service with RCA and its predecessors in the business.

Dr. Ernest A. Cyriax, now a prominent Doctor of Dental Surgery in New York City, had an active and varied radio operating career, starting in 1912 aboard the S. S. *El Rio* and subsequently served aboard the *Alliance*, *Panama*, *Advance* and numerous other ships until 1916.

W. R. Schwalm is another member who started his radio career "way back when." He joined the Navy in 1913 and served in various radio assignments, achieving the rank of Chief Radioman before retiring from the Navy to engage in commercial radio work. He is at present with the American Radio News Company at Carlstadt, N. J.

Monte Cohen who started as a marine operator for the Marconi Wireless Telegraph Company in 1917 later became a transoceanic operator for RCA in New York and then entered the field of radio engineering with the Standard Radio Corporation. His present position as General Manager and Treasurer of the F. W. Sickles Company was preceded by an assignment as Production Engineer for the same company.

Bart McCarthy served as radio operator in the U. S. Navy back in 1918. Apparently he decided the U. S. Government is a good employer as he has served for the past fifteen years in various capacities with the Federal Communications Commission and preceding governmental radio regulatory organizations. He is Historian of the Boston Chapter of our Association.

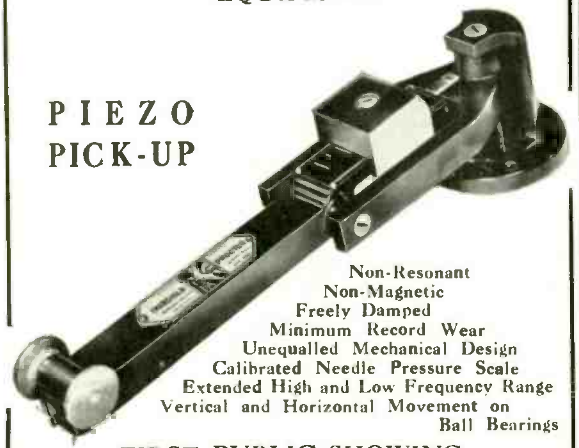
Joseph F. Welsh radio operated at the Bellevue Stratford Hotel in Philadelphia, old "BS," in 1909 and was at Dreamland Park, Coney Island, "DP" in 1910. He started, however, several years earlier in 1907 to delve into the mysteries of the new science, wireless.

C. S. Anderson looked hale and hearty when seen at the Memorial Services with W. S. Fitzpatrick on May 29th. Must be his yen for yachting and fishing that keeps him so young looking. . . . Enjoyed our lunch at that Spanish Coffee Shop with Arthur F. Wallis, Mackay Marine Superintendent. If you like variety in food, we suggest you contact AFW who is an epicure in all languages including the Scandinavian. . . . Aside to HBD: Greetings and best wishes for an enjoyable vacation. . . . W. H. Martin has been busy with details of sound and electrical maintenance for the Ford Motor Exhibit at the Dallas, Texas Exposition. He continues his permanent residence at San Diego, however. Glad to hear that you are enjoying your stay in the Texas metropolis WHM and if at all possible we will accept your invitation to visit there. . . . Ye Secretary is struggling through this page on the first day of his vacation. The July page will have to be readied immediately after return from same. Please make the job easier by deluging us with material immediately you receive this issue. . . . W. S. Wilson, our Resident Agent in Wilmington, is Chairman of the Atlantic Division ARRL Convention which is being held in Wilmington and promises to be an outstanding event in the history of "Ham" get-togethers. We hope to be there on the 20th of June. . . . C. D. Guthrie continues to greet operators with a smile and a cheerio at the Marine offices of the Mackay Company.

FAIRCHILD PROCTOR

SOUND RECORDING EQUIPMENT

PIEZO PICK-UP



Non-Resonant
Non-Magnetic
Freely Damped
Minimum Record Wear
Unequalled Mechanical Design
Calibrated Needle Pressure Scale
Extended High and Low Frequency Range
Vertical and Horizontal Movement on Ball Bearings

FIRST PUBLIC SHOWING

During your visit to the National Association of Broadcaster's Convention, see the Fairchild-Proctor first showing of their complete line of SOUND RECORDING EQUIPMENT at the Hotel Stevens, Chicago.

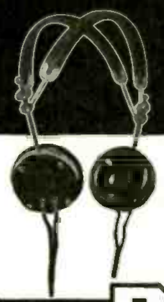
FAIRCHILD AERIAL CAMERA CORP.
62-10 WOODSIDE AVENUE, WOODSIDE, N. Y.

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 1¼x1⅛ 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
1894 E. 40th St. CLEVELAND, O.

