B SELF-SUPPORTING TOWERS
FOUNDATIONS

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1. GENERAL

1.01 This section describes the reinforced concrete foundations for B self-supporting towers.

1.02 This section is reissued to revise information on the following items:

(a) Foundation dimensions

(b) Reinforcing steel sizes

(c) Quantities of concrete required for foundations

(d) Station grounding.

1.03 Local or state laws may require the approval of foundation designs by a professional engineer duly registered and licensed to practice in that state. To facilitate checking the foundation designs, the loads imposed by the towers are tabulated in Part 5.

1.04 A permit to erect and operate a radio system is required by the Federal Communications Commission. Local regulations may also require construction permits. All required permits should be obtained before starting foundation construction.

1.05 The foundation designs shown in this section assume soil adequate to withstand a pressure of 4000 pounds per square foot. In locations where the soil is not capable of satisfactorily bearing this load, soil stabilization or foundations specifically designed to meet local conditions will be required. Investigation has indicated that most Bell System tower locations have soil with a bearing capacity of 4000 pounds per square foot or greater; however, soil with very poor bearing characteristics (as low as 1500 pounds per square foot) has also been found. If there is any doubt concerning the adequacy of the bearing characteristics of the soil at a proposed tower location, actual bearing characteristics of the soil should be determined by suitable tests performed by specialists in soil mechanics.

1.06 The foundations are required to support the weight of the tower and to resist the overturning moment resulting from wind pressure on the tower and its attachments. Depending upon the direction of the wind, a footing will be subject to either a down load or an uplift.

1.07 In some localities, bedrock will be encountered before the designed depth for the foundation mats is reached. Rock excavation is comparatively expensive and economies may be realized by using specially designed foundations anchored in the bedrock. The anchorage must be sufficiently strong to resist the uplifting force. The type, depth, and number of anchors required are dependent upon the type, stratification, inclination of the rift, etc, of the rock. The cross section of a typical foundation is shown in Fig. 1.

1.08 ♦Foundations for the towers are designed to use anchor bolts which are ordered separately from the tower assembly. (See 3.01.) Reinforcing steel for the foundations is usually supplied by the foundation contractor.♦

1.09 In order to avoid damage from lightning, foundations for towers should be equipped with the B self-supporting tower ground, as discussed in Part 4.

1.10 Information on concrete for foundation installations is provided in Section AG25.130.

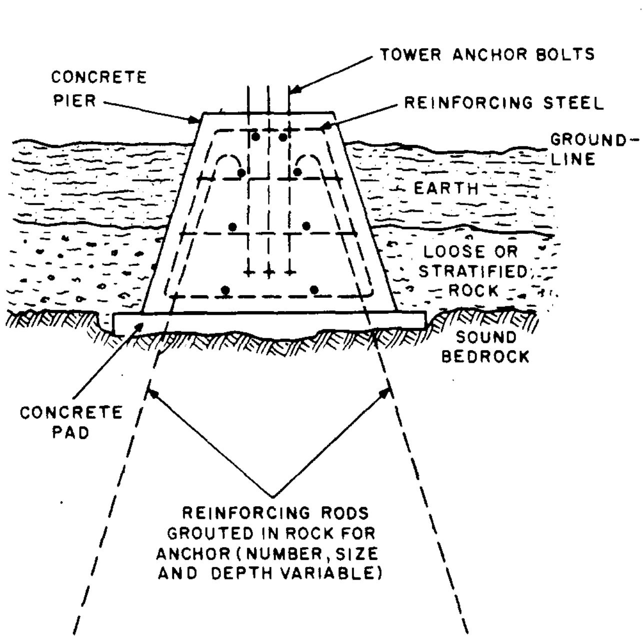


Fig. 1—Typical Foundation in Rock

2. FOUNDATION DETAILS

2.01 Foundations for the towers consist of four reinforced concrete piers on reinforced concrete mats. Piers on a common concrete mat requiring a single excavation are used for towers from 40 through 100 feet in height. (See Fig. 2 and 3 for foundation details and Table A for dimensions and reinforcing information.) Piers requiring individual excavations are required for towers from 120 through 300 feet in height. (See Fig. 4 and 5 for foundation details and Table B for dimensions and reinforcing information.)

