PLASTIC INSULATED CABLE PLANT LAYOUT

CONTENTS

1. GENERAL

1.1 This section is intended to provide REA borrowers, consulting engineers, contractors, and other interested parties with technical information for use in the design and construction of REA borrowers' telephone systems. It relates in particular to the considerations involved in the layout and recommended arrangements of plastic-sheathed plastic-insulated aerial and buried cable. In general, the practices are also applicable to buried wire and aerial multipair distribution wire.

1.2 The information is for use in preparing telephone system specifications, maps, and cable plant circuit schematics for projects using plastic cable facilities. The material herein supplements TE & CM 205, "Preparation of an Area Coverage Design," and TE & CM 210, "Telephone System Design Criteria, Engineering Time Periods." REA TE & CM 629, "Cable Plant Layout," presents technical information and recommendations concerning the use and arrangement of lead cable facilities.

1.3 The average size of paired cables has significantly increased due to subscriber growth and upgrading. Concurrent greater central office equipment capability, supplemented by electronic devices where necessary, permits the widespread use of fine gauge cables. Buried facilities have largely eliminated costly pole line construction. The result is a reduced "circuit mile" cost. Loop plant facilities can be sized and located judiciously without severe cost penalties. Under appropriate conditions "dedicated" circuit facilities are feasible and will provide operational advantages.

1.4 In recent years, cable plant layouts have been influenced by the use of "even count" plastic-insulated conductor (PIC) cables. This type of cable contains no extra pairs (all guaranteed); and permits a number system such as 1-25, 101-150, 201-300, etc., in which all cable pairs are included. Pairs are identified by color-coded insulation according to a pattern that is standard throughout the industry. Random or deviation test splicing for minimizing electrical unbalances is not ordinarily needed. Splicing is facilitated by unsealed "ready-access" terminals which can be placed on aerial plant where needed. Any pair in the entire cross section of the cable is accessible. Cable pairs can also be made fully available in buried plant terminal housings. Upgrading of subscriber service has also been helpful. One- and two-party services are more flexible than four- or eight-party and help to improve plant efficiency. These developments have led to flexibility never before attainable. The need for a complicated multipling and overlapping arrangement with repeated appearances of the same cable pairs in a number of terminals has been largely eliminated.

2. DEFINITIONS

2.1 Working pairs are pairs in subscriber or trunk service or which provide special circuits. The terms spare pair and dead pair used herein have different meanings. A spare pair is a pair designed and made available for service in terminals in a prescribed arrangement suitable for future needs. A dead pair is a feeder cable pair which is not spliced through to the MDF nor from a distribution branch cable to a feeder cable. For example, it may refer to a pair cut dead in a cable beyond the last subscriber for transmission improvement or a pair cut dead to avoid increasing the size of a feeder cable. A dead pair is therefore a segmented pair electrically disconnected from the central office.

2.2 The word terminal used herein includes ready-access enclosures for aerial cable and terminal housings for buried plant.

2.3 Cable fill expresses in percentage the ratio of the number of pairs actually in use (providing service) at a given time in a cable to the total number of pairs contained in the cable.

2.4 Maximum cable fill expresses in percentage the ratio of pairs in service to total pairs in a cable which may be safely and economically used without serious interference with the quality of service. In REA criteria, the five-year design fill is the established objective. It is less than 100 percent because of cable pairs which are unavailable at specific locations due to standard cable size or arrangement, pairs reserved for station fluctuations, possible inoperative conductors, and any pairs provided for maintenance or for forecast variation among small subscriber groups. Recommendations for the number of spare circuits to include are given in REA TE & CM 210.

2.5 In cable design the term multipling has been used to indicate the repeated appearance of the same cable pairs at more than one location. It was more broadly applied to any arrangement of cable pair termination even though no actual repetition occurred. Thus, in the procedure of assigning cable pair counts to cables or terminals, these cables or terminals were said to "multiple" each other. The group of pairs in any cable or terminal was generally called the multiple, although the term pair count (sometimes abbreviated to merely count) is perhaps preferable. This nomenclature formerly referred particularly to paper-insulated cable which used stub type or other limited size sealed terminals.

2.6 A newer term now in general use for plastic-insulated cable facilities associated with the ready-access type terminal enclosure (or housings for buried plant) is known as home count.

2.61 The home count is the engineering application and grouping of specified cable pairs for efficient utilization of the cable capacity and to provide for growth, rearrangement, and maximum quality of service to the subscribers.

2.62 The home count identifies selected pair complements on a preplanned basis to serve specific locations either along a cable route or near its end. The concept requires the engineer to set forth zones of usage or service areas for the various cable complements. Although the home count is specified, it need not be completely terminated.

2.7 Feeder cable is a length of a particular size cable facility which (a) serves no subscribers along its path, (b) has no bridge taps, (c) has no junctions, and (d) has only those terminals or pedestals required for essential splicing such as those for reel ends or loading requirements. A feeder cable is intended to provide service to subscribers beyond its far end by association with distribution cables connected to its terminating point, or it may function as a through trunk. In large systems feeder cables may diverge into two or more "branch" feeders.

2.8 Distribution cables indicate cables on which distribution terminals or pedestals are installed and along which subscribers receive service from these cables. Some "distribution" cables may actually have some feeder as well as distribution pairs in the same sheath.

3. PRELIMINARY CONSIDERATIONS

3.1 The preparation of a cable plant layout includes verifying and checking conformance to the area coverage design (ACD) as to cable routes and sizes and selection of the facilities based on transmission and signalling limits (supervision, ringing, and dialing) for subscriber circuits and trunks ascertaining requirements for load coils, long line adapters, repeaters, and other devices. The various requirements are treated in detail in other REA TE & CM sections, REA Form 511, and in equipment specifications.

3.2 The cable layout for the system plans and specifications begins with ACD maps (corrected to indicate the current location of subscribers and their anticipated grades of service) revised according to latest subscriber signup information. These maps should be made suitable for the use of staking crews--they will show all subscribers to be served and all cable and line facilities as planned in the ACD. The plant is then staked, and cable plant circuit schematics, as staked, are prepared. The schematics and the "as staked" system maps become part of the Plans and Specifications. (The preliminary cable design prepared for an ACD may require some modification during the staking of the plant.)

4. CABLE GAUGE

4.1 Cable gauge selection should adhere to the area coverage design criteria. Fine gauge cables should be used to the fullest extent practicable. When combinations of two gauges such as 24 and 22 gauge are used in subscriber loops, the finer of the gauges in such combinations will be placed at the central office end of the cable layout. The location of the change of gauge will vary depending on the overall circuit length and the most economical matching arrangement of standard cables to meet the service requirements.

4.2 REA TE & CM 424, "Design of Two-Wire Subscriber Loop Plant," sets forth the various loop resistance limits and detailed transmission requirements for subscriber circuits. Mixtures of gauges and types of facilities, temperature effects on aerial plant, some types of inductive loading, and multiparty arrangements tend to reduce transmission limits. Transmission is better for buried plant because it is not subjected to large variations in circuit resistance due to wide changes in temperature.

4.3 The use of 19-gauge facilities should be confined to the smallest sizes due to the cost differential that is imposed. Existing facilities are often composed of coarse gauge cables, and the layout of new cables should take advantage of this existing transmission capability. Existing open wire circuits may be used at the ends of loops if noise characteristics and maintenance costs are satisfactory.

4.4 All loops in cable over 18 kilofeet require load coils; however, transmission on loaded cable places certain limitations on cable plant arrangement. Load points must be located according to a particular pattern. (See TE & CM Section 424.)

5. CABLE SIZE SELECTION AND LAYOUT PRINCIPLES

5.01 The cable sizes in the layout should conform to the area coverage design. REA TE & CM 210 sets forth recommended standard sizing procedures for cable facilities for the five-year design period. The selected cable sizes (based on the number of pairs designated for subscriber circuits plus a recommended number of spares) should be as indicated.

5.011 The proper number of spare pairs for each standard sizes of cable and wire is an important factor in sizing facilities in the cable layout. It is intended that cable plant provide a suitable number of spare pairs (including those that can be provided <u>without</u> making it necessary to increase the size of the feeder cable) between the distribution cable and the MDF. Distribution cable pairs that are not spliced into the feeder (as two 18-pair distribution cables converging into a 25-pair feeder) will be made dead (capped) at the junction point.

5.012 No <u>spare</u> pair in one branch cable ordinarily should be bridged to a <u>spare</u> in another branch cable although the engineer may find it advantageous to bridge pairs actually assigned to multiparty subscribers.

5.02 In base rate areas where all one-party or one- and two-party services are offered, special attention should be given to the proper provision of spare cable pairs to fulfill the need for flexibility in the more concentrated subscriber distribution pattern. (See REA TE & CM 210, paragraph 3.)

5.03 Station movement which takes place whether or not overall increase in subscriber numbers is realized may also be a contributing factor in requiring spare pairs, particularly in base rate areas or other specific localities. Resort areas or places such as construction sites or trailer parks may evidence such subscriber fluctuation characteristics. Relocations of existing subscribers from one vicinity to another may release pairs at the old locations and require pairs at the new locations. Some of the movement will tend to cancel as a subscriber may move in where another has vacated.

