PLANNING

AM/FM

RADIO STATIONS

PART TWO

The Transmitting Plant

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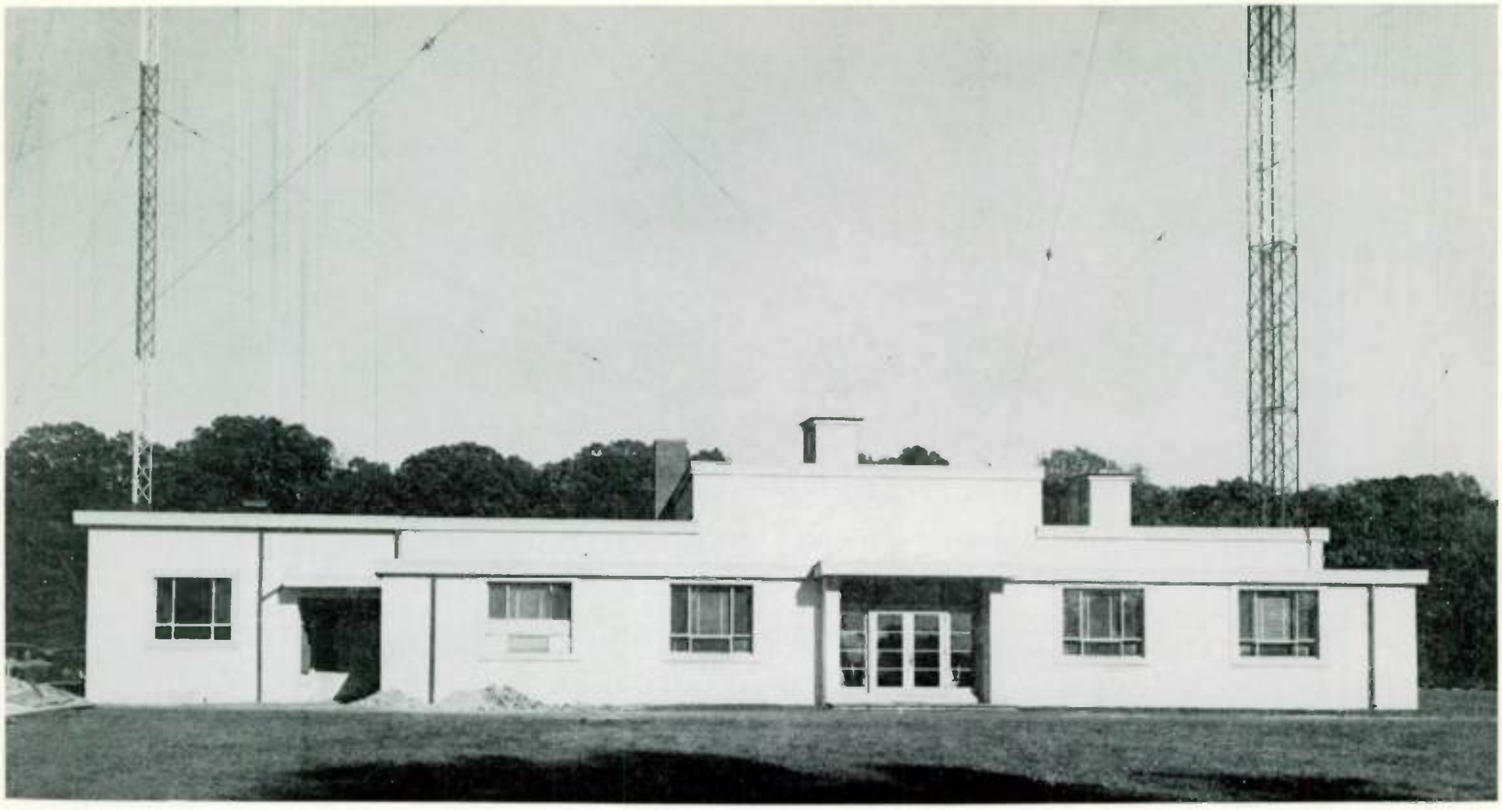

PLANNING AM/FM RADIO STATIONS

PART TWO: THE TRANSMITTING PLANT

(Editor's Note) This portion on radio station planning discusses factors to be considered in the design, layout and construction of the transmitter building, remote control systems, towers, antennas and transmission lines. Part Three, last of the series, will appear in a subsequent issue and will cover the selection, installation and maintenance of AM/FM broadcast equipment.

Transmitter Plant Requirements

Land and building space required for the transmitting equipment increases with station power, although even low power AM installations with directional arrays will require two or more towers as well as additional space in the transmitter building for phasing and branching equipment. FM stations do not need multi-tower arrays or phasing equipment, but provisions must be made in the transmitter building for an external power supply and overhead mounted harmonic filter.

A typical transmitter building layout for a one kilowatt AM directional is shown in Fig. 1. This floor plan, which can also house up to a 10 kW FM transmitter, includes transmitter, phasing cabinet, equipment rack, work space and lavatory. Heating and air conditioning requirements, of course, vary with location. For higher transmitter power the building is usually expanded both in length and width to accommodate the larger equipments.

Types of Towers

The radiating element of today's AM broadcast stations, of course, is the tower itself, while for FM stations it serves only as the antenna support. Combined AM and FM stations can use the tower both as an AM radiator and an FM antenna support.

Towers are divided into two basic types: self supporting and guyed. Either type may be made in a grounded or insulated version. Towers that will serve as AM radiators are usually insulated and are series fed. Grounded towers may be used as AM radiators if shunt feeding is used. Self supporting towers are used where space is limited. They require no guys and the distance between tower legs is normally about one-eighth the total height of the structure. However, guyed towers are more commonly used, though the guys may extend out as far as 75 percent of the tower length. They are less expensive and generally of a smaller, uniform cross section, making a

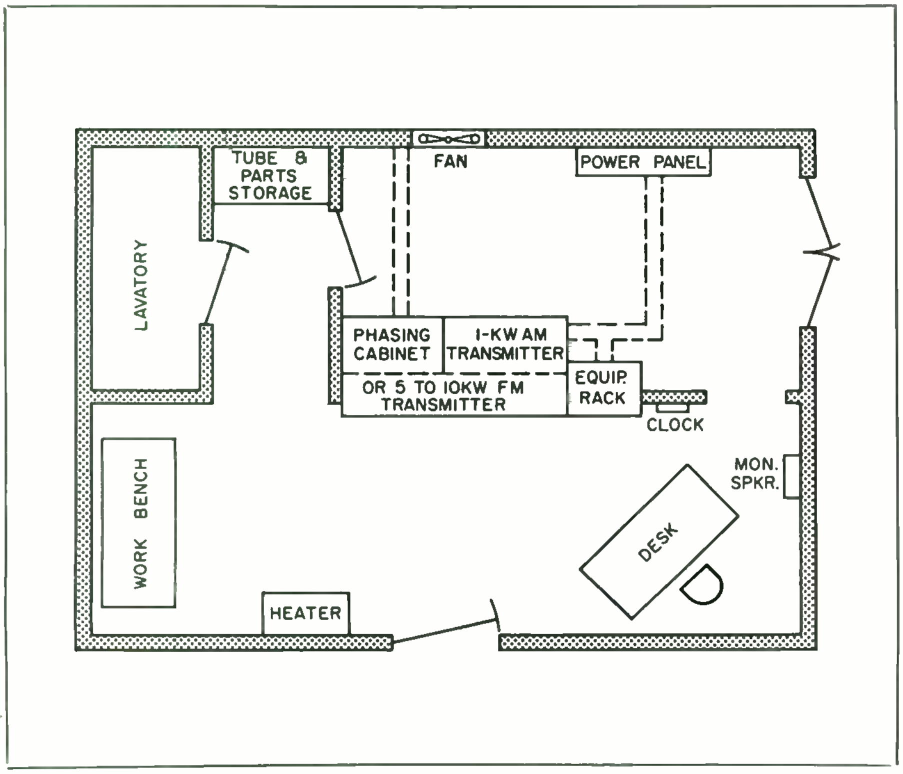

FIG. 1. Typical transmitter building layout for a one-kilowatt AM directional. Floor plan can also accommodate up to a 10-kW RCA FM transmitter.

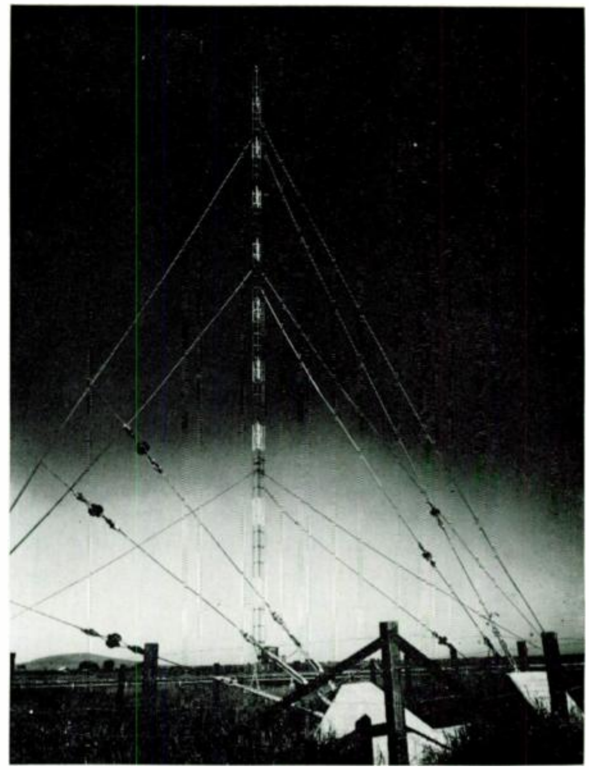

FIG. 2. Insulated guyed tower. Small building at tower base houses antenna tuning unit.

very satisfactory RF radiator for AM installations.

Tower lighting equipment must conform to FCC/FAA requirements as specified on the construction permit. AC lines for tower lighting can either be buried or mounted on the poles supporting the transmission lines. Lighting circuits must be isolated from RF circuits when an insulated tower is used as an AM radiator. This is provided by using either an antenna lighting choke or a lighting transformer. Both devices supply AC to the tower lighting circuits and at the same time prevent appreciable loss of RF energy into the AC power lines.

AM Tower Arrays

An AM station may employ a single tower radiating an omnidirectional signal; but more often, an array employing two or more towers is required to limit radiation in the direction of other stations occupying the same or adjacent frequencies.

Figure 7 illustrates the layout of a typical two-tower directional antenna system. Small buildings have been included at the towers to house the antenna tuning units,

HOW THE ENGINEERING CONSULTANT CAN HELP

At no other phase of station planning are the services of a competent broadcast engineering consultant needed more than in the laying out of the transmitter and antenna installation. Here are some aspects of station design that should be left entirely to him:

- **Establish authorized operating frequency and power**
- **Prepare radiation coverage pattern**
- **Design antenna system and prepare specifications**
- **Perform antenna system tuning adjustments and proof of performance tests for FCC**

isolation coils, lighting chokes and beacon flashers. Phasing and branching equipment and the phase monitor are located in the transmitter building with the transmitter.

