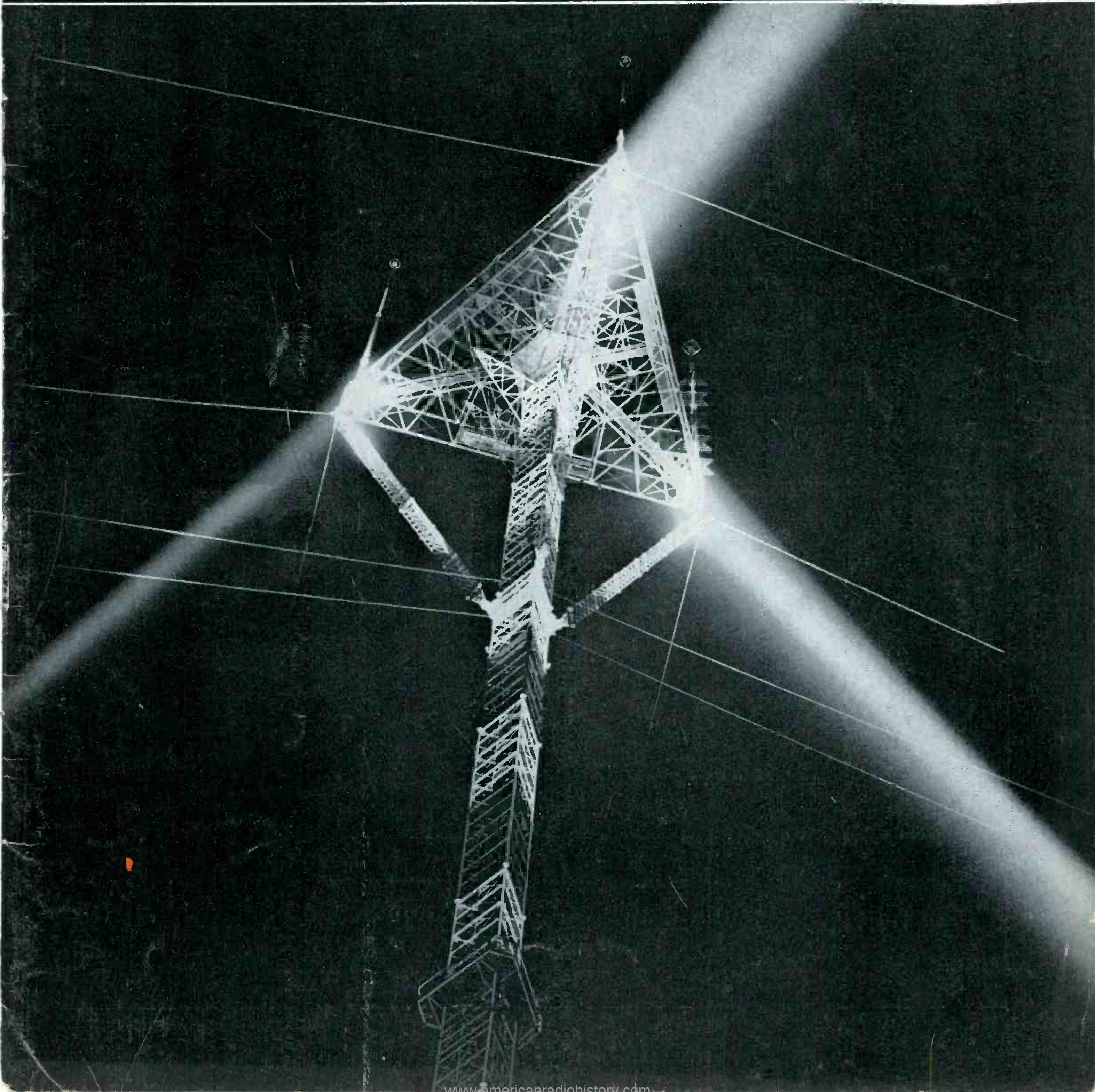
DECEMBER, 1960

BROADCAST ENGINEERING

THE TECHNICAL JOURNAL OF THE BROADCAST INDUSTRY



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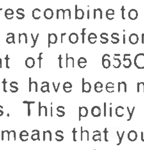

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BROADCAST ENGINEERING

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VOLUME 2 DECEMBER, 1960 NUMBER 12

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Cover Story

Operation of the world's first three-antenna candelabra tower began in Baltimore last year. The 730 foot tower is shown on our cover illuminated with spot lights. Five years of planning preceded construction of the antenna system which serves WBAL, WJZ, and WMAR. Complete details of the project are related in this issue.

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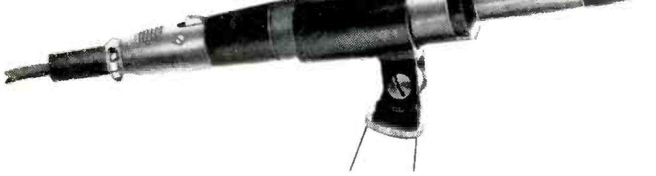

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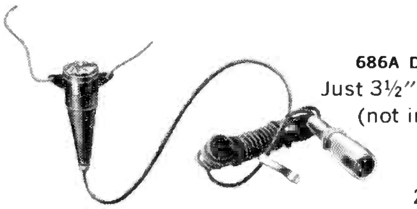

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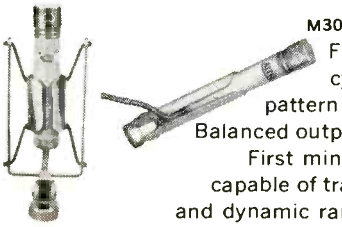

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THE FOLDED UNIPOLE ANTENNA FOR AM

By JOHN H. MULLANEY*

This article will discuss a method for reducing the physical height of an antenna system without seriously impairing its electrical characteristics. This will be accomplished by use of folded-unipole antenna theory. Present day techniques dictate that in order to reduce the physical size of an antenna system and still obtain a reasonable efficiency, inductive or capacitive loading be utilized in order to change the current distribution of the array. It will be shown that by grounding a vertical structure and folding back one or more conductors parallel to the side of the structure, it is possible to obtain a wide range of resonant radiation resistances by varying the ratio of the diameter of the folded back conductor in relation to the tower. It will also be shown that a top-loaded folded-unipole antenna can obtain a wide range of resonant radiation resistances and at the same time obtain a band-width many times greater than the same antenna without loading and use of the folded-unipole method of feed.

Series-fed vertical antennas are commonly used in standard broadcast service today. Some stations use a shunt-fed antenna, but the great majority are series-fed. The folded-unipole antenna could be called a modification of the standard shunt-fed system. Instead of having a slant wire leaving the tower at an angle of approximately 45° (as used for shunt-fed systems), the folded-unipole antenna has wires (one or more can be used) attached to the tower at a pre-determined height, supported by stand-off insulators, and run parallel to the sides of the tower to its base. The tower is grounded at its base—that is, no base insulator is used. These folds, or wires, are joined together at the base and driven at this point through an impedance matching network. Depending upon the type of folded-unipole antenna used. the wires may be connected to the tower at the top and/or at pre-determined levels along the tower (shorting stubs).

The folded-unipole antenna has the advantage of not requiring a base insulator, lighting chokes, or isolation transformers. It provides better protection against lightning, due to the fact that the antenna is grounded. In addition, the folded-unipole antenna, on a comparison basis, will develop a somewhat higher radiation efficiency, particularly for towers of the order of 45° to 60° high. The band-width for the folded-unipole antenna is also superior to that of a series or shunt-fed antenna system. The folded-unipole has an additional advantage over a series or a shunt-fed system in that it will operate with a much shorter ground system and still produce approximately the same effective field.

Basically speaking, a folded-unipole antenna can

*Consulting Engineer, 2000 P St., N. W., Washington 6, D. C.

BROADCASTING

The advantages of using a folded antenna for broadcast include the elimination of the base insulator, lightning choke, and isolation transformer, higher radiation efficiency, wide bandwidth, adjustable radiation resistance, and the use of a shorter ground system. These and other factors dealing with the design and construction of the folded unipole AM radiator are described in this article.

be visualized as a half-wave folded-dipole perpendicular to the ground and cut in half. The following discussion will briefly treat the theory of and results obtained from this type of antenna system.

Theory of Folded-Unipole Antenna

To readily understand the folded-unipole antenna and its use in feeding a grounded tower, let's take a quick look at some basic transmission line theory. We know that a transmission line which is less than 90° in length and shorted at its far end will appear inductive at its input terminals. If this line is increased in length so that it equals a quarter wave, it will appear to be a parallel resonant circuit at its input. That is, it will appear to have very high impedance.

Figure 1 illustrates a one fold, folded-unipole antenna. In order to determine its input impedance, let us assume a generator voltage (e) and then find the current (I) flowing in the lower end of element d_1 as illustrated in Figure 1. Roberts (Input Impedance of a Folded Dipole, R.C.A. Review, Volume 8, No. 2, June, 1947, W. Van B. Roberts) has outlined a method for analysis of a folded-unipole antenna.

Referring to Figure 2, it should be noted that Generator A is opposing Generator C, with respect

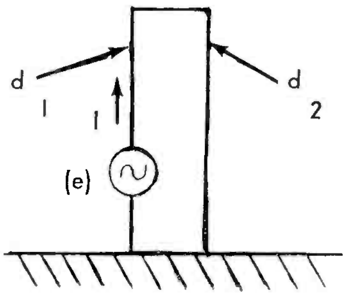

Figure 1. A one fold, folded unipole antenna.

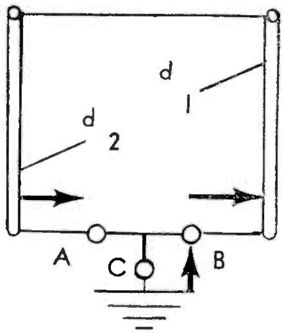

Figure 2.

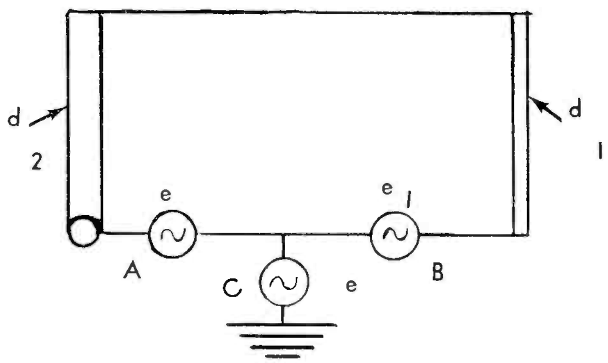

Figure 3. The folded unipole antenna with unequal size conductors.

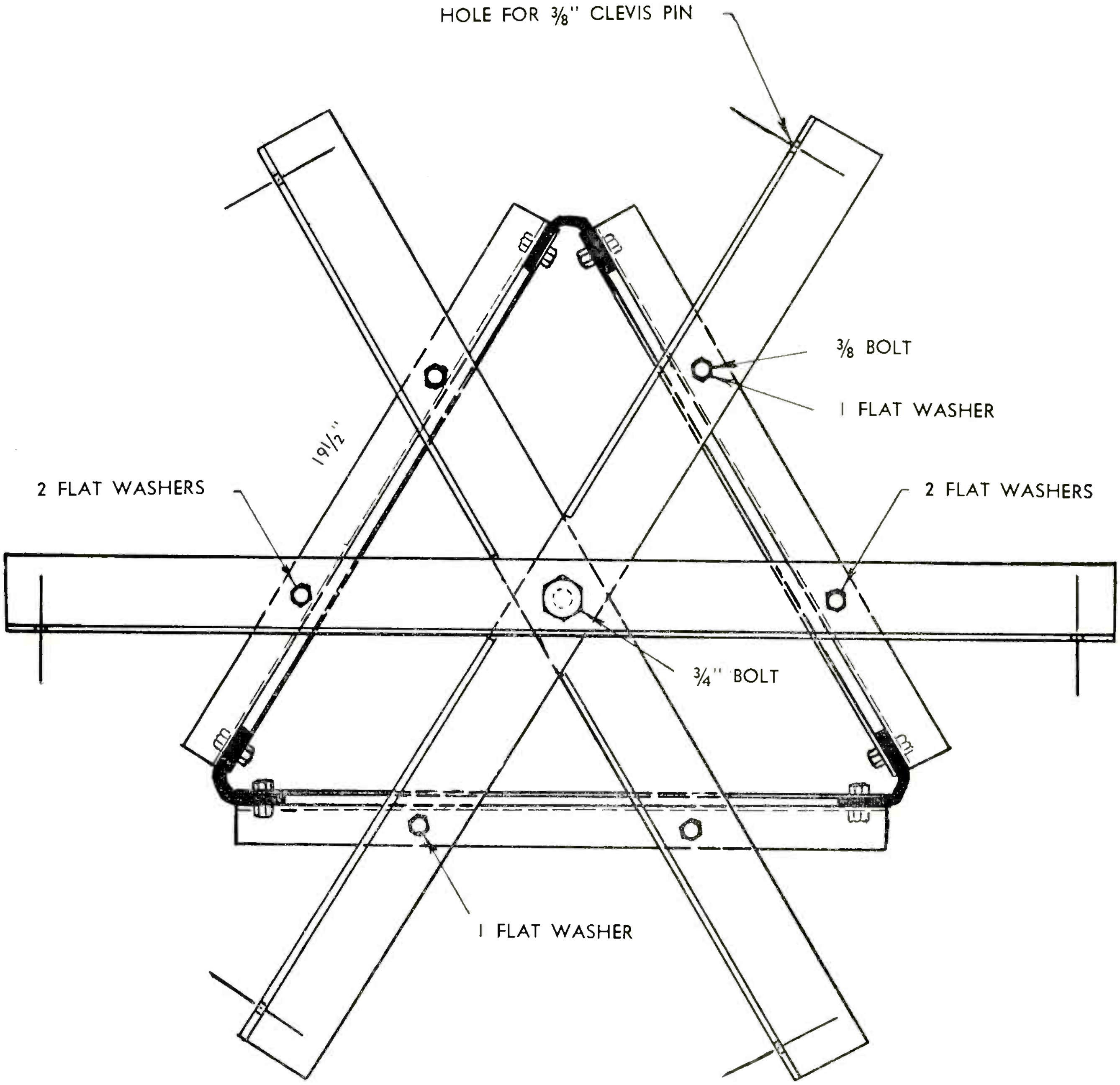

Figure 4. Top view of a uniform cross-section, guyed tower rigged for a six wirefolded-unipole antenna.

to the lower end of element d_2. Thus, element d_2 is grounded so far as any voltage is concerned.

Generators B and C impress a voltage, 2E, on the lower end of element d_1; therefore, Figure 2 is equivalent to Figure 1. Our reason for using three generators is that it is fairly easy to determine the current developed by each generator and then by the principle of superposition, add these currents to obtain the actual current in the lower end of element d_1.

Let's go a little further and first assume that there is no voltage (for the moment) in the lower generator. There is then only the voltage 2E acting between the lower ends of d_1 and d_2. Inasmuch as elements d_1 and d_2 form a 90° transmission line, shorted at the far end, their impedance is very high; consequently, only a small current will flow into element d_1. Next, assume there is voltage only in Generator C. Then, since the lower ends of d_1 and d_2 are shorted together (by the zero internal impedance of A and B), the two elements act as a simple 90° radiator made up of two elements connected in parallel. If R is the radiation resistance of this radiator, Generator C will supply a total current equal to E/R to this composite antenna, but by symmetry, this current divides equally between d_1 and d_2, so that the current entering element d_1 is:

$$I_1 = \frac{\frac{1}{2} E}{R} \qquad (1)$$

Thus, if Generators A, B and C are all working at once, the voltage impressed on element d_1 is 2E, while the current entering it is ½ E/R plus a very small amount produced by Generators A and B working above. The input resistance of element d_1, being the ratio of voltage impressed to resulting current flow, is therefore approximately 4R. If the two elements are close together, the value of resistance will be different from that of a single radiator, and the impedance multiplication due to folding is approximately four.

The impedance transformation can be expressed as follows:

$$\text{The impedance transformation} = \frac{Z_1}{Z_0} = (1 + n)^2 \qquad (2)$$

Where:

Z_1 = input impedance of the folded-unipole antenna.
Z_0 = input impedance of a single antena.

$$n = \text{current ratio } \frac{I_2}{I_1} = 1$$

Up to this point, we have discussed equal size conductors, that is the diameter of the tower and the fold is the same. However, with the introduction of the transformation ratio, as noted in (2), we are now prepared to discuss the operation of a folded-unipole antenna with unequal diameter conductors. Figure 3 illustrates the folded-unipole antenna with unequal size conductors.

