Rural Electrification Administration
Telephone Engineering and Construction Manual

Section 626
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STAKING OF AERIAL PLANT

Contents

1. GENERAL

1.01 This section is intended to provide REA borrowers, consulting engineers, contractors and other interested parties with technical information for use in design and construction of REA borrowers' telephone systems. It discusses in particular staking for construction of aerial telephone plant.

1.02 Staking of buried plant is discussed in REA TE & CM Section 641, "Construction of Buried Plant."

1.03 Staking should be consistant with the construction proposed in the Area Coverage Design. It should be undertaken with the objective of constructing plant which conforms to REA standards of design and construction; is free from hazards, and is the most economical plant practicable.

1.04 The staking engineer should have at his disposal and be familiar with the following material:

The approved Area Coverage Design (Including Maps)
List of signed subscribers
Maps showing available R/W easements
Details of Joint Use Agreements
REA Form 511, Telephone System Construction Contract
National Electrical Safety Code (Latest Edition)
National Electrical Code (Latest Edition)
Wire Manufacturer's Sag and Tension Data
REA Telephone Engineering and Construction Manual Sections

430 Subscriber Line Loading
431 Voice-Frequency Loading for Trunk Cables
462 R1 and R2 Transposition Systems
463 REA-1 Transposition System
465 REA-V1 Transposition System
601 Discussion of the National Electrical Safety Code
602 Clearances
603 Right-of-Way Selection
605 Right-of-Way Clearing and Trimming Assembly Units
610 Poles
611 Design of Pole Lines
615 Design of Open Wire Plant
616 Construction of Open Wire Plant
617 Railroad Crossing Specifications
619 Design & Construction of Insulated Open Wire Plant
620 Design and Construction of Figure 8 Distribution Wire
625 Pole Top Assembly Units
626 Staking of Aerial Plant
627 Route and Pole Numbering
629 Cable Plant Layout
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645 Cable Plant Assembly Units
650 Guys and Anchors on Wire and Cable Lines
690 Joint Use of Poles
701 Station Installations
801 Conditions Requiring Electrical Protection
805 Subscriber Station Protection
815 Electrical Protection of Aerial Cable
820 Open Wire Circuit Protection

821 Multi-Pair Distribution Wire Protection
822 Electrical Protection of Carrier Equipment
830 Electrical Protection Assembly Units

1.05 Staking personnel should attend the Pre-staking Conference and staking should conform to the agreements and requirements contained in the conference notes.

1.06 In order to minimize delay and expense caused by replacement of stakes lost because of subscriber activities, the owner may wish to publicize the staking operation. Figure 1 is a sample advertisement designed to prevent loss of stakes.

1.07 References:

REA Bulletin 380-1, Right-of-Way and Title Procedures
REA Bulletin 383-4, Pre-Staking Conference Check List

2. ACTIVITIES OF THE ENGINEER

2.01 When the system engineer has assembled the information required relative to the characteristics of the circuits and the subscribers to be served, the staking engineer proceeds as follows:

2.011 Give due consideration to farming operations and seasonal conditions so as to minimize the necessity for replacement of stakes.

2.012 Conduct staking operations so as to conform to the latest revision of the National Electrical Safety Code, National Electrical Code and local and state laws; rules, regulations, and orders of state regulatory bodies, whichever are most stringent; and the approved Area Coverage Design.

2.013 Stake only lines shown in the approved Area Coverage Design except for minor changes dictated by field conditions unless written approval is obtained from the owner and REA.

2.014 Give careful consideration to the right-of-way obtained on each parcel of land on which lines are to be staked. If the right-of-way is not satisfactory from an engineering standpoint such as poor routing, hazardous conditions, heavy clearing, inadequate guying space, etc., the staking engineer should discuss the conditions with the owner so that an attempt can be made either to procure additional right-of-way or to relocate the proposed section of line in a more satisfactory location.

2.015 Give careful consideration to the location of station equipment in staking main line pole locations adjacent to a subscriber's premises so that drop and station ground wiring will be as short as practicable.

2.016 In connection with the staking of proposed joint use lines, prepare and submit to the owner detailed information concerning pole changes, insert poles and other changes or modifications in existing pole lines of other utilities to accommodate the owner's facilities. Such information should be prepared with the full participation of the engineering department of the other utility.

2.017 Provide detailed instructions on staking sheets regarding the point of attachment of the owner's facilities on poles proposed for joint use.

2.018 Prepare staking sheets in such form that they may serve as the means by which directions are given for the construction of the project and also provide a permanent outside plant record of the proposed system.

2.019 In connection with the staking of lines along and within the right-of-way of public roads, the staking engineer shall make every effort to determine whether there are any road widening projects contemplated which might cause the owner to relocate a section of line shortly after the plant is constructed. Information on proposed highway construction can usually be obtained from the engineering departments of state and county road commissions.

2.020 Where the owner is required to submit engineering information as a prerequisite to obtaining a permit, license, franchise, or authorization from public bodies or private corporations in connection with proposed construction, the staking engineer shall obtain the necessary field data for the system engineer to prepare the required engineering information and drawings for the owner. Examples of staking that may involve application for permits are as follows:

a. Trimming or removal of trees in public right-of-way.

b. Crossings of state highways.

c. Crossings of navigable streams.

d. Railroad crossings.

e. Joint use of poles with another utility.

f. Crossings of other wire lines.

g. Crossings of land owned or controlled by public bodies.

h. Location of poles in incorporated villages or towns.

2.02 Reference:

REA Form 217, Post Loan Engineering Service Contract

3. NATIONAL ELECTRICAL SAFETY CODE

3.01 It is most important that the staking engineer know and under stand the National Electrical Safety Code (NESC) Requirements for telephone system construction and the rules of particular states where staking must conform to both state and NESC requirements.

3.011 Some states have local requirements for telephone pole line construction. In such states, the latest edition of the NESC or local requirements, whichever is more stringent, must be observed by the staking engineer. For states where no requirements are established, the provisions of the latest edition of the NESC must be met.

3.02 The portion of the NESC that the staking engineer is particularly concerned with is Part 2 which deals with the construction and maintenance of overhead and underground lines. In applying the NESC rules it is well for the staking engineer to keep in mind that the rules set forth therein were not intended to serve as a basis for designing or staking telephone plant. The rules should be considered as the minimum standards that must be met if the plant is to have sufficient strength to withstand the mechanical loads and stresses to which it will be subjected; be reasonably protected from the possible effects of lightning and other electrical disturbances; and to be relatively free from hazards to the general public and to persons maintaining the facilities.

3.03 The requirements of the NESC are such that the strictness of the rules vary with the degree of hazard involved. In order to provide adequate rules for the varying degrees of hazard, the NESC gives special consideration to the following requirements:

a. Clearances
b. Grades of Construction
c. Loading
d. Strength
e. Electrical Protection

3.04 References:

National Electrical Safety Code
REA TE & CM-601, Discussion of the National Electrical Safety Code
REA TE & CM-602, Clearances

4. NATIONAL ELECTRICAL CODE

4.01 The purpose of this code is the safeguarding of persons and of buildings from hazards arising from the use of electricity for light, heat, power, radio, and communication. The National Electrical Code (NEC) contains basic minimum provisions considered necessary for safety.

4.02 Chapter 8 "Communication Systems" Article 800 - "Communication Circuits" discusses minimum conductor installation and separation requirements, protective devices, conductor insulation requirements and station grounding. REA practices follow the NEC requirements in and on buildings rather than the requirements of Section 39 of the NESC.

4.03 References:

National Electrical Code
REA Form 511, Telephone System Construction Contract
REA TE & CM-701, Station Installations
REA TE & CM-805, Station Protection

5. MECHANICS OF STAKING

5.01 Staking of REA borrowers' telephone plant involves the determination of:

a. Control points along the route.

b. The appropriate locations of all poles, anchors, terminals, etc.

c. The appropriate plant assembly unit for each application.

d. The most effective location of the first attachment on the subscriber's building, the protector location and the most effective grounding electrode available.

e. The right-of-way clearing and trimming units.

5.02 This information with a sketch and terrain profile (where difficult terrain is encountered) entered on the staking sheet provide:

a. A means of verifying the selected units.
b. A means of summarizing the units involved in the construction.
c. Instructions for construction of the plant.
d. A means of preparing the final inventory of the completed plant.
e. A necessary plant operating record for the owner.

5.03 Control points are generally the same for aerial wire and aerial cable plant. Control points for both types of plant are points where plant must be located and points that must be avoided. Some typical conditions which determine control points are as follows:

a. Street, alley, and property lines.
b. Street, alley, and highway intersections.
c. Rivers, drainage ditches and canals.
d. Gullies and ditches.
e. Ridges and depressions.
f. Angles and corners in highways and roads.
g. Farm driveways and field entrances.
h. Railway rights-of-way.
i. Pole lines of other companies.
j. Junctions between cable and wire.
k. Junctions with branch lines.
l. Cable terminal locations.
m. Subscribers' premises
n. Trees and brush.
o. Right-of-way restrictions.
p. Changes in grade.
q. Outcropping rock.

5.04 Prior to staking aerial plant the basic pole and basic span length will have been determined. The staking engineer should determine the control points in each section of line and stake approximately equal spans, as close to the basic span as practicable, between those control points. The basic span should be varied from to avoid undesirable pole locations such as in depressions, gullies or ditches, etc.

5.05 An engineer's transit, preferably with stadia hair, should be used to run the line between control points. The transit may be set up and leveled over one of the control points if one point is visible from the other. By taking a "foresight" on a range rod placed vertically at the other control point, the line is established. A rodman thereupon proceeds toward the other control point and the transit man lines him in at points along the line where poles are to be located. A stake marked with the pole number should be driven at each pole location.

5.06 If conditions are such that neither control point can be seen from the other, the transit may be set up at some intermediate point such as a location on the top of a knoll where range rods set at each control point are visible. The instrument is set up on a point estimated to be on the line by backsighting on one of the control points and reversing the telescope on its horizontal axis, a check can be made to determine the extent to which the transit is out from the line. By a "juggling in" process and by repeating the above check one or more times, the instrument is finally placed on line. A rodman then proceeds toward the transit from each control point and the transit man lines the rodman in at each pole location.

