MAINTENANCE OF ANTENNA SUPPORTING STRUCTURES

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1. GENERAL

1.01 With proper maintenance, most antenna supporting structures now in use over the System can be expected to give long and satisfactory service. Without proper maintenance, however, the performance of the associated radio system may be impaired or disrupted and, even though the structure itself appears intact, its physical life will be greatly reduced. Besides these considerations, the regulations of the Federal Communications Commission and/or Federal Aviation Agency may require painting of the structure and operation of the obstruction lighting system.

1.02 Since this reissue covers a general revision, arrows ordinarily used to indicate changes have been omitted.

1.03 Certain work operations mentioned in this section should, in most cases, be carried out by concerns who specialize in tower maintenance, although it may be desirable to have a Telephone Company representative present to ensure satisfactory performance.

2. SAFETY PRECAUTIONS

2.01 Although some inspection and maintenance work may be carried out by Telephone Company representatives, work aloft is usually performed by contractors. The precautions set forth here are, in general, directed toward the protection of Telephone Company personnel.

2.02 ***When it is necessary*** for men on the ground to be within a horizontal distance of the tower less than half its height, protective hats should be worn if any work is ***being performed aloft at the same time.*** Every effort should be made, however, to avoid exposing ground personnel to the hazards of being struck by falling objects. Material accidentally dropped from towers ***can inflict serious injury*** on personnel. Personnel not necessary to work operations should remain a safe distance away when operations are being conducted aloft (about half the height of the highest operation, or more). Similarly, motor vehicles should be kept away from the tower, in order to avoid damage from falling objects. Personnel working aloft should be instructed to prevent tools or material from falling, and to avoid touching air obstruction lighting fixtures when the lamps are burning, as these fixtures will be quite hot.

2.03 In climbing towers, it should be remembered that this is a strenuous exertion and personnel should not climb more than about 25 feet without stopping and resting before climbing further. Suitable protective equipment, such as the tower body belt and a safety strap, should be worn in climbing and working aloft on towers. Towers coated with ice are doubly hazardous because of the increased likelihood of slipping and the danger of being struck by falling ice, so work should be postponed until the condition clears.

2.04 In most cases, the only electric wires near towers will be those used to provide power for the tower lights. These wires are generally enclosed in grounded metal conduit and represent no shock hazard to personnel climbing or working on the tower. Occasionally, however, open electric wires carried on poles or on steel towers may be inadvertently positioned near the tower or its guys. Workmen should be cautioned to avoid contact with such wires and to exercise care so that guy wires are not jerked or oscillated into contact with them. (See 6.03.) Even if the guys are effectively grounded and there is no shock hazard, the arcing which takes place when power wires contact grounded conductors or guys is likely to weaken the guy strand seriously, and may even burn it in two.

3. TYPES OF STRUCTURES

3.01 Antennas may be supported by several different types of structures such as wooden poles, simple tubular steel poles, or fabricated steel structures consisting of members bolted, welded, or otherwise joined together. Since the maintenance of wood poles is already covered in both the Outside Plant Engineering and Construction and Maintenance Practices, this section is primarily intended to cover steel structures.

3.02 Supporting structures for antennas may be broadly classified into two groups: (1) self-supporting and (2) guyed.

(1) Self-supporting structures, except the "flagpole" type, generally are erected with the legs or vertical members forming a square at the base and tapering to a lesser square at the top. Under transverse wind loading, the overturning movement is primarily resisted by the reaction of the foundations. In most cases, foundations for self-supporting towers must be designed to withstand both downthrust and uplift. (See Fig. 1.)

(2) Guyed structures are generally built with little or no taper. Resistance to overturning is supplied by the horizontal component of the tension in the guys. Foundations are thus always under compressive loading and are, therefore, somewhat smaller than foundations for self-supporting structures (see Fig. 2).

4. INITIAL INSPECTION

4.01 It is desirable to make the first maintenance inspection of antenna supporting structures about six months to one year after erection. If the structure is built in the fall, for instance, the first inspection should be made in the spring, when the temperature is at approximately the same level. During that period they may or may not have been exposed to full storm loading, but will at least have experienced quite a range of temperatures and winds. If the initial construction has been correct, very little tightening of bolts or guys will be found necessary. Guy tension tests, [Table A, (1)] should allow for temperature and wind velocity differentials. Guy tension adjustments are not recommended unless they exceed the 15 to 20 per cent maximum set forth in Part 6.

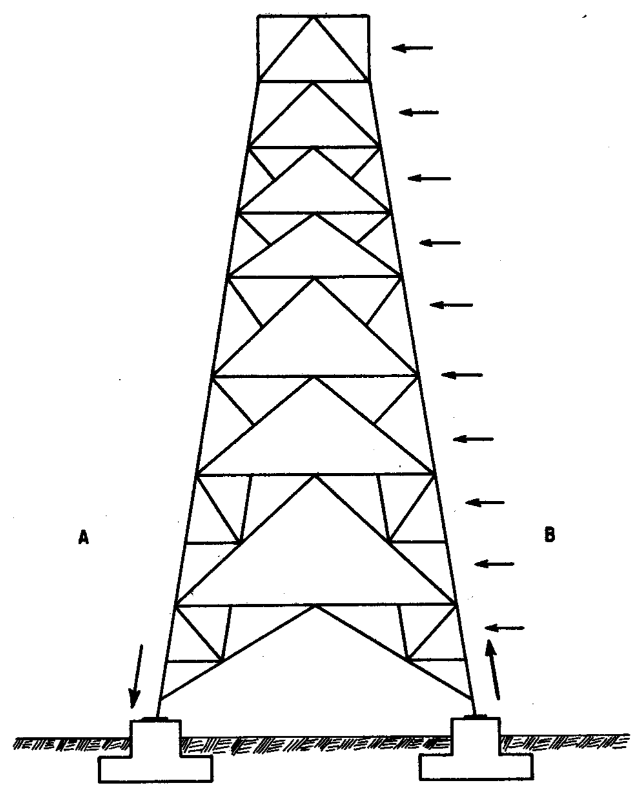


Fig. 1 – Wind Loading on Self-Supporting Tower

Vertical members on lee side (A) are under compressive loading; vertical members on windward side (B) may be under tension.

