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Storm damage problems and electric utility management

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THESIS

Storm Damage Problems and Electric Utility Management

by

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* Drawn by the author

I. INTRODUCTION

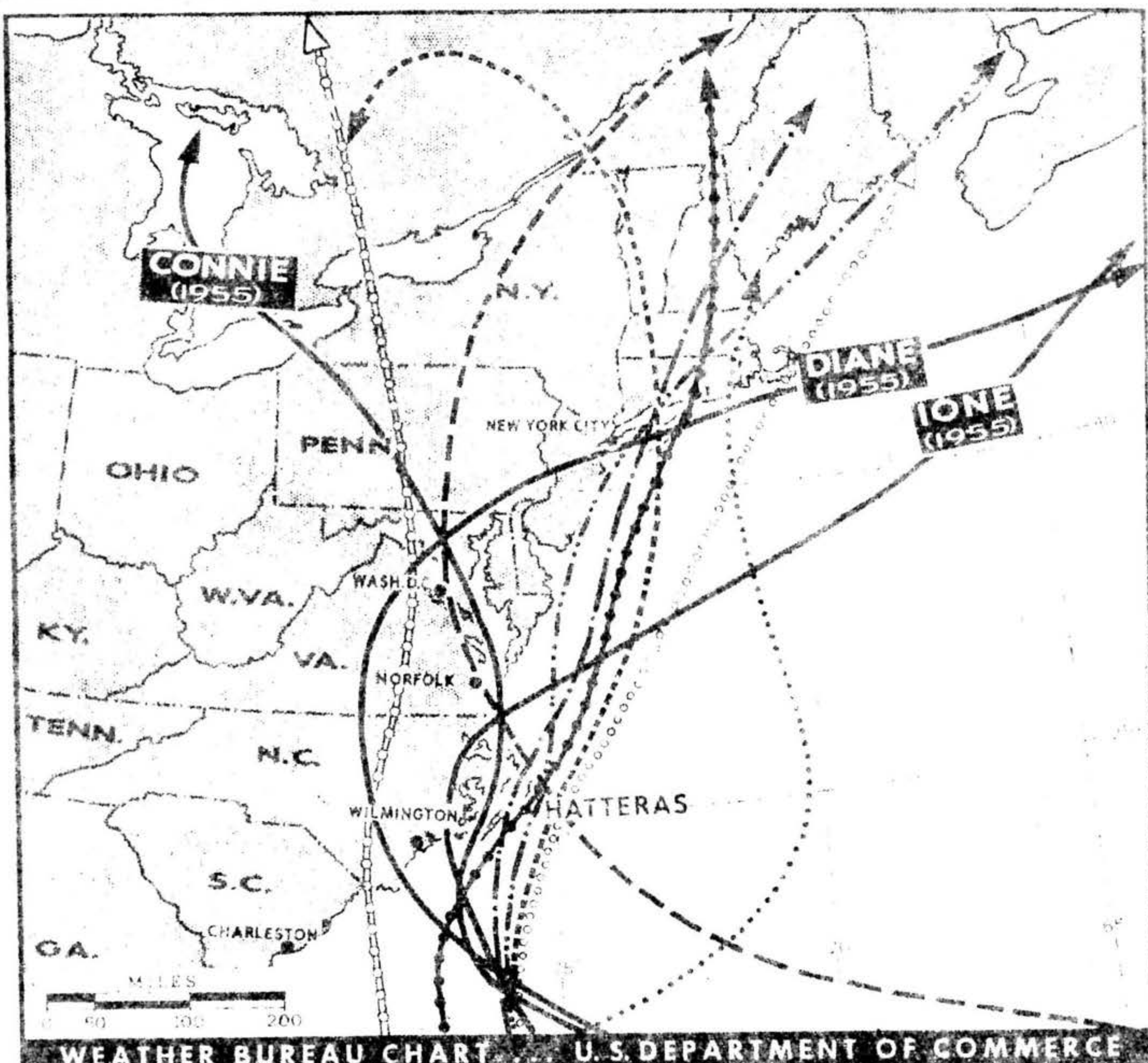
STATEMENT OF PROBLEM

This thesis will deal with some of the special problems which confront the various levels of management of electric utility companies because of damage to their equipment, and hence interruption of service to customers, brought about by the wide spread havoc resulting from storms or acts of God. Everyone living on the eastern seaboard of the United States during the fall of 1954 witnessed the damage brought by the famous hurricanes "Carol" and "Edna" and saw from his own personal angle just exactly what it meant to have his home or shop without electric service for periods ranging from a few hours to many days, perhaps more than a week. (Please note Figure 1.) To the vast majority of the inhabitants of a stricken area the passage of the storm leaves them overwhelmed by the spectacular displays of the storm's forces, acutely aware of the damage to their personal properties, and inconvenienced to various degrees by the lack of electric service. They are aware that the electric company's trucks and men are to be seen in every direction as they start to repair the damage, but the vastness of the problem of restoration receives very little, if any, thought. And rightly so, too, because the problem of restoration in this present day is an extremely complex problem. It is with regard to these complexities that this thesis will deal; enumeration, how and why they arise, how they are handled by different companies, present methods of solution, and some proposed improvements.

The author is aware of the many broad areas which might be construed to come under the chosen title, so he intends to narrow the subject down by mentioning a few subtopics which will not be covered.

L. S. 5512 October 11, 1955

Hurricanes AFFECTING NORTH AND MIDDLE ATLANTIC STATES . . .



SOME MAJOR HURRICANES OF THE PAST

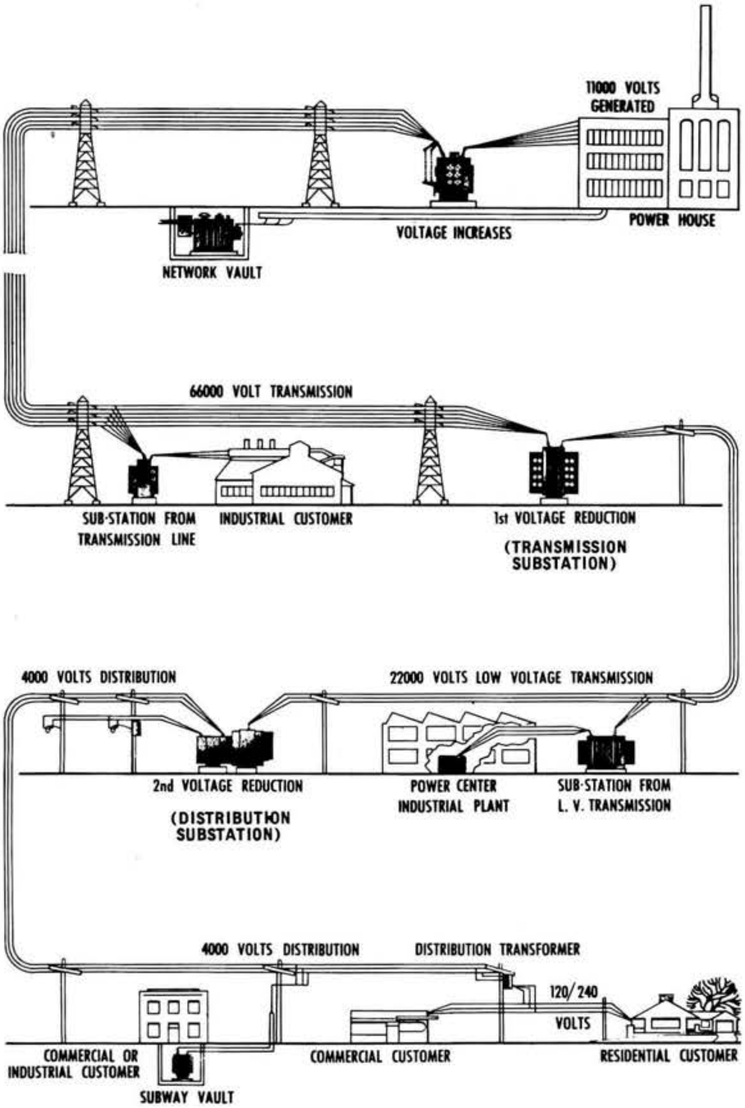
- ····· NEW ENGLAND STORM 1896
- ▬ ▬ D.C.-VIRGINIA-MARYLAND HURRICANE 1933
- ▬·▬ MORRO CASTLE STORM 1934
- - - - NEW ENGLAND HURRICANE 1938
- ▬··▬ GREAT ATLANTIC HURRICANE 1944
- ─●─●─ HURRICANE CAROL 1954
- ○○○○○ HURRICANE EDNA 1954
- ○○○○ HURRICANE HAZEL 1954

Figure 1

(It is assumed that the reader visualizes the basic electrical layout of a modern utility -- generation by large water power or steam stations, transmission over long lines at high voltages, characterized by the big steel towers on private rights-of-way, subtransmission by underground cables and overhead lines on private ways to locality substations, distribution lines on wood poles along public streets which supply neighborhood transformers, and finally to the customers' premises over secondary wires carrying the utilization voltage. See figure 2.)

This paper will not deal with large scale damage to generating stations. The design of modern stations has practically eliminated damage from storms and conceivable acts of God. All large utilities are interconnected with other neighboring companies through strong transmission tie lines and are constantly cooperating with each other so that if any company has a temporary deficiency in generating capacity, the other companies participating in the "power pool" share the increase and contribute very effectively until the original difficulty is remedied. (Two outstanding contradictions of this sweeping generality during recent hurricanes would be the flooding of the large generating stations at Providence, Rhode Island, by tide water swept in by hurricane winds and the accumulation of salt spray on the outdoor bus structure at the large Montaup generating station near Fall River, Massachusetts.)

By the same token, damage to long high voltage transmission lines will not be considered. These "high lines" are always on private rights-of-way, which are cleared of all trees and obstructions by a wide path on each side of the towers so that the biggest source of trouble, falling trees, is eliminated by their design and layout. Modern techniques



Electrical service from the generator to the customer.

Figure 2

From Westinghouse
Transformer
Study Manual

of lightning protection and sleet thawing have also helped immensely to establish the near perfect operating history of this type of equipment. Furthermore, transmission systems are designed to provide satisfactory operation of the utility with at least one line or one pair of lines on the same right-of-way out of service. While most of the large utilities have hundreds of miles of transmission lines running throughout their territory, by comparison with the thousands of miles of wood pole lines on public streets for distribution purposes, the percentage is small and damage to transmission lines is not included in the discussion which will follow.

Areas receiving bulk supply by underground cables or being served by underground distribution cables are also beyond the scope of this paper. By their very nature, electric power cables installed in conduit or duct lines and manholes buried under the public streets, are not subject to damage from storms which involve high winds and sleet, flying debris, or falling tree limbs. Here again, as in the paragraph above, while there are large sections of congested cities where all electrical power conductors are underground, over any given portion of the country the ratio of underground construction to overhead construction is small, so underground trouble is not a part of this work.

It goes almost without saying that no attempt will be made in this thesis to face up to the problem of restoring service if damage comes as the result of an act of war, where the presence of radioactive materials is a factor. Mention is only made of this vast area in case it might suggest a topic for another student, after the techniques which might be required become more fully developed.

Having mentioned several phases of the electric plant which will not be discussed, we can now go back to the point where it was assumed that the reader visualized the typical utility electrical layout. It can quickly be seen that the author has chosen to eliminate problems involving all segments of the electrical layout, except the local distribution lines. To put it another way, the basic question with which this paper will deal revolves around the problems which arise when severe storms cause extensive damage over wide geographical areas to the wood pole lines carrying electrical overhead conductors, which are located on practically all of the streets in any neighborhood and which provide that last link in the long distribution path from the original generating point to the customer's meter.

WHAT AN INTERRUPTION MEANS TO THE CUSTOMER

It is not intended to present a complete historical sketch of the growth of the electric light and power industry in the United States as background information. There is certainly no need to go back to the details of Edison's first commercial generating station at Pearl Street, New York, in 1882, nor to the first alternating current distribution system at Great Barrington, Massachusetts, in 1886. The era when electricity was generated only during certain hours of the day to provide service to a very few customers is just a part of an era gone by. Likewise the period of the 1920's and 30's is not significant because of the manner in which electricity was utilized in the average home at that time. While the electrical loads were growing and the utility business was becoming big business during the 20's and 30's, the large majority of homes used electric power primarily for illumination and miscellaneous appliances energized only occasionally, such as the flat iron and toaster. Just previous to World War II the electric appliance saturation was becoming more and more pronounced and as soon as materials were available after the cessation of hostilities, the boom in real estate, suburban living, and appliance sales was really under way. (See Figures 3 and 4.) This all leads to the present situation where, instead of the typical home using a very few incandescent lamps (perhaps only twenty-five watts each) and a few "electrical gadgets," use of electric light and power is now judged a necessity in the household. Whole neighborhoods or developments are built and sold as "all-electric homes," which can mean an electric water pump, an electrically operated oil burner furnace, an electric stove and electric refrigerator in the kitchen, an electric "deep-freeze" chest down cellar, electric garbage disposal, ever increasing levels of illumination completely by electricity, all followed by a growing list of appliances, including television sets, radios, toasters, washing machines, and clothes dryers. And three large sources of consumption which have appeared only recently and are expected to provide much growth in the near future are the widespread use of air conditioners, heat pumps, and radiant heaters.

The enumeration in the above paragraph is necessary so that the reader will have a quick grasp of what a service interruption means as he goes into the main portion of this thesis. He should realize that just as the applications of electricity in the American home have made it an indispensable commodity, a similar condition presents itself in small commercial customers (heating, refrigeration, ventilation, interior and exterior lighting, motors, and air conditioning) and in large manufacturing

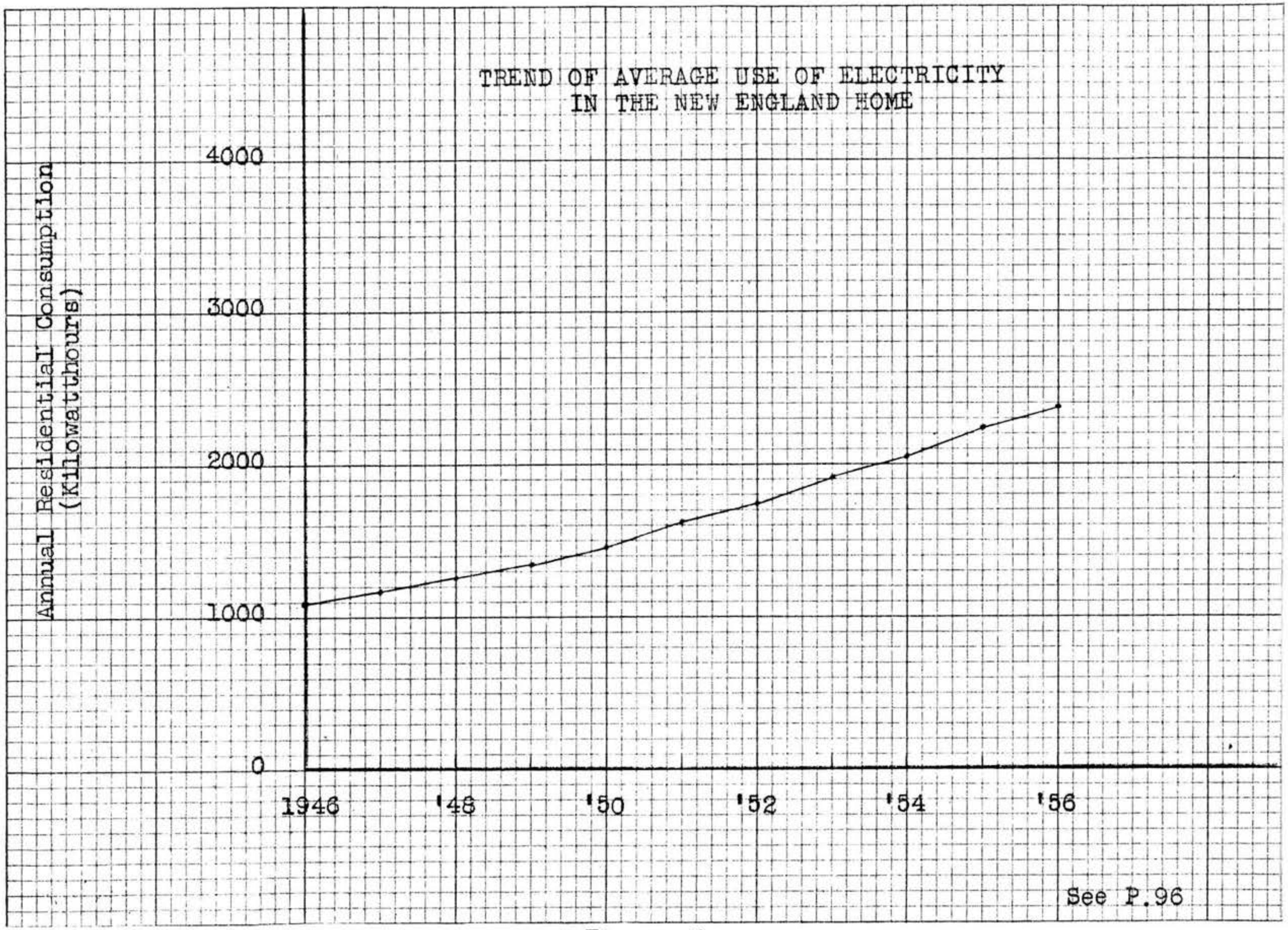

TREND OF AVERAGE USE OF ELECTRICITY
IN THE NEW ENGLAND HOME
Annual Residential Consumption
(Kilowatthours)
4000
3000
2000
1000
0
1946
'48
'50
'52
'54
'56
See P.96