5.07 There may be some sections of line between control points where it is difficult to line in range rods because of brush, trees, crops or other obstacles. In such instances it may be possible to run a parallel line along the edge of a traveled road where visibility is unobstructed. If so, a line may be run as previously described and the pole stake locations determined by offset. If this method is used care must be exercised to make certain that equal offset distances are measured at right angles to the line established along the road and in the same plane or stakes will be located out of line.

5.08 When using the transit at control points to line in stakes, the instrument should also be used to measure the angle of change in the line if there is to be an angle in the line at the control point. If there is an angle, the transit should be used to bisect the angle and establish the line along which an anchor is to be located. A stake should be driven at the anchor location.

5.09 The transit may be used in determining differences in elevation between two points by taking a rod reading at each point with the instrument level and taking the difference in the two rod readings to determine the difference in elevation. Information so obtained is valuable in "grading" a line, determining clearances at highway and power crossings and in staking railroad crossings. The same information may be obtained but with a lesser degree of accuracy by using a hand level. This instrument is a simple device which is held at the eye and the farther end raised or lowered until the bubble is in the center of the tube. When this occurs, a point on a rod in line with the horizontal line is noted and approximate levels measured.

5.10 Where it is probably that there will be difficulty in finding stakes at a later date the stake location should be indicated by driving a four foot building lath adjacent to the stake or by providing some other suitable marker. Where the stakes are located on private right-of-way so as to be invisible from the road because of brush, trees or crops, a suitable marker (such as a strap of cloth on the fence) should be provided so that the location of the stake will be indicated from the road. It will also be helpful to place appropriate notes on the staking sheets.

6. PLANT ASSEMBLY UNITS

6.01 The general design represented by the approved area coverage design must be converted by the staking engineer into a specific design in sufficient detail to enable a contractor or an owner to build the plant. To facilitate this, "assembly units" have been devised for practically all major components of outside plant. By specifying the appropriate type, quantity and location of assembly units, the staking engineer indicates the construction for the complete physical plant as contemplated in the design.

6.02 The staking engineer must be thoroughly familiar with the assembly units and their application. The proper use of the units is discussed in the applicable sections of the manual.

6.03 References:

REA Form 511, Telephone System Construction Contract
REA TE & CM Sections
- 430 Subscriber Line Loading
- 431 Voice-Frequency Loading for Trunk Cables
- 462 R1 and R2 Transposition Systems
- 463 REA-1 Transposition System
- 465 REA-V1 Transposition System
- 605 Right-of-Way Clearing and Trimming Assembly Units
- 611 Design of Pole Lines
- 625 Pole Top Assembly Units

627 Route and Pole Numbering
645 Cable Plant Assembly Units
650 Guys and Anchors on Wire and Cable Lines
830 Summary of Units Used in Protection Systems

7. RIGHT-OF-WAY CLEARING AND TRIMMING

7.01 Right-of-Way Clearing and Trimming units are defined in REA Form 511. Applications of the unit designations are described in REA TE & CM-605. Clearing and trimming units are descriptions of limits within which clearing and/or trimming is to be performed to stated specifications without regard to the amount of timber to be cut or brush to be cleared.

7.02 Minimum right-of-way widths within which clearing is to be done are based on the type of pole line facilitty to be constructed. Normal guide lines are listed below but the staking engineer may find it necessary to deviate from these in some instances.

a. For aerial cable plant - Five feet on each side of the centerline of the pole line.

b. For Multipair and One-Pair Distribution Wire - Five feet on each side of the centerline of the pole line.

c. For Two Wire Open Wire Leads - Five feet on each side of the centerline of the pole line.

d. For Multicircuit Open Wire Leads - Ten feet on each side of the centerline of the pole line.

7.03 The staking engineer must determine the required clearing or trimming in each span and record the applicable units and lengths on the staking sheets.

7.04 The staking engineer shall provide on the staking sheets explicit instructions for clearing or trimming and shaping fruit, shade and ornamental trees, and shall designate all danger trees to be removed or topped.

7.05 If chemical treatment of the cut right-of-way is required, the staking engineer will specify "RC" units.

7.06 Proper location of the pole line or any portion of the pole line within the right-of-way can often result in both lower initial cost and in lower annual carrying charges. This location is generally governed by the control points along and within the right-of-way.

7.07 The greatest benefit can usually be gained from savings in initial right-of-way clearing and trimming and the resultant annual savings in R/W maintenance. Pole line staking to deviate from a straight line in order to avoid trees may require a slightly higher pole line investment but the cost of initial clearing and subsequent reclearing can often be eliminated entirely. Another method of deviation is to overbuild shrubs and brush of limited mature growth instead of clearing the right-of-way to permit using the previously determined basic pole length.

7.071 Figures 2, 3, and 4 illustrate some pole line deviations and methods of determining the economic advantages resulting from methods of avoiding clearing and trimming.

7.072 Telephone Operations Manual, Section 1244, Right-of-Way Trimming, discusses low-growing brush and shrubs, and growth characteristics of a number of tree species. The staker should consider growth factors in staking through, along, or around shrubs and trees.

7.08 References:

REA Form 511, Telephone System Construction Contract
REA TE & CM Sections
218 Plant Annual Cost Data for System Design Purposes
603 Right-of-Way Selection
605 Right-of-Way Clearing and Trimming Units

REA Telephone Operations Manual Section 1244, Right-of-Way Trimming

8. POLE SELECTION

8.01 Basic pole class and height selection in general has been made prior to staking. The staking engineer's responsibility is in choosing the right pole (height and class) for each pole location.

8.02 In the construction of much of the rural line plant, particularly two-wire lines, pole costs may represent as much as 85 percent of the cost of the line. It is absolutely necessary that the proper class and height of pole be selected for a particular application. In addition to the increased material costs, it should be kept in mind that freight costs and handling and setting costs are greater for longer and heavier poles. For example a 25 foot class 7 southern yellow pine pole requires a 25% deeper hole and weighs more than 1 1/2 times as much as a 20 foot class 9 pole.

8.03 Consideration should be given to specifying poles of sufficient height to cross roads with future drops to potential subscribers and to maintain NESC clearances.

8.04 Standardization of pole heights and classes to conform to the general requirements of the facility being staked usually results in construction economies.

8.05 Adequate vertical clearances (NESC or greater) must be maintained over and along public streets, alleys, roads, driveways, field entrances, et cetera. Pole heights will vary as required by the needed clearance, the terrain and sags of wires and cables. The staking engineer should refer to the sag data on the various types of wire and strand with cable issued by the wire manufacturers when determining individual pole height requirements.

8.06 References:

Wire Manufacturer's Sag and Tension Data
REA TE & CM Sections
602 Clearances
610 Design of Pole Lines
615 Design of Open Wire Plant
620 Design and Construction of Figure 8 Distribution Wire
630 Design of Aerial Cable Plant
690 Joint Use of Poles

9. ANCHORS AND GUYS

9.01 Adequate strength and proper alignment of the pole line structure must be maintained. Anchors and guys at corners, deadends and other points of strain should be of proper size to hold the storm loading on facilities expected to be developed during the ten-year period. However, if two guys would be required for an ultimate load of ten circuits, one guy may be sufficient to support the load of the facilities to be placed initially.

9.02 When staking anchors and guys a ratio of lead to height (L/H) of at least one should be obtained wherever practicable so that the minimum size guy and anchor assemblies can be utilized.

9.03 When side anchors are staked in a field, the right-of-way may limit the lead. However, if corner pole locations could be shifted to a driveway line, fence line, line of trees, or outcropping of rock, et cetera, satisfactory leads may be obtained in many cases without objection by the property owner.

9.04 In cases where property owners will not allow anchors in fields it may be possible to place guy stubs with overhead guys at locations a reasonable distance back from the lead where a group of trees, drain, outcropping or other physical condition may allow such construction.

9.05 Situations may arise where pole keys or push braces may be required. These methods are expensive and should be used only when physical conditions or rights-of-way prevent the use of normal construction.

9.06 Corners or slight angles should be accumulated when staking around curves and the number of guys and anchors kept to a minimum.

9.07 When an overhead guy must be installed and an electric supply line occupies the opposite side of the road, the overhead guy and down guy should be attached to an electric supply line pole if possible. This not only saves the cost of a guy stub but will permit grounding the guy to a multigrounded neutral, if one exists, saving the cost of two strain insulators.

9.08 Guys that are classified as exposed guys are considered to constitute an electrical hazard to workmen and the public and must, therefore, be electrically protected. The electrical protection for an exposed guy is accomplished by effectively grounding the guy, or by the insertion of insulators in the guy in order to isolate the electrical hazard. Wherever practicable the guy should be grounded by bonding it to the neutral of a multigrounded supply system, or by bonding it to a systematically and effectively grounded cable strand.

9.09 All angles guyed and unguyed should be shown on the staking sheets.

9.10 References:

National Electrical Safety Code
Wire Manufacturer's Sag and Tension Data
REA TE & CM Sections
611 Design of Pole Lines
650 Guys and Anchors on Wire and Cable Lines

10. AERIAL WIRE PLANT (BARE)

10.01 Staking of aerial wire plant is to a large extent the selection of proper pole top assembly units to support the wire facilities under the varying conditions encountered along the lead. Adequate strength against the transverse loads placed upon the support unit must be determined. This determination is related to the number and types of conductors, the span lengths involved, angles occurring in the lead and grade changes encountered as a result of terrain conditions.

10.02 The primary restriction in staking aerial wire plant is the maximum loaded conductor tension. Maximum loaded conductor tension under NESC loading is established as:

Heavy Storm Loading Area	- 85% Rated Breaking Strength
Medium Storm Loading Area	- 75% Rated Breaking Strength
Light Storm Loading Area	- 60% Rated Breaking Strength

10.03 In the light storm loading area the maximum tension will seldom be realized but for the smaller conductors in the loading area this limitation must be observed.