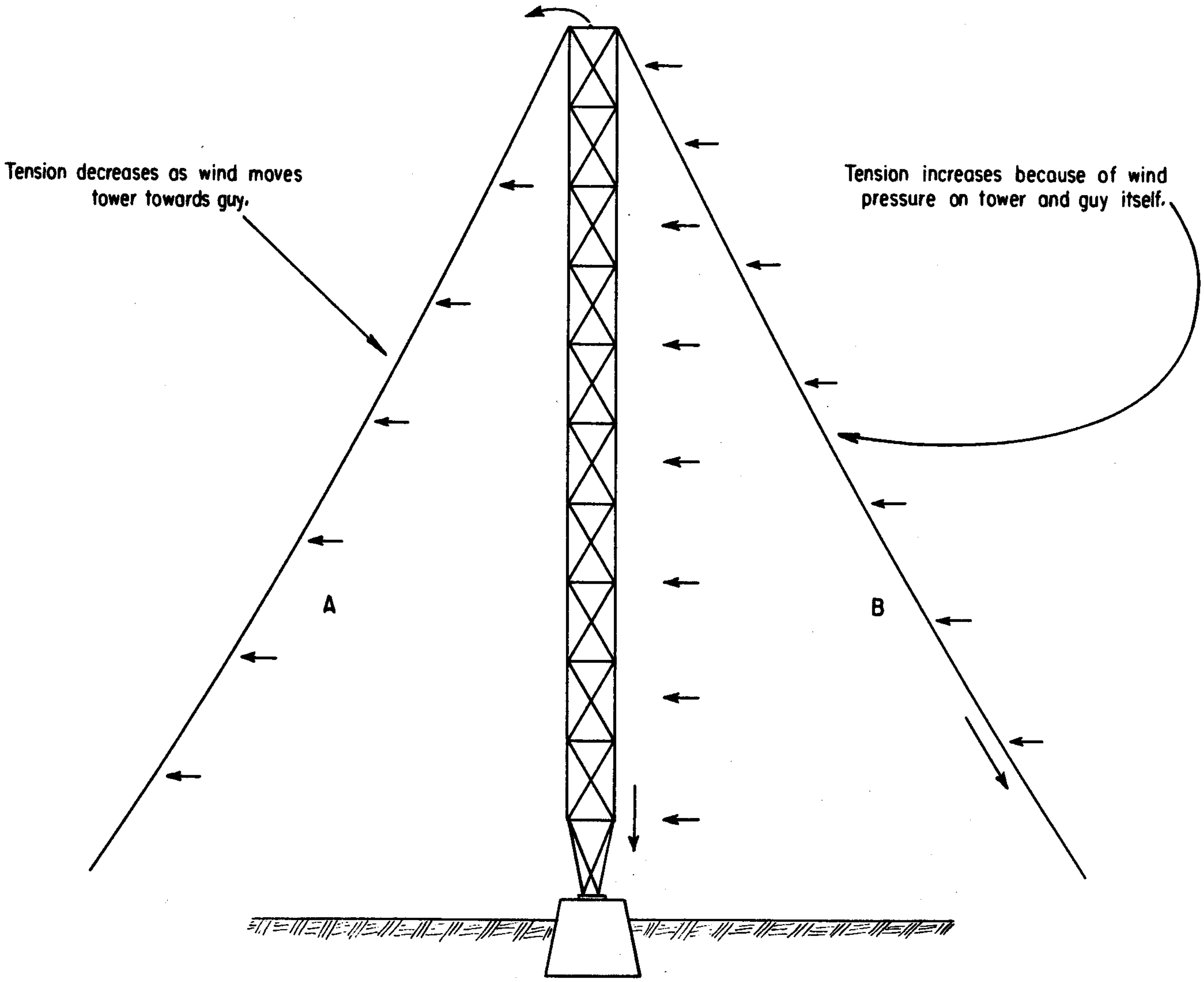


Fig. 2 – Wind Loading on Guyed Tower

Under wind loading, vertical members on windward side (B) are under additional compressive loading as result of increased tension in windward guy.

4.02 Tampering with the tower or its appurtenances by unauthorized persons may result in damaged bolts or turnbuckles, excessively loose or tight guys, broken or missing ground wires, or other damage. Most of the maintenance work required at the first inspection is generally caused by faulty construction, abnormal storm loading, malicious mischief, or improper design.

4.03 A thorough inspection at regular intervals will prevent minor faults from developing into serious trouble. Table A lists items that should be considered. It is anticipated that the items listed as Class I could be repaired during the inspection visit, while the Class II items could be noted and repaired as soon as could be arranged. Towers constructed of tubular members should be inspected for evidence of splitting. This may be caused by freezing of condensed moisture. Split tubes should be repaired by welding and drainage holes should be provided.

TABLE A

Routine Maintenance Items

CLASS I	CLASS II
(1) Incorrect guy tension; loose guy clamps, rods, wire rope serving, jam nuts, turnbuckles; all exposed ground connections.	(1) Guy Cables: Kinks, broken, rusted, dented or broken strands, "birdcaging", etc. Any items broken, damaged, or missing listed under "Minor" (1).
(2) Base Plate: Loose nuts, bolts, general condition of grout.	(2) Component parts of any tower or associated equipment which may be broken, bent, deformed, or missing.
(3) Loose and Missing parts: All accessible bolts, nuts, washers, ring fills, and palnuts of towers, stub towers, waveguide runs, antennas, reflectors, and associated equipment.	(3) Tower Lighting: Broken or cracked lens, frayed insulation, broken or leaking conduit, or exposed wiring.
(4) Tower Lighting: Replace lamps in beacon and side lights. Lighting conduit and junction boxes which may be loose, have plugged drains, or bad water seals.	(4) Missing Step Bolts.
(5) Loose Step Bolts.	(5) Foundations and Anchors: Shifting, cracking, and scaling.
	(6) Finish — Paint and Galvanize: Loose, scaled, peeling, absent, faded.
	(7) Tower Bow and Plumb.

4.04 It may be helpful to use consecutively numbered two-piece bright yellow or other distinctively colored tickets to mark the location of major irregularities. Both pieces of the card should be numbered: one to be attached to the tower as a marker for the repair crew which may follow, the other to be retained by the inspector, who should make a brief notation of the work on his half of the ticket. The repair crew should, of course, remove the tickets as the work is performed and retain them to match against the inspector's stubs.

5. SUBSEQUENT INSPECTION

5.01 The second inspection should not be necessary for about three years, with subsequent inspections at three- to five-year intervals. It may be advisable, however, to make additional inspections after unusually heavy storms such as hurricanes or cloudbursts. Foundations or anchorages may be subject to possible washout, large pieces of debris may have been blown into the tower or its guys, structural members may have been twisted or bent, etc.

5.02 In addition to the points mentioned in the preceding paragraphs, the general condition of the paint should be checked. Generally, the life of the paint film should be the controlling factor as to the interval between scheduled inspections, unless there are some special features of the installation which may require more frequent attention. Also, unless the guy rods are encased in concrete below grade, they should be checked for corrosion.

6. GUYS

6.01 Guyed towers depend on the guying system to withstand overturning forces, and good maintenance is essential to continuous operation. Slack guys may disrupt the operation of the radio system, and may ultimately cause the structure to fail. Guys tend to go slack for a number of reasons. For example, bolted connections in the tower itself usually have a little play and tend to settle under load over a period of time. Anchor rods may not have been installed in line with the load and will tend to knife through earth until they are in line with the load. There may be some slight settling of the foundation unless the base is on solid rock. There may also be some constructional looseness in the guy strands, although this is usually a small factor. Prestressing of guys will minimize this and should be used where applicable erection practices so state. There may also be some outright slippage of the guy strand through the Crosby clips or clamps if they are not tight. This, of course, can be very serious and guys should be carefully checked for evidence of slippage at these points. Slippage can be detected readily if match marks have been painted on the strand. Crosby clips should be installed with the saddle riding the active side of the loop as shown in Fig. 3 in order to develop maximum holding power. Slippage is not apt to occur if pre-formed strand grips are used.

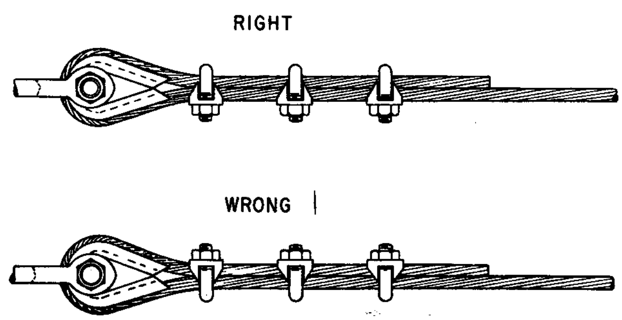


Fig. 3 – Installation of Crosby Clips

6.02 Care should be exercised in checking the smaller (1/2-inch diameter or less) strand clips or grips, as it is quite possible to twist them off with a standard lineman's wrench. For 1/2-inch diameter bolts or fasteners, no wrench longer than 8 inches should be permitted for checking purposes. Tests made on 1/2-inch diameter "fist" grips showed that they would withstand a torque of about 100 foot-pounds before fracture, although manufacturing irregularities would reduce this in some cases to about 80 foot-pounds. Three such grips were found adequate to develop the full strength of 16M strand with a torque of only 60 foot-pounds.

