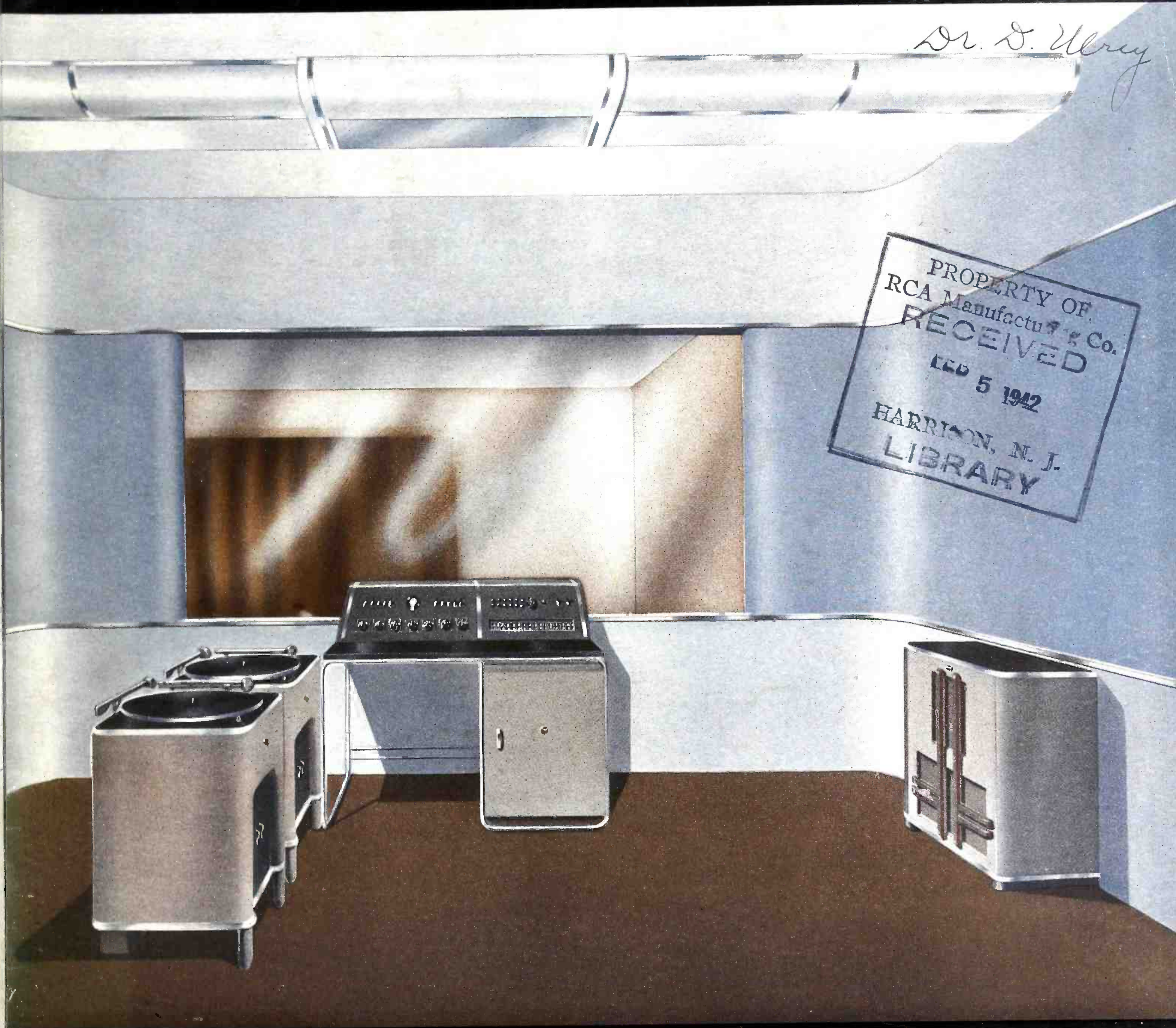
BROADCAST NEWS



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RCA Manufacturing Company, Inc.

A Service of Radio Corporation of America

Camden, N. J.

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BROADCAST NEWS

REG. U. S. PAT. OFF.

PAUL V. LUTZ, Editor

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MODERN DESIGN—SIMPLICITY

New Forms Arise From Industry's Requirements

By LYNN BRODTON

BEFORE attempting to acquaint the reader with fundamentals of method, procedure and results of modern industrial design or styling, it is desired to present a synopsis of the background and conditions out of which modern styling developed.

When artists and designers first became aware of the inadequacies of Rennaisance, Period, Colonial and like modes of art as applied to the problems of the past decade rebellion resulted. A chaotic condition rent asunder the academic and traditional ties and each artist went his respective way in creating new and romantic methods of applying art to the rapidly increasing number of products to which his talents could be administered.

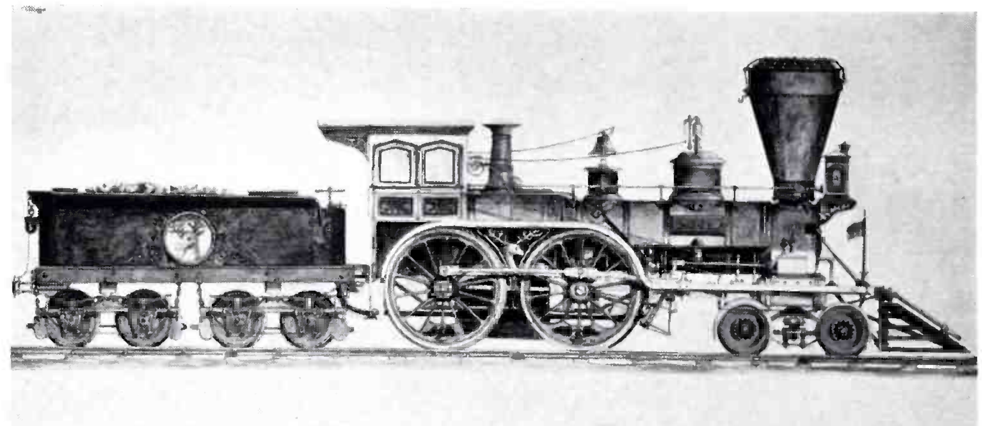


Photo Courtesy of the Franklin Institute, Philadelphia.

A wood-burning Juggernaut of the Nineteenth Century. Decorative effects popular in the homes of that day were often standard equipment on mechanical devices.

Chaotic Era

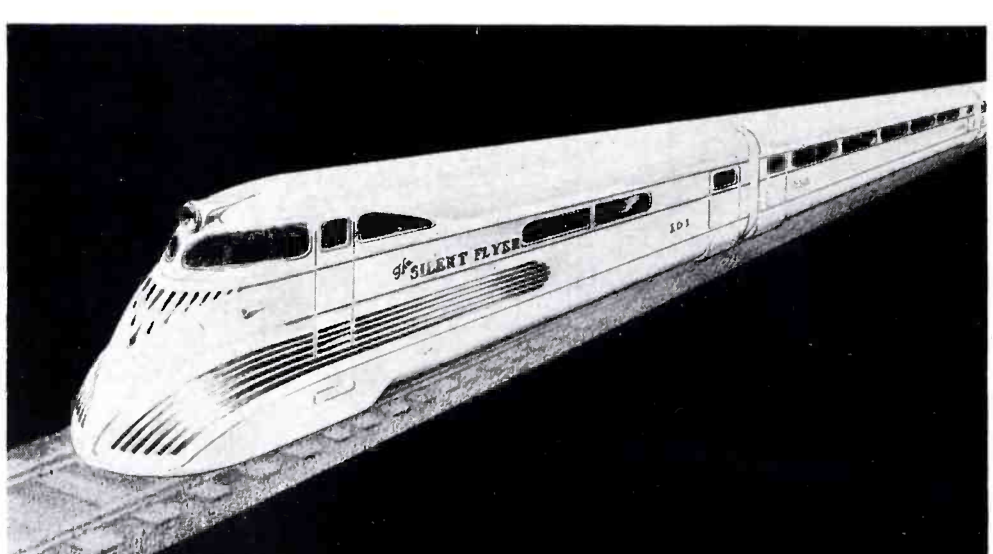
Many undoubtedly will recall that not many years ago, as a result of this chaotic era of art, nearly every restaurant, department store, and cabaret, as well as almost every type of utility and trinket—from a cigarette lighter to an automobile was decorated with meaningles sangles, trapezoids, circles and spirals and were colored in various weird shades. One post-war motor car boasted octagonal fenders!

With so many artists' efforts radiating in diverse directions, it will be appreciated that they could not all be right in their ideas—nor all of them wrong. The result was, that the few who were creating in the more utilitarian channels, were copied to a degree by those artists who recognized the few to be pioneers. The vast majority however returned to academic design and the others fell by the wayside.

While many stylists of today, such as Geddes, Vassos and Dreyfuss, have led the group which narrowed down to inherently correct modern design in which recognizable utility, quality and charm predominate, the remainder of the "field" still allow their ego to dictate that their work should be radically different. Consequently a degree of impracticability is reflected, that not only impairs their value, but puts the better stylists or designs at a disadvantage, since all contemporaries call their work "modern."

"Modernistic" should not be used in the same breath with the names mentioned above, nor should it be confused with the word "modern," since "modern" is an unaffected term in styling intended to differentiate distinctly from the former. It indicates a fundamental design having a form which best accomplishes a given function; and ornate only to the point of creating certain necessary impressions or eye-appeal.

The reader is asked to abandon temporarily any biased opinions on Modern Styling until the conclusion of this article. It is hoped that a sufficiently clear picture of modernity will be presented to enable him to analyze a design—whether period or modern—from a functional, artistic and industrial angle.



A sketch of a modern streamline train where functional design has been emphasized.

No Definite Rules

With the wide variety of enterprises and products to which art it applied today, it is obvious that no definite statement or rule will apply to every condition or product. Therefore, an attempt will be made to classify a few of the major phases of styling as well as certain products and enterprises, any one of which presents necessarily different conditions, even though the fundamental of modern styling (where form follows function) is the same.

The major classification would be somewhat as follows, and listed in the order of cubicle content or size rather than relative importance, are:

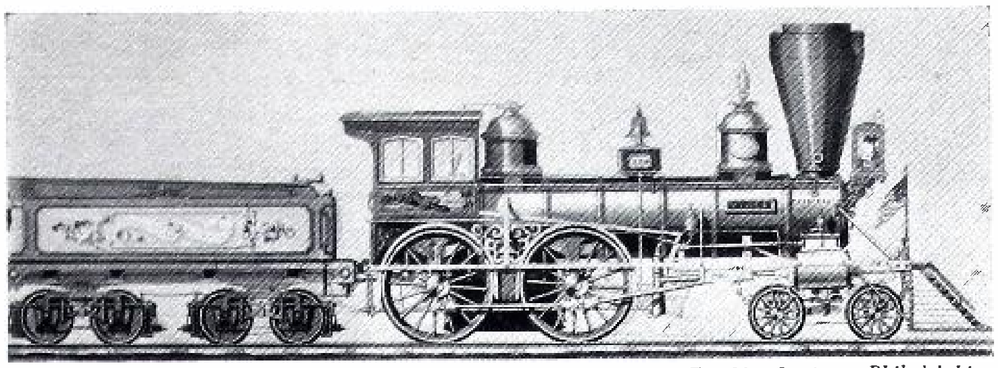


Photo Courtesy of the Franklin Institute, Philadelphia.

Another example of ornate construction in the early days of railroads.

1. **Architecture**—In addition to a pleasing appearance, we must take into consideration the ability of desired materials to withstand specified stresses and maximum ability to retain appearance despite the elements. Further, it is evident that since architecture represents a fundamental in our social structure, it must undoubtedly be considered from more angles and in greater detail than any other individual field and consequently represents a distinct line and type of work for the designer.

2. **Ships**—While basically similar to architecture, the specific methods dealing with balance, distributed weight, stability and seaworthiness present such a different problem, that the designer is governed in its creation by naturally different requirements than architecture.

3. **Interior Decoration** — This is also one of the most diversified lines of art, and incidentally, one in which more errors or more beautiful combinations can be effected than in any other fields of endeavor. When applied to the foregoing two subjects, it will be appreciated that consideration must be given by the stylist to every detail from the glassware to the type of walls, ceilings and lighting.

4. **Aeronautics**—In no field is the case more clear that "form follows function," since an airplane must look the way it does to do the thing it is intended to do. However, you are aware that certain ships are sleek, beautifully streamlined jobs, while others—although able to fly more or less efficiently — lack that certain "something" which gives them grace and eye-appeal as well as superior airworthiness. Here the stylist with aerodynamic knowledge is doing a real job—and improving as time goes on.

5. **Radio**—It is believed no more fertile field is presented for the engineer and stylist than in Radio. If we enumerate only the highlights by mentioning items familiar to the public, the vastness of radio may be partially realized. Therefore, instead of starting at the transmitter, we will consider the continuity of products from the listener's standpoint:

The Microphone

The microphone is the first unit in the chain. It depends upon the studio type and management as to what type of "mike" will be designed and used, as well as the most efficient stand, which must be light and attractive, etc. The studio, of course, must be styled and appointed with efficient components, such as acoustical walls and ceilings, proper lighting, equipment to suit the type of programs, and as many studios must be provided as are necessary for the volume and type of program material and artists.

From the microphone, the program next "passes through" the studio control medium which "regulates" it and introduces it into the speech input equipment before entering the broadcast transmitter. The studio and speech input equipment may vary from a pair of small units to a console and rack, or an elaborate combination or series of both, depending upon the needs of the station. All such units must not only be designed to look well individually, but collectively in a studio, and styled in a manner to offer a minimum of fatigue and eye-strain due to constant operation, and a practical color scheme of serviceable nature applied to the ensemble.

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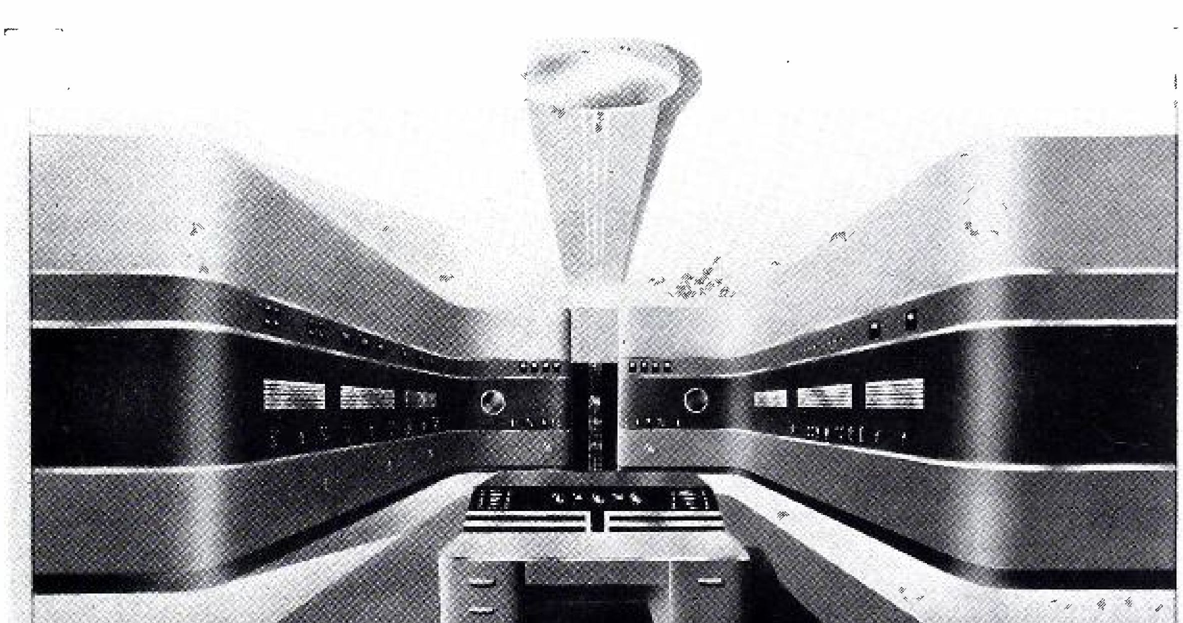

A modern transmitter, the RCA 50-D, designed with its function held clearly in mind and free from unessential decorative detail.

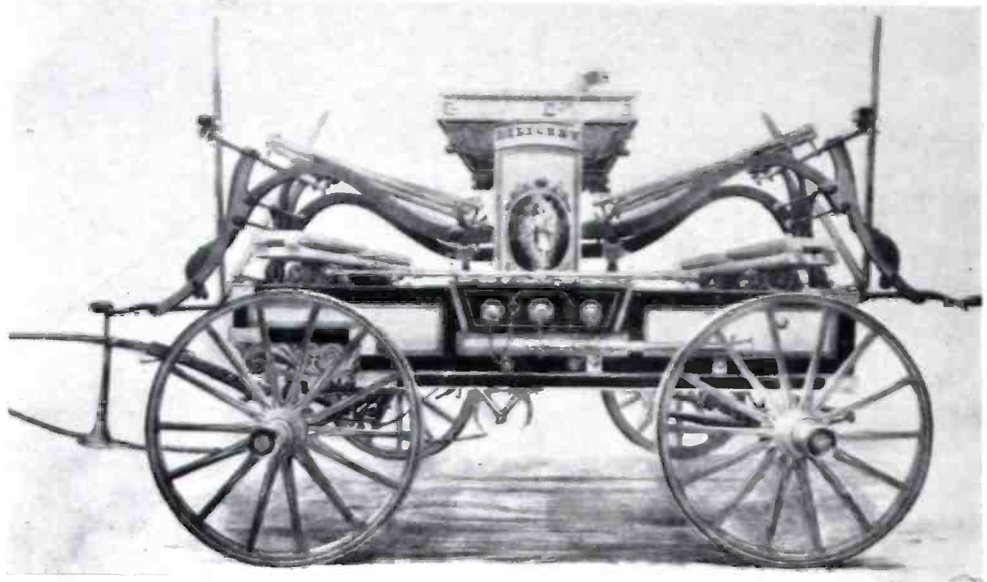

Photo Courtesy of the Franklin Institute, Philadelphia.

The idea of decorating equipment with unrelated designs was carried into many fields. Even fire-fighting apparatus followed the trend.

MODERN DESIGN

(Continued from Page 3)

In the case of a direct broadcast, the transmitter would be the next unit to consider, but for transcriptions, it is necessary to design and style recording and reproducing equipment which must function with the foregoing apparatus and be styled to harmonize.

As has been observed, no detailed styling procedure has been elucidated relative to the foregoing equipment, since the fundamentals of modern styling of transmitters and rooms will present a sufficient basis for drawing conclusions as to the methods employed in the creation of forms, appointments and color schemes for the apparatus.

The transmitter, the next step in getting the program into your home, is illustrated on the preceding page and represents a "medium" sized transmitter of the "deluxe" series, co-styled by John Vassos and the writer.

It will undoubtedly be noticed first that the transmitter appears as a single unit; and that it is U-shape in plan. This is again an outstanding example of form following function, since the panels are arranged to present a focal point at the control console from which all instruments are visible and controls accessible via the shortest distance from the operator.

Closer examination will reveal that the major panels comprise a series of smaller panels and doors, but the series of longitudinal moldings give the effect of undisturbed continuity and serve to combine or unify the series into one large unit and thereby serve a function. A further functional unification is effected by the darker continuous tone of color running the entire length of the transmitter except for the central door.

Visibility

Large windows are provided where maximum visibility of tubes and units is required, while tubes and apparatus requiring less observation are visible behind grilles composed of horizontal series of bar moldings. These not only permit viewing, but also serve the function of protecting from high voltage, and serve to enhance the appearance of the transmitter as well as further establishing horizontal unification of the whole.

The meters are arranged in the light color band along the top of the transmitter proper. They are outstanding and instantly recognizable from the control console and have anti-parallax indicators and bold indicia. Access doors are styled to harmonize and are of the usual interlock type which, when opened, shut off all power for obvious safety reasons.

At waist height along the transmitter are located a series of control panels normally concealed by doors which swing downward to become miniature individual "desks" for each control panel. Lumaline lamps illuminate panel and desk when open for operation.

Minor Details Considered

The dark "undercut" base serves to permit the toes of the operator to actually project under the panels when taking readings close to the transmitter. In addition to the above function this dark undercut further assists in unified appearance as well as "floating" the unit and serving as a "scuffer."

The frieze, or lighter band above the meters, serves to complete the gap between the transmitter proper and the ceiling for better appearance. It also isolates "backstage" transmitter from the control room in order to effect natural circulation of air up through the undercut base and grilles and out the rear of the transmitter room.

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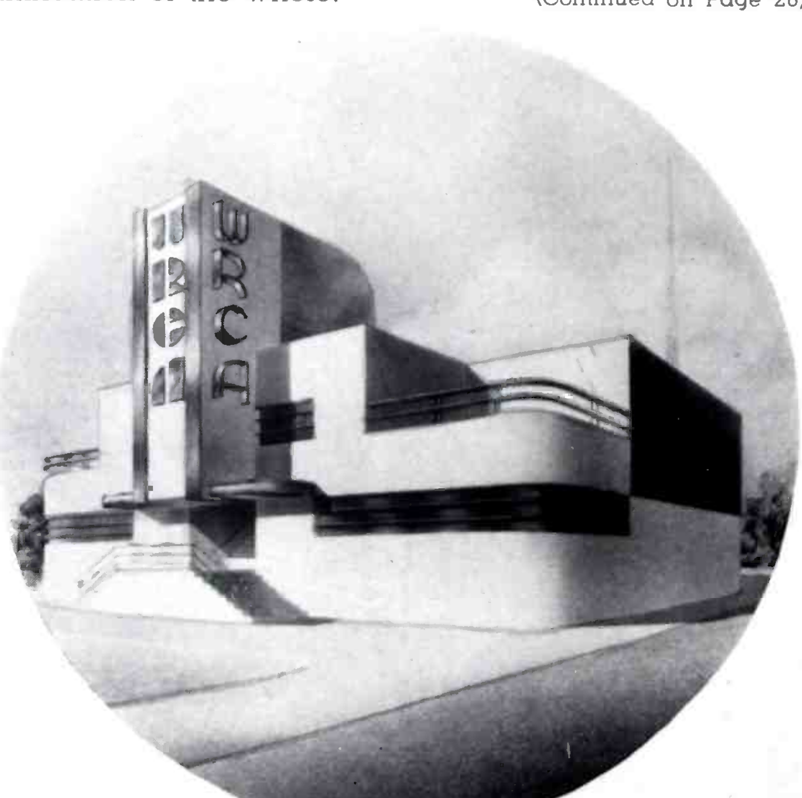


An artist's conception of the building required for a modern 500 KW transmitter.

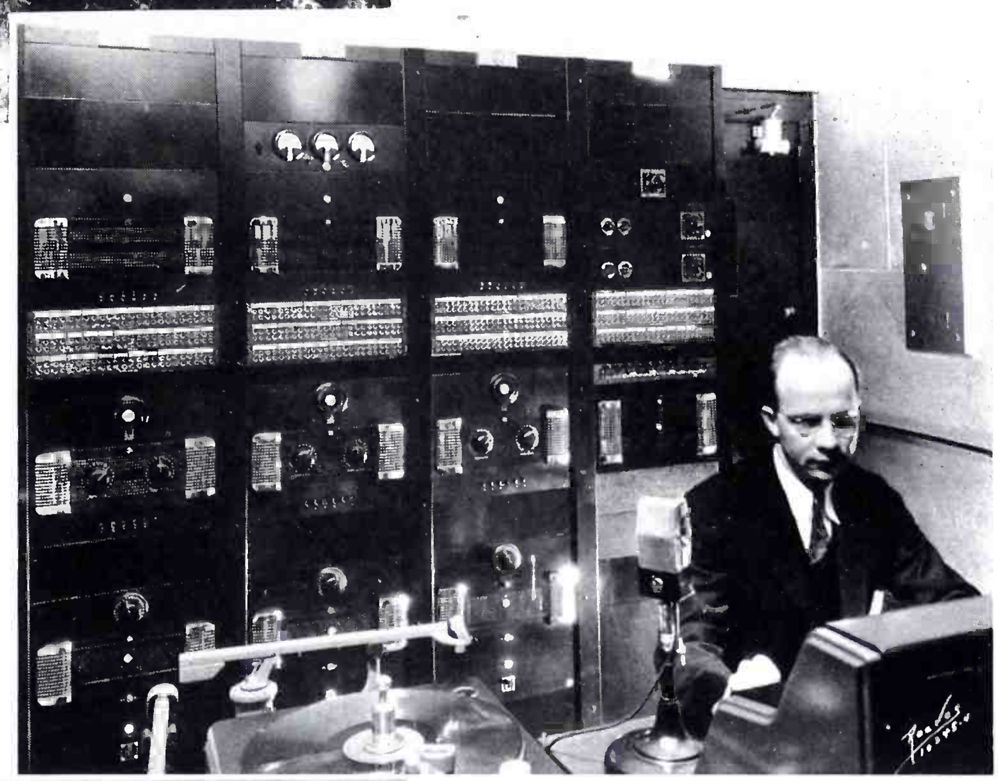
WAGA AND A 1-DA

New Transmitter Improves Signal Strength for Georgia Station

ABOVE: The building which houses the 1-DA.