10.04 The 5th Edition of the NESC required increments of increased ground clearance at 60°F for spans in excess of certain basic span lengths in the heavy, medium and light loading districts The 6th Edition of the NESC eliminates this added increment of ground clearance. However, in order that adequate and required ground clearance is maintained in hot weather when conductors expand and have greater sags, the staking engineer should continue to use the added increments for determining required pole heights. Staking tables available from wire manufacturers include the added increment of ground clearance.

10.05 The increase in sag in a wire under storm loading is often appreciable. If a short span is inserted between two longer spans, however, the greater tension in the long spans under storm loading will cause the pole tops to flex in the direction of the long spans with the result that the tension in the short span is increased and the sag correspondingly decreased. At highway crossings, where it is necessary to maintain clearance even under storm loaded conditions, this can be used to advantage by making the crossing span shorter than the two spans adjacent to it.

10.06 The type and gauge of wire to be used will depend upon the type of subscriber loops or trunks to be provided, type of transposition system, transmission and signaling ranges, and the average and maximum spans as recommended by the wire manufacturer.

10.07 The selection of the length of poles required to support the wire facilities will depend upon the ground clearance required under the wires. The system engineer will have developed a basic pole height required for the lead based upon a determination of the most economical average span for the lead. This basic span in general will be utilized throughout the lead. Terrain conditions, corners, control points, et cetera, may necessitate changing the span length rather frequently throughout the lead. In consideration of longer spans than the basic spans set forth by the design, the staker must determine the height of the pole required for this longer span. This determination will be related to the sag of the conductor, at 100°F and the ground clearance requirement. Rolling type terrain, where small depressions or ridges occur at frequent intervals, may indicate to the staker that a change in the basic pole height and span length may be desirable to more economically provide for the proposed construction. Under such conditions the staker should consult with the engineer with respect to utilizing a basic span somewhat longer or shorter than that specified previously and consequently requiring a somewhat longer or shorter pole. Uniform heights and classes should be used to the greatest practicable extent. Although the basic pole may be higher than necessary in some cases, shortening one pole occasionally is false economy as such variations usually increase construction costs.

10.08 REA TE & CM-625, outlines the different types of pole tope assembly units for use in supporting bare wire plant. This section discusses in detail the capabilities and limitations of the various support units. A thorough understanding of these units and their limitations will facilitate the speed at which the staker can proceed. An examination of these units will reveal that angles in the lead above a certain degree and changes in grade greater than specified limits requires heavier fixtures to support the wire. Proper care by the staking engineer in distributing grade changes to keep the change in grade at any given pole below the specified limit will allow the use of ligher and less costly fixtures on the poles.

10.09 The transposition system and types of wire supports will have been determined in the ACD and the general requirements furnished to the staking engineer. One of the factors which determine the carrier frequency performance of a transposition system is the degree of uniformity in the spacing between transpositions. Every effort should be made by the staking engineer to make the transposition intervals as uniform as practicable. The REA-1 transposition system has definite limits on the deviation between transpositions which must be met. In areas where the terrain is relatively flat and the lines are straight, advantage should be taken of the ability to stake the R1 and R2 transposition systems to the better uniformity requirements of the REA-1 transposition system. This treatment would give the plant a good degree of flexibility from the standpoint of being able to accommodate future carrier expansion economically. Future conversion of R1 system to a REA-1 system would then only involve the placement of the special transposition brackets at certain transposition poles without any pole relocations.

10.10 Span lengths for toll, EAS, and subscriber carrier lines must be as uniform as is practicable in order to meet the transposition requirements. For the same reason, the limiting tension will seldom be a governing factor in the determination of span lengths for this type of plant.

10.11 References:

National Electrical Safety Code
Wire Manufactuer's Sag and Tension Data
REA TE & CM Sections
602 Clearances
462 R1 and R2 Transposition Systems
463 REA-1 Transposition System
465 REA-V1 Transposition System
615 Design of Open Wire Plant
616 Construction of Open Wire Plant
625 Pole Top Assembly Units
627 Route and Pole Numbering
650 Guys and Anchors on Wire and Cable Lines
820 Open Wire Circuit Protection

11. AERIAL WIRE PLANT (INSULATED)

11.01 Insulated aerial wire is intended for use in areas where corrosive atmospheres are known to exist, such as coastal and industrial areas and is particularly adapted for Spanish moss areas.

11.02 Staking of insulated open wire plant involves the same considerations as staking for bare aerial wire plant. The same pole top assembly units are to be used for insulated line wire and other factors affecting the construction of insulated plant are the same as bare open wire such as control points, guying and anchoring, etc.

11.03 Use of the same sag data for insulated wires as provided by the wire manufacturers for normal tensions of bare wire will result in somewhat higher tensions because of the increased weight per foot. However, this increased tension is not appreciable and can be ignored.

11.04 Insulation on the conductors eliminates the effects of mid-span hits. Consequently, tandem transposition brackets are satisfactory for use with all of the REA transposition systems, and point type brackets are not necessary except where required for special transmission reasons.

11.05 The abrasive resistance of the polyethylene insulation permits construction through foliage where bare wire can not be permitted, thus many clearing and trimming units may be omitted.

11.06 REA TE & CM-622, Design and Construction of Long Span Insulated Open Wire Plant, discusses in detail the various factors to be considered when staking this type of plant. The concept of long span plant makes a departure from conventional construction practices and a treatise of its staking considerations is beyond the scope of this publication.

11.07 References:

National Electrical Safety Code
Wire Manufacturer's Sag and Tension Data
REA TE & CM Sections
462 R1 and R2 Transposition Systems
463 REA-1 Transposition System
465 REA-V1 Transposition System
602 Clearances
615 Design of Open Wire Plant
616 Construction of Open Wire Plant
619 Design and Construction of Insulated Open Wire Plant
625 Pole Top Assembly Units
627 Route and Pole Numbering
650 Guys and Anchors on Wire and Cable Lines
820 Open Wire Circuit Protection

12. FIGURE 8 DISTRIBUTION WIRE PLANT

12.01 REA TE & CM-620, gives information on sags and tensions, transverse wind loads and guying requirements which should be used in staking this type of plant.

12.02 It will be necessary in the staking to recognize the increased sag resulting from storm loading and provide sufficient pole height. In order to accomplish this it will be necessary to use the final unloaded sags given in REA TE & CM-620 to provide the required ground clearance.

12.03 References:

National Electrical Safety Code
REA TE & CM Sections
602 Clearances
620 Design and Construction of Figure 8 Distribution Wire
820 Figure 8 Distribution Wire Protection

13. AERIAL CABLE PLANT

13.01 The maximum permissible span lengths for cables depend on the weight of cable, the strength of its supporting strand, and the storm loading to which it may be subjected. The determination of span lengths will be influenced by several factors. In urban areas the span length may be determined by the length of the city block, the requirements for cable terminals and the driveways and property lines. In rural cable plant design factors such as terrain and ground clearances, terminal locations, branch cables, corners, and other control points, and the possibility of joint use with other facilities will have a deciding influence.

13.02 Uniform spacing of poles for aerial cable is not usually critical and advantage should be taken of terrain features to achieve long spans with minimum length poles. Exceptional disparities in span lengths should be avoided. No particular concern need be given to an occasional span shorter than adjacent spans except from the economy viewpoint. However, it may be necessary to use an occasional span longer than the average span to avoid driveways, gates, building entrances, et cetera. In these cases, exceeding the average span by not more than 15% is acceptable. In some cases it may be desirable to adjust several adjacent spans to equalize the load.

13.03 REA TE & CM-630, gives final unloaded sags for cables lashed to galvanized steel suspension strand. REA TE & CM-635, "Construction of Aerial Cable Plant," gives initial stringing sags and tensions for the strand alone before the cable is lashed to it. For the purpose of providing adequate ground clearance, the staking engineer should use the final unloaded sags given in Section 630.

13.04 In urban cable staking the cable terminal poles should be staked in locations so as to provide the best drop wire distribution within the terminal wiring limit, with adjacent spans adjusted. The pole adjacent to a terminal is also a control point. The poles should be located so as to permit the shortest, most direct drop wire run, free of trees and intervening structures. REA TE & CM-629, discusses considerations affecting terminal and ready-access enclosure sizes and location.

13.05 Staking for loading points of a subscriber line should be made so as to locate the loading coils as near to the specified spacing as is economically and physically possible. Some deviation is permissible in order to place a loading point at a regular splice.

13.06 References:

National Electrical Safety Code
REA TE & CM Sections
430 Subscriber Line Loading
431 Voice-Frequency Loading for Trunk Cables
629 Cable Plant Layout
630 Design of Aerial Cable Plant
635 Construction of Aerial Cable Plant
645 Cable Plant Assembly Units
650 Guys and Anchors on Wire and Cable Lines
815 Cable Circuit Protection

14. FIGURE 8 CABLE PLANT

14.01 The staking of aerial Figure 8 cable plant will be similar in most respects to the staking of aerial lashed cable plant. Some differences in initial stringing sags as well as final unloaded sags will result because of the following differences in manufacture and construction practices:

14.011 The suspension strand for aerial lashed cable is either 6M or 10M Utilities Grade galvanized steel. The present design of Figure 8 cable utilizes a support strand made from 1 quarter inch extra high strength galvanized steel strand having a breaking strength of 6650 pounds. Some proposed designs of Figure 8 cable contemplate the use of solid support wires having breaking strengths in the order of 4000 pounds. Sags will thus vary in accordance with the design of support member used.

14.012 In lashed aerial cable construction, the suspension strand is installed, tensioned and clamped rigidly to the supporting poles before the cable is lashed to it. The initial or stringing tension in the supporting strand is thus fairly constant in all spans, When the cable is lashed to the strand, however, the resulting tension in the strand will vary in accorcance with the weight of the cable and span length. In Figure 8 cable construction, since the suspension strand and cable are physically bonded together, the tension will be fairly constant in all spans with the cable in place. Therefore, there will be some differences in sags between the two types of cable in place even though the suspension strands were identical, which they are not.

14.02 Until such time as REA publishes information on the design and construction of Figure 8 cable plant, the engineer must obtain sag and tension data from the cable manufacturer which will enable the staking engineer to choose pole heights to provide required ground clearance.

