

CONVERSION OF ELECTRICAL  
SYSTEM FROM DIRECT CURRENT  
TO ALTERNATING CURRENT

A Thesis

Submitted in Partial Fulfillment of the  
Requirements for the Degree of

ELECTRICAL ENGINEER

By

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B.S. in E.E. 1925

Georgia School of Technology

May 1, 1940

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Approved:

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Sub-Committee of Committee on  
Advanced Degrees

## A THESIS

Conversion of Electrical System from Direct-Current to Alternating-  
Current Operation, State Department Building, 17th and  
Pennsylvania Ave., Northwest, Washington, D. C.

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## A THESIS

### HISTORY OF BUILDING

The State Department Building is one of the oldest and best known of the old Federal buildings in the city and has played a vital part in the development and progress of our national life.

The story of its development resembles that of "Topsy -- it just grew".

It grew in sections or wings, the south wing being started first in June 1871 under the supervision of the Secretary of State and was completed in July 1875. Then followed the east wing which was completed in July 1879 and was occupied by the War and Navy Departments during the same year. The north wing was completed three years later, then followed the west and center wings which were erected on the site of the old Navy building. The building was completed in 1888, seventeen (17) years after its beginning, and was considered adequate to house the three great executive departments, State, War and Navy, for all time.

For more than a score of years it seemed that this might be true, but less than thirty years after its completion, the entry of our country into World War No. 1 forced the greater part of the Army and Navy Departments to seek new quarters, until today, after many changes over a number of years, it is now occupied solely by the State Department.

The exterior exemplifies a stray influence of the French Renaissance period, becoming a composite of all the different types of architecture known to man. But with all of its gingerbread idiosyncrasies, the old building is dearly beloved by all who know it best. As a noted engineer once put it: "She's plumb, she's square, and, boys, she's pretty".

The building is said to be the only one in the world having the entire exterior of granite. The walls, columns, and all outside stonework are of genuine hand-hewn gray stone. The granite was obtained from the Green Quarry on the James River in Virginia and from Maine. The granite structure covers a rectangular plot of ground 342 feet wide by 565 feet long, and has seven stories including basement and sub-basement.

The foundations carrying the main bearing walls are nine (9) feet wide by four (4) feet thick. All foundations are constructed of American natural hydraulic cement and are still very firm and solid after more than fifty (50) years of service.

The outer walls are nearly four (4) feet thick and the granite exteriors are backed up with solid masonry on the interior. The roof, trimmings and chimneys are made entirely of iron. The roof covering is of copper and slate; outer doors, window frames, baseboards and main supporting columns through the building are made entirely of cast iron.

The floors are of brick arching on iron beams, and, being leveled on the floor surface with concrete, cannot sag and are almost soundproof. The only woodwork to be found in the building is in the inner doors, window sashes and floor coverings in the office rooms. All inner walls and partitions are almost two (2) feet thick and of hard, hand-made brick.

Double ornamental borders are found in all rooms, corridors, over all doors and windows. Borders are everywhere, with the famous Wall of Troy as the predominating design.

The building contains nearly two miles of corridors, with an average width of thirteen (13) feet and height of fifteen (15) feet.

The stairways are circular and unsupported by beams or arches, each step being made of solid granite and tightly wedged into a supporting wall at each end to form a cantilever construction. There are eight of these stairways and few in the world can compare in workmanship and beauty of execution. Each stairwell is lighted with huge stained glass domes of distinctive design.

The structure has a total of six hundred rooms, many of which have highly ornamental paneled walls and ceilings finished in gold and beautiful color combinations offering a wide variety of unusual designs. Many of the rooms have played a great part in our national history, including the executive suites of the Secretaries of War, Navy, and State, and housed therein are some of our Nation's most prized documents, including all treaties ever made by this government, the Great Seal of the United States, which is also the Great Seal of the State Department, and the Declaration of Independence.

The electrical systems, as well as plumbing, heating, and mechanical systems originally installed in the building, have undergone many changes, extensions and rearrangements in order to keep pace with the various activities and expansions of the agencies of the Federal Government that have occupied the building during the many years since its completion in 1888. As a natural consequence, there existed a great

confusion of steam, water and various other pipes and valves, as well as electrical conduits, pull boxes, etc., at the time this change of converting the electrical system from direct-current to alternating-current operation was begun.

The original power supply for the building was furnished by several steam-driven, direct-current generators of approximately one thousand kilowatts total capacity. Later, the use of these generators was abandoned, but they were left in place, and direct-current power was purchased from the Potomac Electric Power Company, the local public utility company.

Due to the existing local conditions created by a policy of adding new facilities without altogether removing the old, and also to the peculiar and unusual character and type of construction of the building itself, many difficult and troublesome problems have had to be met and overcome.

The old building was constructed at an original cost of nearly \$12,000,000, and, no doubt, an amount one-third as great has been expended in making changes and in physical improvements since its completion. Time has left the indelible stamp of age upon its face, but for many years to come, the distinctive old edifice will continue to fulfill its mission of service, and in importance, will concede first place only to our Nation's Capitol.



### GENERAL DISCUSSION

When a major change or improvement in an existing electrical system that is in operation and rendering service is contemplated, the first consideration is its justification. The next thought, and of almost equal importance, is the cost of the project. After it has once been decided that the change is justified, the problem begins to resolve itself into its various component parts, such as present requirements, future growth, quality standards involving both intensity of illumination and expected life of equipment and materials, continuity of service, appearance, etc. All of these factors will affect greatly the basic design and, therefore, the ultimate cost of the proposed project.

As the budget items for changes and improvements in Federal buildings are set up, each one, whether large or small, is allotted a specific sum beyond which the cost should not go. However, in many cases construction difficulties that can not always be foreseen will arise necessitating additional expenditure to complete a project satisfactorily. This has been my experience in designing many installations in existing Federal buildings. The problems to be met and overcome in changing and extending an existing installation are numerous and sometimes offer serious difficulties which may require many days of careful study and investigation; however, greater satisfaction always results from having encountered such difficulties and successfully overcome them.

In view of the fact that all U.S. Government contracts for projects of this scope are awarded on open bids to the lowest responsible bidder, in addition to the basic design, it is always necessary to include several

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alternate methods of installing certain portions of the work, varying the type, size and quality of equipment, or omitting certain parts altogether, so that a sufficient number of alternative bids will be obtained which, when combined with the base bid, will result in a satisfactory combination of prices which will total within the amount appropriated for the project. Obviously, this procedure involves a great amount of study and time in working out the design details of each particular portion of the work and in writing specifications in order to obtain the type of equipment desired.

In writing up specifications for a project, the customary and most satisfactory procedure is to include in the base bid all of the features that are desired in the installation.

Upon receipt of the bids, a thorough analysis is then given to the various figures submitted, and the base bid, together with any alternates desired, will be combined to form a lump sum, upon which the award will be made to the successful bidder. This award, after signatures of the Government's representative and the successful bidder have been affixed, becomes a legal binding contract.

The contract drawings, showing the proposed installation, together with the written specifications describing required equipment and materials, and the methods to be used in constructing the installation, constitute the complete contract requirements.

It is the duty and responsibility of the engineer in charge to approve all equipment and materials submitted by the contractor for use in the project, to follow closely the progress of the work during construction, to approve all changes and modifications that may be desirable in the best interests of the work, and to make final inspection and

acceptance tests of the project upon completion.

It is easily seen that to be responsible for the carrying out of a major improvement project of this scope requires not only broad experience in many fields of electrical design, but also, an intimate knowledge of building structures and the various types of mechanical systems found therein, a thorough understanding of the business policies of the operating public utilities, and a firm grounding in the many legal issues involved in executing Government contracts.

My experience has been that the making of improvements in existing and old buildings, due to their very nature and the many varied problems always encountered, offers one many opportunities for ingenuity and application not to be found in the design of new buildings. The knowledge and experience gained in mastering the problems presented by an old building will simplify and make easy the design of any installation in a new building. For, in a new building, space is free for the asking and walls have only the thickness of a line.

## SUMMARY OF PROCEDURE AND DESIGN CALCULATIONS

Under this heading, it is intended to present in a general way the fundamental reasons for the need of this project, the complete general scope of the entire installation, and the most important features of design incorporated therein.

An appropriation of \$150,000 was originally set aside for this project, which was intended to cover the entire cost of changing all electrical facilities in the building from direct-current to alternating-current operation. This work was divided into two separate parts, the primary and the secondary systems, and was awarded as two distinct contracts.

The primary contract was awarded to Central Armature Works, Washington, D.C., in the amount of approximately \$59,000 and included the complete installation of a new transformer vault, high-tension switchgear room, switchboard room, three units of 13.2 KV cubicle type switchgear, three 500 KVA, 3-phase, vault-type, network transformers complete with network protectors, three 13.2 KV primary service feeders from the Potomac Electric Company, the first unit of the power switchboard and main secondary bus complete with all necessary connections to transformers, new feeders to seven (7) modern elevators and certain other incidental work necessary for a satisfactory installation.

The major requirements for the primary installation are shown on Sheets Nos. 1, 2 and 3, which, together with the specifications, constituted the first contract. This work, with the exception of three of the feeders to the new elevators, has been completed.

The second contract was awarded to the L. I. Waldman Company, Inc., of New York City, in the amount of approximately \$93,000, and included the installation of a new lighting switchboard, the completion of the power switchboard, new distribution, lighting, and power panelboards throughout the building, new feeders, the rewiring, recircuiting, and rearranging of the existing electrical wiring system throughout, the replacement of all existing wiring devices and providing new ones where required, the conversion or replacement of all existing D. C. motors, machines, equipment, etc., to A. C. operation, and many other miscellaneous related items of work. This work, at the present time, is about three-fourths complete and has offered a great many construction problems, especially with regard to locations and arrangement of conduits, outlets, etc.; however, careful study of the problems has always resulted in finding a satisfactory solution so far.

Ten (10) drawings were required for the secondary installation and these drawings, together with the specifications, constituted the second contract. The ten drawings consisted of a floor plan for each of the seven (7) floors, sub-basement to fifth floor, inclusive; a feeder plan; switchboard, panel and feeder schedule, and a riser diagram.

The feeder plan, panel and feeder schedule, riser diagram, and a typical floor plan -- the second -- namely, Sheets 4, 8, 9 and 10, are included as a part of this thesis. The others of the secondary contract are omitted, as it is believed that the four drawings will present a clear picture of the work involved. It is desired to point out at this time that in a job of this nature and scope, a multitude of details must be considered and be shown on the drawings or incorporated in the specifications. However, it is obvious that space will not permit their inclusion

here. Moreover, I wish to emphasize that the contract drawings incorporated as a part of this thesis for both the primary and secondary systems, upon which is outlined the work proposed under each contract, do not truly represent the actual work involved in carrying the projects through to a successful completion. In addition to these drawings, and in conformity with the ideas presented thereon and in the specifications, many working drawings must be prepared by the contractor showing in greater detail the various methods of construction and type and arrangement of equipment which he proposes to use. These drawings are examined, then corrected or changed until all the desired features are incorporated, after which all such drawings are given final approval and are signed by the Chief of the Division, then released for construction.

The need for conversion from D. C. to A. C. of the electrical system in this building may be justified very simply by stating a very few pertinent facts connected therewith.

At the beginning of new construction, the existing system was unique in character and since its original installation in 1912, had become wholly inadequate to meet present day requirements and had long since been obsolete. The power and lighting system consisted essentially of the following:

Three sets of feeders in parallel fed into a common bus supplying a 3-wire, 110/220 volt D. C. switchboard of the live-front, knife-switch and fuse type.

Ninety-six (96) lighting and power panelboards, all of which were located in the sub-basement, were supplied in groups by several feeders from the main switchboard on the same floor.

The lighting panels supplied the lighting load on the upper floors by means of numerous small individual feeders in flexible conduit from each panel, each feeder serving a small area of a few offices on its respective floor. Due to the heavily overloaded conditions, prevalent throughout the distribution system because of the small sizes of feeders and the extremely long runs of circuits, the voltage conditions, especially on the upper floors, were very unsatisfactory and produced a very low quality of illumination generally.

It was desired to replace the existing direct lighting fixtures with new and modern fixtures of the indirect or semi-indirect type in order to provide a higher quality of general lighting and improve working conditions. This could not be done since no spare capacity remained in the system and the policy of the power company was to eliminate the need for direct-current from their system as load conditions increased. The only alternative remaining was a conversion to A. C. operation.

The trend today with all progressive utilities producing electric power is to gradually eliminate from their systems loads requiring direct current for their operation. The main advantages to be gained from this conversion are reduction in losses, more flexible means of transmission and distribution, and greater convenience and economy in making additions or extensions to the electrical system. Many authors do not altogether agree on this subject; however, there are many books now available covering the subject, and for further study, reference is made to them.

### Basis of Calculations.

At the present time, the lighting load in the building is by far the largest and most important, and is also the type of load wherein the greatest number of changes and additions must be anticipated. Therefore, lighting circuits and feeders must be designed not only to meet present requirements, but also to provide adequate capacity for future growth and expansion.

The Government has recently adopted as a standard requirement for general office lighting, based on many years experience and study, an arbitrary figure of twenty (20) foot candles or five (5) watts per square foot of illumination intensity.

In illumination design, it is common practice to use the watts per square foot method of calculation, where the conditions are known and are similar throughout the installation. This method is simpler, and if used with care, good results will be obtained. However, if greater accuracy is desired, the Flux of Light Method should be always used.

In the watts per square foot method, it is necessary to know only the desired wattage per square foot and the area in square feet of the room or space to be lighted. Then wattage of lamps = sq. ft. area x watts per sq. ft. Take a room 20 feet by 20 feet. Area = 400 sq. ft. Total lamp wattage =  $400 \times 5 = 2000$  watts; hence 4-500 watt, or 2-1000 watt fixtures may be used.