Generators A and C are alike in order to put zero voltage on element d_2, but Generator B must now be so chosen that no current will flow through Generator C when it is not producing voltage. The determination of this voltage (e_1) is one of the two essentials to the solution of the problem. The other is to determine how the current produced by Generator C, acting above, divides between elements d_1 and d_2. This problem becomes extremely complex because of the non-symmetry of the elements and there are several methods which can be used to solve the problem. "Guertler" (Impedance Transformation in Folded-dipole, Proceedings of the IRE, September 1950) demonstrates a method for determing this voltage. "Roberts" has also demonstrated methods for determining this voltage. We will use the electrostatic or capacitive method discussed by Roberts, since this method appears to offer the most promise for a simple solution. Briefly, this theory states that the current will divide directly as the ratio of the capacities of the elements, while the voltage ratio will be the inverse of the capacity ratio. To solve our problem then, we must assign undefined capacities, c_1 and c_2 to elements d_1 and d_2. Then:

$$\frac{e}{e_1} = \frac{c_1}{c_2} \qquad (3)$$

The current entering element d_1 is the total current produced by Generator C acting alone multiplied by:

$$c_1/(c_1 + c_2) \qquad (4)$$

Neglecting the very small current produced by Generators A and B acting alone, as already discussed for equal elements, the total current due to Generator C alone is:

$$\frac{e}{R} \qquad (5)$$

Where R = radiation resistance of the two elements connected in parallel.

The driving point impedance of the antenna is:

$$\frac{(e + e_1)}{\text{the current entering } d_1} \qquad (6)$$

Thus, it is readily proven that the driving point impedance is:

$$\frac{R\,(1 + c_2)^2}{c_1} \qquad (7)$$

The foregoing method of determination indicates that the impedance step up ratio depends upon the ratio of the elements' diameters, being inversely proportional to the diameter of the excited fold or element and directly proportional to the diameter of the grounded element. The spacing between the tower and fold is not extremely critical, but does determine, to some extent, the impedance transformation ratio. Although this type of antenna has good band-width, its band-width characteristics will be decreased if a transformation ratio of greater than approximately ten is attempted by means of the spacing ratio. It has been found that the best way to increase the band-width of the antenna is to increase the number of folds.

The electrostatic or capacitive method outlined by Roberts is primarily a physicist's approach to a solution of the folded-unipole antenna. It can be shown that the impedance transformation ratio for a folded unipole antenna where unequal diameters are used is:

$$\text{Transformation ratio} = \frac{(1 + Z_1)^2}{Z_2} \qquad (8)$$

Where:

Z_1 = the characteristic impedance of a transmission line made up of the smaller of the two conductor diameters spaced the center to center distance of the two conductors in the antenna.
Z_2 = the characteristic impedance of a transmission line made up of two conductors the size of the larger of the two.

The above equation assumes that the power will be fed to the smaller conductor (fold). That is, the feed line from the transmitter is connected in series with the fold (fold's diameter always assumed smaller than tower's) so that an impedance step-up of greater than four will be achieved.

The magnitudes for Z_1 and Z_2 of equation (8) for uniform cross-section conductors can be determined from standard transmission line formulas.

During the past five years, numerous experimental measurements have been made on different types of folded-unipole antennas for broadcast use. Our ex-

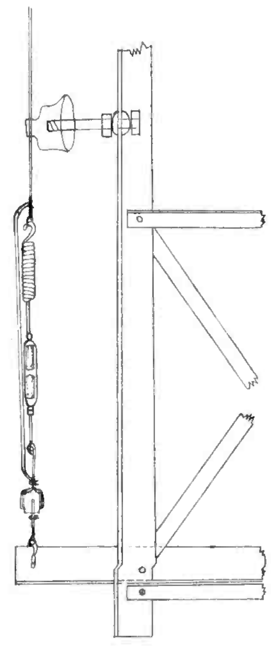

Figure 5. Details of the fold attachment at the tower's base.

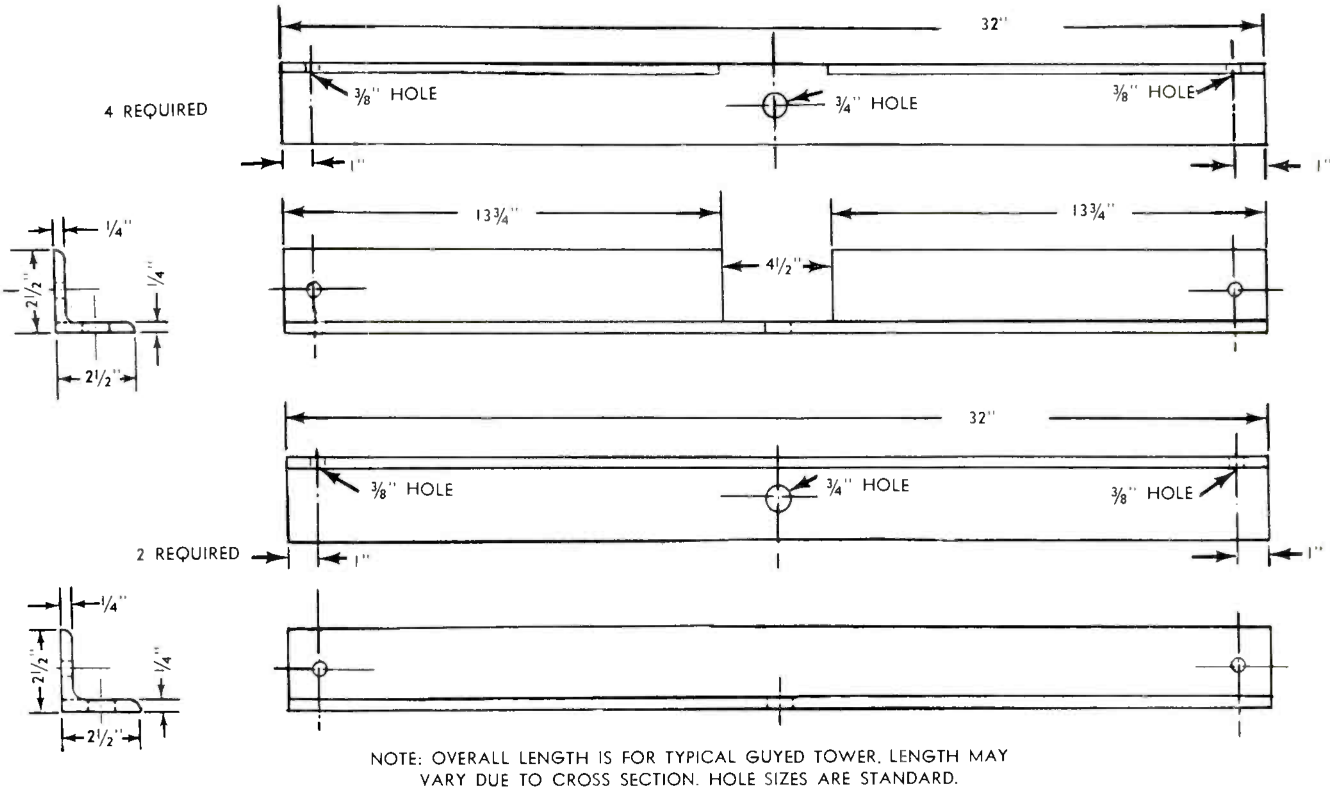

Figure 6. Detailed drawing of the crossarms.

perience indicates that the average height of a non-directional broadcast antenna will vary somewhere between 150 and 300 ft. Inasmuch as the change in frequency from the low end to the high end of the broadcast band is approximtaely three to one and if we assume that the height of the broadcast antenna is not higher than 90° and six driven folds are used on the tower without any shorting stubs, the following empirical expression may be used to obtain the impedance of a folded-unipole antenna:

$$Zfu = 3.6\ (Z_{11}) \qquad (9)$$

Where:

Zfu = base impedance of the folded-unipole in ohms.
Z_{11} = base self-impedance in ohms for the tower height under consideration.
3.6 = empirical constant determined from measurements.

Equation (9) assumes that the folded-unipole antenna is approximately 90° and has not been resonated by use of shorting stubs (that is, wires connected between each of the folds to the tower at predetermined levels, based on impedance measurements at the base of the tower).

In normal practice, it is desirable to resonate the folded-unipole antenna by means of shorting stubs. These stubs are actually short circuits connected between each of the folds to the tower at some point below the top of the tower. The actual location for these shorting stubs must be determined experimentally. To do this, first measure the tower with the shorting stubs at the very top. Then have a tower rigger move the shorting stubs down until j0 is measured at the base. It should be noted that a folded-unipole antenna will initially measure +j. Consequently, if the shorting stubs are moved down the tower too far, the measured reactance sign will change to a minus, indicating that the antenna has gone through resonance. Hence, this means that the shorting stubs should be moved up until j0 is obtained. This condition is theoretically referred to as first resonance. At resonance, Z = R; hence, the following empirical expression may be used for obtaining the resistance of a folded-unipole antenna at first resonance:

$$Zfu = 7.3\ (R_{11}) \qquad (10)$$

Where:

Zfu = base impedance or resistance for folded-unipole at first resonance (ohms).
R_{11} = self-base resistance of tower (ohms).
7.3 = empirical constant determined from measurements.

Practical Aspects of Folded-Unipole Antennas

So far, we have discussed how to determine the impedance for a folded-unipole antenna, assuming it had six folds, but no information has been given with regard to the practical construction of this type of antenna. Equations (9) and (10) were developed from measurements of what we call our standard broadcast folded-unipole antenna.

Figure 4 is a top view of a uniform cross-section, guyed tower rigged for a six wire folded-unipole antenna.

Figure 5 is a drawing indicating the details of the fold attachment at the tower's base.

Figure 6 is a detail drawing of the cross-arms or spider.

Figure 7 is a bill of materials for a typical folded-unipole antenna installation on a uniform cross-section guyed tower.

Figure 8 is a plot of impedance measurements obtained on a 200 ft. tower with six folds at 1570 KC. This tower is 0.319 wave lengths or approximately 115° high and would be expected to have a self-impedance (Z_{11}) of 155 j260; however, when it is converted to a folded-unipole antenna and the folded-unipole shorting stubs have been adjusted to obtain j0 or resonance at the base, the resistance is multiplied up to 1.170 ohms. This is a transformation ratio of 7.55. In order to transform this inpedance to 50 ohms j0 (transmission line impedance), an "L" or "T" type of network may be used. We prefer to use a modified version of an "L" network (See Figure 10) and treat the transmission line resistance as a series resistance of a parallel network at resonance.

The following formulas may be used to determine X_1 and Xc for an "L" network:

$$Zfu = \frac{X_1}{R_1} + R_1 \qquad (11)$$

$$Xc = X_1 + \frac{R_1^2}{X_1} \qquad (12)$$

$$X_1 = \sqrt{(R_1\,Zfu) - (R_1)^2} \qquad (13)$$

The following data furnishes complete information for the construction of a typical standard broadcast folded-unipole antenna.

Where:

Zfu = measured base impedance of folded-unipole at resonance (ohms).
R_1 = transmission line impedance (ohms).
X_1 = reactance of series coil (ohms).
Xc — reactance of shunt condenser (ohms).

Using the foregoing formulas, a modified L network was used to match the impedance shown in Figure 8. Figure 9 is a plot of coupling impedance obtained for this antenna system.

In order to determine the current in the antenna, an ammeter may be placed in either the transmission line output (input to modified L network) or the output of the network (input to the folded-unipole) or at both locations for determining power. The F.C.C. will allow the meter to be placed at either location and to be used for direct measurement of power. Where a folded-unipole antenna is operated at first resonance, it is recommended that the antenna ammeter be placed in the input to the network so that a larger scale ammeter can be used. It should be noted that inasmuch as the antenna is adjusted to j0, line current is a true indication of power.

Figure 11 is a plot of the measured resistance and reactance for a folded-unipole antenna (resonated) which is 70° in height at 800 KC. This antenna would be expected to have a base impedance (when measured without folded-unipole rigging) of 31 +j9. Examination of Figure 11 shows that this antenna (folded-unipole rigged and resonated) has a feed point impedance of 230 ±j0. An impedance match from 50 ohm line to this impedance can be readily obtained by use of an "L" or "T" coupling network.

Current Distribution On A Folded-Unipole Antenna

During the writer's experiments with folded-unipole antennas in 1949 and 1950 for the United States Air Force, it was determined by measurement that the current distribution on a folded-unipole antenna is the same as that of a base insulated antenna of identical height. D. L. Waidelich has proven ("General Folded-dipole Antenna Design," Communications, April 1949) that the current distribution on a folded-dipole antenna is the same as that of a simple dipole antenna. Inasmuch as a folded-unipole is basically ½

FIGURE 7

Bill of Materials for Folded-Unipole Antenna Installation For Uniform Cross-Section Guyed Tower

1. 6 pieces of angle iron (Figure 6).
2. 2 each ¾" x 1¾" bolts and 2 lock washers.
3. 12 each ⅜" x 1½" bolts and 12 lock washers.
4. 12 flat washers 7/16" I.D. maximum O.D.
5. 12 each ⅜" Clevis Shackle.
6. 6 turnbuckles ½" bolts or larger.
7. 3 pieces of copper strap 6" wide (long enough to ground antenna at base).
8. 24 wire clamps suitable to attach shorting straps to antenna (aluminum deadend clamps).
9. 6 folds—No. 4 NCSR, stranded aluminum wire —total length equal to 6 times tower's height plus 25' additional.
10. 6 egg type strain insulators—to insulate folds at base of antenna 3" diameter or better.
11. 36 stand-off insulators (placed at 30' intervals on tower adjacent to folds) (Jocelyn Cross Arm Pin and 15 KV Insulator).
12. 1 variable vacuum capacitor 10/1000 uuF or equivalent 15 KV, 45 amperes (suggest Jennings type).
13. 1 variable inductor 0/60 microhenries—appropriate to handle 1 KW power (suggest Gates, Johnson, or Multronics type coil).
14. 6 springs 4"-6" long.
15. 1 Weston or equivalent R.F. ammeter 0-6 amps (for 1 KW installations).
16. 1 remote antenna ammeter unit.
17. Tuning unit cabinet with bowl feed thru for output connection.
18. Miscellaneous:
    Solder, brazing rod and torches, flux, polyethelene tape, hand tools, and small parts to mount inductor and variable capacitor. Also needed to facilitate the measurements, adequate extension lights and a rough support for the measuring equipment to provide access to the antenna tuner unit.

Note: All hardware to be galvanized or painted with aluminum paint. Dissimilar metal clamps recommended for use between tower and aluminum wire.

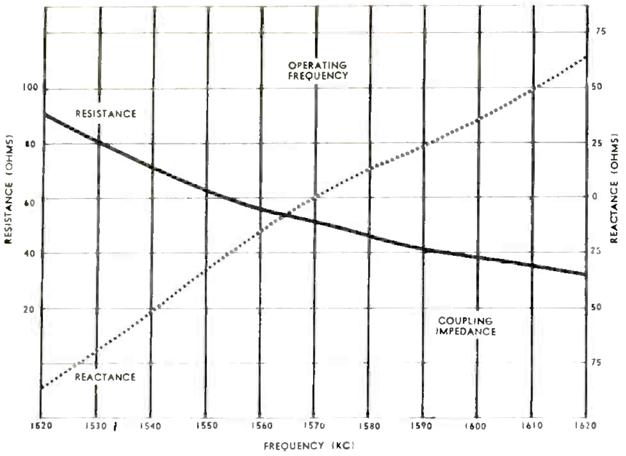

Figure 8. Impedance measurements obtained on a 200 ft tower with six folds at 1570 KC.

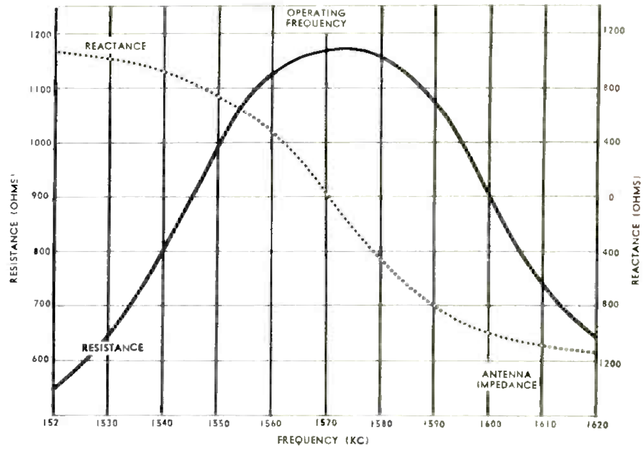

Figure 9. Plot of coupling impedance.

of a folded-dipole antenna, it follows that the current distribution of a folded-unipole would be the same as that of a simple unipole. Further, Schelkunoff ("Antennas Theory and Practice," Wiley) has shown that the current distribution for a folded-dipole is the same as that of a simple dipole of similar length.