The FCC requires that a radiation pattern of the proposed antenna system be filed by applicant prior to the grant of a c-p. The consulting engineer derives this pattern mathematically to produce radiation in the desired direction and at the same time offer the protection required by other stations.

The station's radiation pattern is determined by the number and location of towers, the phase relationship of the RF signal supplied to each tower and the way in which the power is divided among towers. Power distribution and phasing is achieved by the phasing and branching equipment. This equipment is usually located in the transmitter building in a cabinet matching the transmitter. But depending upon requirements, it can be installed on open panels elsewhere in the transmitter building or in a small weatherproof building near the center of the antenna array.

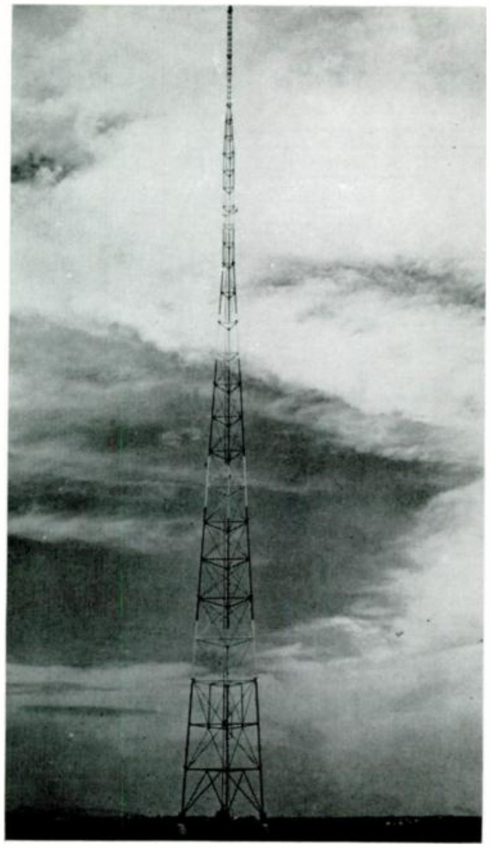

FIG. 3. Self supporting tower. Large base area eliminates need for guys.

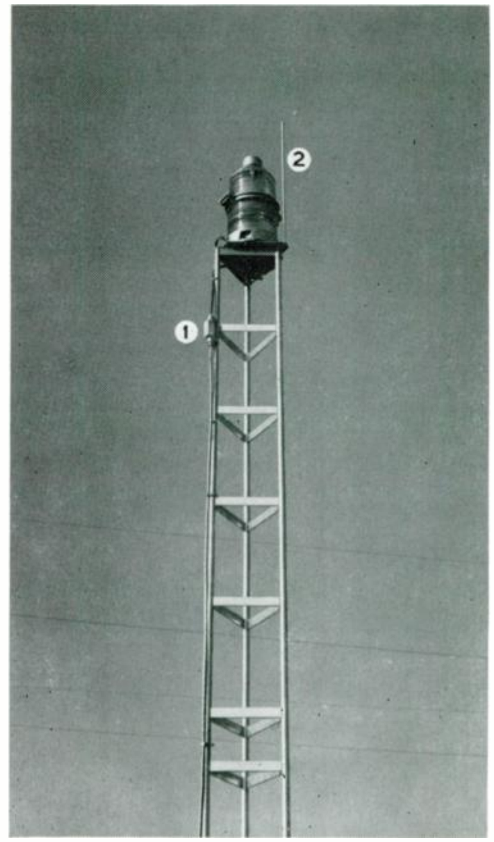

FIG. 4. Tower lighting beacon with junction box (1) and lightning rod (2).

Specifying AM Phasing Systems

The phasing system is the heart of the AM transmitting plant, being called upon to maintain the station's radiation pattern over long periods of time without failure or need for adjustment. Phasing equipment design and cost varies with its quality and complexity. The simplest "jeep" systems employ a single coil with power takeoffs for the various towers in the array. An "ohms law" phasor employs a separate coil for each tower, and features easier setup since there is less interaction between adjustments.

Frequently, requirements for special design or exceptional quality in phasing equipment add a substantial cost factor to the tower system. For this reason, if the filing data submitted to FCC in the application is to be used for cost estimating purposes, it should be accompanied by design information prepared by the consultant that will alert the supplier to the unusual conditions that must be satisfied in the design. Beside the usual array parameters, the data should state:

1. Recommended type and length of transmission line.
2. Type phasor preferred, with components specified, if necessary.
3. Where remote control or front panel control is required.
4. Particular metering requirements.
5. Phasor mounting: in cabinet, open construction.
6. Whether tuning units will be in weather proof houses or of open construction.
7. Monitoring requirements.
8. Tower lighting isolation requirements.

A well prepared specification for phasor design assures a system that will not only comply with FCC requirements, but also be stable, easy to adjust, and require only a minimum of maintenance.

Tower Survey Required

The radiation pattern developed by the engineering consultant is based on theoretical computations and ideal conditions. This makes it extremely important to exercise care in the installation of the system so that variations from the ideal are held to a minimum. Spacing and orientation of towers are extremely critical, since an error in tower alignment may make it impossible to achieve the required radiation pattern. To provide an accurate layout of the antenna towers and satisfy the terms of the specifications, the services of a registered civil engineer or surveyor should be obtained.

Ground Systems

A ground system is required at the base of each tower to simulate as closely as possible the perfectly conducting plane earth assumed in computing the pattern. The ground system usually consists of at least 120 radials of No. 10 soft copper wire, as long or longer than the tower is high. The radials are laid in furrows spaced three degrees apart around the entire tower base. Then a ground screen or mat made of expanded copper mesh is laid over the radials and completely around the tower base, covering an area anywhere from approximately 12 to 24 feet square. The entire system is then bonded together by silver soldering, brazing or welding. In some cases, the ground screen or mat can be replaced by short radials about 50 feet long between the full length radials. All radials should be bonded to a copper strap or to a bundle of seven copper wires around the tower base. It is usual to have a copper grounded strap on each face of the tower support pier. These straps criss-cross under the tower insulator. A similar strap or bundle of wire is required to tie tower bases together as shown in Fig. 11. If the towers are spaced such that the radials do not meet, the radials that can intersect should

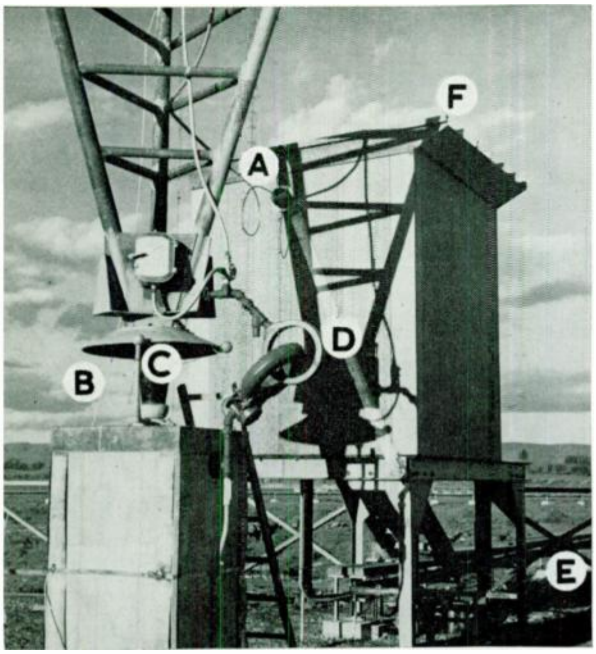

FIG. 5. AM tower showing protective lightning loop (a), tower insulator (b), lightning spark gap (c), Lighting transformer (d), transmission line (e) and tuning equipment house (f).

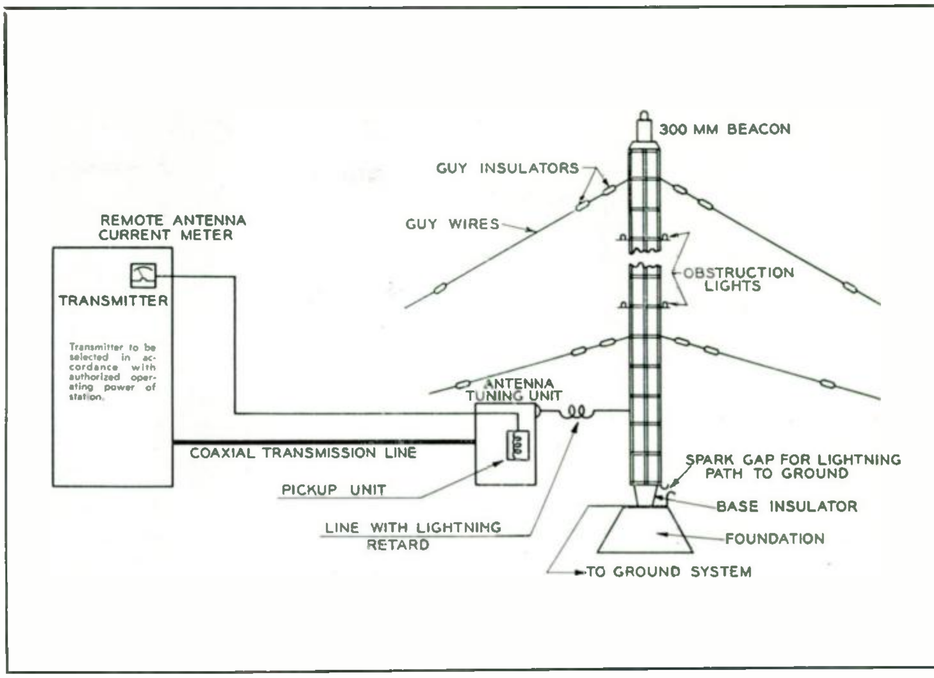

FIG. 6. Typical single tower AM system, showing pickup unit for antenna current measurements, elements of tower installation and position of tower lights.