In the Flux of Light Method,  $F = \frac{S \times E_a}{C \times M}$



where F = total flux in lumens illuminating room or area  
 S = area in square feet  
 $E_a$  = average intensity in foot candles  
 C = coefficient of utilization; from room index table  
 M = maintenance factor (usually 85 or 90 percent)

In a room 20 x 20 ft. square, ceiling height of 14 ft., having light ceiling and dark wall, and using semi-indirect fixtures, desired foot candles, 20. C = .25 from table.

$$F = \frac{400 \times 20}{.25 \times .90} = 35600 \text{ lumens}$$

A 500 watt lamp gives 9800 lumens

$$\text{hence } \frac{35600}{9800} = 4\text{-}500 \text{ watt fixtures are required.}$$

Upon analyzing the arrangement of branch lighting circuits as indicated on Sheet 4, it will be seen that for general office lighting, a separate circuit was provided for 2-500 watt outlets or fixtures, making 1000 watts per circuit. This may seem to be poor economy; however, a more complete analysis will prove the reasoning to be sound. Lighting loads in Federal buildings invariably increase in the course of time, and as panelboards and branch circuits are essentially a permanent part of any electrical system, it is considered good practice to provide adequate spare capacity in branch circuits so that additional outlets may be safely added or wattage of fixtures increased.

For several years it has been Government policy to use No. 12 B&S Gauge wire for branch lighting circuits, fused at 20 amperes or similar circuit breaker setting, thereby providing spare capacity for expansion and assuring satisfactory voltage at the lamps.

In the design of an electrical installation of this character,

where a multitude of various types of circuits are combined to make up the whole, the design of the branch circuit is of fundamental importance, for if an error or the wrong assumption be made here, it will accumulate to serious proportions in the final results.

The basis of calculation for branch lighting circuits for this installation was 500 watts per circuit. On this basis the current required per circuit in lighting panelboards was calculated as follows:

$$P = 1.73 EI \cos \theta, \text{ or } I = \frac{P}{1.73 E \cos \theta}, \text{ where } P = \text{power}$$

$E$  = line voltage,  $I$  = line current,  $\cos \theta = 1$  for lighting circuits

In a 3-phase, 4-wire, 120/208 volt grounded neutral system and a balanced load of 500 watts between each line conductor and neutral:

$$P = 3 \times 500 = I \times 1.73 \times 208, \text{ hence}$$

$$I = \frac{1500}{360} = 4.17 \text{ amperes.}$$

Since the average total number of branch circuits in lighting panels was about 24, of which at least 25 percent were included as spare circuits for future use, a demand factor of 0.75 may be safely applied in calculating the required current carrying capacity of busses in lighting panelboards, and also of feeders serving such panelboards in groups. Hence, the line or bus current per balanced load of 1500 watts, or the equivalent load of the basic branch circuit, =  $4.17 \times 0.75 = 3.1$  amperes.

This figure may now be applied to the total number of branch circuits in all lighting panelboards for calculating sizes of busses in panelboards and, therefore, feeder sizes for lighting risers. As an example, consider lighting riser "P" shown on Sheet 10 of the secondary contract, which serves five (5) panels, one of which has 18 circuits, 2-24 circuits and 2-28 circuits including spares. Hence, the required current capacity of riser "P"

$$I_p = (18 + 2 \times 24 + 2 \times 28) \times 3.1 = 378 \text{ amperes}$$

Since lighting riser "P" is serving several panels a demand factor of 0.8 was applied here.

$$\text{Therefore, } I_p = 378 \times .8 = 302 \text{ amperes}$$

From standard tables, it is seen that a 350 MCM feeder is required - capacity 300 amperes. The next step is to calculate the voltage drop for a 350 MCM feeder to determine whether size is adequate.

Using  $V = IZ$ , where  $V$  is volts drop between lines  
 $I$  = line current,  $Z$  = effective impedance per 1000 feet per ampere, referred to line voltage. Power factor of unity is again taken for lighting circuits.  
 Distance from switchboard to distribution center of load = 260 feet.

$$\text{Hence, for Riser "P", } V = 302 \times (0.031 \times 1.73 \times \frac{260}{1000}) = 4.2 \text{ volts}$$

With a bus voltage of 208, the voltage at the load center would be  $208 - 4.2 = 203.8$  volts

$$\text{Therefore, voltage of branch circuit} = \frac{203.8}{1.73} = 117 \text{ volts}$$

Note: In case of lighting feeder calculations, impedance = resistance.

Good engineering practice permits a maximum drop of 3 volts at the lamps; therefore, this feeder is of adequate size. This system of calculation was used throughout for all lighting feeders.

Calculations for power feeders and motor circuits were made in a similar manner, using full load running currents in all cases, except for elevator feeders, which were calculated on the basis of full load starting currents of the motor-generator sets, since gearless traction, variable voltage, high-speed machines were used in all cases. The ultimate lighting load in the building, calculated on the basis of 5 watts per square foot, or an illumination intensity of 20 foot candles

as previously outlined, and a demand factor of 0.8, was 1200 kilowatts, and the power load at 325 kilowatts at 0.6 demand factor, giving a total ultimate demand of approximately 1500 KW.

This meant that either 3-500, or 2-750 KVA transformers would be required in continuous operation to insure reliable service, with one additional transformer of the same size for a standby in case of failure of one of the others. After considerable study of the problems involved combining arrangement of equipment in the available space, spare capacity, future growth, total cost, etc., it was decided to use 3-750 KVA transformers, each having its own high-tension (13 KV) feeder from the power company's underground system.

The entire project was designed and specifications written on this basis. However, when the bids were all in, it was very evident that certain alternative bids must be accepted in order to keep the total cost of the project within the appropriation of \$150,000, as the lowest bid for the secondary work alone ran to about \$130,000. This meant that certain features incorporated in the original design had to be omitted for the present at least, or until some future time when, it is hoped, additional funds will become available and the ultimate objective may be achieved in accordance with the original design.

It is desired at this point to emphasize the fact that, although several changes were made in the basic design due to the necessity of accepting certain alternative bids such as the omission of the "Type B" disconnect cubicles, the substitution of 500 KVA transformers for 750 KVA transformers, the use of four (4) 300 watt outlets per branch circuit instead of 2-500 watt outlets, the omission of the rewiring of certain

portions of the building, and several others of less importance, the basic design has not been changed materially; a good job will still be obtained and conditions will be improved greatly. Moreover, with the single exception of the transformers, all omissions and changes that have been made can easily be added or changed to approximate the original results.

For this reason, all material presented in this thesis, including written matter, construction and material specifications, drawings, etc., are based on the ultimate objective as hereinbefore outlined.

In view of the fact that in the first, or primary, contract, certain low-tension work, such as new elevator feeders, emergency lighting and other related work, was necessary at that time in order to coordinate the various projects with a prearranged construction program, it will be noticed that this secondary work is shown on the primary contract drawings. However, in arranging the material in the thesis, the work and material required in each system, primary and secondary, are presented entirely separate to prevent overlap and to show the requirements for each in its true light.

## MATERIAL AND CONSTRUCTION SPECIFICATIONS

### A. PREPARATION OF SPACE AND DEMOLITION WORK

1. Scope of Work. The work to be performed under this section of the specifications shall consist of furnishing all labor, equipment and materials necessary to remove certain existing equipment in Rooms Nos. 094 and 096 and to make alterations in the existing building structure as may be required for installing the new work as specified.

The work shall include, among other things, the following major items:

1. The disconnecting and removing of one 400-KVA generator and the Ridgeway Uniflow Engine.
2. The disconnecting and removing of one cast-iron condenser.
3. The disconnecting and removing of all obsolete piping and valves in the above mentioned rooms and the capping of existing piping connections after the obsolete piping has been removed. All obsolete piping in the corridor will be removed by the United States.
4. The removing of certain wood and brick flooring, concrete floor slab, concrete foundations, etc., as indicated on the contract drawings.
5. The cutting of existing concrete footings as may be necessary for installing new concrete floor slabs, etc.
6. The moving of certain existing piping to permit the installation of the new work.
7. The removing of existing walls and partitions, as indicated on the contract drawings.
8. The removing of certain existing doors and windows, as indicated on the contract drawings.
9. The making of such excavation as may be necessary in connection with the work and the disposal of excess excavated material.
10. The filling in of the existing pit beneath the transformer room.

In this connection attention is directed to the fact that certain existing piping will be removed by the United States, as is indicated on the contract drawings.

All existing equipment and materials removed as herein specified and as may otherwise be necessary for the installation of all new work included under the contract shall become the property of the Contractor and shall be removed from the site of the work and disposed of by him.

2. Wrecking. All work of demolition and wrecking shall be executed in a careful and orderly manner and as approved by the Contracting Officer. If necessary, all materials shall be thoroughly wet down to prevent dust from rising from the debris during wrecking or moving.

All salvaged materials shall be promptly removed from the site and the premises shall be kept free of debris and salvaged material and shall be clean at all times.

Portions of the sub-basement are occupied and will remain occupied during this contract, and the Contractor shall arrange his work so as to cause the least amount of disturbance and dirt in these occupied areas. The Contractor shall provide canvas curtains or other approved screens to protect spaces adjacent to the site of the work from flying dust, etc.

3. Excavation. The Contractor shall make all excavation necessary to permit the installation of all concrete floor slabs, footings, concrete manhole, etc., necessary for a complete and satisfactory installation of the required work. All excavation shall be executed by hand and in such a manner to cause no injury to the existing structure. All

excavated material not used in connection with other portions of the work shall be removed from the site of the work by the Contractor.

4. Earth Fill. All material for filling purposes shall be clean earth, free from rocks, cinders, rubbish, etc., and shall be subject to the approval of the Contracting Officer. All fill shall be placed in layers not over 6 inches in depth and shall be thoroughly compacted. It shall be graded level and to the proper elevation to receive the new concrete floor slab. All back fill adjacent to footings shall be thoroughly compacted.



## B. STRUCTURAL CHANGES.

This work shall consist essentially of the following items:

1. The furnishing and installing of concrete floors, footings, foundations, manhole, cement base, etc., as indicated on the contract drawings.
2. The furnishing and installing of brick walls, closures for existing openings, etc., as indicated on the contract drawings.
3. The furnishing and installing of a tin-clad, sliding fire door, together with track, supports, carriers, pulleys, weight, fusible link, roller guide, stops, etc., as indicated on the contract drawings.
4. The furnishing and installing of fire dampers, louvers, structural steel lintels, kalamein and fire doors, man-hole frame and cover as indicated on the contract drawings, the performing of all painting, stuccoing, etc., as specified.

All concrete used in connection with the work shall be an intimate mixture of portland cement, fine aggregate, coarse aggregate and clean water which shall be mixed in such proportions that the finished concrete will contain not less than six (6) bags of cement per cubic yard of concrete measured in place and not more than 6-1/2 gallons of net water per bag of cement.

The cement and fine and coarse aggregates shall comply with the applicable requirements of Federal Specifications SS-C-191a or SS-C-291, and SS-A-281, respectively. All aggregates shall be Grade "A" and the maximum size of the coarse aggregate shall be 3/4 inch. The aggregate shall be proportioned in the ratio of 0.9 to 1.2 parts of fine aggregate to two parts of coarse aggregate by loose volume measured dry.

All reinforcing bars for concrete shall be rolled from new billets made by the open-hearth process and shall conform with the requirements of Federal Specification QQ-B-71 for intermediate billet steel.

All fabric (mesh) reinforcement shall consist of longitudinal main members with transverse members at right angles and adequately welded thereto. The steel fabric shall conform with the requirements of A.S.T.M. Standard Specification for cold drawn steel for concrete reinforcement, Serial Designation A 82-34.

All reinforcing steel shall be free of loose rust, scale, mortar and any other coating material which will reduce the bond between the steel and the concrete.

All steel reinforcement shall be of proper length and shall be bent and placed in strict accordance with the contract drawings. It shall be firmly held in place during the placing of the concrete by fastening the bars at all crossings and splices by means of wire or other approved clips, by the use of bars or other suitable spacers or by special fastenings where necessary.

All exposed surfaces of floors, steps, raised sills, cement bases, etc., shall, except as is otherwise provided, be finished to give a smooth hard troweled surface.

The treads of all steps shall be finished with a sand float finish.

All brick shall be hard-burned, common brick meeting the requirements of Federal Specification SS-B-656, Grade M.

They shall be of such color and texture as will match the color and texture of existing brick masonry at the site of the work.

All mortar for brickwork shall consist of 1 part portland cement and 3 parts sand by dry volume to which lime putty, not to exceed 20 percent of the volume of the cement, shall be added, as may be necessary for a workable mixture.

The cement and sand shall conform to Federal Specifications Nos. SS-C-191a and SS-S-51, respectively. The lime shall be either hydrated lime complying with Federal Specification No. SS-L-351, or pulverized quick lime complying with Federal Specification SS-Q-351, Type C. Pulverized quick lime shall pass a No. 20 sieve and at least 90 percent shall pass a No. 50 sieve.

Lime putty shall be a stiff mixture of lime and water, thoroughly slaked and allowed to cool. Putty shall soak not less than 24 hours after cooling and shall be kept moist until used.

All brickwork shall be constructed to conform accurately to conditions existing at the site of the work and shall be plumb, straight and true.

All bricks shall be drenched with water immediately before being used and shall be shoved into full beds of mortar.

All brick construction shall match existing work as to header courses, mortar joint thickness, etc. All joints shall be completely filled and all masonry shall be bonded or anchored to abutting work.

The surfaces of all brickwork, except those to be stuccoed, shall be finished smooth with full troweled joints.

The Contractor shall furnish and install a concrete encased duct line constructed of four 3-1/2-inch round fiber ducts of standard manufacture equipped with Herrington joints and free from faulty workmanship and material. The ducts shall be arranged in the form of a square and the maximum distance between the centers of adjacent ducts shall be approximately 5 inches.

The ducts shall be securely held in place with reference to each other, shall be enclosed in a concrete envelope of such size that the distance from the exterior surface of any duct to the outside of the envelope at any point will be not less than 3 inches. Separators used to hold the ducts in position during the placing of the concrete shall be constructed of concrete.

Where the ducts terminate in the manhole they shall be provided with porcelain duct bells of an approved type.

All galvanized sheet metal shall comply with the applicable requirements of Federal Specification QQ-I-696, Type II, Class "C" and shall be of the gauge specified or indicated on the contract drawings.

The Contractor shall furnish and install six Type "A" louvers and one Type "B" louver in the locations indicated on the contract drawings. All type "A" louvers shall be rigidly constructed of structural steel angles not less than 3 inches by 3 inches by 1/4 inch in size, which shall be welded to a 7-inch, 9.8-pound standard channel frame and so designed that there will be no direct opening through the louvers, as indicated on the contract drawings.

All Type "A" louvers shall be provided on the outside with a

substantial 1-inch diamond mesh galvanized iron wire screen constructed of No. 10 A.W. gauge wire or larger and mounted in an approved 1-inch by 3/8-inch channel frame bolted in place.