15. JOINT USE PLANT

15.01 The staking of joint use lines necessitates that adequate detailed information be made available to the staking engineer prior to the time actual staking commences. Details of joint use agreements and details of sections of line on which joint use is proposed must be known to the staking engineer. REA TE & CM-690, discusses the considerations that determine the practicability of utilizing joint poles. This section also provides pole strength tables, separation tables and staking curves. These data were developed on the basis that the power conductors were sagged in accordance with the wire manufacturers' tables. Experience has indicated that quite often the power conductors are not sagged in accordance with the manufacturers' data and consequently this introduces a problem of making a new determination of actual sags. This information must also be obtained prior to the actual staking of the line. If the sags are appreciably different than that outlined in the manufacturers' data for the power conductors, it may be necessary to prepare new separation tables.

15.02 The need for strict compliance with the code requirements cannot be over emphasized. Carelessness in obtaining adequate separation between power conductors could possibly result in fatal accidents to line personnel and expensive damage to the telephone plant and subscriber's premices. Where there is any question as to the actual sag of the power conductor, a representative of the power company should be contacted to make actual determinations of the sag characteristics in the lead. In indicating the separation requirement on the staking sheet the staking engineer is required to base this separation on the distance from the bottom of the lowest electrical facility from which the measurement is made to the drilling point for the attachment of the telephone facilities. This distance must include code separation and space for the telephone facilities above the drilling point. Separations should be kept as uniform as is practicable and economical.

15.03 The poles used in the power lead will generally provide adequate strength for the additional telephone facilities. The pole strength tables in REA TE & CM-690 of this manual will provide information for this determination. Where the strength in the existing pole is barely inadequate, the staking engineer should consult with the resident engineer before indicating a changeout. The pole strength tables were prepared on the basis of five diameters of power conductors and two feet incremental increases in separation. There will be adequate strength in many cases where the tables indicate that the strength in the pole is barely inadequate.

15.04 The guying requirements for the telephone facilities attached to joint poles will generally fall at the same pole where guying was provided for the power facilities. The staker should consult with representatives of the power company to determine whether there is remaining strength in the anchor assembly of the telephone facilities to the same anchor. Where insufficient strength remains in the existing anchor assembly of the power company, guying requirements for the telephone facility should be in accordance with the provisions outlined in REA TE & CM-650.

15.05 It will be necessary, in order to properly determine the guying requirements, to measure the angles in the existing pole line. A transit can not be used conveniently for these measurements, because to measure the line angle the transit would have to be placed in the exact position occupied by the corner pole. An instrument, called a "pull finder", provides a method for measuring this angle. The angle in the line and the distance from the pole to the anchor to be used are recorded on the staking sheets.

15.06 The spans encountered in the power lead will influence the type and gauge of telephone conductor to be used. In most areas of the United States the spans in the power lead were staked on the basis of certain ruling spans. It will be necessary for the staking engineer to obtain information on the ruling span for the joint use lead from the power company before proper separation between the power and telephone conductors can be determined. After the ruling span for the power pole line is known, the conductor with the proper physical capabilities may be chosen from the information contained in REA TE & CM-615. In applying the information on the various conductors that might be considered for joint use, it is well to keep in mind the following:

15.061 Occasional spans in excess of the maximum span indicated in the manufacturers' tables may be utilized. These maximum span lengths may be increased by ten percent.

15.062 The average span length of any section of the lead (between deadends) when the above rule is applied should not exceed the maximum span for the conductor involved.

15.063 In unusual situations it may be desirable to insert a few spans of a stronger conductor to satisfy the need for abnormally long spans in the lead. The use of the stronger conductor should be limited to sections of the lead between deadends.

15.07 The factors contained in the applicable REA TE & CM sections on staking non-joint use cable apply also to joint use cable plant. In addition, the factors of separation and clearance must be considered. Where long spans are involved, the difference between initial and final sag as a result of storm loading becomes appreciable after the cable has reached its final sag. Because of the necessity of maintaining code clearances and separations initially and finally both the stringing sags and design or final unloaded sags must be taken into account when staking for joint use construction. In some cases where adequate ground clearance cannot be obtained with 6M strand without pole changeouts, consideration should be given to the use of 10M strand which can be placed at higher tension and less sag than 6M. Addendum No. 2, REA TE & CM-690, provides information for determining the proper separation and clearances for cables supported by 6M and 10M suspension strand.

15.08 References:

National Electrical Safety Code
Joint Pole Practices for Supply and Communication Circuits (Publication M12)
REA TE & CM Sections
615 Design of Open Wire Plant
630 Design of Aerial Cable Plant
650 Guys and Anchors on Wire and Cable Lines
690 Joint Use of Poles

16. RAILROAD CROSSINGS

16.01 The NESC specifies minimum vertical and horisontal clearances for aerial and underground railroad crossings; as well as minimum strength requirements for poles, conductors, anchors and guys, and maximum crossing spans. The Association of American Railroads "Specification for Communication Lines Crossing the Tracks of Railroads" is reproduced in REA TE & CM-617, Railroad Crossing Specifications.

16.02 Some railroads may have their own specifications which may differ from the NESC and REA TE & CM-617. Therefore, consultation should be had with individual railroads in regard to their requirements before design and staking work is undertaken. The most stringent requirements should be followed.

16.03 A detailed crossing layout must be prepared for submission to the railroad for approval and for inclusion in the crossing agreement.

16.04 References:

National Electrical Safety Code
REA TE & CM Sections
602 Clearances
617 Railroad Crossing Specifications

17. STATION INSTALLATIONS

17.01 Station installations include the staking of drop wire assembly units, station protector units, station wiring units and station units.

17.02 Practically every station installation differs from every other installation. The staking engineer, therefore, must exercise considerably judgment. He should be thoroughly familiar with the applicable REA TE & CM sections. There are a number of objectives which are conflicting. Therefore, the proper installation is usually the best compromise between these conflicting objectives. Objectives involving safety and electrical protection are more important than those involving appearance and economy. Conflicts, therefore, between such objectives should generally be resolved in favor of the safety and protection objectives. The drop should not be staked until the location of the best available ground electrode and the location of the telephone set has been determined. REA TE & CM-805, covers the selection of the preferred ground electrode, and selection of the proper type of protector. As a general guide, ground wire runs should not exceed a maximum of 35 feet; horizontal drop wire runs on buildings should not exceed approximately 20 feet, and station wire runs should not exceed approximately 60 feet except in unusual situations. It should be remembered at all times that the use of ground rods alone, regardless of resistance, is not an adequate substitute for interconnection with the power service ground and the subscriber's water system.

17.03 Drop poles, including cable terminal poles, are basic control points and should be located so as to permit the most direct drop wire route, free of tree and foliage interference and intervening pole line and building structures. Drop wires should be staked so as not to cross in front of windows and over doors, and not to attach to the structure under roof drain areas where ice, snow, or excessive moisture can affect the drop wire.

17.04 Where it is necessary to clear streets, alleys, and highways with drop wires to structures too low to provide proper ground clearances the use of a drop pole, a lift pole or a mast is often required. Wherever practicable attachments should be made to other company poles when covered by attachment or joint use agreements.

17.05 Drop wire sag tables list minimum sags. The staking engineer's ground clearance calculations should, whenever practicable, include greater sag if no additional cost is involved.

17.06 When staking drops from or on joint use poles three primary factors must be considered; climbing space, the requirements of the other joint user, and the requirements of the NESC. Attachments to foreign poles should comply with NESC rules for separation and clearance, and the separation should be shown on the staking sheet for the benefit of the contractor.

17.07 References:

National Electrical Safety Code
National Electrical Code
REA Form 511, Telephone System Construction Contract
REA TE & CM Sections
602 Clearances
701 Station Installations
805 Subscriber Station Protection

18. PROTECTION

18.01 The staking engineer should be provided with the detailed protective measures to be employed which have, in general, been decided upon in the system design.

18.02 The principal responsibility insofar as electrical protection is concerned, is to be sure that each protective device is grounded by means of the most suitable available electrode. In most instances, this means grounded to the lowest resistance electrode which is practical to use. The 800 series sections of the REA TE & CM state the preferred electrodes for various situation and various devices and give alternatives if the preferred electrode is not available. Most types of protectors are not effective unless connected to a low resistance ground.

18.03 Where a separate pole line is to be staked for telephone conductors, crossings with power distribution lines should be held to the minimum in the interests of safety. Where the staking of a separate telephone pole line will result in an excessive number of crossings, the possibilities of joint use construction should be re-examined.

18.04 Joint pole crossings are the safest type of crossings and, therefore, should be used whenever practicable. In order to keep the cost of such crossings to a minimum, existing power poles should be used for crossing poles to the maximum practicable extent. Spans adjacent to joint crossing poles should be adjusted so that the joint crossing pole is required for a telephone support pole, and is not just a clearance pole. Where a multigrounded neutral (MGN) type of power line is being crossed, a joint pole crossing has the additional advantage of making the MGN available for grounding cable shields, support wire, and power contact protectors. In many instances the ability to obtain coordinated protection is dependent upon the availability of an MGN as a ground electrode for telephone protective devices. Where it is not practicable to stake an existing electric power pole as a joint crossing pole, consideration should be given to having the power company set an additional pole in their line and attach their conductors to it for the joint pole crossing. Under no circumstances should a crossing pole which is too short for attachment of the power conductors be set in the power company's line (or close enough to the power line to constitute a structural conflict). It is inherently more difficult to provide effective protection of telephone plant against power contacts with other than MGN type systems. Therefore, more reliance must be placed on the structural strength of crossings to prevent contacts. For this reason it is even more important to obtain joint pole crossings with non-MGN power lines than it is to obtain them with MGN type power lines.

18.041 The NESC requires power lines (exceeding 2900 volts to ground) to be of Grade B construction at crossings with open wire telephone conductors unless coordinated protection is achieved. Where coordinated protection is achieved, Grade C construction is permissible for the power line at such crossings. Whenever it is necessary to convert an existing power line span to Grade B construction because of a crossing created by a telephone company, the telephone company is charged with the cost of converting the power line. In many instances, therefore, a joint pole crossing if properly staked is not only the safest crossing but may also be the most economical crossing.