5.04 The probable error in sizing small distribution cables is considerably greater than that for large feeder cables. For this reason the extra pairs in distribution cables should be proportionately larger. Extra pairs in distribution cables reduce the average utilization of the distribution cables, but a degree of flexibility is provided which (1) gives an adequate margin for unexpected circuit requirements in the terminating cables which are relatively costly to reinforce and (2) improves feeder cable usage and efficiency. Thus, the somewhat higher cost for incremental larger size of distribution cable facilities is partially compensated by the increased efficiency of the feeders to which they connect.

5.05 Bridging of the cable pair terminations at the central office MDF is a means of furnishing and maintaining the specific grades of multiparty subscriber service requested. In exchange plant design, bridging of lines at cutover and subsequent operating rearrangements can be performed satisfactorily at the central office if kept within prescribed limits. Although more initial circuitry may be required by this plan as compared to the five-year forecast by subscribers and grades of service, substantial operating economies can be realized. If cable pairs to the individual establishments are available, party line associations can be manipulated as desired. The disadvantages of using additional cable and possible bridge-tap isolators must be weighed against the ability to upgrade or disconnect subscriber service from the central office and the advantages of maintaining proper fills on party lines. There will be a definite saving in COE line equipment, but the cost of bringing outside plant circuits all the way into the CO for bridging will rapidly become too high for loops beyond the normal base rate area. Procedures for bridging cable pairs and transmission limitations are described in more detail in REA TE & CM 424.

5.06 Factors Affecting Diminishing Points in Cable Sizes.

5.061 The normal layout of a cable route from a central office requires the division of the route into a number of distinct sections as the cable sizes get smaller. The number of sections and location of the reduction (diminishing size) points will depend upon the expected locations and pattern of distribution of the subscribers.

5.062 Where possible, the service areas should be chosen so that the locations for reducing cable sizes will be at junctions of branch cables. This will avoid extra splicing which may cost more than extending a larger size cable for a short distance.

5.063 Construction considerations may require some adjustment in cable lengths and sizes. A run of a particular size cable can often be varied in length to some extent to eliminate splices, provide more flexibility, and take advantage of the economy of using standard reel lengths of cable. Short lengths are usually more expensive due to increased splicing costs. Use of two or more central office entrance cables will eliminate the need for a short piece of large cable instead of combining them into one entrance cable. A cable plan should make as much use as possible of standard reel lengths of 2,000 feet or more. The minimum length for changing small cable sizes on a lead should not be less than 1,000 feet.

5.07 Distribution cables are relatively small (usually less than 50 pairs), and may be quite long in low density areas. A single cable with a feeder and a distribution complement may initially serve several ultimate distribution areas. In such cases the service areas may be designed for subsequent "division" to provide adequate distribution facilities for growth in each area for a first five-year period. "Division" can be accomplished by a second "relief" cable picking up the distant end of the original cable it parallels and reinforces. "Feeder" pairs then become available for "distribution" use in the original cable. Many rural cables, especially long rural leads of small size, are as much feeder type as they are distribution cables.

5.08 In the usual case where a cable must serve subscribers along its route as well as connect to cable extensions serving additional subscribers, two cables might be considered in the original design. One might be an existing cable with a new one to be added. A wider selection of size and gauge combinations is made possible with two cables over what can be provided using one standard size cable. The number of pairs in a dual cable plan can be made closer to the actual requirement. It is not advantageous to be forced to provide extra pairs in portions of the cable layout that are not needed to meet the subscriber forecast but are due to limitations in sizes of standard cables. Two cables also permit closer adherence to transmission objectives. Unnecessary use of coarse gauge facilities in a standard size single cable provides higher transmission levels than are needed or warranted for the substantial extra cost involved.

5.09 It may be preferable in a two-cable plan for one of the cables to be a feeder cable as defined in paragraph 2.8. This cable would not be brought into terminals along its route except at the loading point intervals and at reel splices. This would permit the use of smaller size terminal housings in buried plant for the intermediate subscriber services, and would save cable by not having to loop the feeder cable in and out of the various intermediate service terminals. It would also reduce the number of exposures of unsheathed cable pairs.

5.091 A loaded feeder cable needs to be brought into only four terminals in the 18-kilofoot distance from the central office. In an average subscriber distribution, it is likely that there would be a total of 18 or more terminal housings. The length of cable saved should amount to 500 to 1,000 feet. These savings are on the basis that the parallel distribution cable is not subjected to loading as it would need to be if it extended more than 18 kilofeet. Additional savings in cable are possible if buried cable splices are used. With buried splices on one-party systems, there will be no appearances in the feeder sections of the cable. Appearances will commence in the service or "home count" area.

5.092 Disadvantages of the dual arrangement are (1) two separate cables may not be as economical as one, (2) different location of most of the load points must be established for the feeder cable, and (3) access for maintenance is diminished and locating trouble spots may be somewhat more difficult without terminal appearances at the several convenient locations. If two similar cables are placed in close proximity along a route, a suitable means should be provided to subsequently identify either of them to preclude later problems in fault location or service connections.

5.093 It is possible to utilize a composite cable for the feeder cable placing the conductors in the same sheath as the distribution facilities if loading proved to be necessary on both cable complements. This might offer an advantage in annual maintenance.

5.0931 Composite cables with two gauges of conductor under one sheath are available in certain sizes and patterns. They may offer advantages in certain design situations. Very short lengths or unusual combinations of composites should not be used as long delivery periods and excessive costs will likely result.

5.10 In situations where right-of-way is available and particularly where the highway right-of-way is wide, the engineer should study the possible advantages and economy of placing separate cables along both sides of the roadway to provide service to establishments on either side to reduce expensive road crossings. Such crossings usually require special trenching or pipe pushing. It should not be overlooked that the method may double the problems of relocation caused by road widening operations which often affect both sides of the road. It also means two separate leads to maintain whenever any type of excavating is done by other than telephone company personnel. It may also complicate the choice of location for a future reinforcing facility if one should be required.

6. CABLE PAIR ACCESSIBILITY

6.01 Service assignments should be determined from a review of the existing and five-year circuit requirements. The allocation of distribution cable complements should correspond to subscriber locations and be divided in conformance with natural boundaries. The home count for each distribution section should include as many pairs as necessary subject to the constraints that are discussed below.

6.011 It is no longer necessary to give careful consideration to exact terminal locations. The terminals that are required for subscriber service needs can be specifically located at the time of staking.

6.02 Home counts grouping the pair counts of the distribution cables should be reasonably flexible to minimize early changes. The total pairs in the distribution facilities will often exceed those in the feeder. It is preferable to assign clear pair counts until the feeder is allocated. It is not desirable to overlap the count of the individual distribution facilities with its preceding cable.

6.021 Pair counts of the distribution facilities which may be affected by reinforcing cables may be multipled according to a contemplated reinforcing pattern. Allocation of counts within distribution cables should be designated with eventual feeder reinforcement considered. Planning for reinforcement is increasingly important for buried plant. In growth situations it becomes necessary to increase the distribution capability. Feeder cable sizing does not usually include the entire distribution pair counts. The points of relief for future feeder cables should be established in the design before the assignment of counts. The cable sections can be manipulated so that minimum rearrangement will be required for future reinforcement unless the actual growth pattern is extremely different from the ACS prediction.

6.03 In selecting and assigning home counts to specific distribution sectors the engineer will find it necessary in most cases to make certain restrictions concerning the pairs that require loading or other special devices, that might have special service requirements, or are intended for a specific purpose at another location. Examples are (1) pairs that should not be selected for subscriber service between load coil points because of the transmission impairment and (2) bridge taps that should be kept within specified limitations.

6.031 The approximate location of load coil points should be determined, as this will have an effect on the availability of pairs to serve specific establishments. Spare pairs allocated to specific distribution areas should not be loaded initially. If carrier channels are later added, it will not be necessary to remove the load coils.

6.032 Toll, EAS, and some types of special service circuits require exclusive use of cable pairs. It is essential that such circuits be properly treated in the layout.

6.033 Design consideration is now given to buried splices, buried loading points, and buried distribution points. When these are used, there will be a minimum number of aboveground appearance in the buried plant cable layout. Where accessibility is essential, distribution points should be kept aboveground.

6.04 Every pair in a cable passing through a ready-access enclosure or terminal housing is potentially available at that point for service connection, but random assignment of pairs in these terminals is objectionable. Random assignments can disorganize the cable pair groups and complicate the search for a desired pair due to cutting the color-coded group binder threads. Random assignment also makes it more difficult to identify and locate available pairs and may require testing to ascertain the group and count sequence of circuits for future needs. Cable records should be established for the proper assignment of the facilities.

6.041 Ready-access enclosures or terminal housings serving a particular cluster of establishments should be assigned a home count within one 25-pair group. It is intended that all assignments for these particular establishments normally should be restricted to pairs in this count. For example, in a 100-pair cable having a count of 1 to 100, pairs 76 to 100 can be assigned as the home count for a series of terminals along a specific subscriber service area and a different count assigned to another series of terminals serving a second area. On a 50-pair cable with 25 feeder pairs (pairs 1-25) the home count for distribution pairs can be 26 to 35, 36 to 50, or similar consecutive pair counts.