All surfaces shall be primed with an approved red lead and oil paint prior to installation. All exposed surfaces shall be given two field coats of approved lead and oil paint subsequent to installation.

The type "B" louver shall be constructed of No. 16 U.S. Standard gauge galvanized sheet steel and in accordance with the detail indicated on the contract drawings. It shall be constructed so that it will fit accurately into the opening for which it is intended. The Type "B" louver shall be finished with two coats of lead and oil paint subsequent to priming.

Fire dampers shall be provided in all locations indicated on the contract drawings. These shall be constructed of No. 16 U. S. Standard gauge galvanized sheet steel as indicated on the contract drawings. Each fire damper shall be provided with an approved fusible link and, if necessary, the toggle bar connecting the several blades shall be weighted to insure a positive closing of the damper in the event of the fusing of the link.

The Contractor shall furnish and install a sliding fire door for the entrance to the transformer vault as indicated on the contract drawings.

The sliding fire door shall be metal clad, Class A, in strict accordance with the rules and regulations of the National Board of Fire Underwriters.

The sliding door shall be constructed with cores consisting of three thicknesses of 13/16-inch dressed white-pine boards free from sap or loose knots, tongued and grooved, dressed on both sides, and not over 8 inches in width. All layers shall be securely fastened together with all corners smooth and true. The boards of the outside layers shall be vertical and those of the inner layer horizontal. The tin covering shall be primo terneplate I. C. thickness, in sheets of 14 inches by 20 inches applied with 1/2-inch block joints thoroughly nailed. The door shall be provided with approved hand pulls.

The sliding door shall have weights, supports, carriers, roller guides, stops, pulleys and chains that will hold the door open in any desired position. Such equipment shall be so arranged with links that will fuse between the temperature of 160 and 165 degrees F., as to insure a closing of the door in the event of a fire.

The door shall receive a shop coat of red lead and two field coats of lead and oil paint of approved color.

Swinging fire doors shall be provided for the openings into the cubicle room, together with all necessary hardware. These metal clad doors shall conform with all applicable requirements of the National Board of Fire Underwriters and shall be constructed in the manner specified for the sliding fire door.

For both of these openings the Contractor shall furnish and install approved structural steel channel bucks provided with metal stops. The doors shall be installed flush with the outer face of the bucks. The bucks shall be drilled and machined for the installation of the hardware.

The door leading into the east end of the cubicle room shall be provided with a fusible link, weight, pulleys, chain, etc. These shall be so arranged that in the event of a fire and the fusing of the link, the door will be pulled shut.

A reinforced concrete manhole shall be installed as indicated on the contract drawings. This manhole shall be provided with a circular cover and frame. The cover and frame shall be constructed of cast iron, of an approved design and have a clear opening of not less than 24 inches in diameter.

Depressed lifting rings or other approved means for removing the covers shall be provided.

The iron castings shall conform with the requirements of Federal Specification QQ-I-656 for gray-iron castings.

Provisions shall be made in the bottom of the manhole to permit drainage into a gravel-filled pocket beneath the manhole, which shall be approximately two feet in all dimensions.

Detail of the complete manhole shall be submitted for approval.

The Contractor shall paint all structural steel, sheet metal work, doors, louvers, dampers, screens, switchboards, cubicles, etc., as specified.

All structural steel shall be primed with red-lead and oil paint and all exposed surfaces finished with two coats of an approved lead and oil paint of selected colors.

All galvanized metal work to be painted shall have a phosphate

pre-treatment, shall be primed with one coat of red lead and oil paint, and finished with two coats of an approved lead and oil paint colored as directed.

All work furnished with factory priming applied shall be finished with two coats of an approved lead and oil paint colored as directed.

The Contractor will be required to perform all work necessary to reconstruct, repair and refinish any and all destroyed or damaged portions of the building incident to all work executed under these specifications and to retouch and repair all ceilings, walls, floors, trim, etc., where so made necessary because of the new work and in order that they may conform and be in keeping with the general finish and decoration.



## C. ELECTRICAL WORK.

### (a) HIGH VOLTAGE SYSTEM

1. Scope of Work. The work to be performed under this section of the specifications shall consist of furnishing, installing and connecting in every detail, all material, equipment and devices required to provide a new primary alternating-current distribution system for the State Building, as indicated on the contract drawings and as is hereinafter specified.

The work shall include providing all necessary material and labor for a complete, high class, and satisfactory installation and may be divided into the following major items:

- (a) The furnishing and installing of high-tension switching equipment, including cubicles, disconnecting switches, oil circuit breakers, instrument transformers, relays, interlocks, insulators, barriers, bus-work, wiring connections and all necessary accessories required for a complete installation.
- (b) The installation of all necessary primary connections between cubicles and transformers, including conduits, cables, potheads, etc.
- (c) The furnishing and installing of network transformers, including high-tension switches, network protectors, balancing transformers and circuit connections, and all necessary auxiliary equipment and accessories.
- (d) The installation of a new battery and charging panel to supply trip current for the oil circuit breaker protective devices, including all necessary auxiliary equipment, accessories, circuits and connections.
- (e) The installation of a transformer position indicator panel in the electric shop, including lamp sockets and pilot lights, and all necessary circuit wiring and conduit connections.

- (f) The installation of a primary metering panel for recording the power consumption of the system, including the installing of all necessary instruments, metering apparatus, secondary leads, demand meter circuit and all other miscellaneous material and connections required for a complete installation. Attention is directed to the fact that certain equipment will be furnished by the Power Company. All other equipment not to be furnished by the Power Company shall be furnished and installed by the Contractor.

The attention of the Contractor is directed to the fact that the existing direct-current distribution system in the building is to remain intact, excepting the changes required to provide the necessary new alternating-current circuits for the new high-tension installation, as herein specified.

All necessary working drawings, wiring diagrams, test data, etc., shall be submitted on all electrical equipment proposed for use under this contract. It is further emphasized that all such drawings and descriptive and test data, required by the Contracting Officer to determine whether or not each piece of equipment is suitable for the installation and designed to function properly with all other related equipment, shall be submitted complete, before any portion of the work to which they relate is begun.

The work specified herein shall be furnished and installed in a workmanlike manner and in complete working order. The workmanship shall be the best known to the respective trades employed.

Certain standards established for the Electrical Trade shall be applicable to the work specified and shall, unless otherwise indicated, be followed and considered as being incorporated in these specifications. They are as follows:

- (a) The National Electrical Code of the National Board of Fire Underwriters.
- (b) The rules and requirements of the local electric company supplying the current.
- (c) The rules and regulations of the local Electrical Code.
- (d) The standardization rules of the American Institute of Electrical Engineers.
- (e) The standardization rules of the National Electrical Manufacturers Association.

The foregoing rules and requirements shall be followed by the Contractor as minimum requirements, but they shall not relieve the Contractor from furnishing and installing higher grade materials and workmanship when and wherever specified.

All tests, required by the Contracting Officer to show that the requirements of the specifications, and the rules and regulations made a part hereof have been fulfilled, shall be made by and at the expense of the Contractor. All instruments and materials necessary for complete tests shall be furnished and delivered to the building by and at the expense of the Contractor. The tests shall be performed at a time convenient for the Contracting Officer.

2. Incoming High-Voltage Service. Alternating current service for the building will be supplied by three (3) new 13,200-volt, 3-phase, 3-wire, 60-cycle feeders which will be installed by the Potomac Electric Company.

The Government will make the necessary arrangements with the power company for the installation of the high-voltage feeders.

The installation of the entire primary system, including cables,

ducts, potheads, equipment, etc., shall be in strict accordance with the rules and regulations of the power company. The Contractor shall submit for approval all drawings necessary to show the complete assembly of the equipment in the transformer vault and the arrangement of the entire primary installation before any part of the incident work is undertaken. Such drawings will be submitted to the power company for its approval and all revisions required in such drawings in order to provide an installation satisfactory to the power company shall be made.

3. Equipment Furnished by the Power Company. The Potomac Electric Power Company will furnish and install the three (3) primary feeder cables to the potheads at the cubicles.

The power company also will furnish and deliver to the Contractor the necessary cable potheads, current and potential transformers, current-limiting resistors, fuses and a steel metering panel which shall be installed by the Contractor under the supervision of the power company.

The power consumption of the new A. C. service will be recorded by the power company by means of watt-hour meters to be installed on each incoming primary feeder. The Contractor shall install the metering panel in the location indicated on the contract drawing for the installation of the meters by the power company.

The Contractor, furthermore, shall furnish and install two (2) 1-1/2-inch conduits between each Type "A" metering cubicle and the metering panel. One such conduit shall be used for the metering current-transformer secondaries, the other for the potential transformer

secondaries.

4. High-Voltage Cubicles. The Contractor shall furnish and install in the high-tension cubicle room, three (3) Type "A" oil-circuit-breaker cubicles, and three (3) Type "B" disconnecting cubicles as herein specified.

The cubicles shall be complete in every detail, including all necessary control wiring, terminal blocks, cleats, ground wiring, control apparatus and all small items of materials and equipment that may be required to provide a complete and high-class installation.

Each primary-feeder cubicle, designated herein as Type "A", shall be used for metering and shall contain the following equipment:

One (1) set of 3-pole, single-throw, gang-operated disconnecting switches equipped with interlocks as herein-after specified.

One (1) manually-operated oil circuit breaker.

Two (2) current-transformers for metering, to be furnished by the power company and installed by the Contractor.

Three (3) current-transformers, (one in each leg of line) and all necessary relays, tripping coils and auxiliary equipment to provide adequate protection against overload and ground.

One (1) set of current test switches.

Two (2) potential transformers for metering, including current-limiting fuses, resistors and disconnect switches, all to be furnished by the power company and installed by the Contractor.

A through-type wiring trough.

The necessary pilot lights to indicate the position of the oil circuit breaker and trip circuit.

Each other cubicle, designated herein as Type "B", shall be used as a disconnecting means for two (2) main feeder circuits supplying two (2) transformers, one of which is to be installed under this contract, and the other in the future by others.

The Type "B" cubicles shall be equipped with two sets of 3-pole, single-throw, gang-operated disconnecting switches equipped with approved interlocks, as hereinafter specified, suitable through-type bushings and pothead supports, and steel and asbestos insulating barriers.

Each cubicle shall consist of a structural-steel enclosure carefully braced and welded into a rigid structure which shall maintain proper alignment and not be damaged in either shipment or erection, or by mechanical stresses resulting from short circuits. The cubicles shall be completely enclosed on front, sides, back and top with rugged sheet-steel plates not less than 1/8-inch in thickness, reinforced where required and provided with adequate louvers for ventilation. The front plates shall be made of smooth panel steel. The interior framework for supporting equipment shall be an integral part of the cubicle frame.

Sheet-steel barriers shall be provided to divide the interior into compartments completely segregating the oil circuit breaker, the current-transformers and busses, the potential transformers, and the main-line disconnects from each other.

The front and rear plates of each cubicle shall be hinged to the frame and shall be provided with approved cylinder locks of the tumbler type. Three (3) keys shall be provided which will fit all cylinders other than those in entrance-door locks. All doors shall be accurately hung and aligned so as to fit snugly against the frame when closed.

Each unit shall be complete within itself, and, where units are to be mounted adjacent, they shall be secured to each other by means of suitable bolts so that any unit can be removed without disturbing other adjacent units.

Suitable channel-iron sills shall be provided for each cubicle. They shall be grouted into the floor in an approved manner and properly drilled for bolting the cubicles thereto.

On the front of each Type "A" cubicle a smooth steel panel shall be provided for mounting instruments, relays, etc., as hereinafter specified. Panel shall be hinged to the frame and be provided with cylinder locks and keys as specified for cubicle doors.

Insulating barriers of an asbestos, molded phenolic or an approved equivalent composition, shall be provided between and on the outside of all disconnect switches and elsewhere as indicated. All such barriers that are mounted horizontally shall be not less than one (1) inch thick for asbestos compositions and 1/2-inch thick for the molded phenolic. Those mounted vertically shall not be less than 1/2-inch thick for asbestos compositions and 3/8-inch thick for the molded phenolic. All barriers adjacent to disconnecting switches shall extend not less than six (6) inches beyond the arc described by the extreme end of the switch blade when rotated through 180 degrees from the closed position.

The cubicles shall be painted two (2) coats, both inside and outside, the first being a rust-resisting coat and the second a dull black finishing coat on the outside, and a gray finishing coat on the inside. Rust spots, scratches, etc., occurring during erection or otherwise shall be touched up with priming paint and dull black or gray finish

paint and the entire outer surface given a rubbing with an approved polishing oil.

The doors in front of the disconnecting switch compartment shall be equipped with approved wire-glass windows not less than nine (9) inches in height so that the position of the disconnecting switches can be easily determined.

Attention is directed to the fact that the clear headroom in the cubicle room will be approximately 10 feet 3 inches from floor to cross-beams. All necessary equipment required within the cubicle structures shall be arranged in such a manner that the structures can be installed within the available space.

All cubicles proposed for use under this contract shall conform fully with the latest standards of the A.I.E.E. and N.E.M.A., and shall be subject to the approval of the Potomac Electric Power Company.

Complete detailed shop drawings, wiring diagrams, information and test data covering all equipment within the cubicle shall be submitted for approval before manufacture of the cubicles.

(a) Oil Circuit Breakers. The Contractor shall furnish and install within each Type "A" cubicle, as previously specified, an oil circuit breaker of an approved design and of highest-quality construction throughout.

The oil circuit breakers shall be 3-pole, single-throw, rated at 600 amperes and 15,000 volts and of the automatic, manually-operated type, having an interrupting capacity not less than 250,000 KVA based on a standard 15-second, two open-close-open duty cycle.



The breakers shall have a short time current carrying capacity of not less than 30,000 root-mean-square amperes for five (5) seconds and 50,000 amperes for one (1) second.

The oil circuit breakers shall be of the indoor, non-oil-throwing type and properly designed with all moving parts having positive and accurate alignment, liberal factor of safety under the most severe operating conditions, and ample clearances in any position.

The main contacts of the breakers shall be of the full-floating, self-aligning, full-contact type having silver to silver contact surfaces, suitably designed to provide full-contact pressure, and opening and closing at full-contact position. The arcing contacts shall be designed to incorporate the most modern principles of arc interruption, such as deiongrid, oil blast or approved equal in operation, to reduce the arcing time to a minimum.

