VERTICALLY POLARIZED FM ANTENNAS and POWER DIVIDER

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Now, some 18 years after the end of World War II, FM is taking its second wind, with this resurgence of FM broadcasting transmission by Dual Polarized FM Antennas has been developed. Vertical Polarization in conjunction with horizontal polarization provides the maximum coverage of the area a station serves.

Advantages of a dual polarized FM antenna system are: (a) improved reception by receivers using vertical antennas, specifically automobile radios and home receivers with built-in antennas, (b) signal levels may be increased in the null areas of a horizontal antenna.

The FCC FM Rules and Regulations require the transmission of horizontal polarization. Revisions made some years ago authorize the transmission of a vertical component which, in no event, is to exceed the effective radiated power authorized.

The Commission's Rules and Regulations on this subject are as follows:

Paragraph 3.310, Definitions in the FM Technical Standards:

"The term 'effective radiated power' means the product of the antenna power (transmitter output power less transmission line loss) times (1) the antenna power gain, or (2) the antenna field gain squared. Where circular or elliptical polarization is employed, the term 'effective radiated power' is applied separately to the horizontal and vertical components of radiation. For allocation purposes, the effective radiated power authorized is the horizontally polarized component of radiation only."

Paragraph 3.316, Antenna Systems, Paragraph (a):

"It shall be standard to employ horizontal polarization; however, circular or elliptical polarization may be employed if desired. Clockwise or counterclockwise rotation may be used. The supplemental vertically polarized effective radiated power required for circular or elliptical polarization shall in no event exceed the effective radiated power authorized."

Paragraph 3.310, states the effective radiated power authorized is the horizontally polarized component of radiation only. Paragraph 3.316 on antenna systems states, the vertically polarized effective radiated power shall not exceed the effective radiated power. Therefore, an amount of power equivalent to the effective radiated power in the horizontal plane may be radiated by a station in the vertical plane. This does not preclude the fact that specific application must be made under Paragraph 3.257 requesting authority to make a change in the antenna system, if we are talking about an existing station or a CP that has been granted.

The radiating elements of current horizontal FM antennas are modified dipoles. These are spaced one above the other to obtain the desired antenna power gain. See figure 1.

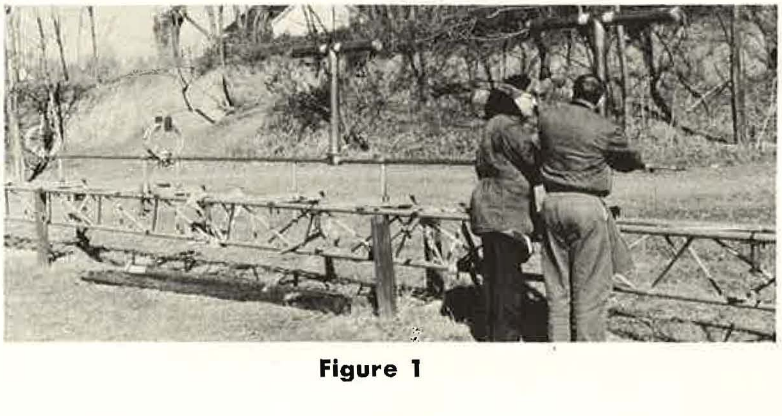


Figure 1

It is this power gain times the antenna input power that determines the effective radiated power of a given FM station.

It is standard practice to stack the antenna radiating elements or bays approximately one wavelength apart. The bays are then fed in phase along a transmission line that may support from one to sixteen bays or radiating elements electrically connected in parallel. See figure 2. The impedance of each dipole, antenna element, or bay is made greater than the transmission line impedance by the number of bays. The input impedance of the antenna, however must be 50 ohms to meet the standard coaxial line transmission impedance.