BELOW: Custom built master control console.

BELOW: The 1-DA installation at the Atlanta station.



ABOVE: Speech input racks in studio control room.

JESS SWICEGOOD
General Manager of WAGA

5000 WATTS FOR WRC

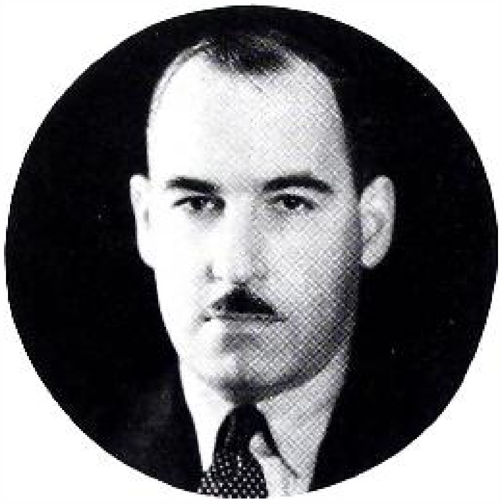
New Transmitter at Nation's Capitol Air-Cooled

By RAYMOND F. GUY

Radio Facilities Engineer, National Broadcasting Company, Inc.

EARLY in 1923 the Radio Corporation of America installed its second broadcasting station, WRC, and later in that year dedicated it to the srevice of the nation's Capitol.

With periodic modernization of equipment at the Riggs Bank Building site, WRC provided 15 years of continuous public service from the one location until it was closed on March 15, when its task was taken over by a sleek and shiny new 5 KW station at Chillum, Maryland. The final program from the old station closed with Auld Lang Syne, which was gradually faded into silence.



Raymond F. Guy

Location of Transmitter

The site of Washington's newest and most modern station is approximately six miles northeast of the Capitol and is marked by its new 400 foot top loaded vertical radiator. The new tower has attracted a large number of visitors and serves as a guide to all who wish to inspect the new station. The new site was selected and the station built after thorough tests by the Headquarters Staff of NBC Engineers. Preliminary studies of station coverage showed that broadcast listeners in the District of Columbia, Virginia and Maryland would be provided with a new standard of service in fidelity of transmission and absence of background noise. The new location is ideal for radio transmission in that the ground about the new vertical radiator is swampy and is occasionally flooded over considerable areas. Interesting results were obtained when soil samples were examined as a quide to foundation design.

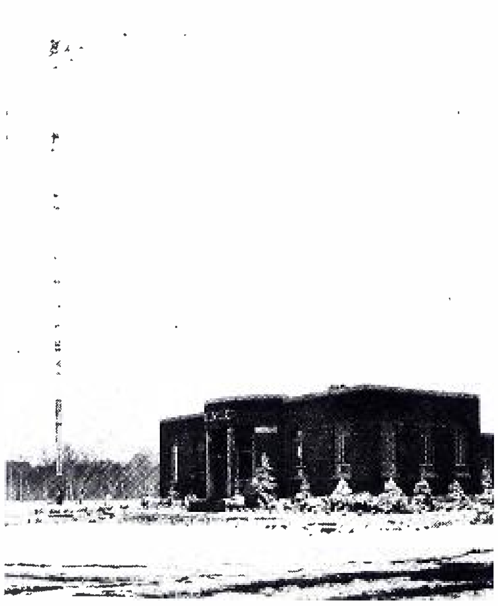


Fig. 1. WRC transmitter building and top-tuned antenna.

The area on which this station is built was once a valley, the floor of which was 30 feet below the existing ground level. Soil borings indicated unusually interesting soil strata, not the least of which was a layer of decayed wood and vegetation. The wood was in a fair state of preservation although having been buried for thousands of years. From a depth of only 12 feet in one of the guy anchor excavations, decayed wood was found which was in an advanced stage of turning to coal. If the original valley floor could be explored many interesting things would be disclosed.

Soil Strata

Although the soil strata was unusual, and swampy terrain of the type encountered makes possible radio transmission, it provides conspicuously poor foundation conditions for antennas and buildings. As a result, the guy anchors, tower and buildings had to be supported on 30 foot wood and concrete piles. The entire building, antenna foundation and anchors are, in addition, built several feet above the maximum recorded flood water level, which occurred in 1933. Since the station has nothing to fear from floods, and ground conditions are improved by them, Mr. Barton Stahl and his station staff are prepared to accept them with equanimity.

Radiator

WRC's new vertical radiator is of uniform cross section from top to bottom and is triangular in shape, with faces five feet wide. At the top of this slender structure there is a steel capacity top 50 feet in diameter. This "high hat" is the top tuning structure which NBC has pioneered at KOA in 1933, WPTF and WHIO in1934, and WMAQ in 1935. It has been developed to a high state of effectiveness and the results obtained from these installations have been described in the RCA Review.*

Although it is usually desirable to erect an antenna to the optimum height, restrictions are frequently imposed by the U. S. Bureau of Air Commerce through and with the aid of the F.C.C., which make it necessary to resort to other expedients to obtain satisfactory efficiency. When these conditions are imposed upon the Broadcast-

* Some Notes on Broadcast Antenna Developments by Raymond F. Guy, RCA Review—April, 1937.

Fig. 2. Laying the ground system for the 400 foot vertical radiator.

ing Industry in favor of the Aviation Industry, properly designed top tuning offers a partial solution. In the case of WRC, the use of a 50 foot diameter steel capacity top, used in connection with the restricted height of 400 feet, made it possible to approach the desired results without supplementary inductance loading at the top of the structure.

Figure 1 shows the WRC transmitter building and top tuned antenna during the last week of the construction period.

Ground System

The ground system for this new structure consists of 66,000 feet of one inch copper ribbon buried in the swamp land beneath it. These ribbons are buried ten inches below the surface and are laid in position by means of a special plow which automatically raises a furrow, guides the ribbons into position beneath it, and partially covers it. The special plow has been developed by NBC over a period of years and is substantially ideal for its purpose. Fortunately, it is simple to build and operate. It is a modified "sub-soiler" adapted for the purpose after trying and using various other types. A mounting is provided on which a reel of copper ribbon can be quickly attached. The end of the ribbon is guided to a roller at the rear of the plow point through which it is deposited at the bottom of the furrow. The "sub-soiler" is equipped with facilities for adjusting the depth of furrow to any value desired. A tractor, preferably equipped with a bulldozer, completes the equipment.

The "sub-soiler" is shipped from station to station, as required, but it is customary to rent the tractors and bulldozers from local contractors. The purpose of the bulldozer is to smooth up the ground after the work is completed, to fill in brooks and ditches by brute force, and to move logs, rocks, etc. With an energetic crew, over 6,000 feet of ribbon can be buried accurately and uniformly per day.

Figure 2 shows the equipment in operation at WRC.

Power Change

The new WRC transmitter is the RCA type 5-D, which comes equipped with facilities for changing power from one to five KW by means of push button control. The transmitter is of the most recent design and features for the first time, by any manufacturer, a new high power tube which does not require water cooling apparatus and radiators, which were formerly something of a nuisance in intermediate powered stations.

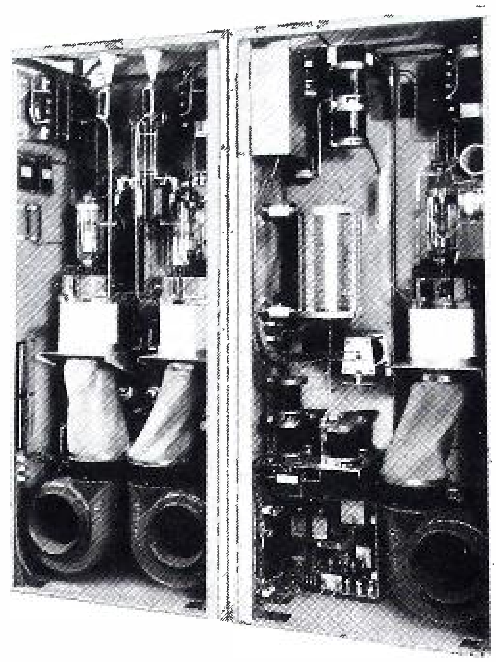


Fig. 3. Looking into the rear of the 5-D. A clear view of the modern, air-cooled tubes.

Contrary to the old procedure, in which the surplus heat from the power tubes was wasted by being dissipated from the water system, WRC makes use of this surplus heat for warming the transmitter building during the Winter season. This new tube has been described elsewhere in Broadcast News. Cooling is accomplished by means of low speed fans which make no perceptible sound when the transmitter is in operation. The absence of noise from blowers, contactors, or other transmitter parts makes possible high fidelity monitoring immediately adjacent to the transmitter.

The new transmitter features improved class B modulation in which the idle plate power is less than 400 watts. The idle modulator plate current can be reduced to zero by means of a simple adjustment, with an increase of less than 1% in harmonic distortion. This system makes possible a very large increase in economy since the power consumed by the modulator is confined to filament lighting during periods of zero modulation. The total power consumed by the new 5-D transmitter is only 16 KW during normal modulation, a reduction of approximately 50% from older designs of 5 KW stations.

Feedback System

The audio frequency system up to and including the modulators is practically all resistance coupled with special attention given to the elimination of phase shift. This makes possible an unusually simple and effective "reversed feed back" system which reduces harmonic distortion and background noise to extremely low values. One of the most attractive features about this feedback system is its utter simplicity. There are no rectifier tubes, amplifiers, or other parts to wear out or require replacement. The feedback system is a simple, permanently fixed resistive network.

Figures 3 and 4 show the transmitter installed.

The radio frequency system utilizes a low temperature coefficient quartz crystal with trimming facilities, by which it is possible to quickly and easily adjust the transmitter to be exactly on its frequency. Crystals are provided in duplicate.

(Continued on Page 25)

The last word in 5 KW installations ready to go on the air.

A RADIO FREQUENCY PHASE METER WITH MANY USES

A Simple, Effective Instrument for Radio Frequency Measurements and for Directive Antenna Adjustment or Maintenance

By DR. G. H. BROWN and GILBERT SWIFT

THE increasing use of directional antenna systems to reduce interference between stations operating on the same or nearby channels has presented some new maintenance problems for the broadcast station engineer. To obtain the proper directional characteristics, accurate adjustment not only of the current ratios but also of the phase relations of the currents in the various antenna towers is required. While the current ratios can be measured conveniently, by means of radio frequency ammeters, the requirement of determining the phase angles has introduced the need for a new measuring instrument. It is the purpose of this article to describe an instrument for measuring the phase relations of the various antenna currents in a directional antenna array. By means of this equipment it is now possible for the engineer to make frequent checks on the operation of the antenna system, thus insuring proper directivity at all times.

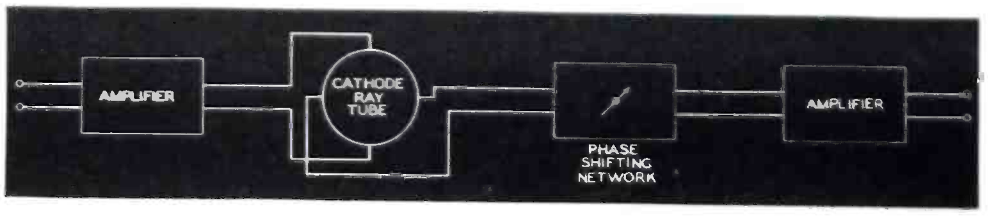


Fig. 2.

Installation

The Type 300-A Radio Frequency Phase Meter is capable of measuring all phase angles from 0 to 360 degrees at any frequency between 200 and 1600 kilocycles. While the instrument is useful for many types of r-f measurements, some of which are outlined below, its primary application is in connection with directional antenna arrays. In such an installation, a small pickup coil is placed near each tower and connected to the phase meter through a transmission line as shown in Figure 1. The instrument accommodates up to six lines and is provided with switches which enable the operator to select any two lines at a time. Thus, the phase angle between the currents in any two towers of the array may be measured.

Operation

In its operation, the phase meter utilizes the ability of a cathode ray tube to indicate with considerable accuracy the condition of two voltages being directly in-phase or 180 degrees out of phase. It is well known that these conditions result in a straight line pattern on the oscilliscope screen while other phase relationships produce an elliptical pattern.

The phase meter consists essentially of two resistance coupled radio frequency amplifiers which feed the two sets of deflecting plates of a cathode ray tube, as shown in the block diagram, figure 2. One of the amplifiers contains a calibrated phase shifting network which may be adjusted to secure an indication of in-phase conditions on the oscilloscope screen. The amount of phase shift introduced is then equal to the phase difference between the two input signals and is read directly from the dial scale. The operation of the phase shifting network may be understood by consideration of figure 3. It will be seen that the circuit consists of a pentode with capacitive load. If the load reactance is low the voltage developed across it will lead the grid voltage by 90 degrees. By connecting a high resistance potentiometer from plate to grid, it then becomes possible to obtain a voltage of any desired intermediate phase angle. Adjusting the circuit constants to obtain equal voltage at each end of the potentiometer provide reasonable constant output voltage together with a well-spaced phase angle scale. Accuracy of the phase calibration is maintained by occasionally checking the equality of the output voltage obtained at each end of the scale.

The operation of the instrument is not affected by modulation; consequently measurements can be made at any time while the station is on the air. The input impedance is approximately 80 ohms to match low impedance cables and the required input signal is less than one volt. Thus, the phase meter requires a negligible amount of radio frequency power for its operation. The equipment is designed for mounting in a standard 19-inch rack and requires 8¾ inches panel space.

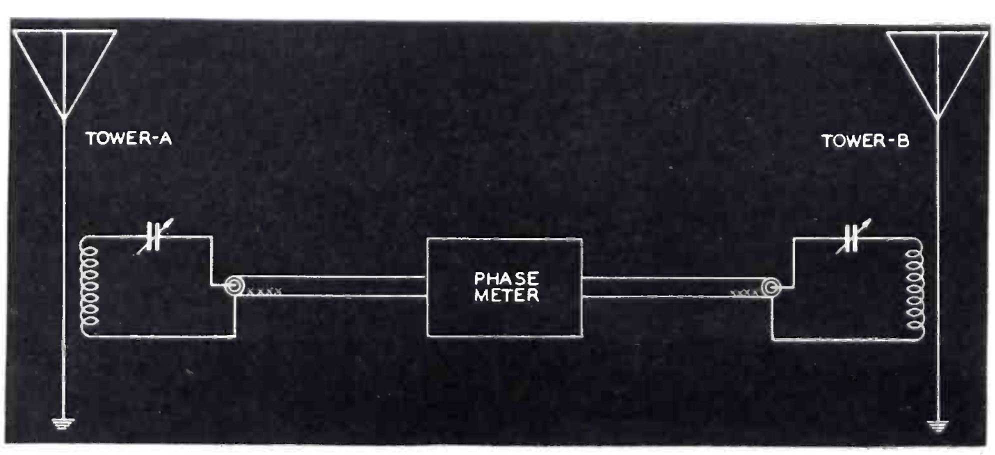


Fig. 1.

Other Measurements

In addition to measurements of the phase difference between currents in various antenna towers,

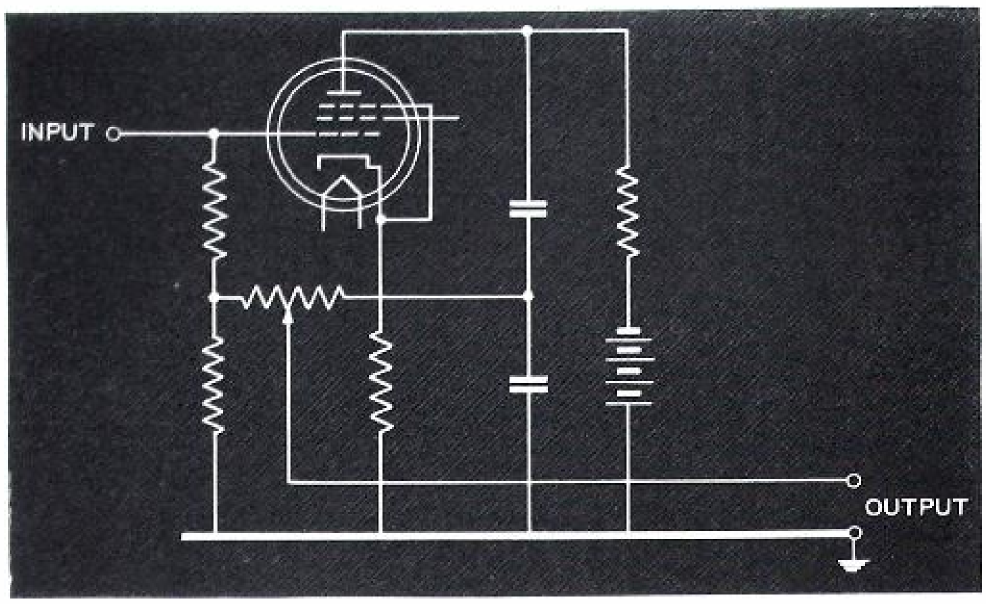


Fig. 3.

several other types of measurements are within the scope of the Type 300-A Phase Meter.

In the installation of a directive array, it is necessary to adjust one or more phase shifting networks. This is usually accomplished by bridge methods, but it is very desirable to check the final adjustment. A typical network, shown in Figure 4 is a simple T section, terminated in a resistance. This load resistor is used to simulate the pure resistance offered by a perfectly matched transmission line. In some of the cases in which the phase meter has been used to check these adjustments open wire transmission lines having a characteristic impedance of 240 ohms have been used. In such cases R-1 is chosen so that, when it is placed in series with the phase meter, a resistance of 240 ohms will be offered to the network. Since the phase meter input resistance is approximately 80 ohms R-1 becomes 160 ohms. The phase meter then reads the phase angle between the input voltage E_2 and the output voltage E_1. Since the network is assumed to be preadjusted to a pure resistance at the input terminals, the measurement may be regarded as yielding the phase relations between input and output currents.

Methods

In the operation of the phase meter in the conventional manner, to measure phase relations in a directional array, the antenna currents are "sampled" by means of small pickup coils and a small amount of energy is fed down a concentric transmission line to a central point where the phase meter is located. If these concentric lines all have equal lengths no correction need be made for the time delay occuring in the lines. However, when the line lengths are unequal, the time delay or phase shift of the line becomes an important factor. The measurement of this phase shift is a simple matter if it is undertaken before the concentric line is laid in the earth. Figure 5 shows the line coiled up at the phase meter so that both ends of the line are readily accessible. The two ends of the line are connected to two input terminals of the phase meter and power is applied to one end of the line. Since the input impedance of the instrument properly terminates the transmission line, measurement of the phase angle between input and output voltages yields the phase delay of the line.

Mutual Impedance

One of the most important quantities to be measured during the course of adjustment of a directional array is the mutual impedance between any two antennas in the array. A method has already been published* which requires the measurement of the self resistances and reactances of the antennas with the other antennas inoperative, and then the measurement of the resistance and reactance of one antenna with the other antennas tuned as parasitic reflectors. Then the measurements are substituted in a formula in which the differences between the resistances appear. This difference relationship makes the method rather inaccurate. A method which is more accurate and rather simple in procedure is as follows: Consider two antennas, A and B, forming a two element directive array. In an orderly process of adjusting the array first the resistance and reactance of Antenna A are measured with Antenna B floating or inoperative. Next, Antenna A is floated and the resistance and reactance of Antenna B are measured. These measurements are usually made at frequencies differing by 10 kc from 50 kc below to 50 kc above the carrier frequency. This information is required as part of the "Proof of Performance" by the F.C.C. (method of measuring mutual impedance not specified).

When the measurements at Antenna B have been complete, this antenna should be tuned to resonance at the carrier frequency by means of a coil or a capacitor, and connected to ground through its resonating circuit and an ammeter. An ammeter is then inserted in series with Antenna A and carrier power applied to this antenna. Antenna B will then act as a parasitic element will will have current induced in it. The two currents I_A and I_B are measured by means of the ammeters and the phase angle between the two currents is determined by means of the phase meter. This gives sufficient information to compute the mutual impedance. The magnitude and phase the mutual impedance are given by the equations:

$$|Z_M| = R_B \frac{|I_B|}{|I_A|}$$

$$\theta_M = \beta \pm 180°$$

where

(Continued on Page 10)

* "Directional Antennas" Proc. IRE Jan. 1937, pp. 126-127.

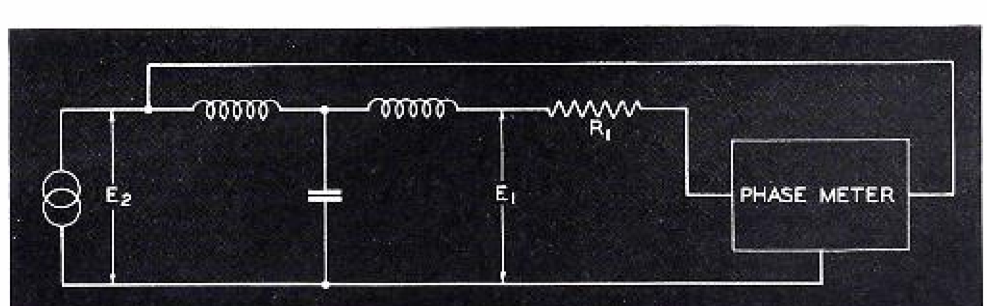


Fig. 4.

R_B is the self resistance of antenna B determined previously
I_A is the current in Antenna A
I_B is the current in Antenna B
β is the angle by which I_B leads I_A

Another type of measurement for which the phase meter is useful is the determination of the impedance of a single antenna of a directive array while the array is in operation. In general the resistance and reactance present at the terminals of an antenna which forms part of a directive array are quite different when the array is in operation than when each antenna is fed alone. The method described here, for measuring the impedance at the antenna terminals while the array is in operation, is also applicable to ordinary measurements, where only one antenna is operating, but is of little importance where ordinary bridge or substitution methods may be used.