Numerous field intensity measurements have been made during the past five years on folded-unipole antennas to determine their current distribution and effective *Erms*. Measurements have been made on series-fed antennas before converting to folded-unipole and then comparison measurements made to demonstrate that the current distribution and effective fields are similar for both antennas. It can therefore be concluded that the current distribution of a folded-unipole type of antenna will be the same as that of a simple base insulated series-fed antenna.

Band-Width Considerations

The band-width of an antenna depends upon its base impedance and the rate with which its reactance changes with frequency. The band-width is considered to be the frequency band within which the power is equal to or greater than one-half the power at resonance. Expressed in equation form:

$$\Delta f = \frac{2Ra}{\frac{dx}{df}} \qquad (14)$$

Where:

Δf = band-width in kilocycles between half-power points.

Ra = measured antenna resistance in ohms.

$\frac{dx}{df}$ = slope of reactance curve at resonant frequency.

The effective band-width will be doubled when the generator is matched to the antenna circuit. The Q of a folded-unipole antenna can be determined from the equation:

$$Q = \frac{f_0}{\Delta f} \qquad (15)$$

Where:

f_0 = operating frequency in kilocycles.

Δf = band-width of antenna in kilocycles.

Our experiments indicate that a folded-unipole antenna has a much more desirable band-width characteristic than an equal height series-fed antenna.

Top-Loaded Folded-Unipole Antennas

For very short towers, advantage may be taken of top-loading to increase the effective height of a folded-unipole antenna.

Our experience indicates that the simplest and most effective means for top-loading a folded-unipole antenna is to connect the top three guy wires to the tower, adjust them to a given physical length and then inter-connecting them at the lower end to simulate a pyramid. Experimental data indicates that the following expression can be used to compute the length of guy wires necessary to obtain a given amount of top-loading:

$$G^\circ_{eff} = \frac{TL^\circ}{0.705} + G^\circ_{11} \qquad (16)$$

Where:

G_{eff} = desired electrical tower height in degrees.

TL° = desired top-loading in degrees.

G_{11} = electrical height of tower without top-loading in degrees.

0.705 = empirical constant.

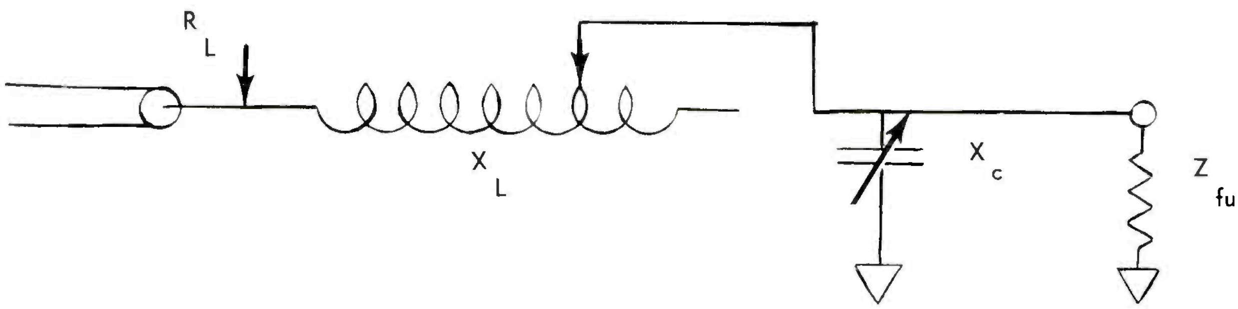

Figure 10. Schematic of "L" type impedance transforming network.

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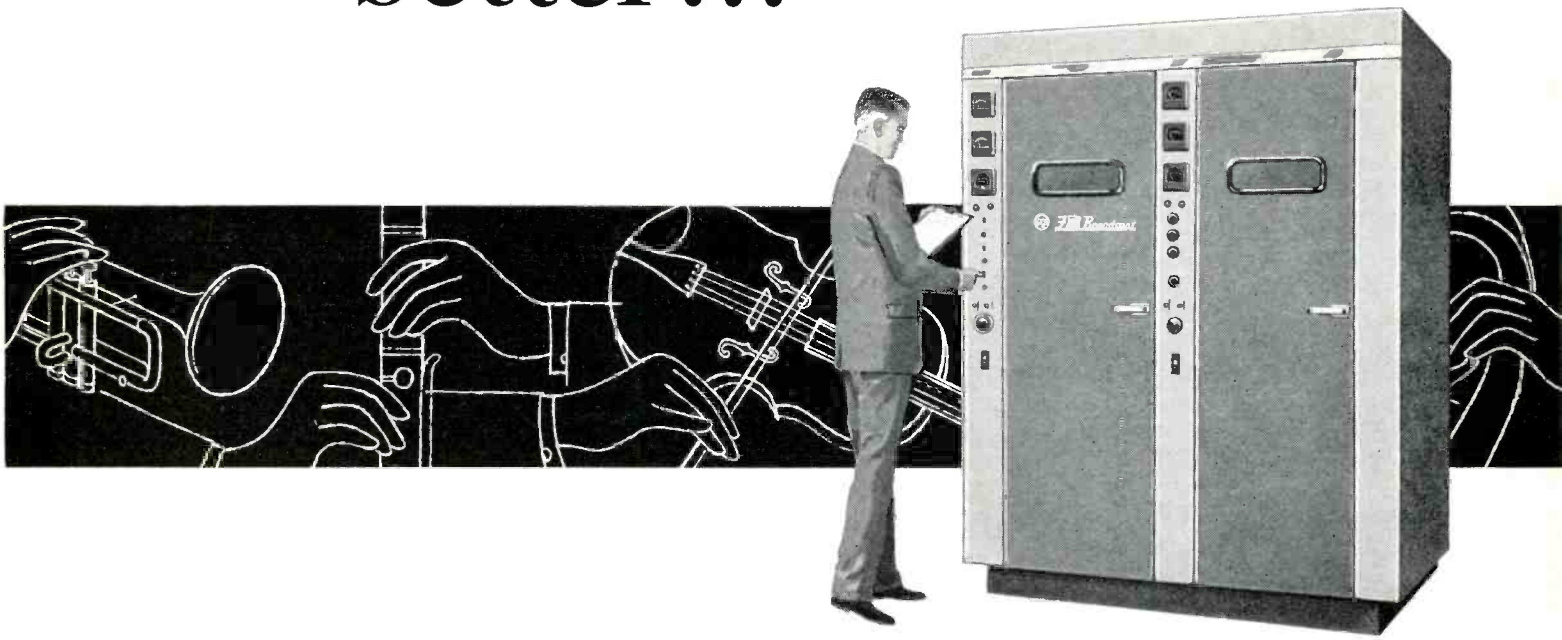

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Many more of these significant advantages add up to the kind of quality that proves itself in year after year of dependable operation. In addition, you'll find that RCA Transmitters usually have *higher* resale value . . .

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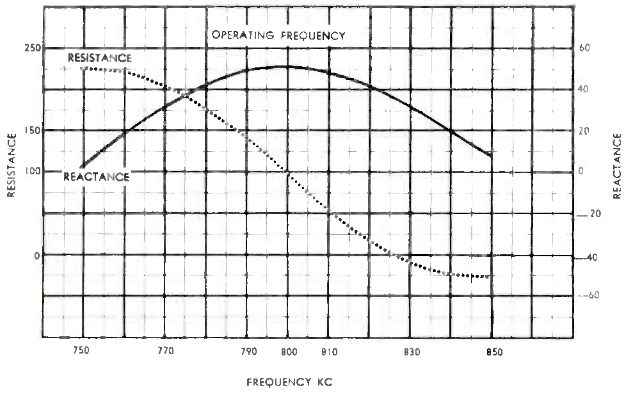


Figure 11. Plot of the measured resistance and reactance for a folded-unipole antenna 70 degrees in height at 800 KC.

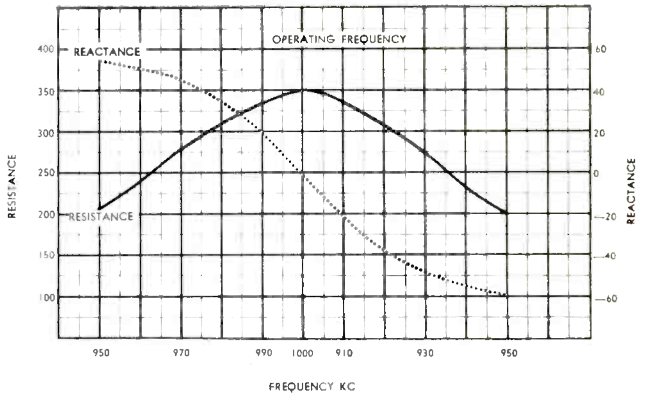


Figure 12. Plot of resistance and reactance for a folded-unipole antenna which is 69.5 degrees in height at 1000 KC and has been top-loaded an additional 15.5 degrees to simulate electrical height of 85 degrees.

Figure 12 is a plot of the measured resistance and reactance for a folded-unipole antenna (resonated) which is 69.5° in height at 1000 KC and has been top-loaded an additional 15.5° to given an electrical height of 85°. This antenna would be expected to have a base impedance of 39 +j40 (when measured without folded-unipole rigging but with top-loading). Figure 12 shows that this antenna (folded-unipole) rigged and resonated) has a feed point impedance of 350 ±j0. An appropriate impedance transformer should be used to match this antenna impedance to a transmission line.

Second Resonance for Folded-Unipole Antennas

A folded-unipole antenna can obtain a wide range of resonant radiation resistance by varying the ratio of the diameters of the folded conductors to the diameter of the tower. The radiation resistance varies as the square of the height and if the transformation ratio is raised enough, the height of the antenna can be reduced, the limit being the point where ground losses consume a prohibitive percentage of the power.

For practical operation a short antenna should have a resistance of at least 50 ohms. Unfortunately short series-fed antennas in the range of 45° to 60° do not approach this value; consequently, this type of antenna has excessive losses. In these ranges, the use of a top-loaded folded-unipole antenna is extremely desirable, inasmuch as these antennas can be operated at first or second resonance. For second resonance, a top-loaded folded-unipole has a length of approximately one-half that of a folded-unipole at first resonance. This is the same as saying that if a folded-unipole antenna had a length of approximately 90° (electrical), we would expect second resonance to occur at approximately one-half this length or 45°. The base impedance for a top-loaded folded-unipole antenna at second resonance can be expressed as:

$$^{R}2r = 1580 \left[\frac{^{h}2r}{2r} \times \frac{\log 4S^2/d_1 d_2}{\log 2S/d_2} \right]^2 \quad (17)$$

Where:

$^{R}2r$ = resistance of folded-unipole at second resonance (ohms).
$^{h}2r$ = height at second resonance.
$2r$ = wave length at second resonance (same units as $^{h}2r$).
S = spacing, center to center, of tower to fold.
d_1 = fold diameter.
d_2 = tower diameter.
S, d_1 and d_2 should be expressed in the same units.

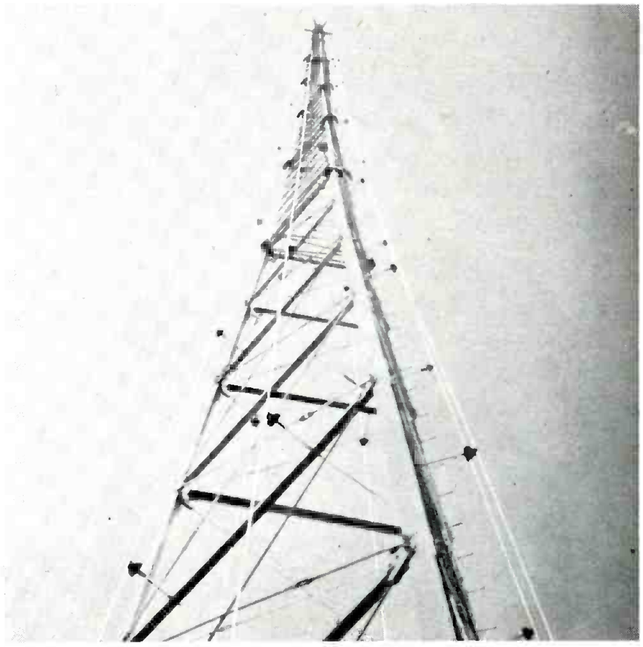
It should be noted that "$\log_{10}$" or log*e*" can be used, inasmuch as a ratio is expressed in equation (17).

It should be noted that the operation of a folded-unipole at second resonance is similar to that at first resonance; however, the ratio of the diameter of the folds to the tower's diameter and the spacing is much more critical.

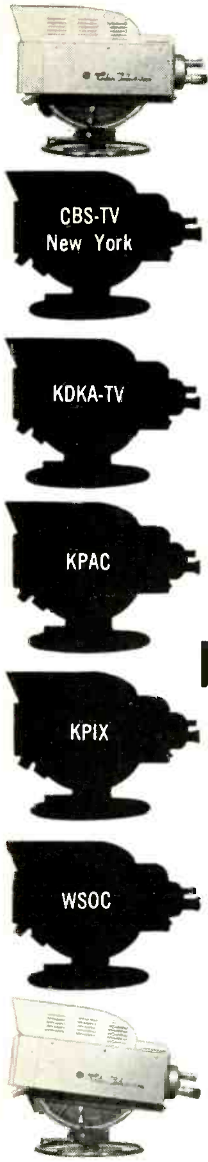
Unattenuated Field Intensity

It has been observed experimentally that a folded-unipole antenna will develop a higher unattenuated field intensity than the same equivalent height series-fed antenna system. The increase in field intensity varies between approximately two to ten per cent. The greatest increase in field intensity is experienced on short antennas in the range 45° to 75°.

This paper was presented at the 14th Annual NAB Engineering Conference.



Rooftop installation of folded-unipole antenna system at WAKE, Atlanta, Ga.



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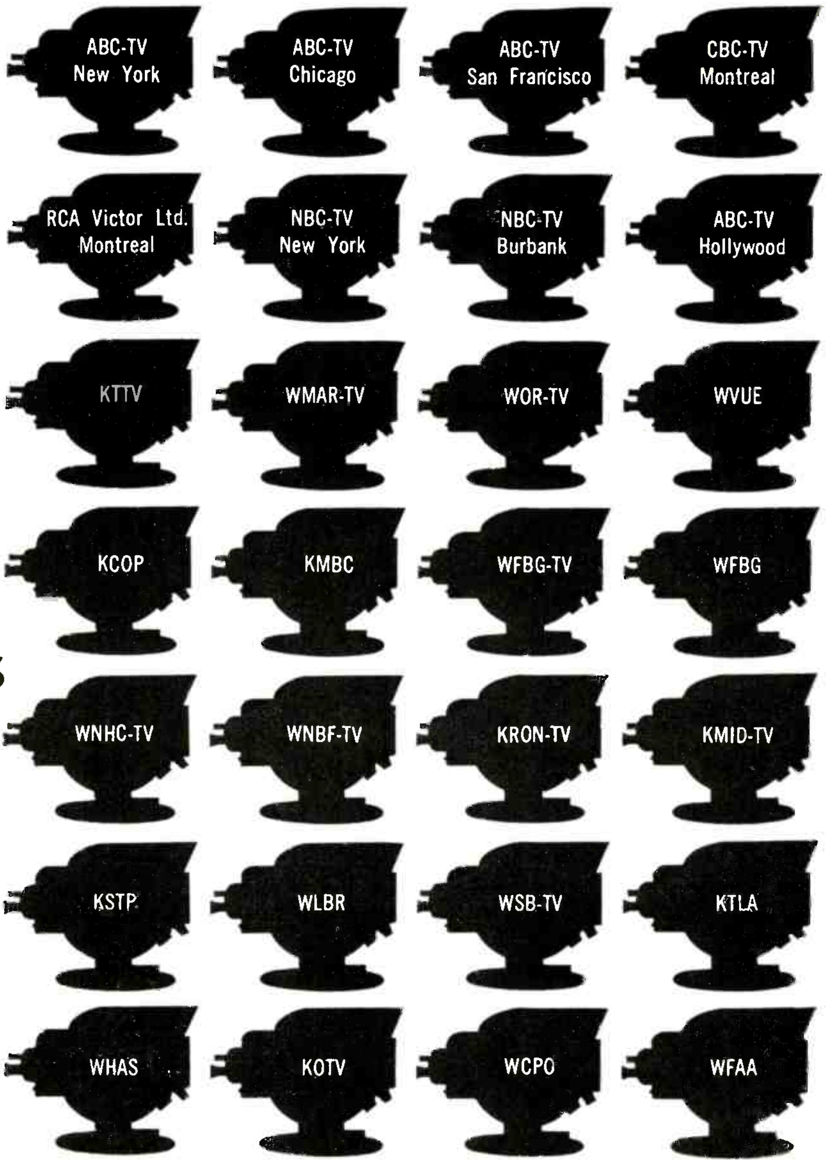

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Multiplex Receiver Installation

To obtain optimum reception of multiplex signals careful attention must be given to the installation details of the receiver.