18.05 Except in areas of high lightning incidence and at poles which are severly exposed to lightning, pole lightning protection wires should be used sparingly. The staker should use engineering judgment in selecting which poles are to be provided with protection. Guide lines for making the selection are contained in REA TE & CM-815.

18.06 The PM2 unit is intended primarily for grounding drainage units. In most areas it does not produce a low resistance ground and therefore, should not normally be used where a low resistance ground is required unless ground resistance measurements in the area indicate that an adequately low resistance can be expected to result from its use. In areas of high earth resistivity, if it is necessary to use a driven ground because of the lack of any other suitable electrode, a PM2 supplemented by one or more PM2-1 units should be specified.

18.07 Cable protection should be staked in accordance with the protection system developed in the design and in accordance with the applicable REA TE & CM sections. The protection features required at each pole should be noted on the staking sheets if they are not specifically covered by the applicable unit or units.

18.08 It is important for the staker to understand the difference in the objectives of station protection as compared to plant protection. Plant protection is principally a matter of balancing the cost of repairing unprotected plant against the cost of applying and maintaining devices which protect the telephone plant. Station protection and other protection measures such as power contact protectors are intended primarily to protect the subscriber, subscriber's premises, telephone users, telephone personnel, and/or the public. Adequate protection of persons and premises should be provided regardless of the cost of providing it. Paragraph 17.02 discusses the details for staking station protectors.

18.09 References

National Electrical Safety Code
National Electrical Code
REA Form 511, Telephone System Construction Contract
REA TE & CM Sections
801 Conditions Requiring Electrical Protection
805 Subscriber Station Protection
815 Electrical Protection of Aerial Cable
820 Open Wire Circuit Protection
821 Figure 8 Distribution Wire Protection
822 Electrical Protection of Carrier Equipment
830 Summary of Units Used in Protection Systems

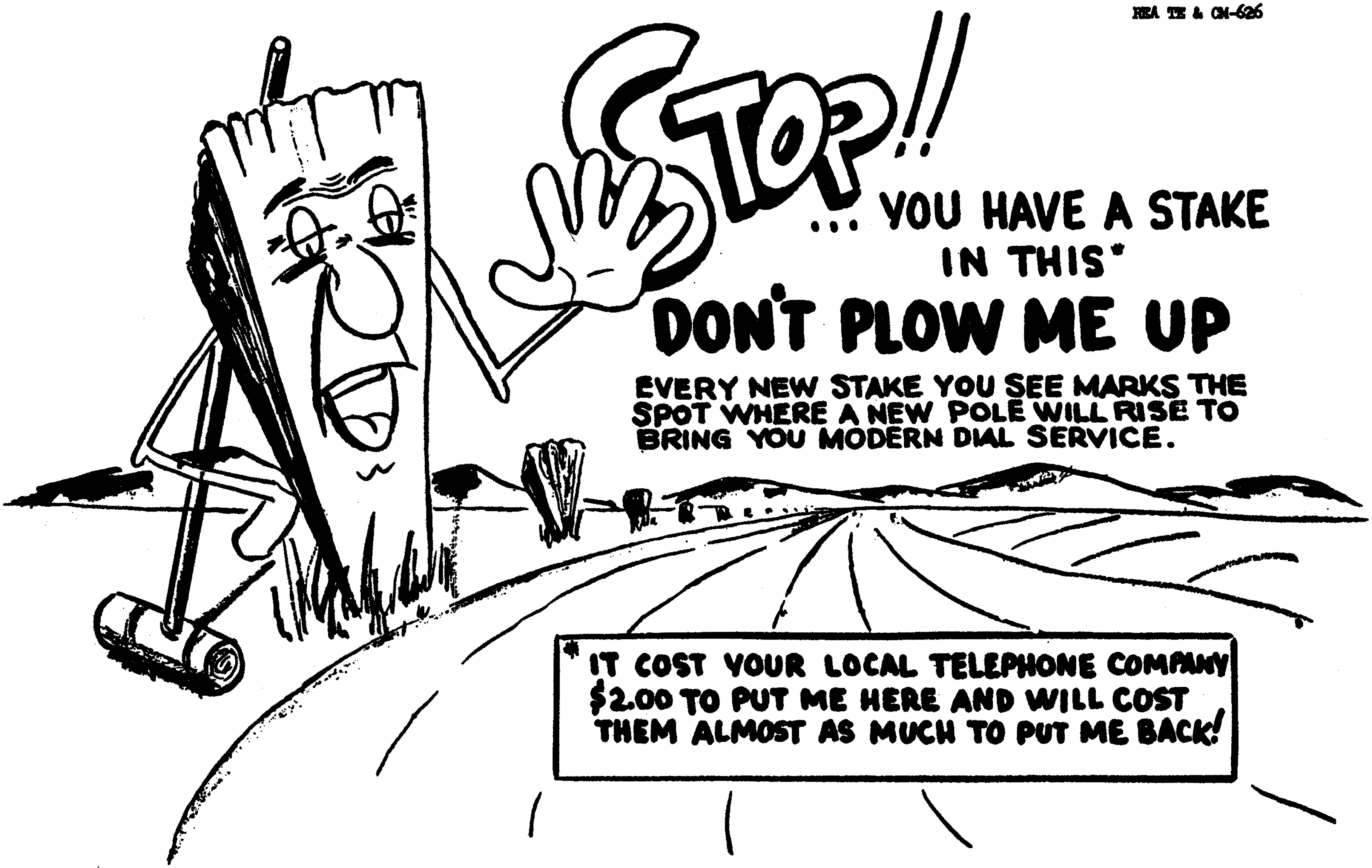
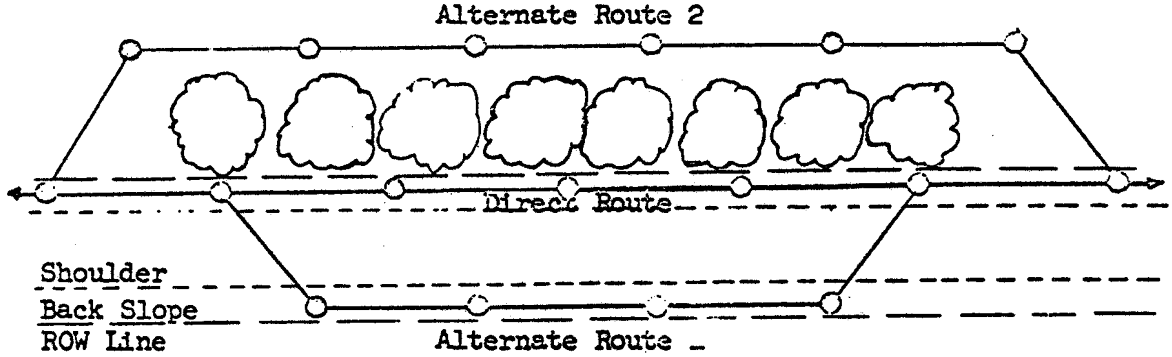

STOP!!
... YOU HAVE A STAKE IN THIS*
DON'T PLOW ME UP
EVERY NEW STAKE YOU SEE MARKS THE SPOT WHERE A NEW POLE WILL RISE TO BRING YOU MODERN DIAL SERVICE.
* IT COST YOUR LOCAL TELEPHONE COMPANY $2.00 TO PUT ME HERE AND WILL COST THEM ALMOST AS MUCH TO PUT ME BACK!

Figure 1

DEVIATING POLE LINE TO AVOID CLEARING OR TRIMMING
EXAMPLE

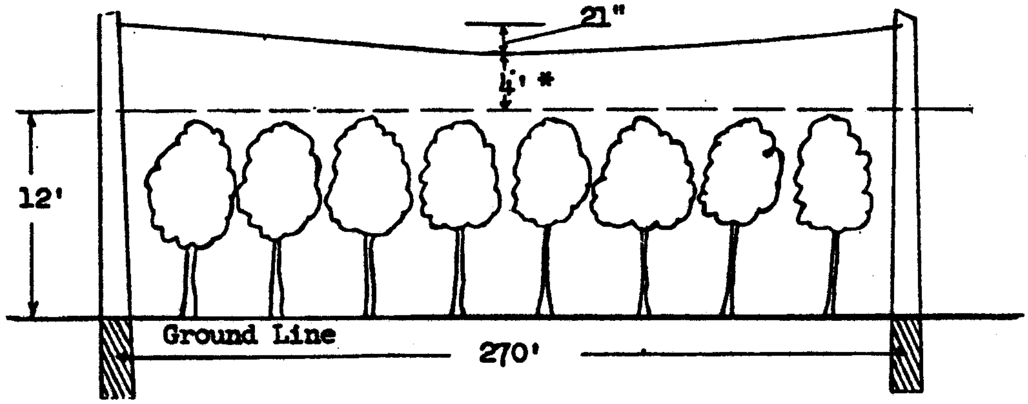


	Investment	Annual Cost
Direct Route (10 Wire Lead):		
Estimated Cost of Clearing and Reclearing		
Initial clearing - one R1-10 unit	$75.00	$ 7.50
Maintenance cost (Reclearing three year intervals)		20.00
Totals	$75.00	$27.50
Direct Route Side Armed:		
Estimated cost of additional pole line material	$47.00	$ 4.70
Net saving due to pole line deviation	$28.00	$22.80
Alternate Route 1:		
Estimated cost of additional pole line material	$126.00	$12.60
Net saving due to pole line deviation	$(51.00)	$14.90
Alternate Route 2:		
Estimated cost of additional pole line material	$108.00	$10.80
Saving due to pole line deviation	$(33.00)	$16.70

Note: Proportionate savings can be provided by similarly deviating a two wire lead to avoid an R1-5 unit. An additional deviation may be possible by using the back slope.