6.03 Initial or nonloaded guy tension is usually set at about 8 to 10 percent of the breaking strength of the strand. Reasonable design standards usually limit the maximum

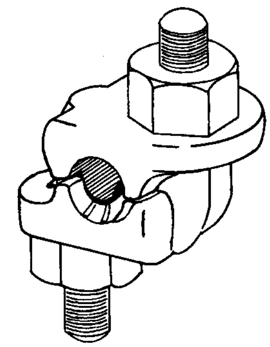


Fig. 4 – "Fist" Grip

tension in guys to about 35 to 40 percent of breaking strength. Guy tensions may be checked approximately by the oscillation method. If the guy is vibrated back and forth in its natural period and a number of oscillations are counted and timed, the following formula may be used to compute the tension if the length and weight of the guy are known. (See Fig. 5.)

$$T = \frac{WL^2}{32.2 \times (S/2N)^2}$$

Where T = Tension in pounds
W = Weight of guy in pounds/foot
L = Length of guy in feet
S = Time in seconds
N = Number of oscillations observed during time (S)

6.04 A nomogram attached to this section is so constructed that guy tensions can be determined from this relationship by drawing three straight lines as follows:

(1) Draw a straight line connecting weight and length; read scale A and mark this value of A on A′ scale.

(2) Draw a second straight line connecting the observed time (S), the number of oscillations (N), and scale B.

(3) Draw a third straight line connecting the intersection of the line drawn under (2) above and scale B, the point on scale A′ determined in (1) above, and scale T, which reads tension in pounds.

When determining the length, particularly on shorter guys (100 feet or less), it may be found

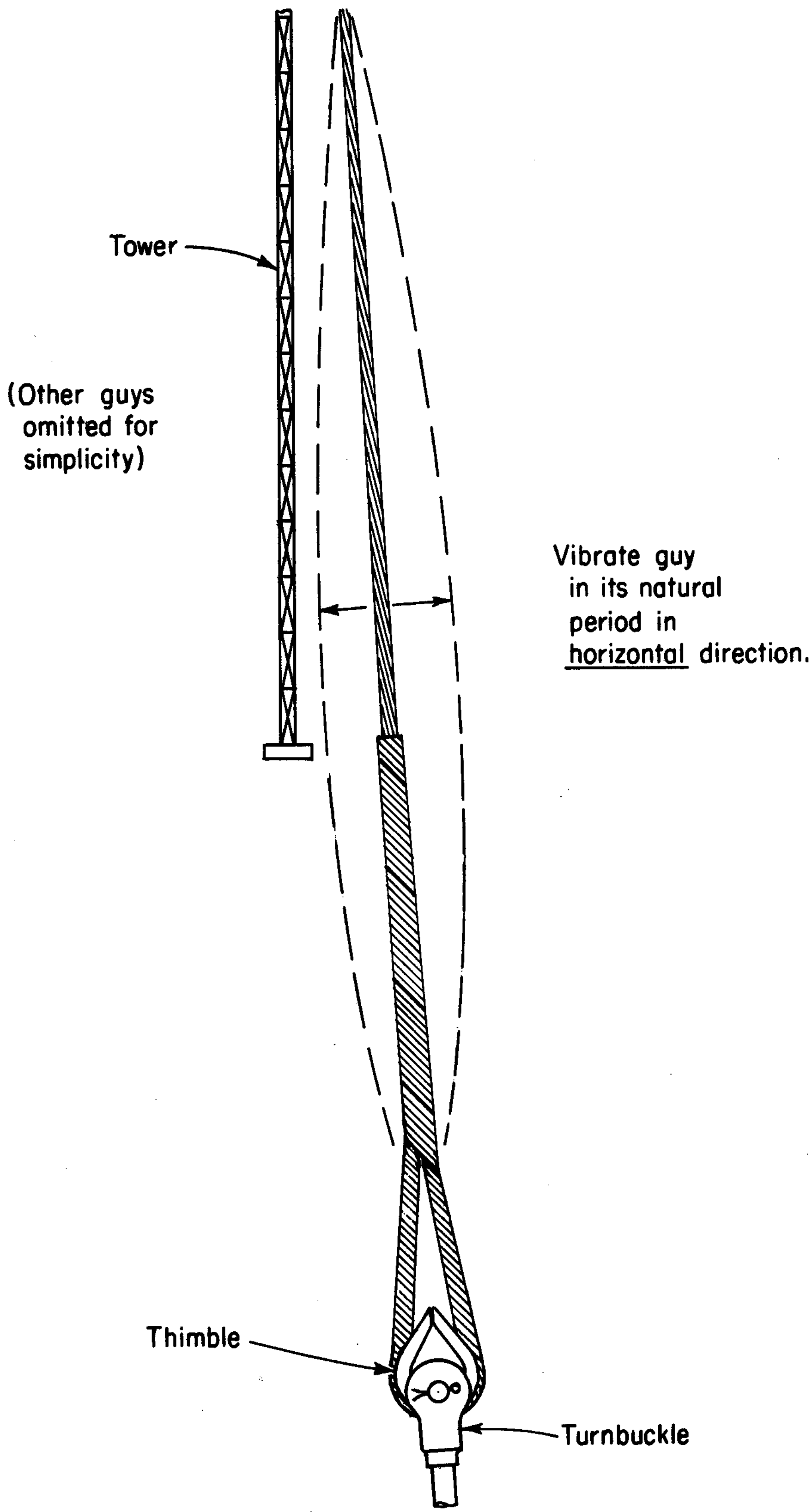


Fig. 5 – Oscillation Method

that part of the anchor rod is also vibrating and, if so, the value of "L" in the formula should be increased by the length of the rod. (Since this appears as a squared term, any error in it is accordingly magnified in the result.)

6.05 Guy tensions should be measured when the air is fairly calm. A rough indication of wind velocity may be obtained by suspending a 12- by 5/8-inch B cable suspension bolt in a vertical position, using a piece of string or fine gauge wire, such as No. 26 AWG copper, arranged so that the upper end of the bolt is 3 feet from the support. Under these conditions, the lower end of the bolt will move about 1-1/2 inches from its no wind position under pressure of a 15 mph wind. A 20 mph wind will produce a movement of about 2-1/2 inches for a similar setup. Measurements of guy tensions are likely to be somewhat misleading if taken when wind velocities are greater than 15 to 20 mph.

6.06 The effect of temperature change is to increase tension as temperature decreases. Generally, if the observed tension is within about 15 percent to 20 percent of that shown on the manufacturer's detail plans, it may be considered as satisfactory. No attempt to measure guy tensions should be made when guys are coated with ice, since the weight of the ice will alter the effective weight of the guy and produce a false value of tension. For field checking, the simplest procedure is to count a previously determined number of oscillations, timing the interval with a stop watch. For a given number of oscillations with a particular guy and the desired tension known, the equation in 6.03 may be restated to calculate the expected time as follows:

$$S = 0.352\ NL\sqrt{W/T}$$

6.07 The guy strand used to support radio towers is not, in general, the same as that used in Bell System standard pole line construction. The strand dynamometer which is normally used to check the tension of standard size strands must, therefore, be calibrated for the particular kinds of strand encountered on towers. The use of the dynamometer may, however, be rendered difficult and even somewhat hazardous where several guys are attached to one anchor. Placing the dynamometer beyond the strand clips and the tail of the loop is rendered difficult by the height of the guy at this point and the natural tendency is to try to stand on one of the lower guys, hang on with one hand, and attempt to operate the dynamometer with the other hand. A small stepladder should be used while such work is being performed.