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

Here Next Month:

Tru-Fidelity

by

THORDARSON

Most Sensational Audio Development in Radio History

JENKINS & ADAIR, INC.

ENGINEERS

DESIGNERS AND MANUFACTURERS OF RADIO TRANSMISSION, SOUND FILM, DISC RECORDING AND COMMUNICATION EQUIPMENT

3333 BELMONT AVE. CHICAGO, ILL.

CABLE: JENKADAIR

WHILE ATTENDING THE

N. A. B. CONVENTION

BE SURE TO SEE THE

TAYLOR TUBES
EXHIBIT
IN ROOM 501
STEVENS HOTEL

TAYLOR TUBES ARE FAMOUS FOR THEIR
HEAVY DUTY CONSTRUCTION
LONG LIFE AND
DEPENDABILITY

203A	204A
211	845
866	872

YOU ARE CORDIALLY INVITED TO VISIT THE TAYLOR TUBE PLANT DURING THE CONVENTION

"More Watts per Dollar"

Taylor Tubes

2341 WABANSIA AVE. CHICAGO, ILL.

THE MARKET PLACE

NEW PRODUCTS FOR THE COMMUNICATION AND BROADCAST FIELDS

CRYSTAL HEADPHONES

The Brush Development Co., East 40th Street at Perkins Ave., Cleveland, Ohio, has just announced the introduction of two new models of Brush crystal headphones to supplement the Brush Type A 2-phone model.

First of these two new developments is a single 'phone instrument with head band and soft rubber pad which holds the 'phone securely in place against the ear of the user. Second of the new models is also a single 'phone instrument . . . but with the 'phone mounted on a 12-inch lorgnette handle. Complete details, including descriptive literature, circuit diagrams, complete installation data and prices can be secured from the company—without obligation.

CENTRALAB CERAMIC SWITCHES

Centralab, 900 East Keefe Avenue, Milwaukee, Wisconsin, has developed a new switching device for use in radio circuits where a low-loss, low-capacity multi-section switch is required. This switch incorporates an Isolantite base, to which are attached sturdy, double bite clips with low contact resistance and free from all looseness or rocking. It is available in a multiplicity of designs.

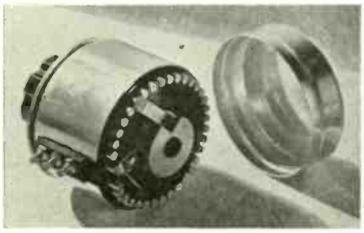
These switches will be engineered to meet individual requirements upon receipt of detailed information as to switching circuit and mechanical specifications desired. Write for Centralab specification form 380.

D-C TO A-C CONVERTER

The Carter Motor Co., 369 West Superior Street, Chicago, Illinois, have announced a new converter which will change 6, 15, 32, or 110 volts d-c to 110-volt, 60-cycle a-c. The output is 40 watts. The unit is designed for continuous operation and will give continuous output. Literature describing this equipment is available from the manufacturer.

VOLUME CONTROLS

The General Radio Type 653 volume control has been redesigned according to an announcement from the manufacturer. The new model is said to have several improvements which increase its usefulness in speech circuits. Full information may be obtained from the General Radio Company, Cambridge, Mass.



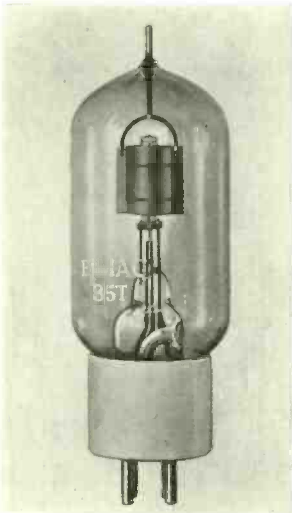
MIDGET AUDIO TRANSFORMERS

New "Midget" audio-frequency transformers have been developed by the American Transformer Company, 178 Emmet Street, Newark, N. J. These units have an average weight of only 3¼ ounces. They are suitable for operation at levels from —80 to 0 db and have a frequency characteristic uniform within close limits throughout the band of 20 to 20,000 cycles, it is stated. Thirty-five standard designs are offered.

In addition to "midget" audio transformers, AmerTran also offer small-size audio reactors, filter reactors, and plate-filament transformers. AmerTran midget components are described in Bulletin No. 1003 which will be mailed free upon request.

EIMAC 35T

Eitel-McCullough, Inc., San Bruno, California, have announced the Eimac 35T, shown in the accompanying illustration. This tube is a high-mu, low-capacity, general-purpose triode suited for use as an oscillator, r-f amplifier, doubler and in Class B audio service.