6.05 The configuration of plastic-insulated cables recommended in REA specifications PE-22 and PE-23 for "Fully Color-Coded, Polyethylene-Insulated, Polyethylene-Jacketed Telephone Cables," makes it most suitable for low count groups of pairs (units) to be assigned nearest the <u>central portion</u> of cables of 50 pairs or larger sizes. These pairs are more difficult to bring <u>out for service</u> termination than pairs in the outer layers of the cable. Therefore, the home counts for enclosures on cables of 50 pairs and larger preferably should not include the low count pairs until the outer groups are assigned. (See Figure 1.) Important considerations associated with the assignment of counts are (1) to maintain individual pair color identification wherever possible--color code continuity is maintained in reel end splices so that each cable pair is identifiable within the sheath, (2) to assign the low counts at the extremity--pair No. 1 is blue and white under blue and white binder--the initial low counts should first be assigned to the trunk complement if any, (3) to avoid assigning counts on a random basis between binder groups in the same cable, and (4) to avoid split (non-consecutively-numbered) counts.

6.06 In a cable extending from the MDF, the pairs are numbered from 1 up to the maximum number of pairs in the cable which may be 100, 200, etc. In a cable plant layout where a large cable is to be spliced to a smaller cable at the diminishing point and this smaller cable in turn diminishes, the lowest numbered pairs at the main frame should be carried straight through to the longest cable. Such a situation might consist of a 200-pair cable at the central office diminishing progressively to 100-pair, then to 50-pair, and so on down to a 6-pair facility. This will keep the color of pairs uniform from end to end for the six pairs. Cable pairs of branch cables should also be spliced color to color wherever practical. However, splicing color to color cannot always be maintained in one- to eighteen-pair facilities such as prevail in many REA rural systems. The blue-white pair in the smaller facility should be connected to the lowest number available in its connecting cable.

6.07 Distribution cable pairs preferably should be spliced to consecutively-numbered pairs in the feeder cable. For example, pairs in a 25-pair distribution cable should be spliced to pairs consecutively numbered in a 200-pair feeder cable. It should seldom be necessary to splice distribution cable to a split or non-consecutive count in a feeder cable.

6.08 The complete count in a particular section of a combination (feeder-distribution) cable would normally not be included in the home count. Ordinarily, feeder pairs in such cables would not be available for subscriber assignment.

6.09 The home count specified by the engineer should be such that assignment of subscribers can be made without further concern for bridge taps or load coils. None or little overlapping of pair counts in successive terminals is necessary where one-party service is involved.

6.091 The home counts assigned to a group of ready-access enclosures and terminal housings should be such that where subscribers for multiparty service are scattered, sufficient pairs will appear in enough enclosures to permit ready association of parties to particular circuits keeping in mind the bridge tap limitations which may be controlling. Examples of rural distribution cable layouts with home counts shown for the various numbers of enclosures are included in the figures attached. Where party line associations are prevalent, the enclosures or housings should provide flexibility in pair assignments by having the same pairs appear in several enclosures. New station installations in this type layout seldom should require transfers of other existing stations from one pair to another.

6.092 Assignment of cable pairs may be affected by <u>aerial open wire plant</u> to which the cable pairs are connected. High fills on party lines can be attainable due to the aerial wire being accessible at all points for termination. Aerial wire also permits much longer end sections. Usually, however, the localities where this type of plant is in use are slow growing with low subscriber density. If proper subscriber assignments are not made initially, the result will be a loss in cable plant operating efficiency (low operational fill that will not be likely to be alleviated by increases in the number of stations).

6.10 Sufficient above-ground appearances for distribution points should be provided on buried cable and buried wire for the expected growth to avoid having to dig out the cable or wire and install terminal housings at a later date. Terminal housings are normally required along the route at the following locations: (a) at junctions with lateral cable runs and possible future runs; (b) at aerial inserts if it is necessary to splice the cable; (c) at cable inductive loading points; (d) at points where bridge tap isolators (BTI) are necessary; (e) at locations within reasonable service distance to all potential subscribers; (f) at points where voice frequency repeater, carrier repeater, or carrier terminal apparatus are to be located; (g) at any additional points along cable routes to insure that the distance between appearances does not exceed 5,000 feet; and (h) at cable size diminishing points for splicing. Additional terminal housings are not required for building-out capacitors because they can be placed in the same housings as the load coils. It is expected that load point terminal housings will be specified to include room for BTI and building-out capacitors (BOC). As direct burial splice cases are becoming available, they may be used at many of the above locations.

6.11 The requirement for ready-access enclosures or terminal housings for subscriber connections is determined by the number and location of subscribers to be served. In many instances, the economy of establishing additional terminal locations as compared to paralleling the cable with drop wire or buried wire for short distances must be determined. The decision to place or omit an enclosure or terminal housing should be based primarily on the comparative costs (or annual charges) for the extra terminal versus the incremental length of service wire to the nearest available terminal. Up to 350 feet of one-pair paralleling aerial drop wire can be placed about as economically as a ready-access enclosure. When tree conditions are bad, the use of drop wire in pole-to-pole spans should be restricted. Up to 600 feet of buried wire may be justified instead of placing a BD 2 type terminal housing. Factors such as plowing and trenching conditions and availability of equipment to do this work may be important. Other types of terminals might increase or decrease this limiting distance. The installation of a terminal or buried splice is preferable unless placing the service wire parallel to the distribution cable results in a definite saving.

6.12 Those pairs that are to be "working" pairs and the spare pairs provided in a branch cable should be spliced to available feeder cable pairs. Any additional distribution cable pairs are "dead" pairs and should be capped appropriately but not grounded. Generally nonworking pairs will be kept spliced from distribution into feeder cable circuits.

6.13 Plastic-insulated aerial cable is comparable to open wire and "multipair distribution wire" as to flexibility because a ready-access enclosure can be added where and when needed to provide service to new subscribers.

6.14 All subscriber circuit assignments should be entered on the appropriate facility record sheet.

6.15 The cable schematic or map should indicate all new and retained cable by route, sections, sizes, and types. The number and the assignment of the counts of the pairs should be shown. Pair count assignment should be determined for both existing and proposed counts for existing cable. Assigned pairs, spare and extra pairs, and pairs to be cut dead should be noted.

6.151 All loading coil locations, type of loading, number of load coils, BTI's, and count of the pairs to be loaded should be indicated.

6.152 All carrier repeater and terminal locations and the count of pairs to be used for carrier frequency circuits should be indicated.

6.153 Suitable notes should denote cable throw, half taps, split counts, tie cables, rearrangement of existing cables, and any other data pertinent to the layout.

7. "DEDICATED" CABLE PLANT

7.1 The need for a rigid number of repeated appearances of individual cable pairs and predetermined connections of certain cable pairs has been greatly reduced with the advent of plastic cable facilities and less party-line subscriber service requirements. These circumstances plus the lack of pair availability and costly operating aspects of multipled cable plant has led to the introduction by some telephone companies of "dedicated" cable plant design. Dedicated plant developed as a result of the technological advances in cable and terminals in recent years and the changing pattern in subscriber demands for service. The trend toward 1-party and graded service is reducing the need for multipled plant.

7.2 In the design of dedicated plant, a cable pair is connected from the central office to each residential and small business location as demand develops. Once connected, the cable pair remains permanently connected. It is "dedicated" to that location. Party-line subscribers are bridged, and the proper number of subscribers per line maintained at the main frame using bridge tap isolators.

7.21 In the dedicated plant concept, distribution cables having installation costs high in relation to their materials cost, due to the small number of pairs they contain, are sized to include all foreseeable requirements. Feeder cables are sized to be large enough for a suitable time period which is dependent on the rate of subscriber growth and cable gauge requirements. Part of the feeder cable pairs are preallocated to specific distribution requirements at the time of the feeder cable installation with no multipling. The balance of the pairs are kept available as spares in the feeder cable and assigned as the need arises.

7.3 The primary objectives of dedicated plant are to reduce annual operating expenses and to increase plant efficiency by simplifying assignment procedures; minimizing plant rearrangements such as transfers of cable pairs, central office jumpers, and station drop wires; and reducing the time required and the cost of disconnecting and reconnecting service since this can be done at the central office. If the subscriber set is left in place on disconnect, a new subscriber may be given service without a visit to the location. Service installations can also be made more rapidly. Requirements for post cutover circuit rearrangement and reassignment are reduced. Reliability of service is improved due to less handling of outside plant facilities. There is less need for extensive revision and correction of plant records.

7.31 Loop transmission will be improved due to the eventual elimination of bridge tap multiples and substantially all long end sections. Transmission criteria are met when the original assignment of the cable pair is made. With a cable pair dedicated to each establishment, future assignment of pairs for subscriber service does not require special engineering in connection with transmission levels, loading, bridge taps, or other parameters.

7.4 In order for dedicated plant to be economically feasible in any given area, the savings in operating expense obviously must clearly exceed the annual charges on any additional initial investment required. This tends to restrict application of dedicated plant to medium and high density areas. Subscriber growth rates and the ratio of served to unserved establishments (saturation) are also important considerations. Because of the relatively low subscriber density, party line development, and long subscriber loops that characterize the operating areas of some REA borrowers, the use of dedicated plant will be too costly as a general practice, although it may be suitable for use in base rate areas or small one-party exchange areas. Even under favorable circumstances, dedication of the longer loops is not economically feasible because (1) a significant number of extra cable pairs may be involved and (2) if two-party bridging is expected to be accomplished at the main frame of the central office, it will require separate pairs to each station with no common portion.