By DWIGHT HARKINS*

THE PURPOSE of this article is convey to those involved in multiplexing the results of actual field experiences involving hundreds of receiver installations in cities all over the United States.

Most of the unsatisfactory multiplex complaints have been traced to incorrect receiver installation procedures. This has resulted largely from the common practice prevailing whereby the duties of installing multiplex receivers are outside of the realm of the station engineer responsible for transmitting the signal. In a large number of cases, the users of the signal are leasers of the subcarrier and not too inclined to have competent engineers in their employ.

When the subcarrier is used to provide a background music service, the receiver locations are not always ideal since they are determined by finding subscriber customers rather than by engineering survey. The fact that the location to be served is located behind a hill, screened by tall buildings, in the basement of a sky scraper, or a hundred miles from the transmitter doesn't seem to alter the requirement that a usable signal is expected.

If the proposed location were surveyed before contracting to provide services, a great deal of expense could probably be saved. Since this is never done, however, we will discuss the ways and means of pulling the acorn out of the fire and obtaining satisfactory service in these "impossible" locations.

The FM signals are in the VHF band along with TV and other services. Unlike the lower frequencies, such as the standard broadcast band, the use of built-in loop antennas does not work out properly. Some sort of an antenna must be used to create a voltage induced by the transmitted energy. It is a well known fact that the waves in the air are easily absorbed, reflected, diffracted, and reradiated by objects that get in their path. Buildings, trees, hills, power lines and moving vehicles all contribute to the degradation of the signal. Along with a degraded signal there are usually present lots of man-made electrical impulses that show up as static and noise caused by adding machines, elevators, light switches, fluorescent lights, neon transformers, automobile ignitions, electric razors, and others.

It all boils down to the fact that the proper engineering of the receiving antenna installation becomes the most important requisite. Some simple rules can be laid out that will be used for judging the requirements at each location.

First we will look at the locations close in to the transmitter where the signal is plenty strong but the population very dense and the area usually consisting of tall buildings and the like. Here the antenna needs to be located on top of a building that will probably be surrounded by other buildings still higher. If permission from the building superintendent (usually the janitor) is requested you might as well forget about it as they are usually against the idea. The best approach found out by practical experience is to proceed right up to the top of the roof and get to work. About five trips by one man will usually supply all the equipment necessary to make the installation. (If the door leading to

*Harkins Radio Co., Inc., 4444 East Washington, Phoenix, Ariz.

the roof has a self locking latch, make sure that the door is blocked from locking itself as it has proven very embarassing to be locked out on a roof top.)

Until a small lightweight portable multiplex receiver is available to use as a signal strength meter it will be necessary to temporarily set up a regular receiver on the roof. This will save many hours of work in the long run.

A five-element yagi antenna is now assembled and mounted on the pipe that is going to be used. Temporarily we will hook some twin lead about 30 or 40 ft. long from the antenna to the receiver which we now have plugged into an extension cord. Before deciding which chimney, sewer vent, or ventilator to permanently mount the antenna near, we will walk the antenna around the roof space at the same time listening to the signal and noting variations in limiting voltage. By orienting the antenna array, several positions will be observed where the signal is without mush or distortion. Aim it in the direction where the limiting voltage is the highest with the least fluctuation. Do not use an orientation that produces flutter of limiting voltage as this indicates too much multipath reception.

Carefully note the antenna position that gives the best results so that the permanent installation can be made identical. Now the twin lead can be removed and the transformer installed to match the antenna to co-axial cable. With certain types of antennas the matching transformer is not needed. At any rate the co-ax is connected and the antenna can be erected, the guy wires attached and the run of the co-ax lead down to the basement can now be started. RG59U lends itself nicely to winding down the sides of buildings, through elevator shafts, in electric wiring gutters or in conduit.

The use of the popular "twin lead" TV transmission line is the worst mistake made in multiplex installations. Although most efficient for residential TV installations, the twin lead cannot be mounted near metallic objects such as conduit, drain pipes, water pipes, etc. To do so effectively short-circuits the VHF signal we are attempting to pass along to the receiver. The twin lead also has another characteristic of easily becoming unbalanced by being in the proximity of metallic objects thus setting up standing waves as well as causing the pick-up of unwanted noise impulses.

In a large number of cities I have run into the common practice of feeding TV twin-lead through conduit on the way to the receiver. At the receiver it was found that connecting the antenna terminals to the conduit gave as much signal as connecting to the twin-lead that came through the conduit. The use of RG59U prevents all of these mishaps and is only a bit more costly. Purchased in 1000 ft. rolls it can be obtained for $32.50 per thousand feet which is cheap in the long run for a good and permanent installation that precludes expensive service calls.

We now come to the actual receiver location. This should be chosen through consultation with the management of the location with special precautions against heat and moisture. Avoid shelves that are convenient for stacking of other objects as the set will soon become completely covered up. My worst experiences in this respect are places where the receiver can be exposed to spilled drinks and the like which often impairs operation very effectively.

(Continued on page 22)

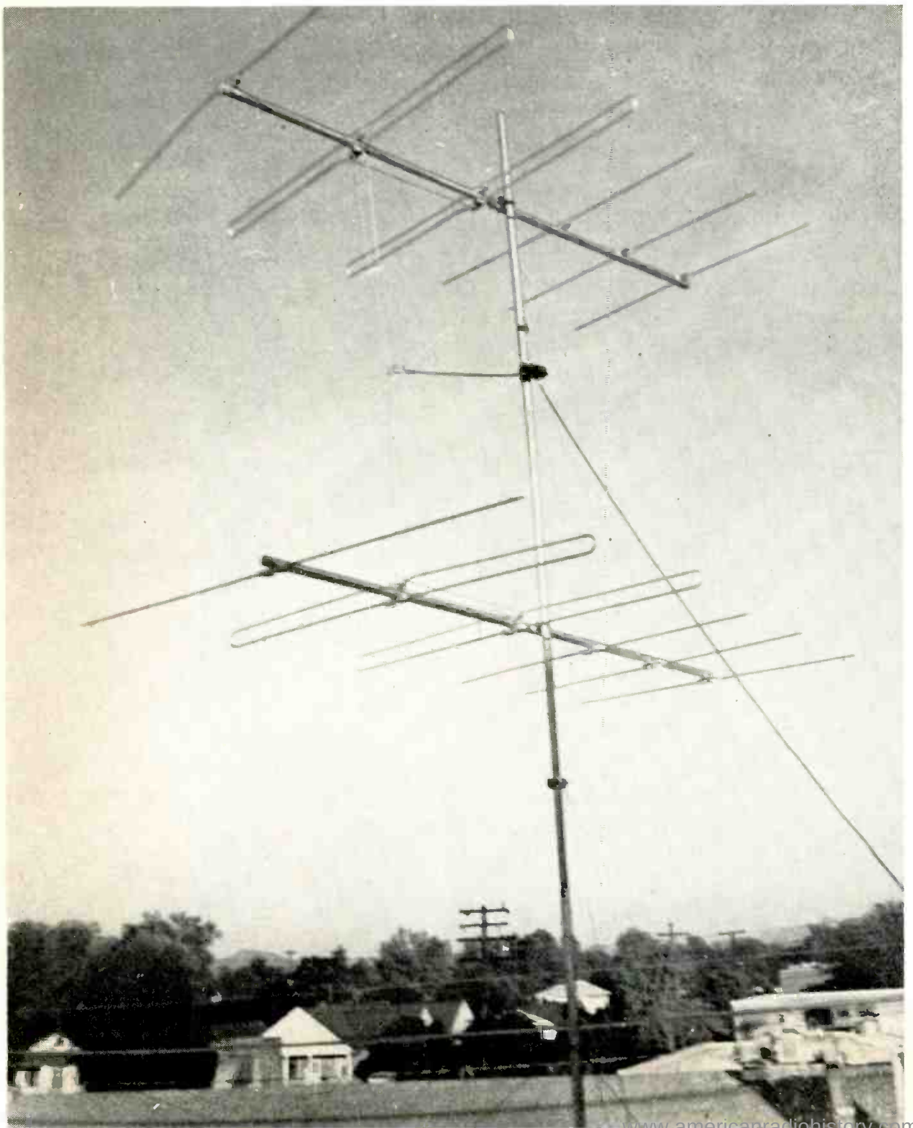


Figure 1. Double stacked Yagi antenna as installed for weak signal pickup. Use of matching transformer to feed RG-59U cable insures proper impedance matching.

Push-Button Audio Switching

By ROBERT F. TILTON*

A simple means of switching input and output circuits of recorders and other studio equipment without the use of patch cords is described.

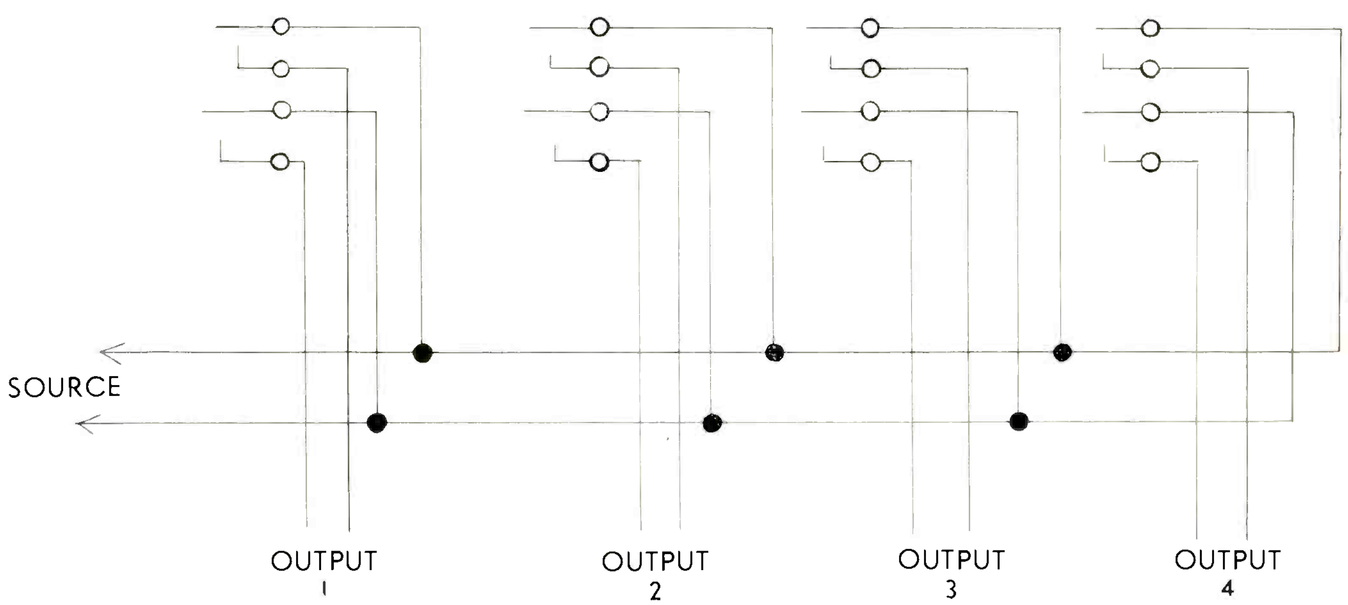
At first thought, the idea of push-button audio switching may not hold much attraction for the average station engineer. However, a system whereby the effective patching of the input and output circuits of tape recorders, disc recorder and the like, without the actual handling of patch cords should appeal to the studio engineer, especially in those stations where so-called combination operation is practiced. It is the purpose of this article to describe such a system and the basic circuitry involved in its construction and operation.

Referring to Figure 1, it will be seen that if a series of relays having their movable contacts paralleled are connected across a source of audio signal, a form of dividing network exists which will divide the signal into as many paths as we have relays. If this audio source is terminated in its characteristic impedance, good engineering practice dictates that we must provide a means of high-impedance bridging at each set of relay contacts connecting to the source of audio signal. Otherwise, placing an additional low-impedance load across an already terminated line will not only result in an intolerable loss of power in the line, the frequency response of the entire circuit will be adversely affected.

Figure 2 shows two accepted methods of providing a bridge across a terminated audio line. The transformer in Circuit A should have a primary impedance of not less than 7,500 ohms. The use of a plate-to-line unit is advocated here, a primary impedance of 15,000 ohms being an optimum value. Circuit B employs a potentiometer which is connected in such a manner as to place the total resistance of the unit across the terminated line. One end of the resistance gives us one leg of the bridging circuit and the movable arm (which is rotated slightly so as to tap off a small portion of the voltage impressed across the potentiometer) the other. The variable resistor should have a value of from 25,000 to 50,000 ohms. Care should be taken to see that the arm is not rotated too far around on the potentiometer. Otherwise, the bridging effect is lost and the signal bus will become unduly loaded and mismatched.

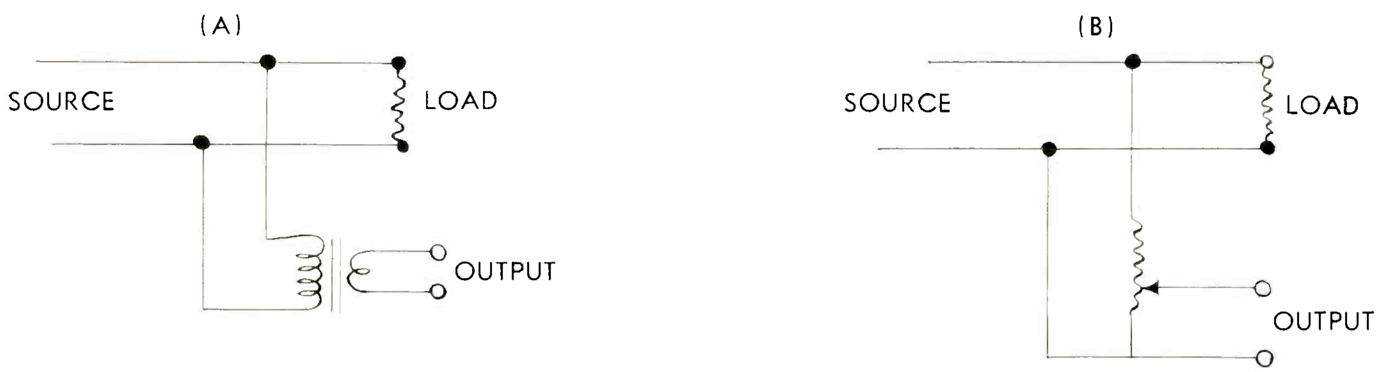
Figure 3 shows the operational circuit of an audio switching panel. This is a portion of the push-button audio switching panel presently in use at Radio Station WDGY in Minneapolis, Minnesota. At this station, two consoles are used in the master control room. One, a modified General Electric, is used primarily for the feeding of program to the transmitter line. The other console is an RCA type 76-B, located some distance from the program console and used mainly for recording operations. Either console can be placed on or off the air simply by depressing a momentary-

Figure 1 — Relay-Operated Dividing Network



*Technical Director, Storz Broadcasting Co., Omaha, Neb.

Figure 2 — Two Audio Bridging Circuits



contact push-button switch on the audio switching panel. Consequently, in the event of failure of the General Electric console, the recording console can be pressed into broadcast service almost instantaneously and with a minimum of "dead air" time.

As shown in the operational circuit, audio from the G-E console is imposed on the upper of the two program lines, while audio from the RCA console appears on the lower bus. Switching of the outputs of either console to the transmitter line is accomplished by relays K-1 and K-10. In the off-air position, the consoles are terminated in their characteristic impedances of 500/600 ohms, the load being provided by the 560 ohm resistors shown on these relays.

The feeding of one or both tape recorders in the control room is accomplished by the energization of relays K-5 and K-6 for the G-E console and by relays K-14 and K-15 for the RCA console. The input of the disc recording amplifier, second house monitor amplifier and the feed to a jack in the jack field marked "auxiliary," are readily bridged across the G-E line by energizing relays K-7, K-8 and K-9 respectively. Similarly, feeds to these points from the RCA console are provided by relays K-16, K-17 and K-18.

Since the tape machines are occasionally used as a source of program at WDGY, it should be mentioned that relays K-5, K-6, K-14 and K-15 have additional contacts that switch the outputs of the tape recorders into appropriate remote channels on both consoles for playback purposes. This is also a necessity for spot production work since echoes are utilized for certain commercial recordings and the tape recorders, operating at either 7.5 or 15 inches-per-second, provide a good echo effect.

