BELL SYSTEM PRACTICES
Outside Plant Construction and Maintenance

SECTION G21.120.1
Issue 1, October, 1954
AT&T Co Standard

PLACING POLES
GRADING

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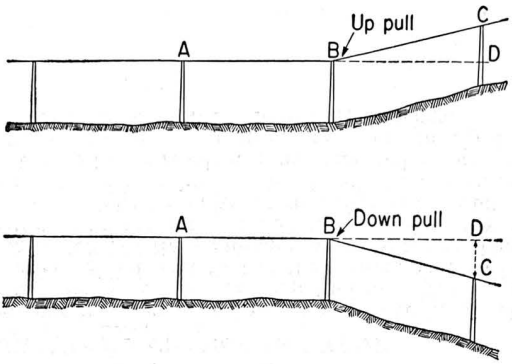
1. GENERAL

1.01 This section replaces Section G21.120, Issue 1, and is issued to provide additional information concerning methods of measuring change in grade. Instructions regarding types of construction to be used at changes in grade are deleted, since such instructions are contained in the Practices covering the placing of the various types of plant.

2. DEFINITION OF CHANGE IN GRADE

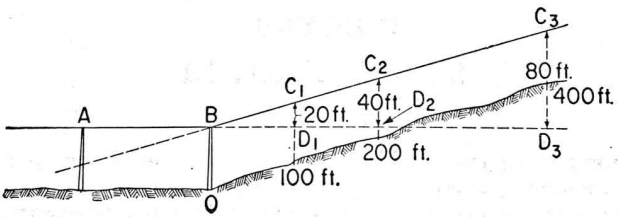
2.01 Change in grade is defined as a change in the slope of a line which results in an Up Pull or a Down Pull at a pole. The effect of a Down Pull in the conductor is to increase the downward load of the conductor on its support. The effect of an Up Pull is to decrease the downward load at the support. In some cases the change in grade resulting in Up Pull may be large enough to exert a lift on the point of support. In open wire lines Up Pull may result in pins being pulled out of crossarms. Examples of change in grade resulting in Up Pull and Down Pull are illustrated in the following sketches.



2.02 Change in grade is expressed as a percentage, such as 10 per cent, or 20 per cent, and is obtained by dividing CD by span length BC in the sketches above.

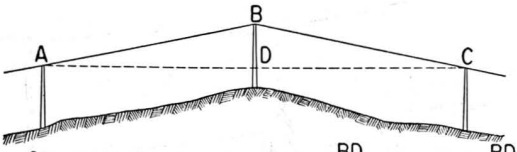
2.03 Theoretically, measurement BD should be used instead of span length BC to obtain an exact measure of change in grade, but since the difference between BC and BD is minor due to the small angles involved, and since span length BC is usually easier to obtain than measurement BD, the span length is ordinarily used.

2.04 Change in grade, thus determined and expressed as a percentage, is always a measure of the amount of Up Pull or Down Pull on the support regardless of the span lengths. In the following sketch, for example, a change in grade of 20 per cent is shown with spans of various lengths. The table shows how the measure of change in grade remains the same for all span lengths.



Span Length in Feet BC	Value in Feet CD	Change in Grade $\frac{CD}{BC}$
100	20	20/100 or 20 per cent
200	40	40/200 or 20 per cent
400	80	80/400 or 20 per cent

2.05 Where it is more convenient and the span lengths are approximately equal, the measure of change in grade at a pole with a Down Pull may be determined in the following manner.



$$\text{Change in Grade at B} = 2\,\frac{BD}{\frac{1}{2}(AB+BC)} = 4\,\frac{BD}{AB+BC}$$

(a) If one of the adjacent spans is 50 per cent longer than the other, an error of about 5 per cent will be introduced in the measurement of change in grade. This percentage of error increases rapidly with greater differences in span length, but for variations within 50 per cent, this method may be accepted as substantially accurate.

3. MEASURING CHANGE IN GRADE—EXISTING POLE LINE

3.01 Measurements of change in grade in existing pole lines will frequently be necessary in connection with pole replacement or relocation work. Some suggested methods are outlined in the following paragraphs. Under many conditions these measurements may be readily obtained by one man.

Sighting from Tops of Poles or Same Relative Locations

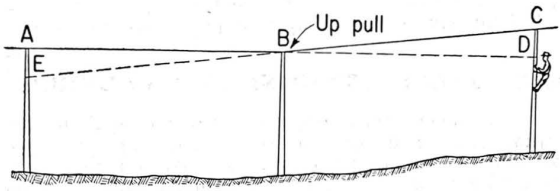
3.02 In some instances where unusually rough terrain is encountered, it may be necessary to climb the poles and sight along their tops. This method should not be followed on jointly used poles where it would be necessary to climb into the

Power Company's space on the pole. The following sketches show methods of measuring at Up Pulls and at Down Pulls.