Figure 3

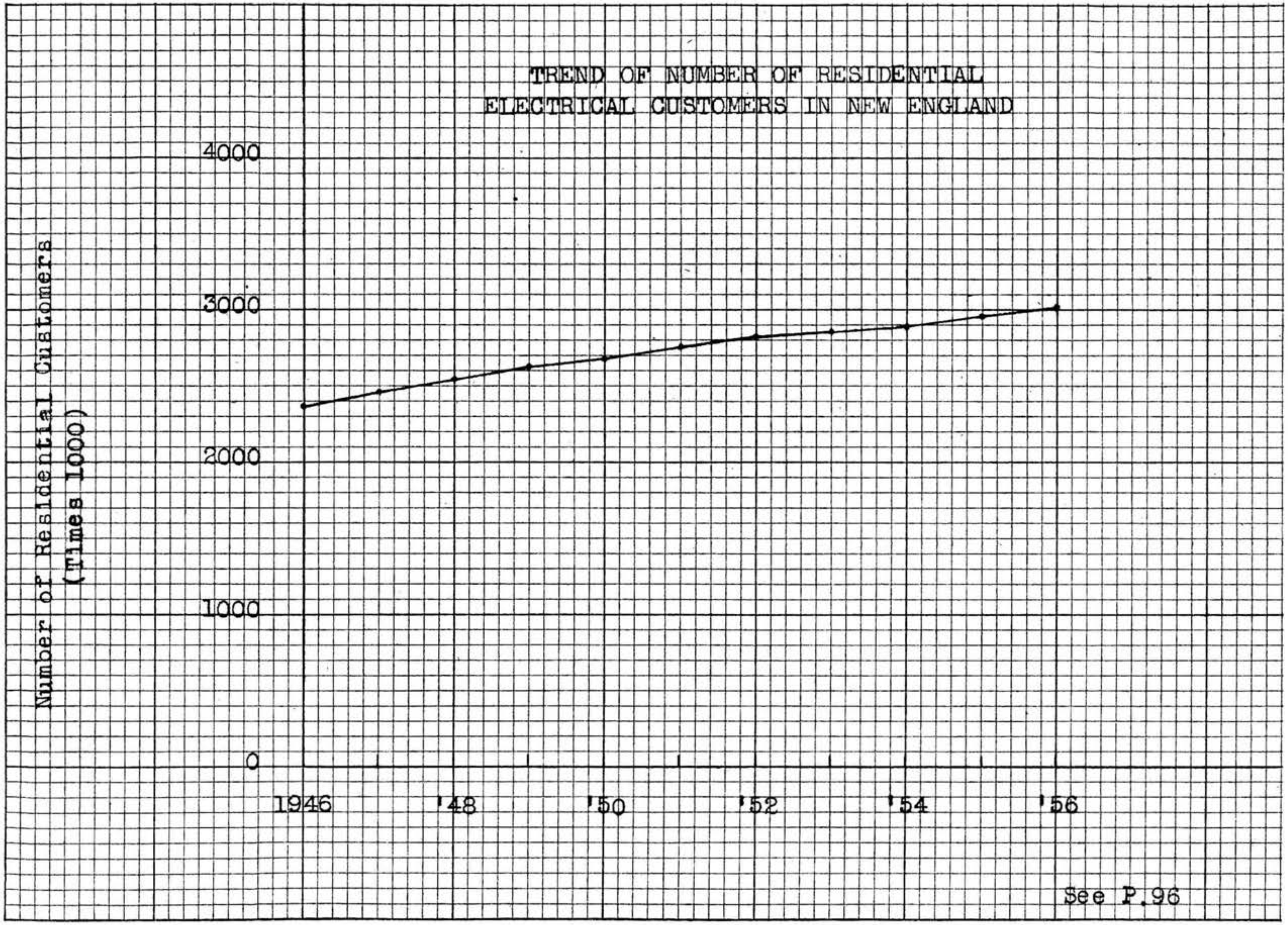

TREND OF NUMBER OF RESIDENTIAL
ELECTRICAL CUSTOMERS IN NEW ENGLAND
Number of Residential Customers
(Times 1000)
4000
3000
2000
1000
0
1946
'48
'50
'52
'54
'56
See P.96

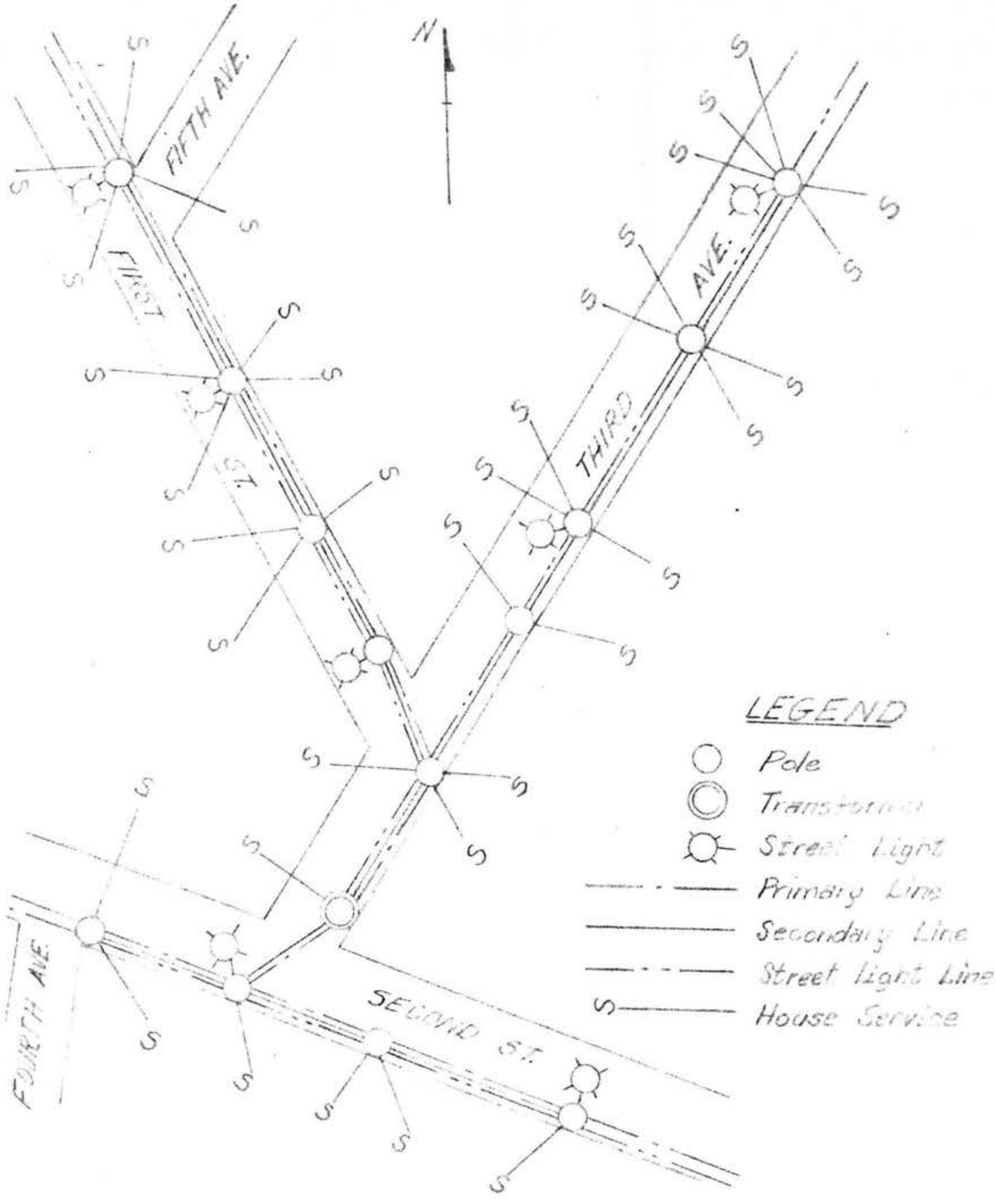
Figure 4

and processing plants, where the accent is on motors, industrial heating, lighting, and ventilating. Whether it concerns individual residences with peak loads in the order of 1 or 2 kilowatts, commercial customers with loads of perhaps from 10 to 100 kilowatts, or large plants having peak demands in the order of thousands of kilowatts, an interruption of electric service means inconvenience, financial loss, and a complete upheaval of the normal day-to-day routine to the customer. The effect of a lengthy electric outage upon stores or small manufacturing concerns may not be too hard to visualize. However, think what it means to have entire residential neighborhoods, towns, or areas without electricity for a day or longer -- thousands of homes unable to use their electric ranges and refrigerators, water pumps, and automatic oil burner furnaces, as well as lights and special appliances.

WHAT IS TYPICAL OVERHEAD CONSTRUCTION

Typical overhead construction, as used by electric utilities for the distribution of electric service, is in evidence everywhere along the streets in all cities and towns excepting those very congested areas where underground cables are feasible. Certainly the reader has seen countless examples; in fact wood pole construction is so much a part of the neighborhood that it very seldom receives a moment's notice from the passerby. Basically poles are set vertically in the ground between the street and the sidewalk with crossarms attached horizontally at the top where small pins and insulators are mounted to support the actual electrical conductors. In practise the modern poles are carefully selected pine from southern United States, treated with creosote under pressure to give many years of service. A typical pole for distribution rises above the ground level approximately thirty to thirty-five feet and is about 12 inches in diameter at the ground line. They are usually spaced along the street at intervals of about one hundred feet, with one located at each street intersection to provide a junction point. (See Figures 5 and 6.) The local telephone company and electric company often own a pole jointly so that the telephone attachments are made part way up the pole, but the electric conductors are always at the top of the pole. The crossarms are also pressure treated with creosote and are about four inches by five inches in cross section with lengths varying up to about ten feet depending on the number of conductors required. Either steel or wooden pins are inserted in the crossarms; and insulators, adequate for the voltage in question, are installed on top of the pins. (Voltages vary from 120 volts to 15,000 volts or more, but the most widely used classes are 120/240 volts and 2400/4160 volts.) The actual conductor which is attached to the insulator and strung from pole to pole is usually made of copper, although recent defense programs and improved technology has brought some aluminum into use. These conductors, depending upon the application, vary in size from AWG 6 or 8 to AWG 4/0 or slightly larger.# The choice of wire size is based on the load in amperes to be carried as well as voltage drop limitations so that it usually turns out that the feeder trunks from substations and main tie lines consist of the heavier wire while short lateral feeds and individual supplies from the street to the house attachment are much smaller conductor.

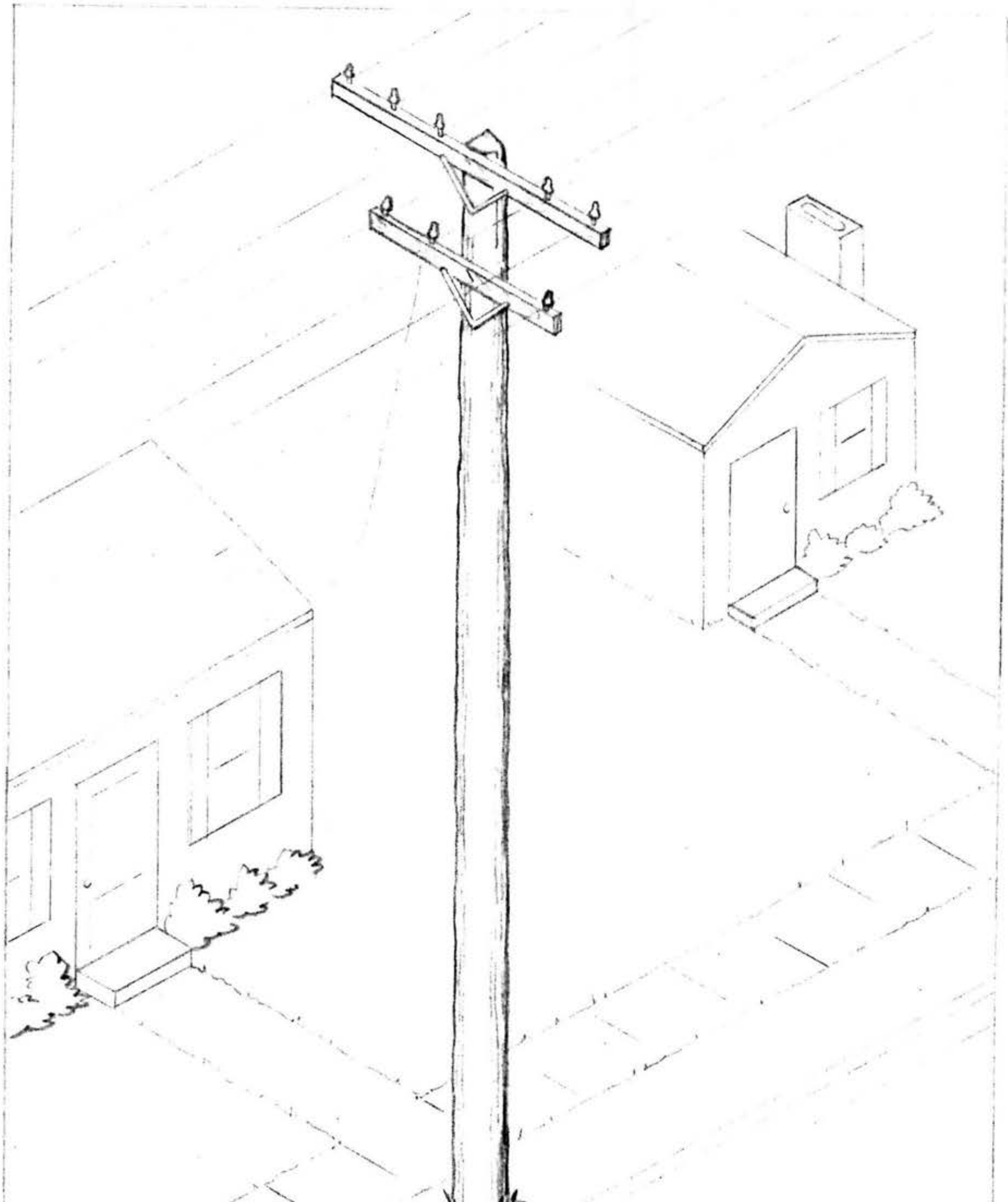
#American Wire Gage 6-outside diameter - .184", breaking strength - 794lbs.
American Wire Gage 4/0-outside diameter-.552", breaking strength-6149lbs.



TYPICAL OVERHEAD ELECTRIC DISTRIBUTION LAYOUT

Figure 5

SCALE 1"=100' approx.



TYPICAL ELECTRIC DISTRIBUTION POLE
Figure 6

WHAT FORM DOES STORM DAMAGE TAKE

Utility poles are guyed and anchored as required, so that the typical overhead equipment is able to withstand excessive mechanical loads brought about by high wind and rain, sleet, and wet snow storms. However, as mentioned in the paragraph above, the poles are usually located along the edge of the street between the curb and sidewalk, and this same area is also the space used to locate so many shade trees -- particularly big elms and maples, which are much taller than the poles. During very heavy storms some of these trees, especially those which have been inadequately trimmed and maintained by property owners or municipal departments, either blow over, sag down, or drop broken limbs onto the electrical conductors or poles. The sudden impact or weight of a falling tree either pushes against two or more conductors so that they touch, arc, burn, and break or the wire stretches from the additional weight so that it breaks and the ends fall to the ground. Broken or badly stretched conductors constitute the bulk of the damage which causes interruptions to customers' service during a storm.