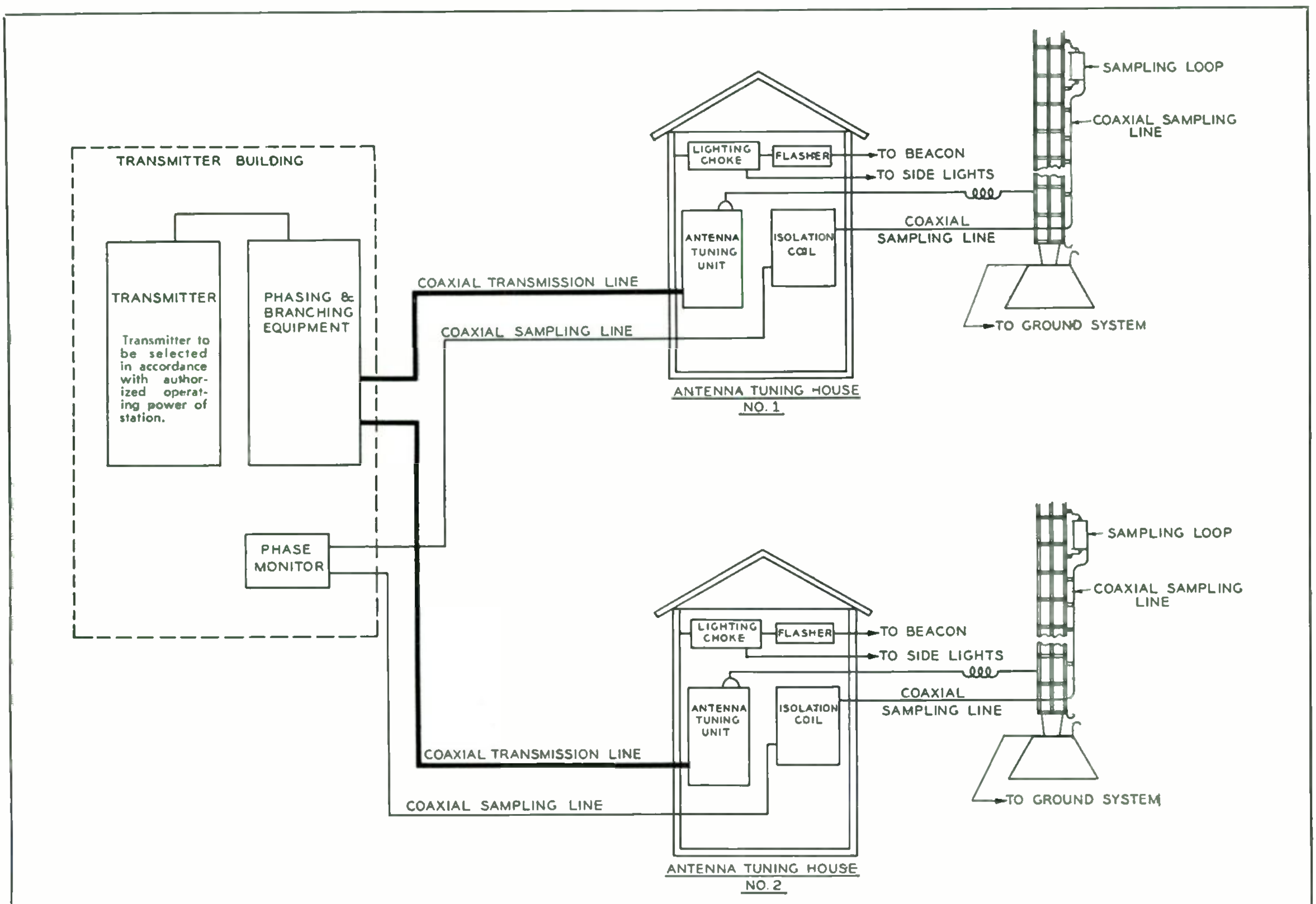

FIG. 7. Typical two-tower directional AM system showing arrangement of phasing and branching equipments.

be extended to a point where they overlap and be bonded in the same way. If the transmitter building is located close to the tower or within the circumference of the ground system, a copper bus or strap should go around the building at the foundation with all radials that approach the building bonded to it. Radials are normally buried just below the surface of the ground, deep enough to protect them from mechanical damage. The actual length and number of radials, the size and shape of the ground system depend upon conditions and should be determined by the engineering consultant.

A chart giving tower height in feet for each 10 kHz increment in the broadcast band is given in Fig. 14.

AM Tower Feed Systems

The two most commonly used methods of feeding tower radiators are the series fed and shunt fed systems diagrammed in Fig. 12. Both systems utilize either 52 or 72 ohm air or solid dielectric coaxial transmission line, and line terminating units (LTU) located in a "dog house" near the base of the tower.

The series fed system requires a tower base insulator, while in the shunt fed system the tower is grounded directly and energy is supplied to the tower via a copper conductor connected to a point well up the tower. The section of tower between the feed point and ground in the shunt fed system serves as an element of sufficient impedance that in combination with the matching network effects a satisfactory transfer of power from the transmission line to the tower.

The transmission line feeding the LTU or ATU (line or antenna tuning unit) can be buried if it is the type of line recommended for that purpose. Alternatively, it can be supported on wood or metal posts and if desired, enclosed in a wood trough for protection against damage from falling ice or other objects. The trough should measure at least four by eight inches, have a removable top and be no more than 36 inches above ground if possible.

Rigid air dielectric coax should always be laid out as straight as possible. Bends, sags or bumps should be avoided, since the flanged seals may have a tendency to leak if there is a bending strain. One end of the line should be anchored and the other left free to move as the line expands and contracts. Portions of the line that run in proximity to the ground system should have the outer conductor bonded to the ground system every 20 feet, preferably to the heavy copper strap running between the towers. In any case, the outer conductor is

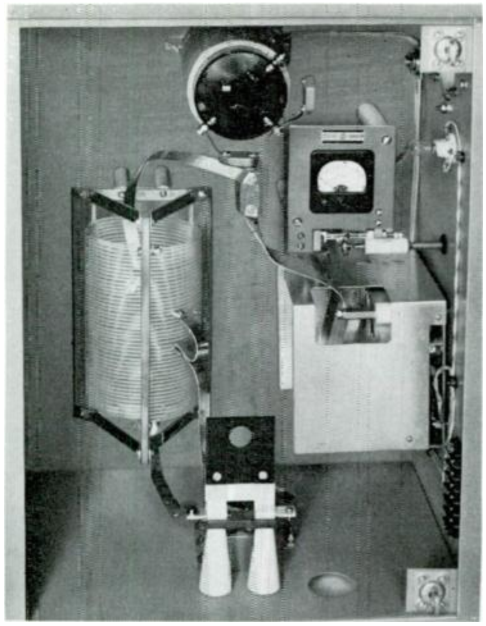

FIG. 8a. Antenna tuning unit. Lighting choke is at top of cabinet.

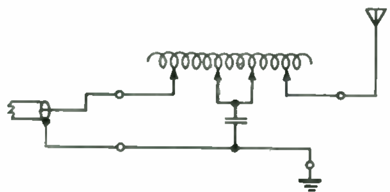

FIG. 8b. Simplified schematic of tuning unit.

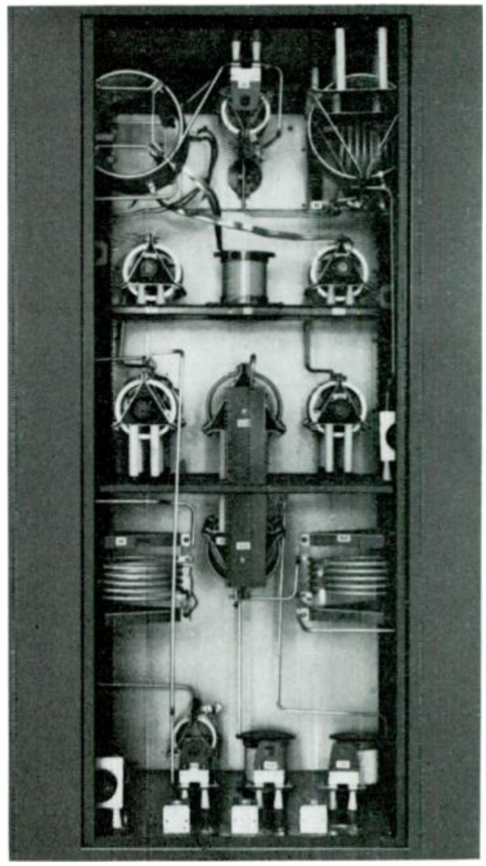

FIG. 9. Phasing equipment for a three-tower system.

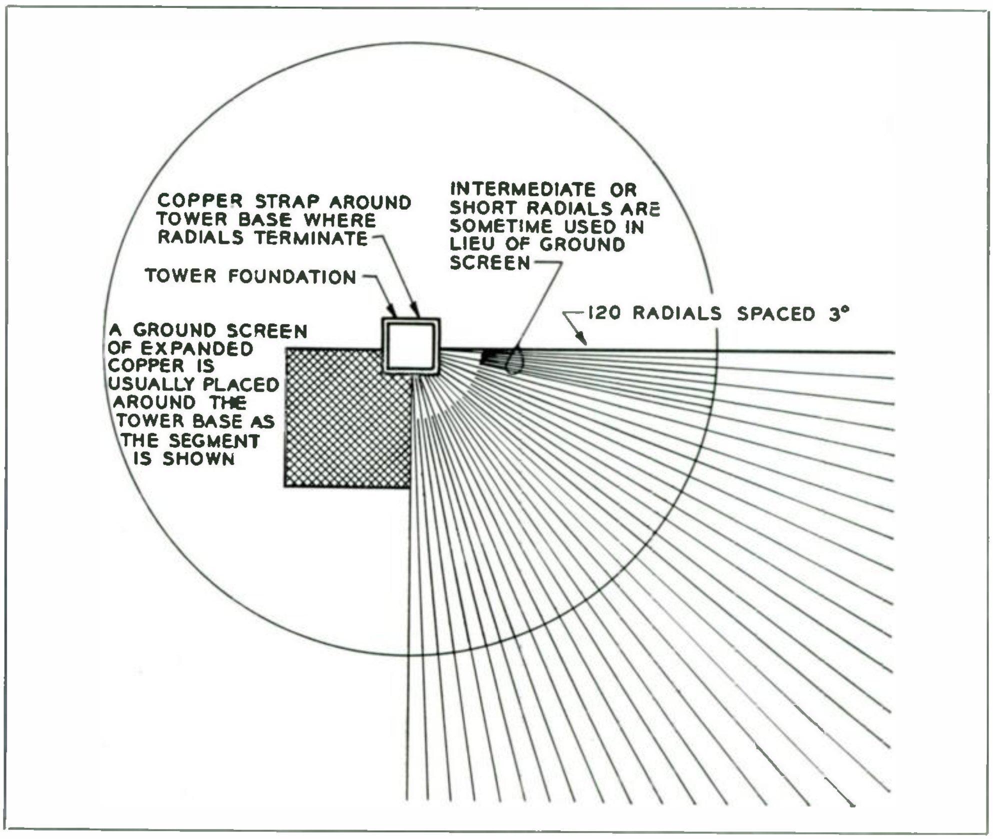

FIG. 10. Typical ground system. Radials and ground screen are positioned all the way around the tower base in each of the four quadrants as shown.