Figure 2

OVERBUILDING BRUSH OF LIMITED MATURE HEIGHT
EXAMPLE



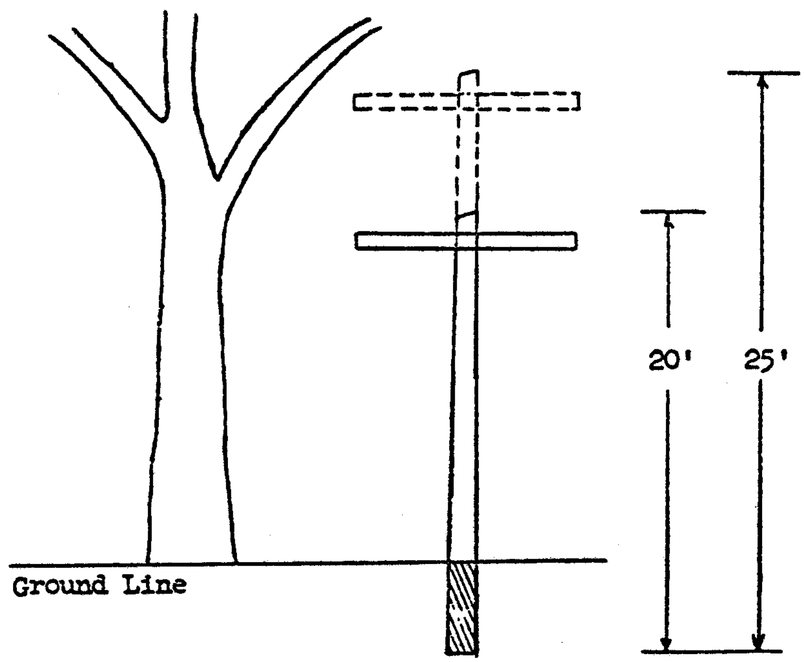
Basic Pole Line - 20' poles, 10 wires, stringing sag 21"
Mature Height of Brush 12'
Desired Clearance Above Brush - Minimum 4'
Required ROW Clearance .27 of one RC2-10 Unit
Height of Poles Required to Clear Brush 25'

Estimated Cost of Clearing and Reclearing	Investment	Annual Cost
Initial Clearing Cost	$31.00	$3.10
Maintenance Cost (Reclearing five year intervals)		2.70
	$31.00	$5.80
Estimated cost of additional pole line material to overbuild brush.	$ 7.00	$ .70
Net saving due to overbuild.	$24.00	$5.10

*Actual clearance achieved - approximately 6'. Desired clearance could have been accomplished with 22' poles but the basic pole lines in this project were 20' and 25' pole lines, so 25' poles were used to minimize supply difficulties.

Figure 3

UNDERBUILDING
EXAMPLE



Assume a row of mature trees 1,000' in length. Trimming required--one R1-10 unit. Estimated cost $75.00. Basic pole line--25' poles, 250' spans, 21" sag, 10 wires.

Direct Route (Maintaining 25' Poles):	Investment	Annual Cost
Estimated Cost of Clearing and Reclearing		
Initial clearing - one R1-10 unit	$75.00	$ 7.50
Maintenance Cost (Reclearing three year intervals).	-	20.00
Totals	$75.00	$27.50
Reducing Pole Height (Underbuild):		
Saving in initial plant investment pole cost	$17.00	$ 1.70
Net Saving Due to Pole Line Deviation	$92.00	$25.80

Figure 4

1. Explanation of Sample Staking Sheet - Aerial Wire

1.01 This section of aerial wire staking assumes that the line is in the heavy loading area, that two of the rural areas served are beyond the supervisory limits of 109SS conductor, and that provision for subscriber carrier for future growth will be needed. The R1 Transposition System is used with point type brackets because of the span lengths and wind conditions.

1.02 This section of line requires 5 circuits from pole 1 to pole 17 and 4 circuits for the remainder of the crossarm lead.

1.03 A basic 25' pole was selected as the terrain permits field entrance of farming equipment at most points along the lead. Class 7 poles are specified in accordance with the Pole Selection Chart 1 of REA TE & CM-611.

1.04 At pole 12 it is determined that the drop wire span from line pole to house is 175' and code clearance across road cannot be achieved with a 25' pole and the required drop wire sag of 5' 6". As the house is low a drop pole is needed to maintain clearance and the crossing span can be shortened to 110' thus reducing the minimum drop wire sag requirement to 2' 10". As the setting depth of a 25' pole is 5' and a minimum of 18' clearance is required the 25' pole is too short and a PM3 unit is specified. In this case the ground level is about 5' higher on the house side of the road and a 25' drop pole is adequate.

1.05 Continuing of pole line on the west side of the road to pole 15, which can be lined up with a lead continuing northward rather than crossing the road at pole 13, results in the saving of one guy and anchor and approximately 150' of R2-10 clearing. Although the 290' crossing span requires 30' poles to provide the basic 18' of clearance at 100°F, the added pole height costs less than the additional guy and anchor. Crossing as shown substitutes one 30° angle for two 40° to 60° angles.

1.06 Although the need for the circuit on pins 5 and 6 ended at pole 17 the wires were carried on to pole 18 as anchoring could not be adequately obtained in the bank of the creek. A PB1-6 was specified in the second gain for deadending the wires.

1.07 A P1-4 fused type protector unit was specified at R. E. Jones because it was assumed that the power system was a non-MGN type and there was no suitable water piping system; fuseless protectors are not permissible under these conditions. A P1-2F fuseless type protector unit was specified at Ch. H. Brown's because an MGN type power system was assumed. Approved fuseless station protectors may be used fron non-cable type plant only if a water pipe or MGN ground electrode is used.

1. Explanation of Sample Staking Sheet - Figure 8 Distribution Wire

1.01 This section of line in the Base Rate Area assumes use of 3 and 6 pair Figure 8 distribution wire. The class of poles are specified in accordance with REA TE & CM-611. The specified heights of the poles conform to the minimum vertical ground clearances of NESC and minimum drop wire sag requirements. PM52-1 Pole Marking units are specified for each pole in accordance with REA TE & CM-627. Control points in this case are the streets and drop wire distribution.

1.02 Although 25' class 10 poles would provide adequate strength (with the exception of the deadend pole) and clearance over and along streets as required by the NESC and the final unloaded unloaded sags given in REA TE & CM-620 they would not provide adequate drop wire clearance across the street. Therefore 30' Class 9 poles were specified for initial and future drop wire runs across North Street. The construction note regarding the point of attachments, in the case of drop wires crossing North Street, provides adequate vertical clearance if the point of first contact on the subscriber's building is 15' or more above grade and the drop wire span is not over 100' - 110'. If the 15' attachment cannot be achieved the subscriber should provide a mast for attaching the drop or a drop support pole should be provided on the west side of the street. Another solution would be to increase the in-line pole height to 35'. This would require a Class 7 pole and would appear to be the least desirable solution.

1.03 No trimming unit is specified for drop wire installations as the K-18 unit includes the necessary trimming.

1.04 It was assumed that the staker found satisfactory buried metallic private water systems at each of these subscribers. He specified water pipe grounds and fuseless station protectors because these are preferred over other types and are permitted under the assumed conditions.

1. Explanation of Sample Staking Sheet - Aerial Cable

1.01 Maximum cable suspension strand tension should not be greater than 60% of the rated breaking strength, the critical load being the weight of a workman and his tools on the suspension strand rather than the storm loading. This limitation will effect, however, only cables of 3/4 pounds per foot or greater when carried on 6M strand.

1.02 For an example, assume a cable weighing 1/4 pound per foot to be installed on 6M strand (minimum size permitted by the NESC) and ground clearance of 14' is required.

a.	Pole height	20'	25'	30'	30'
b.	Depth of setting	4'	5'	5.5'	5.5'
c.	Point of attachment (from pole top)	13'	13"	13"	13"
d.	Ground clearance	13'	15'	17'	15'
e.	Required sag (final unloaded)	22.2"	42.6	68.4"	99.9"
f.	Span length	175'	250'	325'	400'
g.	Poles per mile	30.2	21.1	16.2	13.2
h.	Pole cost per mile	$377	$358	$324	$264

This aerial cable line should be staked for spans as close to 400' as possible using 30' poles. If more than 16 poles per mile are required because of control points such as terminals and angles the line should be staked for 25' poles on 250' to 260' spans.

1.03 The 25 x 22P cable used in the illustration weighs approximately 1/4 pound per foot. The required sags and resulting ground clearances as shown above for 400' spans could not be achieved in this section because of the control points.

1.04 A row of fairly matured upward growing trees exist along the route between pole 65 and 68. Maintaining the 30' pole line in this section would require heavy side trimming or removal. As the prevailing winds were from the northwest it was decided to underbuild the branches to save clearing costs and 20' poles at approximately 200' spacing were specified. The initial saving in this short stretch of 615' would amount to .615 R1-5 unit or about $34.00. Reduction in poles from two 30' 7 to three 20' 7 would amount to only about $3.00 or a total decrease in initial investment requirements of about $37.00.. Annual carrying charges and reclearing costs if this deviation in staking had not been made would have amounted to about $99.00 over a 10-year period, a definite benefit to the owner resulting from good staking.

1.05 PM5, Pole Stepping Units are specified on terminal poles 9-69, 9-71, and 9-73 as these poles may be used considerably by the maintenance people. PM11, Guy Guard Units are specified at poles 9-71, 9-73, and 9-74, to protect the public and the plant facility. PM52-1, Pole Marking Units are specified on each terminal pole and each 5th pole as indicated in Section 627.

1.06 At terminal 9-69 only pair 7 is terminated on PG10-6 terminal block. This one pair is used to serve both subscribers at this location. At terminal 9-71 pairs 8-12 are terminated on a PG10-6 terminal block and #14 gauge bridle wire is used to connect to the five open wire circuits on Route 19. Pairs 1-5 and pair 7 are terminated on PG10-6 terminal block in terminal 9-74. The remaining pairs appearing in the ready-access enclosure at this terminal point will be capped.

1.07 Pole 71 being a junction pole between cable and wire is increased to a Class 6 as provided for in Section 611.

1.08 In order to provide adequate road clearance and to achieve a joint pole crossing arrangements were made for the electric company to change the existing 30' pole 72 to a 35' pole. Clearance on level ground in the back span from pole 72 approximates the following:

Pole height		35'
Depth of setting	6'	
Electric facilities	3'6"	
NEAC separation	3'4"	
Final unloaded sag	4'2"	
		17'
Midspan clearance		18'

As the point of crossing is between midspan and pole 72 the final unloaded sag condition would provide 18' plus vertical clearance over the road.