Figure 3 — Operational Audio Switching System

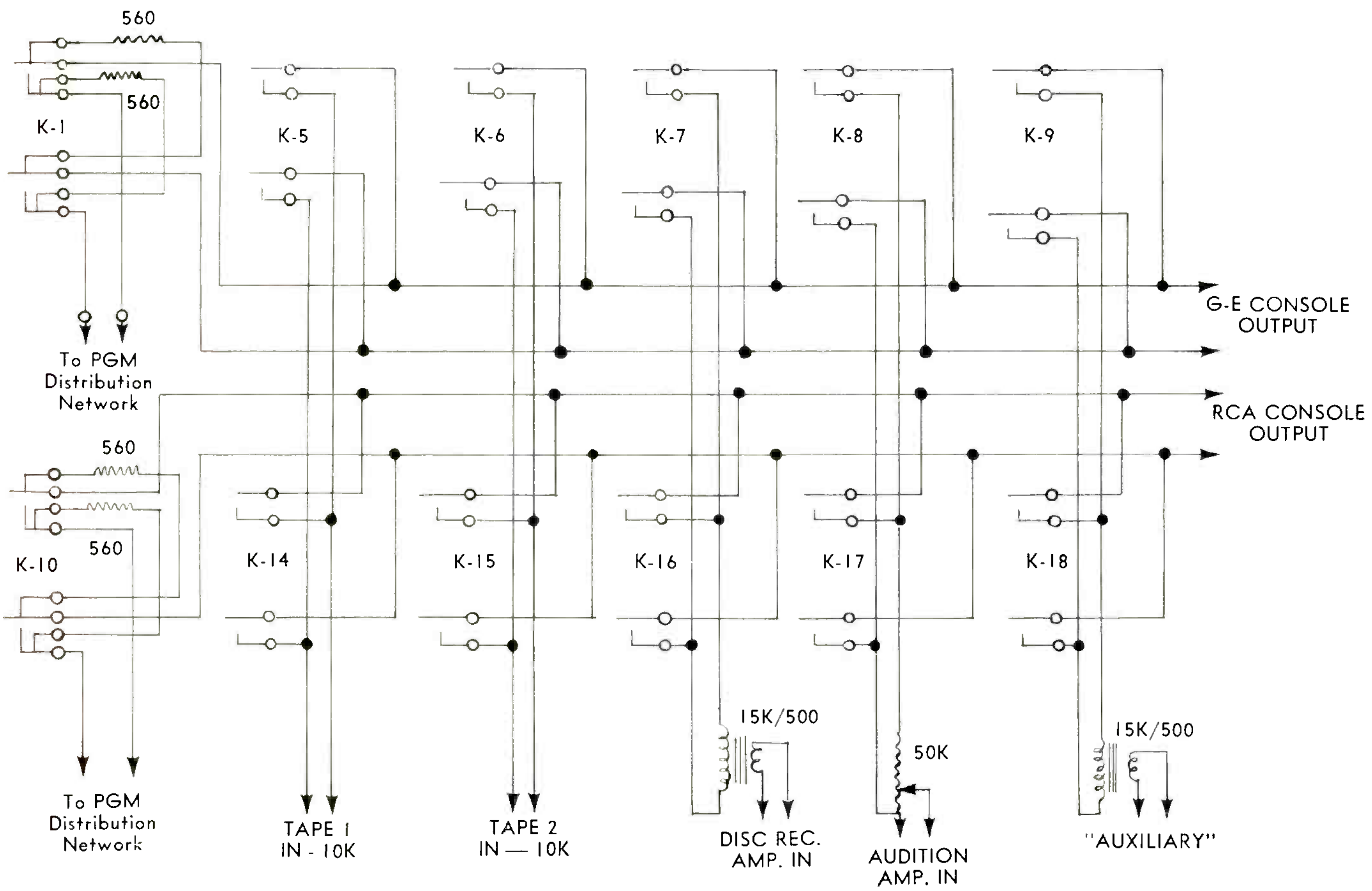
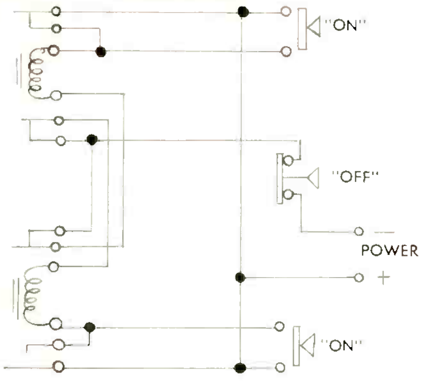


Figure 4 — Relay Control and Interlocking



Some alert observer is bound to raise his hand at this time and point out that the fact that the cross-feeding of signals from the outputs of the two consoles is possible within this unit. This would be so if, for example, relays K-5 and K-14 were to be energized simultaneously. This factor was taken into consideration in the original design of the audio switcher and relays K-5 through K-9 are electrically interlocked with their counterparts, K-14 through K-18, to prevent this from happening. Figure 4 shows the simple method utilized to disable a relay when its corresponding mate is in the energized position. As can be seen, it is physically impossible for both relays to be operated at the same time.

Figure 4 also shows the wiring of the on and off control switches which are mounted on the front panel of the audio switcher. Due to the interlocking system employed in the relay control circuitry, it is necessary to reset or release a relay in the upper channel, for example, before its mate in the lower channel can be energized.

Indicator lights mounted on the front drop of the audio switcher panel inform the control room operators of channels in use and those available for use. 28-volt lamps are used in a 12-volt system. It has been found that the 28-volt lamps provide more than enough brilliance to show through the various-colored pilot light jewels, while operation of the lamps at half their rated voltage more than doubles bulb life.

Direct current relays were used in the audio switcher. While ac relays could undoubtedly be used, it was felt that using them might cause trouble due to sixty-cycle hum being introduced into the audio wiring within the unit. The use of dc relays should not impose any hardship since most stations have an existing twelve-volt supply mounted in the equipment rack. If no such power supply is available, one can be constructed at a relatively small cost since the total current drain imposed on the power supply does not exceed a maximum of about three amperes.

Not shown in the diagram are six additional relays denoted K-2, K-3, K-4, K-11, K-12 and K-13. These relays switch the outputs of the sub-consoles in the studios to remote channels in the control room consoles. Since the type of operation followed at Radio Station WDGY probably would not apply to most stations contemplating the construction of an audio switcher, it was felt that this portion of the circuit should be deleted to avoid confusing the reader.

Additional flexibility of the audio switching panel can be effected by making liberal use of jacks for connections to the unit. Figure 5 exemplifies the general method followed at WDGY in making connections between control room equipment and the switcher panel. Wiring the normal springs of the associated jacks together, as shown in the diagram, allows picking up the inputs and outputs of this equipment as well as making entry into the switcher circuitry. An alternative method of wiring would be to bring the leads from the tape recorders, etc., to their respective jacks in the normal manner and normalling these jacks to the terminals on the audio switcher by connecting to the jack normal springs. If the jacks are available, the former method of connection is to be preferred.

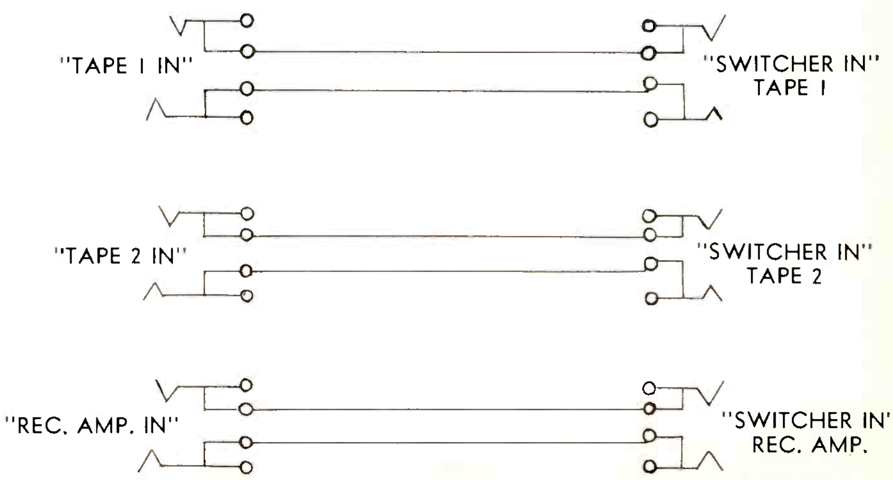
The audio switcher at WDGY is built in a 10½ x 19-inch Gates equipment enclosure with a drop-down, hinged front panel. The system has been in operation at this station for the past two and one-half years. Other versions of this unit are presently installed at Storz Stations in Kansas City, New Orleans and Miami, Florida. Each of the units is designed specifically for the station in which it has been installed. No two switchers are alike since switching requirements vary from station to station.

The system of audio switching herein described does not entirely preclude the use of patch cords in the broadcast studios, nor was it designed to do so. The basic idea behind the system is to provide an easier means of making the day-to-day audio patches encountered in the normal operation of the radio station. It saves the time spent in locating a particular jack, inserting a plug and then looking again for some place to put the other end of the patch cord. The unit provides a simple and foolproof means of patching without patch cords.

The stereo producing equipment for all systems was located at the transmitter. Measurements were made on the off-air transmissions from the station at three different input levels to the receiving equipment.

General conclusions derived from the tests are that good stereo and compatible monophonic output was produced by all systems. Receivers for the system vary in complexity and cost.

Figure 5 — Typical Wiring to Jack Panel



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LINDSEY RIDDLE, chief engineer of WDSU TV inspecting station's radar installation

NASH ROBERTS is checking closed circuit monitor while preparing weather charts

"... makeshift installation will soon need repairs ..."

MULTIPLEX starts on page 14

This illustration of a typical metropolitan installation is not exaggerated in the least but describes typical conditions that must be reckoned with. There have been locations where it was more economical to locate the receiver near the antenna and then feed the audio to the customer on the lower floors. There have also been cases where the antenna is located on a neighboring building in order to capture a better signal. These are all conditions that must be individually solved through the use of judgment gained from knowledge of the existing problems.

Let's turn our attention now to the weaker signal zones. Usually the weak signal areas are not in the locations where high buildings exist. Along with the weak signal, the man-made electrical impulses must now be dealt with. A typical location would be a bank in a nearby suburb. In the bank will be all kinds of electrical fixtures and devices that manufacture interference. In this case the location of the antenna as high as possible and the use of proper co-ax lead-in is imperative. Orientation is not as critical in the absence of multi-path but nevertheless must be reasonably correct and the same procedures can be followed if warranted.

One point must be borne in mind —a good installation need only be made once and will last for years but a makeshift installation soon requires service and repairs. At this time I strongly advise the reading of several TV antenna handbooks for information that applies equally well to the field of FM multiplexing. These handbooks are available at every wholesale parts distributor and should be a guide book for better antenna installations that result in satisfactory multiplex service.

Probably the greatest obstacle to overcome in the case of fringe area weak signal conditions is the impulse noise reception caused by automobile ignition as well as electrical devices located near the receiver.

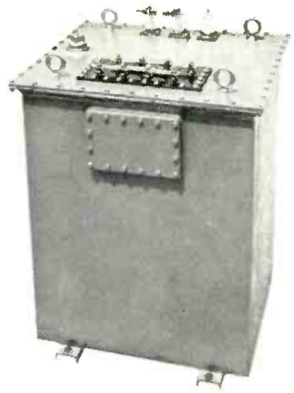
There now comes to light a problem that exists in the receiver function. Those experienced in the matter will verify that the multiplex signal has always been more susceptible to impulse noise than the regular main channel reception. The explanation lies in the fact that the receiver itself causes the noise pulse to phase modulate the received subcarrier. This noise modulation can not be removed by limiting action. It can, however, be remedied in many cases by using the antenna installation procedures outlined in this article.

The currently available receivers are much less noise susceptible than earlier models and continued improvement can be expected as time goes by. Even though the receiver ideal could be realized, the necessity of good antenna installation along with good judgment in wiring and mounting of units will always exist.

There are quite a few types of FM antennas now available which meet all the requirements. We have found the type similar to the TACO five element Yagi together with a 300/72 ohm matching transformer to be the most advantageous for most installations. In weak signal cases we stack two of these using the phasing bars provided by the manufacturer. This builds up the signal to override the noise. Other antennas are available with built-in baluns that permit direct connection of 72 ohm RG59U.

In the ideal strong signal situation where a short piece of wire produces a good signal we still advise the use of an antenna even though it is nothing more than a folded dipole made of twin-lead. This is to prevent the effects of reflection and multipath often encountered under these conditions. The criterion will be the obtaining of stable limiting voltage over a period of time. The use of power line pickup is also possible in many strong signal areas. This is usually accomplished by coupling the antenna lead to one side of the power line with a small condensor. Within a few miles of the transmitter this often gives excellent reception but must be used with reservations since many conditions can cause variations of signal strength over a period of 24 hours.

In conclusion I wish to impress upon the multiplex user that the investment in good antennas, co-ax lead-in, along with proper training of the installer will be the cheapest investment in the long run.



THE WORLD'S FIRST THREE ANTENNA CANDELABRA

Three Baltimore stations have combined their antenna facilities to cut costs of antenna systems and provide better service.

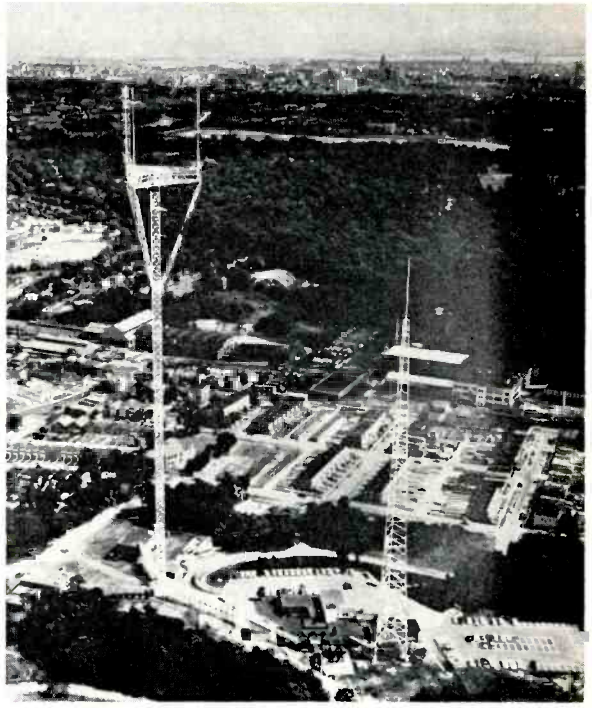


Figure 1. The Candelabra System overlooks the entire city of Baltimore. Here the new structure is shown in comparison to WJZ's old tower. The suburbs of Washington, D. C. can be seen from the platform on a clear day.

By W. J. GROVES*

Interesting Facts About the 3-Antenna Candelabra System

Total Height (exact)	729 ft. 2½ in.
Tower Height (exact)	622 ft.
Platform Height	16 ft.
Platform Face	105 ft.
Tower Face	12 ft.
Center-to-Center Spacing of Antennas	101 ft.
Truss Length	140 ft.
Guy Levels	158 ft., 308 ft., 458 ft., and 602 ft. (Bottom of platform)
Antenna Weights	WBAL, 18,600 lbs. Type TWA-12A, Ch. 11 WJZ, 18,600 lbs. Type TWA-12A, Ch. 13 WMAR, 25,000 lbs. Type TF-6AL (Special)
Wind Loading	Tower 70 lbs./sq. ft. Antennas 70 lbs./sq. ft.
Wind Velocity Limit	165 mph
Weight of Steel Used	500 tons
Amount of Concrete Used	2250 tons
Length of Guy Wires Used	2.3 miles
Amount of Paint Used	3000 lbs.

*Radio Corporation of America, Camden, N. J.

On Aug. 9, 1959, the first three-antenna candelabra tower began operation in Baltimore. WBAL, WJZ, and WMAR are operating at maximum power from this unusual tower to provide TV viewers in Baltimore with improved pictures. Five years of careful planning have produced this amazing structure which could be the pattern for future candelabra arrangements.

Initial Planning

Shortly after completion of the first candelabra for KRLD and WFAA in Dallas, the stations in Baltimore began to consider this type of arrangement. A separate corporation, called Television Tower, Inc. (TTI), was formed to investigate the possibilities of the candelabra arrangement. Each station became an equal stockholder in TTI, and each has equal control of its operation.

Shortly after hurricane "Hazel" scathed the east coast in 1955, the stations in Baltimore decided that stronger towers must be built. Each station needed a tower that would stand up under hurricane winds, thus any new tower built in Baltimore, it was decided, must meet this requirement. When the candelabra antenna system was finally selected, it was designed to withstand winds greater than any that had been previously recorded in the area.

A second problem was height of a new tower. The FCC had set 1,000 ft. as maximum for the area; however, the Civil Aeronautics Commission would only permit a height of 730 ft. Here TTI compromised and erected a structure 730 ft. in height with built in provisions for raising the structure to a full 1,000 ft. if approval for the additional height were obtained later.

Where to erect it was the next question. WJZ's facilities offered the best point in Baltimore. The site selected for the structure is at an elevation of 300 ft. above sea level. This gives the tower a height of 1,030 ft. above average terrain, yet it still meets CAA requirements. The WJZ site also offered ample room for guy anchor points within the property limits, and enough space for WBAL and WMAR to erect new transmitter buildings.