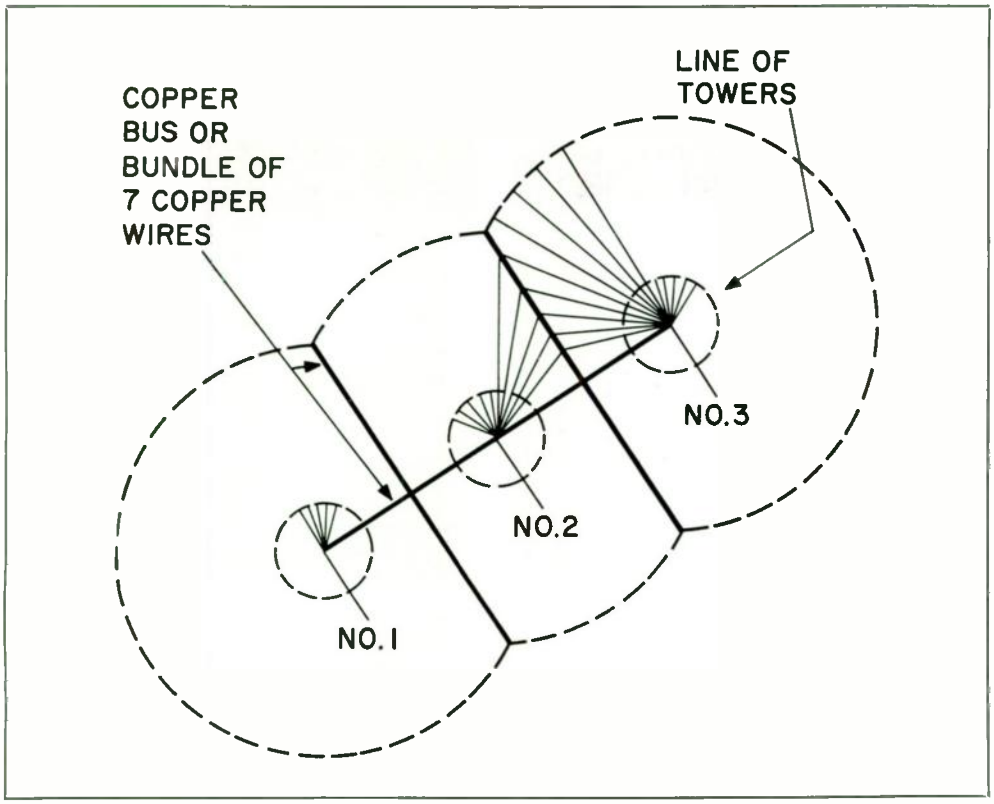

FIG. 11. Ground system for three-tower directional. Diagram shows, in part, ground radials which should be bonded to the main copper busses.

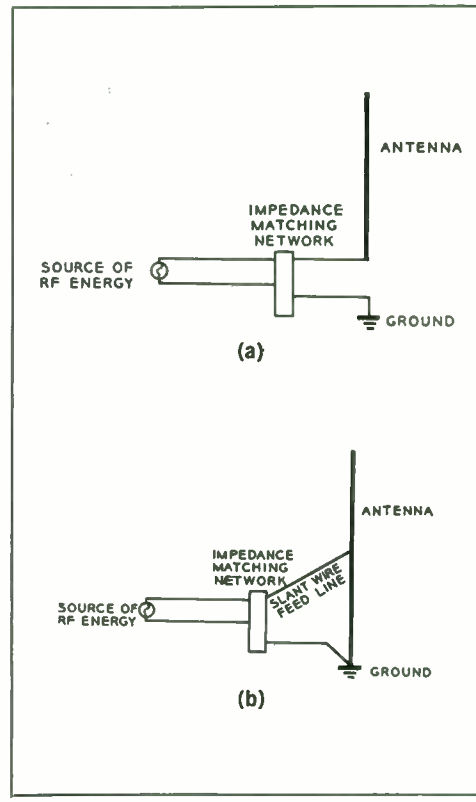

FIG. 12. Schematic representations of series fed tower (a) and shunt fed tower (b).

connected to the ground system of the phasing unit at one end and at the line terminating unit at the other.

Provision should be made so that dry air can be flushed through the line and held at the recommended pressure. All joints, plugs, and end seals should be tested for leaks with a soapy water solution.

RF Sampling

Sampling loops pick up some of the radiated energy from each tower and feed it back to a phase monitor so that the phase relationship between towers can be measured.

There are two methods of sampling. In one, the sampling coil is mounted in the tuning house at the base of the tower so as to sample energy from the LTU. Thus, the sampling coil can be made a part of the line terminating unit or a sampling coil kit can be supplied separately by RCA if desired. The other method of sampling utilizes a shielded or unshielded loop on the tower. Both these methods are illustrated in the simplified diagrams.

Some sort of flexible coaxial line is used for the sampling lines, and they can be either buried in the ground or carried back in the same trough that supports the transmission line. Sampling lines are generally of the same length. They have a characteristic impedance to match the input impedance of the particular phase monitor used. When sampling loops are tower mounted, isolation inductors must be used to bring these lines across the base insulator.

FM Antenna Considerations

Choice of transmitter power and type of antenna can be made only after the station's ERP and antenna radiation pattern (if it is to be directional) is established, and after due thought has been given to the desired polarization of the radiated signal.

ERP as defined by the FCC applies to the measurement of horizontally polarized radiated energy. Today, many broadcasters choose an antenna system that provides some vertical as well as horizontal radiation. This is done to achieve better reception efficiency for car radios and portables with whip antennas and for home receivers with built in or line cord antennas.

The maximum vertically polarized effective radiated power is permitted by FCC to equal but not exceed the horizontally polarized ERP. Thus, a station classified for operation at 50 kW ERP can legally radiate a full 50 kW in the vertical plane as well. This can be done by intermixing vertically

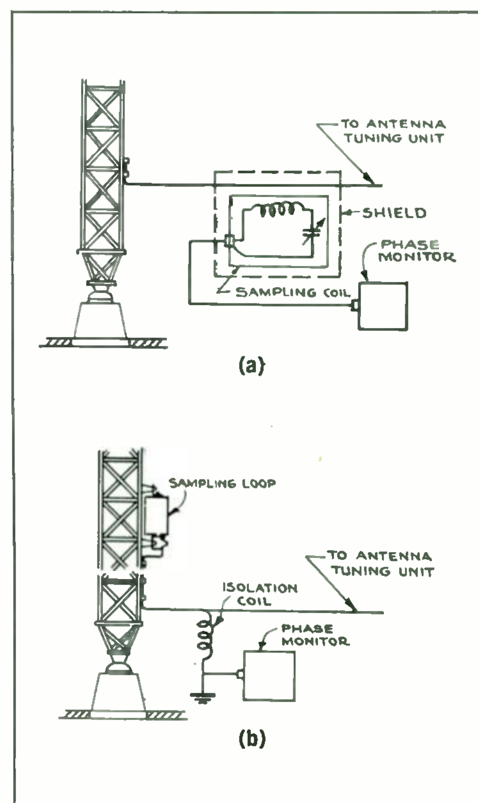

FIG. 13. Two methods of sampling, one employing a coil in the tuning house (a) and the other using a sampling loop on tower (b).

550 KC TO 1070 KC				
KC	METERS	1 WAVE	½ WAVE	¼ WAVE
550	545	1787.6	893.8	446.8
560	536	1758.0	879.0	439.5
570	526	1725.3	862.6	431.3
580	517	1695.7	847.8	423.9
590	509	1669.5	834.7	417.3
600	500	1640.0	820.0	410.0
610	492	1612.7	806.3	403.1
620	484	1587.5	799.7	396.8
630	476	1561.2	780.6	390.3
640	469	1546.3	773.1	386.5
650	462	1515.3	757.6	378.8
660	455	1492.4	746.2	373.1
670	448	1469.4	734.7	367.3
680	441	1446.4	723.2	361.1
690	435	1426.8	713.4	356.2
700	429	1407.1	703.5	351.2
710	423	1387.4	693.7	346.8
720	417	1367.7	683.8	341.9
730	411	1348.0	674.0	337.0
740	405	1328.4	664.2	332.1
750	400	1312.0	656.0	328.0
760	395	1295.6	647.8	323.4
770	390	1279.2	639.6	319.8
780	385	1262.8	631.4	315.7
790	380	1246.4	623.2	311.6
800	375	1230.0	615.0	307.5
810	370	1213.6	606.8	303.4
820	366	1200.4	600.2	300.1
830	361	1184.0	592.0	296.0
840	357	1170.9	585.4	292.7
850	353	1157.8	578.9	289.4
860	349	1144.7	572.3	286.1
870	345	1131.6	565.8	282.9
880	341	1118.4	559.2	279.6
890	337	1105.3	552.6	276.3
900	333	1092.2	546.1	273.0
910	330	1082.4	541.2	270.6
920	326	1069.2	534.6	267.3
930	323	1059.4	529.7	264.8
940	319	1046.3	523.1	261.5
950	316	1036.4	518.2	259.1
960	313	1026.6	513.3	256.6
970	309	1013.5	506.7	253.3
980	306	1003.6	501.8	250.9
990	303	993.8	496.9	248.4
1000	300	984.0	492.0	246.0
1010	297	974.1	487.5	243.7
1020	294.1	964.6	482.3	241.1
1030	291.3	955.3	477.6	238.8
1040	288.5	946.2	473.1	236.5
1050	285.7	937.1	468.5	234.2
1060	283.0	928.2	464.1	232.0
1070	280.4	919.7	459.8	229.9

1080 KC TO 1600 KC				
KC	METERS	1 WAVE	½ WAVE	¼ WAVE
1080	277.8	911.1	455.5	227.7
1090	275.2	902.6	451.3	225.6
1100	272.7	894.4	447.2	223.6
1110	270.3	886.5	443.2	221.6
1120	267.9	879.0	439.5	219.7
1130	265.5	870.8	435.4	217.7
1140	263.2	862.6	431.3	215.6
1150	260.9	855.7	427.8	213.9
1160	258.6	847.8	423.9	211.9
1170	256.4	840.9	420.4	210.2
1180	254.2	834.7	417.3	208.6
1190	252.1	826.8	413.4	206.7
1200	250.0	820.0	410.0	205.0
1210	247.9	813.1	406.5	203.2
1220	245.9	806.3	403.1	201.5
1230	243.9	799.1	399.5	199.7
1240	241.9	793.7	396.8	198.4
1250	240.0	787.2	393.6	196.8
1260	238.1	780.9	390.4	195.2
1270	236.2	774.7	387.3	193.6
1280	234.4	768.8	384.4	192.2
1290	232.6	762.9	381.4	190.7
1300	230.8	757.0	378.5	189.2
1310	229.0	751.1	375.5	187.7
1320	227.3	746.2	373.1	186.5
1330	225.6	739.9	369.9	184.9
1340	223.9	734.7	367.3	183.6
1350	222.2	728.8	364.4	182.2
1360	220.6	723.2	361.1	180.5
1370	219.0	718.3	359.1	179.5
1380	217.4	713.4	356.2	178.1
1390	215.8	707.8	353.1	176.5
1400	214.3	703.5	351.2	175.6
1410	212.8	696.9	348.4	174.2
1420	211.3	693.7	346.8	173.4
1430	209.8	688.1	344.0	172.0
1440	208.3	683.8	341.9	170.9
1450	206.9	678.6	339.3	169.6
1460	205.5	674.0	337.0	168.5
1470	204.1	669.4	334.7	167.3
1480	202.7	664.2	332.1	166.5
1490	201.3	660.2	330.1	165.0
1500	200.0	656.0	328.0	164.0
1510	198.7	651.7	325.8	162.9
1520	197.4	647.8	323.4	161.7
1530	196.1	643.2	321.6	160.8
1540	194.8	639.6	319.8	159.9
1550	193.5	634.6	317.3	158.6
1560	192.3	631.4	315.7	157.8
1570	191.1	626.8	313.4	156.7
1580	189.9	623.2	311.6	155.8
1590	188.7	618.9	309.4	154.7
1600	187.5	615.0	307.5	153.7

FIG. 14. Footage table for broadcast tower heights.