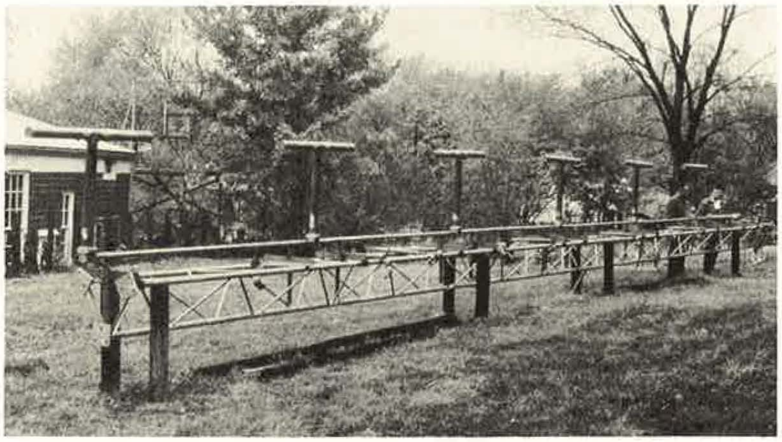
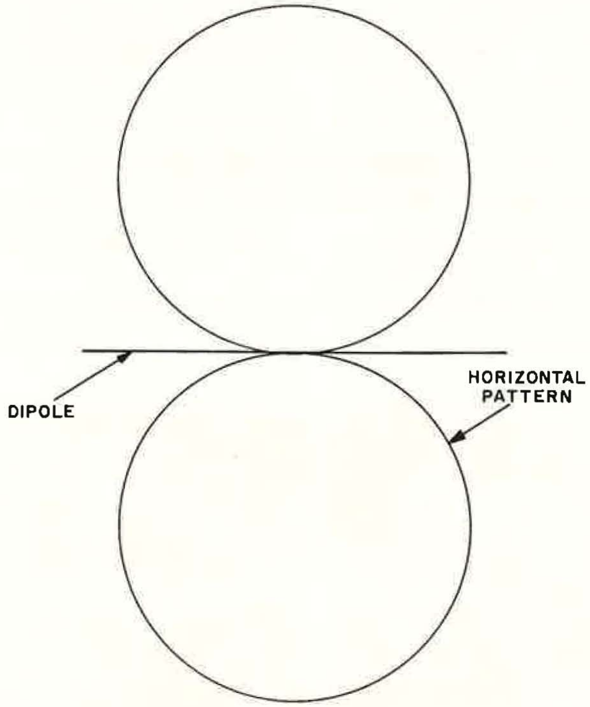


Figure 2

We mentioned earlier that the standard FM antenna on the market is a modified dipole. Now the horizontal radiation pattern of a dipole is a Figure 8. See figure 3.

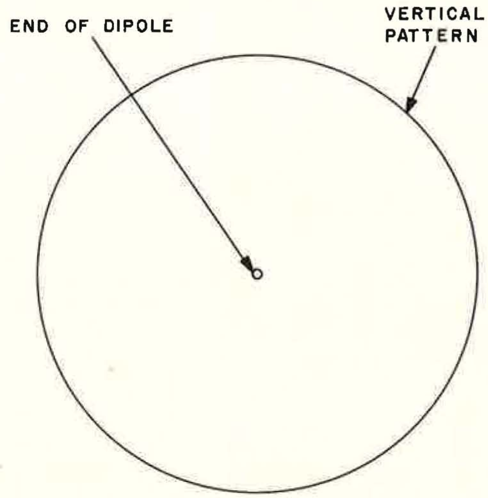


HALF-WAVE HORIZONTAL DIPOLE

Figure 3

If we take the dipole and bend it into a semi-circle, we have a circular dipole and, for all practical purposes, an antenna that will radiate a uniform omni-directional signal within plus or minus one db in free space. The circular dipole is usually end loaded with capacitive plates to provide a more uniform current along the antenna length.

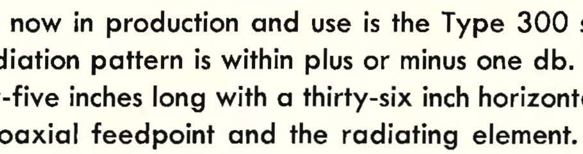
The standard horizontal dipole with a Figure 8 horizontal radiation pattern has, when we look at the end of the dipole, a circular vertical pattern as shown in figure 4.



HALF-WAVE HORIZONTAL DIPOLE

Figure 4

Up to this point we have been discussing the dipole as we normally know it in the horizontal position. Let's tip the dipole up on end. The horizontal becomes the vertical and the vertical becomes the horizontal and we have a circular radiation pattern from the dipole antenna. The resulting radiation pattern is graphically shown as a cross sectional view through the antenna in figure 5.



RADIATION PATTERN FOR A VERTICAL DIPOLE

Figure 5

A vertical antenna now in production and use is the Type 300 shown in figure 6. The circular free space radiation pattern is within plus or minus one db. The radiating element is approximately forty-five inches long with a thirty-six inch horizontal choke and matching section between the coaxial feedpoint and the radiating element. All sections are three and one-eighth inches outside diameter.