Sometimes when large trees are up-rooted and fall against a pole or heavy conductors, the wood pole, or perhaps a series of several poles along that section of the street, is snapped off causing the wires to become crossed and fall to the ground. The additional weight of a huge tree, or trees, is simply beyond the economic design limit of the pole and guys. Along the same line large limbs or trees fall in such a manner that they strike the crossarms so that they either twist around the pole and break the top of the pole or they splinter the crossarms themselves.

One other type of damage which is widespread when a very bad storm passes through an area involves the service wires which extend from the pole in the street to the customer's house. In the conventional case the pole is located so that it is possible to have the secondary conductors pulled directly from the crossarm to the point of attachment on the residence. From the point of attachment the modern cable goes down the outside of the building to the meter and then into the entrance switch. It can be quickly seen that any heavy limbs or trees, located on the customer's premises, which fall into these service wires can rather easily rip the point of attachment free from the house or break the service wire. When this happens, it will cause an interruption to service at least to that particular residence and perhaps to all homes served by that distribution transformer.

COSTS TO REPAIR DAMAGE

According to estimates filed by electric companies with the Massachusetts Department of Public Utilities, the costs for them to repair the damage caused by hurricanes in 1954 and 1955 were approximately $7,770,000. and $840,000. respectively.* Undoubtedly the biggest part of this money, in fact practically all of it, was spent for men and materials to repair damaged overhead lines along public ways. The figures quoted do not include any loss of revenue which the companies suffered because so many customers were without service. Outages which extend for a day or more curtail consumption of electric power and, when integrated over a wide area, this reflects as decreased gross sales and revenue for

* 19, P. 73 and 114

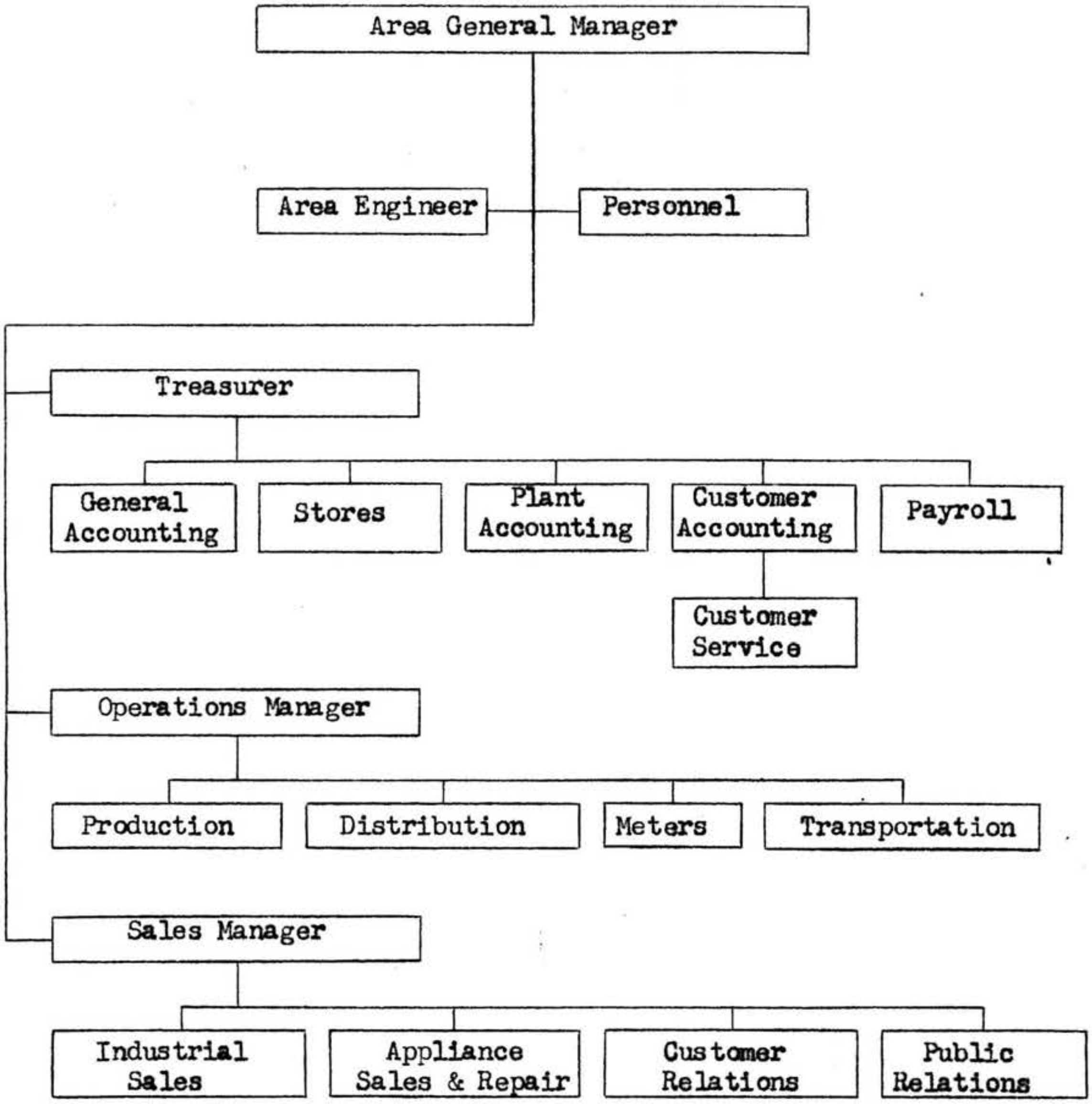
that period. Furthermore, the figures mentioned above do not include any losses by the customers. The loss to factories which had chemical processes interrupted or production lines stopped, or retail stores which had a loss of customers and sales, or the industrial and domestic loss from spoilage due to absence of refrigeration would add to a staggering sum of money beyond the figures quoted to the D.P.U. Without going into any more detail it can quickly be seen that the problem of minimizing the length of electric outages is significant, not only from the personal and public safety and convenience point of view, but also from the pure dollar and cents aspect both to the utility and to the consumer.

II. SIGNIFICANT PARTS OF UTILITY ORGANIZATION UNDER NORMAL CONDITIONS

DUTIES OF MAJOR DIVISIONS, EXCEPT DISTRIBUTION

Briefly the parts of an electric utility organization which become significant and take on additional or different functions after a major storm has caused widespread damage in an area will be described as they function normally. Operating areas are usually defined either by geographical limits or franchise boundaries as they might be assigned to individual companies or portions of a company if a holding company is involved. Each operating area is headed by a manager, who is either responsible to his board of directors, if an independent company is present, or to his top management, if his group is a part of a larger system. Never are two tables of organization identical, but a typical one is indicated in Figure 7.

The treasury section is responsible for general accounting functions, payroll, customer accounting (including billing, collections, and customer service), plant accounting, as prescribed by state and federal regulatory bodies, and the stores department. The names of these various departments suggest their functions under normal conditions so the detailed responsibilities for most of them will not be outlined. However, two groups take on such special significance under emergency conditions that a brief word of their daily work is necessary to appreciate the contrast with emergency conditions discussed in a later section. The two groups are the stores department and the customer service section of the customer accounting department. The stores department handles the receiving of all stock and supplies for operation



PARTIAL ORGANIZATIONAL CHART OF ELECTRIC UTILITY

MAJOR DEPARTMENTS TO BE INVOLVED IN STORM RESTORATION
Figure 7

and maintenance and appliances for re-sale. They maintain stock records, keep inventory control records, and price the materials consumed. And, of course, they assemble and dispense the stock required each day by all of the foremen who have construction or maintenance projects underway. The stores department is more or less tailored to fit the crews normally working in the area as regards the size of loading platforms, material handling equipment, amounts of inventory, and personnel. The other group, the customer service section, is usually located in a room arranged with telephone equipped positions where girls can sit to handle the normal day's incoming calls. These calls from customers cover a wide range of topics and include such items as requests for services to be installed or removed, complaints about the quality of service, reports of burned out street lights, and minor interruptions of power. Here again the work load for these girls receiving customer service calls is quite steady so the number of employees, telephones, and card files required can be determined very efficiently. Unfortunately the requirements for both the stores and customer service sections expand to such an extent under emergency conditions that the normal complement of personnel and equipment is completely inadequate.

Another group, often referred to as "the operating group" includes departments responsible for production, distribution, metering, and transportation. Distribution, because it plays the most significant part in storm damage restoration, is described in more detail in the next sub-topic. The production department, depending upon the area in question, handles operation and maintenance of generating stations, transmission line facilities, and substation equipment. It was mentioned in the introductory section that storm damage to this type of equipment was not expected, so the big additional job for this department during restoration would be to furnish substation operators and switchmen to man substations normally unattended or controlled remotely in a semi-automatic manner. The meter department's normal function is to test, install, maintain, and remove customer metering instruments (not including reading of the meters periodically which comes under the treasury department's jurisdiction). This department takes on extra duties after storms as they check many isolated complaints which involve blown fuses on customer premises. They also lend men to the distribution department to supplement their organization as well as take care of damaged meter equipment, such as kilowatthour meters ripped from the side of a residence. The transportation section's scope is easily defined for normal conditions. They are responsible for routine maintenance and garage service to all company vehicles and combustion engine equipment, which would include company-owned coupes and sedans, as well as a variety of trucks, compressors, pumps, and hydraulic lifts and ladders. In times of trouble the work of this group mushrooms because it is so important to keep all of the motorized equipment operating long hours under abnormal conditions, as well as taking care of additional vehicles which may come into the area just for the rehabilitation work.

Referring again to a typical table of organization, the sales group also takes on special significance when a big storm brings wide scale damage. In the normal routine the customer relations section handles domestic complaints, particularly questions about billing; while the industrial sales group handles all contacts with commercial and industrial accounts, such as type of service, applicable rates, and additional utilization. Public relations handles publicity and releases to the newspapers, radio, and TV.

FUNCTIONS OF DISTRIBUTION DEPARTMENT

The function of the distribution department in a typical electric utility is to maintain, operate, and construct necessary additions to the equipment necessary to distribute electric power from locality substations to the actual customer's premises for consumption. This department is also charged with the operation and maintenance of the street lights throughout the area. See Figure 8.

Under normal conditions, one function of the distribution department is the responsibility of all underground equipment, leaving the various substations to serve loads throughout the city, including inspection and rountine maintenance of manholes, duct lines, underground switchgear, and cables. They perform the required switching to relieve circuits in trouble caused by deterioration and external damage to underground equipment and make the necessary replacements to restore or insure continuity of service. They also maintain all street light fixtures fed from underground mains. As previously mentioned, the underground system represents a small percentage of the total distribution system except in heavily congested areas; so, likewise, the underground portion of the distribution department tends to be smaller than the overhead section.

The overhead division of the distribution department is responsible for the inspection, maintenance, operation, and additions of

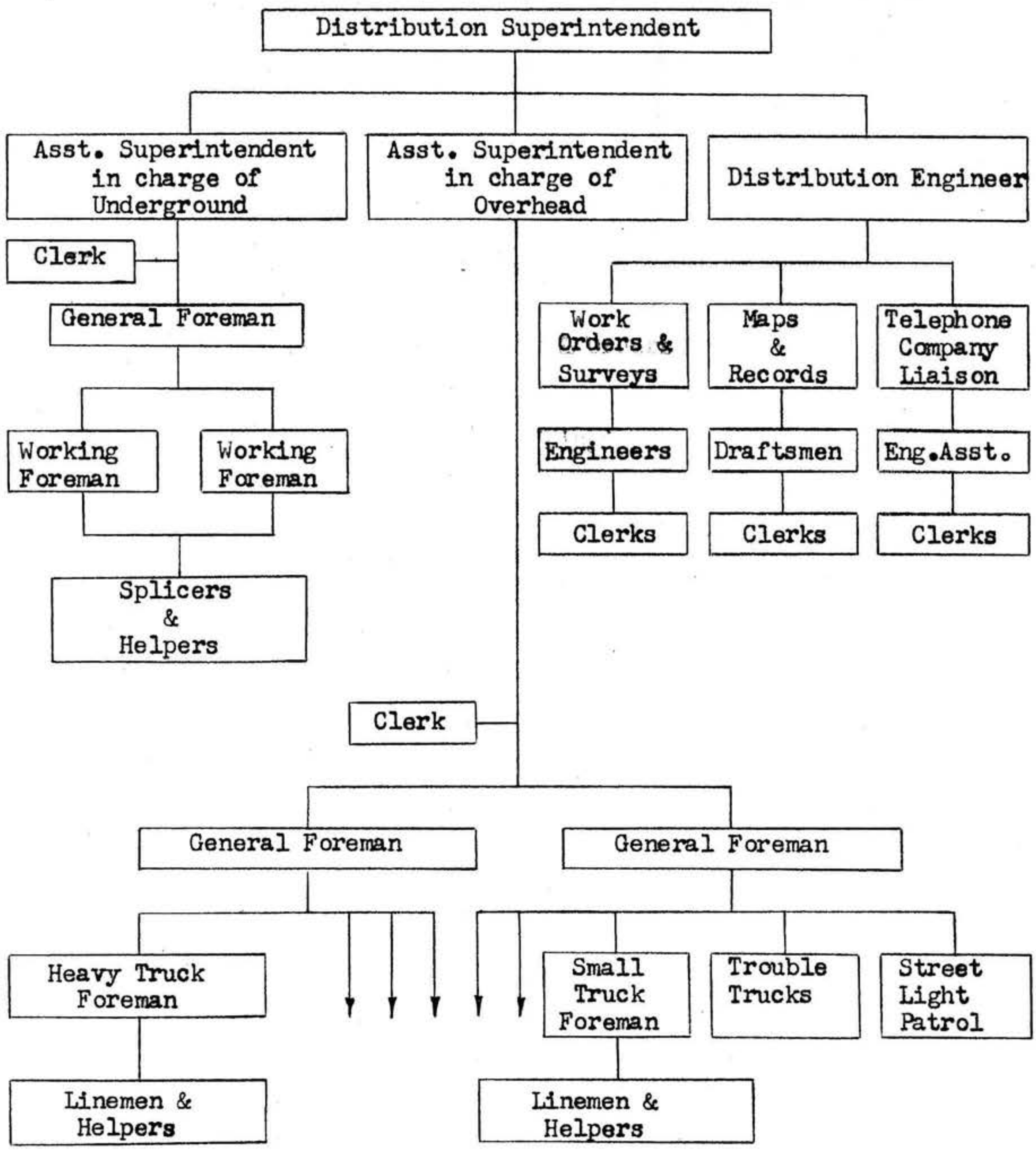


TABLE OF ORGANIZATION
DISTRIBUTION DEPARTMENT UNDER NORMAL CONDITIONS
Figure 8

poles and overhead conductors and equipment serving all types of electric customers in the area -- industrial, commercial, residential, and street lighting. The overhead group operate the big line trucks which are so familar to everyone as they are seen about the streets each day with several linemen riding in the rear and perhaps towing a new pole. These big trucks usually carry eight to ten men, four "hot linemen", and their groundmen-helpers, plus a driver and foreman. They are set up to perform heavy construction involving complicated pole replacements or work on large conductors and equipment. The overhead group also operate smaller line trucks, consisting of three-men crews, who perform line work of a miscellaneous nature, including the very important work of installing new services to new customers or to customers who are increasing their capacity. Street light patrol trucks, under the direction of the overhead department, work each night replacing street light bulbs which have burned out. Finally, this part of the distribution department also sends out the familar one-man trouble trucks. These trucks are operated around the clock by very experienced linemen who serve as emergency men answering all types of trouble calls -- customer has no lights, unidentified wire laying in the street, pole hit by vehicle, and so on.

The distribution department also performs other functions which are not so obvious to general public. An engineering section handles small day to day technical problems which arise in connection with the work of the underground and overhead crews. They lay out the specifications for the work orders given to the various foremen, are responsible for the maps and records pertaining to distribution equipment, handle routine contacts with the telephone company relative to jointly owned poles and guys, and negotiate minor rights-of-way and location permits from municipalities. Electrical inspectors are also a part of the distribution department; their job to check the entrance equipment of new customers to see that company standards have been met.

DAILY TROUBLE CALLS AND SERVICE RESTORATION

It is only economically feasible for a distribution department to carry as many heavy line trucks, service trucks, and trouble trucks complete with appropriate men and equipment as their day-to-day work of operation and maintenance shall require. (This requirement will vary from one company to another depending upon whether they choose to perform their own major construction, which is cyclic at the best, or whether they choose to hire outside contractors for their large capital construction projects.) Their organization is adequate and satisfactory to handle interruptions to service as they may occur in isolated instances from one day to the next. A car hits a pole and knocks out the lights on a particular street, a lightning storm burns out a transformer serving a neighborhood, a few limbs are blown down on a windy, rainy night causing customers' service to fail; certainly the typical distribution department has a smooth functioning organization and can cope with these types of restoration problems with their existing men, equipment, and supervisors.