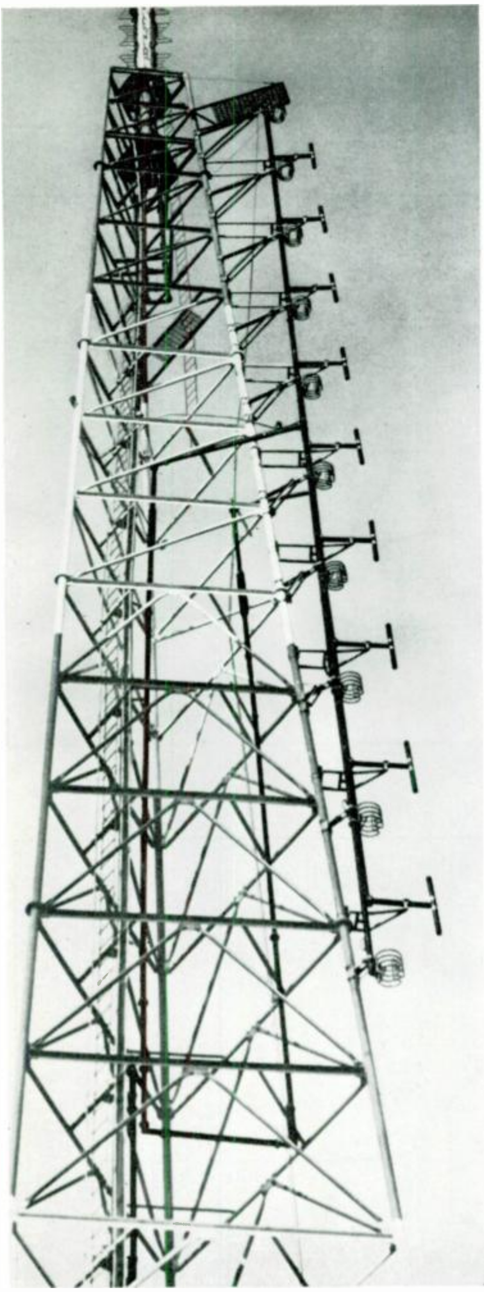

FIG. 15. Interlaced BFA-10 and 300-9V antenna elements side mounted on TV tower.

and horizontally polarized antennas (or by existing stations adding a vertically polarized antenna to their present system) or by installation of a circularly polarized antenna. Each method, of course, requires either additional transmitter power or higher antenna gain to match the original ERP obtained from simply a horizontally polarized radiator.

Achieving V/H Polarization

A signal containing both vertically and horizontally polarized electric vectors can be obtained by: (1) mounting both vertically and horizontally polarized antennas on the tower, and using a power divider either at the base of the antenna or at the transmitter building to split the feed to both antennas; and (2) by using a circularly polarized antenna. For these uses, RCA offers these three antennas: the Type 300-V vertically polarized coaxial antenna rated for power up to 3 kW per section: the Type BFA horizontally polarized antenna for up to 5 kW per section: and the BFC circularly polarized antenna rated at 10 kW per section.

Combined vertically polarized and horizontally polarized antennas are more expensive than the circularly polarized antenna, but they may be of special advantage to broadcasters who already have horizontally polarized antennas and wish to add vertical radiation to their system. The dual antennas for this purpose should have essentially the same gain. They can be mounted in almost any position on the tower, but preferably they should be mounted at the same height and the V and H elements interleaved. Antennas of equal gain mounted this way and fed in quadrature radiate an elliptically or circularly polarized wave. While as yet there is no proof, circular polarization is generally considered superior to that produced by a hap-hazard combination of vertically and horizontally polarized radiating elements. These dual antennas also have the disadvantages of additional weight and higher wind loading than that of a single antenna such as the BFC.

Circular Polarization

Circularly polarized radiation with low VSWR for optimum stereo and multiplex operation can be obtained from any of the BFC Series of FM antennas. These antennas provide equal vertical and horizontal power gains from 0.46 for a single section, to 8.9 for 16 stacked sections. No external combiner is required since power division is accomplished within the antenna. The BFC antenna has a power capability of up to 10 kW per section.

As in the case of the combined antennas, the circularly polarized antenna will require either twice the transmitter power or twice the antenna gain for a given ERP obtained from the horizontally polarized only antenna. This can be seen by comparing the systems. Transmitter power and antenna gain requirements are computed as follows:

$$ERP = P \times G \times Eff$$

where:

P = Transmitter Output Power

G = Antenna Power Gain

Eff = Transmission Line Efficiency

For purposes of simple calculation, it can be assumed that the BFC circularly polarized antenna has a gain of approximately 0.5 per section. For the BFA horizontal radiator as well as the 300-V vertical, the gain is approximately 1.0 per section. Therefore, for either the combined V and H antenna or the circular antenna, the gain should be calculated at ½ per section since power fed to each antenna system is equally divided between the vertically and horizontally polarized modes. This method is useful

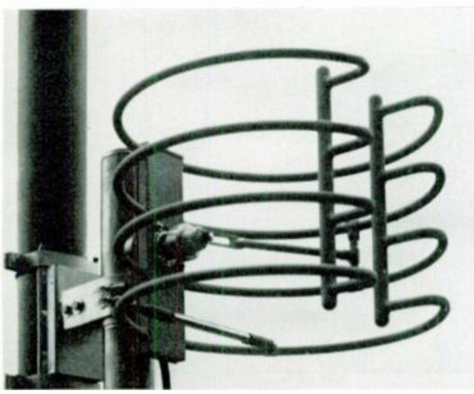

FIG. 16. Radiating element of BFA horizontally polarized FM antenna.

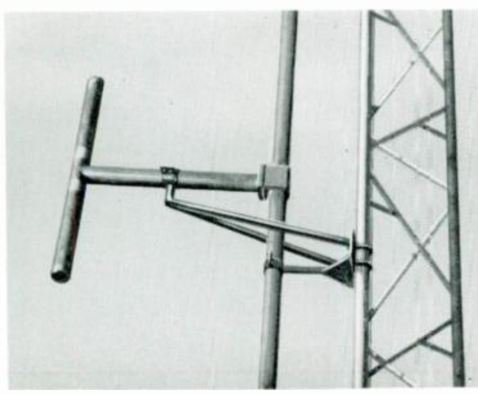

FIG. 17. Radiating element of 300-V vertically polarized FM antenna.

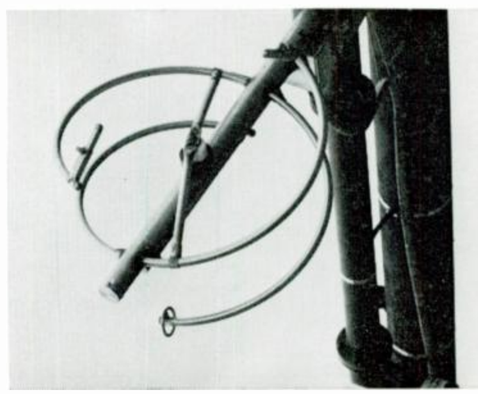

FIG. 18. Radiating element of BFC circularly polarized FM antenna.

TABLE 1. TYPICAL POWER CALCULATIONS

POLARIZATION	TRANSMITTER OUTPUT POWER	(X)	TRANSMISSION LINE EFFICIENCY	(X)	ANTENNA POWER GAIN	(=)	ERP
Circularly Polarized Antenna (BFC-6)							
Horizontal	17.16 kW		0.91		3.2		50 kW
Vertical	17.16 kW		0.91		3.2		50 kW
Note: Total Power Output Requirement is 17.16 kW							
Combined Antennas (BFA-6B and 300-6V)							
Horizontal	8.71		0.91		6.3		50 kW
Vertical	8.60		0.91		6.39		50 kW
Note: Total Power Output Requirement is 8.71 kW plus 8.60 kW or 17.31 kW							