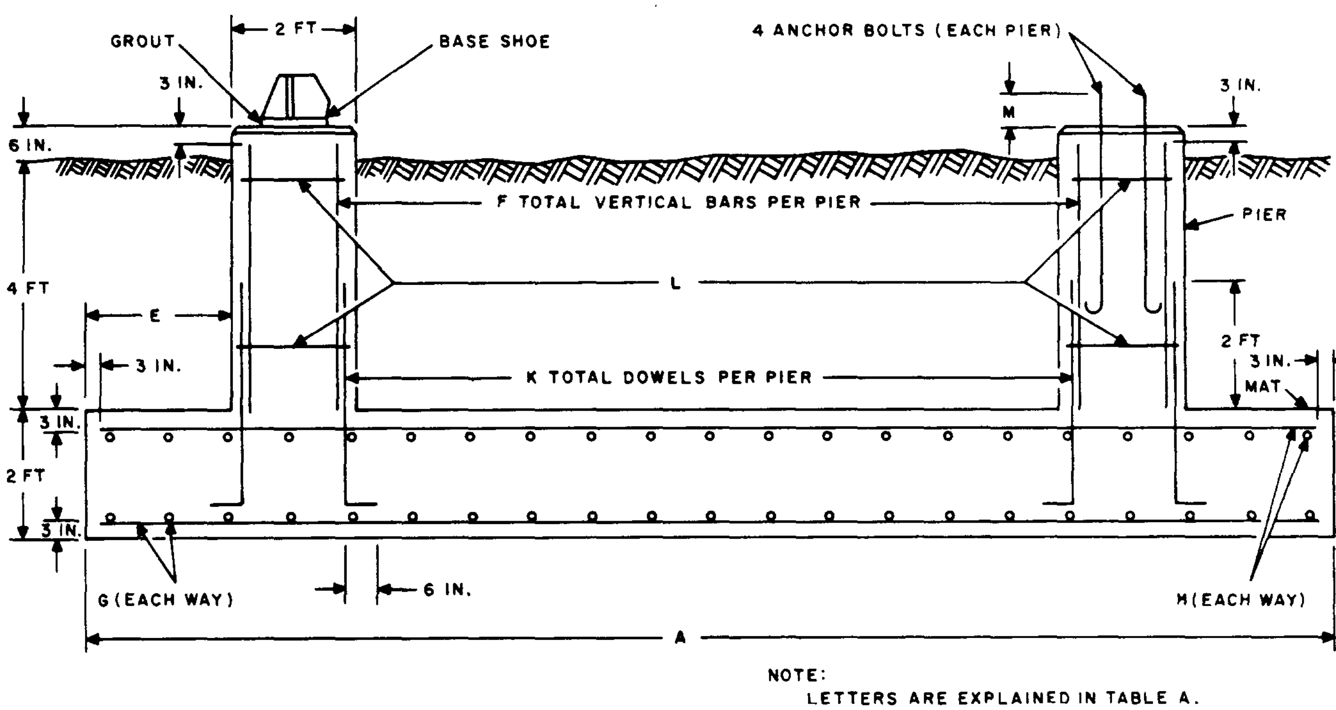