1.09 Although the cable could have been terminated at pole 9-73, it was felt desirable to continue the cable to pole 9-74 to eliminate the necessity of placing the open wire deadend arm and the guy for the cable on the joint crossing pole owned by the Electric Company. It is not necessary to place a guy for the open wire lead at this pole if the separation between the open wire and the cable suspension strand is kept within two feet (See REA TE & CM-650).

1.10 With cable plant and water pipe and/or electric service grounds fuseless station protectors were specified because they are preferred and are permitted.

1. Explanation of Sample Staking Sheet - Joint Use

1.01 This section of joint-use staking assumes that the line is in the medium loading area, that it is single phase, #4 7/1 ACSR conductor constructed on 542' ruling span, on 35' Class 7 poles except the angle poles which are Class 6.

1.02 It is proposed to add two open wire telephone circuits from pole 14-81 to pole 17-5 where one circuit leaves Route 17 to become Route 21 to the west. The remaining circuit continues on to pole 17-14. Poles 1 to 9 are shown on the sample sheet. The communication conductors are .109-135 steel. The R1 transposition system will be used as specified in REA TE & CM-462.

1.03 The longest span in this section of line is 475'. Reference to RD - Figure 27, (REA TE & CM-690) indicates that 5' of vertical separation between the multi-grounded neutral and the telephone conductors will be required for this span length. This same separation should be maintained in all spans if practicable to do so.

1.04 The required pole strength is checked by reference to RD - Figure 8 and it is found that no poles have to be changed out for insufficient strength.

1.05 As no guying can be accomplished at pole 14-81 to hold four .109-135 wires it is necessary to specify slack span construction to pole 17-1, and two lengths of DW1-19 with the necessary PG5-1 units are designated on the staking sheet. Deadending assembly units for the open wire circuits are specified at pole 17-1. Reference to REA TE & CM-650 indicates that electrical protection of the guy is required and a NPE1-2G unit is specified as a MGN is available. Since a NPB5-6 unit has sufficient strength to support four .109-135 steel conductors for this span length it is specified at pole 17-1.

1.06 At poles 14-81 and 17-1 it is also necessary to ascertain that the DW1-19 units can be attached at sufficient height to obtain the minimum code ground clearance over the road. Since the separation between the telephone conductors and the lowest electric facility must be at least 40 inches the DW1-19 units can be attached 21-1/2 feet above the ground which will meet both requirements.

1.07 Single six-pin crossarms, Type 6B are specified on Poles 2, 3, and 4, and the 5' separation achieved.

1.08 At pole 5 one circuit makes a right angle turn while the other continues on the same route. The circuit which serves Route 21 must cross the road with 18 foot clearance or greater. Assuming the span to be 410' a 4-1/2 foot separation at the pole is required. Reference to RD-Figure 58 indicates that the 18 foot basic clearance (19.6 foot actual clearance) cannot be obtained in a 410 span at midspan over level ground. Rule 232B of the NESC permits reduced clearance if the crossing does not occur at midspan. Application of this rule shows that if the point of crossing occurs within 70' of pole 5 only 18' of clearance at midspan will be needed. This means that the staking engineer should specify the drilling point for the upper arm of the PB1-7 unit to support this circuit at "4-1/2 feet." (If the point of crossing occurred at a greater distance from the pole than 70' it would be necessary to replace the 35' pole with a 40' pole to obtain the required code clearance.)

1.081 Two P4-1 units are specified for installation at pole 5 as this point is approximately 20 ohms from the power contact protection on route 14, from the end of route 17, and is the beginning of route 21.

1.082 Space for guying to hold the deadended circuits at pole 5 is available. Two grounded guys are specified. Only one PF1-2 anchor is required as the guy holding route 21 can be attached to the existing power company anchor, since it has been determined that the anchor has sufficient holding power for both loads.

1.083 Code climbing space is provided on the NW quarter of the pole by continuing conductors 7 and 8 on North and assigning pins 3 and 4 to the circuit going West.

1.09 At pole 6 a T-18 transposition unit is specified as the pin spacing on the PB1-4 is 12 inches whereas on poles 2 and 4 the PB3-3 pin spacing is 10 inches and T-19 units were specified.

1.10 At pole 7 it is necessary to increase the separation to 8-1/2 feet in order to clear the secondaries on this pole. This section of line is built in a fence line so a minimum ground. clearance of 8 feet is acceptable. Reference to RD-Figure 58 shows that sufficient ground clearance can be obtained with 8-1/2 foot separation.

1.11 At poles 8 and 9 NPB1-4 units are specified for attachment 4-1/2 feet below the neutral. The reduction in separation is required to provide the necessary road clearance. RD-Figure 27 shows that these separations are not less than the minimum required for a 350 foot span.

1.12 The remainder of this section of joint-use would be shown on Staking Sheet 2 of 2, Route No. 17.

1.13 Fuseless station protectors were specified because it was assumed that all conditions for the use of fuseless protectors were met.

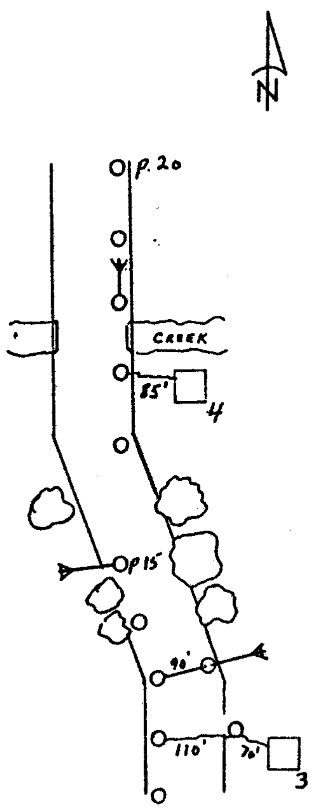
626

SEC. | STAKED BY | **STAKING SHEET & PLANT RECORD** | WIRE & WIRE SUPPORTS OR CABLE & STRAND | SHEET 2 OF 7

TWP | DATE | COMPANY | ROUTE NO. 26 | REA TE & CM-626

RANGE | REVISED | PROJECT NO. | MAP REFERENCE

CO. | REVISED | WORK ORDER NO. | EXCHANGE



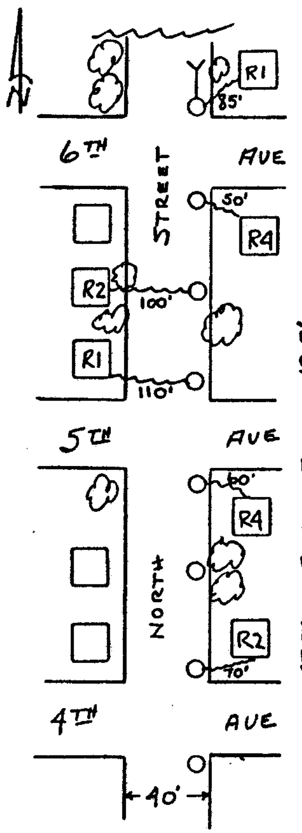
POLE NO.	POLE H/C	SPAN	R	FOREIGN POLE H/C	SEPR *	POLE TOP UNITS PB	GUYS NO	GUYS PE	ANCHORS NO	ANCHORS PF	ANGLE/LEAD	PM	109-135 1/2	080CX30 3/4	109-135 5/6	080CX30 7/8	109-135 9/10	PG	H	K 1/2	P	S	SW	MISCELLANEOUS
20	25/7	305				5-1						52-1	1	18		18	1							
19	25/7	305				5-1							18	1		1	18							
18	25/7	305				5-1 1-6	1	1-1	1	1-2	DEV/16		1	18	5	18	1							PLACE PB1-6 IN SECOND GAIN
17	25/7	300				5-1							18	1	20	1	18			.095	1-4	1	1	R.E. JONES
16	30/7	290				5-1							1	18	1	18	1							
15	30/7	310	200 2-10			5-1	1	1-3	1	1-5	30/22	52-1	18	1	20	1	18							
14	25/7	310				5-1							1	18	1	18	1							
13A	25/7						1	1-3	1	1-5	30/18													
13	25/7	310				5-1	1	2-3					18	1	20	1	18							
12A	25/9																							
12	25/7	306				5-1						3	1	18	1	18	1			.192	1-2F	10	1	C.H. BROWN
11	25/7	306				5-1							18	1	20	1	18							
TOTAL UNITS	9 (25'-7) 2 (30'-7) 1 (25'-9)	3047'	.2 (R2-10)			10 (PB5-1) 1 (PB1-6)	1 (PE1-1) 2 (PE1-3) 1 (PE2-3)		2 (PF1-5) 1 (PF1-2)		2 (PM52-1) 1 (PM3)		23 (T-1) 20 (T-18) 4 (T-20) 1 (T-5) 17.062 (109-135) 12.185 (080CX30)							287 (K1/2)	1 (P1-4) 1 (P1-2F)	1 (S-1) 1 (S-10)	2 (SW)	EXHIBIT B SAMPLE STAKING SHEET AND PLANT RECORD-AERIAL WIRE

*Indicate the vertical distance that the telephone crossarm or cable attachment is to be placed below the lowest existing electric supply or communications facility. Distances are to be measured from the bottom of electric secondary supports, neutral supports, crossarms, transformers, etc.