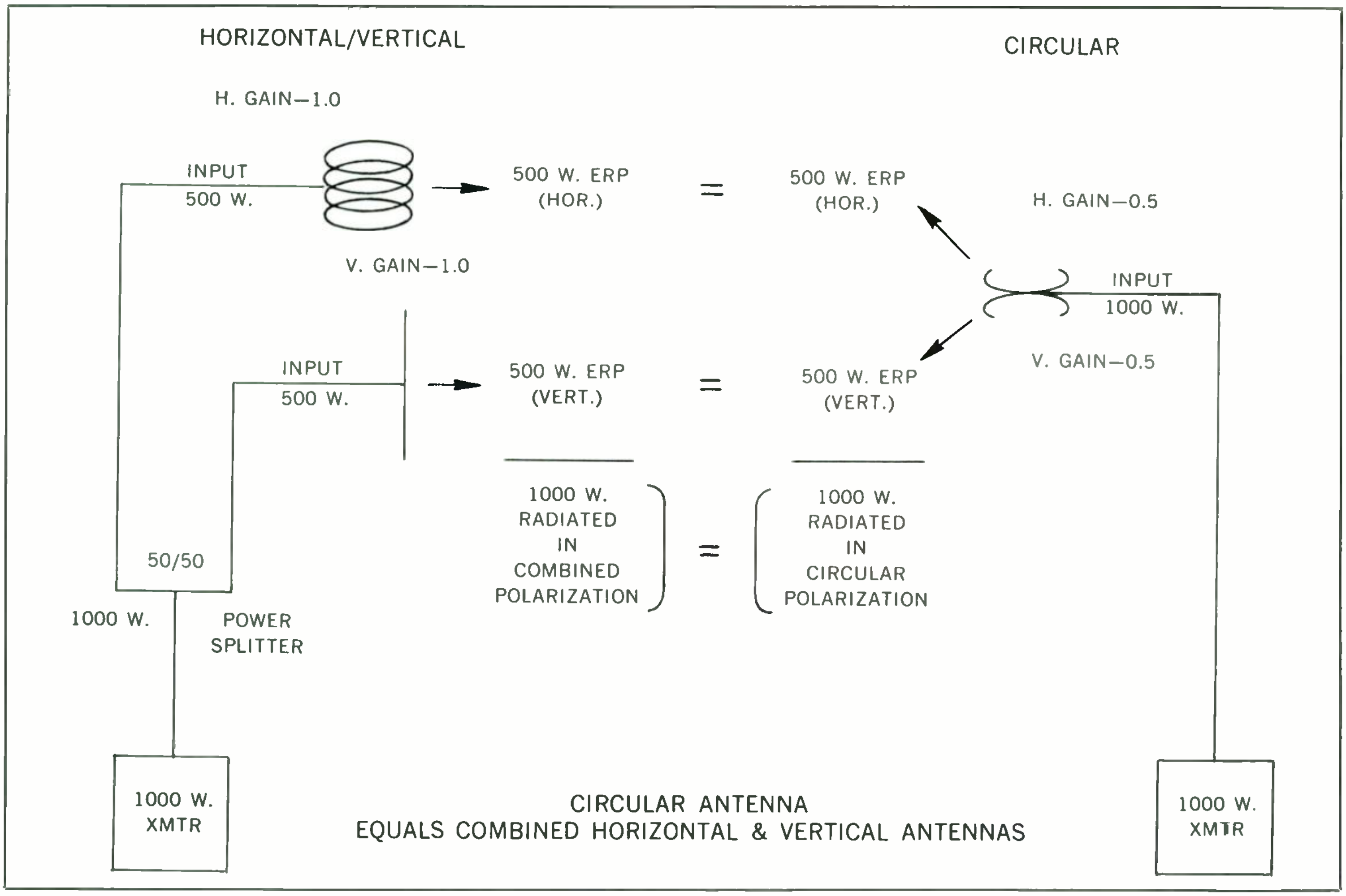

FIG. 19. Chart comparing feed systems and effective radiated power of circularly polarized antenna with combined horizontally and vertically polarized antennas. No power splitter is required for the BFC type antenna.

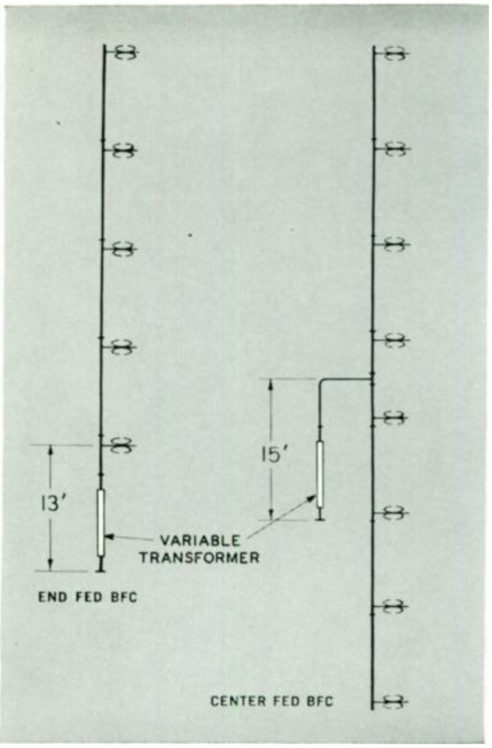

FIG. 20. Simplified diagram showing feed line input locations for end-fed and center-fed BFC antennas. Types with one to seven sections are end-fed, and eight to sixteen, center-fed.

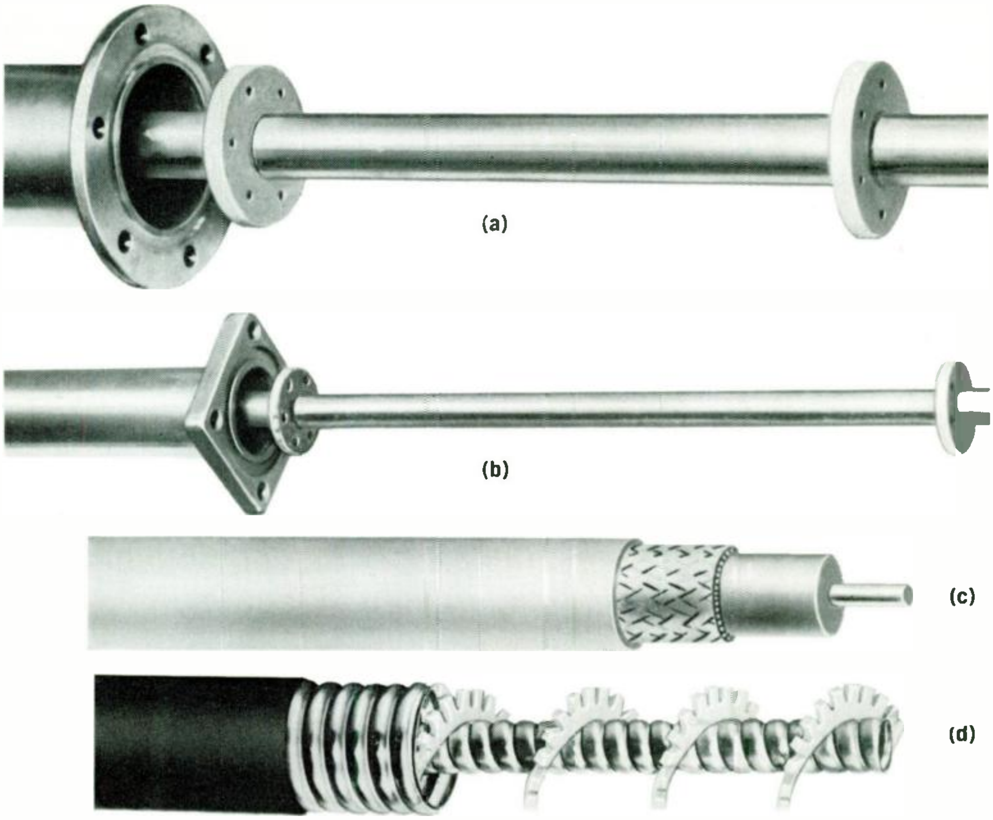

FIG. 21. Types of transmission line. Rigid 3⅛-inch copper (a), rigid 1⅝-inch copper (b), flexible RG cable (c) and flexible Heliax cable (d).

in determining the transmitter and antenna size needed to achieve a given ERP. The consultant or chief engineer filling out the application will of course use exact antenna gain figures, and in the case of a combined antenna system will take into account the required power splitting ratio (typically a ratio of 52/48 percent horizontal input power to vertical input power).

Typical calculations for both a circularly polarized antenna and a combination of a horizontally polarized antenna, plus a vertically polarized antenna appear in Table 1, assuming in each case a 50 kW ERP, use of a 20 kW transmitter and 300 feet of 3-inch Heliax® air-dielectric transmission line.

Mounting FM Antennas

FM antennas of any type can be mounted on top the tower, or side mounted on a face or a leg of the tower. Side mounting is more popular where FM is to be added to an existing AM (or TV) tower because it does not affect the electrical height of the radiator. Changing the effective height of an AM radiator can upset a phased array, requiring FCC and FAA approval for the increased height, and retuning of the system to compensate for the additional height.

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Conversely, the supporting structure always has some effect on the radiated pattern of the FM antenna. Usually, the smaller the structure, the less the effect, but the exact extent of the supporting structure's influence on a radiation pattern is difficult to predict. Side mounting of an FM antenna on a self supported tower introduces a further complication in that the taper of the tower may distort the elevation pattern as well as the azimuthal pattern.

The effect of the structure on the azimuthal radiation pattern of a vertically polarized wave is considerably greater than for the azimuthal radiation pattern of a horizontally polarized wave because there are more vertical components in the structure than horizontal.

For azimuthal horizontally polarized radiation, minimum effect (of the order of ± 1 dB) is obtained with a top mounted antenna. This effect is somewhat greater but still tolerable for antennas side mounted on a tower of 18 to 24 inches cross section but increases rapidly and less predictably for larger cross sections. The size and number of cross members in a tower, the presence of transmission lines and lighting wires, all have a decided influence on any type of FM antenna.*

* This subject is discussed in detail in an article that appeared in *Broadcast News,* Vol. 119, February, 1964.

The net result is that the coverage is generally, but not always, best in the direction the antenna is facing (away from the tower).

Transmission Lines

AM and FM antennas can be fed with rigid coaxial copper lines of either 1⅝-inch or 3⅛-inch outer diameter depending upon power levels used, or with Heliax air or foam dielectric semi-flexible line. In AM applications 1⅝-inch rigid copper line will handle up to 25 kW and 3⅛-inch rigid copper line will handle up to 94 kW. Heliax is available in many sizes and in either air or foam dielectric types having peak power ratings ranging from 2.0 to 820 kW. At FM frequencies, 1⅝-inch line is derated to 10 kW and 3⅛-inch line to 40 kW. The power rating of the various sizes and types of Heliax are similarly derated when used for FM. RG cable is inexpensive and suitable for low power AM requirements.

Attenuation must also be considered when selecting the proper size and type of line. It is often necessary when long transmission line runs are used to select larger or more efficient lines than indicated by power considerations alone.

The VSWR requirements of an AM or FM antenna system also influence the size of the line needed for a given application.

FM antennas can be adjusted to VSWR's of 1.1:1 or 1.18:1 depending on whether single or combined vertically and horizontally polarized antennas are employed. Before (or without) adjustment the VSWR may be as high as 1.5:1 or 1.8:1. In AM applications, VSWR's of 1.5:1 to 2.0:1 are not unusual. Remember also that the peak power output of an AM transmitter is four times the carrier level.

Details of RCA rigid copper transmission lines, Heliax transmission lines and RG type cables are given in the RCA AM/FM transmission line catalog. The choice of type and size of transmission line for critical applications should be made by the consultant.

The semi-flexible, foam dielectric Heliax is lighter and bends more easily than rigid copper line, and it requires no pressurizing. This is an advantage particularly in areas where the line might otherwise be subject to vandalism or accidental damage by hunters' firearms. It should be noted, however, that the feedlines to the FM antennas should be pressurized. Therefore, if foam dielectric cable is used up to this point, a small copper line will have to be run up the tower to pressurize the feedlines and combining harness.