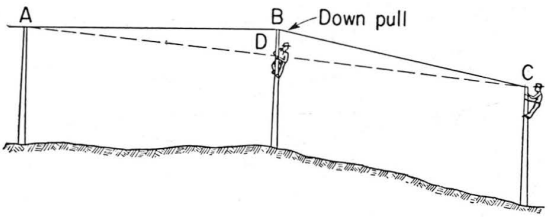
(a) At Up Pulls

(1) Sight from Pole C along line AB and establish point D. Change in grade will be $\frac{CD}{\text{Span BC}}$, or

(2) Sight from pole A along line BC and establish point E. Change in grade will be $\frac{AE}{\text{Span AB}}$.



(b) At Down Pulls. Man at pole C (or pole A) sights along line AC and directs man at B in establishing point D. Compute change in grade as outlined in Paragraph 2.05.

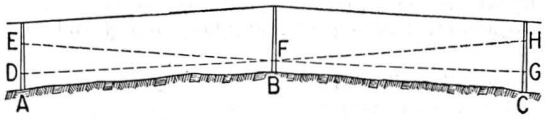


3.03 If there are no obstructions, change in grade may be sighted from the ground in the following manner:

(a) Locate points D, F, and G at same distance from tops of poles A, B, and C. These points may be at any convenient sighting height, or a point at which the distance from the top of the poles can be readily determined.

(b) Man at pole A sights along line DF and directs man at pole C in establishing point H. Change in grade will be $\frac{HG}{\text{Span BC}}$, or

(c) Man at pole C sights along line GF and directs man at pole A in establishing point E. Change in grade will be $\frac{ED}{\text{Span AB}}$.



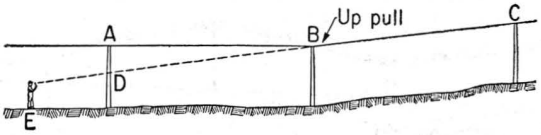
3.04 Where terrain permits, change in grade may be sighted from a remote location. Examples of this method are illustrated below:

(a) At Up Pulls

(1) Find a location along line of sight BC, as at E, and, sighting along line BC, establish point D.

(2) Determine distance AD with B pole scale, or by sighting with a rule and comparing with crossarm spacing, gains or bolt holes, 10-foot brand markings, or other markings of known spacing.

(3) Change in grade will be $\frac{AD}{\text{Span AB}}$.

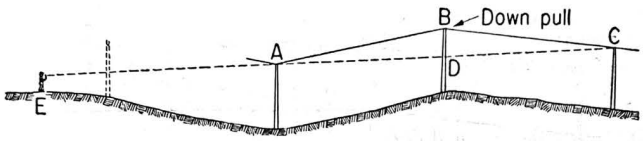


(b) At Down Pulls

(1) Find a location along line of sight AC, as at E, and, sighting along line AC, establish point D.

(2) Determine distance BD in the same manner as described in Paragraph 3.04(a)(2) above.

(3) Compute change in grade as outlined in Paragraph 2.05.



Use of Pull Finder to Measure Change in Grade

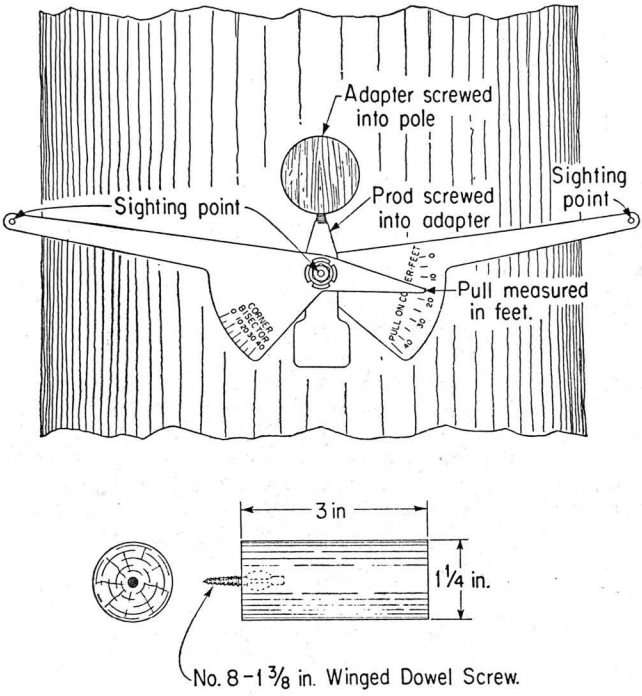
3.05 The pull finder can be used to determine the change in grade at a pole by measuring the "pull" of the vertical corner resulting from the change in grade. The pull finder is used at the pole where the change in grade occurs and the pull in feet is read directly. (Instructions on the use of the pull finder for guying purposes will be found in the Guying division of the G Series.)