EXHIBIT B
SAMPLE STAKING SHEET AND PLANT RECORD-AERIAL WIRE

SEC.	STAKED BY	**STAKING SHEET & PLANT RECORD**	SHEET 2 OF 2
TWP	DATE	COMPANY	ROUTE NO. 23
RANGE	REVISED	PROJECT NO.	MAP REFERENCE BRA
CO.	REVISED	WORK ORDER NO.	EXCHANGE

WIRE & WIRE SUPPORTS OR CABLE & STRAND

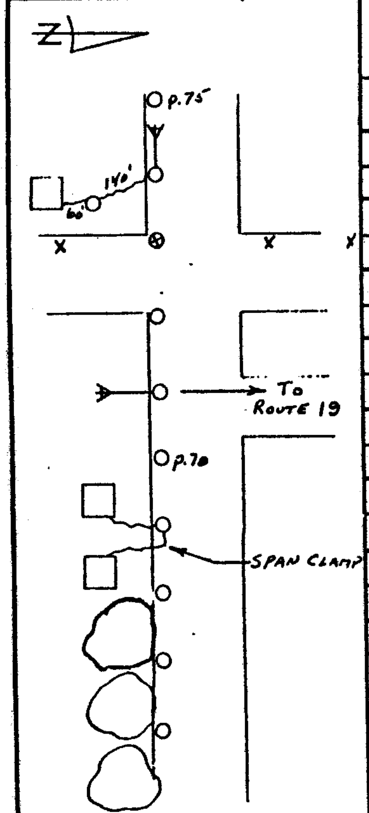


ATTACH SUPPORT WIRE 19.5' ABOVE GRADE
ATTACH DROP WIRES CROSSING STREET 24' ABOVE GRADE

POLE NO.	POLE H/C	SPAN	R 3-5	FOREIGN POLE H/C	FOREIGN POLE SEPR*	POLE TOP UNITS	GUYS NO	GUYS PE	ANCHORS NO	ANCHORS PF	ANGLE/LEAD	PM	DW3-19	DW6-19	PG	H A	K 18	P	S	SW	MISCELLANEOUS
16	25-9	130					1	1-1	1	1-3	72	52-1	T		12-6	D1	97	1-1F	1D	2	J.S. SMITH
																			3D		
15	30-9	154										52-1			12-6	D1	70	1-1F	1	1	JOHN JONES
14	30-9	148	20									52-1			12-6	D1	115	1-1F	1	1	RALPH JONES
13	30-9	135										52-1	⊥	T	12-6	D2	120	1-1F	1D	1	JOHN DOE
12	30-9	145										52-1			12-6	D2	70	1-1F	1	1	E. BROWN
11	30-9	150	30									52-1									
10	30-9	130										52-1			12-6	D2	77	1-1F	1D	2	RALPH PETERSON
																			1D		
9	30-9	140										52-1									
TOTAL UNITS	1 (25-9) 7 (30-9)	1132'	.050(R3-5)				1(PE1-1)		1(PF1-3)			8(PM52-1)	.432'(DW3-19) .700(DW6-19)		6(PG12-6)	3(HA-D1) 3(HA-D2)	.539(K18)	6(P1-1F)	4/1-D 1/3-D 3/1	8	EXHIBIT C SAMPLE STAKING SHEET AND PLANT RECORD - FIGURE 8 DISTRIBUTION WIRE

*Indicate the vertical distance that the telephone crossarm or cable attachment is to be placed below the lowest existing electric supply or communications facility. Distances are to be measured from the bottom of electric secondary supports, neutral supports, crossarms, transformers, etc.

SEC.	STAKED BY	STAKING SHEET & PLANT RECORD	WIRE & WIRE SUPPORTS OR CABLE & STRAND	SHEET 5 OF 11
TWP	DATE	COMPANY		ROUTE NO. C — REA TE & CM-626
RANGE	REVISED	PROJECT NO.		MAP REFERENCE
CO.	REVISED	WORK ORDER NO.		EXCHANGE

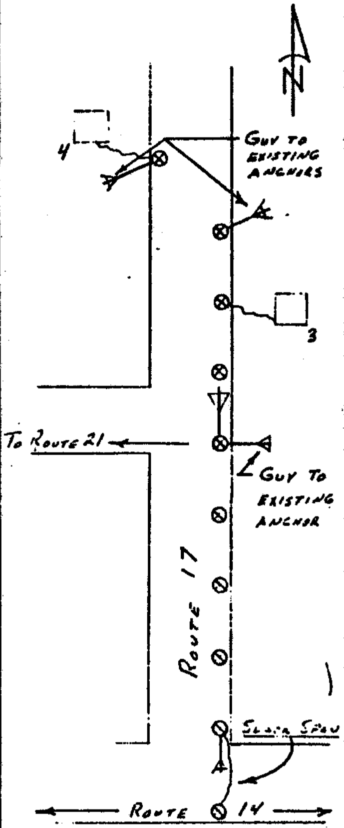


POLE NO.	POLE H/C	SPAN	R	FOREIGN POLE H/C	SEPR*	POLE TOP UNITS PB	GUYS NO	GUYS PE	ANCHORS NO	ANCHORS PF	ANGLE/LEAD	PM	109-135 1/2	109-135 3/4	109-135 5/6	109-135 7/8	109-135 9/10	PG	HA	K 1P	P	S	SW	MISCELLANEOUS
75	25-7	275				5-1							18	1	20	1	18							Pairs 1-5 are connected to open wire
74A	25-10																							
74	25-6	265				5-8	1	1-4	1	1-7	DE 18	5, 11, 52-1	5	5	5	5	5	10-6	R1	.220	1-3F	1	1	Subscriber (Pr 7)
73		280		35-5	40"							2A												
72	25-7	278																						
71	30-6	285				5-8	1	1-4	1	1-7	DE 20	5, 11, 52-1	5	5	5	5	5	10-6	R1					Pairs 8-12 are connected to open wire on Route 19
70	25-7	285																						
69	25-7	270										5, 52-1			C 25-22P			10-6	R1	.113	1-9F	1	1	Subscriber (Pr 7)
																				.180	1-3F	1	1	Subscriber (Pr 7)
68	20-7	205																						
67	20-7	205																						
66	20-7	205																						

TOTAL UNITS	SPAN	R	POLE TOP UNITS	GUYS	ANCHORS	PM	WIRE & CABLE	PG	HA	K	P	S	SW	
4 (25'-7) 1 (30'-6) 1 (25'-6) 1 (25'-10) 3 (20'-7)	2553'	Electric Co. to replace existing 30' electric pole	2 (PB5-8) 1 (PB5-1)	2 (PE1-4)	2 (PF1-7)	3 (PM5) 2 (PM11) 3 (PM52-1) 1 (PM2A)	2 (T-1) 10 (T-5) 2 (T-18) 1 (T-20) 2.750 (D109-135) 2.273 (C25-22P)	3 (PG10-6)	3 (HA-R1)	.510 (K-1P)	2 (P1-3F) 1 (P1-9F)	3	3	EXHIBIT D SAMPLE STAKING SHEET AND PLANT RECORD - AERIAL CABLE

*Indicate the vertical distance that the telephone crossarm or cable attachment is to be placed below the lowest existing electric supply or communications facility. Distances are to be measured from the bottom of electric secondary supports, neutral supports, crossarms, transformers, etc.

SEC.	STAKED BY	STAKING SHEET & PLANT RECORD	WIRE & WIRE SUPPORTS OR CABLE & STRAND	SHEET 1 OF 2
TWP	DATE	COMPANY		ROUTE NO. 17 — REA TE & CM-626
RANGE	REVISED	PROJECT NO.		MAP REFERENCE
CO.	REVISED	WORK ORDER NO.		EXCHANGE MAPLETON



Pole No.	Pole H/C	Span	R	Foreign Pole H/C	Sepr*	Pole Top Units NPB	Guys No	Guys N/PE	Anchors No	Anchors PF	Angle/Lead	PM	3/4 (109-135')	2(DW1-19)	7/8 (109-135')	PG	H	K	P	S	SW	Miscellaneous
9		350		35/7	4½'	1-4	1	1-16			25/1N				1			.130	1-1F	1D	1	R.E. Jones
8		350		35/6	4½'	1-4	1	1-16			23/14				18							
7		370		35/6	8½'	1-4									1			.145	1-1F	1	1	C.H. Brown
6		350		35/7	5'	1-4									18							
5		475		35/7	4½'	1-4 / 1-7	2	1-16	1	1-2	DE/16	52-1	5/5		1				4-1 / 1-1			
4		415		35/7	5'	3-3							19		19							
3		420		35/7	5'	3-3							1		1							
2		445		35/7	5'	3-3							19		19							
1		150		35/7	4'	5-6	1	1-26	1	1-3	DE/12	52-1	5	T T	5	2(S-1)						
81				35/7	4'											2(S-1)						
TOTAL UNITS		3325'				5(NPB4-1) 1(NPB1-7) 3(NPB3-3) 1(NPB5-6)	4(NPE1-16)	1(NPE1-26)	1(PF1-2)	1(PF1-3)		2(PM52-1)	5(T-1) 4(T-5) 2(T-18) 4(T-19) .300(DW1-19) 10.460(D109-135)			4(PG5-1)		.275(K-H)	2(P1-1F) 2(P4-1)	1/1D	2	

*Indicate the vertical distance that the telephone crossarm or cable attachment is to be placed below the lowest existing electric supply or communications facility. Distances are to be measured from the bottom of electric secondary supports, neutral supports, crossarms, transformers, etc.

EXHIBIT E
SAMPLE STAKING SHEET AND PLANT RECORD - JOINT USE

SEC.	STAKED BY	STAKING SHEET & PLANT RECORD	WIRE & WIRE SUPPORTS OR CABLE & STRAND	SHEET OF
TWP	DATE	COMPANY		ROUTE NO. REA TE & CM-626
RANGE	REVISED	PROJECT NO.		MAP REFERENCE
CO.	REVISED	WORK ORDER NO.		EXCHANGE

POLE		SPAN	R	FOREIGN POLE		POLE TOP UNITS	GUYS		ANCHORS		ANGLE / LEAD	PM	WIRE & WIRE SUPPORTS OR CABLE & STRAND					PG	H	K	P	S	SW	MISCELLANEOUS
NO.	H / C			H / C	SEPR *		NO	PE	NO	PF														
TOTAL UNITS																								

Indicate the vertical distance that the telephone crossarm or cable attachment is to be placed below the lowest existing electric supply or communications facility. Distances are to be measured from the bottom of electric secondary supports, neutral supports, crossarms, transformers, etc.

EXHIBIT A
SAMPLE STAKING SHEET AND PLANT RECORD FORM-AERIAL PLANT