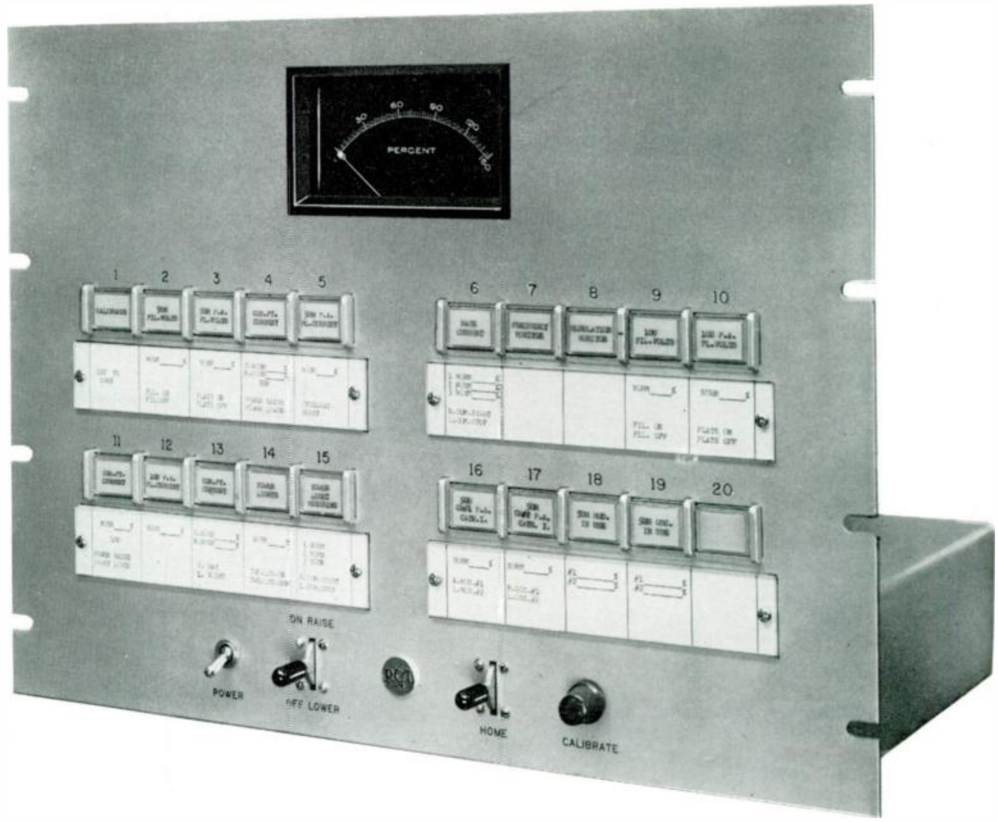


FIG. 22. RCA BTR-20D Remote Control System.

Remote Control

Remote control makes possible an unattended transmitter. This eliminates human environmental requirements in a remote transmitter building, saves space and relocates transmitter personnel to perform duties in the studio or other areas of the station.

A remote control system should be capable of extending from the transmitter to the studio at least four control functions and five metering functions. The control functions are filament power on/off, plate power on/off, power output raise/lower, and overload reset. The five metering functions are plate current, plate voltage, antenna current, frequency deviation and modulation monitor. These meet the basic requirements of FCC. Many AM and FM installations, however, require a much greater number of functions. And, even one or two control functions above requirements should be available in the system for emergencies or for future assignment.

Remote control requires that the transmitter incorporate the necessary relays, motor driven controls and meter shunts. All RCA transmitters produced in recent years have these provisions built in. Transmitters without them, in many instances, can be modified to include the necessary equipment. Extremely high reliability and stability of the equipment are of utmost importance in a remote control installation,

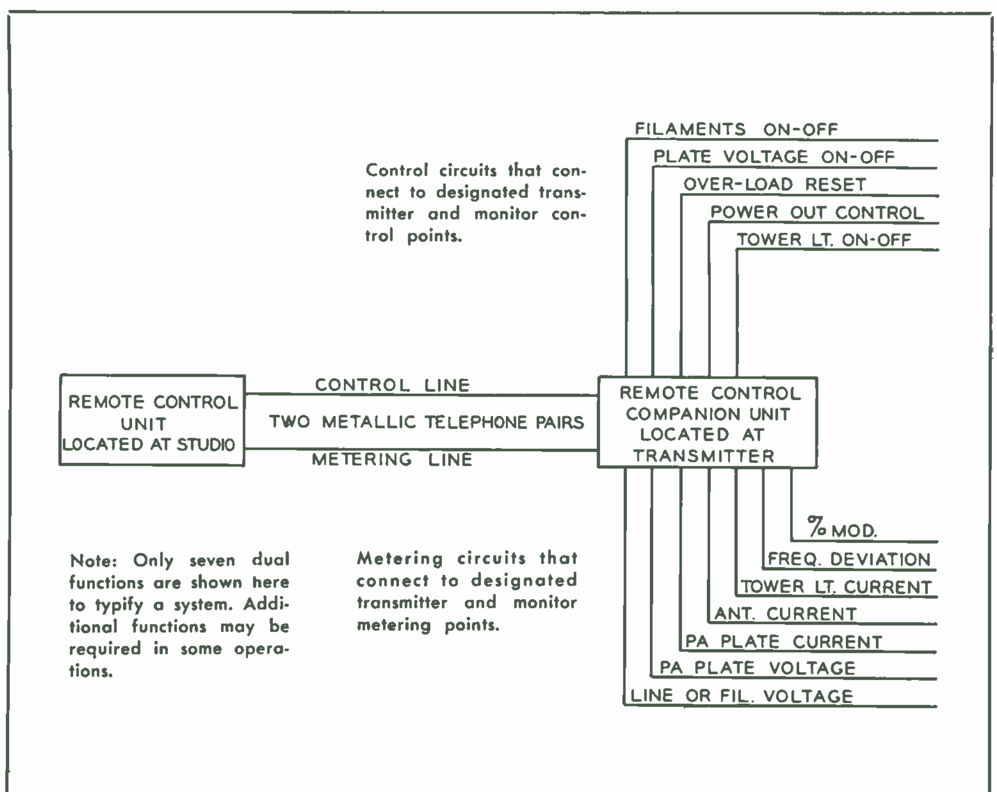


FIG. 23. Block diagram of typical remote control system. Two telephone lines are used between studio and transmitter, one for control, the other for monitoring. Additional functions may be added to system. Equipment is available to convert the BTR-20D to tone operation, permitting operation on a single voice-grade telephone line or microwave link.

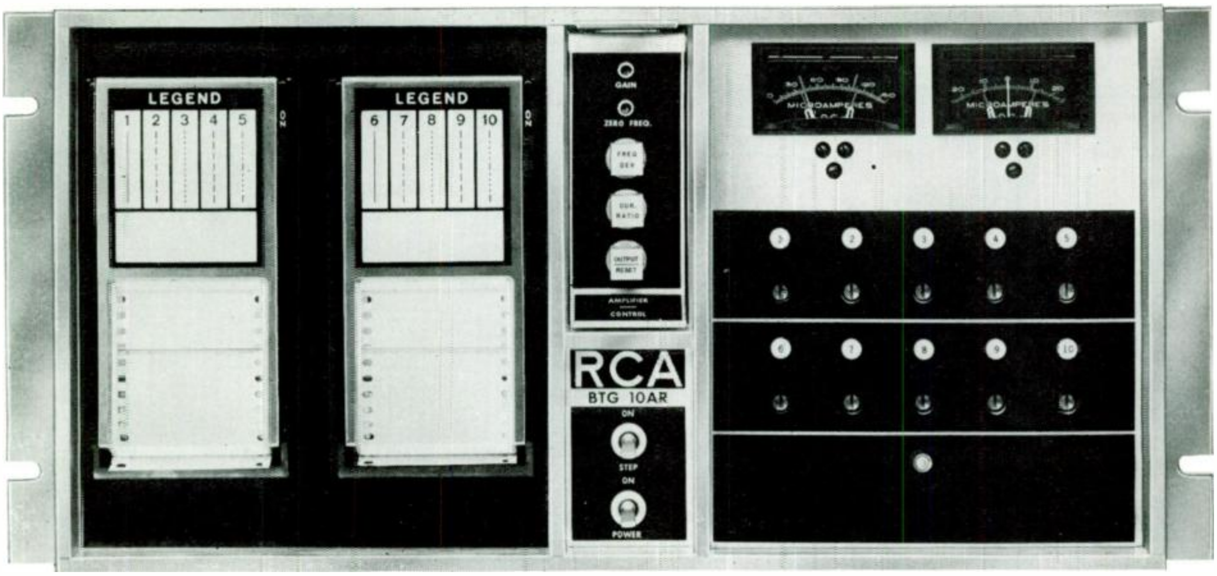


FIG. 24. RCA Type BTG Automatic Logging Equipment. Six systems are available providing local or remote logging of up to 20 functions.

because a minor fault resulting in a power shutdown may cause considerable loss of air time.

Basic Systems

RCA offers two basic remote control systems, a Type BTR-11B providing 11 control and 11 metering functions, and a BTR-20D that performs 20 control and 20 metering functions. Both include "home" and "calibrate" positions which utilize one control and one metering function in each system. The 20/20 system is expandable to 40/40 by using an RCA BTRX-40A extension unit.

Figure 23 is a simplified diagram of the remote control equipment showing the "master" unit at the studio and the "slave" unit at the transmitter. Control orders are sent to the transmitter via telephone lines. A second telephone pair with a 5,000 ohm loop resistance carries metering information back to the studio.

Equipment is available for conversion of the BTR-20D Remote Control System to tone operation. This permits operation on a single voice-grade telephone line or microwave equipment.

Control and metering signals between the units consist of four DC voltages (positive, negative, high level, low level) and a 60 cycle tone. The tone is a fail-safe feature that removes the transmitter from the air (as required by FCC) should any fault or loss of power develop in the control circuits.

In the tone version, discrete tones are substituted for the DC and 60 cycle signals.

Accessories may be added to perform virtually any operation such as the switching in of an emergency power plant, measurement of antenna base currents in large arrays, tower light metering, standby transmitter switching, antenna pattern switching and many others. In addition, a Type BTRA-5C Tone Alarm system that utilizes the same remote control lines as the BTR units is available to detect as many as five separate conditions such as building over temperature, smoke, burglary, in fact, any condition that can be electrically sensed.

Automatic Logging

RCA automatic logging equipment is designed to record all operating parameters required by FCC regulations as well as other important functions. Equipment supporting 5, 10 and 20 functions is available for local operation, or for remote operation in conjunction with RCA BTR Remote Control systems.

Easily read, single point strip chart recorders log up to five operating parameters each. Parameters are selected sequentially by a stepping switch. Each function is recorded within a two second period. Chart paper is the inkless pressure sensitive type requiring a minimum of attention.

Various transducers are available to provide the standard one-volt DC required for full scale readings. The system also may be expanded to include the BTRA-5C Tone Alarm.

The control module of the BTG Series Logging systems is a self contained, solid state plug-in device. The operational amplifier, also plug-in, is stabilized by approximately 80 dB of feedback. Only solid state electronic switching is employed.

Construction and Installation Notes

Construction of the station and installation of equipment will vary with the station plan, local conditions and other factors. During this time, the advice of an engineering consultant is a necessity. Plans and equipment requirements should be reviewed with the consultant and with an RCA broadcast sales representative.