The procedure for making this measurement requires the insertion, in one antenna lead, of a coil and a capacitor which are tuned to series resonance. This series circuit may be inserted without upsetting the antenna adjustment. The circuit is connected, as shown in figure 6, with the coil adjacent to the antenna. The phase meter is connected so that the phase between the antenna voltage and the voltage at the coil-capacitor junction may be measured. Resistances R are inserted in series with the phase meter so that its input impedance will be large compared to the antenna impedance. Thus, it will be determined that the voltage E_1 **leads** the antenna voltage E_a by an angle, θ_1. Next, the tuned circuit is reversed, so that the capacitor is adjacent to the antenna as shown in figure 7. The phase meter is then used to measure the phase between the antenna voltage E_a and the new junction voltage E_2, thus determining the angle θ_2 by which E_a **leads** E_2. Substituting θ_1 and θ_2 in the following equation an angle α is determined

$$\tan \alpha = \frac{\sin(\theta_1 + \theta_2)}{\frac{\sin \theta_2}{\sin \theta_1} - \cos(\theta_1 + \theta_2)} \quad (1)$$

The quadrant in which the angle α lies is determined by considering separately the signs of num-

(Continued on Page 29)

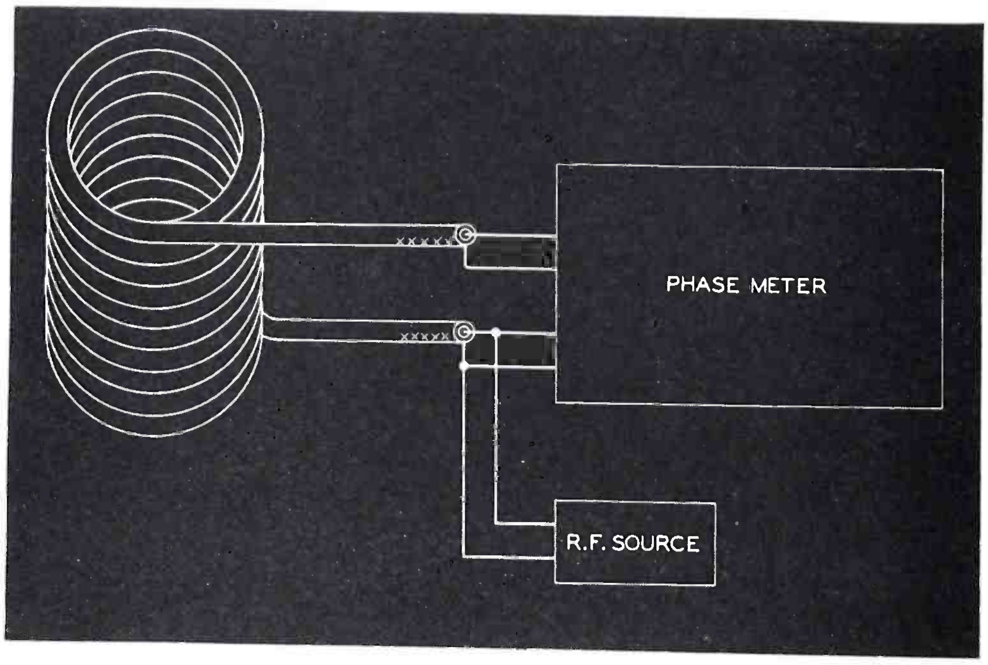


Fig. 5.

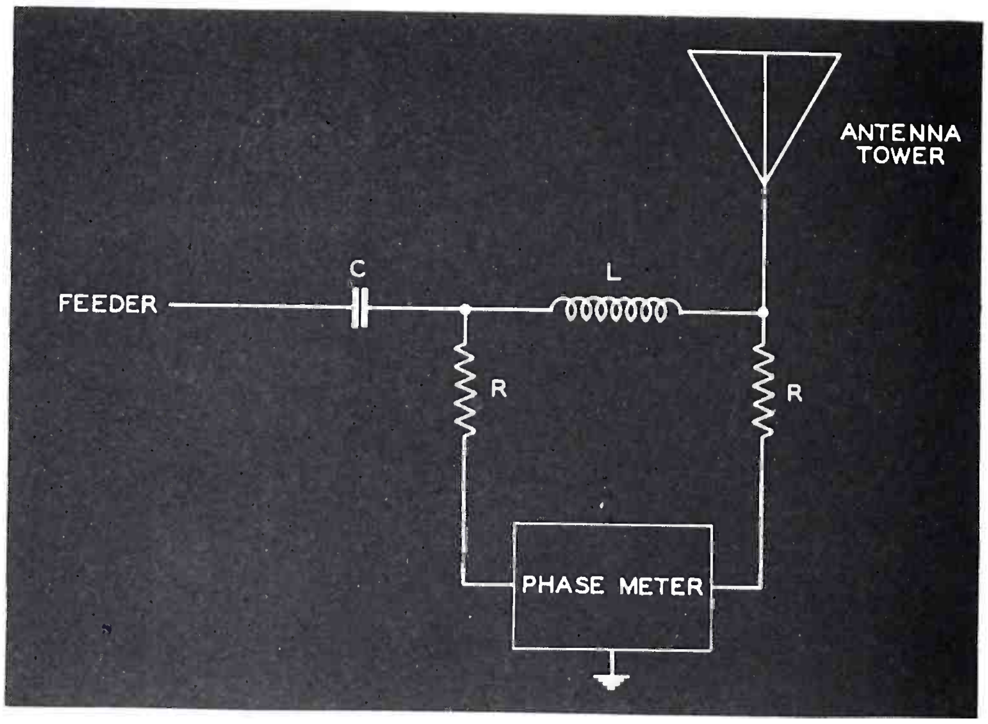


Fig. 6.

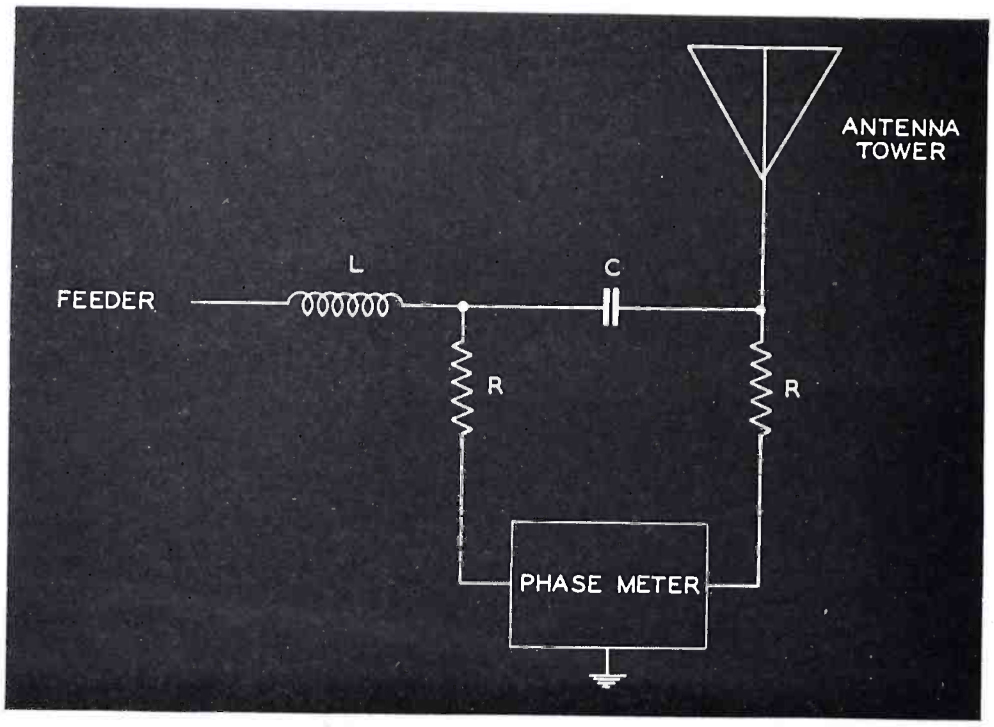


Fig. 7.

KELO EXPANDS FACILITIES

New Transmitter Increases Station's Service

THE Sioux Falls Broadcast Association which owns and operates KELO has for more than ten years been engaged in serving the broadcast listeners of South Dakota, southwest Minnesota and northwestern Iowa though the medium of station KSOO.

Operating on a power of 2500 watts and a frequency of 1100 kilocycles, KSOO was limited by the terms of its license to daytime service only. The limited time requirements not only left this area and the city of Sioux Falls in particular with inadequate night time broadcast services, but also crowded off KSOO's schedule many program services of particularly local interest. The answer to these problems seemed to lie in providing a local full time station. Consequently action was taken to that end, and as a result the Federal Communications Commission granted a construction permit for a new station, KELO.

New Location

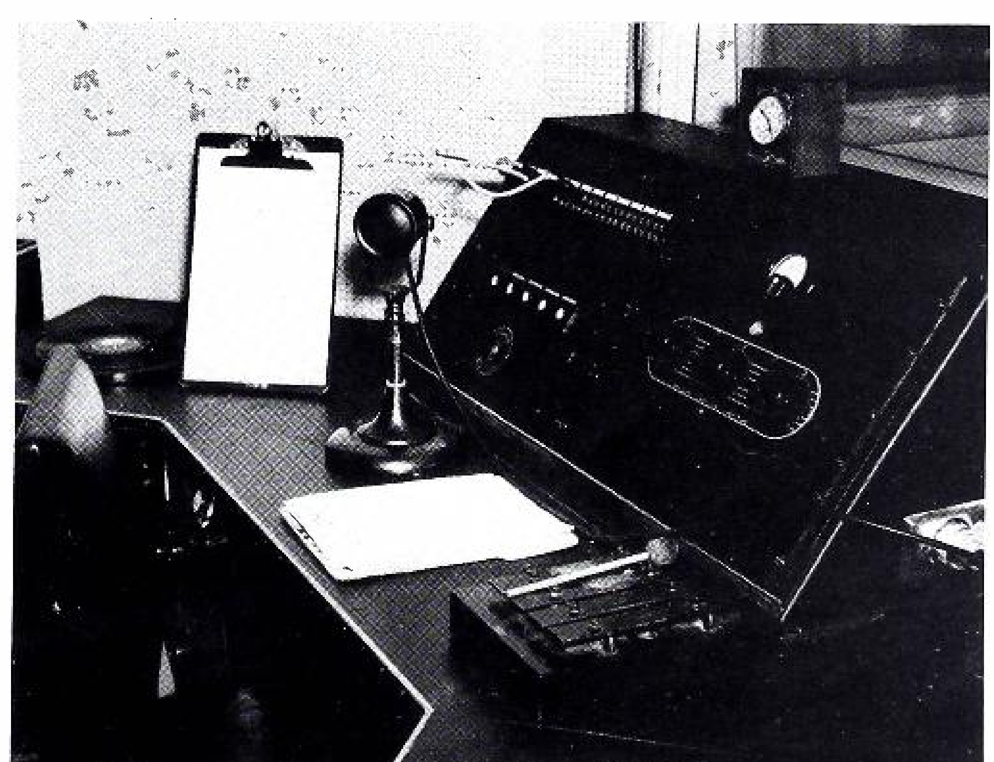
On April 15, 1937, KSOO started operations from its new completely RCA equipped studios. This date also marked the inauguration of NBC programs through KSOO. The initial equipment installation for KSOO studios included two RCA 70-A transcription turntables; one 58-A low level amplifier and mixer; one 40-D program amplifier; RCA Monitoring equipment and line equipment; and, of course, the necessary number of type 74-B and 50-A microphones. The complete installation was made by the regular station technical staff. Because RCA equipment was used exclusively the installation affords a completely unified and flexible input system in which the component units present matched characteristics in both electrical and physical aspects. From a technical viewpoint we knew what to expect in the way of improved transmission fidelity. None the less the enthusiastic comments of the listening audience was a gratifying verification of our expectations.

"RCA All The Way"

By the time construction was to begin on KELO, we had ample opportunity to observe the performance of the studio equipment just described. It was decided to make KELO RCA "all the way." An interesting aspect of the new transmitter installation was that although the licensed carrier power was 100 watts, it was deemed advisable to use the same transmitter location as that of KSOO which is three miles from the business center of Sioux Falls, and even a greater distance from some of the industrial sections in which a high signal to noise ratio could be expected. After a survey of attenuation characteristics between the proposed transmitter location and the described area, it was decided that only a transmitter such as the RCA 100-G which operates with such exceptional output efficiency would insure a signal level sufficiently high to permit high quality reception at all times. The transmitter was installed in the same room with the KSOO 2500 watt transmitter. A two-wire balanced transmission line couples the transmitter to a 215-foot vertical radiator.

Tuning the transmitter to the assigned frequency and proper operating characteristics proved very simple. After a short testing period the KELO transmitter was ready for operation. The speech input equipment in the studios was made to conform very closely to that of KSOO. Using two control rooms with identical equipment in each greatly simplifies the maintenance work.

On September, 1937, KELO went on the air. The response of broadcast listeners in Sioux Falls to this new service indicated that it is fulfilling a definite need. It has been a source of great satisfacton to know that KELO not only provides the city of Sioux Falls with a full time high quality broadcast service, but that its signal is of sufficient strength to include the wide territory populated by prosperous farms and small towns.



A corner of the control room at KELO.

COLUMBUS STATION JOINS 5-D TREND

WBNS Finds Air-Cooling An Outstanding Success

By LESTER H. NAFZGER

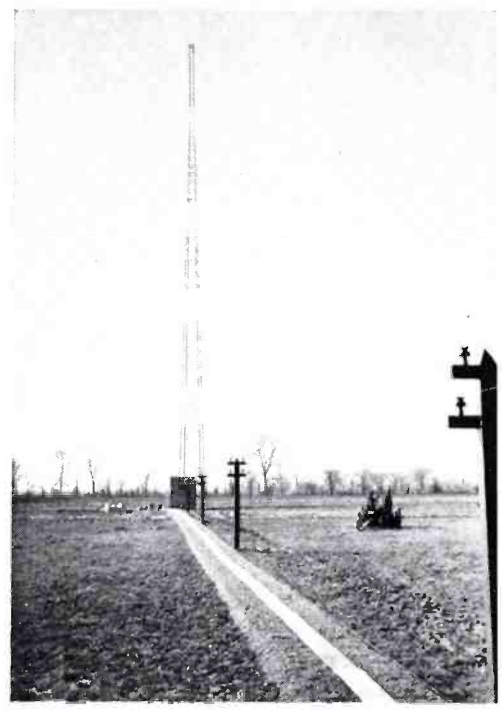
WITH the dedication of its new RCA 5-D transmitter on March 14th station WBNS of Columbus, Ohio, increased its power to 5000 watts day and 1000 watts night. To Central Ohio WBNS continues to set the pace and increases a leadership of many years. WBNS more than ever before is the symbol of radio to Central Ohio furnishing 18½ hours of service each day with the best in programs and the finest in equipment.

Physical Set-up

The WBNS transmitter is located six miles east of the center of Columbus on a 10 acre tract of land. Its main tower is 379 feet high and its reflector tower is 179 feet high. The transmitter building is of wire cut brick. The building consists of the operating room where both the regular and auxiliary transmitters are located along with audio and test equipment. The control desk faces the transmitters and to the rear of the desk are located the four cabinets of test and audio equipment. The console on the desk provides facilities for all phases of the audio operations including transcription and microphone. In the power room is located the gasoline driven alternator furnishing an auxiliary power source and a 50 KVA voltage regulator besides the usual main switches, starters and fuse circuits. The work room includes the work bench, tools, parts and tube storage space and the gas furnace used to heat the building.

Another room houses the gas refrigerator, electric stove and water supply pumps. A lavatory room is provided and a special room to cool the water used with the auxiliary transmitter. A reception hall with observation windows provides adequate view of the transmitting equipment. A large attic furnishes ample space for storage and any additional transmitting facilities. The building is attractively landscaped.

On each corner of the 10 acre tract is located a 1000 watt searchlight atop a 30 foot pole for field illumination purposes. At each guy post of the tower and at two points under the main tower are located 500 watt searchlights for indirect lighting of the tower. On one side of the main tower up about 150 feet, the station call letters are clearly defined in six foot neon letters.



The reflector tower at WBNS

Tuning House

Each tower has a tuning house of wire cut brick to match the main building. In the tuning house are located the coupling and directional equipment. Communication between tuning houses and the main building is efficiently handled by means of a regular interoffice communication installation.

The transmission line is of the four wire unbalance type with an impedance of approximately 240 ohms. It was felt this type transmission line was the best insurance against possible breakdowns in this phase of the installation.

The entire ground system consists of approximately 50,000 feet of copper wire, 20,000 feet having been added for the new directional tower. A central ground for the 5-D transmitter consists of a six foot pit with two four foot copper plates buried in charcoal.

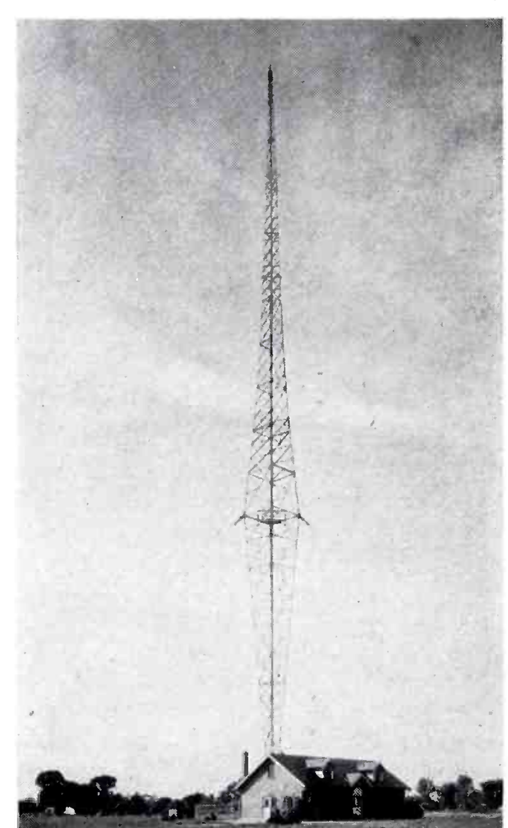
WBNS operates 5000 watts to local sunset and 1000 watts directional after local sunset. The directional equipment is automatically cut in by the same switch that reduces the power of the 5-D. A bridging network located in the first tuning house divides the power fed into the main tower and via the transmission line to the reflector tower. To secure the pattern desired, the towers are separated approximately 382 feet, fed in phase, with .35 of the power into the reflector tower.

WBNS began work on its new transmitter and directional installation on January 4 and finished actual work on February 25. Considering the vast amount of work accompilshed and the bad winter months, we believe this to be a record.

5-D Is Efficient

The RCA 5-D is everything claimed for it. Reports from all over Ohio indicate its efficiency is very high and its tonal quality unusually fine and distinctive. The appearance of the 5-D is very attractive, its construction sturdy and its parts easily accessible.

We were somewhat doubtful as to just how cool the air-cooled power tubes would be after a



The main radiator

day's run. We found after 18½ hours of operation, the bare hands could be placed on the fins of the tubes. This proved the merit of air cooling and the speed with which these tubes may be changed in case of burnout. The ventilation and cooling section of the 5-D is enclosed in its own room with two exhaust fans and filtered air intake. Part of the heat generated by the transmitter may be directed to help heat the building.

The measurements and data secured on the 5-D transmitter form about as perfect a standard of operation as any broadcast station could desire. The frequency, distortion and power consumption data to follow were made at WBNS on the 5-D with the RCA audio oscillator, distortion meter and attenuator assembly which performed in excellent fashion.

Studio Equipment

Other phases of the WBNS technical setup include modern studio audio equipment and modern studios of which there are four. The largest studio contains a pipe organ. RCA 70A transcription equipment with both lateral and vertical facilities are used. WBNS owns and operates its own recording equipment and has the only short wave truck in Central Ohio. The station's short wave equipment includes a truck painted canary yellow and trimmed in chocolate brown. Five transmitters are licensed to WBNS ranging in power from 2 watts to 175 watts. Although two of the transmitters are for ultra high frequency work, WBNS has found the medium frequencies to be far superior in all operations including pack transmitter work. For mobile work on medium frequencies, concentric wound section bamboo poles are used. The truck has a public address system included. A streamline trailer houses a 1000 watt gasoline driven alternator while storage batteries in the truck operate a 160 watt and a 225 watt rotary converter.

WBNS originates many programs for the Columbia network of which it has been a member for eight years. By following an established policy of modern and adequate broadcast and test equipment, good programs and a progressive attitude, WBNS has held high its charter to public interest, convenience and necessity and continues to march forward as a leading radio station.

CHARACTERISTICS SHEET
WBNS Transmitter — RCA 5-D
Feb. 28, 1938

Subject: Power Consumption from 220 Volt A.C. Lines.

Equipment for Measurements: Weston Power Meter; RCA Type 68A Oscillator; G. R. Modulation meter; RCA Cathode Ray Oscilloscope.

Transmitter Power Input	Modulation %	Power in K.W. from 220 A.C.
7.7 K.W.	0	16.5
	10	16.6
	30	17.8
	40	18.6
	50	19.5
	60	20.25
	70	21
	80	22
	90	22.75
	100	23.75
6.4 K.W.	10	15
	30	16.35
	40	16.8
	50	17.75
	60	18.25
	70	19
	80	19.8
	90	20.6
	100	21.5
1.54 K.W.	0	10
	30	10.5

CHARACTERISTIC SHEET
WBNS Transmitter — RCA 5-D
Feb. 28, 1938

Subject: Frequency Response.

Equipment for Measurement: RCA 68A BFO; RCA 69A Distortion Panel.

5000 Watts	Cycles	Modulation %	Cycles	1000 Watts
Plus 1 D.B.	30	60,	30	Plus .8 D.B.
Plus .5	50		50	Plus .35
Plus .15	100		100	Plus .1
Zero	200		200	Zero
Zero	400		400	Zero
Ref.	1000		1000	Ref.
Plus .2	2500		2500	Plus .2
Plus .6	4000		4000	Plus .6
Plus 1	6000		6000	Plus .9
Plus .8	5000		5000	Plus .8
Plus 1	7000		7000	Plus .9
Plus .8	8000		8000	Plus .7
Plus .4	9000		9000	Plus .2
Min .2	10,000		10,000	Min .5

CHARACTERISTIC SHEET
WBNS Transmitter —RCA 5-D
Feb. 28, 1938

Subject: Frequency Response.

Equipment for Measurement: RCA 68A BFO; RCA 69A Distortion Panel.

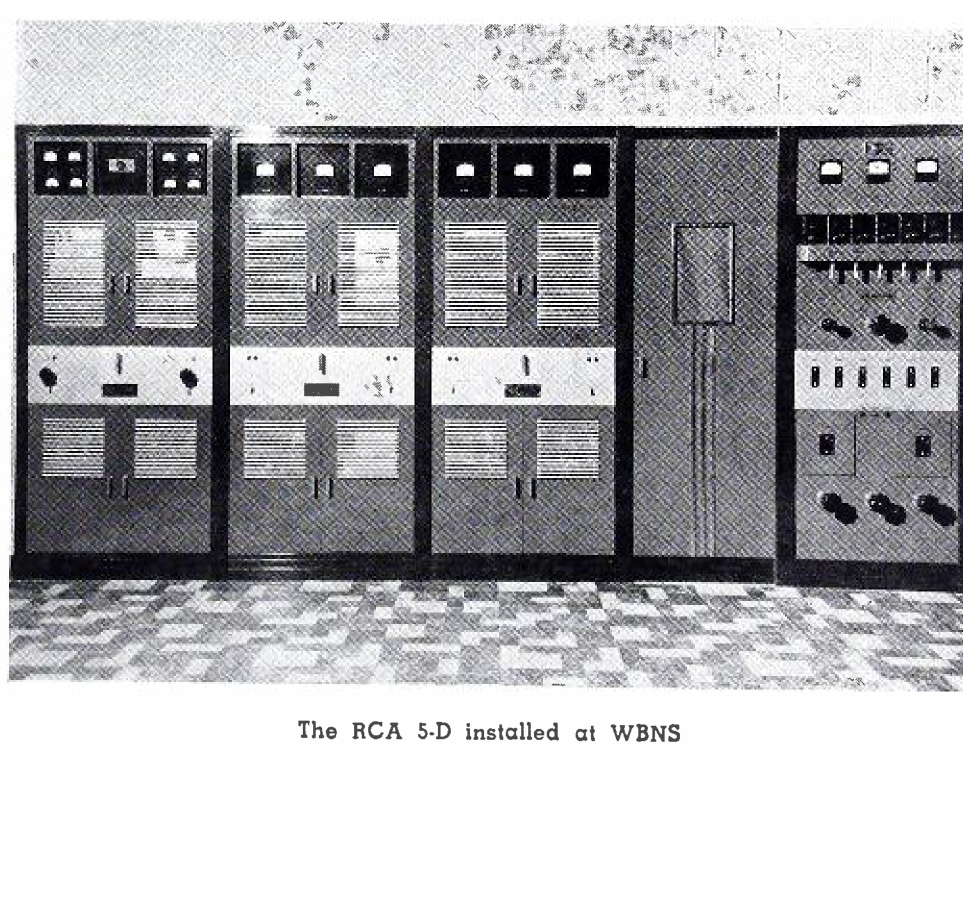
5000 Watts	Modulation Cycles %	Cycles	1000 Watts
Min 1.2	11,000	11,000	Min 1.4
Min 2.2	12,000	12,000	Min 2.2
Min 3.1	13,000	13,000	Min 3.2
Min 4.2	14,000	14,000	Min 4.3
Min 5	15,000	15,000	Min 5
Min 6	16,000	16,000	Min 6
Min 7.1	17,000	17,000	Min 7

CHARACTERISTIC SHEET
WBNS Transmitter — RCA 5-D
Feb. 28, 1938

Subject: Distortion and Noise level on both 5000 and 1000 watts.