6.08 Guys should be inspected throughout their length using binoculars or other suitable optical aids. Rusted or corroded strand should be replaced if it appears that it will have lost 25 to 30 percent of its initial strength before the next scheduled inspection. This, of course, involves an estimate of the rate at which corrosion has been experienced and may be expected to continue. It will be necessary to measure the diameter of the guy strand with a micrometer to make such an estimate. A discussion of the effects of corrosion on the strength of strand is contained elsewhere in the Outside Plant Engineering Practices.

6.09 In adjusting the tension of guys, it should be borne in mind that a relatively small take-up in the turnbuckle may produce a large increase in tension. For example, three turns of a turnbuckle increased the tension of a 150-foot guy about 500 pounds. Discrepancies in guy tensions may be caused by weather conditions because of thermal expansion of guys and tower members as temperatures change. Actual temperature of the metal may change considerably more than that of the surrounding air. It is advisable, therefore, to record the approximate weather conditions at the time of measurement (i.e., sunny, overcast, estimated wind velocity, temperature, etc). Unless these conditions are the same each time guy tensions are checked, differences should be expected. It must be remembered that guy tensions were set originally when there was no equipment mounted on the structure. The added load imposed by the wind pressure on the equipment will cause guy tensions to vary considerably.

7. ANCHORS AND FOUNDATIONS

7.01 Anchors used with radio towers are usually concrete blocks, at least for the larger towers or for those carrying antennas which represent a large wind load. Patent or expanding anchors are sometimes used on the smaller towers, but because of their somewhat limited capacity are not considered generally suitable for use with the larger towers.

7.02 Properly designed and installed concrete block anchors will not move. However, if the block is exposed, it is advisable to inspect it closely to see that no space has developed between the back of the block and the earth. (See Fig. 6.) If there is a space, the anchor has "given" and the design and load on the anchor should be checked. Other indications of inadequate design are humping or cracking of the earth over, or in front of, the anchor. All anchors should be inspected, particularly those located on steep grades, since these may be subject to soil washout. Also, if the top of the block is exposed, or readily accessible, it should be checked for cracking. Radial cracks emanating from the anchor rod are evidence that the concrete has been overstressed. Either a greater thickness of concrete or the use of reinforcing may be indicated.

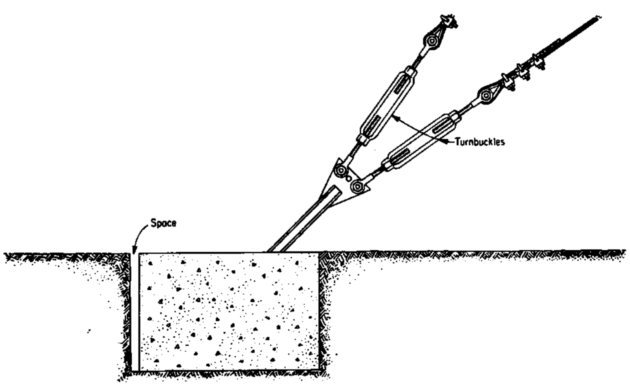


Fig. 6 – Anchor Creep

7.03 Where anchor blocks are not exposed, unless the anchor rod is encased in concrete, the earth around the anchor rod should be removed to a depth of about a foot to see if the anchor rod has corroded. The use of Bitumastic No. 50 coal tar, followed by an application of Johns-Manville 15-pound asbestos pipeline felt, will generally provide fairly good protection against corrosion. Undercoater, such as that used to protect the underside of automobiles, is not as satisfactory because it is too porous, and its use is not recommended. Occasionally, corrosion may be caused by electrolytic action between a copper ground rod and a galvanized anchor rod, particularly in salt marshes. In such cases, it is important to be sure that the anchor rod is completely protected or the action will be intensified on any remaining unprotected metal. The use of similar metals for guys and ground rods in such cases will tend to eliminate corrosion arising from this source.

7.04 Pieces of concrete which may have cracked off the surface of foundations are usually only the finishing layer or grout. This is unlikely to impair the strength of the foundation, although it is definitely good practice to repair such damage.

7.05 To secure a good bond between the old surface and the patch, it is necessary that the old surface be cleaned thoroughly and soaked with clean water. It will be helpful to brush on a coat of portland cement and water, mixed to the consistency of paint, before applying the patching material. Patching material may be a rich (about 2-1/2:1) mixture of clean, sharp sand and portland cement. Epoxy bonding compounds, such as "Sika Colma Bonding Compound" provide a very good bond between old and new concrete. Also, epoxy patching compounds provide a superior material for arresting surface spalling of the concrete.

7.06 Grounding connections should be checked to see that they are tight and that the wire is not broken. (Concrete anchors and foundations are normally protected against the possibility of being split by lightning by having the guys and tower legs connected to ground rods or a grounding bus.)

7.07 Anchorages should be designed to withstand 100 percent more than the storm loaded tension of their attached guys. The detail plans of the tower will ordinarily show the

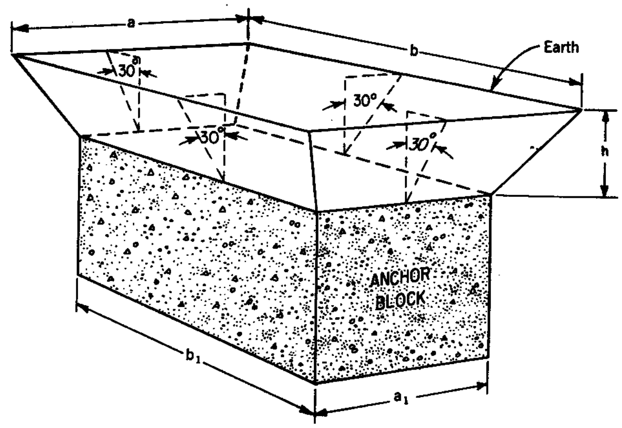


Fig. 7 — Assumed Shape of Earth Engaged by Anchor Block

maximum tension, the weight and length of the guys, the height of attachment, the breaking strength, and other pertinent details of the guying system. The vertical component of the load is resisted by the dead weight of the concrete (figured at 140 lbs/ft^3), plus the weight of the earth above (figured at 100 lbs/ft^3), assuming the anchor engages a frustum of a pyramid or cone of earth with sides at an angle of 30° to vertical. (See Fig. 7.) The horizontal component is resisted by soil pressure on the face or faces in the direction of the load (usually with soil pressure not to exceed 4000 lbs/ft^2 under average soil conditions). It is necessary, therefore, to break the guy tension into its horizontal and vertical components in order to check the anchorage. The horizontal component is simply the cosine of the angle between the guy and the horizontal times the tension. The vertical component is obtained by multiplying the tension times the sine of the same angle. Computations may be performed by using trigonometric tables or a slide rule with trigonometric functions, if available. A simple graphical method of determining these values without the use of either trigonometric tables or a slide rule is shown in Fig. 8.