The characteristics of this tube are as follows:

Filament voltage	5 v
Filament current	4 a
Amplification factor	30
Max. plate current	100 ma
Plate voltage	200-1500 v
Plate dissipation	35 w
Grid-plate capacity	2 mmfd

Literature completely describing the Eimac 35T is available from the above organization.

CRYSTAL HOLDERS

It is very important that a crystal holder be of excellent design, one that will not affect frequency considerably due to temperature changes. The metals of the holder should be of the non-corrosive type and the insulation for these holders should be of a material that is not affected by heat and moisture.

The Scientific Radio Service, of University Park, Hyattsville, Maryland, are pioneers in supplying piezo-electric crystals. Their "A" cut crystals are supplied in Isolantite Monel Metal Precision Holders as approved by the Federal Communications Commission for broadcast-station use. Literature on the above crystals and holders will be sent free upon request.

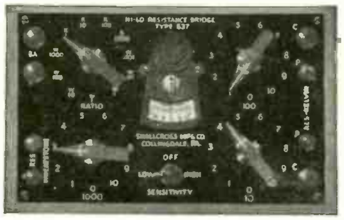
"SILVER-BAND" DYNAMOTOR

The Pioneer Gen-E-Motor Corporation, 466 West Superior Street, Chicago, Illinois, have developed a dynamotor for use in two-way police-radio intercommunication systems. The Pioneer "Silver-Band" is available in sizes suitable to police car, motorcycle or home-station use. Complete information may be obtained from the manufacturer.

RESISTANCE BRIDGE

Recent years have found an increased demand for a Wheatstone Bridge capable of measuring below 1 ohm. The newly developed Shallcross 637 Hi-Lo Resistance Bridge consists of a standard Kelvin Bridge for measuring from 0.00001 ohm to 11 ohms and a Wheatstone Bridge for measuring from 1 ohm to 11 megohms.

The resistors employed are of the well-known Shallcross construction. Any further information regarding this instrument can be obtained by writing to the Shallcross Mfg. Company, Collingdale, Pa.



NETWORK DISTRIBUTION PANEL

The latest product of the Radio Engineering and Mfg. Co., 26 Journal Square, Jersey City, is a new type of sound distribution panel, useful in broadcast control rooms for distributing program material to several outgoing lines at predetermined levels, or for use in centralized control installations where several branch circuits are loaded on the output of the main power amplifiers, and a certain audio level must be maintained in each circuit.

The panel illustrated is in reality an "Inverted Mixer" designed for operation at high audio levels, and its use is said to make for flexibility in the operation of control rooms where output energy is fed to more than one point.

Many adaptations of the same general principle of design are possible, and the manufacturer will cooperate with any organization requiring equipment of this type.

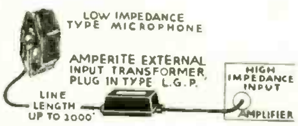
PHOTOPHONE REPRODUCER

A new high-fidelity soundhead reproducer incorporating many refinements and improvements, and retaining the famous rotary stabilizer system of the first RCA high-fidelity theatre sound systems, was announced by Edwin M. Hartley, Sales Manager.

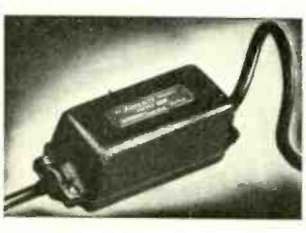
Mr. Hartley emphasized that the new RCA soundhead with improved rotary stabilizer will be standard with every equipment regardless of price or size, to insure full high-fidelity reproduction for all installations. The only variation in the reproducing equipments will be in the amplifying and loudspeaker apparatus appropriate to the size and acoustics of the theatre.

CABLE-TYPE INPUT TRANSFORMER

The new Amperite input transformer of the cable type is designed to operate low-



impedance microphones directly into amplifiers having high-impedance input. It permits the cable of the low-impedance microphone to be any length up to 2,000 feet, and is said to make high-gain amplifiers immediately adaptable to any location. Equal output is obtained by the use of this transformer and the low-impedance velocity as is obtainable with high-impedance microphones. As many as four velocity microphones can be fed into one transformer. Write to Amperite Company, 561 Broadway, New York City.



DISCLUBE

The Presto Recording Co., 139 West 19th Street, New York City, has just announced Presto Disclube for the recording industry. This liquid preparation, which is supplied in bottles, is a lubricant and a preserver of the playback life of instantaneously coated discs, it is stated.

Many coated discs, while soft enough to cut and hard enough to play back, find their life limited when used on spring-wound phonographs with heavy pickups due to digging and sticking of the needle. This can be prevented by dampening a soft cloth with Disclube and rubbing lightly over the surface of the coated discs. This practice is said to guarantee greater playback life and more faithful reproduction under all conditions.