Actually the first indication of a small service interruption as it might occur in a normal day's routine often comes through a telephone call to the customer service section. The customer says that his lights have gone out at a certain address and wants to know when they will be restored. This information is passed along to a supervisor in the overhead department (if the address is in an area served overhead) who dispatches a trouble truck to the area or contacts a truck already in the area by two-way radio. After the trouble man has located the difficulty, he will report that he can fix it or that he needs the help of a small crew or perhaps a heavy line crew. In any event, the damage is quickly repaired, service is restored, and the incident is closed. The significant thing is that these incidents are occuring in an irregular fashion all of the time, both day and night, Sundays, as well as week-days. Restoration is performed time after time with the organization operating in the area in a very routine manner because the number of incidents is proportionately small and can be handled with existing men and equipment. This is not the case when a major storm hits and <u>thousands</u> of customers are without service at the same time.

III. ADVANCE PREPARATION FOR REHABILITATION OF SYSTEM

IS ADVANCE PLANNING NECESSARY

All electric utilities are acutely aware that from time to time they may be hit by a major storm involving winds of hurricane force or sleet or other combinations of elements which will cause widespread damage to their overhead poles and conductors and interrupt service to thousands of customers.* Practically all companies have developed advance plans, at least on paper, describing in varying detail how they propose to restore all interrupted services in the quickest way possible.** No attempt will be made to say "X" company proposes so-and-so, but "Y" company proposes a different approach. Instead various intra-company manuals have been studied, published material read, and different levels of utility management have been interviewed on the general subject to sample a cross section of present day thinking. These thoughts have been coupled with the author's ideas and actual storm experience while working for a utility as an engineer to produce a sample plan of how rehabilitation work could be carried out.

Some companies have developed their storm restoration procedure to the point that they feel it wise to issue manuals detailing

* 9, P. 78
* 12, P. 16
* 15, P. 86
** 3, Appendix II
** 8, P. 71
** 17, P. 116

step by step procedure.* These manuals show the organization as it would be formed in an emergency and give the names and addresses of the individuals who will fill the different posts from key supervisor down to clerk and messenger. Lists of customers affecting public health and safety, special forms to record trouble reports, methods of analyzing the severity of the storm, and many more details are given, even to a listing of locations where dry ice for customer refrigeration may be obtained. Necessarily these are reviewed and revised annually to adjust for system additions and personnel changes.

Other companies have also issued manuals but have not published instructions in detail.** Instead, general policy has been set down and additional responsibilities are assigned to various echelons by the title of the job rather than by personal name. Their thought apparently is to set up the barest framework, interject some company philosophy and leave the rest to the individuals designated as responsible.

Most utilities agree that their plans should be reviewed each year before the hurricane season starts. Some go through the motions of practice exercises which simulate actual conditions with all personnel leaving their daily tasks and taking up their restoration duties.***

* 21
** 21
*** 17, P. 116

Many companies have met with other utilities in their area and formed sectional assistance plans whereby neighboring companies promise to lend men and equipment to help in damaged areas if they are not in trouble themselves. These plans include formal rosters of persons in authority to contact for help. Two examples are the "Electric Coordinating Council of New England," which includes all privately owned electric utilities in New England, and the "Emergency Assistance Roster -- Middle Atlantic States," which includes companies from Pennsylvania, New York, New Jersey, Maryland, District of Columbia, Delaware, and Virginia.*

The question of advanced planning and preparation for storm restoration work then becomes not a question of whether to have an advance plan, but rather a matter of degree as to how detailed the preparations should be. The yardstick to measure the various plans against is obvious; that is, for a given amount of damage how can service be restored to the most customers in the shortest time with the manpower which can be made available. In this problem manpower is sort of a fixed quantity limited by a company's own crews plus whatever they can borrow from utilities which have not been hit and which are close enough geographically to transport their men quickly. The two variables in the problem are the extent and severity of damage and the time required to restore service. The extent and severity are dependent on the magnitude of the storm and the condition of the overhead

* 3, Appendix I

pole plant and nearby trees. The restoration time required is dependent upon post-storm weather conditions and the manner in which the various levels of management use the men, materials, and machines at their disposal.

In the introduction it was pointed out that the present extensive use of electric appliances and equipment in homes and commercial establishments necessitates rapid restoration of service to minimize inconvenience to customers. This is particularly true if the weather is cold and the lack of heating facilities becomes critical within a few hours. Besides the loss in revenue caused by reduced consumption the electric company has selfish interests to speed restoration. One is to minimize adverse public and political opinion which may arise at such times. Another is the matter of prestige as it regards continuity of service and rapid restoration -- a factor which is very hard to measure but certainly reflects in future sales of electrical equipment and consumption of electrical energy.

DISTRIBUTION DEPARTMENT PRELIMINARY PLANNING

Because the distribution department becomes the base of all restoration work and all other departmental activities revolve around it, advance plans for its emergency operation will be considered next. This department will have more men and trucks deployed over the damaged area than all the other departments combined. No matter how well the other departments have their groups organized and working, in the last analysis it is the men of the distribution department, the pole lineman especially, who must go to the scene and make the actual repairs.

The head of the distribution department must make advance plans for the use of his men. He knows that a rapid survey, a very general perusal, must be made to see how hard his system has been hit, as soon as the storm has passed. This quick look should be completed in about one hour by the few very experienced line construction supervisors he has immediately at his disposal. The purpose of this very short inspection is not to locate specific damage, but rather to sample a cross section of the area to "get a feel" of the extent and type of damage. When the basic plans are arranged and reviewed annually, these key men must be informed of their first job so that they can confer with their overhead superintendent and decide which section of the area each will cover, what particular trouble spots they will check, and what route they will drive. The routes will be carefully thought out to avoid possible traffic jams, lowlands where flooding and washouts might occur, or roads exposed to bad ice or drifting snow conditions. The routes will be reviewed and checked from time to time to see that they are not too time consuming. Time is extremely important at this stage because these men must return and pool their observations with the department head so that he can decide what his manpower requirements will be. Based on this first damage report he must request through his top management a certain amount of help from other areas or other companies. While he may have to revise his estimate later based on more detailed information, it is extremely important that he report the condition of his distribution equipment to higher management so that they can start to move line crews into the area. This movement might originate in other portions of the same system or might come through a mutual assistance clearing headquarters. In any event it will take time for the crews and trucks to arrive so the request should be made as accurately and as early as possible.

The distribution superintendent knows how many overhead primary distribution feeders he has under his jurisdiction and knows that practically every one will be knocked out in a very bad storm. While a few may have opened from transient faults, essentially every feeder must be patrolled to locate the trouble spots before switching and re-energizing can start and before restoration crews can be sent to make repairs. It is not uncommon for an operating area to have seventy-five feeders and it usually takes at least two hours to completely patrol a feeder in the daylight. Therefore, at least one patrolman (and a driver for safety reasons) will be needed per feeder, perhaps more for long rural circuits. The length of time required to complete each survey will depend on how much information must be obtained, as some companies want information posted and tabulated about not only damage to primary feeder conductors and poles, but also to street light circuits and fixtures, secondary circuits, customer's services and so on in great detail. To ask for too much information from a patrolman slows him down because he must look for more things and because he will be exposed to more customers along the route who will ask very time consuming questions. Furthermore when information of a very detailed nature is turned in at the operating headquarters a bigger staff will be required to digest it, make out the proper forms, and post it correctly. Detailed information has statistical value and is helpful in the final stages of rehabilatation work, but in the early stages really only damage to primary feeders is of interest. (The reader is reminded that damage to substations and transmission facilities is not covered in this discussion, as mentioned in the introductory section.) Sometimes a primary feeder will only be damaged in one or two places, yet thousands of homes will be interrupted on that one feeder. On the other hand, secondary trouble usually only affects from one to about fifteen customers, but can take nearly as much time to repair as primary trouble.

A roster of patrolmen must be established complete with a list of their drivers, the feeder to be patrolled and their alternate feeder to be surveyed. Each patrolman will be completely familar with the route of his assigned feeder including the location of switches and large or essential customers. He will ride over the route in a leisurely fashion at least once a year following an up-to-date map furnished by the record department and will be equally familar with his alternate feeder. Each man must have an alternate feeder assigned because, when the emergency arises, his circuit may not be in trouble so he can help on another or because some last minute changes in personnel may be necessary due to sickness or out-of-town absences. The roster will also include a few extra men, perhaps five per cent, who are not directly assigned, but who, because of their general familiarity in the area, can stand ready to fill vacancies which can not be foreseen.

These men assigned to the roster of patrolmen must have special qualifications in that they must have some experience or a good understanding of overhead construction. For instance they must be able to trace a circuit through complicated junction poles where other circuits also exist, they must be able to distinguish primary conductors from street lighting wires or telephone wires on the same pole, they must be able to determine if stretched wires have so much slack in them that they can not be energized. They should be able to tell whether a broken pole must be replaced immediately or whether it can be braced up temporarily, whether a big limb can be easily swung away from primary wires by a line crew or whether a tree crew will be required, and other similar matters of judgment all made with practically no hesitation. Conferences between department heads will indicate men working in other departments who have useful experience, perhaps having formerly worked in distribution. Certainly some men will be available from the area engineering group, industrial sales group, various junior management men, meter department personnel, right-of-way men, and field accountants. These can be added to the men available within the distribution department, such as telephone company liaison men, distribution engineering personnel, and retrogressed line construction men re-assigned permanently to lighter work. The difference between the men available and the men required must be selected from different departments and trained to perform surveys at least on the simpler feeder routes. The men to be trained may come from such groups as appliance repair, underground construction, and meter repair. Patrolmen are an absolute necessity, and, if necessary, classes must be arranged complete with periodic refresher courses so that each man has at least enough understanding of pole line construction to accurately report conditions on the feeder assigned to him. To have a well organized and well trained group of men constituting a complete list of feeder patrolmen is a tremendous advantage to the restoration efforts of the distribution department, an advantage sure to start its work off on the right foot and well worth the training time spent.

Some distribution departments call all of their men into the headquarters a few hours before a storm like a hurricane arrives on the theory that they'll have them there for any extreme emergency which might come up as the storm approaches and that they'll be all ready to go as soon as the storm subsides. Other companies send all of their employees home except a small skeleton crew including a few troublemen. Their thought is that the men will be required to work long hours after the restoration plan goes into effect and that they are better off to be resting at home and protecting their own properties and family. There is a psychological lift for the employee to be home during the height of the storm so that he knows that everything was all right with the wife and children when he left, as opposed to having him cooling his heels in a company assembly room wondering how bad the storm is at his house and unable to reach them by telephone. In the advanced training sessions it should be explained to the men that they will be sent home if the height of the storm is expected during normal working hours and that they are to remain there until it is safe to travel after the worst of the storm goes by.

The distribution department must confer with the production and industrial sales groups to decide what feeders require preferential treatment and should be kept alive during the storm if possible. This work can be carried on as a committee and will no doubt take considerable investigation before a list can be prepared and issued to interested parties; but, when the storm has struck, there'll be no time to consider such subjects. Most feeders can be de-energized when the worst of the storm comes, so that they do not suffer damage from wires swinging together and burning and so that the danger to the public of falling live wires will be minimized. Other circuits which are partly underground and partly overhead can have the overhead portions either de-energized or switched to other feeders so that the unexposed underground section can continue in service. A few feeders which serve customers like municipal water or sewerage pumping stations, hospitals, and major chemical plants having goods in-process are designated for preferential treatment and every attempt is made by the substation operators to keep them alive. Another group of feeders are kept alive until their automatic protection devices open the circuit because of trouble, with the thought that they will receive first attention from the distribution crews when they start out after the storm.

While the distribution superintendent does not know how many "foreign" crews will be made available, he knows exactly how many linemen and trucks are in his normal complement. His preliminary plans will include detailed instructions to his general line foreman of the work to be performed immediately after the storm has passed. There will be a period of a couple of hours until the patrolmen return with damage reports which can be spent quite inefficiently unless a detailed plan is worked out, explained, discussed, and practiced in advance (and rehearsed periodically). In order to do the most with the least, the line crews should be split up so that each truck has only two linemen and groundmen besides the driver and foreman or truck supervisor. This means that additional trucks, such as those used for street light patrol, trouble trucks and other miscellaneous vehicles, must be pressed into service. No large crews are required at that time because heavy work typing up large crews for long periods must be by-passed. First these small crews will have a certain number of locations to check where neighbors or police have reported live wires or other hazards to public safety. (A lot of these hazardous-condition investigations can be eliminated if the feeders are de-energized shortly before the storm hits, as mentioned in the paragraph above.) Then these same crews should proceed by pre-determined plan to ride along the routes of certain very important feeders which serve hospitals, city water pumps, police and fire stations, nursing homes, and the like. They would start from the substations and follow only a pre-assigned primary feeder trunk, repairing damage along the way to the primary circuit and not to street lights nor secondary wires. When they had a section ready to re-energize, they would pass the information back by two-way radio and perhaps be told to continue in that area or shifted elsewhere as the patrolmen's reports begin to come in.

There are many other aspects of the problem which the distribution department must consider and organize in advance but only one other general topic will be mentioned. Just as a patrolmen's roster and initial plans for locally-based linemen are important, a trained organization ready to operate as "inside men" is very essential. An enlarged temporary staff must be organized in advance and instructed to handle the overwhelming instances of trouble which occur. But before the inside organization can be set up it must be decided whether to conduct the restoration work from one centralized headquarters or from several decentralized headquarters. This decision will depend to some extent upon the geographical area involved and the number of line crews required; however, if the damage is really severe and the area is typical of so many electric utilities, the decentralized arrangement is much more advantageous. In the decentralized scheme of operation the territory normally served from one operating headquarters is broken up into many smaller areas, often one area per major substation. The man in charge of each smaller area is completely responsible for the work in that area. A temporary branch headquarters must be established at a pre-determined point, somewhat similar to what the army might refer to as a "command post." In the preliminary planning the territory must be split up and the locations for the different groups determined. Often times a group might restore service to all customers served from one large substation or in a less densely populated area the group might be responsible for an entire community, particularly if that town had only one substation. The location which is chosen must be accessible during post-storm conditions of flooding or drifting snow. It must be warm and dry, large enough to accommodate three or four desks and tables, plus telephones and maps. This temporary office should be located so that it is convenient for trucks and cars to drive very close and park, yet still be shut off from the general public.