7.08 If the anchorage is covered with earth, it is necessary to calculate the weight of earth above the block. This takes the form of a frustum of a pyramid. The volume of a frustum of a rectangular pyramid in general may be calculated by the following formula:

$$V = \frac{h}{6}\left[ab + (a+a_1)(b+b_1) + a_1 b_1\right]$$

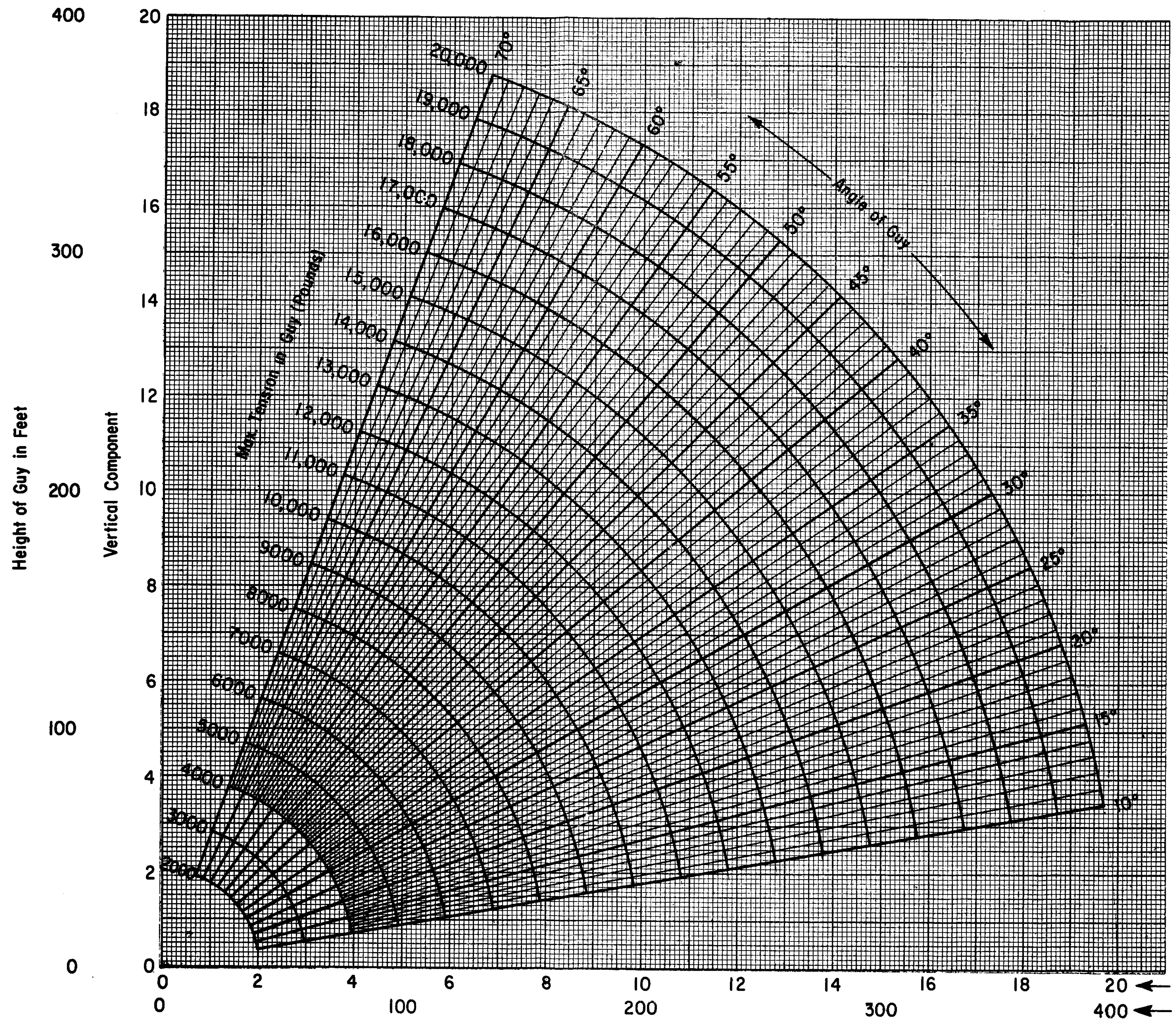
Where V = Volume (in cubic feet)
h = height (in feet)
a, a_1 = width at top, bottom (in feet)
b, b_1 = length at top, bottom (in feet)

If the dimensions of only the anchorage are available and the sides of the frustum of the pyramid are assumed to be at an angle of 30°, it is more convenient to rewrite the preceding equation in terms of known dimensions as follows:

$$V = \frac{h}{3}\left[3a_1 b_1 + 1.732h\,(a_1+b_1) + 1.33h^2\right]$$

8. ALIGNMENT OF TOWER

8.01 The alignment of the tower may be checked with a simple plumb line if the air is calm. The plumb line may be supported by range rods pushed into the ground at an angle and tied together at the top. If available, a transit will provide a more satisfactory means of checking alignment. In either case, two setups (about 90° apart) should be made. Observations may be made as illustrated in Fig. 9 and 10. If the tower is found to be out of alignment, it should be corrected. (See Fig. 11 and 12.) Guyed towers are, of course, more likely to go out of alignment than self-supporting towers (although the realignment of a guyed tower is a far simpler matter than the realignment of a self-supporting tower). Care should be exercised to prevent guys from being overtensioned, as they may fail under storm loading or the tower may buckle under the added compressive load exerted by the guys. It is good practice to adjust opposing guys simultaneously. If the structure supports microwave facilities, it is advisable to have a qualified observer checking the performance of the radio equipment while these adjustments are being made, because the movement of the antenna may put the beam out of alignment with respect to the adjacent relay station, thereby disrupting service.



To determine horizontal and vertical components of guy tension given Lead/Height or angle

1. Find curve corresponding to pounds tension in guy.
2. Follow curve until it intersects angle of guy.
3. Drop straight down and read horizontal component on scale at bottom
4. Read vertical components straight across on scale at left.
5. If Lead/Height is known, lay off lead on horizontal scale, draw vertical line to to point corresponding to height of guy (vertical scale). Follow nearest diagonal line to obtain angle of guy and proceed as before.

Fig. 8 – Determination of Horizontal and Vertical Components

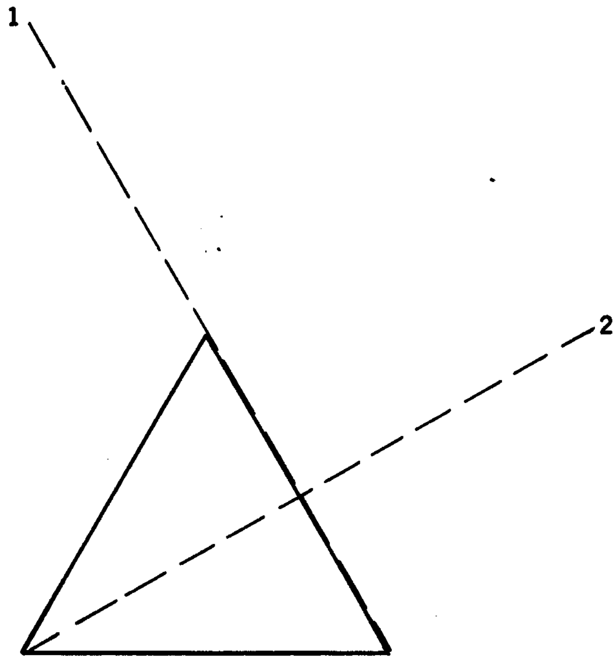


Fig. 9

Points 1 and 2 should be located so that a line of sight from point 1 will place any two of the tower vertical leg angles in line, and a line of sight from point 2 will pass through the lowest diagonal stitch bolt and the center of the far leg angle.

8.02 If a self-supporting tower is found to be out of alignment, it means that the structural members, the foundations, or the soil on which it rests have been overstressed. Any one of these conditions may be quite serious and should be reviewed by a qualified consultant.