The matching section provides a low VSWR and proper impedance when more than one element is installed and separated by one wavelength section of feedline. The choke is to provide electrical balance without openings, which would subject the Antenna to ice and moisture, and thus necessitate the use of deicers.

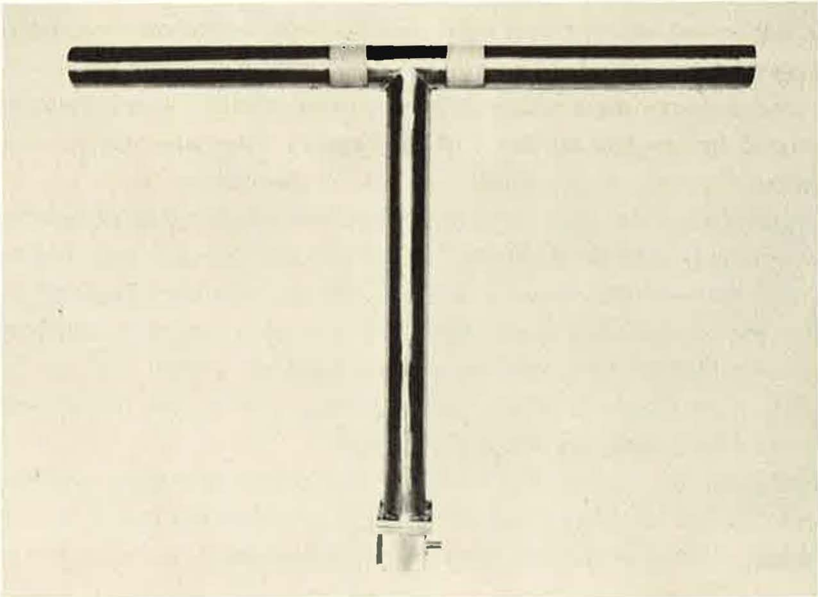


Figure 6

The connecting block at the end of the horizontal choke and matching section may be provided to accommodate the following optional feed systems.

1. Series feed with 3⅛″ rigid line.
2. Series feed with 1⅝″ rigid line.
3. Parallel unit feed with ⅞″ Spir-O-Line and a central power divider.

The antenna is supplied with custom mounting brackets as shown in figure 7. This bracket may be adopted for side or corner tower mounting.

Figure 7

Deicing the vertical antenna element is not necessary due to the broad bandwidth characteristics of the dipole plus the broad cross section and completely enclosed balancing choke section previously described.

Electrically, the antenna covers a frequency range of 88-108 megacycles. The standing wave ratio is 1.1 to 1 or less as tuned at the factory. Each element has a power rating of three kilowatts.

Vertical antennas may be used in combination with other types of horizontally polarized ring or V antenna, but, as we have stated before, it is not permissible as the sole source of radiated transmission energy under existing Rules and Regulations.

Consider the combinations of dual polarized antennas possible. Horizontal antennas are available, consisting of from one to sixteen bays on either 1⅝″ or 3⅛″ line. The vertical Type 300 is available in similar configurations. There are three general methods which may be used for mounting the combinations.

The first configuration, figure 8 is with the horizontal elements mounted above the vertical elements. The center of vertical radiation is considerably lower than the horizontal center of radiation, a large section of tower must be available to mount the complete unit.