The breakers shall be designed for enclosing the three (3) poles in the same tank. They shall be suitable for use with a windlass-type tank-lifting device which shall be furnished by the Contractor, and properly mounted in the cubicle so that the tank can be removed while the breaker is in the closed position.

The oil tanks shall be constructed of heavy plate steel of ample strength to withstand the maximum stresses due to short circuit currents, and shall be provided with suitable means to prevent oil throwing during operation. An exhaust valve shall also be provided to relieve excessive pressure in the tank which may occur during interruption of a short circuit. The circuit breakers shall equal or exceed the latest require-

ments of the A.I.E.E., with regard to insulation and heating of parts under all conditions.

The required amount of oil, of the highest grade obtainable and having a high dielectric strength, high ignition point and high resistance to carbonization shall be furnished with each breaker.

The Contractor shall submit for approval test data showing the characteristics of the oil he proposes to furnish.

Each breaker shall be equipped with suitable trip-free operating mechanism as well as with an operating handle or other approved means for manual opening or closing of the breakers as desired. Manual operating mechanism shall be enclosed within the cubicle.

The breakers shall be provided with over-current protection, as is hereinafter specified.

(b) Oil-Circuit-Breaker Protection. Each oil-circuit breaker in the Type "A" cubicles shall be equipped with three (3) induction-type, over-current relays, two (2) with 4-15 ampere, and one (1) with 2-6 ampere, 60-cycle operating coils. These over-current relays shall be equipped with instantaneous over-current trip devices to provide instantaneous tripping of the oil circuit breaker on very high fault currents and time-delay tripping on low-value ground currents. Target coils shall be furnished to operate satisfactorily with the trip coils of the breakers.

The relays having operating coils rated at 4-15 amperes shall be connected to provide over-current protection, and the other relay with the operating coil rated at 2-6 amperes shall be connected to provide

ground protection.

The method of connecting these relays is shown on the contract drawings. However, such connections shall be subject to the approval of the power company.

The relays shall have single-circuit closing contacts and be designed to operate from the secondaries of the current transformers, as is specified elsewhere in these specifications.

All relays shall be of the semi-flush type and shall be mounted symmetrically on the front panel of the cubicle.

Test switches or links shall be supplied and installed on each Type "A" cubicle for each relay or group of relays and shall be properly labeled for easy identification. The switches shall be rated at 30 amperes and shall be protected with a removable cover. Units shall be suitable for testing and setting relay calibrations without disconnecting the relay control wiring.

Energy for tripping the oil circuit breakers shall be supplied from a battery of not less than 24 volts, as is hereinafter specified.

(c) Disconnecting Switches. The Contractor shall furnish and install disconnecting switches in all cubicles, one (1) set in each Type "A", and two (2) sets in each Type "B" cubicle, as hereinbefore specified.

The disconnecting switches shall be of the porcelain post insulator type, and have ratings of not less than 600 amperes and 15,000 volts. Each set shall be provided with a gang-operating mechanism that can be

operated from the front or in the compartment housing the breaker-operating mechanism of the cubicle.

The operating mechanism shall be rugged yet simple in construction and protected with adequate insulation. Adequate means shall be provided for mechanically and independently locking the switch operating mechanism at will in either the "open" or the "closed" position.

The switches shall have suitable contacts insuring minimum temperature rise and constant high contact pressure between switch and blade. Connections shall be made so that the switch blades will be de-energized when the switch is in the "open" position.

The switches shall be made of high grade, hard-drawn switch copper, shall be of double-blade construction having self-aligning contacts with phosphor-bronze spring washers. Each switch shall be mounted securely on an individual metal base. When carrying rated current, the heating limits in any part of the switch shall not exceed those specified under the latest rules of the A.I.E.E.

The blades of the switches shall be mounted on centers not less than fifteen (15) inches apart between phases and not less than seven and one-half ( $7\frac{1}{2}$ ) inches between phase and side plate of the cubicle. The switches shall be arranged in the cubicles so that the clearance between any structural member of the cubicle and the extreme end of the switch blades when in the "closed" position or in any rotated position through 180 degrees will be not less than seven and one-half ( $7\frac{1}{2}$ ) inches.

The installation of the main-line disconnects in the Type "A" cubicles will be subject to approval by the power company.

(d) Insulators, Supports and Bushings. All insulators required for mounting equipment in the cubicles shall be of the porcelain type, manufactured by the wet process method, and of the one-piece, standard interchangeable type. They shall be homogeneous in structure and without laminations, cavities or other flaws affecting their mechanical strength, and shall be vitrified and non-hydroscopic. All exposed surfaces of each porcelain body shall be glazed all over and surfaces in contact with cement shall be thoroughly sanded.

The glazing shall be impervious to moisture and free from all mechanical imperfections. The insulators shall have a nominal rating of 15,000 volts. They shall be not less than five (5) inches in diameter and otherwise in accordance with Class A-3 of N.E.M.A. Standards.

After assembly, all insulators shall be capable of withstanding a dry flash-over test of 60,000 volts at 60 cycles.

All insulators used for bus supports shall conform to insulator standards herein specified, and shall be of the same class, diameter and rating. Bus clamps of an approved type and design shall be provided for all supports.

Bus supports shall be able to withstand flashover values as specified for insulators and shall be securely bolted to suitable channel irons or plates and rigidly secured in the cubicles.

Approved high-voltage bushings shall be installed in the cubicles at all points where insulated high-voltage wiring or busses pass through the barriers or walls. All such bushings required shall be made of high grade, wet-process porcelain having a wall thickness not less than

7/8 inch and of sufficient length to project not less than four (4) inches beyond both sides of plates or walls through which they pass. The bushings shall be rigidly secured in an approved manner to the medium through which they pass.

(e) Wiring Connections. The cubicles shall be completely wired, including all necessary connections, insulators, cleats, terminals and terminal boards, etc., required for a satisfactory and high-class installation.

Primary connections between all items of equipment shall be made of cable molded-phenolic tubing, channels or copper bus bars thoroughly insulated for 15,000 volts working pressure. All current-carrying parts, except the terminal posts and switch blades of the disconnecting switches shall be fully insulated in an approved manner. All secondary wiring and control wiring shall be No. 12 B&S Gauge wire or larger, varnished-cambric insulated for 600 volts, and finished with a heavy fire-resisting braid thoroughly impregnated with a flame-proof compound. Such wiring shall be run in conduit or otherwise adequately protected from mechanical injury in an equivalent manner and shall be effectively shielded from high-voltage circuits by barriers or conduit. All wiring shall be furnished and installed complete from all sources of supply to all items of equipment and devices to be supplied as may be necessary for proper functioning of the system.

The Contractor shall furnish and install in each Type "A" cubicle two (2) 1-1/2-inch conduits and all necessary fittings from the metering transformers to a junction box near the floor under the cubicles and from there in the floor to the metering panel as indicated on the contract drawings.

The Contractor shall also furnish and install a 1-1/2-inch conduit between the emergency lighting panel and the metering panel for the demand meter circuit. All such metering conduits shall be installed in the new floor slab as directed by the Contracting Officer and terminated in a manner suitable to the power company.

The power company will supply and deliver to the Contractor all necessary wires and meter leads for connecting the meters and the metering instruments. The Contractor shall install all such wires in the conduits and the power company will make all final connections at the transformers and meters.

The demand-meter circuit wiring shall be furnished and installed by the Contractor but will be connected to the meter by the power company.

(f) Tripping Transformers. The required number of current transformers shall be provided in all oil-circuit-breaker cubicles as hereinbefore specified.

The transformers shall be of the indoor, dry type, insulated for 15,000 volts and having a current ratio of 100/5 amperes.

They shall be designed to have a mechanical and thermal rating sufficient to withstand the effects of short-circuit currents, mechanical stresses, and heating effects equal to the rating of the oil-circuit breakers previously specified.

Accuracy of the current transformers shall be in accordance with the latest classification of the N.E.M.A. and all transformers shall be

properly classified for the burden imposed upon them in accordance with rules and regulations set forth in the classification.

All current transformers shall be properly identified for polarity with standard marking and symbols. The transformers shall be capable of carrying rated primary current continuously with open secondaries, without damage to the insulation, and shall be of ample capacity for the burden imposed upon them.

(g) Interlocks. Mechanical interlocks of an approved key type, or direct connected linkage shall be provided in all cubicles and shall be so designed and arranged in the cubicles that neither the main line disconnecting switches nor the feeder disconnects can be opened while the oil circuit breaker connected to the same feeder is in the "closed" position.

Interlocks shall also be provided between the disconnecting switches and the doors of the compartments housing the switches. The interlocks shall prevent the opening of the doors when the switches are closed and the closing of the switch when the doors are open.

5. Potheads and Mountings. The necessary cable potheads for terminating the incoming primary feeders at the cubicles will be furnished by the power company, but shall be installed by the Contractor in an approved manner and as directed by the power company. All other potheads required in the installation shall be furnished by the Contractor and installed in an approved manner.

The potheads shall be of the three-conductor, indoor through type with diverging insulators, having a nominal voltage rating of 15 KV and



a minimum dry flashover value of 60 KV. The potheads shall be not less than No. 1/0 in size and shall be designed with the standard stuffing-box conduit type of cable entrance fitting suitable for direct conduit connection.

The potheads shall be filled with the proper amount of high-voltage compound of the highest grade obtainable and having a dielectric strength adequate to withstand the maximum operating requirements specified.

Suitable and approved pothead mountings shall be supplied by the Contractor and installed on the front and near the top of the Type "A" cubicles for mounting the incoming feeder potheads.

The mountings shall be made of steel angles, channels and plates of adequate strength and thickness, and shall be securely bolted or welded to the cubicles to provide a rigid and permanent installation.

An opening shall be provided in the Type "A" cubicles of such size as to give proper clearance between pothead bushings where they enter the cubicle.

Similar pothead mountings shall be provided and installed in Type "B" cubicles for feeders to transformers, as indicated on the contract drawings.

6. Storage Battery and Charging Unit. The Contractor shall furnish and install in the cubicle room a 48-volt, heavy-duty, storage battery of the lead-acid type, consisting of 24 cells and having not less than 120-ampere-hour capacity based on an 8-hour discharge rate.

The cells shall be constructed of Plante-type positive plates and Plante-type or box-type negative plates. The separators for the plates shall be constructed of high-quality materials and designed to last the full life of the battery. The elements of each cell shall be assembled in moulded or blown-glass jars with sealed covers constructed of acid-resisting material and provided with spray-proof vents.

The Contractor shall furnish and install suitable racks on which to mount the batteries. The racks shall be substantially constructed of steel and installed as directed by the Contracting Officer.

The Contractor shall also furnish, install and connect complete for proper operation, a suitable and approved dry-plate charging rectifier unit. The charging unit shall be suitable for floating the battery on the line and for continuous charging at a rate recommended by the manufacturer of the battery to maintain it in a charged condition.

The charging rate shall be adjustable from  $1/4$  to 2 amperes, and shall have five (5) stops between the  $1/4$  and  $3/4$  ampere rates.

The charging unit shall also include all necessary indicating meters, switches, wiring, etc., that may be required for a complete installation.

The meters shall be not less than 3-1/2 inches in diameter and of the flush-mounted type. The voltmeter shall be of the high-resistance type.

The Contractor shall furnish and install all necessary conduit and wiring to provide a single-phase, 120-volt power supply for charging the

battery and for supplying direct-current to the cubicles for tripping the oil-circuit breakers.

The tripping circuits shall be properly fused in each cubicle, and a small indicating lamp, back of a red-glass bull's-eye, shall be provided and connected to indicate that tripping circuits are energized.

The Contractor shall submit for approval complete information relative to the storage battery and charging equipment, including wiring diagrams, catalog data relating to equipment proposed, etc.

7. High-Voltage Lead-Covered Cables. The Contractor shall furnish and install all necessary high-voltage cables required on the primary system, excepting the main incoming feeders to cubicles, which will be supplied in place by the power company.

The cables for connecting the Type "B" cubicles with the transformers shall be of the "solid" type, 3-conductor, lead-covered and varnish-cambric insulated for an operating pressure of 15,000 volts. All cables required shall be of the highest quality obtainable, and manufactured strictly in accordance with the latest standards of the I.P.C.E.A.

The thickness of the insulation on each conductor shall be  $13/64$  inch and on the belt  $13/64$  inch. The thickness of the lead sheath shall be in accordance with the table located toward the end of this paragraph.

The varnished cloth insulation shall consist of a high-grade varnished cloth substantially free from blisters and other imperfections. It shall have an insulating compound between the layers of varnished cloth and shall meet the requirements herein specified.

Methods of sampling and testing, except as specifically covered in this specification, shall be those given under A.S.T.M., "Tentative Methods for Testing Varnished Cloth and Varnished Cloth Tapes", Serial Designation D295-37T.

The cloth shall be woven from clean, first quality, long-staple cotton yarns. The number of threads per inch shall be not less than 60 by 55. The cloth shall be free from any sizing or dressing to such an extent that the varnish may thoroughly impregnate the fabric.

The varnish used shall be prepared from selected vegetable oils, carefully blended with asphaltic materials to provide in the finished product the highest possible degree of flexibility and toughness, high dielectric strength and low dielectric losses.

The varnish coating shall be pliable and shall not crack when the varnished cloth is doubled upon itself. The number of coats of varnish on each side of the cloth shall be not less than three (3) when the thickness of the varnished cloth is 7 to 13 mils inclusive and not less than two (2) for varnished cloth less than 7 mils in thickness.

The varnished cloth shall be applied in the form of helically wound tapes. The tapes shall be of such width that they will lie smoothly and be as free from wrinkles as practicable.

A compound shall be applied between alternate layers of varnished cloth so as to exclude, as far as practicable, all air and moisture, and, together with the varnished cloth, form a firm semi-flexible wall of insulation.

The compound applied between the layers of varnished cloth shall

be a viscous, non-hardening compound having a mineral base. It shall have slow drying characteristics and shall have no deleterious effect on the varnished cloth.

Separately insulated conductors shall be cabled together with a suitable layer of tape and have the interstices filled with a sufficient number of saturated jute or paper laterals, or with other approved materials, to give the completed cable an even circular cross-section.

The lead sheath shall consist of virgin lead, not less than 99.85 percent pure. The sheath shall be formed tightly on the core, shall be of uniform thickness and composition, and shall be applied by a process which will eliminate dross, oxide, cracks and other imperfections.