9. PAINTING

9.01 Paint can be expected to have a life of approximately five years under average conditions. Where painting is required by F.C.C./and or F.A.A. regulations (air obstruction markings) discoloration may force repainting at somewhat more frequent intervals. In this connection, reference should be made to the Practice 760-380-150, paragraph 1.03 and 1.04. In view of the statement made in paragraph 1.04, it is important to make sure that the latest issue of the F.C.C. regulations is followed. With regards to the tower itself, most structures are galvanized and the life of this coating is largely a function of the concentration of corrosive elements in the atmosphere and the

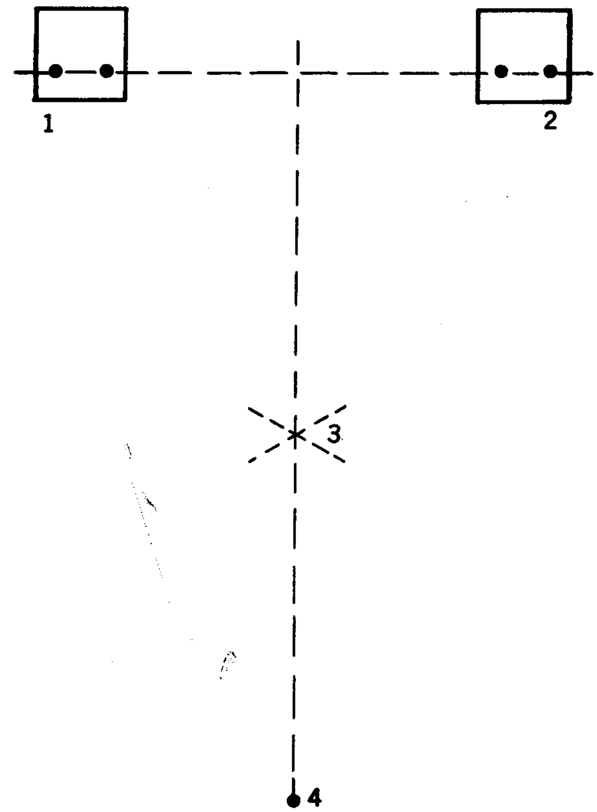


Fig. 10

Scribe arcs on the ground at any convenient equal distance from corresponding base shoe anchor bolts on the same face of the tower, points 1 and 2. Set a stake at the intersection of the arcs, point 3. Set and level the transit at point 3 and sight on the lowest diagonal stitch bolt of the near face of the tower. The lowest diagonal stitch bolt of the far face of a B tower or the center of the far leg angle of a C tower should be on this line of sight. Plunge the telescope and set a stake on the line of sight at a point from which the top of the tower can be sighted with the transit. Set up the transit on point 4 and sight on point 3. Elevate the telescope on this line of sight and focus on all diagonal stitch bolts of the near and far faces of a B tower. Stitch bolts on the same face should be in the same relative position with respect to this line of sight. On a C tower, the vertical center line of the far leg angle and the diagonal stitch bolts on the near face should be in the same relative position with respect to this line of sight. Perpendicularity measurements should be made on two adjacent faces of a tower.