The staff for each group headquarters will consist of a group leader, a commercial representative, one or more clerks, at least one messenger, and as many acting general line foremen as are required. The staff will also include a night man to be on duty through the night when restoration work is not in process. Work crews will be assigned to the various groups as the overhead superintendent stationed in the central headquarters shall judge, weighing the relative needs of his various groups. See Figure 9. It will be the sole responsibility of the group leader in each area to deploy the crews assigned to him, keeping in mind priority customers as listed and being aware of suggestions from the commercial representative assigned to that group. The commercial man will work closely with the group leader and will receive information relayed from the customer service group at the main operating headquarters pertaining to customers with urgent needs. He will, in turn, keep the customer service group informed of approximate times when service will be restored on certain streets and other similar questions which arise by the dozen. The clerk will keep a log of significant events such as the time when major switching was performed, the times when service was restored to key customers and areas and other related subjects. The acting general foremen will be picked from the more experienced patrolmen after they have turned in their primary patrol reports. These general foremen will have direct supervision over the line trucks, tree crews, and small service trucks assigned to

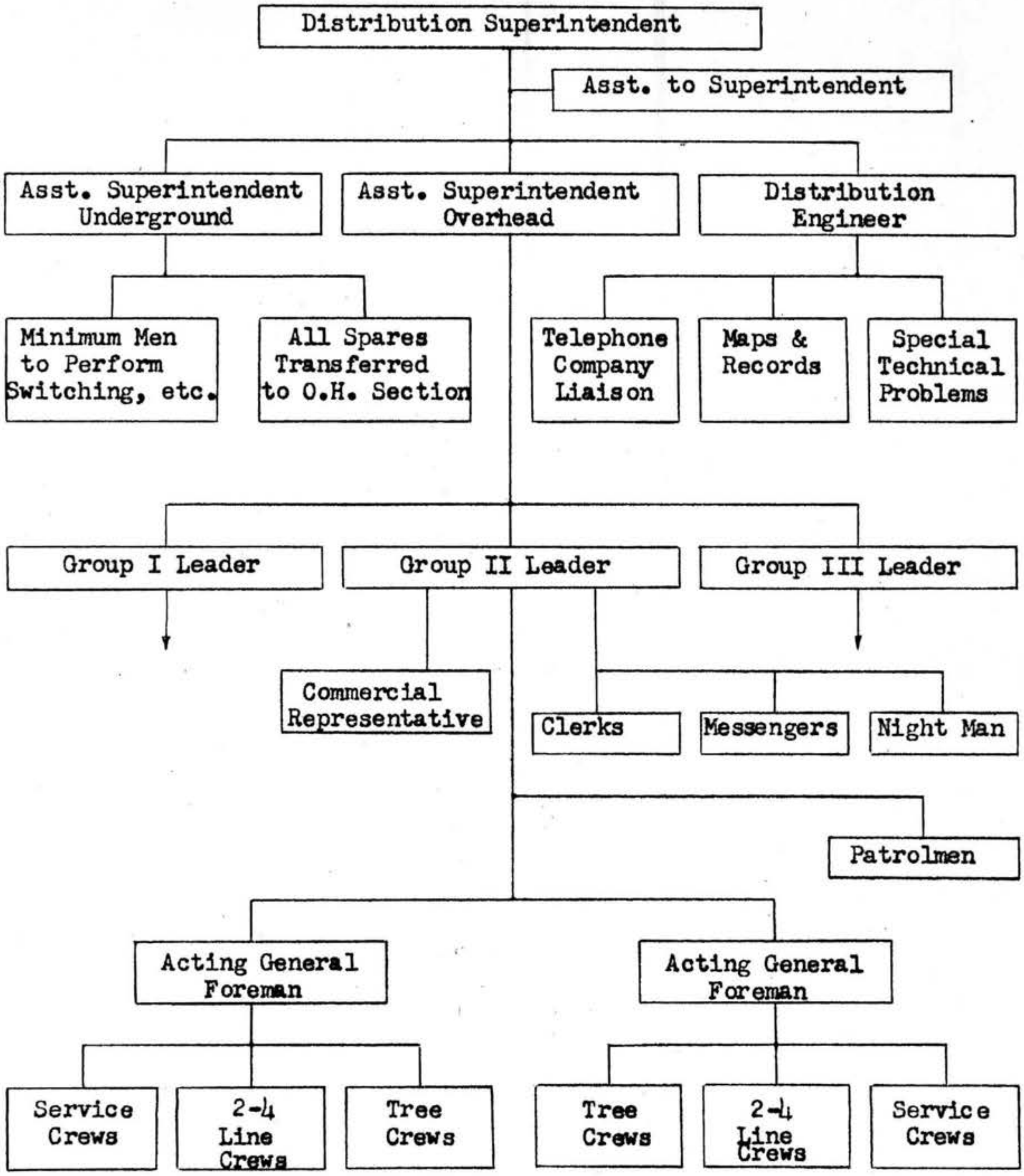


TABLE OF ORGANIZATION
DISTRIBUTION DEPARTMENT UNDER EMERGENCY CONDITIONS
DECENTRALIZED TYPE OF OPERATION
Figure 9

them by the group leader and will work in the field with the truck leaders to see that the actual restoration work is carried out as efficiently as possible. They will also supervise all distribution switching as directed by the group leader and will coordinate with other group leaders for switching between areas.

If the restoration is carried on from decentralized points, the organization at the central operating headquarters will be quite small. The distribution superintendent and the person designated as his assistant for night coverage, the assistant superintendents in charge of both overhead and underground operation, the distribution engineer, and a very small group to handle reproduction of maps, telephone company liaison, special problems as they might filter in from group leaders, and progress charts or maps showing areas restored, work in progress, and so on, will comprise this central group. Even if the outer areas are decentralized, there is a chance that some companies will try to handle the area around the central operating headquarters with the central headquarters staff. This comes about because day-to-day restoration is handled from there and because they are often located in the same building or very near to a large substation. This idea would appear to be a mistake in most instances. If a decentralized plan is to operate successfully all areas should be set up similarly, even if it turns out that a group leader has his office in the same building with the distribution superintendent. This permits the men in charge of the overall problems to be isolated from some of the confusion and gives them a chance to stand back and run the complete rehabilitation without being influenced nor distracted by all of the little incidents which are really the group leaders' problems.

CUSTOMER SERVICE PRE-STORM PLANNING

As mentioned in a previous section, the customer service section normally is equipped with several telephone positions, where girls take incoming calls from customers who want a service installed or removed, who have a "no-lights" call or other complaints, or who want appliance service of some sort. This group is sometimes under the distribution superintendent, but is considered here to be a treasury function, a sub-division of customer accounting. This arrangement has the advantage in normal times of facilitating close checks with the credit department, which is also under treasury. Furthermore, because so many girls are involved, it seems to blend with other accounting groups, which also require large amounts of female help, instead of into the distribution department, which requires only a small amount of stenographic help otherwise.

The staff of girls normally handling customers' incoming calls is entirely too small to handle the vast number of telephone calls which will start at the first sign of storm trouble, hit its peak as soon as the storm has passed and caused widespread interruptions, and will continue at an abnormal rate as long as service restoration is in process. Arrangements for many extra 'phones must be made with the telephone company, space to accommodate this enlarged group must be earmarked, and a roster of employees to operate this center on a shift basis must be made, keeping in mind the labor laws pertaining to the number of hours female help may work. Girls can be made available from different sections of the accounting department, but they must be trained, practiced under simulated conditions, and given refresher courses periodically.

Either male or female overseers for these operators must also be designated and thoroughly acquainted with their responsibilities. Representatives from the industrial sales group and a management representative should also be attached to the emergency customer service section because certain irate customers are not satisfied to talk with a girl, but feel happier after having talked with a man, while others insist on talking "to the boss." Customers coming in person to any of the company's business offices will be handled by men from the customer relations group.

All of the members of the temporarily enlarged customer service section serve a tremendously important function in storm rehabilitation work, not only because the information which the customers report is very valuable to the restoration efforts of the distribution department, but because in the majority of cases the girl taking the customer's call is the only contact the customer will have with the company during the post-storm period. Telephone etiquette and the manner and content of information given to the customer forms the basis from which the public builds a picture of company attitude and efficiency. A great deal of work can be done to acquaint the operators with their mission and to point out to them what to expect from the customer. It may prove worthwhile to "zone" incoming calls so that the girls gain a certain familiarity with a section and can speak with customers from that section with more confidence and ready information. When a customer calls, he is naturally in an unhappy frame of mind because he has been inconvenienced by the electric outage. He will say where he lives and usually ask just one question, "When will I have my lights back?" Without feeling "brushed-off," he quickly must be given the best information available from the group leader's office and must be made to feel that his problem is understood and is being handled in the best possible manner by an efficient restoration organization. Great improvements can be made in customer complaint telephone techniques with training in classes and in practice exercises. Here again the roster must be reviewed at least twice a year because of the turnover in female help, and instruction and refresher courses are required to keep the group in a shape to go into action on very short notice.

All incoming customer calls should be recorded on separate forms. These forms should be very simple because very little actual information is required, because the time required by the operators to fill in the forms should be minimized, because some customers will feel harassed to answer a long list of questions, and because the information must be very brief to be utilized quickly by the group headquarters. Completed forms will be zoned and sent to the proper operating group for their guidance and action.

INDUSTRIAL SALES PREPARATIONS

The industrial sales group should have an up-to-date list of their industrial customers who will suffer particularly from an extended electric outage. When a storm appears imminent, all of the larger and essential customers should be contacted to warn them that an outage might be expected if the storm developes as indicated, to suggest that they check their auxiliary generators if they have such, to reassure each that all will be done to restore service promptly, and to remind the customer of the commercial representative to ask for if he finds it is necessary to telephone during the outage. They will carry out an investigation and keep an up-to-date reference list, for the convenience of customers, of locations where dry ice may be obtained and where small portable electric generators may be rented or bought. The industrial sales group must, of course, be prepared to furnish men for patrol, assignment to group headquarters, or the customer service center, as indicated on the rosters mentioned previously.

ADVANCE PLANNING FOR THE STORES DEPARTMENT

The prime function of the stores department is to keep all crews adequately supplied with all required materials to use for rehabilitation. This will include crews loaned from other areas as well as locally based crews. A minimum pre-storm inventory must be established after consultation with the distribution department and other interested groups. This inventory must contain enough material to completely restore service after any conceivable big storm and should include ample quantities of items, such as connectors, splices, crossarms, poles, certain sizes and types of wire, and hardware. Some storekeepers may say that they are located near large supply warehouses and can obtain essential materials on a very short notice. This tends to be a hit-or-miss scheme and can cause delays in the deployment of crews because of material shortages. The storekeeper not only must keep his storm inventory list revised and current, but he must have a scheme to rotate these materials with his regular stock so that shelf life deterioration and slight model changes do not become a problem.

A personnel roster must be arranged within this department so that the stockroom is manned at all times and so that extra men are available during daily rush periods, which are just after dark and just before daylight during storm damage work. Several line trucks and crews could be tied up waiting to take on stock causing much valuable time to be lost, so every move must be thought out in advance and the normal staff supplemented with trained spares to be sure that no field crews are delayed by lack of material.

In planning conferences with the distribution department's staff it may develop that trucks not normally used in line construction will be pressed into service for the initial phase of the restoration. (This is the phase mentioned in an earlier section when it was pointed out that crews used in preliminary restoration, at least, should not include more than two linemen.) If additional trucks are to be used, the storekeeper shall arrange in advance to have tool kits ready to equip these trucks in addition to the usual materials and supplies required by all of the regular trucks. These tool kits would include rope, blocks, bolt cutters, battery lanterns, warning flags, tree trimmers, ladders, jumpers, wire grips, protective safety equipment, and other similar equipment to equip a small crew for light work, perhaps from a rented truck.

ADVANCE PLANS FOR TRANSPORTATION DEPARTMENT

The transportation department must make plans to handle a threefold problem during the rehabilitation period. First they must thoroughly prepare their normal fleet of vehicles, pumps, and other motorized equipment so that they can all be pressed into service without the least delay. Secondly, they must have workable plans for the maintenance of vehicles coming into the area from other companies. Third, they must have firm commitments with a rental agency to obtain the use of extra cars and trucks.

The regular garage staff of servicemen, mechanics, and supervisors is only adequate to take care of the locally based fleet as it is operated in a conventional workweek. Just the extra demands upon the garage to keep their own vehicles working long hours is enough to overload the regular work force, especially where so much of the work must be performed in the night to keep all trucks working through the daylight. Superimposed on this work load can be at least three or four times as many vehicles sent into the area from other distant locations. While no major maintenance will be performed on this visiting fleet, daily servicing must be accomplished somehow. The transportation supervisor, after learning from the distribution department the number of extra trucks which might be expected after a severe storm, must set up a roster to handle this increase during the entire extent of the restoration period. It may be that he does not have access to sufficient manpower and must make specific plans with a large public garage to loan him men or to send the vehicles from other companies to that public garage for nightly service. Arrangements must also be made for night parking of the extra line trucks. These trucks have many articles like rope, wire, and tools in their open bodies, so pilferage can become a problem and a nuisance. It is practically out of the question to put all of these vehicles in a garage each night but usually they can be lined up in a company-owned parking lot enclosed with a chain link fence and guarded by a special policeman or company watchmen. This in turn means that the crews must have limousine service to their quarters, which is a detail to be worked out with the person in charge of accommodations (discussed in the next sub-topic).

After the distribution department has established its roster of patrolmen, group leaders, acting general line foremen, and messengers, the head of the transportation section can count the total number of passenger vehicles required and can decide how many cars must be obtained from a rental company. Persons authorized to use a rented car should be so listed on the rosters so that there will be no misunderstanding nor last minute delays. It may be that the type of damage in a particular storm requires the use of many small crews and practically no large crews. This may necessitate the use of rental trucks. In any event the problem of supply, billing, and on-the-spot maintenance must be discussed by the transportation head with the selected rental agency and a firm agreement developed so that the correct number of vehicles can be obtained without confusion and delay.

MISCELLANEOUS ITEMS IN ADVANCE PLANNING

One item which has no equivalent in normal operations pertains to the accumulation of weather information indicating the progress of an impending storm. Some progress is being made to have a system of communicating bad weather conditions through normal dispatching channels from one utility system to the next. Also, suggestions are often made to retain a private meteorologist to advise of the routes and severity of threatening storms. However, the best source of weather information is the U. S. Weather Bureau and it would appear that the proficiency of this bureau will continue to improve as further scientific advances in forecasting are made. The management should arrange to station company representatives (on a shift basis) at the nearest U. S. Weather Bureau so that the operating group can be informed directly by one of its own employees of all pertinent weather data whenever a major storm, particularly a hurricane, is a distinct possibility. This source of information, to the exclusion of all others, should be the basis of the decisions by management to put the various phases of the emergency restoration plan into effect.

Another item which does not appear in routine operations but takes on major proportions during rehabilitation work is the matter of providing meals and quarters for "foreign crews" and perhaps local crews as well. This responsibility is usually assigned to some non-operating department supervisor who is well acquainted with eating and lodging facilities in the area. This is a vitally important subject and requires a lot of forethought and investigation; but, because the speed of restoration is a direct function of each line crew's productivity, the personal welfare of the men cannot be overemphasized.

Temporary dormitories with cots are definitely not the answer to the housing problem because it must be remembered that these men are used to being with their families and sleeping in their own homes and cannot readjust to the noise and confusion of crews and individuals coming and going in a make-shift dormitory. Sleeping quarters in modern motels are one solution. The accomodations do not need to be luxurious but must be clean, warm, dry, and quiet, and generally located near the area where work is to be performed; remembering that if the company expects a top performance of physically hard work from a lineman laboring under abnormal conditions from daylight until dark, he must be well rested. If the quarters are remotely located and require excessive travel time, either less time is spent on the job or less rest and relaxation is available to the men.

The reasoning pertaining to meals is similar. Linemen are traditionally strong, outdoor-type men doing very hard work and require and deserve ample portions of first quality food served, not necessarily in luxury, but in pleasant, clean surroundings. One arrangement which usually is satisfactory to all concerned is to have credit accounts set up at acceptable restaurants with the truck leader authorized to sign the check for the whole crew each meal. Care must be taken to see that the men can have a hearty breakfast before they go to work at daylight. Not always are there enough restaurants open that early in the morning to serve heavy meals to so many men. Inevitably a line crew which has had to wait around unnecessarily to eat a cold breakfast which was not to their liking is faced with lowered morale and decreased productivity. Conversely if the crews feel that the company has made good arrangements and that they "are eating well," they tend to be in high spirits which is beneficial to all concerned.

The man charged with the responsibility of providing meals and billets must find out how many men might be transferred into his area for emergency work and then canvass the area taking the above factors into consideration. His agreements with restaurants and motel operators must be firm so that he will not find himself disappointed when the emergency arises because of occupancies by temporarily displaced persons, extra telephone company crews, or other transients seeking accommodations because of the storm disaster. He must have some sort of a plan which will indicate where each visiting crew is quartered so that the men can be reached with personal messages and long distance calls. Most of all, he must remember that while these strange crews are working in his area, they are, in one sense, guests of the company. The impression of the organization which they take back is important and will be based to a large extent upon his efforts to house and feed them, not elegantly, but properly.

IV THE DISTRIBUTION DEPARTMENT UNDER EMERGENCY CONDITIONS

MAJOR STORM APPROACHES THE AREA

Following along with the ideas for advance preparation set forth in Section III, which would have been revised, reviewed, and rehearsed each succeeding year, the distribution department is rather clearly committed to a plan of action as a big storm approaches. Their mission can be simply stated -- to operate, construct and maintain all distribution equipment to give the best electric service to their customers. However, their mission can not be simply carried out. Even in the best organized company, storm damage means hectic long hours of work and many customers inconvenienced by outages.

Each summer before the hurricane season starts, the distribution department will review its rosters of personnel assigned to various storm restoration tasks to be sure that no vacancies have occurred through retirement, resignation, or sickness. This should be a detailed annual study and should include one day set aside for rehearsal by all employees. Along with everything else this rehearsal will make everyone conscious of the approaching storm season which really carries beyond the hurricane period and through the winter sleet and ice storms, too.

When it appears from the U. S. Weather Bureau radio reports that a hurricane is a threat to the area, previously designated men will establish themselves at the weather bureau and be in touch with the management and head of the distribution department. At this time group leaders should go to their proposed group headquarters and see that their office is already to be occupied, and utilized as planned, after the storm has passed and a decentralized plan is put into effect. Finally when it appears that the storm will pass near enough to cause wide scale damage, the emergency plan will be pronounced in effect by the manager. The distribution department will send home every person it can possibly release, as planned, and proceed to do last minute pre-storm switching. Otherwise only the barest minimum of men and supervisors will be on hand for high priority emergency calls involving distinct danger to human life. Nothing further worthy of note can be done until after the worst of the storm has passed.