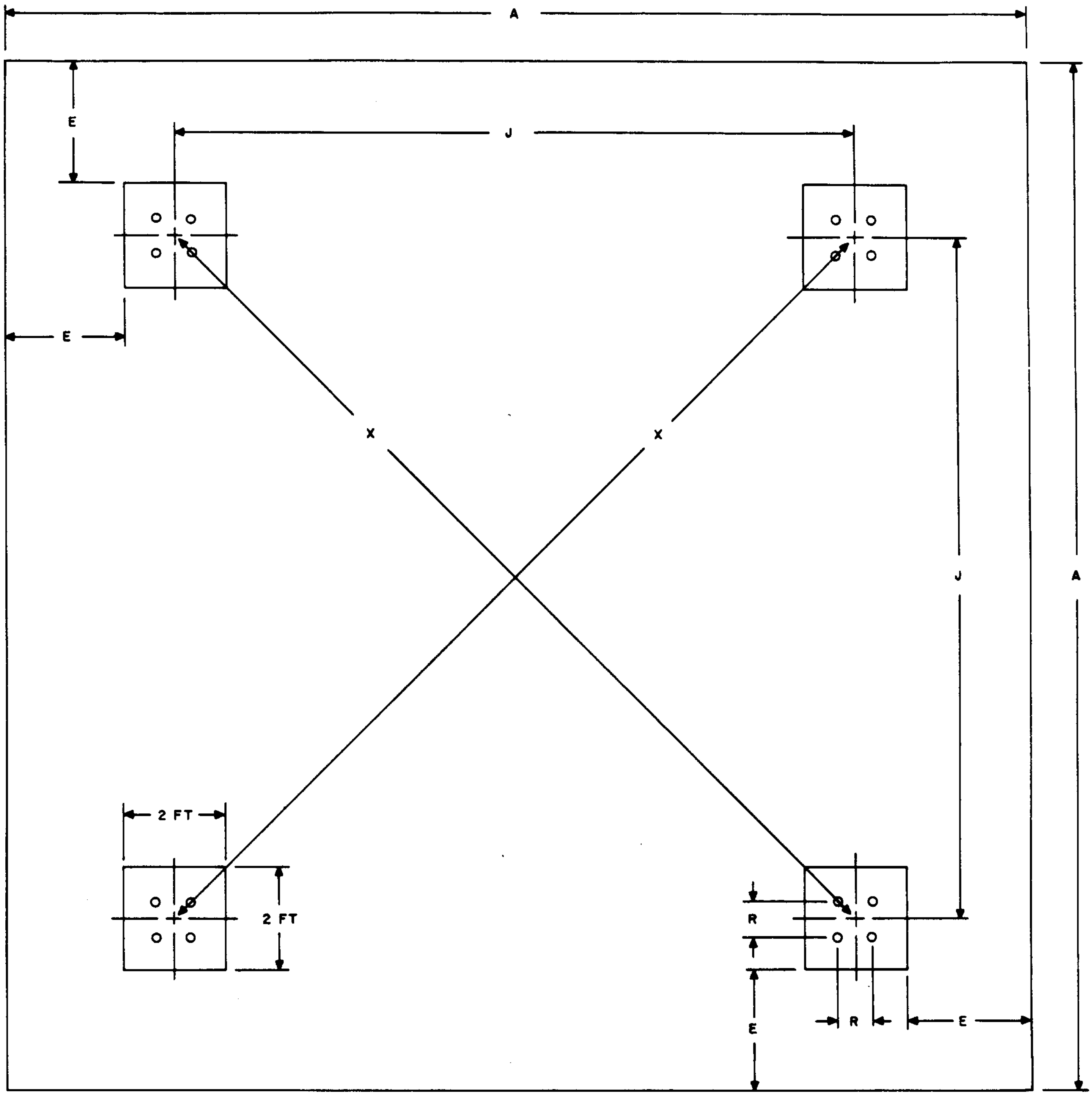