The thickness of the lead sheath, based on the diameter of the core, shall be as indicated in the following table, using the major axis in the case of twin cables.

#### THICKNESS OF LEAD SHEATH

<u>Diameter of Core</u> (inches)			<u>Thickness of Lead Sheath</u> (inches)      (mils)	
.0	to	.425	3/64	47
.426	to	.700	4/64	63
.701	to	1.050	5/64	78
1.051	to	1.500	6/64	94
1.501	to	2.000	7/64	109
2.001	to	3.000	8/64	125
3.001	and larger		9/64	141

8. High-Voltage Braided Cables. All high-voltage braided cable required for making connections between the various pieces of equipment on the 13,200-volt system shall have the same insulation characteristics as specified previously for "High-Voltage Lead-Covered Cables",

except that braid covering shall be substituted for lead covering and that the varnished cambric insulation for single-conductor cables shall be not less than 26/64 inch. The cable shall be manufactured according to the Standards of the American Institute of Electrical Engineers and those of the Insulated Power Cable Engineers Association. The Contractor shall submit reports of Standard A.I.E.E. tests of the cable as well as a sample of the cable for approval.

9. Transformers. The Contractor shall furnish and install three (3) 750-KVA, vault-type, self-cooled, network distribution transformers, as indicated on the contract drawings.

The transformers shall be designed for use on a low-voltage A.C. network distribution system and shall be complete with three-position primary disconnecting and grounding switches and automatic low-voltage network protectors hereinafter specified.

The transformers shall be 3-phase, 60-cycle transformers, and shall be specifically designed to step down the voltage from 13,800 volts (nominal primary voltage) with primary system generator neutral solidly grounded and to deliver power to a nominal 208Y/120-volt 60-cycle, 3-phase, 4-wire, low-voltage, A.C. network distribution system operating with a solidly-grounded neutral. The transformer shall be capable of carrying not less than 125 percent of its rated capacity for a period of at least two (2) hours without a temperature rise in excess of the 55 degrees Centigrade hereinafter specified.

The high-voltage winding shall be connected "delta" and the low-voltage winding "wye", with the neutral lead brought out and grounded solidly to the transformer tank. The phase relations between the primary

and secondary windings shall comply fully with the latest standards of the A.I.E.E.

The transformers shall be designed for five (5) percent nominal inherent impedance and with a tolerance factor of  $7\frac{1}{2}$  percent plus or minus from the nominal in accordance with N.E.M.A. standards.

The transformers shall be suitable for group operation in parallel, and shall be capable of withstanding short-circuit currents for a period of three (3) seconds without damage to any part of the equipment under normal voltage conditions.

The transformers shall be self-cooled and filled with the required amount of an approved non-inflammable and non-explosive insulating and cooling liquid. Complete assembly shall be made at the factory, including high-voltage switches and switch chambers, and all necessary auxiliary fittings and accessories.

The design, manufacture, tests, methods of conducting tests and preparation of reports concerning the transformers proposed for use in this installation shall be strictly in accordance with the latest standards of the A.I.E.E. and of the N.E.M.A.

All material used in the manufacture of the transformers shall be of the highest quality obtainable for the purpose for which each is used, as to strength, durability, insulating qualities, and best engineering practice.

(a) Tests. All transformers shall be subjected at the factory to the following tests by and at the expense of the Contractor:

- (1) Resistance Measurement. - The cold resistance of the high-voltage and low-voltage windings shall be measured.
- (2) Ratio Tests. - During this test the transformers shall be operated at or above the rated voltage and at or below the normal voltage.
- (3) Polarity. - Angular displacement and phase sequence shall be checked with the leads connected as when ready for shipment.
- (4) No-Load Loss. - Measurement shall be made of no-load loss in accordance with the latest A.I.E.E. regulation.
- (5) Load loss and Impedance Voltage. - The load losses and impedance volts shall be measured and referred to a reference temperature of 75 degrees Centigrade.
- (6) The transformers shall be tested by the method that subjects the unit to the full-rated voltage and current simultaneously, and shall be operated self-cooled on the primary voltage tap producing the greatest loss. The temperature rise shall be determined by the resistance method and corrected to the instant of shutdown.

The transformers when tested in accordance with the latest standards of the A.I.E.E. and operating at rated load, voltage and frequency, shall deliver the rated kilovolt-ampere output continuously at the secondary terminals. This test shall be run at or corrected to an ambient air temperature of 40 degrees Centigrade and the temperature rise shall not exceed 55 degrees Centigrade when measured by the resistance method over a twelve (12) hour test run.

The Contractor shall determine by actual test the maximum overload that the transformers will carry for a period of two (2) hours without exceeding the temperature rise specified herein, after continuous operation at one-half ( $1/2$ ) the rated output until a constant temperature has been obtained.

- (7) Dielectric Tests. - Each transformer, after being completely assembled, shall be tested in accordance with the latest Standards of the A.I.E.E.

The transformers shall be guaranteed to have efficiencies at different ratings not less than the following: Full load, 98.58;  $3/4$  load, 98.72;  $1/2$  load, 98.73; and  $1/4$  load, 98.28.



All tests required by the Contracting Officer after installation, but before final acceptance, to demonstrate that the transformers are satisfactory shall be made by the Contractor at a time convenient to the Contracting Officer.

Before shipment, the Contractor shall supply the Contracting Officer with three (3) copies of a certified test report showing the results of all tests run at the factory as herein specified.

(b) Fittings and Accessories. Each transformer shall be provided with the following fittings and accessories:

- (1) An approved liquid temperature indicator. This instrument shall be a dial-type thermal indicator calibrated in degrees Centigrade and arranged to indicate continuously the temperature of the hottest liquid in the tank, by means of a black hand. A red hand, actuated by the movement of the black hand, shall also be provided and shall indicate the maximum temperature reached. Adequate provision shall be made for proper adjustment of the black hand and for resetting the red hand. Any part of the device projecting into the transformer case shall be adequately protected from accidental contact with current-carrying parts by means of substantial, metallic, perforated wells rigidly supported from the case.
- (2) A 1-1/2-inch brass globe valve for draining.
- (3) A 1-inch brass globe valve for filter-press connection near the top of the unit.
- (4) An approved spring-closing sampling valve at the 25-degree-Centigrade liquid level.
- (5) A flush-type liquid-level gauge reading maximum and minimum located at the 25-degrees-Centigrade level.
- (6) An approved spring closing sampling valve to be used for gas-pressure testing, located above maximum liquid level.

All accessories shall be designed for the particular use for which intended, and shall be properly installed in positions on the transformer in accordance with the latest standard practice of the N.E.M.A.

c. Taps and Tap Changers. The transformers shall be provided with four (4) 2-1/2-percent full-capacity taps below 13,800 volts in the high-voltage windings. No taps will be required in the low-voltage windings. A suitable and approved device shall be provided in each transformer for changing tap connections. All changes shall be made within the transformer tank and shall only be made when the transformer is disconnected from the system.

The tap changer shall be manually, gang-operated by means of a single shaft and handle brought through and outside the tank through a pressure-tight stuffing box and arranged to be securely held in position by means of locks or studs. Suitable means shall be provided on the exterior of the tank for indicating the position of all tap connections. The design and construction of the entire device shall be such as to provide positive, identical and simultaneous movement of the contact-making elements in the three (3) phases during all tap changing operations.

Suitable mechanical interlocking devices shall be provided between the primary disconnecting and grounding switches and the tap-changing devices which will positively prevent the changing of taps when the primary switch is in the "transformer" position.

(d) Primary and Secondary Leads. The high-voltage leads shall be brought out through wet-process porcelain, demountable, pressure-tight,

stud-type bushings, and shall be provided with suitable bolt-type terminals for making flexible connections to the primary disconnecting and grounding switch in the terminal chamber.

The low-voltage leads shall be brought out through stud-type porcelain bushings as above specified, and equipped with suitable bolt-type terminals for making flexible connections to the busses of a non-submersible, low-voltage A.C. network protector to be mounted on the low-voltage end of the transformer.

The low-voltage neutral lead shall be solidly grounded, with a demountable connection, to the inside of the transformer tank. The grounding lead shall be brought outside of the tank for connecting the neutral of the transformer to the neutral of the distribution system.

All leads and taps shall be supported in such a manner that all weight is removed from the coil, and shall be securely braced to prevent injury in transit, during the installation, and during periods of short circuits occurring in regular service.

All small conductors shall be properly supported at points of connection to prevent breaking of conductors due to movement of the liquid and vibration of the transformers.

(e) Tank. Each transformer shall be mounted in a pressure-tight copper-bearing-steel tank having a steel self-supporting base, and a pressure-tight copper-bearing-steel cover with suitable gaskets and secured to the case by adequate clamping or bolting attachments.

The transformer tank, the high-voltage-switch-chamber and accessories shall be capable of withstanding any internal or external

pressure encountered in normal operation without developing leaks, etc.

The tank shall be rigidly designed, and of sufficient strength to withstand safely the lifting of the core, coils, high-voltage terminal chamber, network protector and accessories assembled as a unit, and the lifting of the tank and oil without excessive distortion when the windings, cover, coils, and core are removed.

All bolts, nuts and washers shall be made of non-corrodible metal having a high tensile strength.

All glands shall be of the stuffing-box type, properly designed and have adequate provision for adjustment and repacking.

The tanks and high-voltage terminal chambers shall be painted with at least two (2) coats of suitable paint of approved type and color.

(f) Lifting Attachments. Suitable lugs or eye-bolts shall be provided for lifting the transformer by means of jacks or other equipment, so that the transformer together with the core, coils, high-voltage terminal chamber, network protector, accessories, and liquid, assembled as a unit, may be safely lifted, leveled, raised and lowered, without injury to any part. The lifting lugs shall be so located that the load will be balanced sufficiently to permit level lifting with and without the network-protector attached to the transformer.

The internal arrangement of the transformer shall be such that the case may be lifted with the cover off and the oil, core and coils removed and that the windings and core may be lifted as a unit.

(g) Name Plate. Each transformer shall be provided with a

nameplate of non-corrodible metal giving complete data in accordance with the latest standards of the A.I.E.E.

This plate shall be attached to the high-voltage end of the transformer tank, and, in addition to the information called for above, shall state in separate figures, the weight and number of gallons of liquid in the tank and in the primary terminal chamber. The serial number of each transformer as given on the name plate shall also be stenciled indelibly on its tank and cover. The nameplate shall clearly show all internal connections of the transformer and have all terminals properly marked for easy identification.

(h) Dimensions and Drawings. The overall height and width of each transformer, assembled at the factory as a complete unit including the high-tension switch chamber and all parts and accessories but without the network protector, shall permit the passage of the transformer through a clear rectangular door 7 feet high by 6 feet wide in the vault.

The Contractor shall check the headroom and all other dimensions given on the contract drawings and will be fully responsible for the moving of all transformers proposed for use in this installation into their proper positions in the transformer vault.

The Contractor shall obtain from the manufacturer and submit for approval before placing the order, four (4) copies of the drawings giving complete and accurate information, test data, etc., of the transformers proposed for use in this installation.

10. High-Voltage Disconnecting and Grounding Switches. Each transformer shall be provided with a 15-KV, 3-pole, 3-position, group-

operated disconnecting and grounding switch completely enclosed in a high-voltage switch chamber to be mounted on the high-voltage end of the transformer. This switch shall be properly connected to the high-voltage studs of the transformer brought through the back of the switch chamber and to the primary-feeder terminals entering the bottom of the switch chamber from the cable terminal chamber.

The switch shall be capable of carrying the full rated primary current of the transformer continuously without damage. Furthermore, the switch and terminal connections shall be designed to carry without damage 10,000 amperes for a period of two (2) seconds with the rated voltage maintained.

When in the "transformer" position, the switch shall connect the primary windings of the transformer to the high-voltage supply feeder of the 13,800-volt system. When in the "open" position, the switch shall disconnect the primary windings from the high-voltage supply feeder, but shall not ground the supply feeder. When in the "ground" position, the switch shall ground and short circuit the three (3) conductors of the supply feeder, but shall not ground the primary winding of the transformer.

The switch shall be manually operated by a handle attached to an operating shaft which shall be extended outside the switch chamber through a stuffing box. Suitable markings to indicate the position of the switch by the position of the handle, and suitable means for padlocking the switch at will in any one of the three (3) positions shall be provided on the exterior of the switch chamber. Mechanical means shall be provided to prevent moving the switch to the ground position without first

passing through the closed position. This phase of the operation shall require a sufficient dwell in the closed position to allow the electrical interlock to pick up if the transformer is energized. The switch-operating handle and interlocks shall be made entirely of an approved non-corrodible metal.

The switch contacts shall be self-aligning, readily removable, and provided with means that will maintain the required contact pressure during a long period of continuous service. All flexible connections shall be as short as practicable and shall be arranged so that they can not cause a short or ground between any live parts.

The switch shall be provided with an electrical interlock which will prevent the moving of the switch from any position when the transformer is energized. The interlock coil shall be designed for operation on 120 volts, but shall function satisfactorily on a voltage range from 90 to 130 volts with the armature in any position. The voltage at which the interlock will drop out shall be as low as practicable.

The interlock coils shall be designed for a temperature rise not greater than 55 degrees Centigrade and shall not be damaged in case of false operation.

A mechanical interlock shall be provided between the switch and the tap changer which will prevent the operation of the tap changer when the switch is in either the closed or the "transformer" position. However, this interlock shall permit the changing of taps when the switch is in the "open" or "ground" position.

(a) Switch Chamber and Accessories. The high-voltage switch

chamber containing the high-voltage switch, transformer high-voltage terminals, and primary-feeder terminals, shall be substantially constructed of copper-bearing steel, shall be pressure tight, and shall be provided with a tight-fitting, bolted-on cover and suitable gasket. It shall be securely mounted on the transformer tank, and shall be arranged in such a manner as to prevent the transfer of liquid between the switch chamber and the transformer tank. With the cover removed, ample access shall be afforded for maintenance and removal of the entire switch assembly.

The switch chamber shall be equipped with the following accessories:

- (1) A one-inch globe valve for draining.
- (2) A suitable connection for filling with liquid.
- (3) A flush-type (liquid-level gauge as specified for the transformer.
- (4) An approved spring-closing sampling valve to be used for gas pressure testing and located above the maximum liquid level.
- (5) An approved spring-closing sampling valve to be located at the 25-degrees-Centigrade liquid level.
- (6) An approved pressure switch suitable for connecting in series with a pressure device of a future supervisory system.