8. CABLE REINFORCEMENT PRACTICES

8.1 The service requirements of new subscribers and the upgrading of service for existing subscribers will inevitably fill many cables to capacity. This creates a need for reinforcement of the affected facilities at some particular time. A decision must be made as to when and how the most economical expansion can be provided. The best approach for ascertaining the optimum method for reinforcing is to develop several alternate methods and analyze the labor and materials cost to obtain the basis for the engineering selection.

8.2 Maximum usage must be made of the latest materials and techniques in designing plant for reinforcement purposes. Using acceptable new products and techniques results in economies and flexibility not attainable a few years ago. Central office equipment is more versatile and has increased signaling limits. New types of self-regulating solid state carrier and repeaters are being perfected. Transmission criteria have been updated to reflect greater ranges and capability of modern apparatus. Techniques have been established to effectively share special equipment that must be provided for long loop operation.

8.3 It is important to avoid frequent reinforcing. Adding extra capacity to meet unpredicted growth must usually be done on a piecemeal basis and becomes unnecessarily expensive. To avoid this in the initial design, the cables must be properly sized according to the ACS subscriber indications and the rate of growth that is forecast.

8.4 If unusually rapid growth in an area is forecast by the ACS, most all of which is potential and dependent on the construction of new dwellings, it is advisable not to oversize the the initial cables. <u>Planned</u> reinforcement of cables larger than 100 pair may be more economical than providing a <u>single large</u> cable initially in the design. Reinforcement may be contemplated by means of a second cable to be extended from the central office to a carefully selected point along the <u>initial</u> cable. The reinforcing future cable will not need to have terminations enroute except at <u>reel-end</u> splices and loading coil locations. If the expected growth fails to materialize or is delayed, a substantial investment in idle pairs in the initial cable may be deferred or perhaps avoided entirely.

8.41 Carrier or line concentrator reinforcement may also be made a planned part of the original design for meeting selected portions of the future subscriber growth. The extent of the fixed physical plant can be reduced. Subsequent carrier additions can be matched to the growth requirements. The cost of this equipment can be deferred or saved if the growth does not develop as expected.

8.5 Methods to consider for cable relief are:

(a) Older types of existing cables may be replaced by new ones--usually larger.

(b) Existing cables may be paralleled by a new facility--aerial or buried as suitable. Due to improved construction methods, direct buried cable costs often compare favorably with aerial facilities even where pole lines exist.

(c) New feeder cables may be placed along the same or alternate routes to effect "division" of the service requirements.

(d) New types of subscriber carrier equipment are also economical and flexible as relief measures for many expansion situations. See REA TE & CM 911, "Station Carrier," and REA TE & CM 905, "Cable Carrier Systems and Carrier Frequency Transmission through Cable." Line concentrators may also be useful and economical for such applications. See REA TE & CM 340, "Use of Line Concentrators."

8.6 The majority of outside plant of REA borrowers' systems is still aerial although the proportion of buried facilities has been steadily increasing since 1960. The continued utilization of serviceable existing aerial cable for subscriber service on long loops may make it practical to reinforce by burying a supplemental feeder cable. This will reduce the length of the new cable requirements, and often will allow the use of finer gauges than if the entire reinforcement were buried.

8.7 Buried facilities may be reinforced using the same or different routings. Earlier placement of buried plant was often near the ditches adjoining highways. In such situations, reinforcing leads can be added on private right-of-way at a safe plowing distance from the original facility. Another way of supplementing buried plant is to use the same right-of-way making aboveground terminal appearances only where necessary to terminate the conductors for carrying out the service reinforcement. The reinforcing facility must be placed carefully so as not to damage the original lead. Another method of supplementing is to use the opposite side of the roadway from the original lead, setting new terminal housings wherever necessary. This method minimizes the need for numerous roadway crossings and provides improved accessibility to the subscriber locations.

8.8 When designing cable routes to relieve existing cables, the relief should be provided by extending the new count of pairs in the supplemental cable to a selected cable junction rather than providing a series of new terminals along the route and making a "throw." This method sometimes requires longer runs of new cable, but the additional cost may be offset by the saving in terminal housings and the ease in making the conversion.

8.81 No simple rule can be given as to when a cable should be reinforced or replaced by a larger facility. The cost of removal is likely to exceed the salvage value of existing aerial plant. If the existing cable has many terminals in the section to be paralleled or replaced, the cost of new terminals on a new cable and the subsequent transfer of drop wires to the new terminals will be a significant expense that might be avoided or reduced by placing a parallel cable. It is usually cheaper to install new terminals on a new cable than to transfer old terminals to a new cable. Old type terminals of limited (10, 11, 16, or 26 pairs) size on paper-insulated, lead-sheathed cable may be replaced by ready-access type having lead sheath and plastic-insulated conductor sealed stubs. Cross connecting terminals (crossboxes) can sometimes be used advantageously.

8.9 Proper cable record revisions are required when making changes in cable plant. Changes in the records may be required by such plant changes as:

(a) transfer of terminals from one cable to another parallel relief cable

(b) transfer to subscriber services from existing terminals to new terminals on the same or different cable

(c) transferring a distribution or branch cable from one feeder to a different one--this is called a "cable throw."

(d) changing the pair count of a branch or distribution cable from one count in the associated feeder cable to another count in the same cable

(e) transfer of subscriber services from an existing open wire or RDW line to a cable which is intended as a replacement

(f) regrouping or reassignment of subscriber services for upgrading

8.91 A typical form which can be made locally is illustrated in REA TE & CM 128, "Cutsheet." This form has column headings suitable for use for the subscriber transfer records or "cut" listed above.

8.92 When making major changes in cable plant, it is recommended that a cable and central office facility record system be prepared and utilized such as described in TE & CM 116, "Plant Engineering and Records System."

9. ILLUSTRATIVE LAYOUT EXAMPLES

9.01 Figure 1 indicates a pattern of spare pair distribution. The arrangement should be such as to obtain maximum use of the facilities. A suitable complement of spare pairs should be allocated to the various distribution areas. Attention should be given to the distribution of extra pairs that are obtained along a lead as a result of standard cable sizing.

9.02 Figure 2 shows a typical configuration of PIC cable in the sheath and the related pair counts into terminals along the lead.

9.03 Figure 3 illustrates a nonloaded distribution cable arrangement resulting in suitable sizing of the feeder cables. As many feeder pairs should be spliced through to the MDF as possible as long as to do so causes no increase in feeder cable size.

9.04 Figure 4 illustrates a 25-pair nonloaded combination feeder distribution cable serving two 6-pair and one 12-pair distribution cables. This is an exception to the situation where the feeder capacity is less than the distribution cables.

9.05 Figure 5 illustrates the use of a 75-pair feeder distribution nonloaded cable feeding one 25-pair distribution cable and one 50-pair distribution cable with a complement of the distribution pairs bridged.

9.06 Figure 6 is an illustration of a 75-pair feeder cable serving an 18-pair distribution cable and a 50-pair feeder distribution cable which in turn serves an 18-pair and a 25-pair distribution cable. Spare pairs are established for each section.

9.07 Figure 7 shows a loaded cable pattern. It is intended that the home counts avoid subscriber assignment between load coils and segregate the nonloaded circuits. Spare pairs are kept clear of loading where carrier may be added in the future.

9.08 If additional circuits are necessary to provide service to a new residential development, a plan of alternate routing such as shown by Figures 8 and 9 may be advantageous. Methods such as this can save considerable cable compared to placing supplemental cable along the same route of the existing feeder cable.

9.09 Cost data is essential to assist in determining the optimum cable selection for a particular application. In dealing with cables up to 200 pair, comparisons show that the incremental cost of obtaining extra cable pairs diminishes considerably as the cable sizes grow larger. The next larger size of the same type can provide extra pairs at a lower price per pair than the per pair cost of the smaller of the two cable facilities. The reduced circuit mile costs of the next larger size cables indicate the importance of a sound subscriber forecast. It is evident that the cost to reinforce a 6-pair facility with another 6-pair facility in a short time period is much more expensive than to provide a 12-pair initially. This is true of other small sizes as well. Unpredicted growth demanding relief within a short period creates penalties in plant costs.

9.10 It should not be construed that extra pairs should be placed in plant indiscriminately or unnecessarily as a substitute for proper design or without regard for the area coverage design information. It is not desirable in any layout to include excess plant on many leads as a contingency for "possible" growth.