Equipment for Measurements: RCA 68A BFO; RCA 69A Distortion Panel; RCA Oscilloscope.

5000 WATTS Noise 66 D.B. Below 100% Mod.			1000 WATTS Noise 62 D.B. Below 100% Mod.	
Distortion %	Cycles	Modulation %	Cycles	Distortion %
1.05	50	100	50	.9
1		75		.65
1		50		.95
1.1	100	100	100	.97
1.1		75		.7
1		50		1.00
Couldn't phase	200	100	200	Couldn't phase
		75		
		50		
1.05	400	100	400	.95
1.1		75		.75
1		50		1.00
1.25	1000	100	1000	.95
1.2		75		.78
1.15		50		1.00
1.7	2500	100	2500	.92
1.5		75		.94
1.35		50		1.00
1 85	5000	100	5000	1.35
1.8		75		1.2
1.5		50		1.1
1.8	7500	100	7500	1.9
1.6		75		1.7
1.3		50		1.4

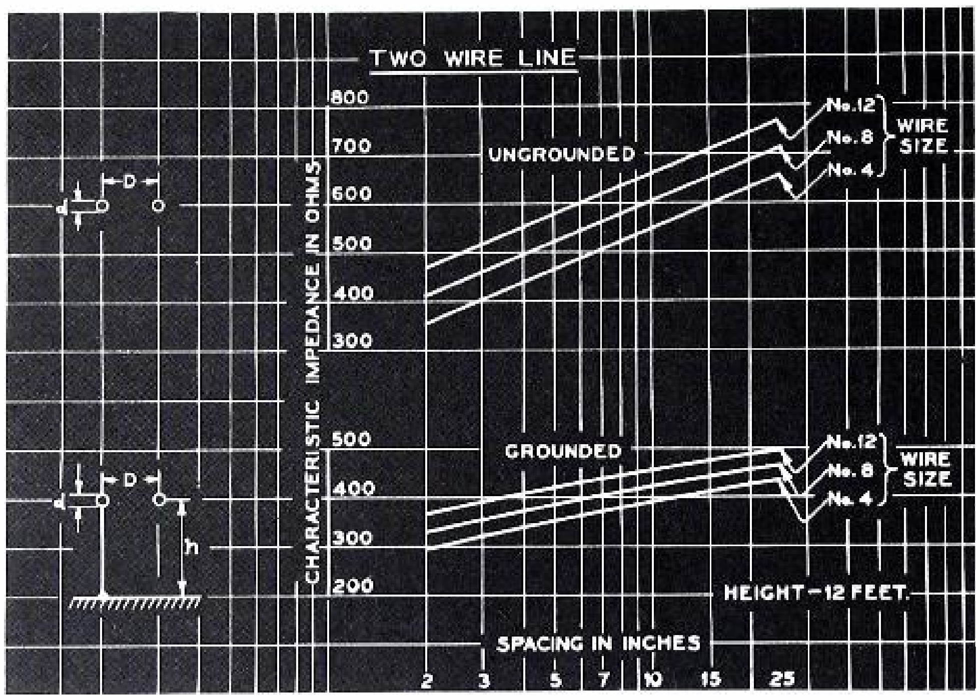


The RCA 5-D installed at WBNS

TRANSMISSION LINES

Some New and Useful Charts

By R. D. DUNCAN, JR.



TRANSMISSION lines are universally employed in radio for connecting antennas with remotely located transmitting and receiving apparatus. They are of two general types, the concentric tubular and the open wire. It is with the latter that this paper is concerned. Open wire lines may consist either of a pair of conductors carrying the going and return currents, or of a multiplicity of conductors interconnected in different manners. One of the important line properties with which the engineer has to do is its characteristic impedance. A requirement for efficient operation is that the impedance of the antenna which connects with one terminal of the line and of the transmitting or receiving apparatus which connects with the other terminal, be matched with the line characteristic impedance.

In transmitter practice it is desirable to ground one conductor, or in the case of a multiple wire line, one set of conductors, as this arrangement permits of employing less complicated and expensive impedance matching equipment at both the antenna and transmitter line terminals than would be required if the line were operated ungrounded. This immediately raises the question . . . to what extent does grounding of a line affect its characteristic impedance?

Formulas are available for calculating the character impedance of lines when ungrounded and when the going and return currents are balanced, but so far as the writer is aware no such formulas have hitherto been available for grounded lines.

The effect of grounding upon the characteristic impedance of a line has been investigated experimentally and theoretically, as it applies to open wire lines of the type employed in transmitter operation and in the normal broadcast frequency range of 500-1500 kilocycles. Formulas have been derived for calculating the characteristic impedance of different types of lines for both grounded and ungrounded conditions. A brief discussion of the results of this investigation together with formulas and curves showing the manner of impedance variation with the line dimensions, is presented in the following:

The characteristic impedance of a transmission line is given by the expression

$$Z_0 = \sqrt{\frac{R + j \cdot 2\pi fL}{G + j \cdot 2\pi fC}}$$

where R, L, G and C are respectively the resistance, inductance, leakage conductance and capacity, per unit length of line effective at the frequency . . . f. At radio frequencies and with reasonably well insulated lines the resistance R and leakage conductance G may be neglected for most practical purposes and the expression for the characteristic impedance written in the usual simplified form

$$Z_0 = \sqrt{\frac{L}{C}}$$

If the inductance is in henrys and the capacity in farads the characteristic impedance will be in ohms.

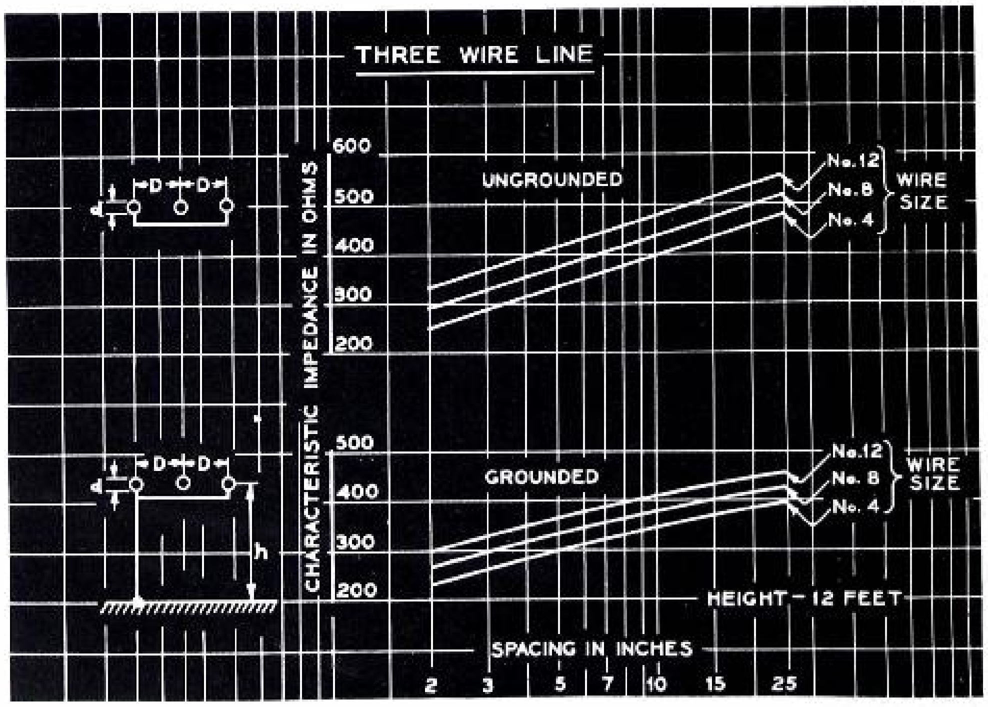
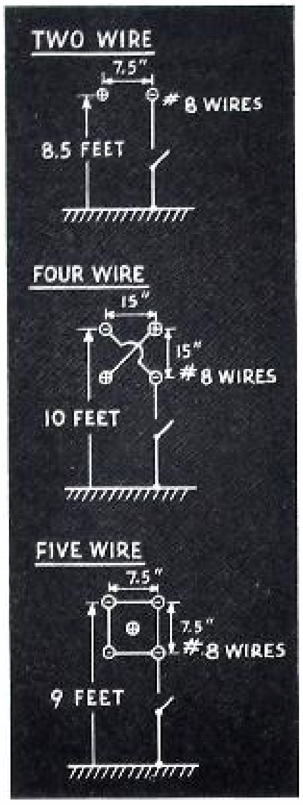


TABLE I.



LINE	CHARACTERISTIC IMPEDANCE (Ohms) Ungrounded	Grounded	Change	Ratio	CAPACITY (Mmfd.) Ungrounded	Grounded	Change	Ratio
Two wire	570	403	Decrease —29.3%	Ungrounded / Grounded = 1.41	715	1090	Increase —52.5%	Grounded / Ungrounded = 1.52
Four wire	290	231	Decrease —20.3%	Ungrounded / Grounded = 1.25	1350	1780	Increase —31.8%	Grounded / Ungrounded = 1.32
Five wire	355	346	Decrease —2.5%	Ungrounded / Grounded = 1.025	1100	1132	Increase —2.91%	Grounded / Ungrounded = 1.03

These expressions hold whether a line is grounded or ungrounded; it is merely rejuired to know the value of inductance or capacity effective for the condition in question.

The effect of grounding an open wire line may be best understood from consideration of a simple two wire line. Connecting one of the wires to ground will increase the capacity effective between the wires and, as it destroys the current balance between wires, the earth carrying a large portion of the current of the grounded wire or wires will decrease the inductance. Since the chacteristic impedance varies inversely as the capacity and directly as the inductance it will decrease in value from that holding for the ungrounded line. The same conditions prevail for the more complex line structures.

Measured values of characteristic impedance and capacity, of three types of open wire lines, ungrounded and grounded are given in Table I. The characteristic impedance is an average value for the frequency range, 500 to 15000 kilocycles. Capacities were measured at 1000 cycles.

It is observed that the characteristic impedance of the grounded line decreased to a lesser degree than the capacity increased. The impedance was of the order of 30% for the two wire line, 20% for the four wire line and 2.5% for the five wire line. Theoretically the ratio of ungrounded to grounded impedance should equal the ratio of grounded to ungrounded capacity. This is seen to be true within the error of measurement from the table. The five wire line very closely approaches a true concentric line and it is not to be expected that grounding of the outer conductors will materially affect its capacity or impedance.

Expressions for the capacity and inductance of ungrounded open wire lines, from which expressions for the characteristic impedance are immediately obtainable, may be derived without difficulty. However, when one conductor of a line, or in the case of a multiple wire line, when a number of its conductors are grounded, the theoretical problem becomes more difficult, the complexity increasing quite rapidly as the number of conductors is increased. Specifi-

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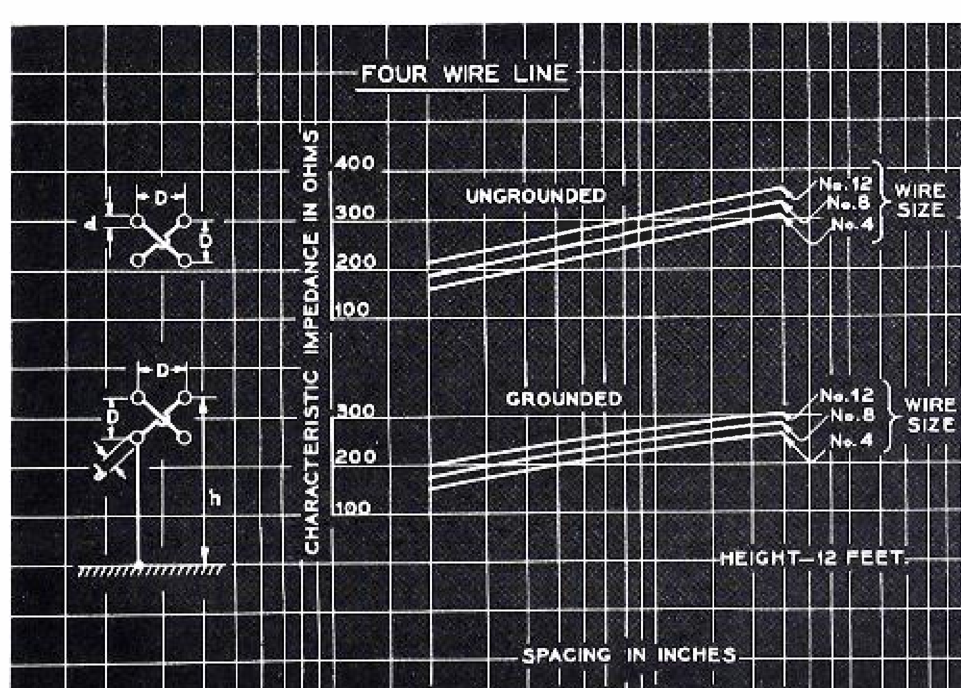
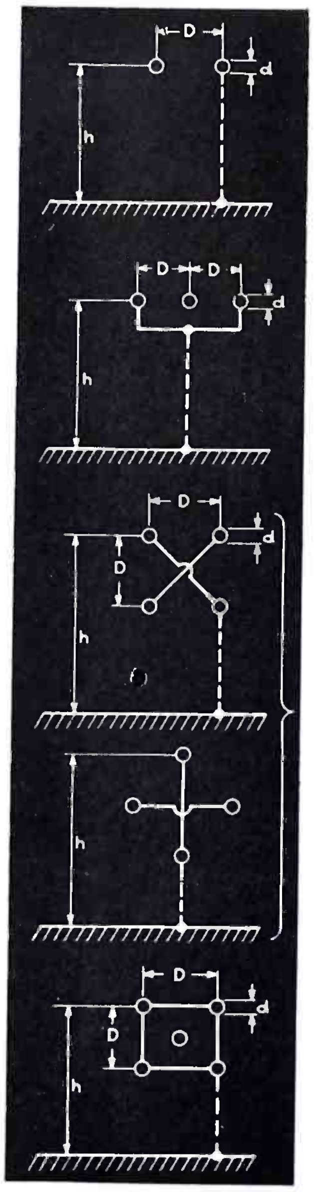


TABLE II. CHARACTERISTIC IMPEDANCE IN OHMS



LINE	UNGROUNDED	GROUNDED
1	$Z_0 = 276 \log_{10} \frac{2D}{d};$	$Z_0 = 276 \dfrac{\left(\log_{10} \frac{8h^2}{Dd}\right)\left(\log_{10} \frac{2D}{d}\right)}{\log_{10} \frac{8h^2}{Dd} + \log_{10} \frac{2D}{d}}$
2	$Z_0 = 69 \log_{10} \frac{4D^3}{d^3};$	$Z_0 = 69 \dfrac{\left(\log_{10} \frac{16h^3}{dD^2}\right)\left(\log_{10} \frac{4D^3}{d^3}\right)}{\log_{10} \frac{16h^3}{dD^2} + \frac{1}{6} \log_{10} \frac{4D^3}{d^3}}$
3	$Z_0 = 138 \log_{10} \frac{\sqrt{2}\,D}{d};$ *	$Z_0 = 138 \dfrac{\left(\log_{10} \frac{8h^2(2h-D)^2}{\sqrt{2}\,dD^3}\right)\left(\log_{10} \frac{\sqrt{2}\,D}{d}\right)}{\log_{10} \frac{8h^2(2h-D)^2}{\sqrt{2}\,dD^3} + \frac{1}{2} \log_{10} \frac{\sqrt{2}\,D}{d}}$
4	$Z_0 = 69 \log_{10} \frac{\sqrt{2}\,D^3}{d^2\sqrt{dD}};$	$Z_0 = 69 \dfrac{\left(\log_{10} \frac{256h^5}{dD^4}\right)\left(\log_{10} \frac{\sqrt{2}\,D^3}{d^2\sqrt{dD}}\right)}{\log_{10} \frac{256h^5}{dD^4} + \frac{1}{10} \log_{10} \frac{\sqrt{2}\,D^3}{d^2\sqrt{dD}}}$

All dimensions in same units.

* Derived by P. S. Carter of RCA Communications, Inc.

TRANSMISSION LINES

(Continued from Page 15)

cally, its solution requires the determination of the distribution of charges between the conductors resulting from grounding on or a number of them. It involves the use of Maxwell's coefficients of capacity or potential, a discussion of which is to be found in most textbooks on advanced electricity.[1]

In Table II are given expressions for calculating the characteristic impedance in terms of the line dimensions, for four different types of open wire lines, for both grounded and ungrounded conditions. These have been checked experimentally with an agreement between calculated and measured values sufficiently exact for all practical purposes. The accuracy of the expressions for the grounded condition becomes less, the greater the spacing is between conductors, with respect to the height.

The expressions show the effect of grounding in decreasing the characteristic impedance. For example in the case of the two wire line, comparing the expression for the ungrounded and grounded conditions it is seen that,

$$Z_{0\,(\text{Grounded})} = Z_{0\,(\text{Ungrounded})} \left(\frac{1}{1 + \dfrac{\log_{10} \frac{2D}{d}}{\log_{10} \frac{8h^2}{Dd}}} \right)$$

Since the logarithm terms are both positive, the characteristic impedance of the line when grounded is less than when ungrounded. The same is true for the other lines as will be evident from comparison of the expressions.

In using the expressions of Table II it is to be noted that all dimensions are in the same units, viz., inches, or centimeters, etc., and the logarithms are to the base 10. The impedances are in ohms.

The manner of variation of the characteristic impedance with conductor size and spacing is illustrated in the chart, which shows curves giving the calculated impedance values for four different types of lines, for three conductor sizes, viz., Nos. 4, 8 and 12 B. & S., and spacing between conductors varying from 2 to 25 inches. A single height of 12 feet was taken for the grounded condition. A

(Continued on Page 29)

[1] For an explanation and illustration of use as applied to a two wire line, see "Electrical Engineering—Advanced Course" by E. J. Berg—First Edition, Chapt. XX. See also, "The Calculation of Capacity Coefficients for Parallel Suspended Wires" by Frank F. Fowle, Elc. World, Vol. 28, 1911. Page 386, etc.

SANTA BARBARA STATION COMPLETELY RCA

KTMS Finds Flexibility in Unified Equipment

Seated before the console is Bill Sanford, KTMS Announcer; beside him, Bill Randol, Program Director.

RADIO Station KTMS, Santa Barbara, California, is "RCA ALL THE WAY"—from microphone, network line, transcription turntable to transmitter input. The needs of KTMS's two studios and control room are served admirably by the RCA 78-B speech input assembly whose ease of operation and performance is unique in the history of two studio operation.

Control Room

The control room at KTMS is situated so the control operator can see all parts of each studio while seated at the confortable, slanted 78-B control console. All ordinary program operations such as control of one to three RCA type 44-B Velocity microphones in studio 'A', or two RCA 44-B microphones in studio 'B,' network or remote inputs, studio or transcription auditions, or the control room microphone are accommodated by simple key control. The addition of a very complete patching panel makes for flexibility unusual with similar combinations.

The two studios, control room and business offices of station KTMS are located in the News-Press Publishing Co. building on beautiful De la Guerra Plaza in the heart of Santa Barbara. The transmitter is located at an air line distance of seven and one-half miles from the center of town on a scenic marine site near Goleta, California.

At the KTMS transmitter the program amplifier is an RCA type 40-D. The audio monitoring equipment is an RCA 94-C amplifier and 64-A loud speaker. KTMS proposes, with the use of RCA remote equipment, to broadcast each and every event of outstanding local interest in and about Santa Barbara.

Remote Equipment

Remote broadcast equipment at KTMS consists of several of the simple and rugged RCA 62-A portable broadcast amplifiers with a complement of 74-B junior velocity microphones.

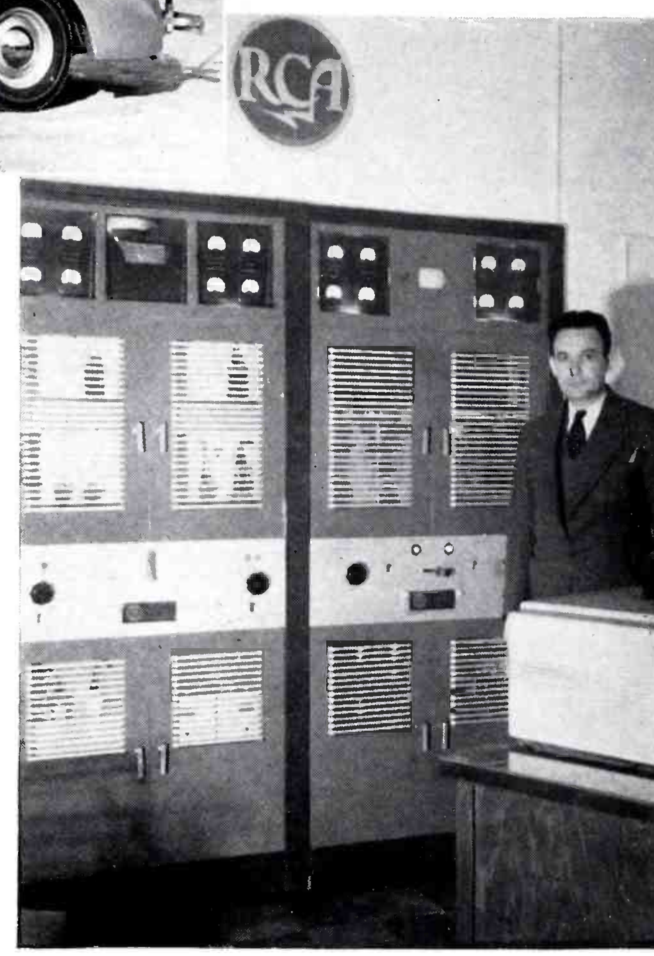
The studios and transmitter building at KTMS are well built and attractively finished in a modernistic mode in keeping with the attractive lines of RCA equipment. This, coupled with excellent response and performance, a fine antenna, ground system and location, assures listeners to station KTMS years of high quality programs.

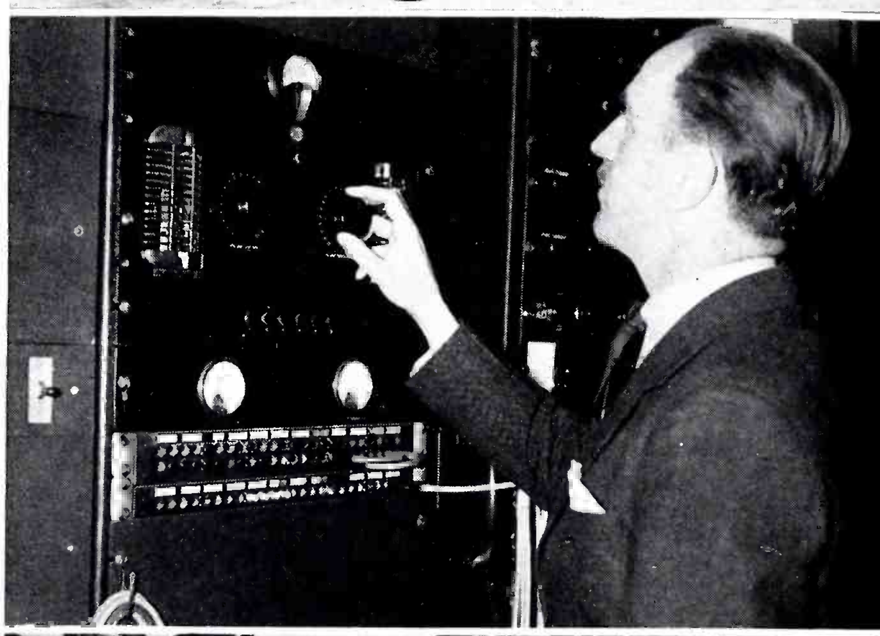
Budd Heyde, Manager of KHMS.