Scale Model Tested

Before building this radically different type of tower, the stations decided to have RCA (the prime contractor) investigate the feasibility of the three-antenna candelabra. Figure 3 shows an exact scale model constructed for this purpose. From this model several important facts were determined: (1) the exact center-to-center spacing of the antennas, (2) the width of the triangular platform, (3) the effects of each antenna upon the other, and (4) the type of coverage to be obtained. At this time each station was considering the superturnstile type of antenna; however, WBAL and WJZ later decided to use the Traveling Wave Antenna while WMAR selected a custom built superturnstile antenna. The accuracy of scale model testing has been proven by the actual results of the candelabra installation, since all data obtained from the model corresponded with the final structure. Scale model testing eliminated the chance for errors that could have proved very costly on the completed structure.

The Tower Proper

Built by Dresser-Ideco, the tower has three legs which are 12-ft. apart at the base and, for the first 480-ft. of the structure are solid steel, 7 inches in diameter (see Fig. 4). A special high nickel-chrome alloy steel having very strong corrosion resistant characteristics was used in the structure. If ordinary steel had been used, the legs would have to have been almost 12-inches in diameter. Above the 480-ft level the leg diameter reduces to 5¾ inches. Diagonals are made of 1¾ inch solid steel alloy.

Wind loading of the tower is 70 pounds per-square foot, equivalent to peaks of 165 mph winds. Towers used in Baltimore before the Candelabra were only 80 mph structures, thus hurricane dangers have been greatly minimized.

Dual Guys

Twelve sets of dual galvanized guy wires support the structure at four levels (see Fig. 5). Size of the guy wires range from 1 5/16 to 1⅞-inch stranded bridge-type steel cable. Breaking strengths, from 212,000 to

Figure 2. Extensive testing proved the feasibility of this Candelabra system. A scale model, shown here, was constructed by RCA to determine the exact spacing of the antennas and their effects upon each other. The accuracy of this small model has been proved in the performance of the completed structure.

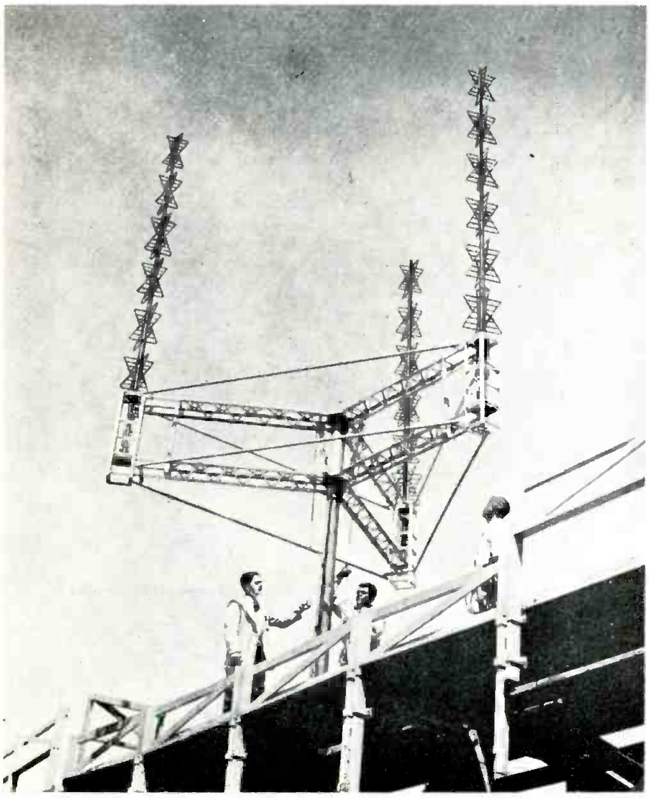
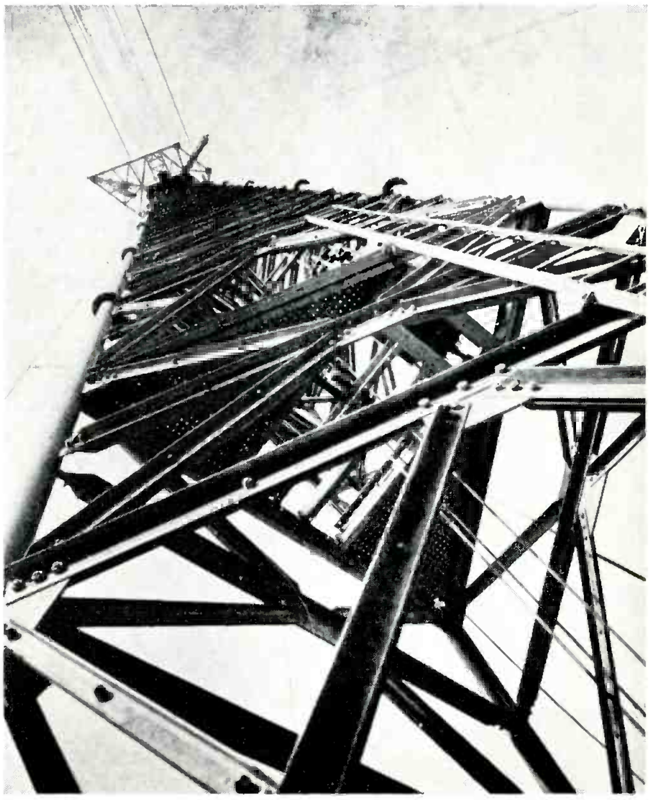


Figure 3. The solid steel legs of the tower are shown here. Extra strength is obtained from the elaborate cross bracing in the tower. Note that when this photograph was taken the platform erection was in progress.



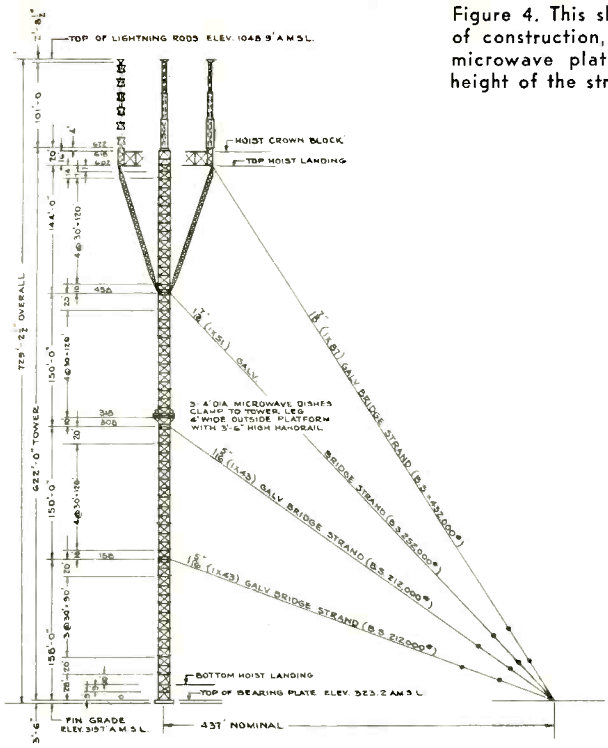
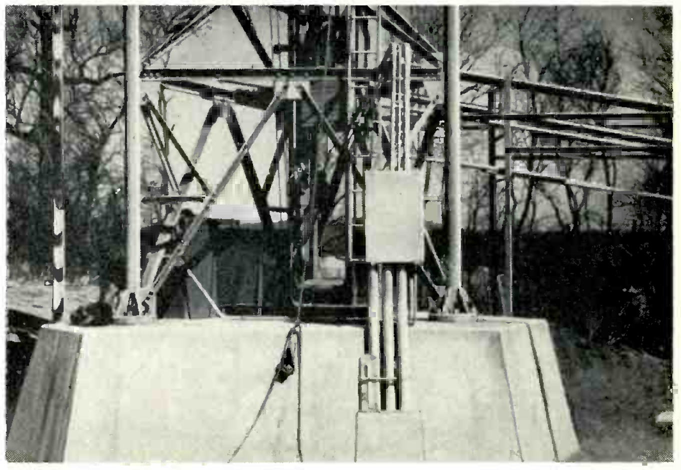


Figure 4. This shows the four guy levels, their size and material of construction, as well as overall tower dimensions. Note the microwave platform at the 318-foot level. The exact overall height of the structure is 729½-feet.

Figure 6. This is the tower base which measures 15 feet on each face. The reinforced concrete used in this base was poured to a depth of 20 feet to compensate for conditions caused by a nearby quarry.



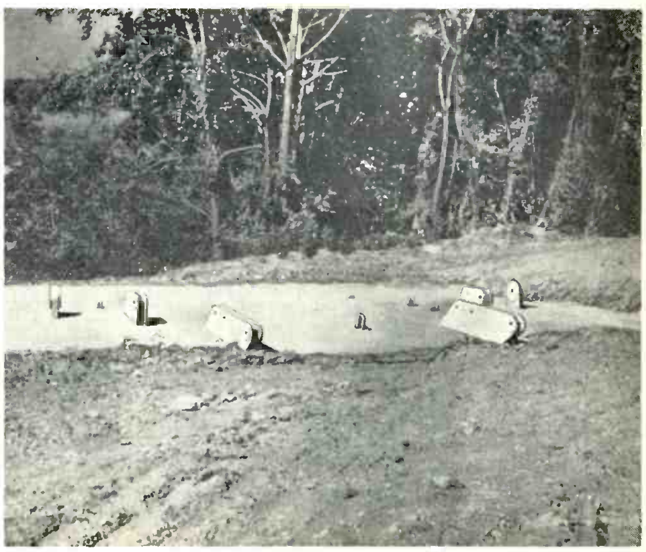
432,000 pounds offer ample protection. The dual guys afford extra reliability and make it easier to replace them without jeopardizing the structure. Figure 6 reveals the extraordinary size of the guy turnbuckles. A total of 14,700 ft. (2.8 miles) of bridge cable was used in the guy wires. Two "Stockbridge" harmonic guy dampers are used in each guy wire to eliminate harmonic vibration.

Tower Base

A 20-ft. deep, hexagon-shaped reinforced-concrete pier supports the weight of the tower (see Fig. 7). This base is 15 ft. on each face, and it withstands a complex thrust of 3,800,000 pounds, a bending minimum of 5,300,000 foot-pounds and a horizontal shear of 68,000,000 pounds. The tower base, as well as the entire structure was designed to withstand earthquake conditions, because of blasting at a nearby quarry. A total of 2250 tons of concrete were used for the base and the three anchor points. It took a line of concrete trucks spaced six minutes apart from 5 a.m. to 8 p.m.

Figure 5. One of the guy turnbuckles is shown in comparison to a man. (A dual guy system is used, making it easier to replace guy wires without jeopardizing the entire structure).

Figure 7. Three guy-anchor points, each identical to the one shown here, are used to support this tower. Extra anchor points were installed for future elevation of the structure. The anchors are 16 feet deep and 33 feet on a side, made of reinforced concrete.



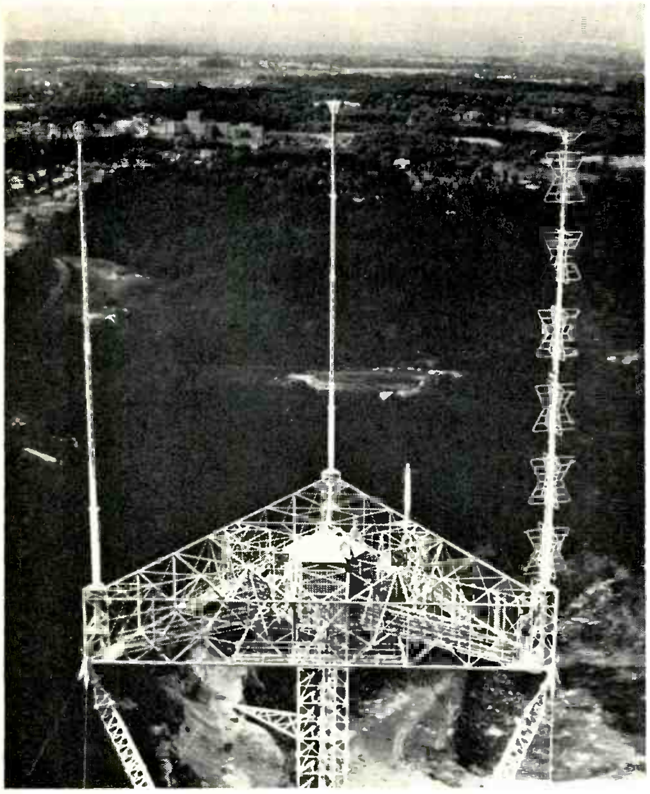
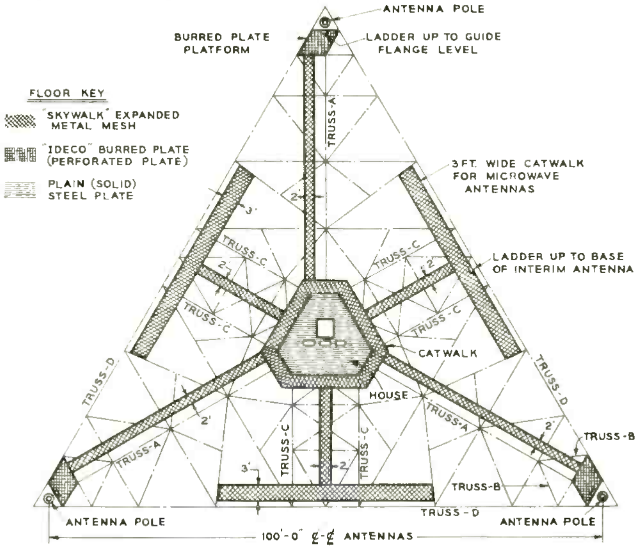


Figure 8. The platform, shown from the air, begins at the 625-foot level. The two Traveling Wave and one Superturnstile antennas are mounted on the corners of the platform. In the center is the penthouse, connecting with each antenna by catwalks. One of the microwave dishes and a standby two-bay superturnstile antenna can also be seen.

Figure 9. This is a drawing of the platform showing location of catwalks, penthouse, and antennas. The platform measures 105 feet, end to end, on a face.



to fill just one of these four excavations with concrete.

Guy Anchors

Each of the three anchors is in the form of a concrete polygon buried flush with the ground (see Fig. 8). The 16-ft. deep concrete anchors are 33 ft. on a side. The anchor points are of molded concrete, and extra points were poured anticipating a future increase in tower height. The anchors were designed for an upward thrust of 3,320,000 pounds and a horizontal shear of 1,734,000 pounds.

The Platform

The Candelabra platform was built 625 ft. above ground. Triangular in shape, the platform is 105 ft. on a face and is 16 feet high, supporting over 60,000 pounds of antennas including auxiliaries and microwave equipment (see Figs. 9 and 10). Knee braces support the platform at a point 140 ft. from the top of the tower (see Fig. 2). Steel catwalks on the lower level of the platform permit maintenance on the antennas and microwave gear. At the platform level a person has a view for 33 miles, almost to Washington, D. C., on a clear day.

Antennas

Each corner of the triangular platform supports one antenna. WBAL and WJZ are using Traveling Wave Antennas while WMAR is using a custom built special TF-6AL Superturnstile antenna (see Figs. 11 and 12). An emergency antenna for WBAL is mounted on the center of the platform face, consisting of two bays of a Superturnstile (see Fig. 9). WJZ plans to hang a separate aural antenna from the bottom of

Figure 10. This is one of the Traveling Wave Antennas as seen looking up from the platform catwalk.

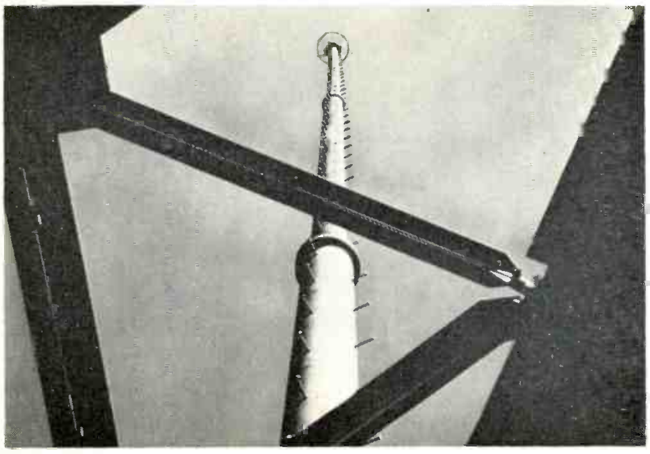
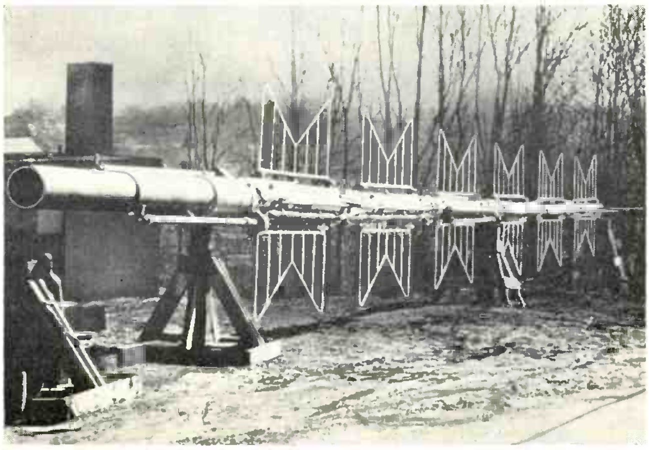


Figure 11. WMAR's custom built Superturnstile antenna is shown on the ground just after final assembly.



the platform, and to use the Traveling Wave Antenna for visual only. In an emergency WJZ will be able to use either antenna for both aural and visual signals. The special WMAR Superturnstile has split feed provisions so that either the upper or lower six sections can be used separately.