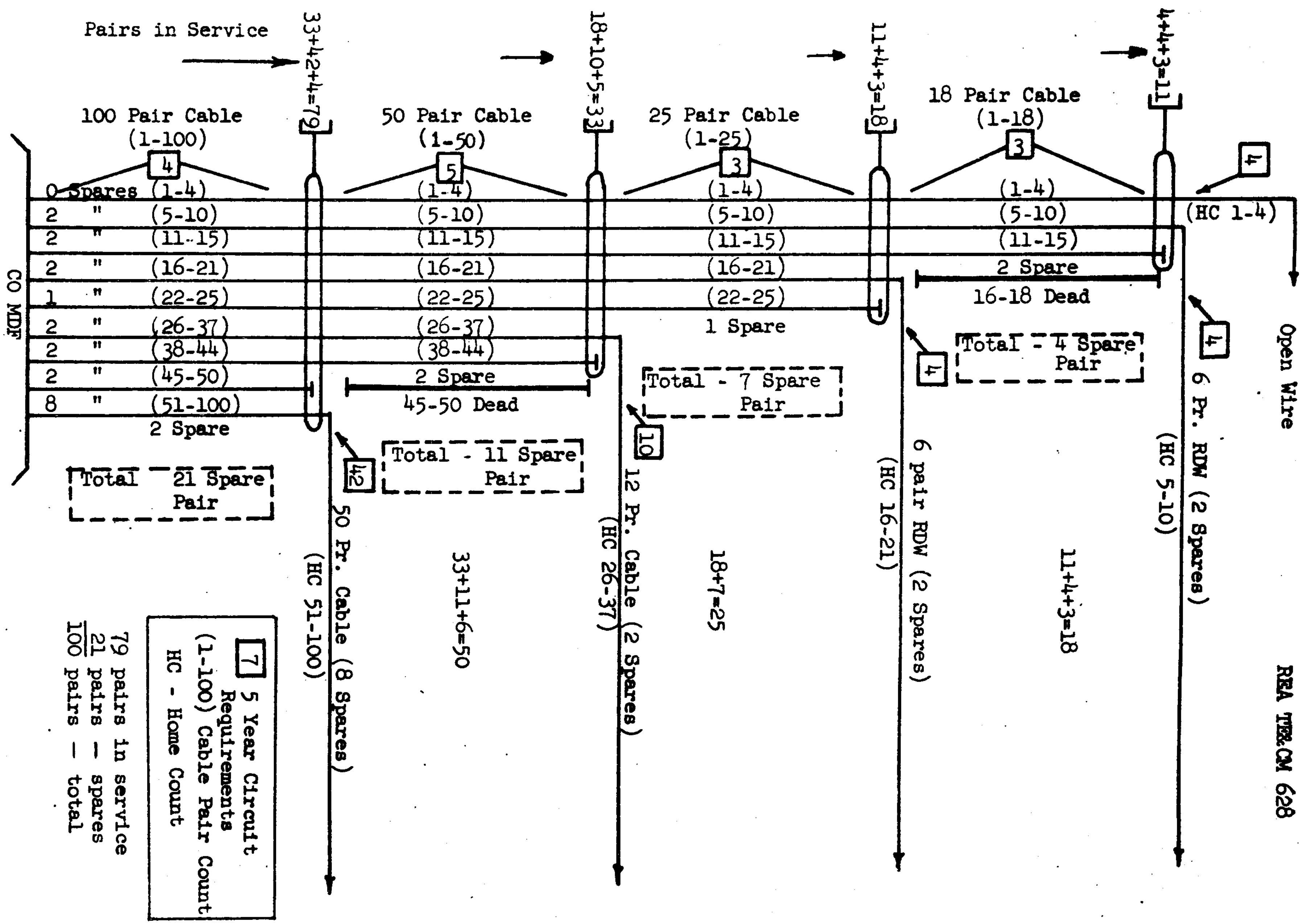


Figure 1 - Illustration of Spare Pair Distribution

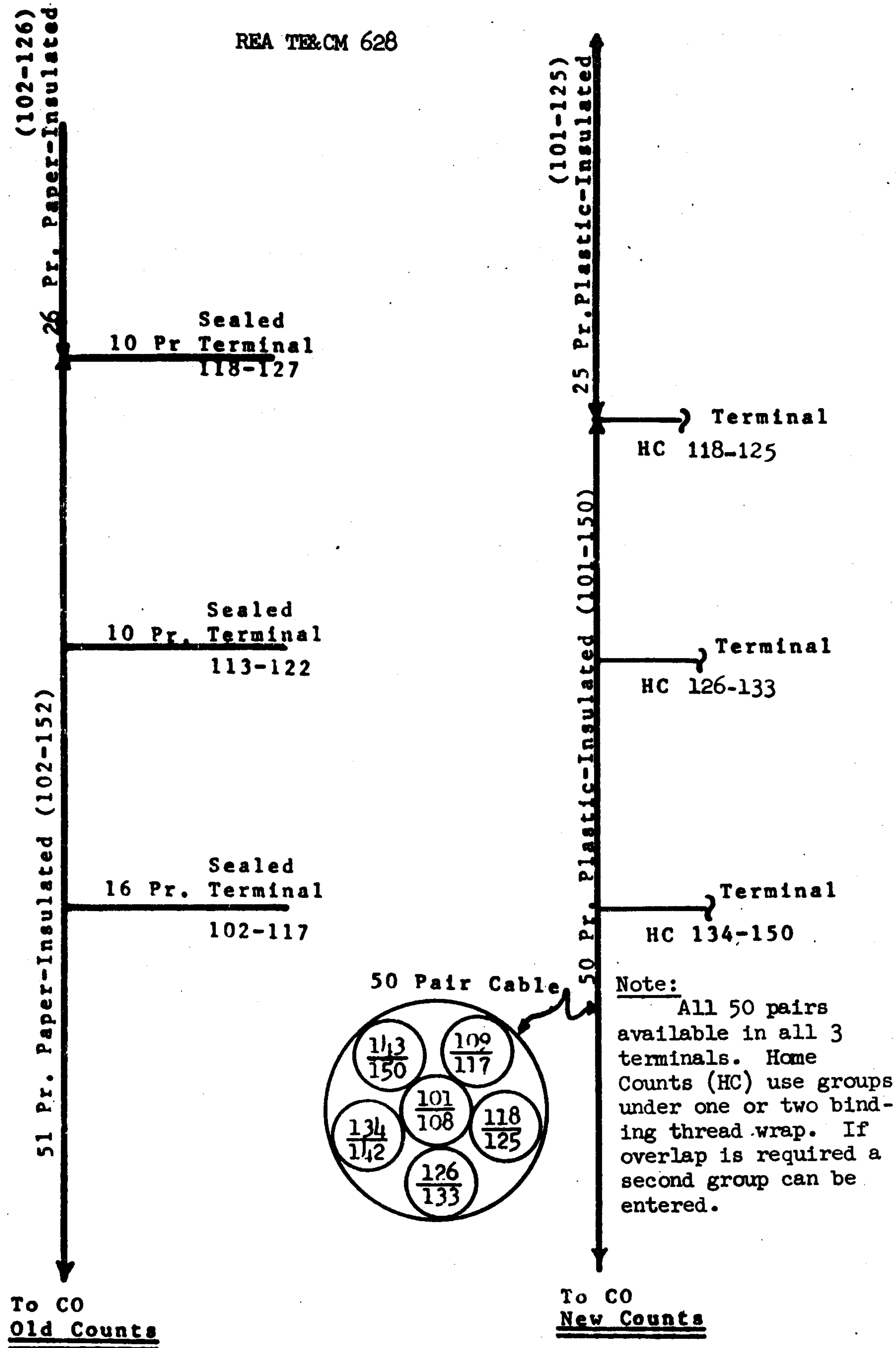


Figure 2 - Terminal Arrangements

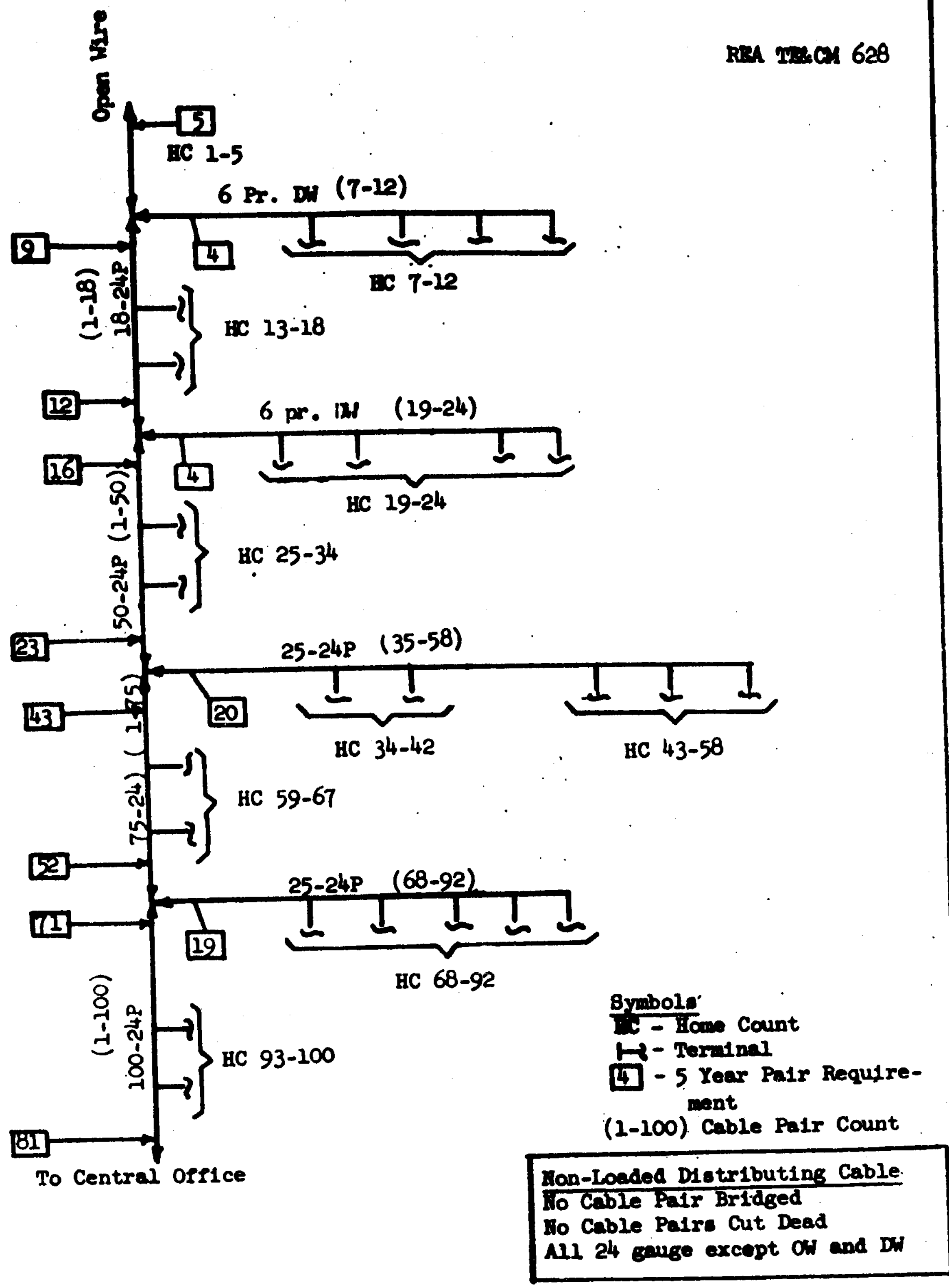

Open Wire
5
HC 1-5
6 Pr. DW (7-12)
9
4
HC 7-12
(1-18) 18-24P
HC 13-18
12
6 pr. DW (19-24)
16
4
HC 19-24
50-24P (1-50)
HC 25-34
23
25-24P (35-58)
20
43
HC 34-42
HC 43-58
75-24) (1-75)
HC 59-67
52
25-24P (68-92)
71
19
HC 68-92
(1-100) 100-24P