A GLIMPSE OF STATION PERSONALITIES

LEFT: W. F. Peterson, Jr., (left) and Earl C. Hull (right), Chief Engineer of WKY, standing beside one of the station's mobile units.

BELOW: Wilfred H. Wood, Technical Director at WMBG, Richmond, Va., looking over the RCA 1-DA transmitter.

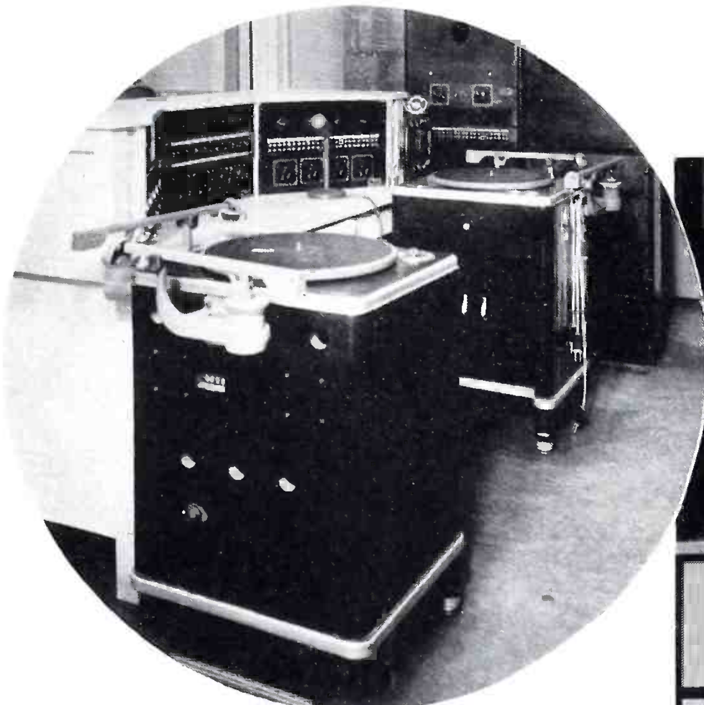




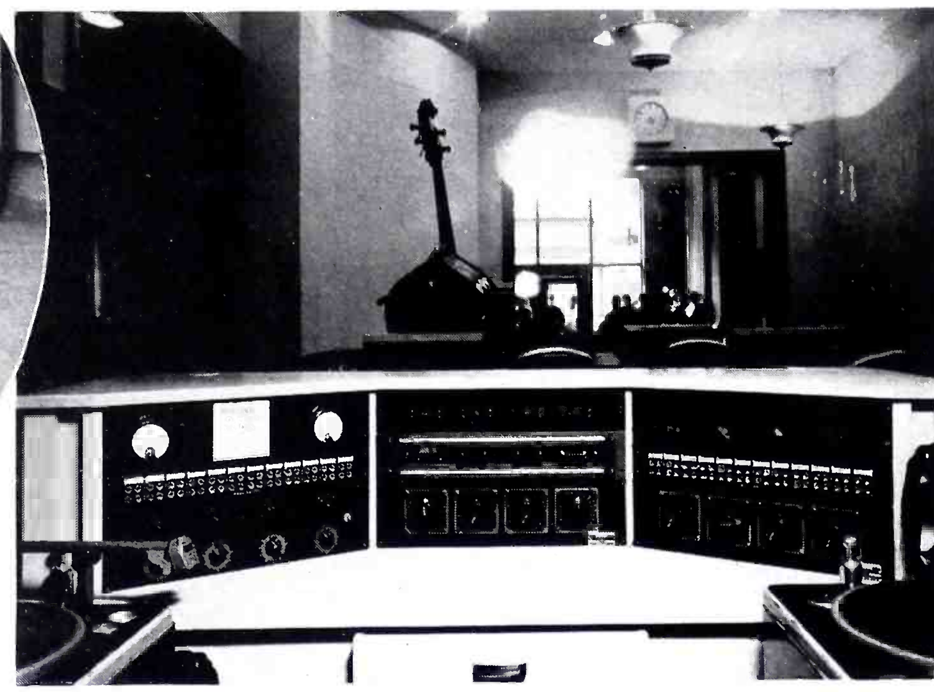
LEFT CENTER: R. V. Howard, Chief Engineer of KSFO, adjusting the RCA 40-D Amplifier.

LEFT: Merrill DeWitt, KSFO Engineer in Charge of Recording, using the 72-A recorder attached to the 70-A turntable.

LOOKING IN ON THE STATIONS



Turntables on duty at WMPS, which flank the desk shown on the right



ABOVE: Studio Equipment at WMPS, Memphis.

LEFT: KVI took a velocity mike to the Snoqualmie Ski Bowl to broadcast the events.

ABOVE: Architecture at KPFA, Helena, follows a traditional western style.

LEFT: One of the studios at KPFA which presents something different than conventional design.

A CATHODE RAY TUBE HIGH SPEED RESPONSE INDICATOR AND RECORDER

A Device with Novel Features for Taking Circuit Characteristics Quickly

By R. A. HACKLEY

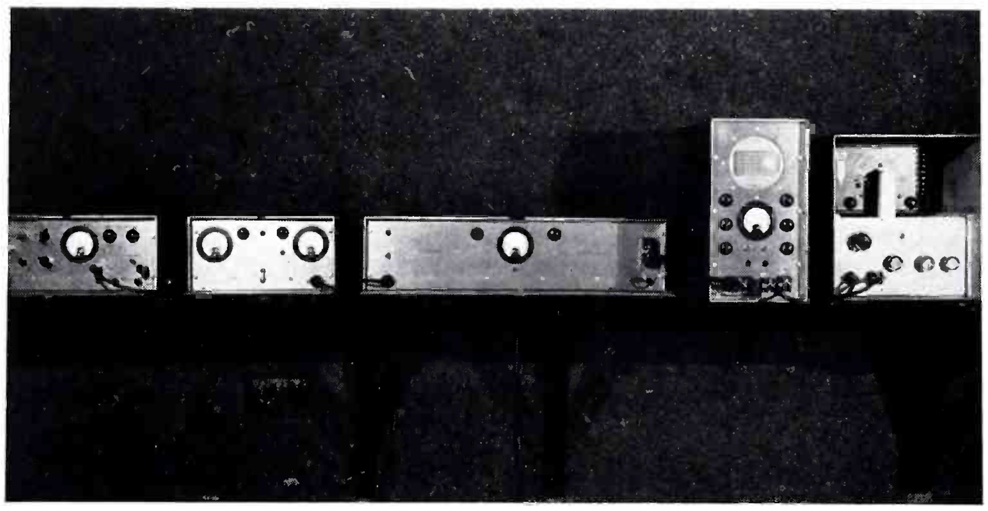


Fig. 1. High speed level indicator and recorder using cathode ray tube for recording response.

THE response, as a function of the frequency, is one of the most important characteristics depicting the performance of acoustic apparatus. Therefore, the problem of securing apparatus to quickly and accurately determine this characteristic is an important one. The possibility of using a cathode ray oscillograph for this purpose was early considered. In using this instrument to study electrical phenomena, under steady state conditions with constant frequency variation, a linear horizontal sweep, synchronized with the vertical deflecting voltage, is used, and the trace is repeated with sufficient rapidity to give the appearance of a stationary image. The minimum rate of repetition is determined by the retentivity of the screen of the cathode ray tube. Since, in an ordinary cathode ray tube, the retentivity of the screen is only a small fraction of a second, the scanning rate must be high.

Long-Persistence Screen

However, in the case of the response-frequency characteristics of acoustic apparatus, each point on the curve is the resultant of several complete cycles of the driving voltage. Hence, it was found that when the rate of scanning was fast enough to give the appearance of a stationary image, the low frequency end of the curve followed the form of individual partial cycles of the driving voltage rather than being made up of points which were the resultant of several complete cycles.

Recently the Radiotron Division of RCA Manufacturing Company, Inc., has placed a cathode ray tube on the market which has a long-persistence screen. With this tube a single trace on the screen can be observed for several minutes after the phenomena has occurred. Using a tube with this long-persistence screen it is now possible to make the rate of scanning low enough so that response-frequency characteristics can be shown without the difficulty noted above. Moreover, the trace persists long enough so that several curves can be traced and compared. A high speed level indicator and recorder using this type of cathode ray tube has been developed for use in making acous-

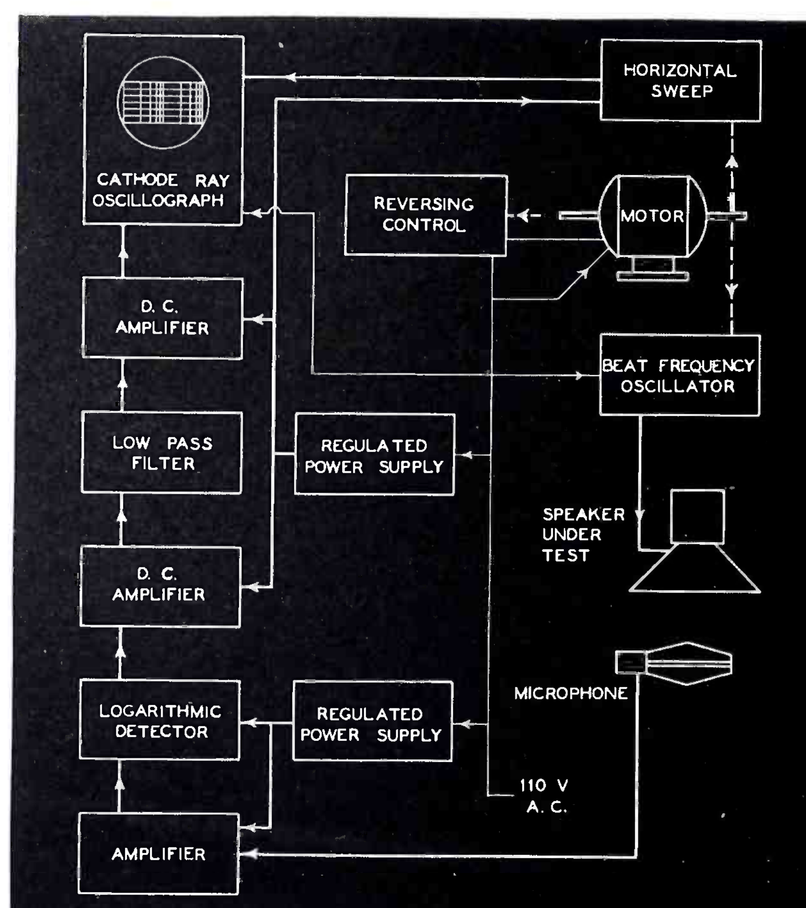


Fig. 2. Schematic block diagram of high speed level indicator and recorder.

tic measurements. The complete equipment is shown in Figure 1.

Method of Operation

The various units of the system are connected as shown in the schematic block diagram on Figure 2. The function of each unit is as follows: The apparatus under test, as for example a loudspeaker, is driven by the beat frequency oscillator. The variable condenser of this oscillator is sowly rotated by means of a motor so that the output voltage varies in frequency over the band being observed. At each frequency the voltage remains impressed long enough to pass through several cycles, so that the loudspeaker passes through its transient condition and assumes a steady state condition. The acoustic output of the loudspeaker is picked up by the microphone and converted back into electrical energy. The output of the microphone is amplified and fed into the detector. Here the alternating voltage is first rectified, and then impressed upon the logarithmic portion of the detector. The output voltage of this unit varies logarithmically with the input voltage. In other words, a meter reading this voltage could be calibrated so that its reading would always express the input amplitude variations in decibels. The detector output is amplified in the first stage of a direct current amplifier.

The output of this amplifier contains, in addition to the direct current component, the double frequency alternating current component resulting from the rectification of the amplified signal. This alternating current component is removed by means of a low pass filter, the cut-off frequency of which is low enough so that none of the cyclical variations are passed. However, the time constant of the filter is low enough to pass the amplitude variations in the direct current component resulting from the variations in the acoustic output of the loudspeaker. The filter output is amplified in a second stage of direct current amplification to a value sufficient to give full scale deflection of the beam of the cathode ray tube to whose vertical deflection plates it is applied.

Horizontal Switch

The horizontal sweep consists of a potentiometer, motor driven through a variable speed friction drive by the same motor which drives the variable condenser of the beat frequency oscillator. The potentiometer is connected across the output of the regulated power supply which also supplies the two direct current amplifiers. One of the horizontal deflection plates of the cathode ray tube is connected to the electrical midpoint of the power supply. The other plate is connected to the variable contact of the potentiometer. By

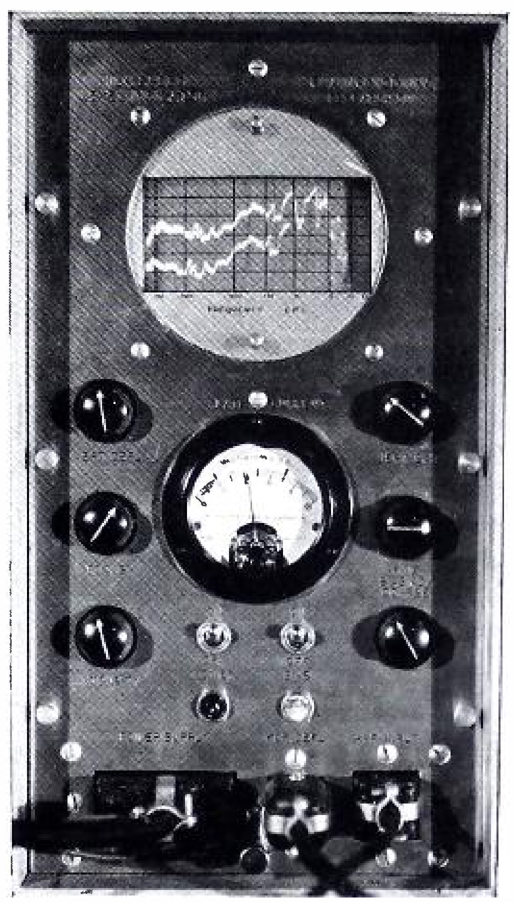


Fig. 3. Front view of oscillograph showing response curves on long-persistence screen of cathode ray tube.

means of the variable speed friction drive it is possible to so adjust the apparatus that the curve will cover the entire horizontal scale regardless of the frequency range being scanned.

The maximum frequency range of the oscillator is 30 to 15,000 cycles per second. The maximum range, or any portion of it, may be scanned. The end frequencies of the scanning range are determined by the points of reversal of the motor drive. These points of reversal are controllable by the position of two movable brushes of a rotary contactor which controls the action of the relay used to reverse the direction of rotation of the motor. The sensitivity of the instrument is continuously variable from a maximum of 6 db to a minimum of 48 db for full scale variations. At minimum sensitivity the instrument is capable of following variations occurring at the rate of 2000 db per second. Figure 3 shows the front of the oscillograph with the trace of one complete curve showing and another curve in the process of being traced.

Although designed primarily for laboratory work in acoustics, the high speed level indicator is suitable for other applications. It offers a very convenient means for determining the response-frequency characteristics of such electrical equipment as amplifiers and transformers. Routine factory tests on radio receivers, amplifiers and all forms of acoustic apparatus can be made cheaply and quickly with this instrument. It can also be used to determine the sound distribution in auditoriums, thus aiding in the orientation of the speaker system and the compensation of the amplifiers. Normally the instrument is used as a visual indicator. However, if a permanent record is desired it may be recorded photographically.

NEW BROADCAST EQUIPMENT CATALOG READY

In this issue we announce the new RCA Broadcast Equipment catalog. For the first time in the history of the industry a comprehensive listing of the electrical and mechanical instruments required in broadcasting is available.

Beginning with microphones, the engineer can follow in logical sequence through speech input, transmitters and test equipment, to tabulations and charts which will be found invaluable in his daily calculations.

In preparing this volume we have gone beyond the mere listing of units. A very definite effort has been made to make it as convenient and easy to use as possible. Where questions of comparison might arise, the functions, ratings and other information on similar units have been listed on one page to avoid the necessity

(Continued on Page 31)

WLAW FORGES AHEAD

Massachusetts Station Increases Listener Area with New Equipment

By IRVING E. RODGERS

WLAW of Lawrence, Mass., sends its "Voice of Northern New England" daily over an area with a population of more than two and one-half million people. Although but a thriving baby (it came into being on December 19, 1937), WLAW has already contributed generously and effectively to a program of civic achievement, commercial value and public interest.

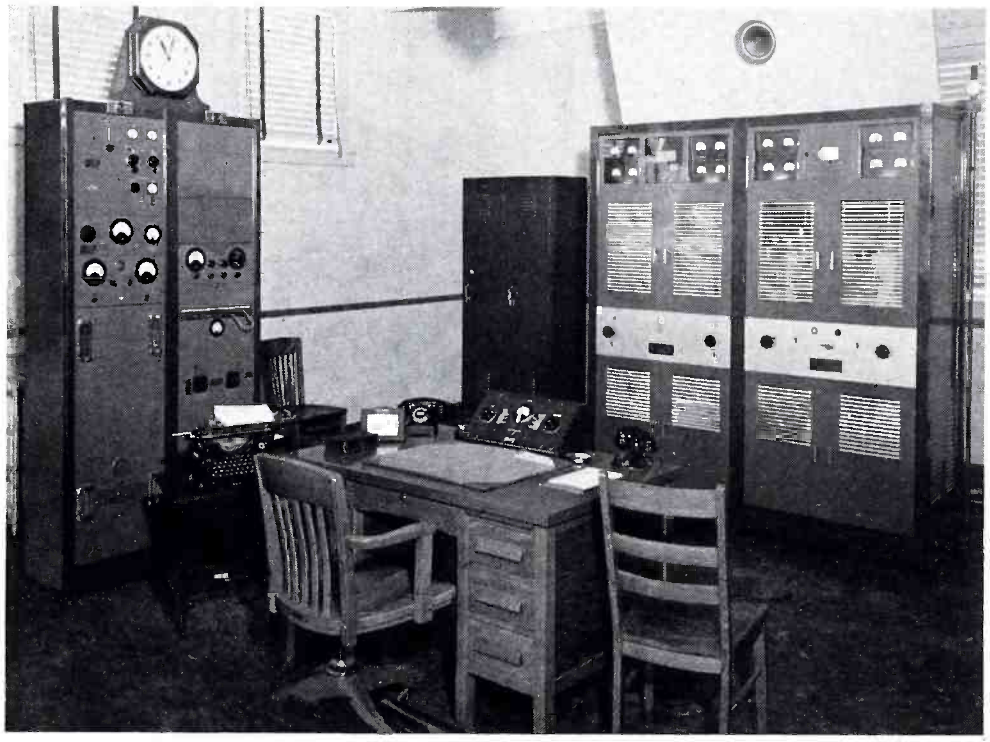
WLAW, owned and operated by the Hildreth and Rogers Company, publishers of the Lawrence Daily Eagle and the Evening Tribune, was dedicated with a brilliant program which featured Governor Charles F. Hurley of Massachusetts, two of the highest ranking member of the judiciary of the Commonwealth, and the chief executives of the three major cities of the Merrimack Valley.

With power of 1,000 watts, and operating on a carrier frequency of 680 kilocycles, WLAW has, since its inception, introduced a steady series of novel attractions and varied presentations which have captured and sustained public interest, admiration and appreciation.

George R. Luckey, Chief Engineer of WLAW.

Modern Equipment

The facilities of WLAW represent the last word in modern radio engineering. The transmitter plant is located in the adjacent town of Andover, and is three and one-half miles, air line, from Lawrence.



The 1-DA installed at WLAW.

The building is of fire-proof brick construction, finished in white, and houses, in addition to the equipment, a garage, sleeping quarters for the operators and extra space for future expansion. The equipment which is entirely RCA, consists of a type 1 D-A transmitter and two relay racks of equipment. The latter consists of one 96-A limiting amplifier; one 94-C monitoring amplifier; and one 64-A loud speaker; volume indicator; complete oscillator and distortion measuring equipment, consisting of one 68-A beat-frequency oscillator, one 69-A distortion and noise measuring unit, one attenuator panel, an RCA 681-A frequency-deviation meter, and an RCA 66-A modulation monitor. More test equipment is to be added in the near future as WLAW engineers believe that a station is no better than the quality of the test equipment used.

Transmitter Site

The 300 foot Lehigh shunt fed tower is located 400 feet from the transmitter building, and is fed by means of a gas filled concentric transmission line which is enclosed in a trough on a line of fence posts. This method of mounting the line was selected because of its dual features of economy and accesibility. The ground system beneath the tower consists of a 48 foot square expanded copper screen to which are connected 120 radials, the shortest of which is 400 feet and the longest 600 feet, and consisting of 56,000 feet of No. 12 hard drawn copper wire.

Studios

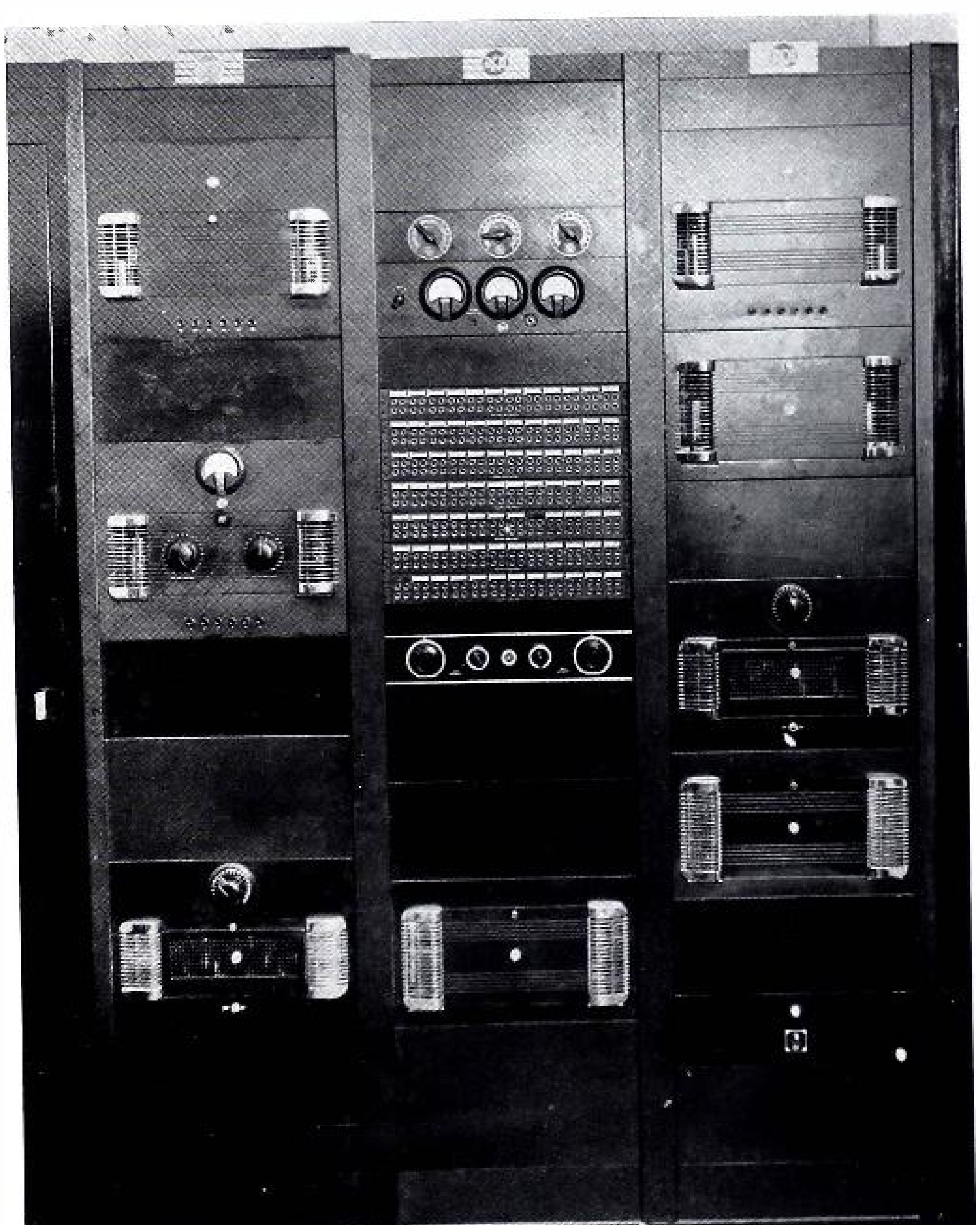
Beautiful studios, designed in the modernistic manner, are located in the Oswald Building and occupy the entire second floor of this business structure which is located in the center of the commercial district of the community.