(b) Terminal Connections. The incoming three-conductor, lead-covered feeder cables to the transformer shall enter a terminal compartment to be permanently located on the bottom of the high-voltage switch chamber.



The terminal compartment shall be of an approved type and suitable design, and equipped with an approved conical wiping sleeve designed to permit the entrance of the cable by means of a clamping ring attached to the compartment. The clamping ring shall permit the conical wiping sleeve to be rotated to the proper position to receive the incoming cable before being clamped into place.

Connections from the grounding switch to the terminal compartment shall be made through pressure-tight, stud-type, porcelain insulators to be permanently installed between the bottom of the switch compartment and the terminal compartment.

The bushings shall be equipped with suitable cable lugs, so arranged that any conductor of the incoming cable can be connected as may be desired to any one of the high-voltage stud-type bushings. The terminal compartment shall be of adequate size and proportions to permit the proper termination of the individual conductors of the three-conductor cable.

The terminal compartment shall be provided with suitable means for filling with an insulating compound and also for draining when desired.

The construction shall be such as to guarantee that the filling compound in the terminal compartment and the insulating compound in the cable cannot leak into the non-inflammable cooling liquid provided in the switch compartment.

11. Low-Voltage Network Protector. A network protector shall be furnished and installed on the secondary end of each transformer and

shall be properly connected to the low-voltage terminals of the transformer in an approved manner. Each unit shall be fully-enclosed, shall be equipped with a 3-pole, motor-operated, automatic, air circuit breaker, rated at 2500 amperes at 208 volts, and shall be arranged for outgoing secondary bus connections at the top. The air circuit breaker shall have an interrupting capacity not less than 20,000 root mean square amperes at rated voltage.

The network protector shall be equipped with all necessary open-link fuses, relays and auxiliary devices required to perform the following functions automatically:

- (a) Close the breaker when its transformer is energized, provided the transformer secondary voltage and phase angle are in such relation to the network voltage and phase angle as to cause a power flow, upon closure of the breaker, from the transformer to the network.
- (b) Open the breaker if there is a net power flow from the network to its transformer, including the value of the exciting current of the transformer.

Adequate means shall be provided for increasing the value of the reverse power required to trip the breaker under normal operating conditions. A sensitivity sufficient to trip the breaker automatically under short-circuit conditions shall be maintained for all values of reverse power settings.

An operating handle, properly marked with three (3) positions, namely, "open", "closed", and "neutral", shall be provided for manual operation of the breaker.

In the "neutral" position the breaker shall perform its automatic

functions. In the open position the breaker shall be tripped mechanically and the closing circuit shall be opened by an auxiliary interlock. In the closed position the breaker shall be trip free.

A suitable switch shall be provided for de-energizing the control wiring without de-energizing the main circuit. Also, an auxiliary switch shall be provided to open automatically the 3-position interlock circuit hereinbefore specified.

The air circuit breaker shall be provided with fuses having a current rating of approximately twice that of the protector. The Contractor shall submit a data sheet showing the type and performance characteristics of the fuses he proposes to furnish. An additional complete set of main contact points shall be furnished for each network protector to provide for future replacements.

Each protector shall be housed in a rigidly-constructed sheet-steel enclosure, which shall be dust-proof, adequately ventilated and designed for bolting directly to the transformer case.

Complete shop drawings and data relating to the protectors proposed for use shall be submitted for approval before the order is placed.

## 12. Network Load-Balancing Transformers and Contractor Panel.

Each network transformer shall be equipped with load-balancing transformers to assure proper division of the load.

The load-balancing assembly shall consist of three (3) single-phase, 60-cycle transformers, rated at 3000 amperes.

The three (3) individual units shall be mounted on a common support-

ing base and so arranged that the entire assembly can be located at the top of the low-voltage network protector.

One end of the primary winding of these transformers shall be connected to the terminals of the network protector by means of a flexible connector. The other end of the primary winding shall be connected to a fuse mounting and fuse similar to that of the network protector.

A suitable contactor for short-circuiting the secondary winding of each balancing transformer shall be provided and shall be constructed as an integral part of the assembly. Suitable mechanical or electrical means shall be provided for actuating the short-circuiting contacts. The contactor panel shall be equipped with suitable terminals for interconnecting the secondary windings of the balancing transformers on each distribution transformer.

The network balancers shall be designed for operation on the 208-volt bus, shall be capable of withstanding 20 times normal current for three (3) seconds, and shall be designed to limit the unbalance between the secondary voltages of the transformers to a maximum of 8 volts or 3 degrees.

The connections between the secondaries of the balancing transformers and the short-circuiting switches shall not be smaller than No. 3/0 B&S Gauge rubber-covered wire, and shall be installed in conduit in an approved manner.

13. Operation Indicator Panel. The Contractor shall furnish and install in the electric shop on the sub-basement floor an approved indicator panel designed to give a clear and visible indication of the

positions of the network protectors and of the oil-circuit breakers when in the "open" and "closed" positions. The panel shall be equipped with lamp sockets and glass bull's eyes for each protector and each breaker. Each lamp shall be properly marked with a nameplate to indicate the number of the protector or breaker to which it is connected.

The panel shall be designed to permit the installation of similar indicating lights for three (3) additional future transformers and three (3) circuit breakers.

The Contractor shall furnish and install all equipment, conduit and wiring, and shall make all connections necessary to provide a complete and satisfactory installation.

Complete details of the indicator panel showing arrangement and markings shall be submitted for approval.

14. Transformer Vault Ventilation. The Contractor shall furnish and install in a rigid and secure manner a ventilating fan in each of four (4) window openings indicated on the contract drawings.

Each fan shall have a rated capacity of not less than 10,000 C.F.M. when operating at a speed of approximately 580 R.P.M. This rating shall be based on a free flow or flow through an unrestricted area with air at 70 degrees Fahrenheit and at a barometric pressure of 29.92 inches. Fans shall be of the propeller type, each direct connected to a 208-volt, 3-phase, 60-cycle, 1/2 HP, constant-speed, ball-bearing motor of an approved manufacture. The fan blades, ring and spider arms shall be designed for heavy duty. All fans and motors shall be reasonably quiet in operation. The fan shall be designed in strict accordance with the

applicable standards of the National Association of Fan Manufacturers and the American Society of Heating and Ventilating Engineers.

Each fan shall be controlled by means of a tilting-mercury-tube, line-voltage type of thermostatic switch set to start the fan at a predetermined room temperature and keep it running as long as the room temperature is at or above that temperature. In the case of the transformer vault the first fan shall start when the room temperature reaches 90 degrees Fahrenheit; the second fan shall start when the room temperature reaches 95 degrees Fahrenheit; and the third fan shall start when the room temperature reaches 100 degrees Fahrenheit at which temperature all three (3) fans will be running. The thermostats shall stop the fans in the reverse order.

In the case of the switchboard room this fan shall start when the room temperature reaches 90 degrees Fahrenheit.

The thermostats shall be of the wall-mounted type and shall be set approximately 5 feet from the floor. Each thermostat shall be equipped with a heavy cover on which shall be mounted an accurate thermometer. Each thermostat shall have an inside adjusting device, accessible only to authorized persons, for changing the settings of the thermostats. Each thermostat shall have a range of settings of from 60 degrees Fahrenheit to 120 degrees Fahrenheit. It shall not be possible to remove the covers from the thermostats except by authorized persons equipped with a special key, three (3) of which shall be furnished to the Contracting Officer for each instrument. Each thermostat shall be furnished with a heavy guard to protect the instrument from damage from being struck.

Each fan motor shall be fed through a Type "A" safety switch and

motor starting switch. The thermostat switch shall act as a pilot switch to operate the holding coil of the motor-starting switch.

In addition the Contractor shall furnish and install a three (3) point manual push-button station, of the momentary contact type, located near each of the thermostatic switches. These switches shall have "hand", "automatic", and "stop" points so connected that when in the "stop" position the fan will not run regardless of the thermostatic switch; that when in the "hand" position, the fan will run regardless of the thermostatic switch; and that when in the "automatic" position the fan will be under the control of the thermostatic switch.

In addition, provision shall be made to stop all fans automatically upon the closing of any automatic louver damper, or the breaking of any fusible link. Limit switches or similar approved means shall be used for this purpose.

The Contractor shall furnish and install all conduit, wires, switches, fittings, etc., necessary to connect the fan motors and accessories for proper operation. The Contractor shall submit for approval a complete wiring diagram of the fan control system.

15. Grounding. The Contractor shall provide a common grounding bus for the grounding of all non-current carrying apparatus and equipment in the transformer vaults, cubicle room and switchboard room. It shall consist of a 1/4-inch by 2-inch copper bus supported by the walls, ceiling or framework of the room in which it is installed. It shall be run parallel with or perpendicular to the member, or members, by which it is supported. No sub-grounds or runs to equipment or apparatus shall have a carrying capacity less than 1/5 the rated carrying capacity of the equipment to which it is attached. In no case shall a ground be smaller than No. 1/0. The ground conductor shall be of hard-drawn copper bus and, where it is necessary to make joints or splices, they shall be made in an approved manner and with reinforcing of the clamp type over the joint or splice. The lead from the main grounding bus shall be continuous without splices and shall connect to the nearest cold-water pipe that is not less than two (2) inches in diameter. The ground connection shall connect to the street side of the water meter or an approved, rigidly-constructed jumper shall be installed around the meter to insure an effective ground at all times.



(b) LOW-VOLTAGE SYSTEM

1. Scope of Work. The work to be performed under this section of the specifications shall consist of furnishing, installing and connecting complete in every detail, all material, equipment and devices required to rewire and convert the existing secondary electrical distribution system to 3-phase, 4-wire, 120/208-volt, alternating-current service.

This work shall include new lighting and power switchboards, main bus trough and bus structure, D.C. and A.C. metering equipment, power and lighting feeders, panelboards, conduit and fittings, wire and cable, pull and junction boxes, outlet boxes, local switches, convenience outlets, metal molding, safety switches, fuses, motors, starters and controllers, lighting fixtures, and all necessary miscellaneous material, equipment, parts and labor that may be required to convert the existing installation for proper and efficient operation on alternating current.

The work shall include also, among other things, the following items:

- (a) The furnishing and installing of all new outlets for lighting and for the various wiring devices required in the installation, as indicated on the contract drawings and as hereinafter specified.
- (b) The furnishing and installing of all new local switches, convenience outlets and other wiring devices, as indicated on the contract drawings.
- (c) The replacement of all existing wiring devices as specified.
- (d) The furnishing and installing of all new branch circuit conduit, metal molding and wiring on the load side of the new panelboards, as indicated

on the contract drawings and as hereinafter specified, including all necessary connections to the existing system that may be required to provide a first-class installation.

- (e) The reconditioning and reconnecting of all existing branch circuit conduits, fittings, junction boxes, etc., now in use and indicated to be re-used in the completed installation.
- (f) The furnishing and installing of new lighting fixtures in certain rooms and areas, as indicated on the contract drawings and as hereinafter specified.
- (g) The making of all necessary changes in the existing circuits, equipment, connections, etc., that may be required to provide satisfactory, efficient and reliable A.C. service for the proper operation of all equipment now in use by the Postal and Western Union Telegraph Companies, and the C. & P. Telephone Company, located on the fourth floor in Rooms Nos. 485, 487 and 489.
- (h) The conversion of all equipment, motors and machines as outlined in the equipment list, including new motors, starters, controls, miscellaneous parts and accessories and all wiring and connections that may be required to provide proper, efficient, and satisfactory operation on alternating-current service.
- (i) The making of certain changes in the existing outgoing D.C. feeders serving the Winder Building, 1724 "F" Street, and the White House, including new switches, meters and connections as specified.
- (j) The rearranging, extending and connecting of existing circuits serving the watchman's, fire alarm, buzzer and air-conditioning systems in the building, as indicated on the contract drawings.
- (k) The removal of all equipment and material in the existing D.C. system now in use and not indicated to be re-used in the completed installation.
- (l) The performing of any other work required and the furnishing of all miscellaneous labor and material that may be required to provide a complete and satisfactory installation as specified and as indicated on the contract drawings.
- (m) The furnishing and installing of new exit light fixtures, circuits, etc., as indicated on the contract drawings.

All patching of existing portions of the building incident to and made necessary by any of the work of this contract is also included.

The location of the various conduits, switches, outlets, metal molding, panelboards, etc., as shown on the drawings, are intended to be general only. The Contractor shall execute his work to conform to conditions in the building and any minor changes in the locations from those shown on the drawings shall be included as part of the work to be performed under this contract.

The furnishing of lamp bulbs is not included under this contract.

Lighting fixtures, except such as are specifically specified or indicated on the contract drawings to be furnished, are not to be furnished under this contract.

The Contractor shall furnish for approval a complete list of materials to be used in the work, together with the names of the manufacturers, brands, catalogue numbers, etc.

Upon request, all necessary shop drawings and wiring diagrams shall be submitted for approval before the work to which each relates is started.

2. Removal of Existing D. C. Equipment. The Contractor shall dismantle and promptly remove from the building and the site of the work all existing equipment and material in the existing D. C. installation that is to be replaced by the new work called for under this contract, and not indicated or specified to remain. All such equipment and material to be removed shall become the property of the Contractor.

The Contractor shall also dismantle and remove certain existing

equipment on the load side of the existing A.C. meter service switch as indicated on the contract drawings. All such equipment to be removed shall become the property of the Contractor, except as is otherwise specified.

The major items of equipment to be removed under this contract are as follows:

- (a) All existing D.C. panelboards, except certain lighting panelboards in the sub-basement that are to be re-used.
- (b) All existing D.C. feeders and conduits, pull and junction boxes, branch-circuit wiring and flexible metallic conduits serving all floors from sub-basement panels, and all rigid steel conduit, metal molding, wiring to outlets, etc., not indicated to be re-used in the completed installation.
- (c) All existing D.C. motors, starters and related equipment to be replaced by the new work.

Special attention is directed to the fact that the existing D. C. switchboard shall remain intact for the present and services to all electrical facilities shall be maintained at all times except as may be otherwise specifically provided. Each lighting feeder or other connection to the existing D.C. switchboard shall be removed as the load on each feeder is cut over to the new A.C. service.