Preliminary tests made on these antennas indicate that all predicted performance data will be met. The emergency antenna arrangements offer the stations added reliability, and permit operation at reduced power in case of damage or for normal maintenance.

Transmission Lines

WMAR is using two 6⅛-inch line for the main feeds. WBAL and WJZ have installed 3⅛-inch auxiliary lines and 6⅛-inch main lines. WBAL's lines run approximately 825 ft., WJZ runs 897 ft. and WMAR is the shortest with a 746 ft. run. Transmission lines are run

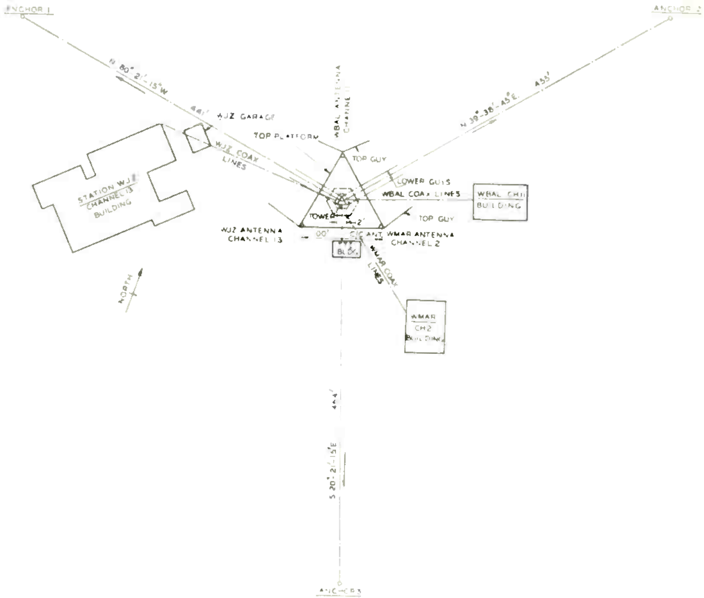


Figure 13. Transmitter building locations are shown in relation to the tower. The guys are shown with the longest running south, downhill.

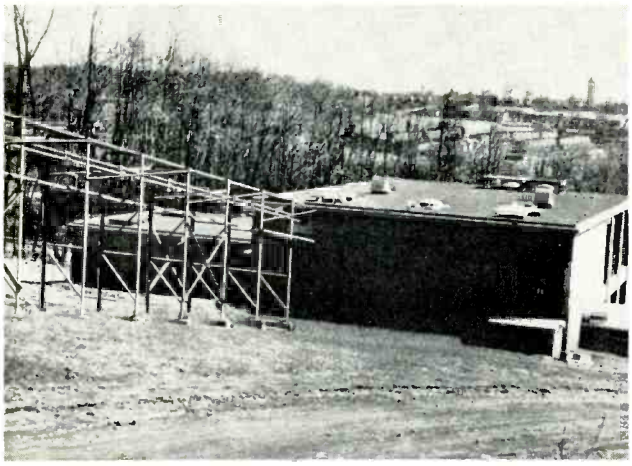


Figure 12. The transmission line of each station is run to the tower on a steel frame as shown here at the WBAL building. Small pipes have been mounted over the lines to prevent damage from falling ice.

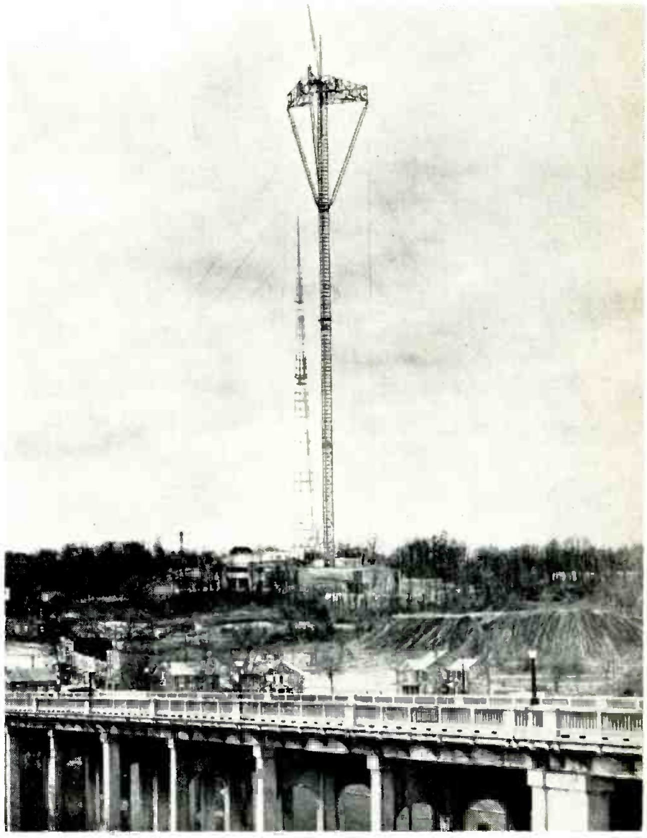


Figure 14. The Candelabra is shown in contrast to the surrounding terrain The overall height of the structure is approximately 1000 feet above sea level; however, the physical height of the structure is 730 feet.

Those Who Participated In This Candelabra System

1. The Engineering Committee of Television Tower, Inc. WBAL-TV, John Wilner (Chairman); WJZ-TV, Ben Wolfe; WMAR-TV, Carl Nopper.
2. Television Tower, Inc. Board of Directors: WBAL-TV, Mr. Provost and Mr. Gunts; WJZ-TV, Mr. McClay and Mr. Wolfe; WMAR-TV, Mr. Jett and Mr. Schmick of the Sunpapers.
3. Prime Contractor: Radio Corporation of America; Broadcast and Television Equipment Division.
4. Tower Design and Fabrication: Dresser-Ideco, Inc., Columbus, Ohio.
5. Foundation Contractor: Whiting-Turner Contracting Co., Baltimore.
6. Tower Erector: J. F. Beasley Construction Co., Oklahoma City.
7. Antennas and Transmission Lines: Radio Corporation of America, Broadcast and Television Equipment Division.
8. Mechanical Consultant: Dr. Robert Rowe, Duke University.
9. Roadway Grading: Drummond and Co., Baltimore.
10. Underground Power. Baltimore Gas and Electric Co.
11. Underground Television Telephone Facilities: Chesapeake and Potomac Telephone Co.

to the tower base on steel supporting braces (see Fig. 14). Above the transmission lines the stations have placed a row of small pipes to protect the transmission lines from falling ice.

Tower Elevator

A two-man radio-controlled elevator has been installed within the tower for maintenance (in an emergency it could carry four men). The elevator takes personnel to the floor level inside the penthouse at the top of the tower. Two-way communication is possible at all times from elevator to ground. The elevator can be controlled from the ground or the penthouse on the platform, as well as from within the elevator itself.

Microwave Facilities

A 3-ft. catwalk built around the tower at the 300-ft. level is used for microwave antennas. The stations will use microwave at this level primarily for studio-transmitter links. WBAL and WMAR to move their remote microwave gear mounted on the upper portion of the platform. These three antennas have been placed close to the roof of the penthouse on the platform. WJZ does not require a STL link since its studios are at the tower site.

Station Facilities

The Baltimore Candelabra tower was built on land recently purchased from WJZ, and this required WBAL and WMAR to move their transmitter plants to the new site. The new buildings erected by WBAL and WMAR are adjacent to the antenna base. WJZ has both studio and transmitter facilities at the site, eliminating microwave links. Figure 15 shows the tower and guy locations in relation to the various buildings; transmission line runs are also indicated.

Costs Equal for Each

With each station absorbing one third of the total cost of this Candelabra tower the cost per station obviously became lower. Now that this candelabra is operating the maintenance costs should be lower for each station. This type of antenna arrangement also benefits the TV viewer, by making it simpler to orient antennas. Baltimore's new Candelabra system is the only one of its type in the world, and it is a tribute to the stations cooperation.

Industry News

Foto-Video Appoints Sales Manager

Foto-Video Electronics, 30-36 Commerce Road, Cedar Grove, N. J., has announced the appointment of Herbert P. Michels to the post of East Coast sales manager. He previously served as engineering sales representative in the New York City-New Jersey area. His background includes five years as director of engineering for the Cornell University commercial broadcast station. He also held engineering posts with WNEW, New York, and Federal Telephone & Telegraph Co.

KSTP-TV Modernizes

KSTP-TV in Minneapolis-St. Paul has launched a broad range modernization program which will give them a full array of the latest technical equipment housed in expanded quarters. The new equipment includes a station break automation system, TV tape recorders, complete color facilities, transistorized switching equipment and a mobile studio capable of handling both color or black-and-white remote programs.

The KSTP-TV engineering staff was assisted by RCA engineers in drawing up plans for the integrated layout which features the centralization of all equipment in one area. The KSTP-TV equipment central will be a 60 by 80 ft. room in a new addition to the present building. A new 40 by 60 ft. color studio will be in the addition. A studio which will allow closed circuit TV presentations for audiences up to 300 persons is included. Strategically located monitors will bring each individual within easy viewing range.

A station break automation system for handling up to a dozen events during the break period will be used. Three transistor switching systems are included for the two main studios and master control. The master control switcher can be controlled by the automation equip-

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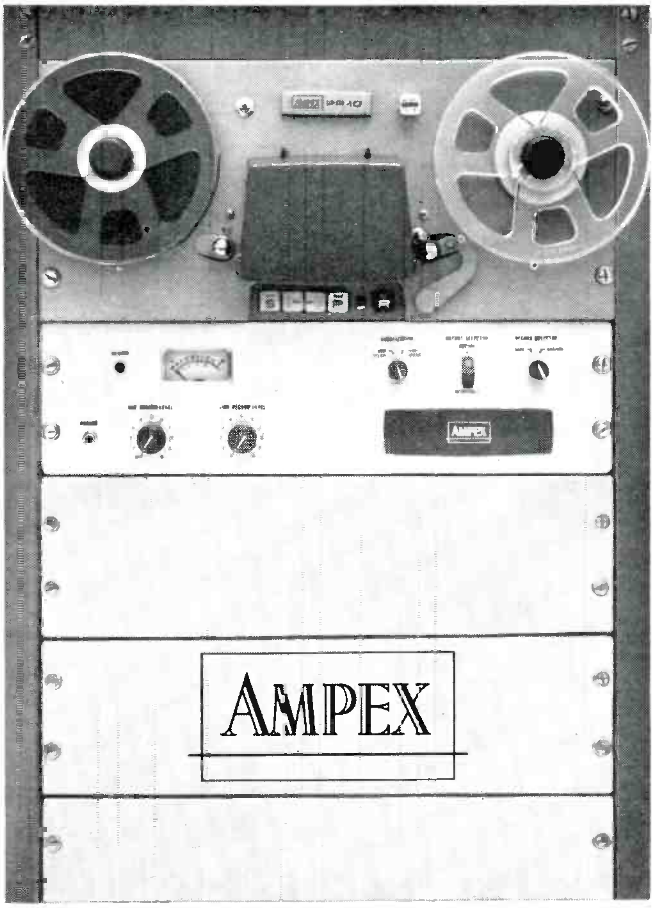

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COpley 7-4700
DeMambro Radio Supply Co., Inc.
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Graybar Electric Co.
HUbbard 2-9320
Lafayette Radio Corp. of Mass.
HUbbard 2-7850

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NOrmandy 2-4457
Detroit
Ferguson Electronics, Inc.
UN 1-6700

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BAltimore 1-1155
St. Louis
Graybar Electric Company
JEfferson 1-4700
New Hampshire—Concord
Evans Radio
CApital 5-3358
New Jersey
Camden
General Radio Supply Co.
WO 4-8560 (in Phila.: WA 2-7037)
New Mexico
Alamogordo
Radio Specialties Company, Inc.
HEmlock 7-0307
Albuquerque
Radio Specialties Company, Inc.
AM 8-3901
New York
Binghamton
Stack Industrial Electronics, Inc.
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BEekman 3-2980
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Priest Electronics
MA 7-4534
Washington—Seattle
Western Electronic Company
AT 4-0200
West Virginia—Bluefield
Meyers Electronics, Inc.
DAvenport 5-9151

ment. Two new RCA TK-41 cameras will be employed for live color broadcasts to complete the color facilities which include color equipped recorders. A special mobile unit accommodates four monochrome and two color cameras. Built-in microwave facilities will be used for the studio link. Monochrome cameras equipped with 4½ inch image orthicons will be used for higher quality. The modernization project will be completed with a new 25 kilowatt transmitter. RCA is furnishing the major equipment items.

Norton Appointed at Ampex

Charles E. Norton has been appointed manager of Ampex International's Video Marketing Department, according to an announcement by Ralph E. Endersby, AI Marketing Division Manager. In his new position Norton will be responsible to Endersby for supporting Videotape television recording marketing activity by Ampex International outside the United States.

Norton was formerly southern area manager for the Radio Corp. of America. Headquartered in Dallas, he was in charge of engineering and sales of RCA communications equipment for the southern half of the United States.

Before joining RCA in 1953, he was manager of his own company specializing in the installation of broadcast and antenna systems.

New Translator Firm

Electronics, Missiles & Communications, Inc., has established headquarters at 262 E. Third St., Mount Vernon, N. Y. The newly formed firm will produce translators and microwave relay equipment especially adapted for handling television signals. The company's line includes a one-watt VHF TV translator built to broadcast standards. The firm also offers a control and identification which will be required by many translators to meet new F.C.C. rulings.

President of the firm is Dr. B. W. St. Clair who formerly was director of research development at Adler Electronics, Inc. Henry Shapiro and Robert F. Romero have joined the company as vice-presidents.

Industry News

Good Results in Stereo Tests

A. Prose Walker, manager of engineering for the NAB, reports that good results have been obtained with the five stereophonic broadcast systems tested in the field trials at Uniontown, Pa. Any one of the five systems tested may be adopted, a composite of several, or a completely different system may be chosen. The F.C.C. is expected to establish the FM stereo standards early next year.

The field trials were conducted by the National Stereophonic Radio Committee to help the F.C.C. determine the future of FM stereo broadcasting. Mr. Walker was the chairman of the panel that actually conducted the tests. About 40 engineers, using the facilities of station KDKD-FM at Uniontown, Pa., put in 1,300 man-hours of work on the field trials. The systems tested are known as Crosby, Calbest, Halstead, Percival, General Electric and Zenith.

Color TV Weekend

More than 18 hours of network television programming was scheduled over the weekend of Nov. 11-13 by NBC. The purpose of the expanded color schedule was to give dealers an opportunity to demonstrate color television receivers over the weekend which included Veterans' Day on Friday. RCA promoted the color programming by advertising in 127 newspapers and local dealers and stations cooperated with promotion campaigns.

New Marketing Manager For Sarkes Tarzian

F. R. (Russ) Ide has been appointed marketing manager for the Broadcast Equipment Division of Sarkes Tarzian, Inc.

Russ Ide moves to Sarkes Tarzian, Inc., from Ampex Professional Products Co., where he was assistant to the national sales manager. Before his employment with Ampex, Mr. Ide worked for Sarkes Tarzian, Inc., in the capacity of sales engineer covering the midwest, and as master control supervisor for Station WGN, Chicago.

New Television Recording Firm

McNally Television Recording Corp. has recently been organized by John P. McNally, long closely associated with kinescope operations in the television industry. Production of high fidelity kinescope recordings is now the principal business of the company, but McNally states he anticipates expanding into closely allied fields in the future. Offices of the company are at 205 West 58th St., New York.

Women Operate Videotape Recorders in Australia

Amalgamated Television Services of Sydney, Australia, has trained female operators for its television re-

cording department. Skilled technicians concentrate on maintenance and technical alignment of the equipment. There is a greater than normal interest in the operation of the machines, according to the report from Australia.