Three studios are used and are of the very latest design. All of the acoustic work in the studios was completed by the Johns-Manville Company. The studios are air-conditioned and are artificially lighted to insure correct illumination for the performing artists. The large studio which is 25 x 60, has in addition to the usual studio equipment, a Wurlitzer three-manuel organ, specially built for radio broadcasting and the largest in any New England studio. A small studio is provided for small groups and speakers. This studio is 14 x 18. All the studios are equipped with loud speakers for cueing purposes. These speakers may also be switched to the audition channel so that auditions may be heard in any one of the studios and offices. A total of seven loud speakers are used in addition to the control room loud speaker. Another small studio is provided for the transcription and recording equipment. The equipment consists of two RCA 70-A turntables and associated switching equipment and loud speaker.

The Control Room equipment consists of the RCA DeLuxe type, and consists of two complete channels. One is used for program and the other for audition and emergency purposes. All this equipment is mounted on three relay racks. Mounted on these racks, is a special nemo line unit which consists of several pads and an equalizer which is a necessary part of the equipment when remote pickups are used. The master control console was designed and built by the station's chief engineer, Mr. George R. Luckey, and is the most flexible and efficient unit of this type. It consists of switching facilities for programming or auditioning from eight sources, either individually or at the same time. Programs may be fed to nemo pickup lines for cueing purposes. Talk-back facilities to the studios are provided by merely pushing a key and talking. RCA 44-B microphones are used throughout the studios.

Frequency runs on the entire equipment show it to be substantially flat from 20 to 17,000 cycles. The total harmonic distortion at 100% modulation is not over 2.4% and over most of audible range is not more than 1.7%. The design and erection of the entire system was under the personal direction of Mr. George R. Luckey.

WLAW is under the personal direction of Irving E. Rogers as General Manager. The personnel includes George R. Luckey as Chief Engineer; Stanley N. Schultz, as Program Director; David M. Kimel as Commercial Manager; and Richard H. Gumb, Herbert W. Brown and James H. Riley as members of the Engineering Staff.



Studio control panels at the Lawrence station.

L. W. LYNDON ON LEAVE OF ABSENCE

The many friends of L. W. (Larry) Lyndon will be interested to know that he is on leave of absence from the RCA Engineering Department for a time in order to operate the Lyndon Ranch near Alberta, Canada. Due to the death of his father it became necessary for Larry to superintend the cattle ranch which comprises an area of ten thousand acres in the Canadian Northwest.

Appropriately enough for an engineer dealing with broadcasting equipment, one of the brands used on the ranch is a circle enclosing the letters VI. Larry's many friends wish him good luck together with good riding and good roping in his new role.

His work on handling custom-built speech input systems and other audio engineering matters is being taken over by W. L. Garnett who is also well known to broadcasters.

"HOOK-UPS" IN TRANSMITTER SALES

Beginning in February with R. A. Wilson of the Chicago office three members of the transmitter group have been lured by the strains of the wedding March. F. S. Hart of the Camden sales office said "I do" in April. Ben Adler, manager of the New York office, slipped under the wire to become a June bridegroom on the thirtieth of the month.

IT'S A 5-D AT BIRMINGHAM

WBRC Solves Transmitter Problem with Air-Cooled Installation

Looking straight ahead at the 5-D speech input and test equipment on the left.

ON the morning of January 1, 1938, WBRC went on the air with the new 5-D, 5 kilowatt RCA transmitter. Telephone calls, letters and telegrams from listeners in the rural sections poured in, complimenting the increase in signal strength and quality of programs. Prior to January 1st WBRC operated with 1000 watts and a composite transmitter with the usual linear amplifier using a water cooled tube. This equipment, while fairly efficient, had long served the management and had reached the retirement age.

Transmitter Problem

When the question of which type of transmitter to purchase came up for discussion, several factors peculiar to the operation of WBRC were considered. First was the fact that every drop of water used at the transmitter had to be hauled over six miles of country road. Second, the transmitter building is located within 100 feet of an unpaved, dusty road with heavy truck traffic. High level modulation was preferred, because of the simplicity of design, ease of adjustment, and the average high percentage of modulation with minimum harmonic distortion.

The installation of the 5-D was made according to the factory specifications. Air drills were used to dig up the concrete floor for the trench-ducts used to carry all the wiring between the units. Lead covered varnished cambric covered wire was used throughout the installation. As a distinct compliment to RCA on their nice job of designations, prints, etc. not a single wire had to be changed by Dana Pratt, of RCA Field Engineering, when he arrived to tune it up.

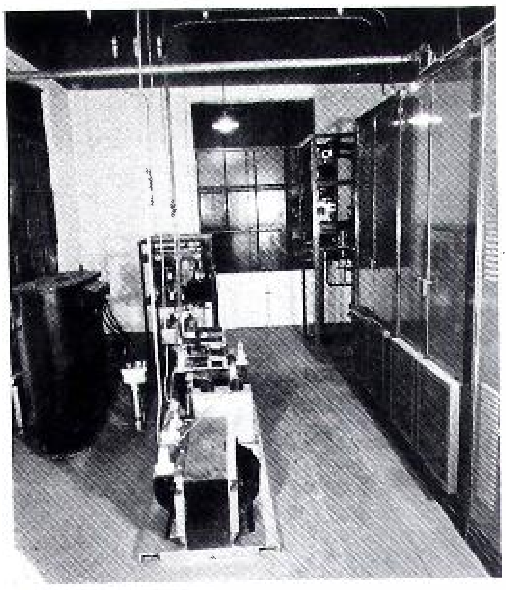
An order has been placed with RCA for one of the new 80-A Studio Desk type speech input units which will be installed in the near future.

Interesting History

The history of WBRC is interesting. In April 1925, the station was licensed to operate at a power of 10 watts. For several years WBRC was the only station in the state. During the spring of 1929, the station joined the Columbia Network with a power of 500 watts, being the first network station in the state. The management of WBRC has consistently adhered to the policy of "keeping abreast" of the times. The first Vertical Antenna, a Blaw-Knox, 280 feet high, in the state was installed during 1936, the first volume Limiting Amplifier and Distortion Measuring Equipment in the State soon followed.

The station is operated by two of the three owners of the Birmingham Broadcasting Company, Inc. Mr. K. G. Marshall, President, who has ten years of close association with radio broadcasting,

Studio "B" at WBRC.



Rear side view of the 5-D.

and Mr. J. C. Bell, Vice-President, and Manager also looks after the engineering. Mr. Bell has been with the station since its first license in 1925.

5000 WATTS FOR WRC

(Continued from Page 7)

The station power supply is provided in duplicate, incorporating separate buried armored cables, transformer and metering equipment, terminating in a fully automatic switch which instantly changes power lines in the event of a failure. This "automatic switch man" operates when any one of the three phases fails and will change from one line to the other so rapidly that the program is not interrupted, thus providing better protection against such failures than could be obtained by manual operation. Programs are transmitted from the Washington studios over special telephone circuits which provide a wider and more uniform range of musical tones than has heretofore been the case.

Transmission Line

The transmission line which connects the radio transmitter with the antenna is a two inch coaxial system, using a new type of insulator developed in connection with the WRC project by Mr. William Duttera. Mr. Duttera's development work in connection with these insulators resulted in an increase of more than 300% in the breakdown voltage of the two inch line. The insulator developed is a result of several experimental samples, each of which was tested, and the final design has been adopted as standard equipment by the manufacturer from whom the equipment was purchased.

Laying the Line

The WRC line is buried a minimum of three feet in the earth. The experience gained in connection with making the buried line gas-tight may be of interest to readers of these pages. The first attempt to make it gas-tight was with the use of ordinary solder and blow torches at the joints. Sections of 40 feet were connected together in the transmitter building, where soldering conditions were best, and then moved to the trench for assembly to adjacent sections. It was found that when joined with ordinary solder the sections could not be moved appreciably without leaks developing. Accordingly, the attempt to solder sections together in the transmitter building was abandoned and the entire line was assembled in the trench. The sections were suspended by 2 by 4's laid across the trench and the complete line was lowered into position simultaneously after assembly.

A few joints had been made in the line before the use of ordinary solder was discontinued in favor of a much harder product containing silver. The temperatures required for hard soldering were very much higher but the joints were much stronger and once tight would remain so. The joints were all completed with hard solder before leakage tests were made. Despite careful workmanship and close inspection of each joint by several interested people, over a dozen severe leaks were found.

Coarse leaks can be found by the use of liquid soap but it was found that this method is not satisfactory for discovering those minute leaks which make the difference between a line which is tight and one which is not. The final operations consisted of closing small leaks caused by minute blow holes in the castings. Such leaks cannot be detected by any practical method except immersion in clean water. The line maintained 40 pounds pressure, with no loss for three days, before it was finally placed into position and covered. At the end of the next five weeks there was still no loss so the pressure was reduced to normal. A section of this line with the new insulators was tested before installation, for voltage breakdown and also for heating. The heat run was made at a radio frequency voltage equivalent to that which would be obtained with a transmitter power of 2,000 KW. In final position the line rests on planks and is protected by split tile.

The specifications for the WRC vertical radiator insured not only high electrical efficiency but also greater mechanical strength than is customary. It is built to withstand an indicated wind velocity of 120 miles at the top and approximately 95 miles at the bottom, as a result of investigation of wind velocity distribution at various heights above the earth. The tower is constructed of solid round steel members electrically welded together into sections 22 feet long. These sections are fabricated in the steel mill and assembled by means of bolted flanges in the field. As specified for all NBC towers, the complete guy wire and insulator system was assembled and stressed up to the maximum possible stress conditions in a suitably equipped testing plant. This not only eliminates any possibility of unsuspected weakness but also increases the modulus of elasticity of the guy cables. The use of track bonds around bolted joints insures satisfactory electrical connections.

Fidelity Insured

To insure that the fine fidelity characteristics of the 5D transmitter may be properly checked and maintained, WRC was equipped with an RCA type 69A distortion meter and type 68A audio oscillator. This combination of instruments is particularly adaptable to use in high fidelity installations because for such use there is required an oscillator with extremely low harmonic output, such as is characteristic of the 68A type. With this combination of instruments the percentage of distortion at any frequency within the transmitter range may be measured quickly and accurately and the background noise level may be measured with equal facility. The RCA Manufacturing Company and NBC have jointly developed a modulation limiter to meet the needs of NBC and other broad-

(Continued on Page 28)

SIMPLIFIED SOLUTION FOR ANTENNA IMPEDANCE MATCHING NETWORKS

By A. VOLLENWEIDER

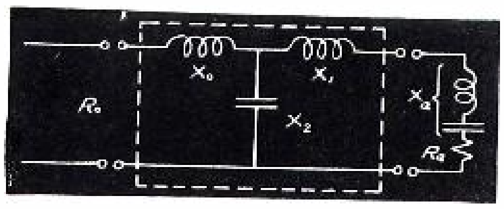


Fig. 1.

The "T" nework, essentially a simple "T" filter section, may serve the broadcast engineer many useful purposes. While it is true that the technical literature is filled with information relative to filter network solutions, it is unfortunate that the direct application of this information quite frequently tends to obscure the full usefulness of the device. The following discussion approaches the solution of the T network from a point of view intended to avoid this obscurity.

The solution of an antenna coupling unit is presented as illustrative of the method used. Its simplicity and directness have the advantage of suggesting its further application to the engineer's own specific problems wherever networks of this and similar types are employed. Basically, the method is a graphical one and therein lies its principal value from the point of view of insight which it affords. A set of equations is then derived from the geometry of the graphical solution.

It is hoped that the actual application of these equations, either directly or in conjuction with a rough diagram, will lead to both clarity and practicability.

Referring to Figure 1, let us suppose that we desire to couple a transmission line of given characteristic impedance, R_0, to an antenna having both a resistive and a reactive component of impedance. We seek the network constants X_0, X_1, and X_2 which will result in correct line-to-antenna impedance match. If in Figure 1 we combine the reactances X_1 and X_a and replace them by a net reactance X_{an}, we see that the problem of matching a complex antenna impedance to a line reduces to the problem of matching a pair of resistive impedances as shown in Figure 2.

Forgetting for the moment any limits which our antenna may place on the value of X_{an} we construct the graphical solutions for the pure resistance matching network of Figure 2 as follows:

(See Figure 3)

(1) Assume any convenient power,* P, and compute I_a and I_0 from the relations

$$I_a = \sqrt{\frac{P}{R_a}} \qquad (1)$$

$$I_0 = \sqrt{\frac{P}{R_0}} \qquad (2)$$

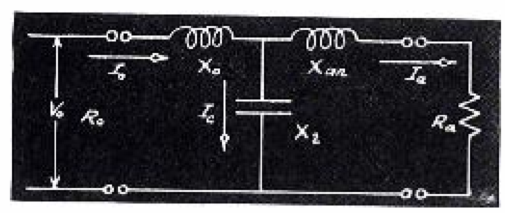


Fig. 2.

(2) With O as the origin scribe a circle whose radius is the product $(I_a R_a)$ to some convenient scale.

(3) With O as origin scribe a second circle or radius $(I_0 R_0)$ to the same scale.

(4) Select any point A outside of both circles; connect O and A.

(5) From A draw tangents $\overline{AC}$ and $\overline{AD}$ to the circles, these tangents to lay on opposite sides of $\overline{CA}$ as shown. (Two sets of tangents are possible; for networks in which X_0 and X_1 are inductive and X_2 is capacitive those shown are used; for X_0 and X_1 capacitive and X_2 inductive, the alternate set should be used.)

*For purpose of a general solution P may have any convenient value since X_0, X_{an} and X_c are independent of the power transferred through the network. In specific applications of the method where it isuseful to know voltage and KVA ratings of component parts the actual power should be used in equations (1) and (2).

(6) Connect the points of tangency, C and D, to the origin.

(7) Along $\overline{OC}$ lay off the current I_a to scale (not necessarily the same).

(8) Along $\overline{OD}$ lay off the current I_0 to the same current scale.

(9) Connect the ends of the current vectors.

Steps (2) to (6) constitute the construction of a voltage diagram; steps (7) to (9) constitute the construction of the current diagram; together they go to make up the vector diagram for the T network circuit. It will be observed that

(a) $\overline{OC}$ to scale equals voltage drop in R_a

(b) $\overline{CA}$ to scale equals voltage drop in X_{an}

(c) $\overline{OA}$ to scale equals voltage drop in X_2

(d) $\overline{AD}$ to scale equals voltage drop in X_1

(e) $\overline{OD}$ to scale equals input voltage V_0

(f) $\overline{OE}$ to scale equals output current in R_a

(g) $\overline{EF}$ to scale equals condenser current

(h) $\overline{OF}$ to scale equals input current to network.

For this perfectly general construction it is at once apparent that the network impedances X_0, X_{an}, and X_2 may be evaluated as follows:

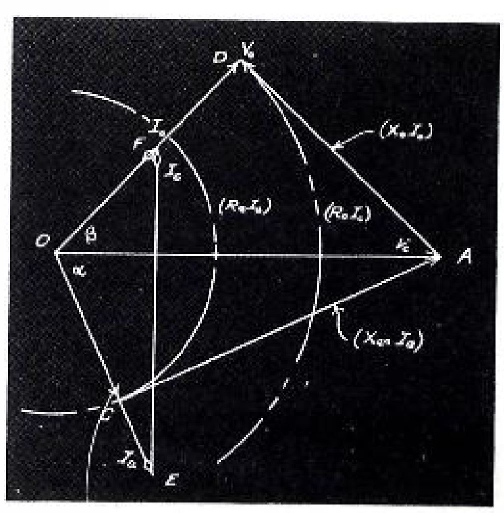


Fig. 3.

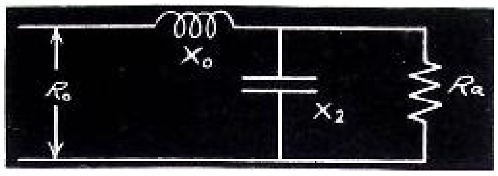


Fig. 4A.

$$X_0 = \frac{\overline{AD}}{\overline{OF}} \quad (3)$$

$$X_{an} = \frac{\overline{CA}}{\overline{OE}} \quad \text{All elements measured to proper scale.} \quad (4)$$

$$X_2 = \frac{\overline{OA}}{\overline{EF}} \quad (5)$$

The total phase shift through the network is obviously equal to the angle between I_a and I_0; namely,

$$\varphi = \alpha + \beta.$$

It is important to note that the values given by equations (3) to (5) are not unique but are, instead, entirely a function of the distance from O at which point A was selected. It is evident that a number of equally valid solutions may be had by varying the position of point A. This useful fact, not generally evident in the usual network equations, is discussed later in the article.

For the restricted case of matching two pure resistances the sole restriction on A thus far has been that it shall not lie within either of the circles. Experience shows the most economic design is one in which A lies on the circumference of the outer circle. For this position of A either X_0 or X_{an} reduce to zero and the KVA rating of the condenser X_2 is a minimum; further φ reduces to simple α or β and is a minimum. Figure (4a) and (4b) show the resulting electrical configuration.

Consider the effects of variations in the position of A on the phase shift angle φ and the value of the shunt reactance X_2. As pointed out previously the minimum angle of phase shift through the network occurs when

$$\varphi = \alpha + \beta \quad (6)$$

and either α or β is equal to zero. For R_0 equal to R_a the diagram of Figure 3 become symmetrical about the line $\overline{OA}$ and α equals β; for this special case the minimum value of φ becomes zero. The values of α and β are given by

$$\alpha = \arctan \frac{X_{an}}{R_a} \quad (7)$$

$$\beta = \arctan \frac{X_0}{R_0} \quad (8)$$

and since both may be made to approach 90° as A is taken farther and farther away from O it follows that the upper limit of φ is 180°.

Thus, it becomes evident that the T network may also be used as a phase shift network. Large angles of phase shife in a single T section are economically as well as theoretically impractical because of the physical size of the component circuit elements. Where angles of phase shift in excess of 90° are required it usually is advisable to cascade two T sections, arranging each to produce approximately one-half the desired shift.

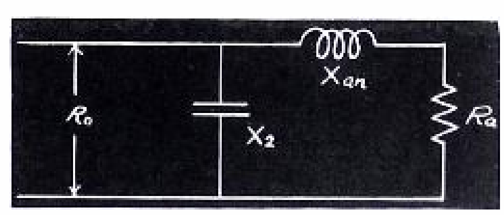


Fig. 4B.

A study of the diagram of Figure 3 shows that as φ is varied the values of V_c and I_c are likewise changed. Thus, as φ varies through its range from minimum to 180°, V_c takes on values ranging from V_c equal to V_0 (or V_a) to V_c equal to infinity. For the same variation in φ, I_c ranges from some minimum value, zero in the limit, to a value I_c equal to the algebraic sum of I_a and I_0. Since X_2 is equal to V_c/I_c, it follows that the impedance varies from some high value, approaching infinity, through a minimum and back to infinity. There will, accordingly, be some angle, φ, for which the shunt capacitive reactance, X_2, is a minimum, and at this angle the harmonic attenuation in the network will be a maximum if R_a is a constant independent of frequency. The T network used for impedance matching will therefore, also possess a harmonic attenuation characteristic.*

Thus far, we have concerned ourselves principally with a network intended to match two pure resistances. We have pointed out that such networks have a solution exhibiting a remarkable degree of freedom in the selection of circuit constants. We have shown how this freedom permits of designs which possess phase shift and harmonic attenuation possibilities along with the desired impedance matching characteristics. It remains only to mention that in cases where impedance match is our sole purpose the same degree of freedom permits the use of "fixed" units and hence tends toward cost reduction.

The more general case of matching two complex impedances may be simplified to the restricted case of matching pure resistances by simply combining the reactive components of input and output impedances with the branch members X_0, and X_1, respectively. The values X_{on} and X_{an} are then determined by equations (3) and (4) and the actual series members found from the relations:

$$X_0 = X_{on} - X_1 \quad (9)$$

$$X_1 = X_{an} - X_a \quad (10)$$

The actual and equivalent circuits are shown in Figure 5.

(Continued on Page 30)

*The problem of harmonic attenuation in antenna coupling units is enormously complicated by the fact that the antenna impedance is a function of frequency. A unit designed to properly match line-to-antenna at fundamental will not necessarily present the correct match for the harmonic frequencies. The work of Dr. G. H. Brown seems to indicate that the correct selection of T or π network in any particular case can have a highly beneficial effect on the harmonic attenuation. Though the evidence is not conclusive, experience seems to indicate that maximum harmonic attenuation occurs for values of X_2 which are at or near maximum.

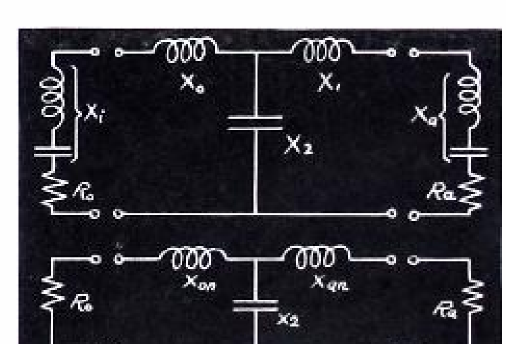


Fig. 5.

MODERN DESIGN

(Continued from Page 4)

It will be noted that the overhead lighting of the room is concentrated over the control desk for the efficient illumination of master controls. The remainder of the lighting is directional horizontally only to each wing of the U-shaped panels for illuminating meters and the like. The ceiling is always a flat (non-glare) finish, preferably approaching white, or a light hue of the transmitter color.

The floor is preferably of linoleum-covered cork which offers a maximum of wear with a minimum of operator fatigue. The linoleum of two tone color complementary to the transmitter, while the console is two toned in the same colors as the transmitter. Its writing surface, linoleum-covered in one of the colors of the floor, presents unity and color harmony of the ensemble.

When it is remembered that recently an article appeared in this publication which dealt with the background and history and design of a knob, and required nearly two pages of copy and four illustrations, it will be realized why only generalities are discussed herein. An occasional reference to a detail which is believed noteworthy will be made—but without the background of research and investigation involved from its inception to ultimate creation and acceptance.

The Antenna

Continuing in the sequence which started with the microphone, the next step is to send the program out through the antenna or radiator tower into the ether whereupon it is picked up by radio receivers. This, then, constitutes the point at which the sequence of styling modern radio apparatus will be picked up in the next issue. In addition to home receiver types, we will include styling special receivers and individual loudspeakers, Photophone and general motion picture equipment, Facsimile, Test Equipment, experimental Television demonstration units and general apparatus.

Before leaving the transmitter, however, it might be mentioned that transmitter housing presents a sufficient number of problems to warrant the stylist laying out an efficient floor and general plan for the accommodation of associated equipment for greatest economy and co-ordination of such equipment with the transmitter proper.

To this end, and to aid the architect and builder, as well as to assist the station-management, a building is laid out to accommodate personnel and auxiliary equipment coincident with size and requirements of a particular transmitter. The size illustrated requires a tube room and shop; the former, incidentally, making an interesting display behind a glass-partitioned portion. Then there is always the office, and for this particular layout, a studio and an audio room for local programs, in addition to the regular studios whose programs come to the transmitter by wire.

This size transmitter is on the air almost continuously and consequently requires sufficient attention to warrant living quarters. This must be designed for a given sized family, planned to be livable, efficient, and attractive, yet without affecting in any manner the installation or maintenance of the transmitter and vice versa.

Ventilation

Ventilation, heating and general conditions of lighting must of course be considered and planned. In this regard, glass-brick and the like are being found to be ultimately the least expensive in view of the amount of artificial light eliminated during the day.