3.06 The pull in feet, as determined by the pull finder, is converted to "Change in Grade" by multiplying pull by 2/100. Examples of this conversion are shown in the following table:

Pull (Feet)	Change in Grade
5	10/100 or 10 per cent
10	20/100 or 20 per cent
15	30/100 or 30 per cent

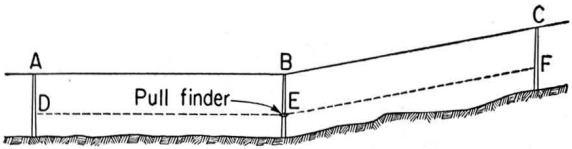
3.07 The pull finder should be attached at a convenient point on the pole where the change in grade occurs. In order to simplify the procedure, the point of attachment of the pull finder and the sighting points on the adjacent poles should all be at the same relative positions; that is, all at the tops of the poles or all at the same distance from the tops of the poles. At Down Pulls the tops of the corresponding crossarms may be convenient points; at Up Pulls, the bottoms of corresponding crossarms may be found convenient.

3.08 For measuring change in grade from the ground, the pull finder may be mounted on the pole by means of an adapter. A simple type of adapter which may be used for this purpose is shown in the following sketch. No arrangements have been made for supplying this adapter as a Bell System standard, inasmuch as the quantity required will be small. A short cylindrical shaped piece of soft wood of approximately the dimensions shown, equipped with a No. 8 winged dowel screw, will serve the purpose.



(a) This adapter is equipped with a pin in one end, as shown, with a wood screw thread for attaching to the pole. The pull finder is first affixed to the adapter, and the adapter is then screwed into the pole.

3.09 The following sketch illustrates the method of measuring change in grade from the ground by use of the pull finder.



(a) Select and mark points D, E, and F at the same distance from the tops of poles A, B, and C, and with point E at a convenient height for sighting.

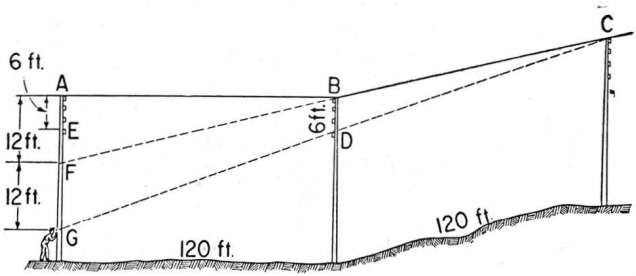
(b) Attach the pull finder to pole B at point E.

(c) By aligning the legs of the pull finder along lines DE and EF, read the pull of the vertical corner.

(d) Convert the pull in feet to change in grade in accordance with Paragraph 3.06, above.

Sighting Through Points Which Are Not at Same Distance from Tops of Poles

3.10 Change in grade can be measured by sighting through points which are not at the same distance from the tops of the poles, and by making adjustments to compensate for the differences. This procedure is illustrated in the following sketch.



3.11 In the above sketch, the change in grade is $\frac{AF}{\text{Span } AB}$.

Since sighting from point F (as illustrated in Paragraph 3.02(a), above) would require climbing the pole, the change in grade may be determined in the following manner.

(a) Sight from pole A across the top of the top arm on pole C and one of the lower arms on pole B. (In this case, the arm in the fourth gain.) From this line of sight, CD, establish point G on pole A.

(b) Determine measurement BD by means described in Part 5. (In this example, BD = 6 feet.)

(c) FG will be greater than BD by the ratio of the sum of the spans to span BC ($\frac{FG}{BD} = \frac{\text{Span AB} + \text{Span BC}}{\text{Span BC}}$). (In this example, FG is twice BD or 12 feet.)

(d) Determine measurement AG by methods described in Part 5.

(e) Subtract FG from AG. The remainder will be AF. (In this example, 24 feet − 12 feet = 12 feet.)