Fig. 2—Cross-Sectional View—Foundations for Towers From 40 Through 100 Feet in Height



NOTE:
VALUES OF DIMENSIONS ARE SHOWN IN TABLE A.

Fig. 3—Plan View—Foundations for Towers From 40 Through 100 Feet in Height

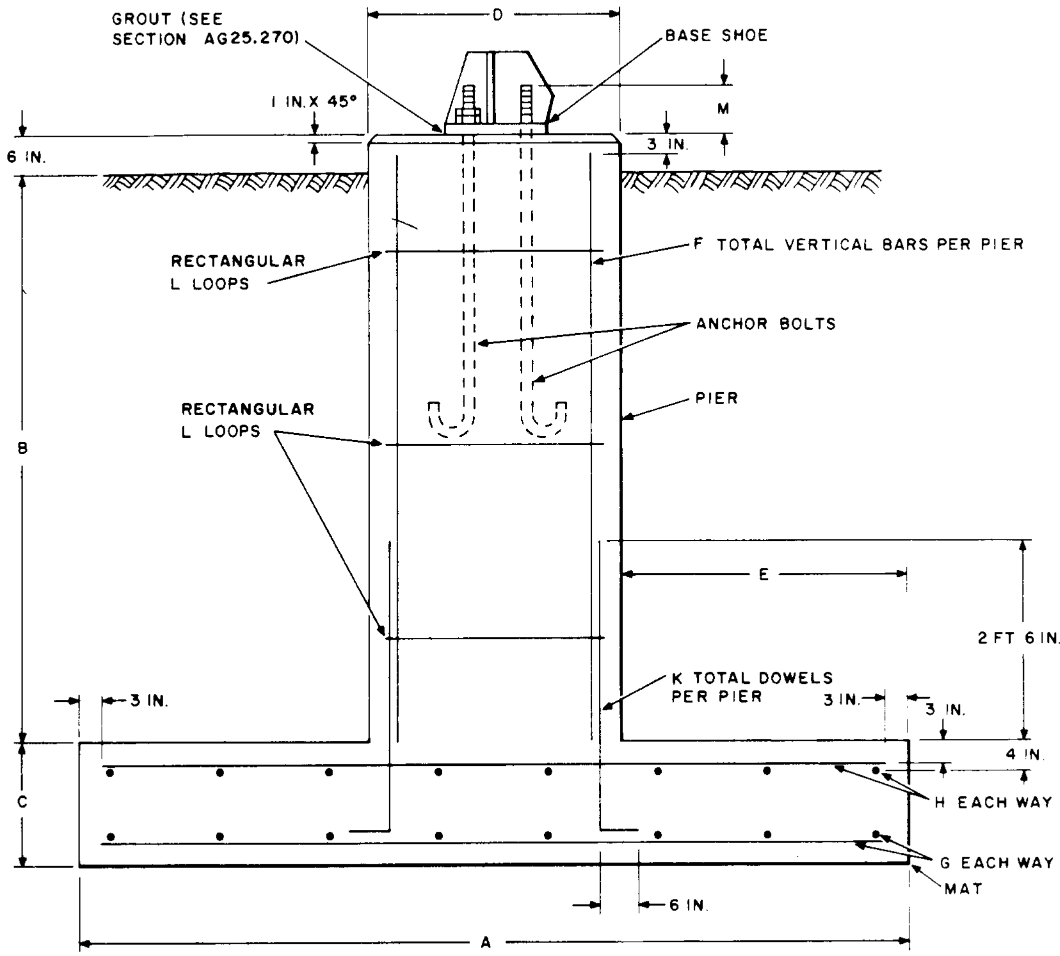
TABLE A

FOUNDATION DIMENSIONS AND REINFORCING STEEL FOR TOWERS FROM 40 THROUGH 100 FEET IN HEIGHT

	TOWER HEIGHT			
	40′	60′	80′	100′
Dimension A	15′ 0″	17′ 6″	20′ 0″	22′ 6″
Dimension E	2′ 4-3/8″	2′ 4-3/8″	2′ 4-3/8″	2′ 4-11/16″
Dimension J (±1/8″)	8′ 3-1/4″	10′ 9-1/4″	13′ 3-1/4″	15′ 8-5/8″
Dimension R (±1/16″)*	0′ 8-1/4″	0′ 8-1/4″	0′ 8-1/4″	0′ 9-1/8″
Dimension M (±1/2″)	0′ 6″	0′ 6″	0′ 6″	0′ 7″
Dimension X†	11′ 8-3/8″	15′ 2-3/4″	18′ 9-3/16″	22′ 2-3/4″
Reinforcing F (bars)	12 #5	12 #6	12 #6	16 #6
Reinforcing K (bars)	12 #5	12 #6	12 #6	16 #6
Reinforcing G (bars)	16 #5	18 #5	21 #5	23 #5
Reinforcing H (bars)	16 #5	18 #5	21 #5	23 #5
Reinforcing L (ties)	2 #3	2 #3	2 #3	2 #3

* The distance from the center of any bolt to the center line of its pier (R/2) must also be held to within ±1/16 inch.