AFTER THE STORM HAS PASSED

When the storm starts to subside, the distribution department head will immediately send out the few key men he has selected and trained to make a rapid survey. Patrolmen will meet with their drivers and conduct the surveys of the primary feeder assigned to them. As fast as crew members report from their homes they will be assembled in small crews and sent out on the highest priority feeder routes so that actual physical restoration is started at this point. Considerably before the patrolmen return, the rapid survey will have been completed and analyzed so that requests for extra crews can be initiated. If the damage is substantial and many "foreign" crews will be required, it follows that the trouble is sufficient to put the decentralized plan of operation into effect. Group leaders will have finished the job of patroling their primary feeders and will proceed to the group headquarters location, assume responsibility for distribution switching, and commence operations as fast as their staff arrives and crews are assigned.

The order of restoration will be hazardous conditions, customers associated with public health and welfare (hospitals, pumping stations, nursing homes, police and fire stations), primary feeders involving customers with exceptional losses from long outages (ice cream plants, meat storage, process plants), all remaining primary trunk feeders, short or lightly loaded primary lateral feeders, secondary distribution, individual customer's services, and finally street lighting equipment.

The primary feeder maps turned in by the patrolmen will be marked to indicate location and type of trouble. These will be studied by the group leader, his acting general foremen, and his commercial representative to establish an estimate of the extent of the damage. This estimate will naturally be more accurate than the rapid survey made directly after the storm by the distribution superintendent's immediate staff. Each group leader will inform the overhead department supervisor at the central headquarters of the extent of damage in his area and the number and type of additional crews he needs. This information will be based on his observations, his study of the patrolmen's reports, and the comments of his staff and should be sent to the central headquarters as soon as he has hastily organized his office and deployed the available crews under the direction of their acting general foremen. The group leader or his commercial representative will also contact the customer service center and inform them generally of the type of damage, where he has men working, and how much he expects to have restored that day. Periodically the commercial representative will receive the information collected at the customer service center; but unless a call is particularly significant for some reason, no special attention will be paid to a customer's "no light" call until after the field work has reached the point that main primary feeders are being made alive. Often times one damage spot curtails service to hundreds of customers; and, as soon as that damage is cleared or it is by-passed by alternate switching, almost all of that whole block of customers will have service again. This action continues until all of the primary feeders are energized again; the group leader "playing checkers" all of the time, placing new crews if they are assigned to him because his area is in particularly bad shape, relinquishing crews if they are needed more urgently elsewhere, but always trying to restore service to the most customers with the means at his disposal.

While the restoration of primary feeders is in progress, there will be ample time for the patrolmen not reassigned as group leaders or acting general foremen to complete surveys, within the area allocated to their group, of damage to secondaries, house services, and street lights. This type of survey is very time consuming if the damage is extensive, but it can now be handled without so much pressure because the primary feeder work is underway. When the reports of secondary and street light trouble have been marked on appropriate maps, the group leader not only has a complete guide to the work before him, but he can pass information back to the center headquarters estimating the time required (on a crew-day basis) to restore service completely.

The overhead lines supervisor at the central headquarters will reassign crews from one group to another so that all groups approach one hundred per cent restoration at about the same time. When the percentage of restoration reaches a high point, ninety-eight per cent for example, the work in the field may become so miscellaneous in nature that it will be decided to dissolve the decentralized groups and pass their authority back to the central headquarters. Then the amount of work, being relatively small, compares with that of an ordinary storm and can be handled with the regular staff and conventional operating procedure.

Excluding a few very rare exceptions no crews would be required to work after dark. The conditions under which storm damage must be repaired are very arduous. If the work is to continue for several days, it has been generally found best to see that the men have their rest and good meals, laying out the work and providing proper supervision to realize the maximum from their efforts through the daylight hours. Likewise, the office work connected with this type of work has been found to be very nerve-racking and fatiguing, so men in these capacities must also have regularly scheduled hours for meals and relief.

V CUSTOMER RELATIONS UNDER EMERGENCY CONDITIONS

ADVANCE WARNING TO CERTAIN CUSTOMERS

As a major storm approaches the area, there is no need to try to contact all of the residential and small commercial customers -- they receive ample warning through the newspapers and radio. However, the industrial sales department will contact a substantial number of customers who have special problems when electric service is interrupted. The customers to be reached via telephone are all listed as a part of that department's preliminary planning. All hospitals and nursing homes must be warned that there is a chance that their electric service may be interrupted by the storm. It should be suggested that they check their auxiliary equipment to be sure that it is in top operating condition. The same applies to municipal pumping stations, police and fire stations, and radio broadcasting stations. Large industrial users should also be contacted so that they can schedule their production differently if there is an outage. Also, chemical plants having goods-in-process which would be damaged by an interruption should be notified. In every case they must be assured that the electric company is watching the developing weather situation very carefully, that their organization for restoration work is trained and ready to start when the time comes, and that every effort, including help from other companies, will be made to restore their service promptly. They should also be reminded that they are welcome to contact that department after the storm has passed if they have special problems or require information about when to start scheduling production again. So that these customers may reach company personnel who are familar with their problem during the post-storm period, they should be given the name of the industrial sales representative who will be acquainted with their problem and told to ask for him by name if they find it necessary to call.

CUSTOMERS' INCOMING CALLS

As soon as the strength of the storm begins to assert itself, indirectly causing interruptions to service, the flood of telephone calls from customers will begin. There is no better evidence of the use of electricity by the public than the number of calls which pour into the customer service center. In a minor storm, such as is encountered in normal operation, customers' calls help to locate the small area in trouble. From the addresses of the customers calling, it soon becomes evident that certain streets are all right or that another street has trouble only beyond a sectionalizing point. However, when damage is widespread in a big storm, incoming calls do not help because all of the primary feeders, which are de-energized because of trouble, have to be patrolled before restoration can start. Then in the final stages of the large scale restoration program, the customers' calls again act as a guide to locate where damage still exists and help to direct the final clean-up work.

Following the preliminary plans discussed in a previous section, additional 'phones and trained operators will be required as soon as the height of the storm has passed. The work of this enlarged group of operators cannot be stressed too much. While the information must be recorded accurately, threats to public safety given quick attention, and the forms zoned for transmittal to the correct restoration group, the most important function is to leave a satisfied attitude with the customer who has called. Because each customer is a daily consumer of electrical energy, owns many electrical appliances, and is a potential purchaser of additional electrical equipment, he is entitled to know how long his interruption is expected to be or an answer to whatever his specific question was. He must not be "brushed off," but must be provided with an answer which leaves him with a clearer picture of what he must face in the way of inconvenience. Particularly where commercial establishments are involved, it is important to give the customer concise information regarding the length of the outage so that he can evaluate his own position and readjust his own plans.

Even though a fine job of restoration is taking place in the field, if this problem of answering calls in the customer service center is not handled correctly, the customers will be disturbed and call back repeatedly. These repeat calls only tend to jam the incoming telephones which are already busy. This all leads to irritated customers who turn to their political representatives in desperation. Political interference of this sort is unnecessary, puts additional pressure on the management, and generally distorts the rehabilitation problem.

The customer service section and the various group operating headquarters must work very closely to interchange information. Customer complaint forms must be collected and distributed to the groups by messenger on a periodic schedule (perhaps hourly), although urgent situations should be reported directly by telephone. The group headquarters must fulfill its responsibility to the customer service section by making very frequent calls to inform them of their latest actions and thinking from the field. Without these detailed reports from the groups, it is hopeless for the customers calling to receive the type of information which was pointed out as so necessary in the paragraph above.

VI PUBLIC RELATIONS UNDER EMERGENCY CONDITIONS

ADVANCE WARNING TO PUBLIC

While it is impossible to contact each customer individually before a storm, it is desirable to try to reach them through regular information channels. The public needs to be reminded to stay away from broken wires lying in the street. It is very hard to impress them that every wire, while it may look harmless, constitutes an unsafe condition and can easily be the cause of an electrocution. Every attempt must be made to tell people to call the electric company if they have a wire lying on the ground and to guard or barricade the area until a company employee arrives.

Also, as a part of the advance warning, people should be instructed on how to treat their deep freeze chests so that the food will not spoil. Suggestions on the possible use of containers of dry ice to be packed in the freezer if the outage becomes prolonged could very well eliminate considerable food spoilage and many telephone calls. At least the customers can be reminded not to open the freezer at frequent intervals "to see how things are," but rather to keep the doors or covers closed to keep out as much heat as possible.

This type of information can be presented to the public at least by paid advertising space on the local radio and television stations and in the newspapers which are circulated locally. It could well be that it will not be necessary to buy space, the information being dispensed as a public service. Another possibility would be interviews between editors or radio commentators and public relation officials of the company. On a more long range basis it should be possible to bring this message to school and social groups who might be desirous of a "guest speaker." By any and every means which the public relations director feels is worthwhile, the public must be educated on the safety aspect of damaged utility equipment and instructed in the manner of handling electrical facilities on their own premises. This is a never ending project and one which must be re-emphasized when big storms are a threat.

POST-STORM PROCEDURE

As soon as the storm has passed and it becomes known that extensive damage to the electric distribution system has been done, the electric outage becomes front page news for the newspapers and radio stations. The public relations group must be prepared to meet reporters and give them the information they need for their stories. The newsmen will not be allowed unescorted in the substations, operating headquarters, or customer service sections, so it is the complete responsibility of the public relations department to provide hospitality, arrange tours and interviews, and give out the facts such as number of customers without service, when restoration will be completed, number of crews in the area, and other associated data.

It may prove worthwhile for the public relations department to furnish a room at the main office of the company to serve as sort of a lounge or assembly point for reporters. This room would be a "show-place" of the company's restoration activities and include area maps showing damaged and rehabilitated areas, boards listing crews with their home base and present working area, and other information of this type which would be useful for the reporters assigned. At certain specified times each day prepared bulletins would be issued by the company telling of the progress in rehabilitation and these could be released at this "news release lounge." Also, reporters and photographers who had appointments to meet with public relations representatives to tour company properties and activities could use this room as a convenient meeting place.

Depending on how well the company's restoration work is being covered by the editors, the public relations director and the management may decide to buy space in the local newspapers to describe the extent of the storm's damage and the progress of their restoration work. This "advertising" can not give information which is specific enough to be worthwhile to any particular customer, but probably helps to create the impression that the company's efforts are well organized and always in the best interests of the customer.

VII AREAS FOR IMPROVEMENT IN RESTORATION OF SERVICE

NEED FOR IMPROVEMENT OF EXISTING TECHNIQUES

The organization and plans described in the preceding four major sections are not a sketch of an actual utility company's procedure, but rather the framework of a program synthesized from existing practices in different companies and the author's opinions based on his experience in this field. Without a question, storm rehabilitation techniques have not reached the point that the efforts of all personnel have been maximized. All levels of utility management recognize the need for the most rapid methods of restoring service promptly. What was formerly not an unsatisfactory length of time for an interruption now causes too much hardship and inconvenience. It would appear that an acceptable length of time for an outage today will be too long and entirely unsatisfactory a few years hence. Please note Figure 10, which has duplicated the information of Figure 3, showing the rise in average annual consumption of electricity for New England homes and then added the corresponding average annual consumption for residences throughout the United States. The difference between the consumptions in New England and the nation as a whole is substantial and serves as a forecast of what might be expected in New England regarding the magnitudes of future loads. This seems to add the necessary emphasis to substantiate the need for improving any factor which will help to minimize the frequency and length of electric outages. Certainly as the consumption of electrical energy per residence increases, the demand of the public will be for less frequent interruptions of shorter duration.

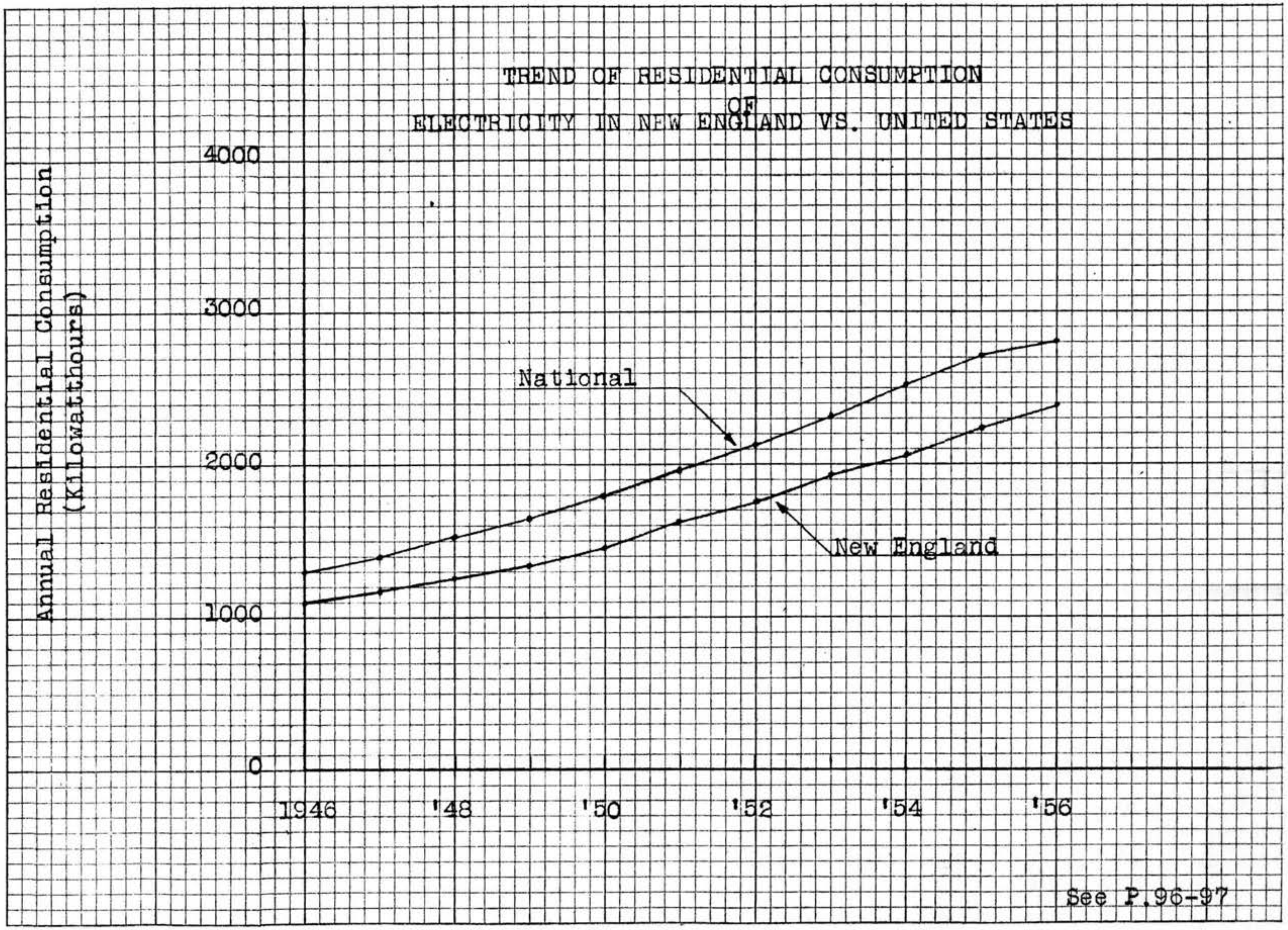

TREND OF RESIDENTIAL CONSUMPTION
OF
ELECTRICITY IN NEW ENGLAND VS. UNITED STATES
Annual Residential Consumption
(Kilowatthours)
4000
3000
2000
1000
0
1946
'48
'50
'52
'54
'56
National
New England
See P.96-97

Figure 10

SHOULD ALL POWER WIRES BE PLACED UNDERGROUND

The possibility of removing all overhead distribution conductors along the streets and replacing them with cables buried in the ground is often presented as a suggestion to eliminate outages from damaged overhead conductors. Underground conductors have the advantage of being out of sight and of being able to route many circuits along the same street, as well as not being exposed to falling trees, wind, and sleet. The public is quick to think that, because the power conductors are underground, the electric service will never be interrupted; but this is not the case, unfortunately.