Attention is specifically called to the requirement that the D.C. services to the Winder Building, 1724 "F" Street, N.W., and to the White House shall be permanently maintained and no outage will be allowed.

The cut-over of any feeder, both D.C. and A.C. shall be limited to the minimum time required and shall be arranged at a time suitable for the users of such services.

3. Main Bus Trough. The Contractor shall furnish and install a metal bus trough from the transformers to the main power and lighting switchboards, enclosing the full length of the bus work, as indicated on the contract drawings.

The bus trough shall be constructed of No. 12 U. S. Gauge sheet steel and lined with an approved insulating material not less than 1/4 inch thick. The Contractor shall also provide insulating supports for the low-tension busses located in the bus trough. Where the busses enter the bus trough from the network protectors, the trough shall be sealed with a sheet of ebony asbestos.

The bus trough shall be reinforced with angles and properly supported in place, and shall terminate in the pull box of the power and lighting switchboards in an approved manner.

The bus-trough cover shall be removable at the bottom and shall be held in place by means of 1/4-inch round-head brass screws spaced not more than 6 inches on centers.

Detailed working drawings showing the proposed method of installation and arrangements of the bus trough shall be submitted for approval before incident work is started.

4. Main Bus Structure. The Contractor shall furnish and install a main bus structure, extending from the load side of the network protectors to the midpoint between the new power and lighting switchboards as indicated on the contract drawings. This bus shall be designed to carry the full rated current of the three (3) network transformers.

Bus taps shall be taken from the main bus and extended to the main

air circuit breakers on the new power and lighting switchboards. The taps shall be designed to carry the full current ratings of the main breakers.

Bus taps from individual transformers to main bus shall be made of  $1\frac{1}{4}$  in. by 4 in. bars, and shall be designed to carry the full rated capacity of a single transformer. The main bus and the taps to the switchboards may be constructed of larger sizes, as may be necessary to provide a satisfactory arrangement and the required capacity.

The Contractor shall provide an independently grounded neutral bus, having a capacity not less than one-half the carrying capacity of the bus of any phase, and connecting the neutral of each transformer to the main neutral bus which shall be installed in a manner similar to the main busses and shall terminate in the bus trough for extension to the future lighting switchboard. All bus work shall be securely mounted on an approved type of insulated bus support spaced on centers not greater than 24 inches, and rigidly braced to prevent movements or deflections of bus bars due to magnetic fields set up by load currents. All necessary connections between busses shall be bolted or brazed with an approved type of silver solder. Laminations shall be interleaved to provide maximum contact area. All contact areas shall be bright and clean when assembled.

All bus bars shall be made of rectangular, bar copper having a conductivity of 98 per cent and shall be installed in a neat and workman-like manner. They shall be designed to carry the full rated capacity as herein specified, based on a current density of 800 amperes per square inch of cross-sections and 50 amperes per square inch of contact area. Where bends occur they shall be made at right angles.

When more than one (1) copper bar is used in a leg of the bus, they shall be properly spaced in accordance with the latest rules and regulations of the A.I.E.E. for bus structures. In no case shall they be closer together than  $1/4$  inch.

The busses forming the risers from the network protectors to the busses on the ceiling shall be taped with a double layer of varnished-cambric tape and painted with an insulating compound.

Openings by means of which bus bars pass through the walls between the transformer vault and the switchboard room shall be sealed with sheets of ebony asbestos.

Complete detailed drawings showing the arrangement of busses and the proposed method of installation and supports, shall be submitted for approval.

5. Main Lighting Switchboard. The Contractor shall furnish and install in the switchboard room, as indicated on the contract drawings, new lighting and power switchboards, each consisting of a main circuit breaker and metering panel and the required number of feeder panels equipped with circuit breakers to serve the various feeders listed in the switchboard schedule.

The switchboards shall be of the dead-front, safety-type, and shall be designed for 3-phase, 4-wire, 60-cycle, 120/208-volt, A. C. secondary distribution.

The switchboards shall be constructed of a structural or formed steel framework carefully braced and welded into a rigid structure which shall maintain proper alignment and not be damaged in shipment, during

erection, or by stresses resulting from short circuits during operation.

The frame shall be completely enclosed on front, sides and back with sheet-steel plates not less than  $1/8$  inch in thickness, except that removable front sections not supporting circuit breakers may be  $1/16$  inch thick. Adequate louvers shall be provided for ventilation. Plates for front panels shall be made of stretcher-leveled steel.

Pull boxes constructed in a manner similar to that specified for the switchboards, not less than 2 feet in depth and matching the switchboards in length and finish, shall be provided at the top of the switchboards. The bottom of the pull box shall be made of slate or ebony-asbestos board provided with individual openings or slots through which busses from circuit-breaker studs shall extend for connecting to outgoing feeder cables in the pull box.

The pull boxes shall be divided by partitions so that each feeder and connecting bus bars will be isolated. This protection shall be adequate to prevent the destruction of adjacent feeders in case of short circuit. All connections between outgoing cables and bus bars shall be made with approved bus to cable connectors.

The entire units shall be securely bolted to channel iron sills grouted into the floor.

The switchboards shall be painted two (2) coats of approved paint, both inside and out, the first coat being rust-resisting coat and the second coat a dull black. The front shall have a dull gloss finish.

The switchboards shall be sectionalized vertically and each panel section shall be readily removable to provide access to the circuit breakers.



All bus bars shall be designed to carry the combined rated capacity of the circuit breakers to which they are connected, based on a current density not greater than 800 amperes per square inch of cross-sectional area and 50 amperes per square inch of contact area. The copper shall be hard drawn and have a conductivity of not less than 98 percent.

All bus to bus connections shall be made with bus bar clamps. All laminations shall be interleaved to secure the maximum contact area.

All busses shall be located in the rear of the circuit-breaker bases.

Detailed drawings showing the complete assembly of panels, busses, circuit breakers, etc., shall be submitted for approval before construction of the switchboard, etc., is undertaken.

6. Meters. The Contractor shall furnish and install a voltmeter, ammeter and power-factor meter, and an ammeter and voltmeter transfer switch on the new lighting and power switchboards. The meters and selector switches shall be mounted on the main circuit-breaker panel of the switchboards in an approved manner.

The meters shall be of high-quality construction. They shall be designed with high overload capacity and equipped with movements practically free from voltage, frequency and wave-form errors over a wide range.

The meters shall be contained in cases not less than 7 inches in diameter, shall have easy-to-read, uniform scales not less than five (5) inches long, and shall provide a metering range covering the maximum operating conditions of the new system. They shall be insulated for 750 volts and shall be accurate to within plus or minus one percent.

The ammeter transfer switch shall be so arranged that the ammeter can be connected to any phase desired.

The voltmeter switch shall be so arranged that the voltmeter can be connected to give voltage readings between any two (2) phases and between any phase and the neutral.

A watt-hour meter of an approved recording type shall also be provided for each switchboard. They shall be rear-connected and suitable for use on the service as specified.

7. Main Circuit Breakers. The Contractor shall furnish and install automatic air circuit breakers on the lighting and power switchboards, as indicated on the contract drawings and as herein specified.

The main air circuit breakers shall be connected between the main network bus and the lighting and power switchboard busses, so that the switchboards can be isolated from the network if desired.

The main breakers shall be of highest-quality construction in all respects. They shall be 3-pole, single-throw, trip-free, automatic, manually-operated breakers equipped with direct-acting, time-delay features for overload protection, and having continuous current ratings of 5000 amperes for the lighting switchboard and 4000 amperes for the power switchboard at 250 volts A. C.

Each breaker shall be equipped with three (3) overload trip coils, and three (3) current transformers having secondaries properly connected to the trip coils to provide the desired protection.

All current-carrying parts of the breakers shall be made of highest-

quality copper, and all contact surfaces shall be heavily silvered to reduce oxidation. The main current-carrying contacts shall be made up of pure-copper laminations reinforced by a plate of phosphor-bronze or similar approved material.

The arcing contacts of the breaker shall consist of durable carbon blocks having high mechanical strength and electrical conductivity, and reinforced by a heavy coating of copper.

The main breakers shall have an interrupting capacity of not less than 80,000 root-mean-square amperes.

8. Feeder Circuit Breakers. The circuit breakers controlling all feeders on the lighting and power switchboards, as indicated on the contract drawings, shall be 3-pole, 250-volt breakers of the automatic, trip-free, thermally-operated type or of the air type as indicated, and having inverse-time-limit overload characteristics, and current ratings as indicated on the contract drawings.

The thermal breakers shall have a quick-make and quick-break toggle mechanism insuring full contact to the time of opening during both manual and automatic operation, and shall be provided with a suitable means for indicating when the breaker has been automatically tripped. They shall be suitable for operation in any position and shall be accessible from the front of the switchboard without disturbing adjacent units.

All breakers shall be mounted in an approved manner and shall be arranged for rear connection to the dead-front switchboard busses and to the outgoing feeders. Complete information, data, and arrangement of all breakers shall be submitted for approval before beginning construction.

9. Panelboards. The Contractor shall furnish and install new panelboards having the number and type of feeders and branch circuits including the number and type of spare circuits, indicated on the contract drawings.

The new panelboards shall be for flush or surface mounting, as specified, of the dead-front, safety type, and designed for 4-wire, 120/208-volt or 3-wire, 208-volt mains with lugs only and a solid neutral strip, as may be required. The panelboards shall be equipped with automatic thermally-operated circuit breakers of the individual-unit-construction type so arranged in the panel that each separate unit may be replaced without disturbing adjacent units in the panel.

All current-carrying parts, including the tripping units of each breaker, shall be enclosed in a separate compartment made of bakelite or similar approved material. The breaker handle only shall be accessible to the operator.

The panelboards shall conform with all applicable requirements of Federal Specification W-P-131.

Each branch circuit shall be designated by a nameplate and listed on a directory which shall be mounted inside of the cabinet door.

The busses and neutral bar shall be designed for the capacities indicated based on a current density of 800 amperes per square inch of cross-sectional area and shall be constructed of copper having a conductivity of 98 percent. Each terminal on the neutral bar shall be numbered to correspond with its respective branch circuit.

The cabinets shall be rigidly constructed of No. 12 U.S. Std.

gauge or greater galvanized sheet steel. They shall have a minimum wiring space four inches wide on all sides and be provided with a hinged door and trim positively fastened to the cabinets.

Each cabinet shall be provided with an approved cylinder lock and two keys.

Complete detail drawings of the panelboards proposed for use under this contract shall be submitted for approval.

The Contractor shall utilize certain of the existing 3-wire lighting panelboards in the sub-basement for the new lighting on this floor. In all such panels to be reused, the Contractor shall remove the neutral fuse clips, and shall install a solid copper strap connecting each neutral bus strap solidly to the terminal stud of the neutral in an approved manner.

The Contractor shall connect the new lighting feeders serving the 3-wire panels in the sub-basement in such a manner that a minimum unbalance between phases of the switchboard bus will result.

The panelboards to be installed in the sub-basement shall be of the surface type. All others shall be designed for flush mounting.

10. Safety Switches. The Contractor shall furnish and install wherever indicated on the contract drawings new 3-pole, 230-volt, fusible, single-throw, Type "A" safety switches, and having the ratings indicated on the contract drawings.

The switches shall be provided with a quick-make and quick-break operating mechanism and shall be capable of rupturing full rated capacity

under load. They shall be equipped with positive-pressure fuse clips and jaws mounted on individual bases of an approved insulating material. The switches shall be completely enclosed in heavy sheet-steel cabinets equipped with interlocked covers which shall prevent operation of the switch when the door is open and the opening of the door when the switch is closed. The switches shall be provided with manually-operated handles extending through the case and arranged for padlocking in the "off" position.

All wires connecting to the switch terminals shall be neatly and symmetrically arranged in the switch cabinet so as to prevent them from becoming entangled with the switch mechanism.

11. Fuses. The Contractor shall furnish and install in each new fused switch, a complete set of new fuses having ratings as required to provide adequate protection for the various power circuits and feeders.

The fuses shall be of an approved bi-metallic, thermal type, designed to provide inverse-time-limit protection against temporary overloads up to 500 percent of their rating, and yet shall provide instantaneous protection against short circuit.

12. Changes in Existing Equipment to Operate on Alternating Current. The Contractor shall furnish and install alternating current motors, starters, and safety switches, etc., wherever required, and make all necessary changes, adjustments or replacements in the following equipment to provide efficient and satisfactory operation on alternating current:

MOTOR LISTSUB-BASEMENT FLOOR

<u>Room</u> <u>No.</u>	<u>No.</u>	<u>H.P.</u>	<u>Amps.</u>	<u>Volts</u>	<u>Speed</u> <u>R.P.M.</u>	<u>Use</u>
O24	2			110		Mimeographs
O27	2	7-1/2	28.6	230	1750	Vacuum Pumps
"	1	1/4	1.6	120	2000	Ironer
"	1	1/4	1.32	220	1725	Drier
O31	4	3/4	9.0	110	7000	Vacuum Cleaners
"	11			110		" "
"	4			110		" "
"	2	1/4	2.55	115	1725	Polishing Machines
"	2	1/2	4.2	115	1725	" "
O50	1	1/2		115	1725	" "
"	1	1/3	2.85	115	1725	" "
"	1	1/3		115	3500	Spray Machine
O53	1	5	20.	220	1750	Saw
"	1	7-1/2	33.	220	1200	Planer
"	1	5	19.8	220	3500	Shaper
"	1	3	11.5	230	1725	Joiner
"	1	2	8.	220	1800	Wood Working Machine
"	1	2	8.	220	900	Band Saw
"	1	1/2	2.	220	600/3000	Lathe
"	1	1/2		110	1750	Portable Saw
"	1	1	4.15	220	1150	Band Saw
"	1	1	4.1	220	1750	Grinder
O59	1	2	8	230	1750	Paint Sprayer
"	1	1	9.0	115	1725	Vacuum Cleaner
"	1	1	8.3	110	1750	Paint Sprayer
"	1	1	8.3	110	1750	" "
"	2	1/2	3	110	3450	Jack-of-All-Trades
O63	1	1/8		110	1400	Jigsaw
O67-9	1	5	21.3	220	1300	Counter Shaft
"	1	5	19.1	220	1150	Lathe
"	1	2	7	220	1600	Grinder
"	1	2	8.1	220	1150	Grinder
"	1	1	3.95	230	1140	Grinder
"	1	1/2	1.5	220	1600	Drill
"	1	7-1/2		220	1200	Countershaft
O73	1	1-1/2	6.4	230	1750	Vacuum Pump
O79	2	1	4.4	230	3450	Fuel Oil Pumps
O85	1	2	8.1	220	1800	Pipe Threader
"	1	1	4.5	230	1750	" "
"	1	1	9	110	4200	" "
O91	1	1/4	2.3	110	1200	Exhaust Fan
N.Corr.	1	5	19	230	1800	Circulating Pump
"	1	1	4.1	220	1675	" "
N.Court	1	20	78	220	975	Compressor
"	1	2	8.5	230	850	Paint Mixer
Boiler Rm.	2	5	19.7	230	1150	Fuel Oil Pumps