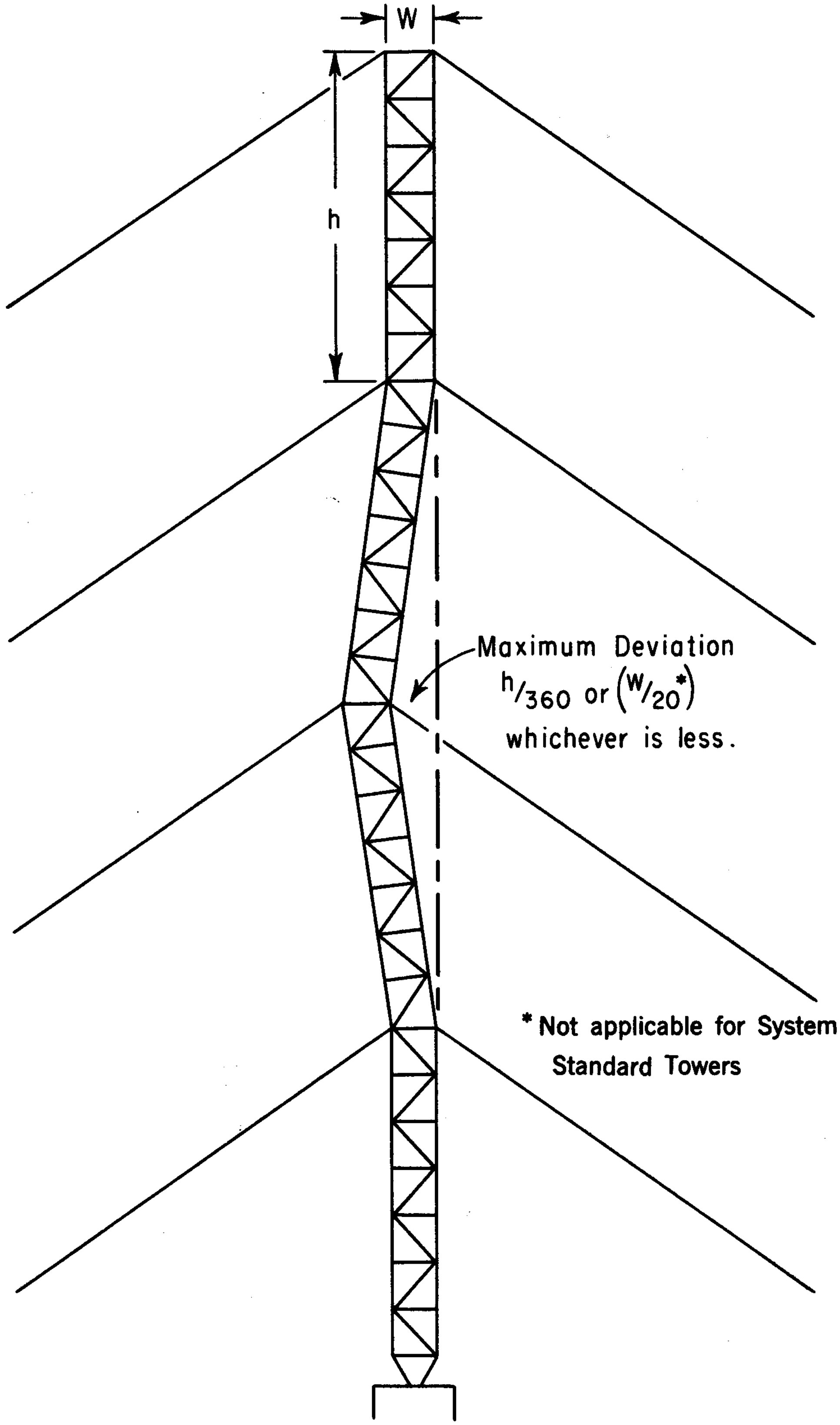


Fig. 11 – Maximum Allowable Deviation . . . . Between Guy Points

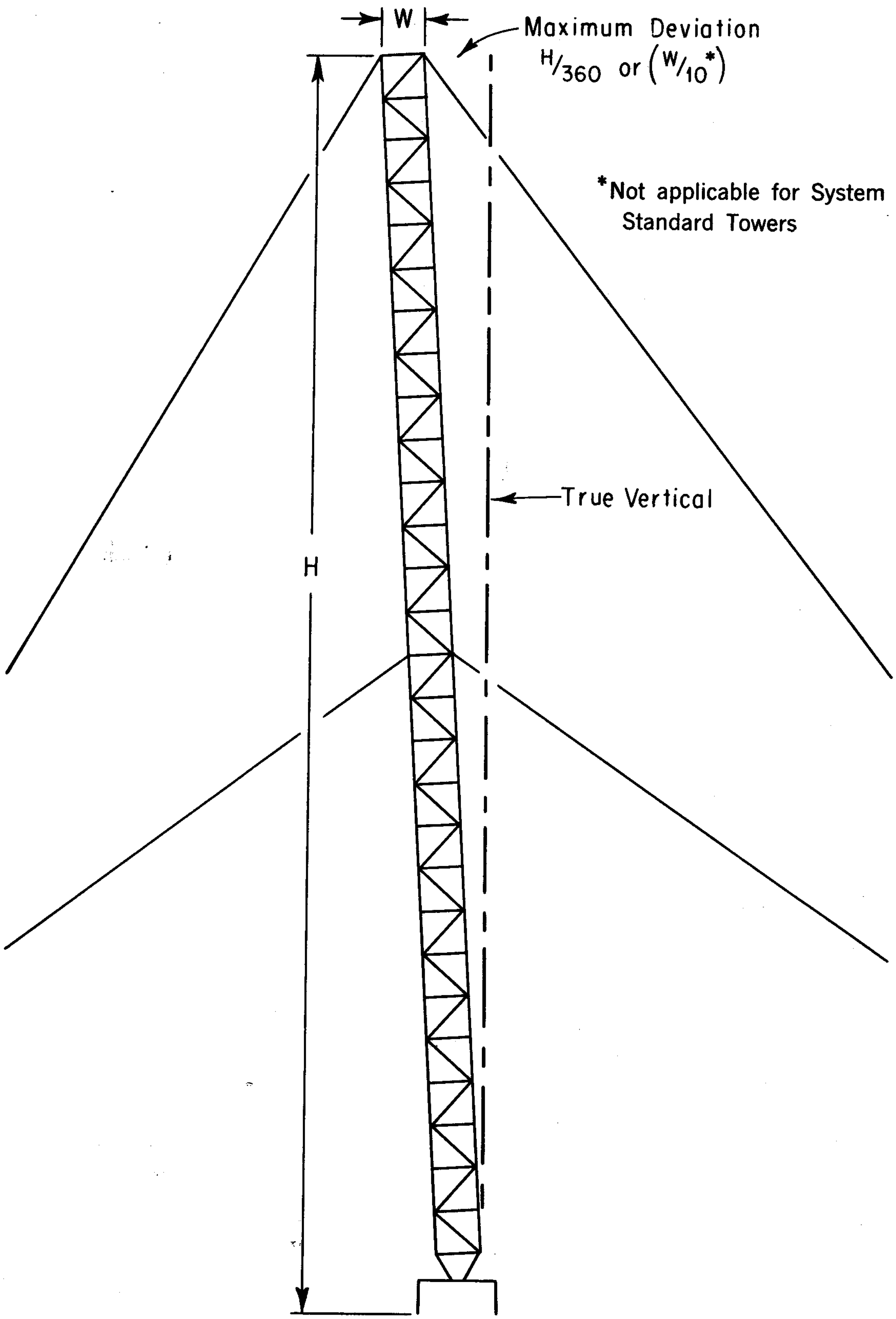


Fig. 12 – Maximum Over-all Allowable Deviation for Guyed Towers

thickness of the zinc. In dry rural areas, for example, 2 ounce galvanizing may last 20 to 30 years. In river valleys where heavy concentrations of coal smoke may be encountered, galvanizing has disappeared in less than 10 years. Some towers, of course, are not galvanized and here the paint film must be relied upon to protect the metal.

9.02 Towers in seacoast locations may show deterioration of paint in two or three years because of the effects of wind driven sand, the added intensity of reflected sunlight, and the direct rays of the sun. Although paint may still be adhering to the surface, it may be "dead" even though it appears satisfactory. If the paint film retains any life, a knife blade drawn across the surface at an angle will produce a "curl," much like the shaving made by a plane. If the paint is brittle and crumbles as it leaves the knife blade, it is dead and the structure should be repainted. This criterion should be applied particularly when the paint film is primarily for protection against corrosion. This test should be made on the face or faces of the tower which are most exposed to the sun (usually the southern exposure).

9.03 There is no paint known which will adhere to surfaces covered with loose dirt, grime, rust, bird droppings, grease, loose scale, etc. The surface to be painted must be thoroughly cleaned before painting, or early peeling may result. It is not generally practical to use pneumatic or electric tools for cleaning tower surfaces, and it is customary to employ manual cleaning methods using hand tools.

9.04 The equipment required for preparing a tower for painting includes coarse sandpaper, scrapers, and light chipping hammers. Wire brushes with fine, soft bristles tend to polish the surface, while coarse wire bristles have a fairly effective cleaning action. Coarse sandpaper or emery cloth is also effective. Lightweight hammers are not only less tiresome to use but also reduce the possibility of bending lightweight structural members.

9.05 Where painting is required because of F.C.C. and/or F.A.A. requirements, the finishing coat (which should be a good grade of outside enamel) must provide the alternate color bands of international orange and white. In cases where painting is required largely for appearance, a finish coat of aluminum enamel generally will be satisfactory. The aluminum finishes best suited for this purpose are shipped with the aluminum powder in a separate container and for best results should not be mixed until just before using.

9.06 Broadly speaking, enamel consists of an oil compounded with resin, with pigment and dryer added — in other words, a pigmented varnish. Paint may be described as a pigmented oil plus a dryer. The major difference in characteristics of the two is that enamel tends to be somewhat more brittle than paint. Enamel may be made more elastic by decreasing the amount of resin with respect to the amount of oil. There are, of course, borderline cases where one manufacturer may call his product an enamel, while another may have almost an identical product and call it paint. Generally, however, enamels wear somewhat better than paints because they are harder finishes.

9.07 While many installations are fenced in, it may be desirable to provide temporary fencing in grazing areas, as there have been cases where cattle fatalities have resulted from licking fresh paint. Also, when towers are located near highways, the possibility of paint spattering passing automobiles should not be ignored, as there have been cases where substantial expenditures have been incurred due to such negligence.

9.08 Experience indicates that good painters should be able to clean and paint from 280 to 370 square feet of tower surface in an eight-hour day. Coverage of paint ranges from about 350 to 400 square feet per gallon on this type of work. Variations in coverage are caused by such factors as surface texture, painting skill and practice, and weather conditions. Rough surfaces, of course, cut down the coverage and the amount of rough or pitted areas directly affects the coverage. The amount of brushing out also affects the coverage. Lower temperatures tend to cause paint to thicken, also reducing coverage. Painting should be avoided at temperatures under 50°F, and also when the surface is moist.

10. TOWER LIGHTS

10.01 The Federal Communications Commission and/or the Federal Aviation Agency may require towers to carry air obstruction warning lights, and it is highly important that these lighting systems be kept in good repair. If the lights are off for a period exceeding 30 minutes, the outage must be reported promptly to the nearest FAA Flight Service Station, who must also be notified when lights have been restored. No specific time limit has been prescribed for restoration of air obstruction lighting, although every effort should be made to have this done as promptly as possible.

10.02 Certain lamps used for this kind of service are designed to provide extra long life (3000 hours). Actually, lamps given a 3000-hour rating may or may not be good for that long a period of operation, since life ratings are based upon tests indicating that half of the group of lamps tested failed in that period. The particular long life lamps used for this service are the 107- and 620-watt sizes. (These are used where the FAA specifies 100- and 500-watt lamps, respectively.) Increased length of life is obtained by operating the lamp filament at a lower temperature. This, in turn, results in a somewhat lower lamp efficiency (i.e., to obtain the same light output, a greater part of electrical energy is dissipated as heat). Since the increased life is obtained by this means, it follows that operation of these lamps at voltages in excess of their rating will materially reduce their life expectancy.