The widespread use of underground electric distribution has many disadvantages. The first overwhelming disadvantage is the installation cost of an underground system. To install a typical American underground system, a complete system of manholes, interconnected with layers of ducts encased in concrete, must be constructed in every street which now has a pole line. Insulated conductors must be pulled into the ducts and watertight cable joints made in each manhole. Larger manholes are required to contain submersible type transformers and switches. Because cable joints can only be placed in the manholes (and not in the duct lines), the manholes must be located so that service pipes can be extended from them to the customer's premises. Anyone can quickly visualize the amount of excavation and road repavement which would be required to install such a duct system throughout every residential street. Also, since each conductor must be fully insulated and protected from moisture, the additional cost to buy and install underground materials instead of overhead materials can perhaps be imagined. An investigation made in 1956 by the Commonwealth of Massachusetts legislators, who were checking into the electric companies' performances during the hurricanes of 1954 and 1955, showed that it would cost an estimated three billion dollars to convert all overhead construction to underground.* The time required to accomplish this vast undertaking was generally estimated between twenty-five and fifty years. These costs do not include the costs to the individual customers to have an underground service pipe and conductors installed from his property line to his entrance switch. This cost per customer will vary widely depending on the terrain and the distance the house is from the street, but an average figure would be about $200.00 each.

Another disadvantage of a completely underground system is the length of time required to perform maintenance work. In an area served by overhead distribution, trouble can usually be found by driving slowly over the route and making a visual inspection. If the conductors are broken, it is only a short time before the crew has spliced them back together again and the wires are back in the air ready to be re-energized. When underground cables fail, test equipment is usually required to locate the trouble, which may take several hours. When the trouble has been located, crews must take new cable to the site, remove the damaged cable, install the new, and perform rather involved splicing operations requiring skilled personnel. Repairs to underground cables which have failed often require from a twelve hour minimum to two days to repair. If the cable is directly buried and not in ducts,

* 19, P. 5, 9, 106, 115

the time of the outage can be considerably longer, because costly and time consuming excavations must be made to definitely locate the trouble and to prepare a trench for the replacement.

To operate a completely underground system requires some arrangement of duplicate feeds because it is not possible from a safety standpoint to work on cables while they are energized. Either alternate feeds must be available or customers must suffer an outage whenever the cables require work. Of course, this is not the case with overhead conductors, which are handled alive each day because the crews have adequate space in the pole tops to use protective rubber safety equipment or "hot sticks."

There are other disadvantages to underground systems which might be considered at great lengths, like damage to duct lines by digging machinery and damage to cables by overloads and lightning, but such a discussion diverges from the topic. Cable systems have their place in very crowded city districts and can be operated with excellent records of continuity. However, it is agreed by all who are familar with the industry, that the conversion of all overhead distribution to underground is economically unfeasible and out of the question.

USE OF AERIAL CABLE

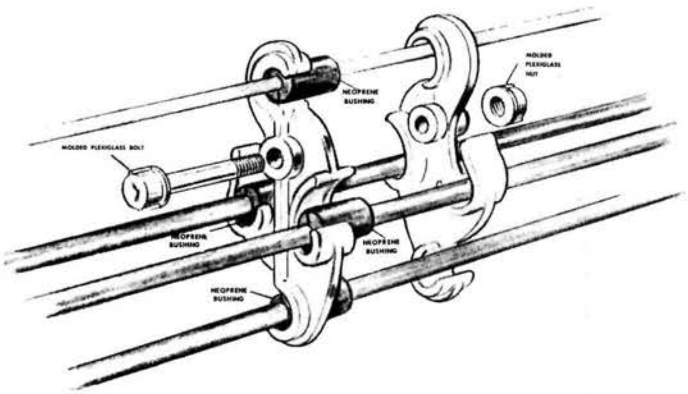
In an attempt to combine some of the good features of underground cable with the advantages of overhead construction, aerial cable in very limited quantities has been in use throughout the industry for a number of years. Aerial cable for distribution use consists of individually insulated conductors bound to a bare strong messenger wire.

The messenger is attached to each existing wood pole and is designed to have enough strength to support the insulated conductors (usually three) and to withstand the impact and weight of falling trees up to some economical limit. The use of aerial cable eliminates the need of an expensive duct and manhole system, which reduces the costs immensely. However, each conductor is insulated and must be spliced carefully, using special high grade tapes and cements applied to specified dimensions. Furthermore location of trouble can be a very slow process unless a complete, visual burn-off has occurred. If work is performed on this type of cable while it is alive, it is certainly a much slower process and very limited in scope compared to similar work which might be performed on open wire circuits. Also, because the conductors are insulated and wrapped together around the messenger, their capacity is limited by the heat and voltage which the insulation can safely withstand without permanent damage. While the installed cost of aerial cable is several times that of open wire construction, it does have definite advantages in areas of heavy trees, it presents a neater appearance, and it has had a very good operating history during storms. It probably deserves more use than it has had and should look forward to even greater use.

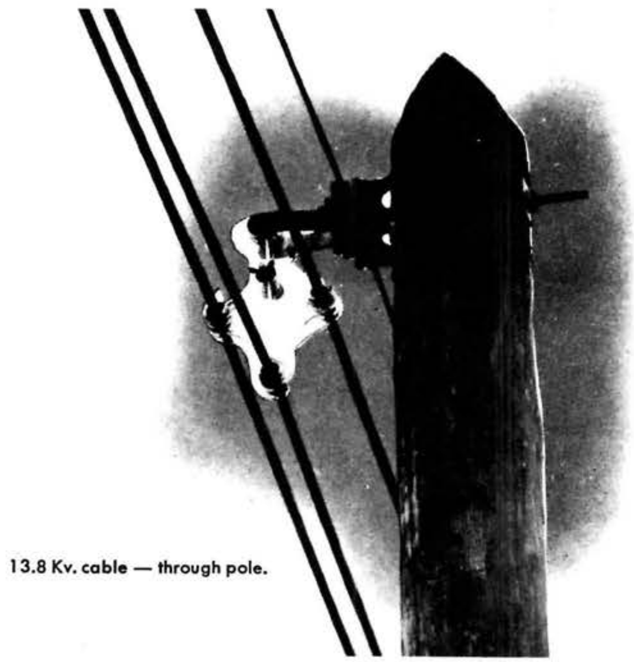
About six years ago a revolutionary design in aerial cable came on the market and would appear to hold much promise for future construction. Practically all of this new type aerial cable has been made by only one company and is known as Hendrix Aerial Cable. Its installed costs are considerably less than for the conventional aerial cable mentioned in the paragraph above, yet it seems to have most of the advantages. There are over 500,000 circuit feet of this type cable in use in the central and northeastern portions of the country, all operating satisfactorily.* The Hendrix cable consists of three plastic insulated conductors equally spaced in a triangular configuration and attached to the messenger with Plexi-glass spacers approximately every thirty feet. The messenger is a bare high-strength cable (Copperweld) attached to each pole and designed to handle the weight of the three insulated conductors under ice and wind loadings plus the weight of limbs which may fall into it, similar to the messenger of the previously mentioned aerial cable. The Hendrix cable can be quickly installed by regular line crews and does not require a highly skilled cable splicer to make the joints. Because the insulated conductors are held apart by the plastic spacers, they never touch each other and do not require so much care in splicing. Likewise, being spaced in free air, the heat dissipation problem is more favorable. Furthermore, because they are spaced apart, it is considered easier to make tap connections for a lateral feed. (Please note Figure 11.)

The author has been personally involved in the installation of some Hendrix cable to be used as a primary distribution feeder and has seen several installations made by others. Because of its relatively low cost, ease of installation and operation, and its inherent ability to withstand falling limbs and trees, it is expected that the utilities will look to this type of overhead construction much more in the near future.

* 18, P. 130



Hendrix Spacer Clamp, Disassembled



HENDRIX CABLE ILLUSTRATIONS

Figure 11

Courtesy of
Hendrix Wire
& Cable Corp.

SEVERAL MISCELLANEOUS SUBJECTS FOR IMPROVEMENT

There is one more major topic to be discussed, but that will appear as the last item in this section to add emphasis to it. The first miscellaneous item pertains to the problem of making a quick initial appraisal of the extent of the damage. If there was some magic way to know in a matter of minutes, or perhaps one hour, just how badly a system had been disrupted, the preliminary stages of restoration could be so much better organized. This information is now best obtained by a few very experienced line construction supervisors taking a ride in their cars and making a very hasty general inspection. Because men with this type of background are available, they can rely heavily on their experience and knowledge of the area and give the distribution superintendent a pretty good picture of conditions. At the best it leaves something to be desired. Not only does the distribution department need the most concise information possible, but the customer relations section needs it too so that they can answer customers calling and requiring specific answers. As it is now, during the first few hours after a storm, no appraisal of the situation is available in sufficient detail to form the basis for the specific answers which some factories, dairies, ice cream plants, and similar enterprises require and deserve. The use of helicopters has been suggested and apparently works very well on long transmission line patrols. To use helicopters to survey distribution pole lines where wires might be wrapped around trees and trees leaning on poles would appear too slow, particularly where so many feeders are involved and especially where a large fleet of rented helicopters seems out of the question. The sampling technique has been tried and has considerable merit, but it fails when it becomes necessary to answer specific questions from customers with concise information. Some correlation between measured wind velocity and the extent of damage has also been suggested, but at the best this can only be a very general yardstick and does not provide a detailed picture. Perhaps the answer lies simply in the use of more patrolmen. It was suggested in Section III that a patrolman and driver be assigned to each feeder and that they patrol only the primary conductors with the thought they would return to their headquarters with a primary feeder map marked to show locations and types of damage. After the restoration organization has been established and trained, it may develop that more patrolmen could be taught to help on feeders which had difficult and very time consuming routes. Certainly if information could be obtained and turned in at headquarters by sets of patrolmen so that it could be digested and given to the interested departments within one to two hours, the company would have a fine initial grasp of the situation.

Another topic pertains to the reluctance of regular operating personnel to delegate responsibility to employees from other departments who have been reassigned for storm work. It is a natural reaction for supervisors working on pole top construction problems every day to feel that a man from the accounting department, industrial sales, or some similar group does not understand enough about overhead construction to be assigned responsible work in the emergency. Experience by companies who have used men from other departments to supplement the normal overhead force, both in the field and in the office, does not substantiate this reluctance. In fact, their results have been quite to the contrary and they have found these "recruits" to be useful and welcome additions to the staff of acting general foremen and the like. It is so important to utilize the services of all employees that the misconceived ideas of a few must be eliminated. This is another reason for practice sessions and rehearsals because invariably these differences work themselves out as the groups become better acquainted. The end result often is that members of the regular overhead group are remarking about what fine work certain individuals from completely disassociated departments performed under adverse conditions.

The next subject to be mentioned for study and possible improvement is really a repeat of the work of the customer service section discussed on Page 61. The group of girls who receive customers' incoming calls must be expanded many times its original number in a very short time. This means more telephones connected temporarily, enlarged working space, and many other factors which can lead to real confusion. The importance of the work that the customer service section does during the post-storm period cannot be emphasized enough. They are the contact between the electric company and hundreds of customers who call, and the impression they leave with the customers is tremendously important. Continual practice and training classes are required. Manuals suggesting methods of handling certain classes of calls, types of replies to make and not to make, and general telephone etiquette should be developed to the advantage of all. Establishment, training, and perpetuation of a staff of men and women to operate a really efficient customer service section which can fulfill its obligation to the customers and the restoration forces in the field is a problem deserving of management's best efforts.

The problem of providing field forces with the necessary materials is a topic which should be reviewed. As pointed out in a previous section, quantities of material are kept in the "emergency reserve" inventory so that there will be no question of availability when a storm strikes. It was also mentioned that time spent by line trucks waiting at the stockroom to load supplies is very valuable time lost which could otherwise be spent on reconstruction in the field. By tradition, under normal conditions, line trucks pick up their work orders and draw the necessary materials before starting out to the job each morning. The possibility of a temporary fleet of pick-up trucks to take the materials from the storehouse directly to the line crews at the job site seems attractive. Excluding poles, which are transported on a two-wheel trailer behind the line truck, there are practically no bulky items to be transported. Pole mounted distribution transformers are heavy but not bulky and seldom have to be replaced because of storm damage. The types of material usually in demand would include crossarms, line hardware (nuts, bolts, washers, clamps, etc.), relatively small quantities of wire, liberal amounts of different sizes of splices and connectors, and tool replacements. It would appear that some study and rehearsals by stockroom and distribution personnel could devise a workable plan whereby the acting general foremen in the different group operating areas could telephone the stockroom and have materials delivered to the job. This would be not unlike the way the housewife in a previous era used to call her grocer each morning, after which he would put up her order and have his delivery cart take it to the customer's house. Certainly delivery of construction materials directly to the line trucks on the job will permit them more time for reconstruction in the field and will simplify confusion and crowded conditions around the stockroom.

TREE PROBLEMS

The broad topic of tree problems in electric utility management has been left until the last section in this report to give additional emphasis to the subject. It could well be placed at the very beginning of this thesis because of its importance, or maybe someone might say that the whole problem of trees and their effect on the operation of an overhead electric distribution system is such a fundamental subject that it should be the basis of a separate report. Perhaps another student will choose to expand this phase into a lengthy investigation. When it is realized that an estimated ninety per cent of the damage to overhead equipment from the 1954 hurricanes in Massachusetts was directly attributable to trees, one begins to see the significance.* Very seldom does a high wind or heavy snow bring down wires, instead limbs are broken or trees tip over because of the force of the storm and the weight of the limbs in turn break the wires and cause the interruption.

Probably the first thing to consider to decrease the damage done by broken trees would be to improve and expand both the municipal

* 19, P. 89

and utility tree trimming programs. Many trees are much taller than the poles and wires along the street and these trees contain many dead or weak limbs. If the trees are not trimmed regularly and thoroughly, it is easy to see how large limbs are broken by the wind or snow and crash down on the electric wires. In spite of the fact that good trimming makes healthier trees, "many municipalities have been shortsighted in refusing to appropriate adequate funds for the removal of trees that seriously threaten lives and property."* Local tree wardens have jurisdiction over the extent of trimming permitted, but property owners sometimes become involved in questions regarding trees along the street in front of their houses and "sentimental objection is successfully made to both the removal of trees in dangerous condition and to proper tree trimming."* This factor has made it very difficult to establish and maintain good tree clearances.

Since the tree wardens only reflect the thinking of their town's officials and citizens, it follows that the general public (incidentally the same people whose electric service would be interrupted) must accept and demand improved trimming. This all serves to emphasize the point that the electric companies must educate the public to the advantages which better tree clearances will bring them before they can inaugurate a more comprehensive program. This type of education must be based on a long-range plan with the results of the efforts appearing very slowly. The possibilities which "off-street plantings" and the use of functional types of trees offer are practically unknown to

* 19, P. 7

the general public, so this message must be brought before all of the citizens through every available channel. Because improved tree clearances invariably bring improved operating conditions, this aspect is obviously a real and current management problem requiring great tact and knowledge of local conditions.

Utilities usually hire independent tree surgery companies to perform their tree clearance work for them on a contract basis. Recently both the tree surgeons and the utilities have purchased trucks rigged with special hydraulic booms and insulated "buckets" attached to the far end of the boom. A man standing in the insulated bucket can operate the boom remotely and raise himself to the correct position among the tree limbs to perform the desired trimming. Under normal working conditions these hydraulic buckets (often referred to by a popular trade name, "Sky-Worker") speed up the tree surgery work considerably. Under emergency conditions they are of inestimable value as they can drive along the route of a feeder and clear away trouble so that a line truck following can quickly make the repairs. Often times during storm restoration work line crews are held up waiting for tree crews to go to work ahead of them, with the result that the linemen must stop their line work and turn to tree work with crude tools. Because these hydraulic booms are so useful both in routine work and in rehabilitation work, they will become a more significant part of a utility's equipment or the utility must have some firm commitment with a private tree surgeon to furnish them for storm restoration work as well as daily trimming functions.

Situations arise sometimes following a bad storm where so many trees are blown down and across the road that it is impossible to drive line trucks into the area. The responsibility for clearing the streets and highways does not rest with the utilities, but in many cases the municipalities are very slow to move into action. Once again this creates the situation where line crews must do tree surgery in order to straighten things out enough to start their line work. This problem would appear to be one where much preliminary planning could be organized between town and electric company officials. Because time is so critical, a situation where the town or city might spend one or two days organizing its clearing crews is to be avoided if at all possible. It may turn out that the towns feel that in extreme cases they cannot handle their responsibility as quickly as they might like, so they must look to the state to call out the National Guard because of the emergency. (To see that the National Guard units had the proper tools to help in this type of work would be part of the preliminaries.) Certainly if it was agreed that the towns would ask for outside help, such as the National Guard, a great amount of work would be necessary in advance to have the plan completely outlined, up-to-date, and ready to go into use on short notice. In any event whatever amount of time and effort is required by the utility management to promote coordination with all municipalities to insure efficient disposal of debris will pay big dividends in an improved restoration performance.