HC 93-100
81
To Central Office
Symbols
HC - Home Count
- Terminal
4 - 5 Year Pair Requirement
(1-100) Cable Pair Count
Non-Loaded Distributing Cable
No Cable Pair Bridged
No Cable Pairs Cut Dead
All 24 gauge except OW and DW

Figure 3

REA TE&CM 628

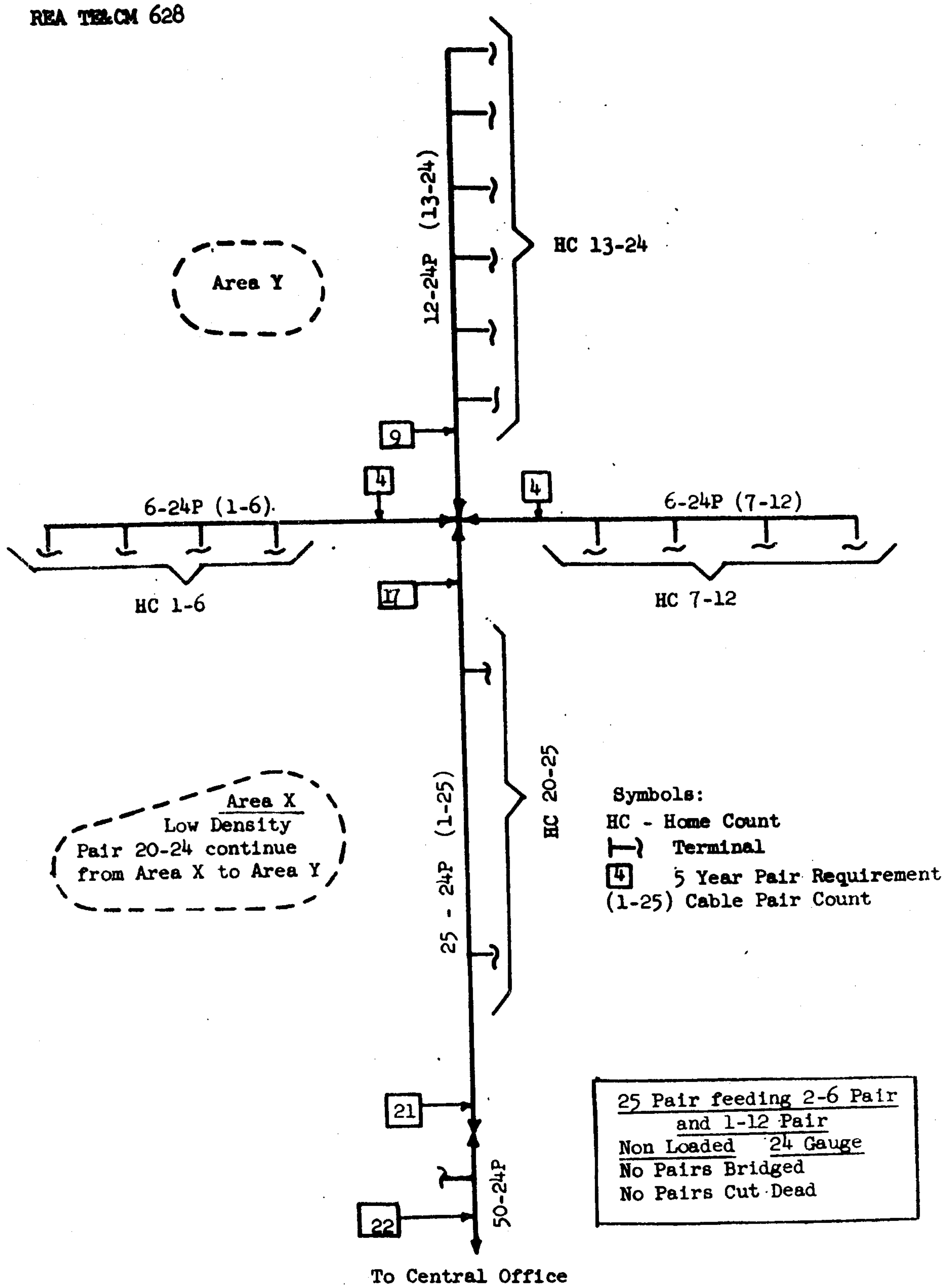
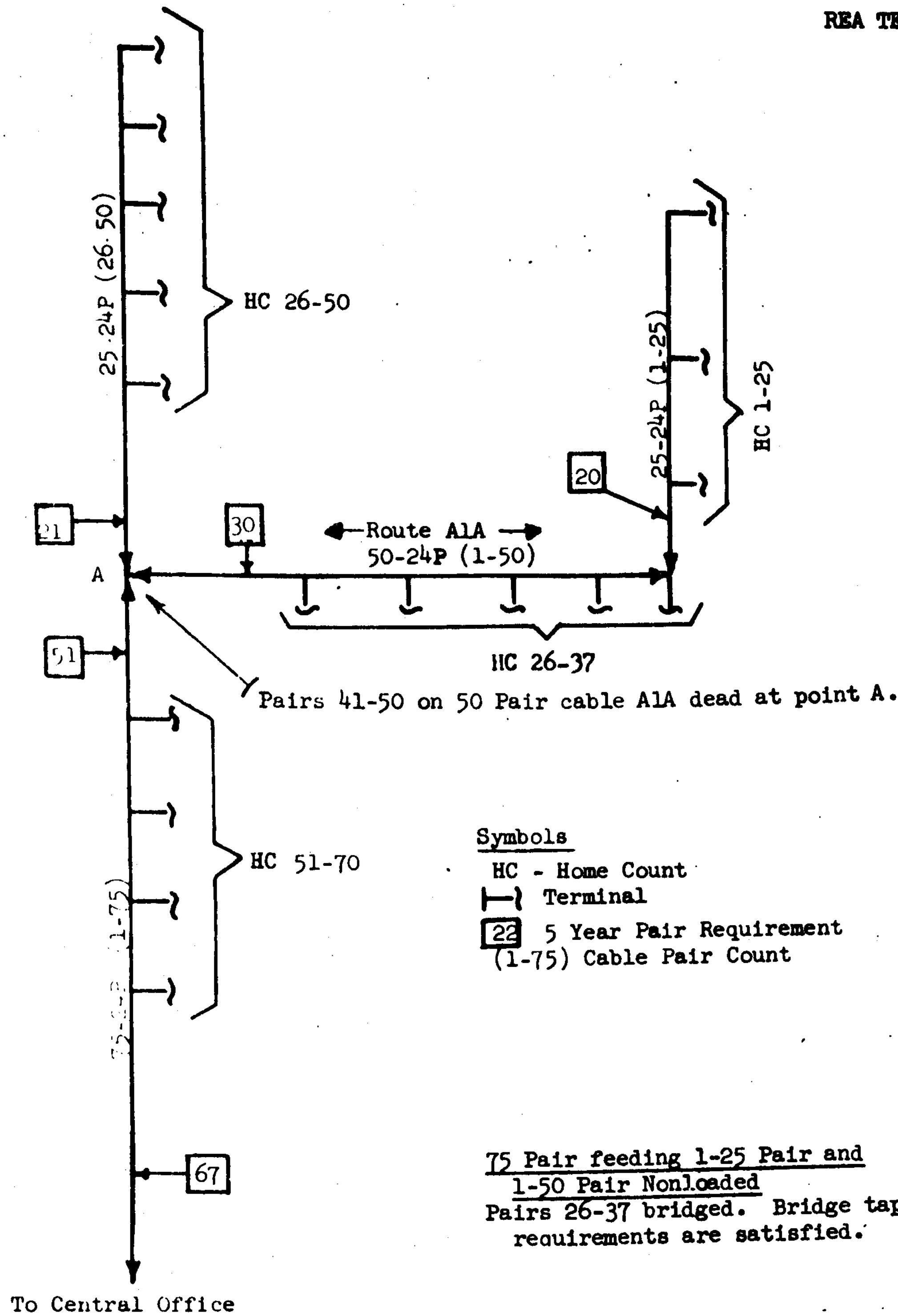


Figure 4



75 Pair feeding 1-25 Pair and 1-50 Pair Nonloaded

Pairs 26-37 bridged. Bridge tap requirements are satisfied.