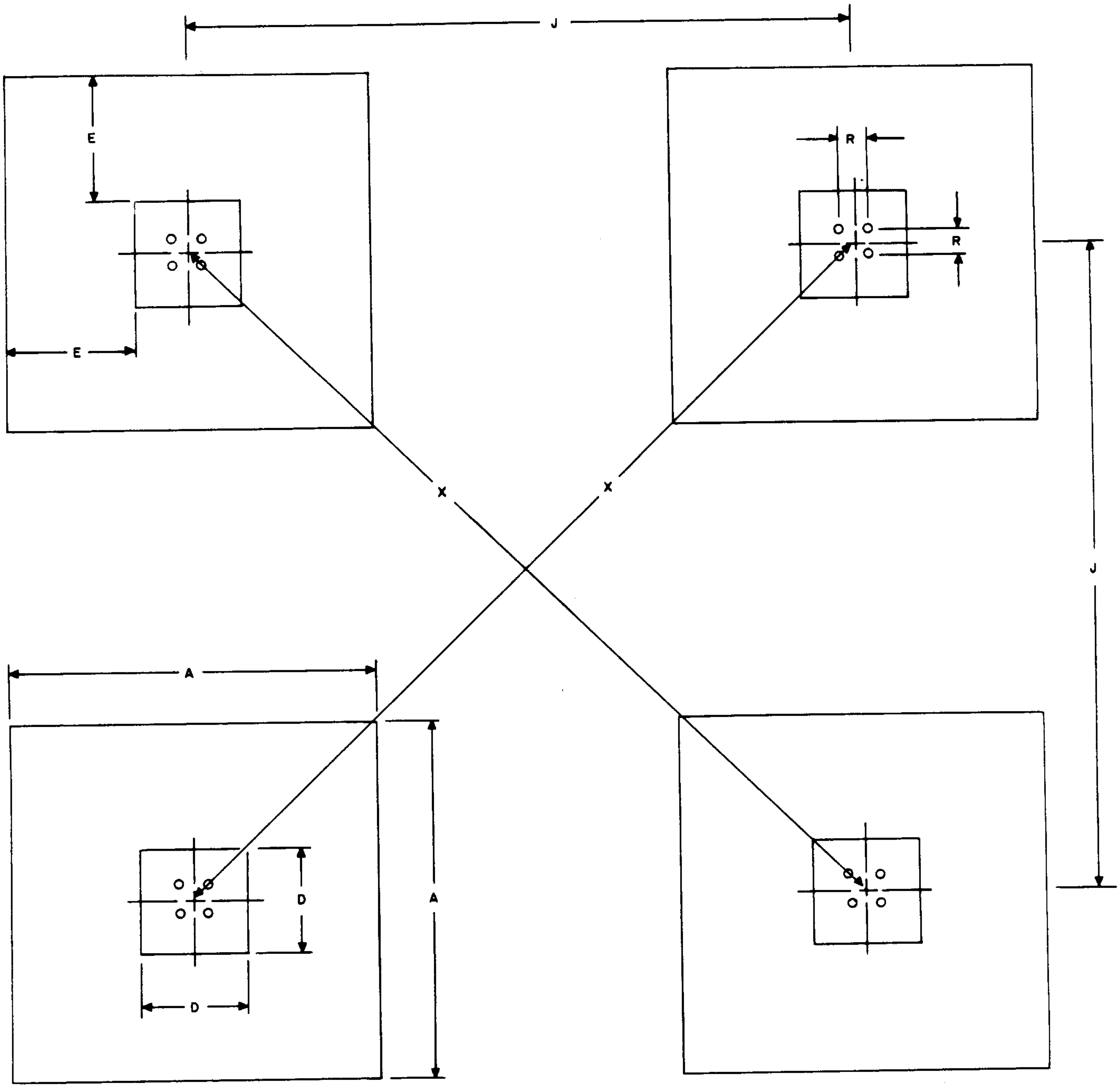
† The difference between diagonal measurements must not exceed ±1/4 inch.



NOTE:

VALUES OF DIMENSIONS AND QUANTITIES OF REINFORCING STEEL ARE SHOWN IN TABLE B.

Fig. 4—Cross-Sectional View—Foundations for Towers From 120 Through 300 Feet in Height



NOTE:
VALUES OF DIMENSIONS ARE SHOWN IN TABLE B.