10.03 To avoid the uncertainties of operation, maintenance, and added investment for equipment, it is often customary to leave the tower lights on continuously, rather than employ photoelectric control. Under these conditions, it will usually be desirable to replace lamps at about 3-month intervals. If lamps are switched off during daylight hours, the replacement interval may be proportionately increased. When towers are located in areas where there is considerable air traffic, the importance of air obstruction lighting is greatly enhanced. By the same token, if very little air traffic is involved, the hazard must be somewhat reduced. Replacement of lamps in areas having little air traffic may be considered on a 4-month basis if 3000-hour lamps are used 24 hours per day. As before, if lamps are switched off during daylight hours, the replacement interval may be proportionately lengthened. The cost of relamping a tower varies considerably, depending upon local circumstances. Travel time of workmen is very much a factor in determining the charge for this service. The height of the tower involved is sometimes a factor, with charges based upon a flat fee plus an increment per foot of tower height. Emergency restoration of lighting generally involves a higher charge for lamp replacement than does scheduled replacement. In general, it has been the practice to have this work performed by a contractor.

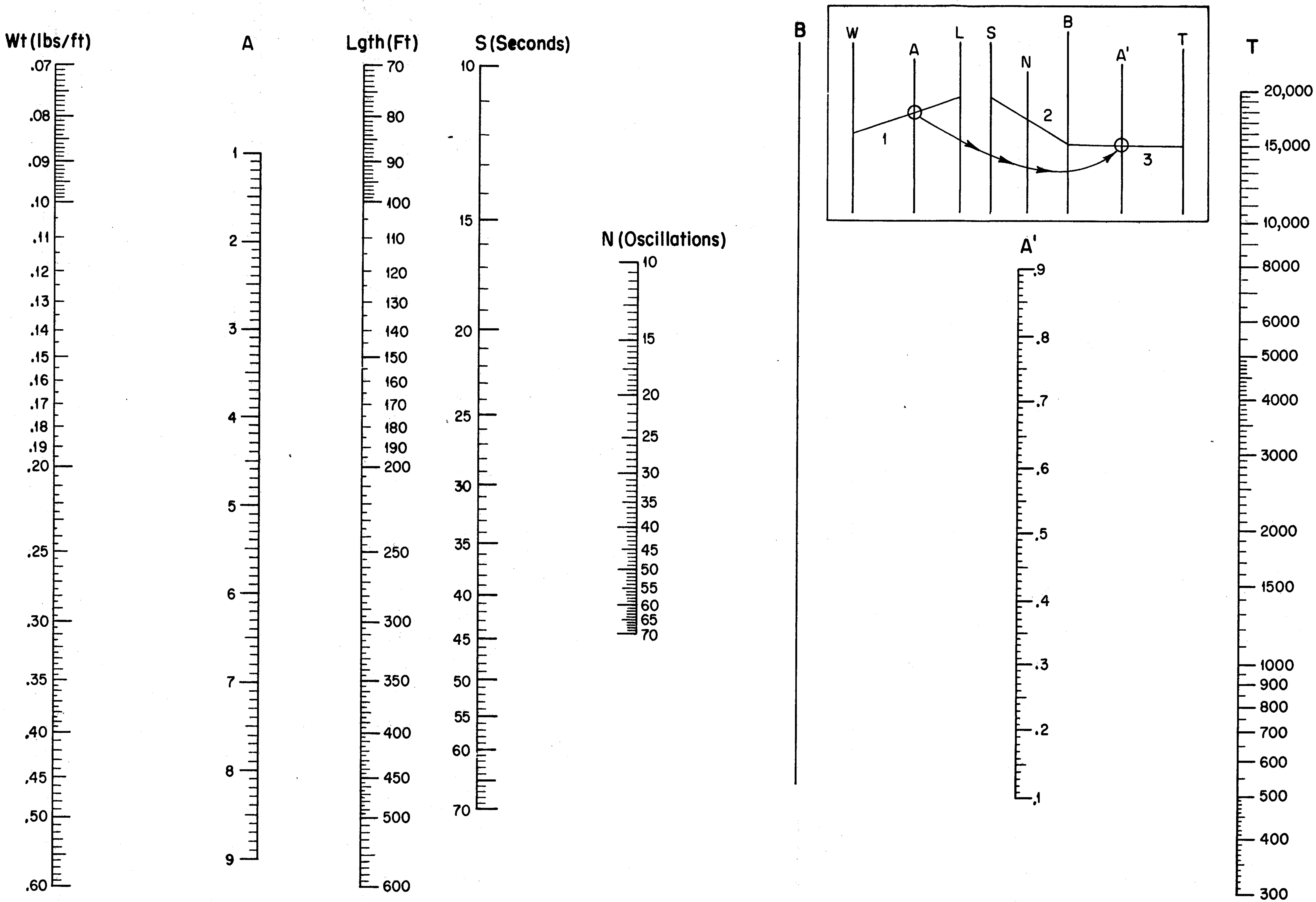
10.04 Not all lamp outages are due to open filaments or power failures. Occasionally, some lamps fail because of cracked or shattered glass. These failures seem to occur when non-tempered glass envelope lamps are used in areas where heavily moisture laden winds are frequently encountered, coupled with the possibility of sudden temperature changes, as, for example, areas adjacent to the Great Lakes. Failure of the glass envelope is apparently due to stresses set up by sudden cooling as would occur when moisture contacts the glass. The use of pyrex or "tempered" glass envelope lamps, because of their low coefficient of expansion, eliminate this difficulty.

10.05 Accumulations of foreign matter on the Fresnel globes or lenses should be removed periodically. Generally, this should be done about once a year unless local experience indicates more or less frequent cleaning will be satisfactory. A cloth dampened with glass-cleaning fluid will usually be adequate for this purpose. While the Fresnel globes or lenses are off for cleaning purposes, the inside of the fixtures should be cleared of any foreign matter, such as accumulation of dead insects, dust, etc. A small paint brush will be found helpful for this sort of work. Cracked or broken globes or lenses should, of course, be replaced. Faulty or deteriorated gaskets should also be replaced or the fixture will leak, and the entrance of water into these fixtures will tend to cause corrosion and other troubles.

10.06 Lamp fixtures become extremely hot when in operation and workmen should be cautioned to wear gloves, as considerable heat may be retained in fixtures for some time after the lamps have been turned off. Tower lights should be turned off before the tower is climbed if work is to be performed on the fixtures or if the lamps are to be replaced. In some cases, this may necessitate giving the contractor a key to the power room of the station in order to gain access to the switch controlling the lights. It should be established that the contractor is thoroughly trustworthy before this procedure is adopted. External switches protected by lock and key may be preferable. Since many installations are equipped with automatic alarm systems to indicate lamp failure, the lamps should never be turned off without advance notice to the person responsible for such matters. Also, in order to avoid the possibility of leaving the lights off, it is advisable to require a telephone call verifying that the work has been performed and that the lights have been turned on again.

10.07 Conduit, including its associated junction boxes, fittings, and fastenings should be inspected and painted at the same intervals as the tower itself. Rusted conduit should, in general, be treated the same as rusted structural members as far as painting is concerned. Conduit which has rusted through should be replaced to avoid damage to the wiring. Split conduit should likewise be replaced. No attempt should be made to repair split conduit in place by welding unless the conductors are removed, since the high temperatures caused by welding may damage the insulation.

Attached:
Nomogram


Wt (lbs/ft)
.07 .08 .09 .10 .11 .12 .13 .14 .15 .16 .17 .18 .19 .20 .25 .30 .35 .40 .45 .50 .60
A
1 2 3 4 5 6 7 8 9
Lgth (Ft)
70 80 90 100 110 120 130 140 150 160 170 180 190 200 250 300 350 400 450 500 600
S (Seconds)
10 15 20 25 30 35 40 45 50 55 60 70
N (Oscillations)
10 15 20 25 30 35 40 45 50 55 60 65 70
B
W A L S N B A' T
1 2 3
A'
.9 .8 .7 .6 .5 .4 .3 .2 .1
T
20,000 15,000 10,000 8000 6000 5000 4000 3000 2000 1500 1000 900 800 700 600 500 400 300