Figure 5

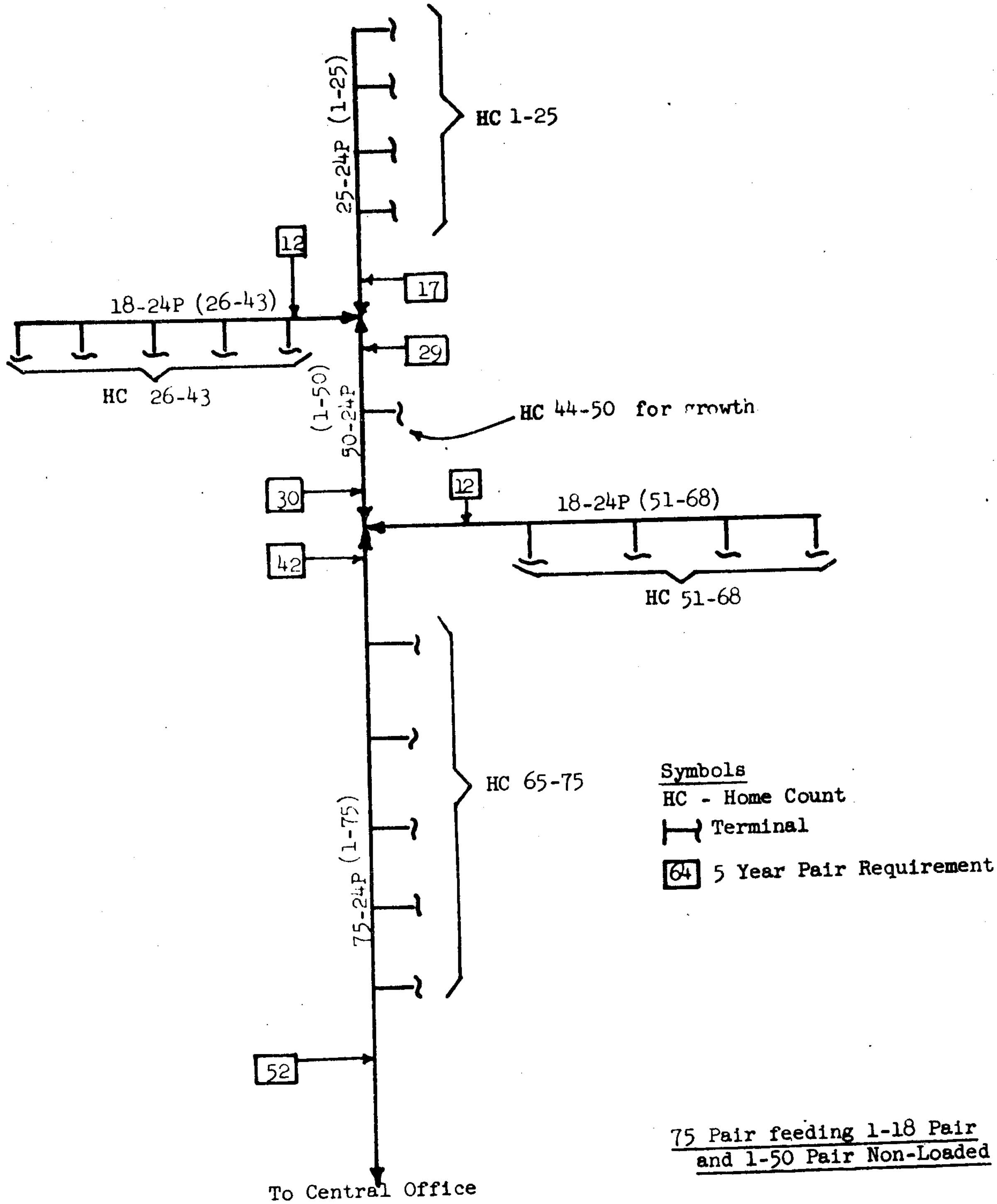

25-24P (1-25)
HC 1-25
12
17
18-24P (26-43)
29
HC 26-43
(1-50)
50-24P
HC 44-50 for growth
30
12
18-24P (51-68)
42
HC 51-68
HC 65-75
75-24P (1-75)
52
To Central Office
Symbols
HC - Home Count
Terminal
64
5 Year Pair Requirement
75 Pair feeding 1-18 Pair
and 1-50 Pair Non-Loaded

Figure 6

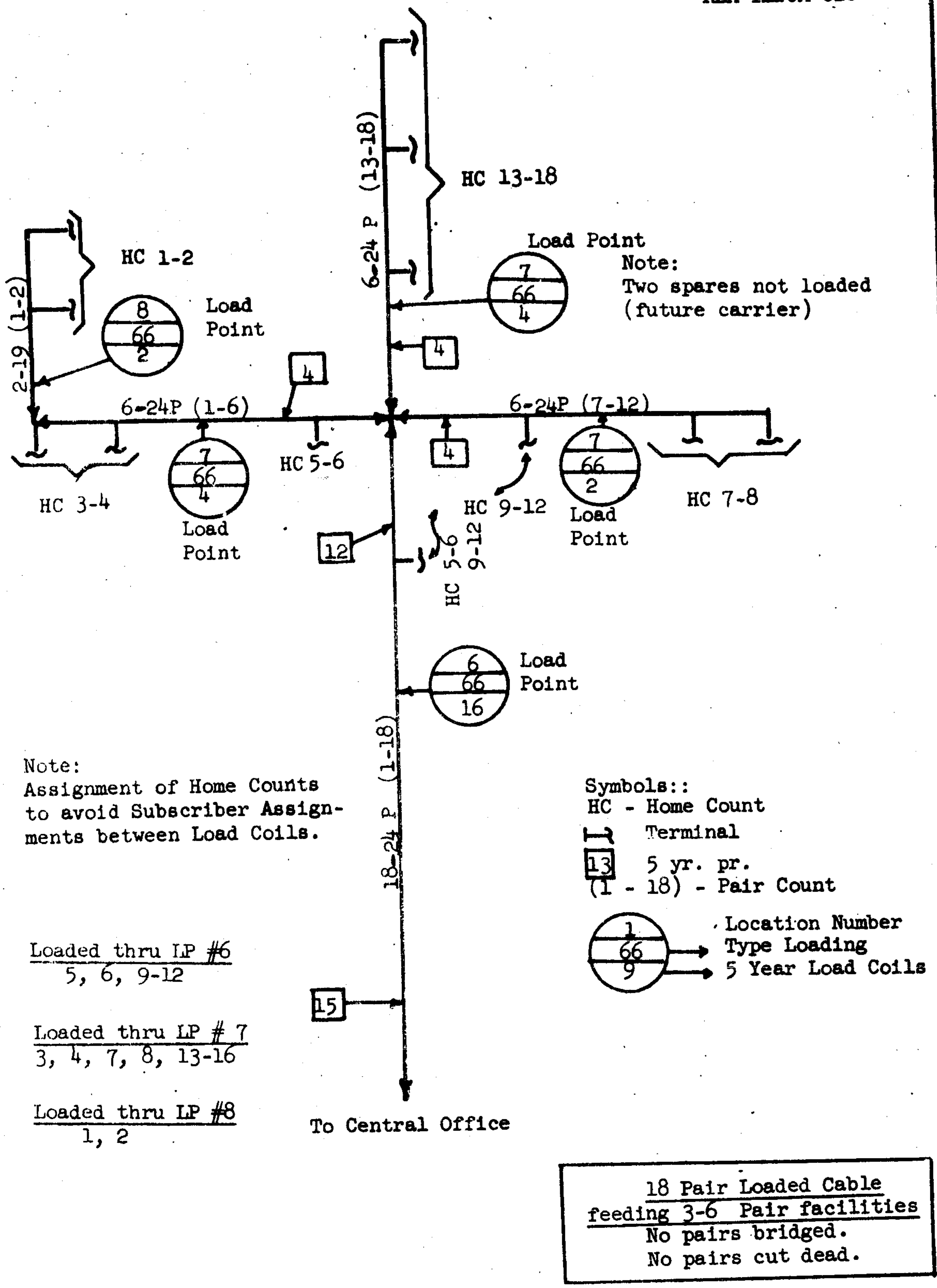

HC 13-18
6-24 P (13-18)
Load Point
Note:
Two spares not loaded
(future carrier)
HC 1-2
2-19 (1-2)
Load
Point
6-24P (1-6)
6-24P (7-12)
HC 3-4
HC 5-6
HC 9-12
HC 7-8
Load
Point
Load
Point
HC 5-6
9-12
Load
Point
18-24 P (1-18)
Note:
Assignment of Home Counts
to avoid Subscriber Assign-
ments between Load Coils.
Symbols::
HC - Home Count
Terminal
5 yr. pr.
(1 - 18) - Pair Count
Location Number
Type Loading
5 Year Load Coils
Loaded thru LP #6
5, 6, 9-12
Loaded thru LP # 7
3, 4, 7, 8, 13-16
Loaded thru LP #8
1, 2
To Central Office
18 Pair Loaded Cable
feeding 3-6 Pair facilities
No pairs bridged.
No pairs cut dead.