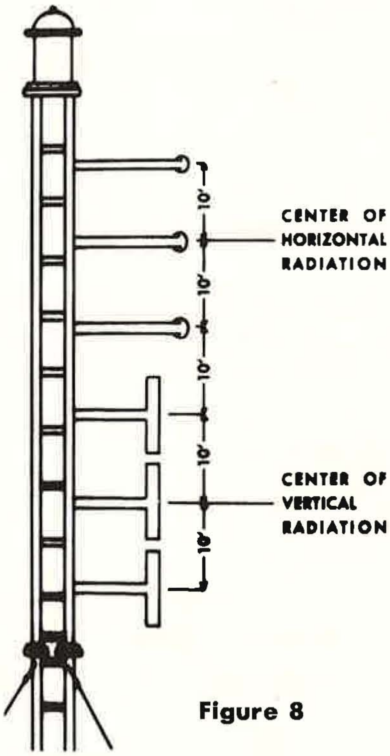


Figure 8

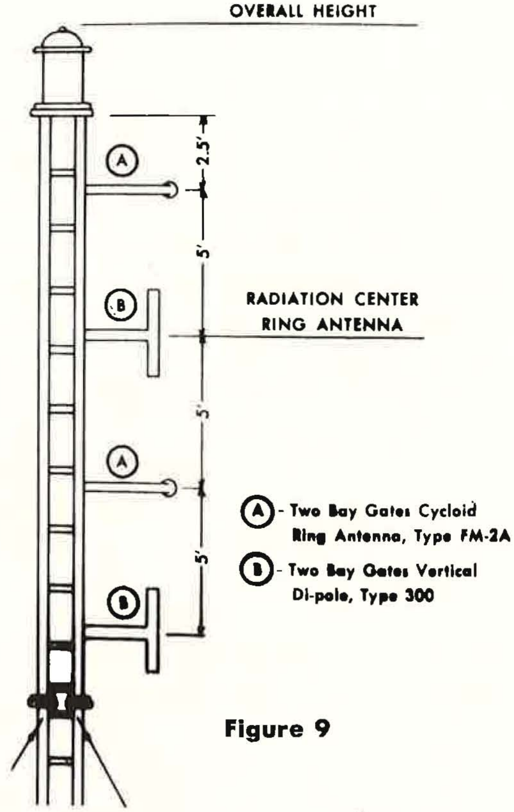


Figure 9

A second method, figure 9, is intermingling of the horizontal and vertical bays. This requires less tower space and places the vertical center of radiation approximately five feet below the horizontal.

A method of mounting, figure 10, which tends to equally distribute the total weight of the antenna on the tower is with the vertical elements on one side of the structure and horizontal elements on the opposite. This system of mounting and intermingling of the bays, will be, we anticipate, the most common prescribed methods of installation.

Antennas consisting of one to nine radiating elements are end fed. Antennas with ten elements and more are center fed. If the antenna consists of an odd number of elements, the feed point is at a point one-half bay below the center. In other words, an eleven bay antenna is fed at a point one-half way between the sixth and seventh bay, or 55 feet from the top.

EXPANDED VIEW OF FM RADIATOR

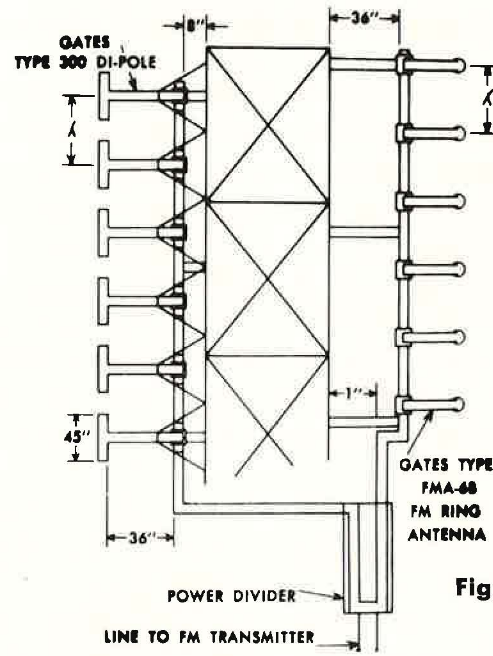


Figure 10

We have not mentioned power dividers. Our discussion has centered around the description of the antenna, installation, and combinations thereof. Normally, we have one transmitter supplying RF to the antenna.

Now with dual polarization we have the gain of the horizontal elements, the gain of the vertical bays, and the power supplied to each. The gain of the vertical bay, or bays, is not identical to that of the equivalent number of horizontal bay, or bays. See figure 11.

GATES CYCLOID FM ANTENNA
GAIN AND PATTERN DATA
DUAL POLARIZED

Figure 11

	HORIZONTAL			VERTICAL		
No. of Loops	Power Gain	Field Gain	Mv/M/KW	Power Gain	Field Gain	Mv/M/KW
1	0.9	0.95	131	.950	.975	134.7
2	2.0	1.41	194	1.969	1.403	194.0
3	3.0	1.73	238	3.120	1.766	244.2
4	4.1	2.02	278	4.198	2.049	283.2
5	5.2	2.26	311	5.310	2.304	318.4
6	6.3	2.51	345	6.393	2.528	349.4
7	7.3	2.70	372	7.500	2.738	378.5
8	8.4	2.90	399	8.571	2.928	404.6
9	9.4	3.07	421	9.755	3.123	431.6
10	10.5	3.24	446	10.960	3.310	457.6
11	11.5	3.40	468	11.870	3.445	476.1
12	12.7	3.56	490	13.195	3.632	501.9