Fig. 5—Plan View—Foundations for Towers From 120 Through 300 Feet in Height

TABLE B
FOUNDATION DIMENSIONS AND REINFORCING STEEL FOR TOWERS FROM 120 THROUGH 300 FEET IN HEIGHT

	TOWER HEIGHT									
	120′	140′	160′	180′	200′	220′	240′	260′	280′	300′
Dimension A	10′ 0″	11′ 0″	11′ 0″	11′ 0″	12′ 0″	12′ 0″	13′ 0″	13′ 0″	13′ 0″	13′ 0″
Dimension B	7′ 0″	8′ 0″	8′ 0″	8′ 0″	8′ 0″	8′ 0″	9′ 0″	9′ 0″	9′ 0″	9′ 0″
Dimension C	1′ 6″	1′ 9″	1′ 9″	1′ 9″	1′ 9″	1′ 9″	2′ 0″	2′ 0″	2′ 0″	2′ 0″
Dimension D	3′ 0″	3′ 0″	3′ 0″	3′ 0″	4′ 0″	4′ 0″	4′ 0″	4′ 0″	4′ 0″	4′ 0″
Dimension E	3′ 6″	4′ 0″	4′ 0″	4′ 0″	4′ 0″	4′ 0″	4′ 6″	4′ 6″	4′ 6″	4′ 6″
Dimension M (±1/2″)	0′ 7″	0′ 7-1/4″	0′ 7-1/4″	0′ 7-1/4″	0′ 8-1/4″	0′ 8-1/4″	0′ 8-1/2″	0′ 8-1/2″	0′ 8-1/2″	0′ 8-1/2″
Dimension J	18′ 2-5/8″	20′ 8-5/8″	23′ 2-5/8″	25′ 8-5/8″	28′ 2-5/8″	30′ 8-5/8″	33′ 2-3/4″	35′ 8-3/4″	38′ 3″	40′ 9″
Dimension R	0′ 9-1/8″	0′ 10-5/8″	0′ 10-5/8″	0′ 10-5/8″	0′ 11-7/8″	0′ 11-7/8″	1′ 1″	1′ 1″	1′ 1″	1′ 1″
Dimension X	25′ 9-3/16″	29′ 3-9/16″	32′ 10-1/16″	36′ 4-7/16″	39′ 10-7/8″	43′ 5-5/16″	47′ 0-1/16″	50′ 6-7/16″	54′ 1-1/8″	57′ 7-1/2″
Reinforcing F (bars)	16 #5	24 #5	24 #5	24 #5	24 #5	24 #5	24 #6	24 #6	24 #6	24 #6
Reinforcing K (bars)	16 #5	24 #5	24 #5	24 #5	24 #5	24 #5	24 #6	24 #6	24 #6	24 #6
Reinforcing G (bars)	16 #5	22 #5	22 #5	22 #5	24 #5	24 #5	24 #6	24 #6	24 #6	24 #6
Reinforcing H (bars)	16 #5	22 #5	22 #5	22 #5	24 #5	24 #5	24 #6	24 #6	24 #6	24 #6
Reinforcing L (ties)	3 #3	3 #3	3 #3	3 #3	3 #3	3 #3	3 #3	3 #3	3 #3	3 #3

2.02 ◆For estimating purposes, the approximate quantities of concrete and reinforcing steel, in addition to the volume of excavation, are shown in Table C. Quantities of concrete are based upon the dimensions shown in Tables A and B, with no reduction for the volume of reinforcing steel and anchor bolts. However, this reduction involves a relatively small quantity, which is about 1 percent or less of the total volume of concrete required. Minor variations in excavation can affect the actual volume of concrete.◆

TABLE C

QUANTITIES OF CONCRETE AND STEEL VOLUME OF EXCAVATION

TOWER HEIGHT (FEET)	CONCRETE (CUBIC YARDS)	REINFORCING STEEL (POUNDS)	EXCAVATION* (CUBIC YARDS)
40	19.3	2050	50
60	25.6	2600	68
80	32.4	2800	89
100	40.2	3000	113
120	32.2	3100	126
140	42.7	5000	175
160	42.7	5000	175
180	42.7	5000	175
200	57.5	6200	208
220	57.5	6200	208
240	72.6	8680	275
260	72.6	8680	275
280	72.6	8680	275
300	72.6	8680	275

* Assumes vertical side walls.

3. ANCHORS

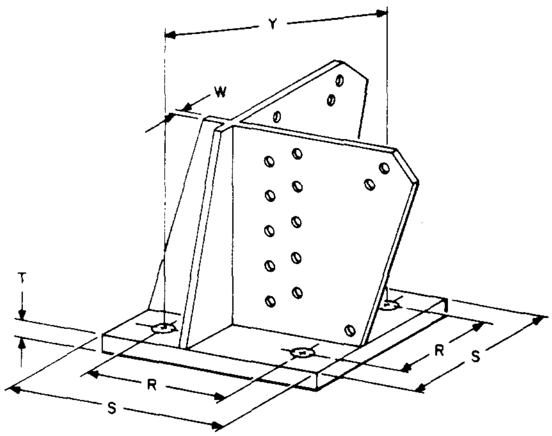
3.01 Each standard foundation requires 16 B anchor bolts. These bolts are ***not*** shipped with the tower and must be ordered ***separately***. The B anchor bolt is a J-shaped, galvanized steel bolt equipped with two galvanized nuts. The following sizes are used in foundations for towers of the heights indicated:

BOLT SIZE (INCHES) DIAMETER-OVERALL LENGTH	TOWER HEIGHT (FEET)
1-1/4 x 38	40, 60, 80
1-1/2 x 51	100, 120, 140, 160
1-3/4 x 65	180, 200, 220, 240
2 x 81	260, 280, 300

These bolt sizes meet the bond stress requirements of the 1963 American Concrete Institute Standard 318.