Figure 7

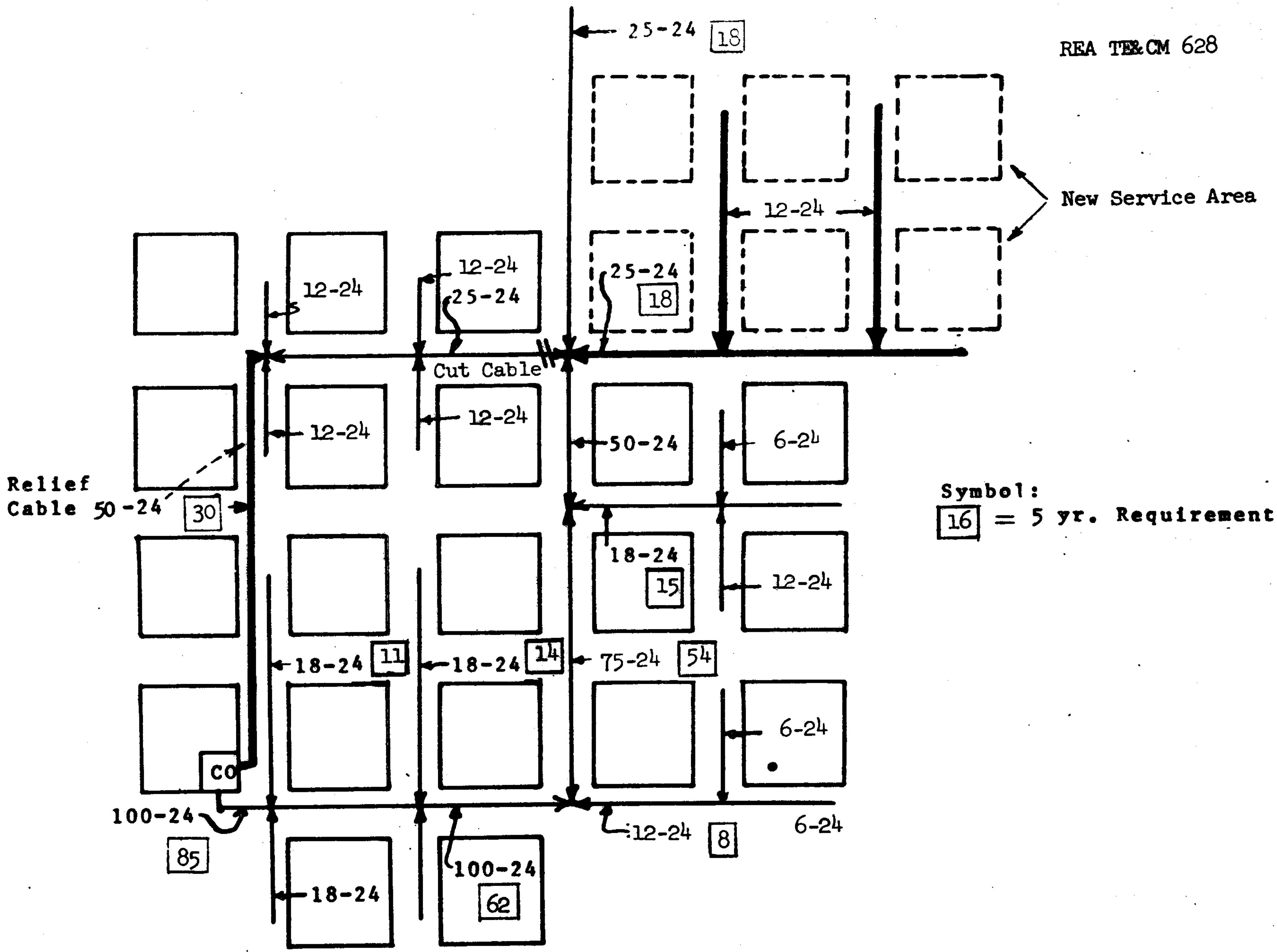
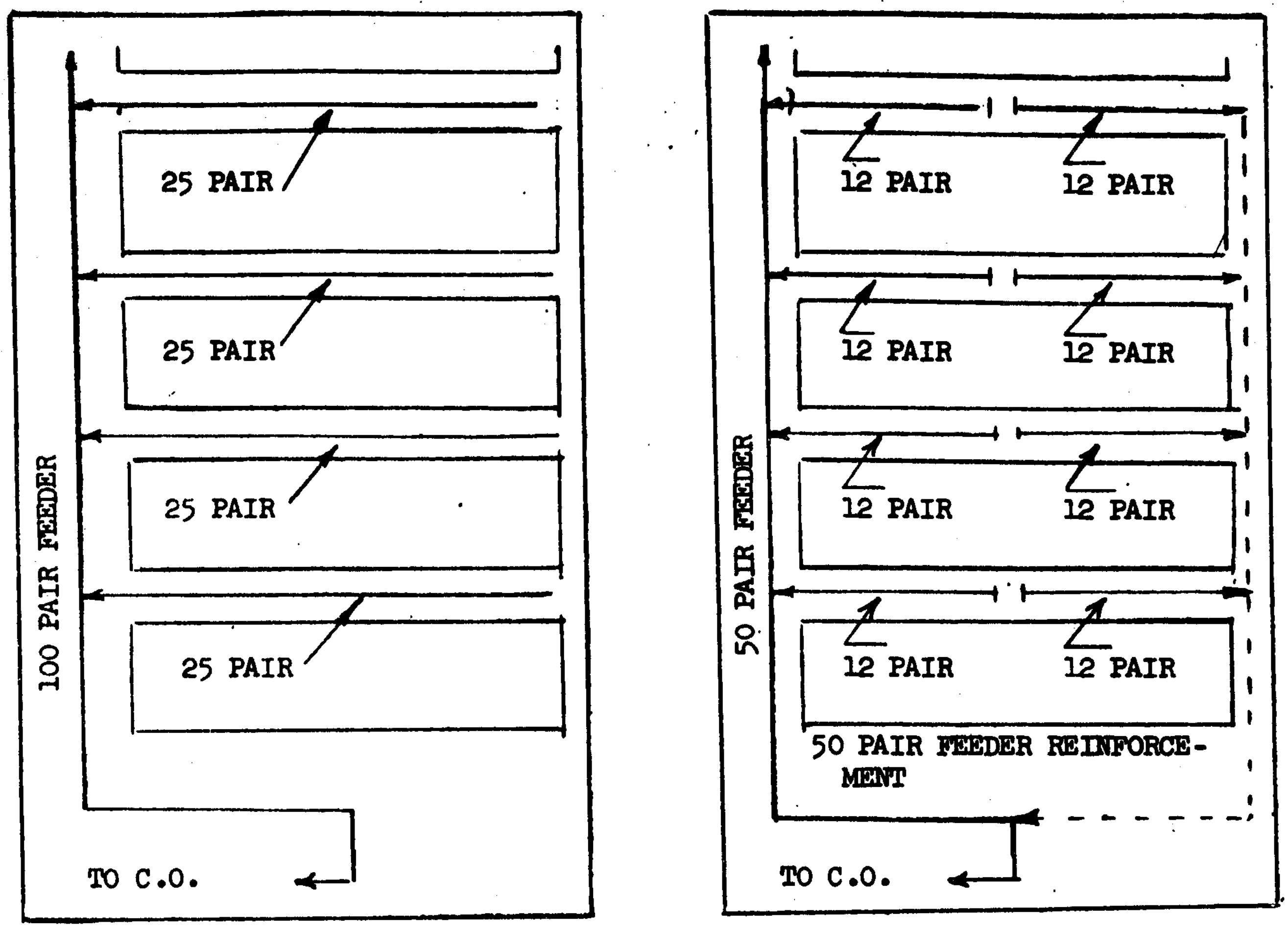


Figure 8

Reinforcement by Alternate Route

REINFORCEMENT BY ALTERNATE ROUTE
(HOUSING DEVELOPMENT)



PLAN 1 PLAN 2

In Plan 1, a 100-pair feeder cable is required to serve four 25-pair distribution cables that are planned for a projected housing development. In view of the uncertainty of sufficient financing for the housing construction, Plan 2 is also prepared. In this case, the 25-pair cables within the development are reduced to 12-pair and are served initially by a 50-pair feeder. If the forecasted growth is sustained, a second feeder can be installed using an alternate routing. The 12-pair distribution cables are cut at midpoint and served by the second feeder. This gives essentially the same number of circuits in the development.

Plan 1

BJ 100-24	2 mi. @ $3,850	=	$ 7,700
BJ 25-24	4 mi. @ $1,780	=	$ 7,120
			$14,820

Plan 2

BJ 50-24	2 mi. @ $2,420	=	$ 4,840
BJ 12-24	4 mi. @ $1,265	=	$ 5,060
			$ 9,900

Optional:

BJ 50-24	2 mi. @ $2,420	=	$ 4,840
			$14,740

Figure 9