(f) As stated above, the change of grade is $\frac{AF}{\text{Span AB}}$. (In this example, $\frac{12 \text{ feet}}{120 \text{ feet}}$ = 10 per cent, or 1/10.)

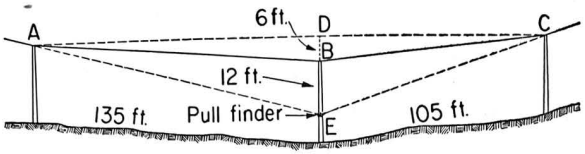
3.12 The pull finder can be used for sighting through points which are not the same distance from the tops of the poles. Use of this method requires reference to previous paragraphs in this section:

(a) Under Paragraph 3.05 it is pointed out that the pull finder provides a reading which can be converted directly into change in grade, without regard to length of span or the relation between span lengths.

(b) As discussed in Paragraph 2.05, the computation of change in grade from a vertical measurement at the pole where the change occurs requires that the two adjacent spans be approximately equal.

(c) The adjustment in vertical measurement, which is made in the following example to compensate for differences in distance of sighting points from the tops of the poles, also requires that the adjacent spans be approximately equal.

(d) Proceed with measurement of change in grade as follows.



(1) Attach pull finder to pole B at convenient point E. Sight through tops of poles A and C and read pull as described in Paragraph 3.05, above. (In this example, assumed to be 15 feet.)

(2) Change in grade at point E will be 30 per cent or 3/10.

(3) Compute average of spans AB and BC ($\frac{135 \text{ feet} + 105 \text{ feet}}{2} = 120$ feet).

(4) Multiply change in grade by average span length and divide by 2. This is distance DE. ($\frac{.30 \times 120}{2} = 18$ feet.)

(5) Determine distance E to top of pole by methods described in Part 5. (BE = 12 feet.)

(6) Subtract BE from DE. The remainder is DB. (18 — 12 = 6.)

(7) Multiply DB by 2 and divide by average span length from (3), above. This is the change in grade of the pole line at pole B. ($\frac{6 \times 2}{120} = 10$ per cent, or 1/10.)

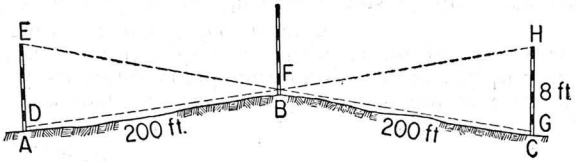
4. MEASURING CHANGE IN GRADE—LAYING OUT NEW LINES

4.01 In laying out new lines, changes in grade may be determined from profile diagrams, by use of a transit or hand level, or with ranging rods. It is the use of ranging rods with which this practice will be concerned.

4.02 Methods of sighting and measuring changes in grade will be somewhat limited as compared with those available on existing lines, as described in Part 3. The added height of poles over ranging rods will not be available for sighting, and, of course, there will be no poles which can be climbed to assist in sighting.

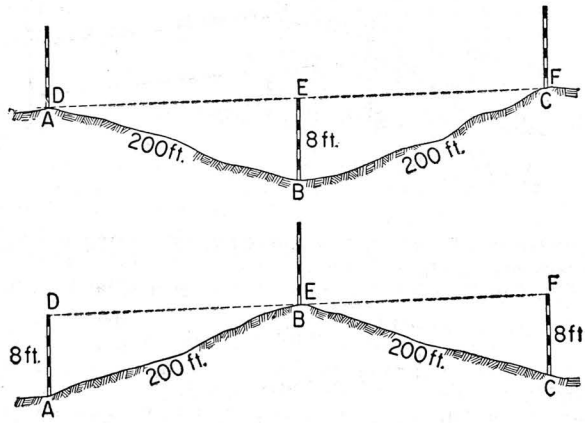
4.03 In laying out new lines, measurements in change of grade will be related to changes in the contour of the ground. The grading of the pole line, and the heights of poles required in various locations, can be determined by computation, with the aid of simple sketches.

4.04 Change in grade can be measured with ranging rods in the manner illustrated in Paragraph 3.03. The amount of change in grade which can be measured in this manner is limited by the length of the ranging rods. This is illustrated in the following sketch.