For further information, communicate with the manufacturer.

AMPERITE STAND

The smooth and positive action of the Amperite banquet stand, shown in the accompanying illustration, is due to the incorporation of the Amperite ball-bearing

clutch. A 1/8 turn with the tip of the fingers is all that is necessary to tighten the stand securely. Once tightened, the stand will not "creep" and the ball bearing permits the microphone to be rotated without loosening the clutch, it is said. The quick grip thread requires only two or three turns to fasten the microphone. By removing the rod, the base can be used for a desk stand.

Further information may be obtained from Amperite Corporation, 561 Broadway, New York City, N. Y.

COMPACT AUDIO UNITS

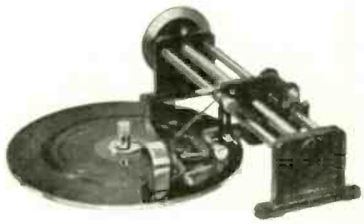
United Transformer Corp. has designed a new series of ultra-compact audio units as companions for acorn- and metal-type vacuum tubes. They measure up to good broadcast standards, having a response uniform within plus or minus 2 db from

30 to 20,000 cycles, it is stated. Average weight, 6½ ounces; overall dimensions, 1-7/16 x 1-7/16 x 1-15/16 inches.

These units are primarily intended for noise-meter, aircraft and remote-pickup work.

RECORDING LEAD SCREW

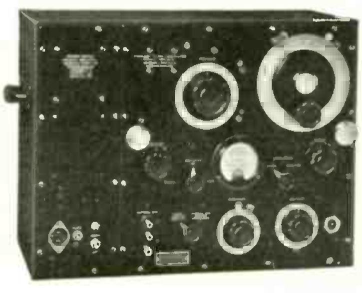
Radiotone Recording Company, 6103 Melrose Ave., Hollywood, Calif., announce



their new line of professional recording lead screws. These screw feed assemblies have been made available for the sound equipment dealer who intends to construct his own instantaneous recording machine. Complete information will be mailed upon request to the manufacturer.

SIGNAL GENERATOR

The General Radio Company, 30 State Street, Cambridge, Mass., have just announced a moderately priced "all-wave" signal generator featuring many electrical and mechanical improvements. This direct-reading unit is said to be simple to operate, accurately calibrated, and thoroughly shielded. This signal generator possesses the following features: continuous frequency range from 10 kc to 30 mc, a-c operation, internal or external modulation, no frequency modulation, and no thermocouples. Write for Bulletin 23-Y.



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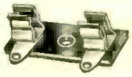


The Tops

NEW–LOW COST FUSE MOUNTING

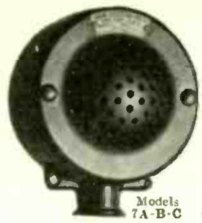
Littelfuse No. 1128 Fuse Mounting for 1¼" 3 AG Fuses meets the demand for a quality mounting — yet is *low in cost* — economical. Will save money wherever used. Rugged construction. Non-corrosive cadmium plated clips. Insulated base for metal panels.

Write for Sample and Prices

LITTELFUSE LABORATORIES
4242 LINCOLN AVE. CHICAGO, ILLINOIS

IMPROVED PERFORMANCE AT LOWER PRICES

GREATER SENSITIVITY— EXTREME RUGGEDNESS



Models 7A-B-C

An inquiry on your letter-head will bring immediate information.

RADIO RECEPTOR

Dynamic Moving Coil

MICROPHONES

have been drastically reduced in price, due to greatly increased production and improved manufacturing facilities.

The Moving Coil Dynamic Microphone is undoubtedly the most practical and efficient of all types of microphones.

They are not limited as to distance from amplifier; wide angle pickup; uniformity of product.

RADIO RECEPTOR CO., INC.
Manufacturers of Radio and Sound Equipment Since 1922
106 SEVENTH AVENUE NEW YORK, N. Y.

JUST OFF THE PRESS

New six-page catalog describing the most diversified line of quality microphone stands ever offered by one manufacturer.

Write for your copy to

EASTERN MIKE-STAND CO.
56 CHRISTOPHER AVE. BROOKLYN, N. Y.
Dickens 2-3538

RANGERECORD

Cutting Needles for Instantaneous Recordings on any Acetate Blanks

The Needle par excellence—read what users say—

"One cut fifteen, fifteen minute transcriptions before even a trace of surface noise appeared."—"Good for two and a half hours steady recording."