While increased trimming programs, the use of modern machinery, and improved debris removal procedure by municipalities will help immensely to decrease damage by trees and help to speed restoration, these suggestions are only a relief to an existing bad situation and are not a cure. Simply stated, the only real cure lies in the removal of large forest-type trees which conflict with the electric wires. Particularly in New England where people are so proud of their tree shaded streets, a large scale program of tree removal certainly looks formidable. Such a suggestion must include not only the removal of the existing trees but also a program for their replacement by other species of trees. The trees planted as replacements would be of carefully chosen species which would not grow so tall but would still add beauty and shade to the area.* These replacements might be planted on private property instead of in the grass strip between the curb and the sidewalk, as has been the custom in the past. A solution involving careful selection of types of trees and locating the plantings other than near the curbstones is not exactly a new thought to the electric utility industry but it is one which certainly has not been developed in actual practice in any extent until quite recently.** *** ****

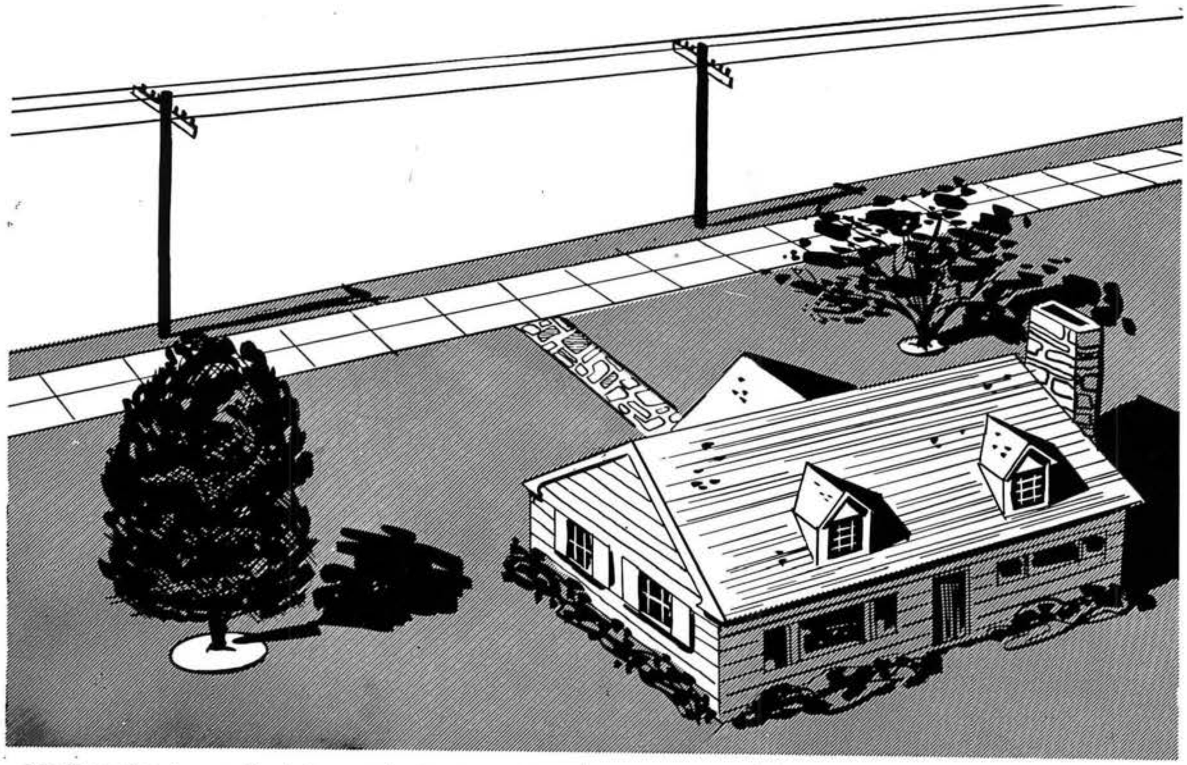
This whole idea of tree removal and tree replacement is so basic to the solution of the problem of trees conflicting with overhead power conductors that it deserves additional explanation. In years gone by the trees which were planted by the municipalities were usually elms or maples, forest-types, which grew to be very large, causing interference with the wires and requiring considerable money to maintain. The mistake of these plantings is now recognized by city planners,

* 7, P. 54
** 7, P.73 and P. 106
*** 13, P. 25
**** 14, P. 30

arborists, tree wardens, and utility representatives -- no attention was given to the species chosen and the plantings were made exactly in the areas which would cause the most interference with traffic and with utility conductors. One solution lies in the choice of species of trees which fit the location desired. The location may require trees which will not grow taller than twenty-five feet, thus never rising to touch the wires. Perhaps the streets are narrow or the houses are close to the sidewalk so that wide-spreading branches are undesirable. In other words, functional types must be chosen to fit the particular conditions on any given street. The expression "functional types" pretty well suggests the approach of "tailoring" the trees to fit the conditions by choosing a suitable species and spacing the plantings correctly.

Hand-in-hand with the use of functional types of trees instead of the forest types comes the thought of locating the plantings on private property instead of along the curbs. This approach is referred to as "off-street planting." It may be of interest to quote from the Commonwealth of Massachusetts General Laws #87, Section 7:

> "Towns may appropriate money to be expended by the tree warden in planting shade trees in the public ways, or, if he deems it expedient, upon adjoining land, at a distance not exceeding twenty-feet from said public ways, for the purpose of improving, protecting, shading or ornamenting the same; provided, that the written consent of the owner of such adjoining land shall first be obtained."



Medium-size trees planted on private property enhance street and home appearance; at the same time leave overhead lines free from excessive tree growth.

OFF-STREET PLANTINGS USING FUNCTIONAL TYPE TREES

Figure 12

Courtesy of
Boston Ed.Co.

Upper - FUNCTIONAL SPECIES BETWEEN STREET AND CURB

Lower - FUNCTIONAL SPECIES PLANTED "OFF-STREET"

Figure 13

Courtesy of
Conn.Lgt.&Pwr.Co.

Obviously, trees of carefully chosen types, planted with the property owner's permission a substantial number of feet inside the property line beyond the sidewalk, offer distinct benefits to all concerned -- municipal authorities, property owners, utilities, and the general public.

Immediately in favor of any program to improve tree conditions are the facts that many trees are dying of Dutch elm disease annually and many more trees must be cut down anyhow because of highway construction programs. Also adding to the argument is the fact that tall trees, weakened by old age and past storms, are a menance to nearby property owners. It must be emphasized that before such a program could be initiated, a tremendous effort to educate the public would have to be planned and patiently carried out. To point out the benefits of the use of functional types of trees and off-street planting to the general public and to gain their acceptance is a real challenge. (Along this same line some areas have legislation controlling the type of trees planted in new housing developments.) After public acceptance had been gained, a long period of time would be required to complete the removals and planting. Programs of this sort have been instituted on small scales, have met with favorable public reaction, and have produced operating conditions which are very much improved. Of course some of the most troublesome spots would be replaced first so that some improvement would be realized shortly; but, at the best, a period of many years and a vast amount of never-ending liaison work is involved. Such a program is not repetitive; that is, once the trees causing the trouble have been removed and that area has been planted with a recommended species, it will not be necessary to return there for future removals during the life of the newly planted trees, estimated at forty years. This idea is a very basic solution, a philosophy, and holds the one great hope for electric utilities to continue to handle increasing loads with decreasing outages. Therefore, because of its overwhelming importance to the future growth of the industry, the obligation weighs very heavily on utility management to face the problem squarely, initiate sound action, shoulder their responsibility in this far-reaching community project, and see it through to the mutual advantage of all.

VIII CONCLUSION

It would appear that there are several basic points to be concluded as a result of the material presented in this thesis. The fundamental thoughts which were brought out in the preceding sections will be briefly summarized in the following paragraphs and the conclusion associated with those ideas will be indicated.

The introduction acquainted the reader with the basic layout of an electric utility system and then narrowed the subject to pertain only to restoration problems resulting from storm damage to the overhead distribution system. Our modern society is so dependent upon electric service that any extended outage causes inconvenience and hardship. Residences without electric service for cooking, heating, refrigeration, and pumping, as well as appliances and lighting; commercial establishments without electric power for their larger refrigeration, heating, pumping, and ventilation units; and the factories without large blocks of power for their motors, industrial heating, ventilation, heat and lights; these all add to make the electric utility management's responsibility to maintain an extremely high degree of service continuity of the utmost importance.

Also in the introduction the conventional type of construction for overhead distribution equipment was described. It was pointed out that these distribution lines are built along practically all of the streets of each community so that service can be given directly to each customer. Tall shade trees also line most New England streets, with the result that the tree branches conflict with the electric wires.

When heavy wind or sleet storms occur, the trees break, cause damage to the wires, and interrupt electric service to whole neighborhoods, even entire communities. Damage to electric utility equipment from the 1954 hurricanes in Massachusetts alone was nearly eight million dollars ($8,000,000.). With the frequency of severe storms in New England increasing these last few years and more customers using larger amounts of electricity, electric utility management has a real problem and a challenge to insure an increasingly high standard of service continuity.

The various divisions of a utility which would be directly affected by a major storm were described as they would function in the normal course of events. Actually the electric companies are such well organized teams that people have come to expect practically uninterrupted service. These people, the home-owner, shopkeeper, and factory manager, have based their whole utilization of electricity upon the high degree of reliability which they enjoy day after day. Minor interruptions, of course, occur somewhere every day but the distribution departments with their crews, together with the stores departments and customer service sections, handle these minor incidents so efficiently so that the areas involved are very small (perhaps only one customer) and the inconveniences are minimized. However, these existing organizations do not have the personnel or facilities to cope with a major storm, such as a hurricane, which interrupts service to whole communities and involves tens of thousands of customers.

In order to restore service rapidly when a major storm passes through an area requires careful, detailed, advance planning. After a storm has hit and chaos reigns, there is no time to think about the establishment of a disaster organization. Advance planning and training of personnel is an absolute necessity if service is to be restored quickly and efficiently. The various levels of management must lay very complete plans for the operation of the customer service section, the sales, stores, and transportation departments, and especially the distribution department. Rehearsals must be held at least once a year and the personnel rosters continually brought up to date.

The distribution department carries out the most important single function during the restoration because it is this department which actually sends the pole linemen to make the repairs. While operations for a distribution department are normally handled from a single headquarters, major storm damage increases the scope of the work required to such an extent that it is necessary to delegate authority to "non-operating personnel" and to decentralize the operation. This means that rosters of men experienced in distribution techniques, but not normally assigned to the distribution department, must be drawn from the engineering groups, sales, and accounting departments, as well as junior management levels to serve as patrolmen, general line foremen, and the like. A large well-trained group of patrolmen is particularly desirable because they must furnish the distribution department superintendent with a quick, accurate, and detailed picture of the damage throughout the area. The patrolmen's reports must serve as the basis for requests for outside help. The sooner these requests for additional crews are made, the sooner "foreign crews" will arrive from neighboring utilities. A rapid, concise appraisal of the damage is very important and constitutes the first and biggest step towards efficient restoration. Decentralization and speedy action in the first hours after the storm has asserted itself are so basic to a good restoration plan that they cannot be emphasized enough.

While the distribution department stands in the spotlight during the emergency period, the work of the supporting departments must not be underestimated. The customer relations section, the sales department, and the public relation division have heavy responsibilities to the public in general and to individual customers in particular. No matter how well restoration work is being carried out by the distribution department, unless customers and the public are given quick, satisfactory answers to the question, "When will I get my lights back," the entire rehabilitation efforts of the company will not create a favorable impression. Customers expect and deserve accurate appraisals of the situation as it affects them, so all efforts to train personnel to handle the flood of customers' telephone calls will be repaid many times over.

Similarly the departments which directly serve the distribution department, like the stores and transportation sections, as well as the men stationed at the weather bureau, must have advance plans which are ready and realistic. Obviously, additional materials beyond the normal flow will be required and without them reconstruction bogs down miserably. Additional vehicles of all sorts must be available too, so the transportation section must stand ready to provide rented trucks and cars, as well as around-the-clock garage service without hesitation.

Every indication is that the use of electricity will continue to increase and that the customers will demand and deserve improved service continuity. The possibility of improving service by placing all of the wires underground is not feasible. Initial costs of underground construction are prohibitively high, maintenance and operation are more costly, and outages are longer when they do occur because of the difficulty to perform repairs. However, the use of aerial cable which combines some of the features of both underground and overhead construction at intermediate costs has been a distinct possibility in recent years. Even more recently a cable design known as Hendrix Aerial Cable has been developed, marketed, and operated successfully throughout the Northeast. The Hendrix Cable uses aluminum line wire and plastic separators to keep the wires evenly positioned in a compact space so that it is easy to install, much simpler to operate and maintain, and very reliable during heavy storms. Relatively, only token amounts of aerial cable have been used, but it would appear that utility managements should be attracted to its many advantages, particularly the attractive features of the Hendrix design. Large increases in the use of the Hendrix aerial cable should be expected shortly.

Several phases of the restoration procedure now used should continually come up for review to take advantage of the latest training methods and other improvements. The use of more patrolmen to locate trouble after a storm will permit more rapid appraisal of the damage and start restoration even quicker. Management must recognize the importance of a well-trained roster of patrolmen and continually try to enlarge and improve this group. Likewise there will probably always be new ways developed to improve the abilities of the customer service section. The telephone technique, with which the clerks meet the public, is of so much importance that management must see that training courses, refresher classes, rehearsals, and revised personnel rosters are constantly brought up for discussion and action.

Finally this thesis points out that the most basic approach to improving service during and after storms is to eliminate the damage which falling trees cause to the wires. (It was pointed out that the bulk of the recent hurricane damage was directly attributable to falling trees and broken limbs.) Both the municipal and utility tree trimming programs must be improved and expanded. Existing shade trees are tall and, as they become old and diseased, they are continually disrupting service unless trimming is obtained to provide adequate clearance for the wires.

Actually the most promising solution to the problem of eliminating damage to wires by trees lies in the removal of the existing "forest-type" trees along the edges of the streets. To preserve the shade and beauty of the area, new trees of carefully chosen species must be planted away from the curb where they cannot interfere with utility wires. This approach is known as the use of functional types of trees and "off-street plantings." The idea has been utilized in isolated instances for some time but only recently is becoming more popular. Operating records where this approach to the tree problem has been made are very impressive. At the best, the planting of functional species of trees is a long-range program which requires close coordination between municipal authorities and utility officials, as well as a thoroughly planned educational program for the general public. The many advantages of a wide-scale program of this type are so attractive that all levels of utility management must study it carefully and inaugurate a course of action suited to local conditions. Conscientious pursuit of that plan year after year will undoubtedly improve service immensely. In fact, the author believes that initiation of a tree removal-replacement plan, coupled with "off-street" plantings, is the real basis for the future development of a larger, more reliable electric utility distribution system.

IX APPENDIX

Information from Statistical Bulletin for the year 1956, Electric Utility Industry in New England, Electric Council of New England and used in the graphs of Figures 3, 4, and 10.

Trend of Average Use of Electricity in the New England Home

Year	Annual KWHRS. Used
1946	1099
1947	1170
1948	1255
1949	1335
1950	1465
1951	1616
1952	1747
1953	1908
1954	2049
1955	2231
1956	2390

Number of Ultimate (Residential) Customers (in New England) at End of Year

Year	Residential Customers
1946	2,387,927
1947	2,465,942
1948	2,539,464
1949	2,613,989
1950	2,689,471
1951	2,756,663
1952	2,817,941
1953	2,858,045
1954	2,895,257
1955	2,956,315
1956	3,021,298

APPENDIX CONT'D.

Information from Statistical Bulletin for the year 1956, Electric Utility Industry in the United States, Edison Electric Institute and used in the graph of Figure 10.

Energy Sales - Total Electric Utility Industry

Year	Total Residential Sales - KWHRS in Millions
1946	38,571
1947	44,171
1948	50,978
1949	58,139
1950	67,030
1951	77,024
1952	86,780
1953	97,063
1954	108,465
1955	120,524
1956	133,851

Customers - Total Electric Utility Industry

Year	Total Residential Customers
1946	29,769,107
1947	31,621,959
1948	33,549,396
1949	35,375,366
1950	37,532,549
1951	39,224,621
1952	40,738,718
1953	41,981,633
1954	43,139,998
1955	44,408,690
1956	47,711,460

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