A typical work schedule is given in Table 2, and is as follows: tower foundations, tower erection, tower lighting equipment, buildings, ground system, inside technical equipment, antenna resistance measurements, equipment tests, tuneup of phasing equipment, pattern measurements, proof of performance, and program tests. A delivery schedule should be worked out with the supplier to assure arrival of items when they are needed.

Tower Construction

Towers must be designed to withstand the maximum wind velocities that may be encountered. Tower foundation specifications for a given tower and for normal soil conditions having an allowable pressure of 4,000 pounds per square foot, will be supplied by the tower manufacturer. If soil conditions are abnormal, or not known, test borings may be necessary as a worthwhile safety measure. Foundations and guy anchors should be poured at least a week or ten days before any load is applied. The curing time will vary with location and conditions. However, during this period the tower sections can be painted, guy wires fabricated and the tower lighting kit prepared for installation.

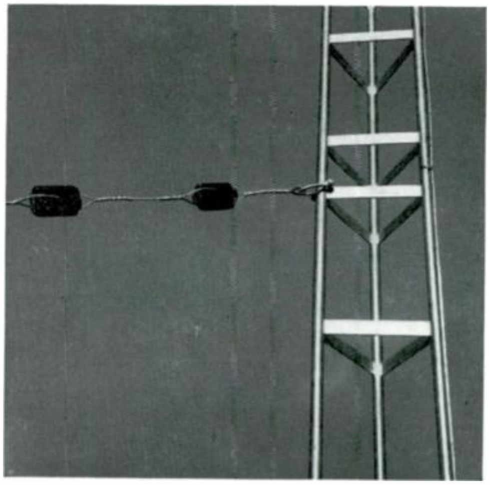
Towers for directional arrays should be as nearly identical as possible with respect to guy wires, height, azimuth location, positioning of guy insulators, etc. After erection, all towers should be inspected to be sure bolts are pulled tight to assure a continuous steel radiator. Painting and lighting must be in accordance with FAA requirements. Guy tensions must be uniform and towers plumb.

Until RF is fed to the tower, a temporary ground should be connected to the tower itself to minimize the possibility of damage due to static charges or lightning during the construction period.

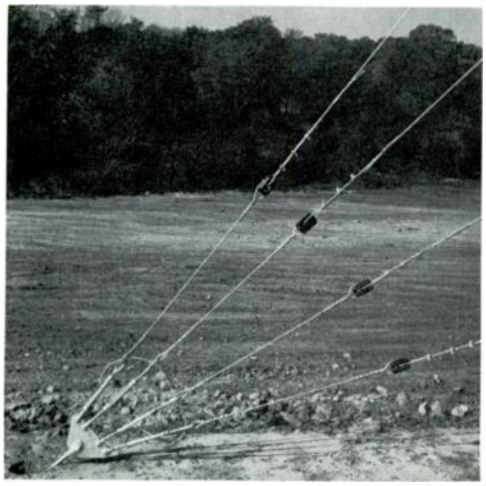
TABLE 2. SUGGESTED CONSTRUCTION PROCEDURES

1. Review plans and equipment requirements with RCA broadcast sales representative and consultant. Make sure equipment list is complete.
2. Obtain services of qualified civil engineer or surveyor to lay out antenna tower system.
3. Proceed with tower foundations, tower erection, tower lighting.
4. Construct buildings.
5. Install ground system.
6. Install transmission lines, sampling lines, AC lines and intercommunication line supports.
7. Complete electrical work, transmission line and sampling line runs. Install line terminating units. Make antenna resistance measurements.
8. Arrange with consultant for phasing of array and making proof of performance measurements.

(a)



(b)



(c)

(d)

FIG. 25. Tightly bolted tower sections to provide good electrical conductivity (a); insulators in typical guy point assembly should be larger at this point to reduce hazard of static discharge from guy wire to tower (b); ground anchor point showing cable looped through turnbuckles to prevent turning (c); lightning spark gap at base of tower and criss-crossed ground straps beneath insulator (d).

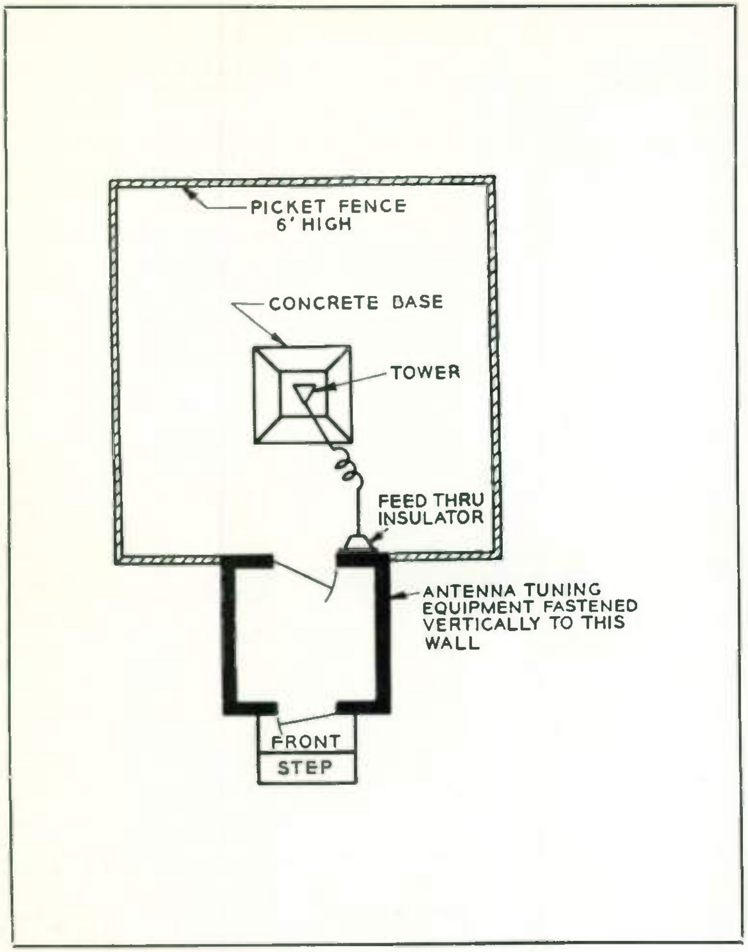


FIG. 26. Plan view of typical antenna tuning house and area at base of tower.

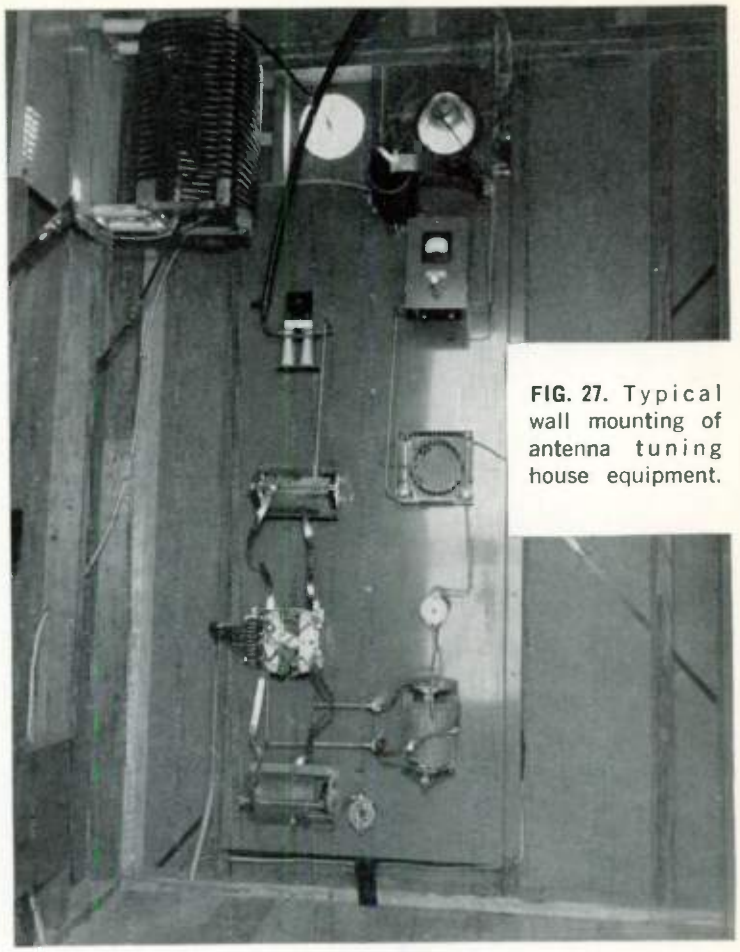


FIG. 27. Typical wall mounting of antenna tuning house equipment.

A fence is usually placed around each tower to prevent unauthorized entry or vandalism. If this structure is metal it should be bonded to the ground system, and its construction completed before any impedance measurements are made on the tower.

Lightning and Static Protection

All insulated AM towers should include a ball gap installed on or across the base insulator. Although a properly adjusted ball gap will often provide all the lightning and static protection needed, it is frequently desirable to add a static drain resistor or static drain choke in each antenna tuning unit to prevent static accumulation on the tower. It may also be desirable to specify a larger than usual number of tower-to-guy-wire insulators in order to reduce the frequency of guy wire to tower static discharges.

In severe cases the addition of static drain resistors across the guy wire insulators may prove helpful in preventing damage to guy wires resulting from continuous arcs struck from static discharges. Consideration should be given to matters such as larger guy wire insulators or the addition of static drain resistors before the tower is selected and installed, since these measures may require a heavier tower structure than would otherwise be necessary.

The connection from the antenna tuning unit to the tower should consist of heavy copper tubing formed to provide a one or two turn coil approximately 8 to 12 inches in diameter. This small inductance will help retard lightning discharges through the antenna tuning unit. In some cases the tower lighting wires or the phase sampling line can be installed inside this tubing.

Building Construction

Figures 26 and 27 suggest layout plans for a tuning house at the base of the tower. Tuning houses should be as entry proof as possible. They should be provided with light, power and at least two power outlets. Ordinarily they need not be shielded. A heavy ground strap is required to bond the tuning panel to the ground system. A sound powered telephone between towers and transmitter building will aid in tower construction and future servicing. It is good practice to make sure that all metals utilized anywhere in the station, such as ductwork, conduits, metal window frames, cabinets, etc., are bonded together and securely connected to the station's ground system. Proper ventilation and cooling should be provided for the technical equipment. Areas that are soundproofed, such as the studios, should be well ventilated.

Proof of Performance

Before the station is authorized to go on the air, it will be necessary to submit a proof of performance that the directional antenna as installed meets the requirements of the construction permit and good engineering practice. In addition, the usual proof of transmitter performance measurements are required. These measurements will be made from microphone terminals at the studio to antenna output, thus including the effect of the telephone line.

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