For example, three bays of horizontal have a power gain of 3 and a field gain of 1.73, while an equivalent number of vertical bays has a power gain of 3.12 and a field gain of 1.766. Therefore, if we want to operate with the same horizontal and vertical E.R.P. and are using one transmission line to the antenna, we must control the power to the vertical and horizontal assemblies. This may be done with a power divider. With the many combinations of antennas, R.F. power and resulting effective radiated power, you can see the power divider is presently customed designed for each specific installation.

A variable transformer, figure 12, may be used between the power divider and vertical and horizontal antennas to assure proper matching and power distribution.

Fixed power dividers are available, assuming we have exactly matched loads on the power divider output. For example, if we want to divide ¾ of the available power and supply it to the horizontal antenna and the remaining one-fourth to the vertical, and we know the input power, a standard power divider may be provided. Currently the loss in the power divider has been assumed to be the loss obtained from an equal length of transmission line.

I regret we are unable to provide at this time actual comparison field measurements of a horizontal installation with a combined horizontal and vertical system. This project still remains to be completed. Clearly it must be realized that a large amount of work within the industry remains to be done in assembling detailed field information on elliptical polarization.

The photograph, figure 13, is of an actual installation consisting of two Cycloid bays and two Type 300 vertical elements. Reports on the results of current dual polarized installations are most gratifying both from the listener, the station, and the manufacturers' viewpoint.

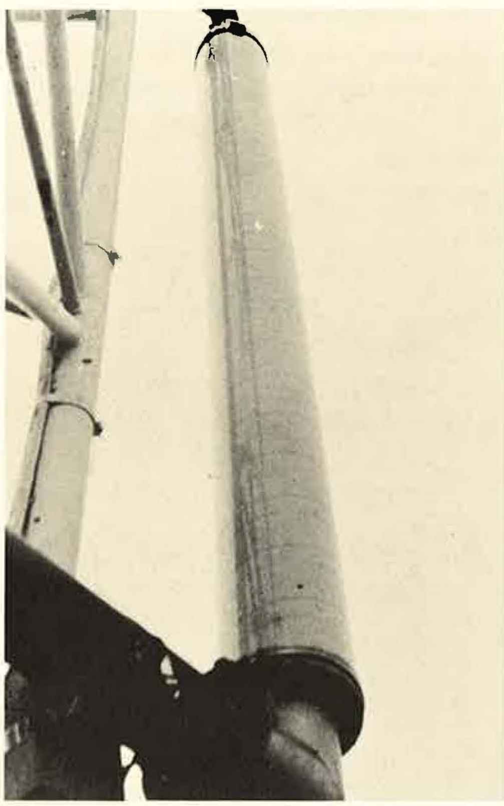


Figure 12

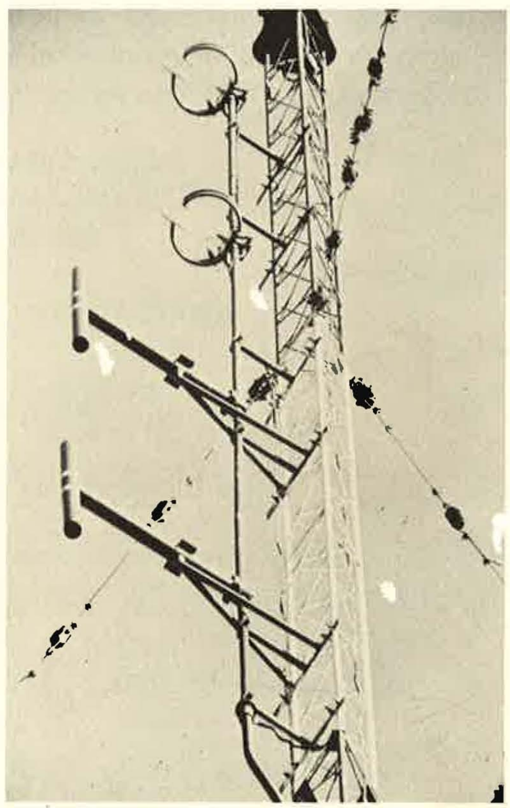


Figure 13