KOA Installs New 50 KW Transmitter

Denver Radio Station KOA has purchased a new General Electric 50,000-watt broadcast transmitter. It replaces a G-E 50,000-watt transmitter that has been in continuous operation since 1933. The equipment is designed for future remote control operation from the station's new studio building.

KOA, a National Broadcasting Co. affiliate, broadcasts at a frequency of 850 kc. The station, one of Denver's first, went on the air Dec. 15, 1924. Founded by G-E, the station became an NBC affiliate in 1928 and its operation was taken over by the network the following year.

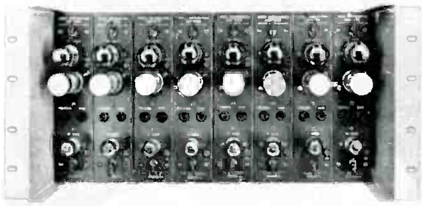
NBC purchased the KOA facilities from G-E in 1941 and retained ownership until June of 1952 when the Metropolitan Television Co. bought the station. Comedian Bob Hope was a member of the new owner's board of directors. The company's president is William Grant.

KOA and KOA-TV last year occupied their new 2½-story headquarters at 1044 Lincoln St.

Literature Available On Educational TV Rebroadcast

A recent study by Adler Electronics describes an economical method for extending the coverage of Florida's educational TV stations to all major communities in the state. Through the use of translators most schools and homes will be able to receive at least one educational TV program service. This 11-page study is available without charge from Adler Electronics, Inc., One LeFevre Lane, New Rochelle, New York.

Product News



MODULAR VIDEO AMPLIFIERS

The Daven Co., Livingston, N. J., a subsidiary of General Mills, Inc., has developed an integrated line of plug-in and rack-mounted video distribution amplifiers.

A featured member of this line is the Type VA-P-101, a plug-in video distribution amplifier for systems requiring a simple one input, one output unity gain limit.

Eight of these amplifiers plug into a shelf 8¾ inches high which mounts in a standard relay rack. Filament and bias voltage is provided by the shelf and the only other power which must be supplied is 117V ac and regulated 285V dc. The amplifiers may be used individually, or any number of units up to eight may be "multed" together so as to provide a maximum of eight outputs from one input. Inductors are permanently built into the shelf to prevent the accumulation of shunt capacity from causing termination difficulties when several inputs are "multed." When sync-adding is required the Type VA-P-102 Sync Adding Amplifier plugs into one of the positions, allowing the addition of sync to one or any number of the remaining seven VA-P-101 video amplifiers.

NEW DYNAMIC MIKE

A new model in the Collins line of dynamic microphones has been designed to meet professional audio requirements in radio broadcasting, television, recording studios and quality public address systems.

The Collins M-30, a pressure operated dynamic with a frequency response from 50 to 15,000 cps, assures a high fidelity reproduction of voice and music.

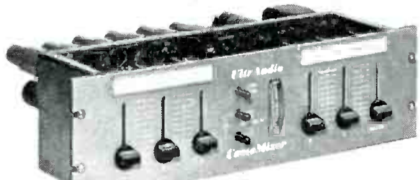
It is essentially omnidirectional which makes it ideal for a variety of speaking situations such as panel discussions, conventions and school programs, in addition to broadcast use.

With a selection of either 50 ohm or 200 ohm impedance, the M-30 may be used with any amplifiers having a 35-80 ohm or 150-250 ohm input. The output level at 50 ohms or 200 ohms is —150 db, with reference to RETMA sensitivity rating.

The microphone body is made of aluminum and has a non-reflecting, blue-gray baked enamel finish.

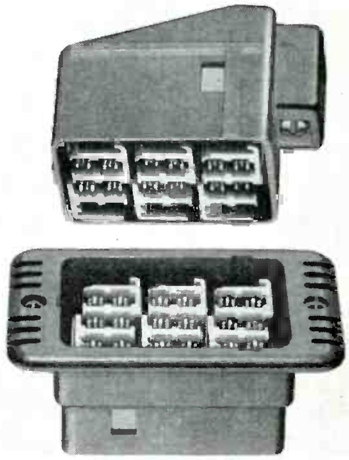
NEW DYNAMIC PROBE MICROPHONE

New Shure Model 545 Unidyne III microphone is a unidirectional dynamic microphone with probe styling which enables it to be used as a stand-mounted or hand-held microphone. Frequency range is 50 to 15,000 c.p.s. Dual-impedance microphone is finished in brushed satin chrome and high-impact black plastic. Unit weighs 0.6 pounds and is 6 inches long.



NEW AUDIO MIXER

UltrAudio Products, 7471 Melrose Ave., Los Angeles 46, Calif., has developed a new line of mixer amplifiers for use by recording studios, broadcasters and audiophiles. The units are known as CustoMixers because of the user's ability to purchase only those plug-in shock-mounted preamplifiers and input transformers he needs. A feature of both the 5-position single channel CustoMixer and the 4-position 2-channel stereophonic version is the Line-Aten straight-line volume control. Input and output impedances are from 50 to 600 ohms plus hi-z. An illuminated VU meter is on each output line, with further provision for stereo headphone monitoring and feed to external power amplifiers and public address systems.



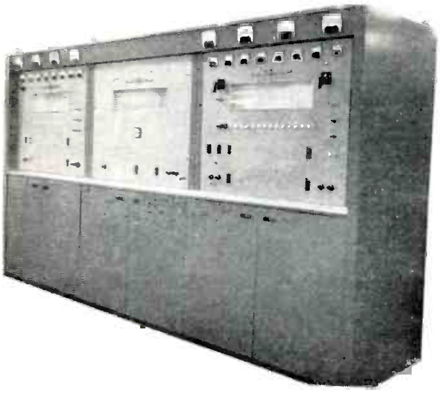
NEW PLUG DESIGN

Cannon Electric Co., 3208 Humbolt St., Los Angeles 31, Calif., is now marketing its newest development, the Morpho series of Cannon Plugs.

The Morpho, series MH, represents a new concept in plug design and development. It features hermaphrodite contacts and insulators which fit both plugs and receptacles.

The extraordinary design of these plugs makes them easily adaptable to many configurations and a variety of layouts is possible within each shell style. Snap-in crimp-type contacts cut assembly time and facilitate maintenance.

The Morpho is said to be a high quality plug especially suited to commercial applications such as business machines, computers, communications equipment, and the like. The versatility of these low cost plugs will make them useful in many other military and civilian applications.



35 KILOWATT TV AMPLIFIER

The Communications Products Department of the General Electric Co. Lynchburg, Va. has announced the development of a new 35,000-watt amplifier with a driving power of less than 5,000 watts. G. E. states that the amplifier will make it feasible for more stations to increase their effective radiated power to 316,000 watts. The air-cooled amplifier, designated type TF-14-A, includes such features as dc filaments, built-in electronic r-f sweep generator, a double-stub loading control, and a unique triplex cavity with three parallel tubes. A semiconductor bias power supply is used which is filtered for the reduction of the 360-cycle component. The aural and visual amplifiers use a common power supply. The amplifier is contained in three cubicles for the visual amplifier, aural amplifier, and rectifier control equipments.

Advertisers' Index

Classified

Advertising rates in the Classified Section are ten cents per word. Minimum charge is $2.00. Blind box number is 50 cents extra. Check or money order must be enclosed with ad.

EQUIPMENT FOR SALE

Western Electric 18" Electro-Dynamic woofers, drivers, horns, baffles. Altec 604C and Jim-Lansing 150-4 15" woofers. Reasonable. Otto Fichtman, 600 Timpson Place, Bronx, New York 55, N. Y. 12-60 1t

AMPEX 400 TAPE RECORDER. Single case portable. Manual controls. $400. Jon Monsen, 1350 N. Harding, Pasadena, Calif. 12-60 2t

Commercial Crystals and new or replacement crystals for RCA, Gates, W. E. Bliley and J-K holders: regrinding, repair, etc. BC-604 crystals. Also A.M. monitor service. Nation-wide unsolicited testimonials praise our products and fast service. Eidson Electronic Company, Box 31, Temple, Texas. 12-60 tf

Surplus F-129B Tubes, 7.5KW dissipation water-cooled triodes, unused and guaranteed perfect, still in original crates packed by Federal-IT&T in 1959. Presently offered by maker at $385 each, we offer six for $385, or $75 each, while they last. Get your name on our mailing list for unusual bargains. Specify your requirements in used test equipment, microwave materials—large variety in stock. Engineering Associates, 434 Patterson Road, Dayton 19, Ohio. 12-60 1t

BUY, SELL OR TRADE

Will buy or trade used tape and disc recording equipment — Ampex, Concertone, Magnecord, Presto, etc. Audio equipment for sale. Boynton Studio, 10-BE Pennsylvania, Tuckahoe, N. Y. 11-60 4t

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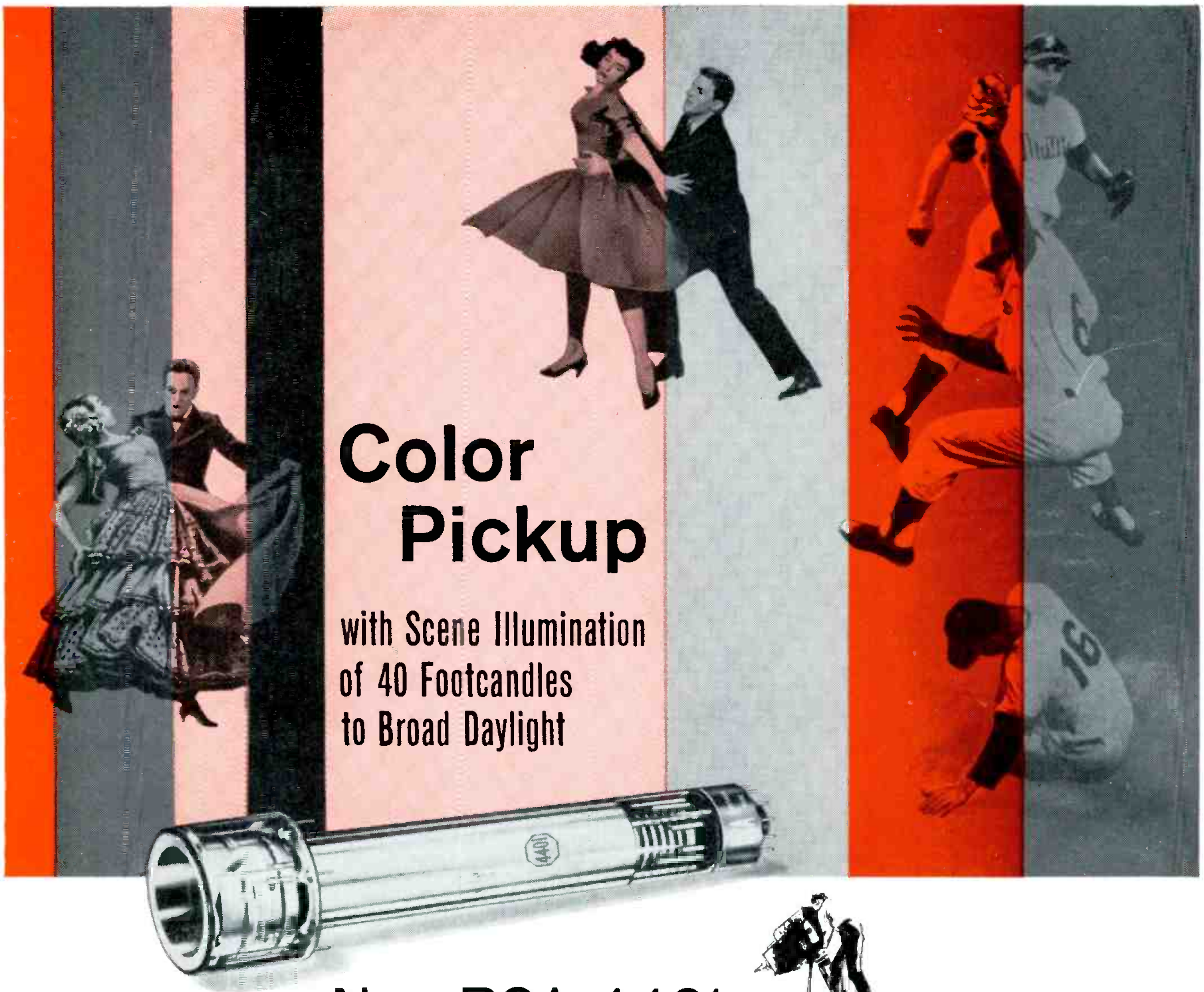
Broadcast Engineering Magazine welcomes editorial contributions from its readers. Articles on everyday operational methods, studio or transmitter layouts, construction projects, and other topics on the technical aspects of broadcasting will be paid for on acceptance. Write us concerning rates and other information. Broadcast Engineering, 1014 Wyandotte Street, Kansas City 5, Missouri.



New RCA-4401 Image Orthicon

High sensitivity and high signal output of RCA-4401 make possible quality color pictures at black-and-white light levels.

Now every TV studio can be made into a color studio. RCA-4401 eliminates the need for extra lighting and air conditioning. It produces high-quality color pictures with a scene illumination of 150 footcandles. Satisfactory color pictures can be obtained with a lens opening of f/5.6 at scene illumination as low as 40 footcandles.

A single color camera equipped with RCA-4401's can put you in business. It can be used in the studio or taken to remote locations and operated as light levels change from daylight through dusk to artificial lighting. These versatile tubes have been successfully used to colorcast night sports events at light levels once adequate for black-and-white pickup only.

Designed to fit color cameras using 3-inch image orthicons, the 4401 is unilaterally interchangeable with RCA types 6474 or 7513. RCA-4401's are provided in factory-matched sets of three, including one tube preselected for the blue channel. Availability is no problem; the RCA-4401 is in full production.

Get in touch with your RCA Broadcast Tube Distributor today for more details on how RCA-4401 can broaden your colorcasting capability—and cut costs at the same time. *RCA Electron Tube Division, Harrison, N. J.*

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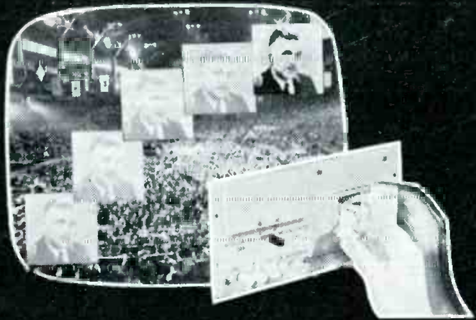
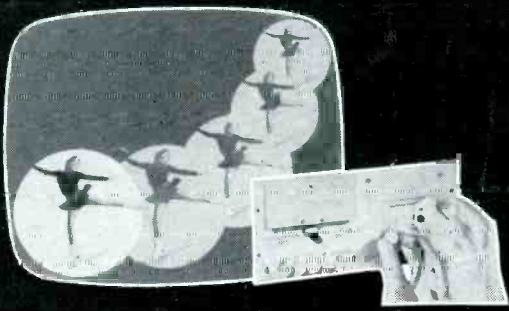
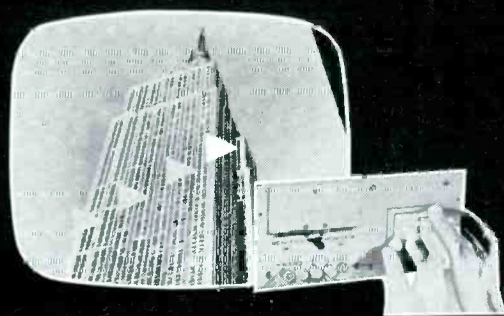
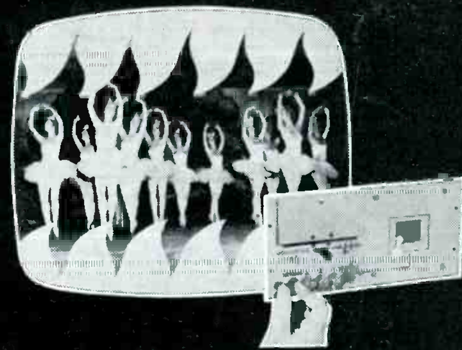

Insert May be Placed at Any Position on Raster


Electronic Spotlight


Electronic Pointer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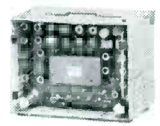
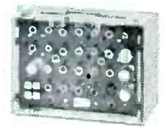
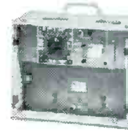
Full Specifications & Details or Demonstration Available on Request


490WA1 Waveform generator. Generates keying signals for the 72 different wipes.


490SA1 Switching Amplifier. Combines two picture signals in accordance with applied keying waveform.


490RA1 Remote Control Unit. Selects and controls desired effect. Designed for console or desk mounting. Easily modified for integration into existing studio facilities. Complete with power supply—Model 512C1

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