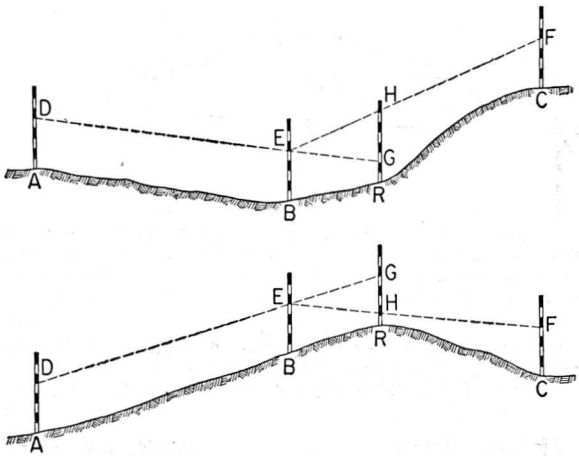
(a) If conditions of terrain were such that it would be possible to obtain a full 8-foot reading at GH or DE, the change in grade in a 200-foot span would be only four per cent.

(b) The amount of change in grade which can be measured will be increased by using the method shown for Down Pulls in Paragraph 3.02(b). This method can be used for either Up Pulls or Down Pulls as shown below.



(c) As pointed out in Paragraph 2.05, the measurement taken on rod B will be multiplied by two and divided by the average of spans AB and BC. Thus the change in grade will be $\frac{8 \times 2}{200}$ or eight per cent.

4.05 Whenever it is necessary to measure a change in grade that is in excess of the amounts possible by the methods described in Paragraph 4.04 above, the following method can be used.



(a) Use four ranging rods. Place one rod at each of the three proposed pole locations, A, B, and C. In span BC, and in line with rods B and C, place the fourth rod R at a distance of about 30 feet from B.

(b) Man at A sights through points at the same height, say the 5-foot mark, on rods A and B and directs man at R in locating point G on rod R. If rod R is outside line of sight DE, move closer to B until it can be sighted and point G located.

(c) Man at C sights through points on rods C and B at the same height above ground as those sighted on rods A and B (in this case, 5 feet) and directs man at rod R in establishing point H.

(d) Change in grade will be $\frac{GH}{BR}$.

(e) Computations will be simplified if rod R is located at a distance from B which is a multiple of 10, such as 40 feet, 30 feet, or even 10 feet.

(f) It is not necessary that the ground level at rod R be in line with that at B and C, since the measurement GH is taken between two points on the rod R and the height above ground is not considered.

4.06 In difficult terrain, the pull finder may be used in conjunction with ranging rods for measuring change in grade. The procedure will be similar to that described in Paragraph 3.05.

4.07 Sectional ranging rods may be lengthened by the use of one or more extension sections to increase the amount of change in grade which can be measured by the methods described in Paragraph 4.04.

5. MEASURING VERTICAL DISTANCES

5.01 Several methods are available for determining vertical distances. Although some of these are not exact, they are sufficiently accurate for use in measuring changes in grade. Some suggested methods are listed below:

(a) When change in grade is obtained by climbing the poles, as in Paragraph 3.02(a) and (b), a rule or measuring tape is the most convenient means of measurement.

(b) In determining change in grade from the ground, as in Paragraph 3.03, a rule or a measuring rod may be used.

(c) When sighting from a remote location, as in Paragraph 3.04(a) and (b), a rule held vertically in the line of sight may be used for measuring the vertical distance by comparing it with known distances, such as spacing of crossarms, pole gains, or crossarm bolt holes. If the point to be measured is a considerable distance below the crossarms or other known spacings, particularly on a high pole, compute the distance between the lowest identifiably spaced marking, such as a pole gain, and the 10-foot brand mark on the pole and, by sighting with the rule, determine the location of the point with respect to these markings. To the measurement thus taken, add the known spacings to determine the total distance.

(d) The B pole scale may also be used for this type of measurement.

(e) When measuring from the base of a pole, particularly a tall pole, as in Paragraph 3.10, the range finder provides a quick means of making a reasonably accurate measurement.

6. ALLOWABLE CHANGE IN GRADE

6.01 Instructions concerning the maximum permissible amounts of change in grade, and the types of construction to be employed for various lesser amounts, are contained in the sections of the practices covering the placing of the types of plant involved.

6.02 Specific instructions for open wire construction will be found in the Pole Attachments division of the G Series under "Placing Crossarms—Grade Construction" and "Tandem Transposition Brackets" and in the Open Wire division under "Open Wire—Tying."

6.03 Instructions for aerial cable construction are included in the Aerial Cable division under "Aerial Cable—Attachments for Suspension Strand."

6.04 Requirements for additional guying are specified in the Guying division for both open wire and aerial cable construction.

6.05 If the downward change in grade on a pole exceeds the allowable maximum for the type of plant involved, the condition can be corrected, and additional strength provided at the critical point in the pole line, by placing an additional pole as shown below.