3.02 The spacing of anchor bolts in each pier must conform to the dimensions given in Tables A and B in order to assure proper fit of the base shoes on the anchor bolts. The anchor bolts should not deviate more than 1/16 inch from true vertical.

3.03 ◆The base shoe is shipped as a part of the tower assembly. The dimensions of the base shoe for the various tower heights are shown in Fig. 6.◆



TOWER HEIGHT (FEET)	R (INCHES)	S (INCHES)	T (INCHES)	W (INCHES)	Y* (INCHES)
40,60,80	8-1/4	13	1-1/2	1/2	11-11/16
100,120	9-1/8	15	1-3/4	5/8	12-7/8
140,160,180	10-5/8	16-1/2	2	3/4	15
200,220	11-7/8	18-1/2	2-1/4	3/4	16-13/16
240,260, 280,300	13	20	2-1/2	3/4	18-3/8

* ROUNDED TO NEAREST SIXTEENTH.

Fig. 6—Base Shoe

4. GROUNDING

4.01 The B self-supporting tower ground is a unit consisting of ground rods, grooved washers, connectors, and a length of No. 2 AWG bare tinned copper wire. One unit is required for each tower. Sufficient wire is provided to ground the tower, but not to connect the tower grounding system to the station grounding system. This connection should normally be made, but since the distance between the tower ground and the station grounding system will vary for each installation, the length of wire required for this connection should be included in the wire ordered for the station grounding system. For detailed information on station grounding, see Section 876-210-100.

4.02 One ground rod should be installed at each foundation pier. As shown in Fig. 7, each rod is connected to a leg of the tower by the wire and is also connected to a loop of the wire which surrounds the piers. The ground rods should be installed approximately vertically and should be located not more than 1 foot from the outer edge of the foundation mat. The lower end of the rod should extend at least 2 feet below the bottom of the mat.

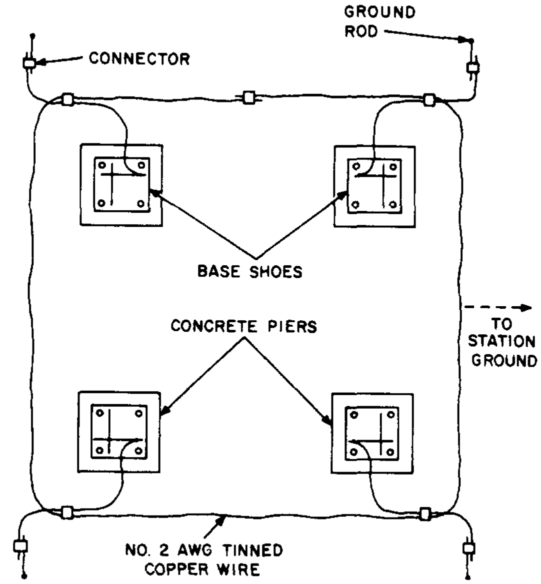


Fig. 7—Grounding System

4.03 Since the top of the ground rod will be several feet below the surface, the ground rods and the wire used to connect the rods to the tower legs should be installed before the excavations for the foundation are backfilled. The encircling loop should be installed when the excavation has been backfilled to within about 1 foot of the top.

4.04 The wire connecting the ground rods to the tower legs should be long enough to permit laying the wire on the mat between the ground rod and the pier and extending it vertically up the pier with about 3 feet extra to make the connection on the tower. The wire should be firmly connected to the tail of the ground rod by one of the connectors furnished with the grounding kit. About 1 inch of each wire should extend beyond the connector. The excavation may be backfilled after the connection is made and the wire is temporarily anchored at the top of the pier.

4.05 Backfill should be placed in about 2-foot layers and thoroughly tamped to minimize settling. When the backfill has been placed to within about 1 foot of the top of the final grade, the loop of wire should be laid to surround all four piers. For larger towers, where separate excavations have been dug, a trench about 1 foot deep extending between excavations will be required in order to finish laying the wire. The wire should form a complete loop with the ends joined by a connector provided for that purpose. The wire loop should be about 6 inches from the piers and should be about 1 foot below the finished grade.

4.06 Before covering the wire loop with earth, the wires connected to the ground rods should also be connected to the nearest point of the loop with connectors. The wires must be parallel at the point where they are connected. This will require some bending of one or both wires. Sharp bends or kinks should be avoided. The connection between the loop and the station ground should also be made at this time. All connectors should be tightened securely, after which backfilling and tamping should be completed.