Harder than steel—tougher than sapphire. Hand-lapped with diamond dust.

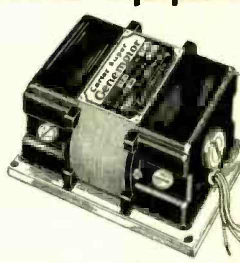
Price, 75c each.
Resharpened 20c ea.
(in lots of 6)
Send for a week's supply

RANGERTONE, INC.
201 Verona Ave., Newark, N. J.

Hi-Power for Sound Equipment

The Carter Genemotor supplies the most Reliable and Economical "B" Power for Class A or B Amplifiers from a 6 or 12 volt battery. Output up to 500 volts. Sturdy—Compact—Quiet operation—No oiling—Guaranteed.

Models for Two-Way Police Radios, Aeroplane Sets, Transmitters, Farm Radios, etc. Write for Bulletin showing complete line of Genemotors or specify your requirements. Also AC output up to 40 watts.



CARTER MOTOR COMPANY
373 West Superior St. Chicago, Ill.
Cable Address: GENEMOTOR

VIBRO-MASTER Model 10

Portable Recorder

Professional Type

New!

Records on acetate or aluminum at 33⅓ and 78 rpm; 32 to 6200 CPS. Play-back range 32 to 16,000 CPS. Increased hi-fidelity. Weight approximately 52 lbs. complete. Single carrying case with microphone and stand. Price is complete—*nothing else to buy!* Send for details.

Also—Model 15 for 16" recordings

$410
No Extras

DENCOSE, INC.
1650 BROADWAY, N. Y. Dept. B-6
"If it pertains to sound—see DENCOSE!"

UNIVERSAL

VELOCITY and CARBON MICROPHONES

●

Universal's latest achievement—Ideal for stage use—Not affected by temperature or humidity—Flat frequency response curve from 40 to 10,000 c.p.s.; Output —63 db; Low impedance or direct to grid types. Compact, 2¾ x 4¾ in. by 1½ in. thick—Weight, less than 18 oz.—Head swings to any desired angle—Beautifully finished in black enamel and artistic chrome plate—Ask for new catalog sheet describing Models RL, RP, RH and CB—List $22.50—Latest model music type sectional stand for above microphones—List $10.00.

UNIVERSAL MICROPHONE CO., Ltd.
424 Warren Lane Inglewood, Calif., U. S. A.

Here Next Month:

Tru-Fidelity

by

THORDARSON

Most Sensational Audio Development in Radio History

DIRECT READING
10 kc to 30 Mc

A NEW G-R STANDARD-SIGNAL GENERATOR

Announced after several years of development—a moderately priced "all-wave" standard-signal generator with many electrical and mechanical improvements.

Simple to operate—accurately calibrated—thoroughly shielded—the new General Radio Type 605-A Standard-Signal Generator has all the conveniences you have been asking for.

Check these features:

★ DIRECT READING—no calibration curves to read—no plug-in coils.

★ A-C OPERATED — built-in voltage regulator — line voltage fluctuations have no effect upon frequency.

★ CONTINUOUS FREQUENCY RANGE—10 kc to 30 Mc.

★ INTERNAL OR EXTERNAL MODULATION—internal fixed at 400 cycles; external, flat from 30 cycles to 15 kc.

★ NO FREQUENCY MODULATION.

★ NO REACTION OF ATTENUATOR ON FREQUENCY.

★ NO THERMOCOUPLES — vacuum-tube voltmeter indicates carrier amplitude — cannot be burned out.

PRICE: Type 605-A Standard-Signal Generator: $415.

Complete with accessories and tubes.
Specify a-c or battery model.

Write for Bulletin 22-K for Complete Description.

Address:

GENERAL RADIO COMPANY
30 State Street, Cambridge, Massachusetts

SPECIFICATIONS

Circuit: Master—oscillator—amplifier.

Frequency Calibration: Direct-reading to 1%. Straight-line logarithmic frequency scale.

Output Voltage Range: 0.5 microvolt to 0.1 volt.

Output System: 10-ohm constant resistive from 0 to 0.01 volt and constant 50-ohm from 0.01 to 0.1 volt.

Modulation: Continuously variable to 50%. Settings accurate to ± 10%.

Stray Fields: Electrostatic and magnetic stray fields negligible.

Power Supply: Three a-c operated models available, for 60, 50 and 42 cycles. Built-in voltage regulator compensates for line voltage fluctuations between 100 and 130 volts.

Battery Operation: Battery operated model available for 200-volt plate and 6.3 volt filament supplies. Control panel contains plate and filament meters and necessary controls.

GENERAL RADIO COMPANY