Here again form follows function. For example, in the transmitter room light is needed directly over the transmitter and control console, and consequently dictates where the glass-brick portion of the building shall be and at what elevation, since low light is not desirable, due to reflection in meters and instruments which would prevent readings from the console.

The office and studio are necessarily immediately accessible from the entrance. Studio-windows, if any, should be high to avoid distracting artists by outside activities, etc. This further dictates the form of the building illustrated, by reason of the functions to be performed. By examination of the exterior view of one size of building proposed for this transmitter, it will be seen that it is necessary to supply such exterior view to the architect and builder of the transmitter house since the plan automatically dictates the principal exterior form in modern styling or design.

It is deemed proper to direct attention at this point to the fact that in previously mentioning the necessity for developing a type of design other than period, it will be appreciated such designs would not only be impracticable of application to the units and apparatus involved, but costs would be prohibitive with no desired or required advantages.

This is not due to the fact that period designers were impractical but in former times such men as Sheraton, Adams, Chippendale and others were not confronted with present day requirements. Therefore, they had no reason to develop necessarily simple, functional design which would be inexpensive of manufacture to the point of being competitive, and above all, pleasing.

(To Be Continued)

5000 WATTS FOR WRC

(Continued from Page 25)

casting stations. This is known as the 96A limiter and has been installed at all NBC stations. It has individual input and output level controls, facilities for checking the tube characteristics, and facilities for disconnecting the limiting action so that the unit may be used as a straight amplifier for almost any purpose. NBC has found that by means of these limiters it is possible to gain an average of 3 db in modulation without sacrificing quality. For aural monitoring there was provided one of the new high quality type 64A monitoring loudspeakers, which operates in conjunction with its associated type 82A monitoring amplifier.

Dummy Antenna

To facilitate transmitter testing off the air the station was provided with a simple dummy antenna consisting of Ohmspun resistor units connected to simulate the characteristics of the coaxial transmission line.

A field intensity survey of the new WRC station was made as soon as it was placed in operation. The measurements show that the results expected were slightly exceeded and that WRC excels in providing service in the District of Columbia and its environs.

PHASE METER

(Continued from Page 10)

erator and denominator of equation (1)

Numerator	Denominator	α
+	+	First Quadrant
+	+	Second Quadrant
—	—	Third Quadrant
—	+	Fourth Quadrant

Substitution in the following equations will then give the antenna resistance and reactance

$$R_a = \frac{X_c \sin\alpha \sin(\theta_1 + \alpha)}{\sin\theta_1} \qquad (2)$$

$$X_a = \frac{X_c \sin\alpha \cos(\theta_1 + \alpha)}{\sin\theta_1} \qquad (3)$$

where X_c is the reactance of the capacitor used in the resonant circuit $(+ \frac{1}{2}\pi fC)$

A typical measurement of this type might yield the following data:

$\theta_1 = +$ 8 degrees
$\theta_2 = +$ 20 degrees
$X_c =$ 100 ohms
Thus $\theta_1 + \theta_2 =$ 28 degrees

Then, from equation (1)

$$\tan\alpha = \cfrac{+0.47}{\cfrac{(+0.342 - 0.882)}{(+0.14)}}$$

$$= \frac{+0.47}{+1.558} = +0.3015$$

and $\alpha = 16$ deg. 47′

$\theta_1 + \alpha = 24$ deg. 47′

Equation (2) yields

$$R_a = \frac{100 \times 0.288 \times 0.42}{0.14}$$

$$= +86.5 \text{ ohms}$$

and equation (3) gives

$$X_a = \frac{100 \times 0.288 \times 0.91}{0.14}$$

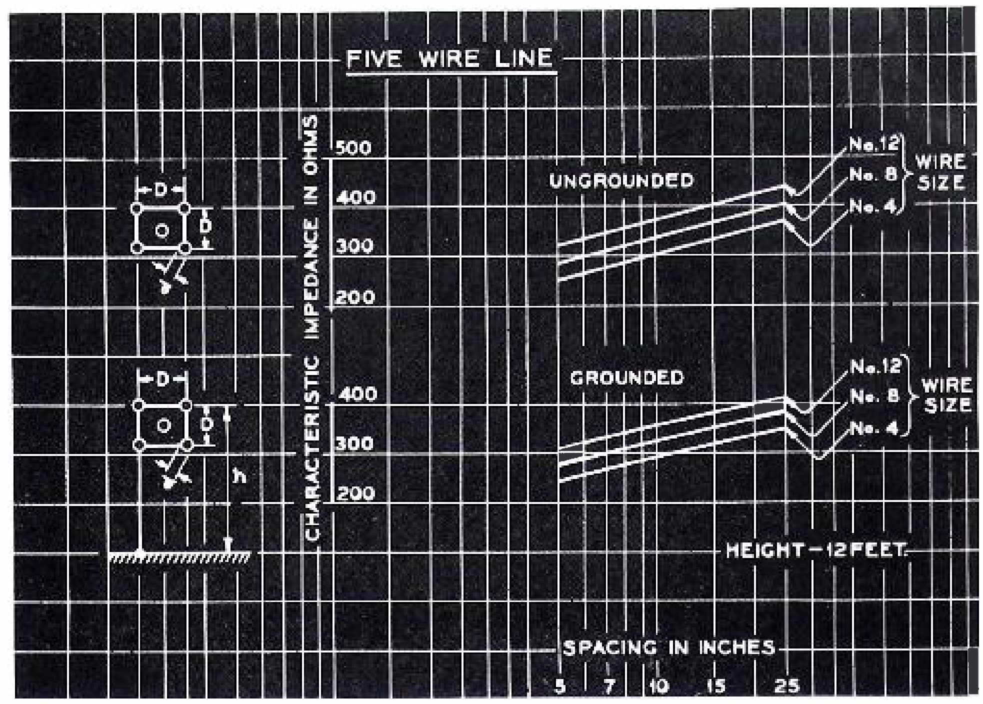
$$= +187 \text{ ohms}$$

From experience with this method of measurement, as well as a study of the equations, the following table has been compiled as a guide to determine the signs of the resistance and reactance.

θ_1 and θ_2	Resistance	Reactance
Positive and $\theta_2 > \theta_1$	Positive	Positive (Inductive)
Positive and $\theta_1 > \theta_2$	Positive	Negative (Capacitive)
Positive and $\theta_1 = \theta_2$	Positive	Zero
Negative and $\lvert\theta_2\rvert > \lvert\theta_1\rvert$	Negative	Positive
Negative and $\lvert\theta_1\rvert > \lvert\theta_2\rvert$	Negative	Negative
Negative and $\theta_1 = \theta_2$	Negative	Zero

The many capabilities of the Type 300-A r-f Phase Meter, together with its wide frequency range from 200 to 1600 kc, make the instrument extremely useful to consultants in making antenna performance measurements as well as to station engineers for antenna system maintenance.

The 300-A Phase Meter.



TRANSMISSION LINES

(Continued from Page 16)

variation of ± 4 feet in height from this value will produce a change in the calculated impedance not exceeding 5% for the 25 inch spacing with a lower percentage difference for smaller spacings.

For transmission lines of appreciable length grounds should be made at several intermediate points along the line as well as at the two ends. Measurement has shown that with ground connections at only the transmitter and antenna line terminals there may be a substantial variation in characteristic impedance with changing frequency. However, with the line grounded at several points a uniform value of impedance is obtained over the broadcast frequency range. Grounds made every seventy feet have been found adequate. A metal stake or pipe driven in the earth to a depth of several feet will usually suffice for the ground contact.

Another result of grounding an open wire is an increase in its radiation field. This is due to the fact that the "going" and "return" circuits are unbalanced, the earth carrying most of the current of the grounded conductors, with the result that the radiated field strength is increased above that which would exist if the line were ungrounded. However, even for the grounded condition, the line field is of a low order compared to the field of the antenna and except possibly in the case of highly directional antenna systems, its effect is negligible in transmitter practice.

It is desired to acknowledge the cooperation of Mr. Dale Pollack in this investigation.

ANTENNA IMPEDANCE

(Continued from Page 27)

Since any impedance matching problem may be reduced to an equivalent resistance matching problem the relations indicated in the vector diagram of Figure 3 are still applicable. In the general case, however, the construction of the diagram is complicated by the restrictions which the value of X_i and X_a place on the choice of point A. Because of this complication the graphical method, in all but the simplest of cases, is no longer expedient in an actual network solution and direct substitution in convenient equations should be used. Such equations may be readily derived from the geometry of Figure 3.

The derivation which follows is for the case of a T network intended to match a line of characteristic impedance, R_0, to an antenna of general impedance, Z_a. This case was chosen because it retains sufficient generality to be illustrative of the reasoning used and yet has the advantage of resulting in a set of equations which are directly applicable to the broadcast engineer's line-to-antenna matching problems.

From the vector diagram of Figure 3 we have

$$V_c = \sqrt{(I_a R_a)^2 + (I_a X_{an})^2} = \sqrt{(I_0 R_0 + I_0 X_0)^2} \qquad (11)$$

from which

$$(R_a^2 + X_{an}^2)\, I_a^2 = (R_0^2 + X_0^2)\, I_0^2 \qquad (12)$$

Since power input is equal to power output we may write

$$P = I_a^2 R_a = I_0^2 R_0 \qquad (13)$$

or

$$\left(\frac{I_a}{I_0}\right)^2 = \frac{R_0}{R_a} \qquad (14)$$

Substituting (14) into (12) and solving for X_0 we obtain

$$X_0 = \sqrt{\frac{R_0}{R_a}(R_a^2 + X_{an}^2 - R_a R_0)} \qquad (15)$$

Also from the diagram

$$I_c = I_0 \sin\beta + I_a \sin\alpha \qquad (16)$$

Letting

$$Z_{an} = \sqrt{R_a^2 + X_{an}^2}$$

$$Z_0 = \sqrt{R_0^2 + X_0^2}$$

then from (12) and (14)

$$Z_0 = \sqrt{\frac{R_0}{R_a}}\, Z_{an} \qquad (17)$$

We see from the diagram that

$$\sin\beta = \frac{X_0}{Z_0} \qquad (18)$$

$$\sin\alpha = \frac{X_{an}}{Z_{an}} \qquad (19)$$

with the aid of equations (17) to (19), we may rewrite (16) as

$$I_c = \left[\frac{R_a}{R_0} X_0 + X_{an}\right] \frac{I_a}{Z_{an}} \qquad (20)$$

From the diagram

$$X_2 = V_c / I_c$$

and from (11) and (20) this becomes

$$X_2 = \frac{Z_{an}^2}{\frac{R_a}{R_0} X_0 + X_{an}} = \frac{R_a^2 + X_{an}^2}{\frac{R_a}{R_0} X_0 + X_{an}} \qquad (21)$$

(Equations (15) and (21) permit the evaluation of all network constants once X_{an} has been determined. Setting a value for X_{an} is the equivalent of graphically selecting a point A. In the graphical method it was shown that either X_0 or X_{an} should be made zero or held to a minimum for the most economical solution of a purely impedance matching problem. Based on the same considerations we may define our choice of X_{an} as follows:

(a) If R_0 is less than R_a, X_{an} should be zero.

(b) If R_0 is greater than or equal to R_a, the minimum permissible value of X_{an} is given by*

$$X_{an} = R_a \sqrt{\left(\frac{R_0}{R_a} - 1\right)} \qquad (22)$$

*Equation (22) is based on the equivalent statement that X_0 should be zero. Substituting this value of X_0 into equation (15) and solving for X_{an} results in equution (22).

It should be remembered that X_{an} must always be inductive. For the case of a capacitive antenna the value of X_{an} as specified under parts (a) or (b) can always be obtained by adding sufficient inductance in the X_1 branch of the network. For case of an antenna having inductive reactance in excess of that specified for X_{an} under parts (a) or (b) the value of X_1 reduces to zero and the value of X_{an} must be taken to equal the X_a of the antenna itself.

For the case of X_{an} equal to zero, condition (a) (above), the network constants reduce to:

$$\left.\begin{aligned} X_0 &= \sqrt{R_0 R_a - R_0^2} \\ X_{an} &= 0 \\ X_2 &= \frac{R_a R_0}{X_0} \end{aligned}\right\} \qquad (23)$$

For the case of X_{an} equal to the minimum specified under (b) the network constants reduce to

$$\left.\begin{aligned} X_0 &= 0 \\ X_{an} &= R_a \sqrt{\frac{R_0}{R_a} - 1} \\ X_2 &= \frac{R_a^2 + X_{an}^2}{X_{an}} \end{aligned}\right\} \qquad (24)$$

Equations (23) and (24) represent the solution of the circuits of (4a) and (4b) respectively.

For values of X_{an} differing from the minimum specified under (a) and (b) equations (15) and (21) apply

$$X_0 = \sqrt{\frac{R_0}{R_a}(R_a^2 + X_{an}^2 - R_a R_0)} \qquad (15)$$

$$X_2 = \frac{R_a^2 + X_{an}^2}{\frac{R_a}{R_0} X_0 + X_{an}} \qquad (21)$$

Equations (15), (21, (23), and (24) represent the general and restricted solutions of the T network as that circuit is applied to the problem of matching transmission line to antenna;* they are the "conventional" equations found in the technical literature for such circuits. With slight modification in

*See Appendix for typical solutions based on this analysis.

method as suggested by rough vector sketches, the broadcast engineer may readily obtain the solutions of related circuits of special interest and importance to himself.

This brief description can only hope to serve as a suggestion. Its main purpose has been one of recalling to the reader the construction and value of the vector diagram as an aid in the visualization of the function of component elements in a common broadcast circuit and to show how complete equations may then be had quite simply from the geometry of the diagram without recourse to complex or calculus notations. If it has been of aid to the reader as a way to simplification in his problems it shall have served its purpose.

Appendix

The following cases are typical of antenna-to-line matching problems.

Example 1:

$F_c = 1430$ kc.
$R_0 = 70$ ohms
$R_a = 130$ ohms
$X = 180$ ohms (capacitive)

Since R_0 is less than R_a and X_a is capacitive, condition a on page 30 will always apply; accordingly from equations (23) we have

$$X_0 = \sqrt{70 \times 130 - 70^2} = 64.8 \text{ ohms}$$

$$X_{an} = 0$$

$$X_1 = 0 - (-180) = 180 \text{ ohms}$$

$$X_2 = \frac{130 \times 70}{64.8} = 140 \text{ ohms}$$

The corresponding values of network constants at carrier frequency are

$$L_0 = \frac{64.8}{6.28 \times 1430 \times 10^3} = 7.2 \text{ uh}$$

$$L_1 = \frac{180}{6.28 \times 1430 \times 10^3} = 20 \text{ uh}$$

$$C = \frac{1}{6.28 \times 1430 \times 10^3} \times 140$$

$$= .000795 \text{ ufd.}$$

Example 2:

$F = 1010$ kc.
$R_0 = 70$ ohms
$R_a = 50$ ohms
$X_a = -100$ ohms (capacitive)

Since R_0 is greater than R_a and X_a is capacitive condition (b), page 30 may always be applied; equations (24) yield,

$$X_0 = 0$$

$$X_{an} = 50\sqrt{\frac{70}{50} - 1} = 31.6 \text{ ohms}$$

$$X_1 = 31.6 - (-100) = 131.6 \text{ ohms}$$

$$X_2 = \frac{50^2 + 31.6^2}{31.6} = 111 \text{ ohms}$$

Again at carrier frequency we have

$$L_0 = 0$$

$$L_1 = \frac{131.6}{6.28 \times 1010 \times 10^3} = 20.7 \text{ uh.}$$

$$C = \frac{1}{6.28 \times 1010 \times 10^3 \times 111} = .0142 \text{ ufd.}$$

Example 3:

$F_c = 1010$kc.
$R_0 = 70$ ohms
$R_a = 50$ ohms
$X_a = 100$ ohms

(Same as Example 2 with the exception that X_a is now inductive.)

In example 2 we saw that when condition (b) was applied the resulting value of $X_{an} = 31.6$ ohms was less than the actual antenna inductance $X_a = 100$ ohms. Accordingly, the minimum value of X_{an} is given by $X_{an} = X_a$ and equations (15) and (21) must be used; thus

$$X_0 = \sqrt{\frac{70}{50}(50^2 + 100^2 - 50 \times 70} = 112 \text{ ohms}$$

$$X_{an} = 100$$

$$X_1 = 100 - 100 = 0$$

$$X_2 = \frac{50^2 + 100^2}{\frac{50}{70} \times 112 + 100} = 69.3 \text{ ohms}$$

(This same procedure would be required in Example 1 had X_a been inductive.)

Comments on Illustrated Examples

The values of X_0, X_1, and X_2 as found in the above examples are not unique as was shown in the text of the article. Accordingly, if the corresponding values of L_0, L_1, and C are impractical, new and somewhat larger values of X_{an} may be assumed and the values of X_0, X_1 and X_2 be recalculated by the use of equations (15) and (21). A point in case is that of the value of C as obtained in Example 2; standard values for fixed capacitors do not include the calculated value. To obtain a solution which would permit the use of a fixed capacitor it would be necessary to assume several values of X_{an} greater than 31.6 ohms and to then comput the corresponding values of X_2 and C by equation (21). A rough plot of C versus X_{an} and an interpolation for the correct value of X_{an} might minimize the number of approximations necessary for the desired solution.

It should be noted in the above examples that it is entirely unnecessary to first resonate the antenna so that it becomes a pure resistance before attempting a match. The reactance of the antenna, regardless of whether it be inductive or capacitive, is taken care of by assigning the proper value to X_{an}. Neither is it necessary that the value of the shunt capacity X_2 be such as to resonate the circuit looking toward the antenna. The vector diagram shows that this can never be the case if the line is to have an equivalent pure resistance presented to it by antenna and network.

CATALOG

(Continued from Page 21)

of constant reference to different pages.

Designed primarily for the station engineer, this catalog has been crammed with the facts and features in which the engineer is interested to the exclusion of "selling points and sales talks." We feel that a clear exposition regarding a unit is all that the intelligent engineer needs or desires.

The preparation of this catalog has been expensive and for this reason the distribution has not been as extensive as we might have liked. However if you have not, by any chance, received a copy and if you feel that you could use one profitably, please be sure to let us know.

AN ULTRA DIRECTIONAL MICROPHONE

New Development "Spotlights" Radio Performers

By DR. H. F. OLSON

Fig. 1. The ultra directional microphone.

IMPORTANT research work is being done on an Ultra Directional microphone under the direction of Dr. H. F. Olson in the RCA Research Laboratories. The outstanding feature of this highly directional microphone is a directional pattern which is independent of the frequency. The polar directional characteristics of this microphone are shown in Figure 2.

The directional characteristics of the RCA "Velocity" and "Uni-directional" microphones are independent of the frequency and therefore do not introduce frequency discrimination for points removed from the axis or for generally reflected sound. The satisfactory performance and universal acceptance of these microphones for high quality sound pick-up may, in a large part, be attributed to this outstanding feature of these microphones. In the same way the directional characteristics of the Ultra Directional microphone are independent of the frequency.

In the past a large number of highly directional systems have been introduced from time to time. However, none has met with any outstanding success due to the fact that the directional characteristics varied with frequency. These systems usually exhibited directional characteristics which were extremely narrow at the high frequencies and very broad at the low frequencies. Such systems have always been discarded due to the introduction of frequency discrimination.

Increased Distance

It is quite well known that the distance of pick-up can be increased as the effective collection angle is reduced. For example, in the Uni-directional microphone with the cardioid characteristic the energy response to random sounds is 1/3. Therefore the Uni-directional microphone can be operated at 1.7 times the distance of a non-directional microphone. In the Ultra Directional microphone, shown in Fig. 1, the energy response to random sounds is 1/10 that of a non-directional microphone. This means that this microphone can be operated at 3.2 times the distance of a non-directional microphone.

Another microphone of this type is being developed in which the directional characteristics are narrower than those shown in Fig. 2. As in the microphone of Figure 1 the directional characteristics will be independent of the frequency. The energy response to random sounds will be 1/40 that of a non-directional microphone. With this microphone it will be possible to operate at 6.3 times the distance of a non-directional microphone.

Advantages

The long distance over which sound can be picked up with an Ultra Directional microphone as compared to existing microphones is the outstanding advantage possessed by this microphone.

The long distance pick-up characteristics are particularly suitable in sound motion picture recording, television, pick-up of large stage productions in radio broadcast, etc., where it is desirable to keep the microphone out of the action.

JOHN P. TAYLOR LOCATED AT DALLAS OFFICE

John P. Taylor, who has been connected with the Sales office at the Camden plant of RCA for many years has again taken up active work in the field. Mr. Taylor, widely known to broadcasters all over the country through his work with RCA and his authoritative articles appearing in numerous technical publications, will contact stations in the Southwestern District.

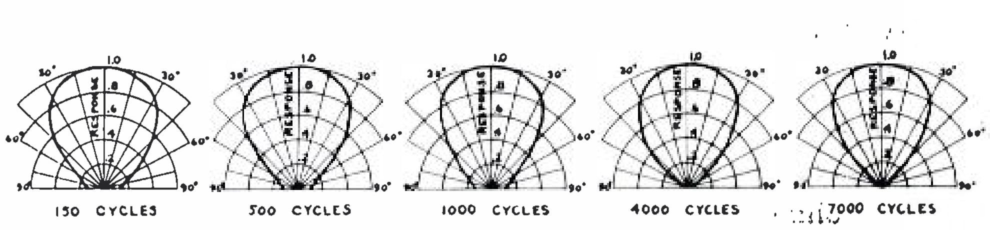


Fig. 2. The polar directional characteristics of the ultra directional microphone.

DIRECTIONAL ANTENNAS

A Development of Analytical Methods Applicable to General Problems in Array Design

DR. G. H. BROWN

Reprinted through the courtesy of Proceedings of the I. R. E.

VI. A Single Parasitic Reflector

(a). The Transmitting Case

We will next consider the case of an antenna with a single parasitic element. In Fig. 22, 0 denotes the antenna driven by the transmitter while No. 1 is the parasitic element excited by radiation coupling. This element is grounded through a reactance. For simplicity, we will consider each antenna to be one-quarter wave tall.

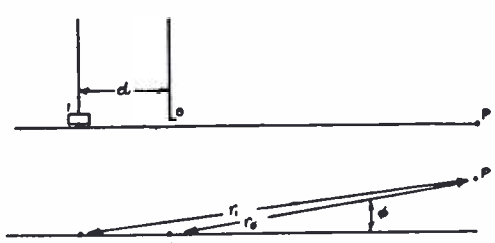


Fig. 22

Writing Kirchoff's law for the two circuits involved,

$$\left.\begin{aligned} \bar{V}_0 &= \bar{I}_0\bar{Z}_{00} + \bar{I}_1\bar{Z}_{01} \\ O &= \bar{I}_0\bar{Z}_{01} + \bar{I}_1\bar{Z}_{11} \end{aligned}\right\}. \qquad (76)$$

The parasitic current is expressed in terms of the main antenna current, thus,

$$\bar{I}_1 = -\frac{\bar{I}_0\bar{Z}_{01}}{\bar{Z}_{11}} = -\frac{\bar{I}_0\,|Z_{01}|}{|Z_{11}|} \angle\, \theta_m - \tau = \bar{I}_0\,|Z_{01}|\,\angle + \beta \qquad (77)$$

where,

θ_m = phase angle of the mutual impedance

$$\tau = \tan^{-1}\frac{X_{11}}{R_{11}}$$

X_{11} = reactance of the reflector antenna proper plus the grounding reactor.

β = angle by which I_1 leads I_0 $= 180° + \theta_m - \tau$.