4.07 The ground connection to the base shoes should be made immediately after the legs of the first section are bolted in position. Care should be taken to avoid damaging the ground wire when driving the structural rib bolts which secure the legs to the base shoes. Since the tower is leveled by means of steel wedges which are usually driven by a sledge hammer, it may be advisable to temporarily remove the ground connections during this operation. These connections should be restored immediately after the leveling is completed.

4.08 The connection between the conductor from each ground rod and the leg of the tower is made to the base shoe. The wire is held under a square, grooved washer by a 1/2-inch bolt, as shown in Fig. 8. Since the wire is copper and the base shoe is galvanized, the presence of water in the joint will cause an electrolytic action between the dissimilar metals. The bolt should, therefore, be drawn up tightly and the area painted with hot pitch or other waterproofing material.

4.09 Where local conditions, such as foundations on bedrock or in high-resistance soil, make the standard grounding arrangement impractical, a specially designed grounding system to provide the necessary protection may be required.

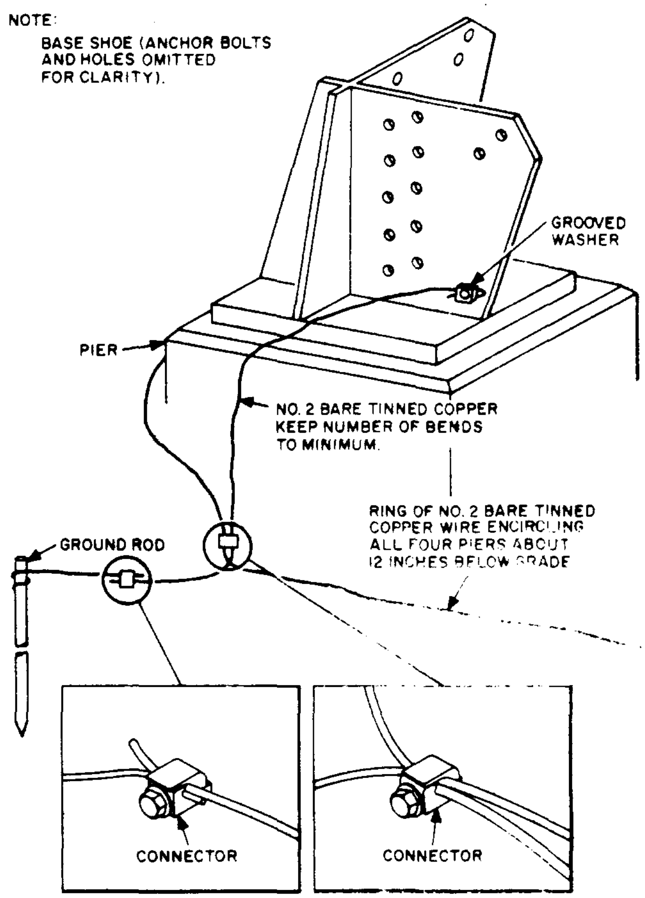


Fig. 8—Grounding Connections at Base Shoe

5. FOUNDATION LOADS

5.01 The foundation loads shown in Table D are based upon a wind pressure of 40 pounds per square foot applied to 1.75 times the projected area of one face of the tower plus the sail area of the permitted appurtenances (antennas, waveguide, etc).

TABLE D
FOUNDATION LOADS

HEIGHT OF TOWER (FEET)	MAXIMUM REACTION PER LEG (THOUSANDS OF POUNDS)			DEAD WEIGHT OF TOWER ONLY (THOUSANDS OF POUNDS)	OVERTURNING MOMENT (THOUSANDS OF FOOT-POUNDS)
	DOWN LOAD	UPLIFT	SHEAR		
40	39.4	35.0	3.20	8.4	429
60	48.8	43.8	3.65	10.4	692
80	58.6	52.6	4.34	12.8	1025
100	68.3	61.1	5.20	16.0	1413
120	77.5	69.1	5.86	19.6	1853
140	87.5	77.3	6.89	24.0	2366
160	97.2	85.2	7.59	29.2	2930
180	107.0	93.2	8.45	34.0	3566
200	118.5	102.4	9.44	40.0	4287
220	130.2	111.1	10.64	48.0	5090
240	142.4	120.5	11.71	55.6	5987
260	155.4	130.0	12.84	64.8	6978
280	169.0	140.1	14.09	74.0	8069
300	182.1	150.7	15.11	80.8	9260