The field at a point, P, is

$$F = +j\frac{60}{r_0}\left[\bar{I}_0 + \bar{I}_1 \angle -\frac{2\pi d}{\lambda}\cos\phi\right] \angle -2\pi r_0/\lambda = +j\frac{60\bar{I}_0}{r_0}\left[1 + \frac{|Z_{01}|}{|\bar{Z}_{11}|}\angle\beta - kd\cos\phi\right]\angle -\frac{2\pi r_0}{\lambda}. \qquad (78)$$

$$\bar{V}_0 = \bar{I}_0\left[\bar{Z}_{00} - \frac{\bar{Z}_{01}^2}{\bar{Z}_{11}}\right] \qquad (79)$$

or,

$$\bar{V}_0 = \bar{I}_0\left[R_{00} - \frac{|Z_{01}|^2}{|Z_{11}|}\cos(2\theta_m - \tau) + j\left\{X_{00} - \frac{|Z_{01}|^2}{|Z_{11}|}\sin(2\theta_m - \tau)\right\}\right]. \qquad (80)$$

Then the resistance of the main antenna with the parasitic element present is

$$R_0 = R_{00} - \frac{|Z_{01}|^2}{|Z_{11}|}\cos(2\theta_m - \tau). \qquad (81)$$

The reactance of the main antenna changes from X_{00} to

$$X_{00} - \frac{|Z_{01}|^2}{|Z_{11}|}\sin(2\theta_m - \tau).$$

Thus, to tune the main antenna to resonance, we must assign a value to X_{00} so that

$$X_{00} - \frac{|Z_{01}|^2}{|Z_{11}|}\sin(2\theta_m - \tau). \qquad (81a)$$

For a constant power, P_0, the antenna current is

$$I_0 = \sqrt{\frac{P_0}{R_0}}. \qquad (82)$$

The field intensity expressed as a fraction of that obtained with the same power into a single antenna is

$$\frac{F}{F_0} = \sqrt{\frac{R_{00}}{R_0}}\left[1 + \frac{|Z_{01}|}{|Z_{11}|}\angle\beta - kd\cos\phi\right]. \qquad (83)$$

When $\phi = 0$, (83) yields the field in a forward direction

$$\frac{F_F}{F_0} = \sqrt{\frac{R_{00}}{R_0}}\left[1 + \frac{|Z_{01}|}{|Z_{11}|}\angle\beta - kd\right]. \qquad (84)$$

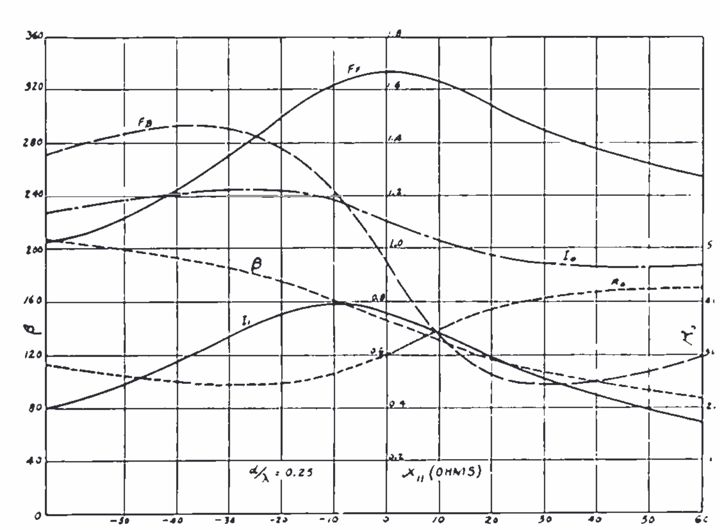


Fig. 23—The effect on the circuit conditions of tuning a parasitic reflector. (Spacing between antenna and reflector = 0.25λ.)

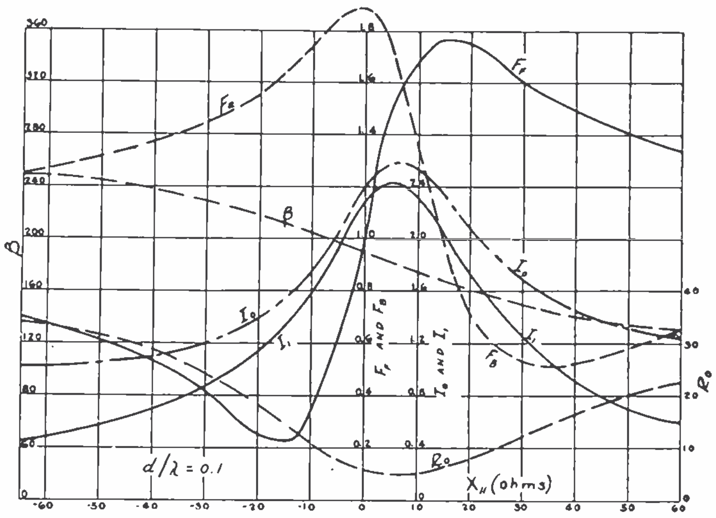


Fig. 24—Similar to Fig. 23, except that spacing is 0.1λ.

When $\phi = 180$ degrees, the field in the backward direction becomes

$$\frac{F_B}{F_0} = \sqrt{\frac{R_{00}}{R_0}} \left[1 + \frac{|Z_{01}|}{|Z_{11}|} \angle \beta + kd \right]. \quad (85)$$

Fig. 23 shows F_F, F_B, I_0, I_1, R_0, and β as a function of X_{11} for a spacing $d = 0.25\lambda$. The currents and electric intensities are expressed in terms of the values which would obtain if a single antenna were operated at the same power. We see that as the parasitic reflector is detuned by making X_{11} large in magnitude, the quantities in question approach the values obtained with a single antenna.

Fig. 24 shows the same quantities for a spacing, $d = 0.1\lambda$.

From Figs. 23 and 24, as well as similar diagrams for other spacings, it is possible to find the maximum F_F and F_B that may be obtained for each spacing. The result of such a procedure is shown by Fig. 25. The corresponding values of X_{11}, the reactance of the parasitic element, are given by Fig. 26, while Fig. 27 illustrates the values of resistance as measured at the terminals of the driven antenna when maximum forward or backward field is being obtained.

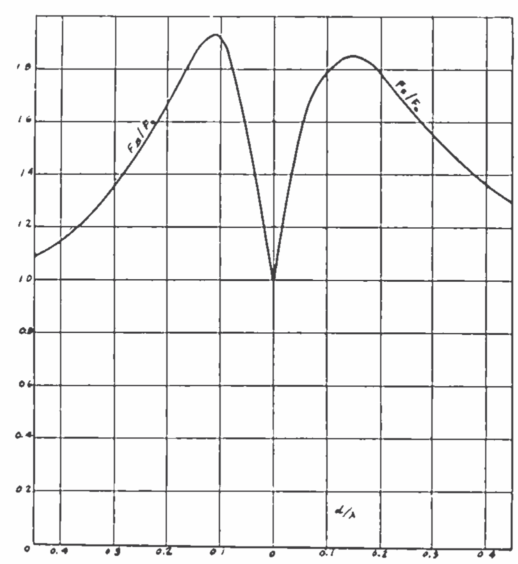


Fig. 25—The maximum increase in forward and backward signal as a function of spacing between the antenna and the reflector.

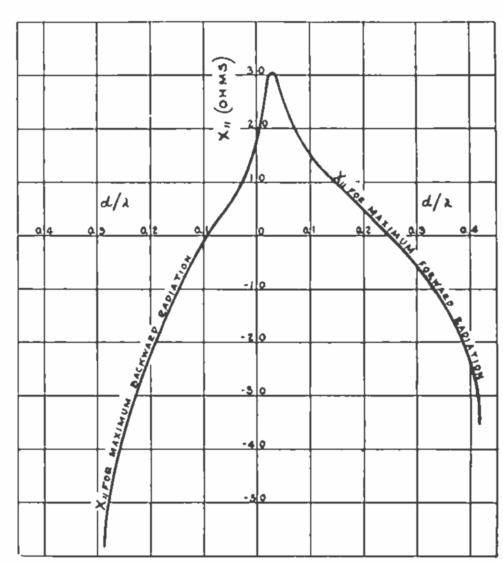


Fig. 26—The tuning condition for maximum forward or backward radiation.

An inspection of Fig. 25 shows that a spacing of one-quarter wave it not an optimum value for either maximum forward or backward radiation. Much smaller spacings are preferable.

Fig. 28 shows horizontal polar diagrams for a number of spacings and tunings of the parasitic element. The circles indicate the value of field intensity obtained from a nondirectional antenna operated at the same power.

Another case of interest is that in which the parasitic antenna is self-resonanted so that $X_{11} = 0$.

Then,

$$R_{11} = 36.6 \text{ ohms}$$
$$\tau = 0$$
$$\beta = 180 + \theta_m$$
$$R_0 = R_{00} - \frac{|Z_{01}|^2}{R_{11}} \cos(2\theta_m) \quad (86)$$

$$\frac{F_F}{F_0} = \sqrt{\frac{R_{00}}{R_0}} \left[1 - \frac{|Z_{01}|}{R_{11}} \angle \theta_m - kd \right] \quad (87)$$

$$\frac{F_B}{F_0} = \sqrt{\frac{R_{00}}{R_0}} \left[1 - \frac{|Z_{01}|}{R_{11}} \angle \theta_m + kd \right]. \quad (88)$$

The various pertinent quantities are shown in Fig. 29 as a function of d/λ.

(b). The Receiving Case

Before proceeding with the analysis of a receiving antenna with a parasitic reflector, we must examine the case of a single receiving antenna. Let us suppose that in the transmitting case (Fig. 22), the parasitic reflector is moved away from the main antenna a great distance, many miles if we wish. However, equations (76) are still valid. They are rewritten here for ease of reference.

$$\bar{V}_0 = \bar{I}_0 \bar{Z}_{00} + \bar{I}_1 \bar{Z}_{01} \quad (89)$$

$$0 = \bar{I}_0 \bar{Z}_{01} + \bar{I}_1 \bar{Z}_{11}. \quad (90)$$

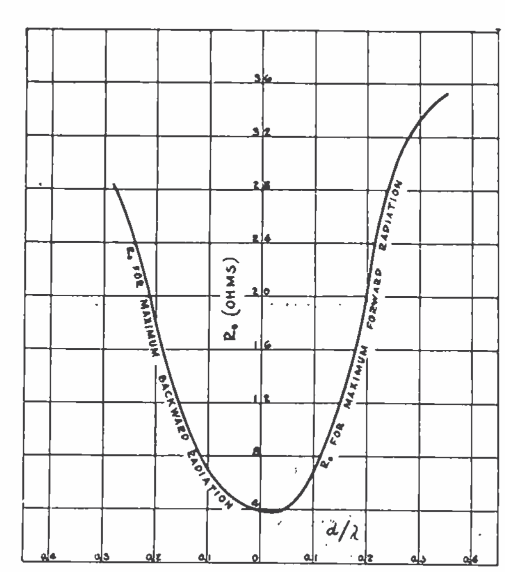


Fig. 27—The radiation resistance measured at the main antenna terminals when the reflector is adjusted for maximum forward or backward radiation.

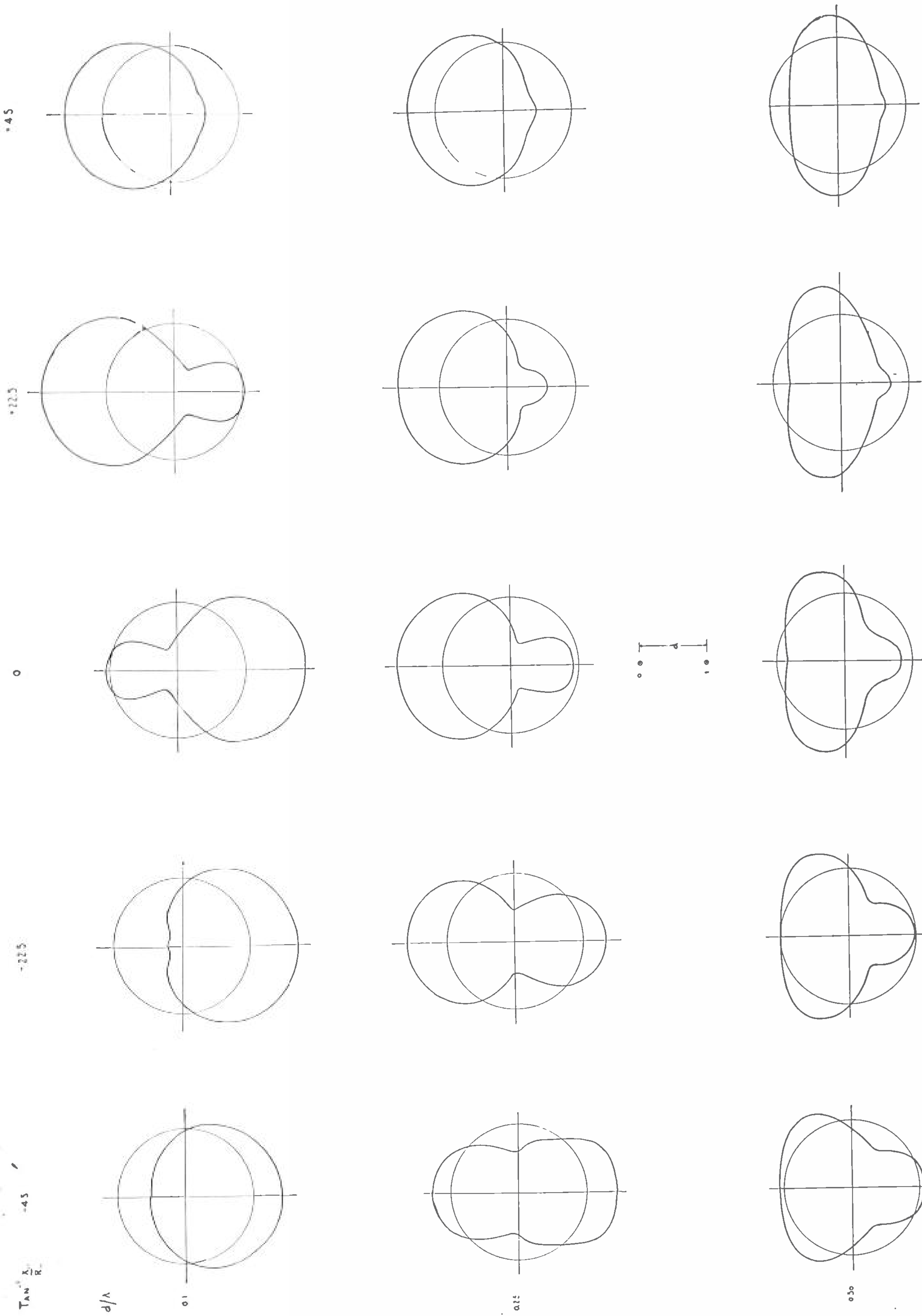


Fig. 28—The horizontal radiation patterns of an antenna and a single reflector, for a number of spacings and tuning conditions.

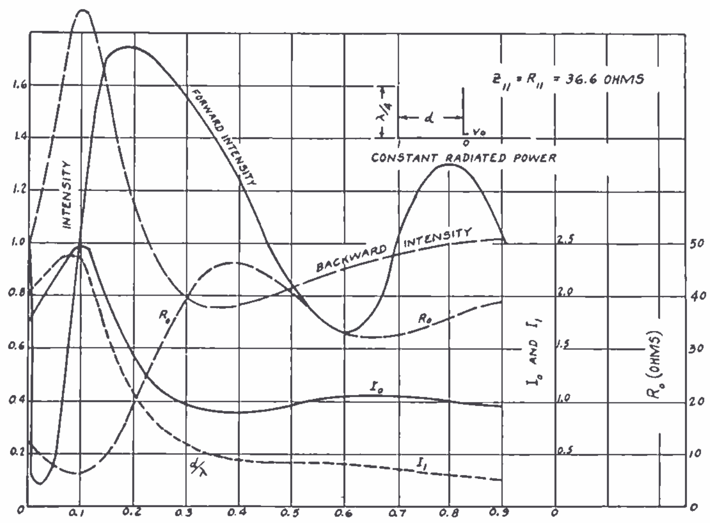


Fig. 29—The circuit conditions when the reflector is self-resonant.

With this large separation, we have no trouble in visualizing antenna 0 as the transmitter and antenna 1 as the receiving antenna. The current in antenna 1 is so weak that the reaction back into antenna 0 is negligible so that (89) becomes

$$\bar{V}_0 = \bar{I}_0 Z_{00}. \qquad (91)$$

Thus I_0 remains independent of anything that transpires in the circuit of antenna 1.
From (90),

$$-\bar{I}_0\bar{Z}_{01} = \bar{I}_1 Z_{11}. \qquad (92)$$

The term $-\bar{I}_0\bar{Z}_{01}$ may then be regarded as a voltage induced in antenna 1. This voltage is constant in magnitude.

Let us now turn to the definition of Z_{01} as given by (14)

$$\bar{I}_0\bar{I}_1\bar{Z}_{01} = p_m = -\int_{y=0}^{y=a} F_y i_y dy. \qquad (93)$$

Then,

$$-\bar{I}_0\bar{Z}_{01} = -\frac{1}{I_1}\int_{y=0}^{y=a} F_y i_y dy. \qquad (94)$$

Here F_y is the electric intensity along antenna 1 due to the current in antenna 0. Because of the large separation between antennas, this intensity is essentially constant over the antenna length. Then

$$-\bar{I}_0\bar{Z}_{01} = \frac{F}{I_1}\int_{y=0}^{y=a} i_y dy. \qquad (95)$$

Then,

$$E_i = -\bar{I}_0\bar{Z}_{01} = Fh \qquad (96)$$

where,

E_i = the induced voltage

$h = \frac{1}{I_1}\int_{y=0}^{y=a} i_y dy$ = the effective height, which is a function of configuration, only.

For the top-loaded antenna of Fig. 1,

$$h = \frac{\lambda}{2\pi}\,\frac{\cos B - \cos G}{\sin G}. \qquad (97)$$

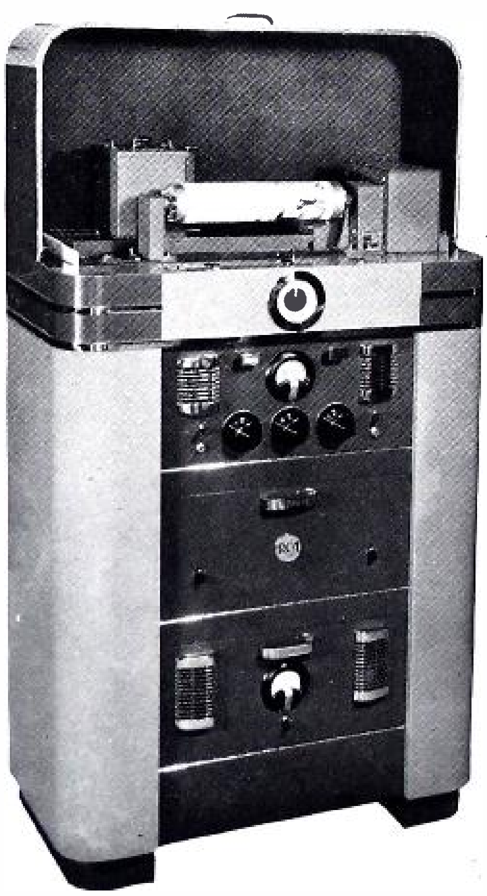
For a simple quarter-wave antenna with no top loading, the effective height is simply

$$h = \frac{\lambda}{2\pi}. \qquad (98)$$

We are now ready to attack the case of a receiving antenna and a parasitic reflector. The receiving case may be divided into two distinct classes. First, if we have available a detecting device which requires no power for its operation and the antennas themselves have only slight losses, we are primarily interested in getting as large a current as possible in the main antenna element. With no losses, all of the energy absorbed by the wave is reradiated. In the second case, however, where the detector has a finite resistance, we are interested in absorbing in the detector resistance as much power as possible. For the present, we will examine a few cases which fall under the first class.

NEW FACSIMILE EQUIPMENT NOW AVAILABLE

Facsimile equipment first demonstrated at the recent NAB convention, will soon be delivered to a number of stations. One of the scanners now in production is shown below, giving some idea of the finished appearance and superb workmanship in the new units. The modern design and striking color combination give it a display value unusual in technical equipment.



I. R. E. CONVENTION

An excellent display of Test Equipment and various new items featured RCA's participation in the Thirteenth Annual Convention of the I. R. E. at the Hotel Pennsylvania, June 16th, 17th and 18th.

Approximately thirty members of the Engineering and Sales Departments were in attendance to explain and demonstrate new units and their uses.

Among the units exhibited were the 70 B Turntable, Ultra Directional Microphone, OP-5 Portable Amplifier, a Distortion and Noise Measuring Set, a Square Wave Generator, a Phase Meter and Transmitting Tubes.

Forty-nine papers were presented to the engineers attending and of this number nineteen were in whole or in part the work of RCA engineers.

Notes About Our Contributors

LYNN BRODTON—Class of '25 (Law) University of Virginia. Asst. Mgr. V. J. Evans & Co., N. Y., 1925-7 (Patent Law). Victor Co. and RCA, 1927 to date in the following capacities respectively; Mechanical Draftsman; Mechanical Designer; Development Engineer; Technical Illustrator; 1934-6 in charge Illustration Division of Engineering; 1936 to date in charge Styling Products of Engineering and coordinating cabinet design.

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R. D. DUNCAN, Jr.—Mr. Duncan graduated from Washington University, St. Louis, with an Electrical Engineering degree, in 1914. He was Assistant Radio Inspector, U. S. Department of Commerce, 1914-15, and with the Bureau of Standards 1915-17. He joined the Signal Corps, U. S. Army, where he remained from 1917 until 1922. After leaving the Signal Corps he became associated with Wired Radio, Inc., and continued with them until 1936, when he joined RCA.

• • •

R. F. GUY—Mr. Guy graduated from Pratt Institute and received his first radio experience as a ship operator. He was associated with Westinghouse in the early days of WJZ, and then joined RCA at the T. and T. Lab in broadcast station work. Since 1930 he has been with NBC, in charge of Radio Frequency Facilities.

R. A. HACKLEY—Born December 15, 1907, at Oakfield, N. Y. Received B.S. degree, 1931; M.S. degree in Electrical Engineering, 1933, Yale University. Graduate assistant, Yale University, 1931-1933. Engineering Department, RCA Manufacturing Co., Inc., 1933 to date. Member, Tau Beta Pi; Sigma Xi.

• • •

L. F. NAFZGER—Mr. Nafzger, who contributes the interesting story on WBNS for this issue, is Chief Engineer for that station. He has been in various phases of the radio business for many years.

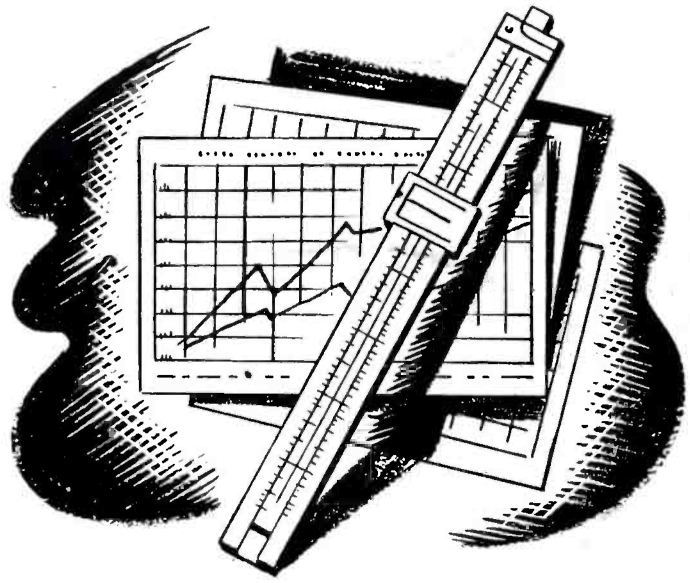
• • •

GILBERT SWIFT—Born in Brooklyn, N. Y., in 1912. Received B.S. in E.E. from the Moore School of Electrical Engineering at the University of Pennsylvania in 1933. Joined the Test Equipment Section of the Engineering Department, RCA Manufacturing Company, in September, 1935.

• • •

A. VOLLENWEIDER—Mr. Vollenweider received his B.S. in E.E. from the University of Wisconsin in 1936. For a time he was with the Wisconsin Telephone Company, and left that position to join RCA, where he is now connected with the Transmitter Section.

Frequency Measuring Service



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