BASEMENT

<u>Room</u> <u>No</u>	<u>No.</u>	<u>H.P.</u>	<u>Amps.</u>	<u>Volts</u>	<u>Speed</u> <u>R.P.M.</u>	<u>Use</u>
1	1					Calc. Machine
17	1		2.5	115		Adding Machine
19	1					Friden Calculator
20	1					Monroe Calculator
32-1/2	1	1/4	2.4	115	1725	Lathe
"	1	1/2	5	115	1725	Compressor
"	1	1/20		110	1750	Drier
"	1	1/4	2.2	115	1725	(Bodine Motor)
"	1	1/20	0.7	110	1750	(Emerson Motor)
"	1		6.0	110		Instograph
"	1		1.5	110		"
"	14			1110		Dictaphones
"	1	1/10	1.07	110	1700	Adding Machine
38	1					Hot Plate
"	1					Pelton Sterilizer
"	1					Heat Lamp
41	1					Vent Fan
44	1		.9	110		Adding Machine
49-51						
53-55	2					Exhaust Fans
"	1	1/6	1.7	115	1140	Stitching Machine
54	1	1/4	2.2	115	1750	Compressor
"	1	1/4	2.2	115	3450	Grinder
"	1	1/4	1.32	220	1750	Lathe
60	2					Time Stamp Clocks
"	1	1/10	0.7	110	1200	Adding Machine
61	1			110		Exhaust Fan
65-7-9-						
71-73	2			110		" "
"	1					Hot Plate
70	1		.6	110		Adding Machine
77-79-						
81-3-5	2			110		Exhaust Fans
88-87	2		0.9	110		Adding Machines
"	2					Bookkeeping Machines
"	2		0.6	100/110		
"	1		0.8	110		Adding Machine
"	1	1/20	0.65	115	1725	Bookkeeping Machine
89	1		0.7	110		Bookkeeping Machine
"	1		0.8	110		Adding Machine
"	1	1/4	2.4	115	1725	Addressing Machine
91	1					Exhaust Fan
93-5	2					" "
Cafe-						
teria	1		2500W	110		Hot Plate
"	1		1800W	110		Coffee Urn
"	1		3000W	230		Coffee Urn
"	1	1/4	2.1	115	1725	Ice Cream Box



FIRST FLOOR

<u>Room No.</u>	<u>No.</u>	<u>H.P.</u>	<u>Amps.</u>	<u>Volts</u>	<u>Speed R.P.M.</u>	<u>Use</u>
100-1/2	1	1/15	0.9	110	1700	Adding Machine
"	1	1/4	2.35	115	1140	Perforator
102	1					Adding Machine
103-1/2	1					" "
106	1		0.75	110		" "
108	1					Electric Heater
112	1					Adding Machine
"	1	1/8	1.5	110	1750	" "
113	1	1/50		110	1925	Marchant Calculator
142	1					Monroe Calculator
"	1		1.5	115		Adding Machine
149	3					Dictaphones
"	1					Exhaust Fan
"	1		1.5-.4	110		Glue Pot
155	1					Exhaust Fan
"	1					Time Stamp
"	1					Cancelling Machine
157	1					Dictaphone
160	10					Dictaphones
159	1			110		Stromberg Time Stamp
"	1	1/8		85-130		Adding Machine
162	3					Dictaphones
161	2	1/4		115	1125	Perforator
"	1	1/30	.58	115	1150	Envelope Sealer
"	1		1.7-.4	110		Glue Pot
"	4		660W	115		Hot-Point Irons
164	3			115		Dictaphones
166	2			115		Dictaphones
167	4			115		Dictaphones
169	2			115		Dictaphones
171	1			110		Stromberg Time Stamp
175A	1			115		Shaving Machine
179	1	1/16		85-125		Adding Machine
174-1/2	1					Electric Heater
183	1		0.8	110		Adding Machine
"	1					Exhaust Fan
187	1					" "
197-9	2					" "

SECOND FLOOR

208	2					Unit Air Conditioners
210	1					" " "
212	1					" " "
"	1					Telephone Amplifier
"	1					RCA-Victor Radio
211	1					Shaving Machine
"	1					Dictaphone

SECOND FLOOR (Cont'd)

<u>Room</u> <u>No.</u>	<u>No.</u>	<u>H.P.</u>	<u>Amps.</u>	<u>Volts</u>	<u>Speed</u> <u>R.P.M.</u>	<u>Use</u>
254	1	1/4	2.6	115	1725	Polishing Machine
275	1					Exhaust Fan
276-1/2	1	1/10	1.07	110	1700	Adding Machine
"	1	1/20		115	1725	Marchant Calculator
281	1					RCA-Victor Radio
288	1					DeWald Radio
289	1					Acme Electric Heater
"	1		500W	110		Wax Pot

THIRD FLOOR

330-1/2						
331	1	3/4				Air Compressor
"	1					Vari-typer
"	1					Erasing Machine
347-55	1	2	7.8	220	1750	Paper Cutter
"	1	1/6	2.0	115	1140	Boston Stitcher
"	1	1/6	1.81	115	1150	Boston Stitcher
"	1	1/8	1.4	115	1725	Mimeograph
"	1	1/10		110	1750	"
"	2	1/6	1.7	115	1725	Multigraphs
"	3	1/8	1.41	115	1725	Mimeographs
"	1	1/6	1.5	115	1725	Mimeograph
"	1	1/4	2.6	115	1725	Mimeograph Feeder
"	1	1/30	0.5	115	1725	Setotype
"	1	1/3	3.5	115	1725	Challenge Paper Drill
"	1	1/4	2.43	115	1725	Addressellot
"	1	1/16	0.78	115	1750	Photo Dryer
"	1		3000W	110		Photo Dryer
"	2		3.5	124		Mercury Arc Lights
"	1		3.5	125		C-H Vertical Lamp
"	1		660W	115		Flat Iron
356	1		.75	110		Adding Machine
392	1		0.9	110		Calculator

FOURTH FLOOR

404	1			115		Time Stamp
405	1			115		Erasing Machine
477	1			110		Lightning Letter Opener
"	4					Stromberg Time Stamps
485	1	1/8	1.05	110	1700	Adding Machine
487	1					Master Clock
"	5					Teletypes
482	1	1/4	2.2	115	1725	Multigraph
"	1		3-0.8	110		Sta-Warm Wax Pot
484	2	1/8		115	1725	Mimeographs

FIFTH FLOOR

<u>Room</u> <u>No.</u>	<u>No.</u>	<u>H.P.</u>	<u>Amps.</u>	<u>Volts</u>	<u>Speed</u> <u>R.P.M.</u>	<u>Use</u>
574	1					Time Stamp

The Contractor shall furnish and install all incidental equipment and connections required to connect the above equipment to the alternating current system in a satisfactory manner.

All motors larger than 10 horsepower shall have reduced voltage starting. Motors of 1/2 horsepower and larger shall be designed for 3-phase, 208-volt service. All motors shall be of the same manufacture except on special equipment where they shall be similar to those now installed.

The connections of the motors to the driven equipment shall be made by the required number of V-belts of proper size wherever direct connection is not possible.

All motors shall be of the standard, general purpose type, except where other types are required to meet the specific requirements of each particular type of service to be rendered by each machine.

Motor starters and controllers shall be of high-quality construction and of suitable type and design for proper operation of the motors and equipment with which they will be used. Motors and starters shall conform fully to the latest rules and regulations of the N.E.M.A. and A.I.E.E.

All motor starters for use with motors larger than two (2) horsepower shall be of an approved magnetic, across-the-line type, equipped with thermal overload and undervoltage inverse-time-limit protective devices.

Each starter shall be controlled by a push-button station of the two position, "start" - "stop" momentary-contact type which may be mounted integrally with the cover of the starter.

13. Conduits. The Contractor shall furnish and install a rigid steel conduit system connecting all new and existing equipment, as shown on the contract drawings and as hereinafter specified. All ends shall be carefully reamed and all joints made up with white lead applied so that the continuous grounding system will not be broken.

All new conduit shall be zinc coated and otherwise in accordance with Federal Specification WW-C-581a.

All conduit elbows shall be of the same quality of tubing as the conduits, shall be smooth inside and outside, and shall be machine bent with long radii and free from kinks, dents and bucklings.

Care shall be taken to prevent the entrance of dirt and other foreign matter into the conduit while in storage and during construction.

The entire conduit system shall be swabbed clean before wires and cables are inserted and pulled into place. At least one pull box shall, unless otherwise indicated, be installed in an approved location in feeder conduits as follows:

- (a) In straight runs of one hundred fifty feet in length.
- (b) In runs of one hundred feet in length with one right angle bend.
- (c) In runs of seventy-five feet in length with two right angle bends.

The use of running threads will not be permitted. Where conduits cannot be joined by the standard threaded coupling, approved water-tight conduit unions shall be used. All bends or offsets shall be avoided wherever possible. Conduits crushed or deformed in any way shall not be installed and shall be removed from the building without delay. Conduits shall be run at least six inches from hot-water pipes, steam pipes and flues. All new conduits used in connection with lighting or power circuits shall be not less than 3/4 inch.

Vertical runs of conduit shall be supported at intervals not exceeding ten feet by approved clamp hangers. All exposed runs of conduit shall be securely fastened in place at intervals of not more than five feet by one-screw pipe-clamps and substantial screws in lead expansion-shields, by approved beam clamps or by approved single or gang pipe-hangers spaced not more than ten feet apart as conditions require. All conduits shall be securely fastened to cabinets, outlet boxes, junction or pull boxes, etc., by approved locknuts and bushings.

The entire conduit system, together with all fittings, fixtures and equipment, shall be thoroughly and adequately supported in place. All conduits shall be run parallel with or perpendicular to beams, walls, columns, etc.

No conduit shall be chased into or run horizontally in partitions or load-bearing walls.

All new lighting and power feeder conduits required under this contract shall be installed as near the ceiling of the corridors as possible and adjacent to the north wall of the center corridor, and adjacent to the inside walls of the east and west corridors in the sub-basement. The conduits shall be supported by a steel rack and hanger of strong construction securely supported from the ceiling beams or masonry in an approved manner.

All feeder conduits to new lighting panels on all floors above the sub-basement shall be run concealed up the existing flues, and all new branch circuit conduits to be installed above this floor shall be concealed in the walls and ceilings, as indicated on the contract drawings. All extensions of and connections to existing branch circuit conduits shall be run concealed on all floors except the sub-basement, unless otherwise indicated on the contract drawings.

14. Conduit Fittings. All conduit fittings shall be of cast metal and shall be finished in an approved manner.

The type of conduit fittings selected shall have been designed for the application under consideration. Ample wiring space, free from sharp edges and burrs, shall be provided for in the design. All hubs

shall be so tapped that they will have the proper angular relations with each other and insure proper line up during installation.

All conduit covers shall match the conduits with which they will be associated.

Insulating bushings shall be provided for all conduit connections to pull boxes where cables of No. 1/0 and larger are to be installed. The bushings shall be constructed of molded bakelite, or similar approved material and shall have standard conduit threads of the sizes required.

15. Junction and Pull Boxes. All junction and pull boxes shall be constructed of not less than No. 10 U. S. Standard gauge metal for all boxes having a face area of 144 square inches and larger, and of not less than No. 12 U. S. Standard gauge metal for all boxes having a face area less than 144 square inches.

These boxes shall be designed for the specific purpose for which they shall be used, shall be framed with small angles or welded, and shall be drilled only for the number of conduits required. The covers for these boxes shall be made of metal of the same gauge as that of the boxes on which they will be used, and shall be securely held by means of not less than eight (8) round head brass machine screws. The boxes, covers, and reinforcing angles, if used, shall be constructed of hot dipped galvanized iron.

All pull boxes shall be of adequate size to provide ample space for making cable bends, and shall be located as directed. Complete details of the main pull box in the center corridor adjacent to the switchboard room shall be submitted for approval.

16. Outlet Boxes. The Contractor shall furnish and install outlet boxes for lighting fixtures and wiring devices where required.

Outlet boxes for concealed work shall be flush with the ceiling or wall and shall be located in the positions specified. All outlet boxes for concealed work shall be not less than 1-1/2 inches deep by 4 inches square, or octagonal, except where building conditions will not permit boxes of that size to be installed. Ceiling and bracket outlets shall be provided with approved open covers or plaster rings where walls and ceilings are plastered. Outlet boxes for exposed work shall be of an approved conduit type with threaded hubs.

All outlet boxes shall be constructed of galvanized or sherardized steel and shall be approved by the Underwriters Laboratories.

Existing concealed outlet boxes from which wiring devices will be removed, as indicated on the contract drawings, shall be closed with blank covers of an approved type.

17. Convenience Outlets. All existing single convenience outlets on walls and all new A. C. convenience outlets as shown on the contract drawings, shall be equipped with outlets of the twin type and rated at 15 amperes and 125 volts. They shall be top wired and shall have bakelite or composition bodies.

All 208-volt convenience outlets shall be 3-pole, 20-ampere, 250-volt outlets and shall be of a type that will permit grounding of the equipment.

The Contractor shall furnish and install adjacent to each lighting panelboard on all floors except the sub-basement, a 3-pole, twist-



lock polarized receptacle having a rating of 20 amperes and 250 volts. These devices shall be of an approved type and design and shall be mounted in suitable outlet boxes installed flush in the corridor wall. The outlets shall be fed direct from the lighting panel busses by concealed conduit and wiring connections. A sample of this outlet shall be submitted for approval.

18. Local Switches. The Contractor shall furnish and install new local switches to control all new lighting and shall replace all existing local switches as indicated on the contract drawings with new ones. These switches shall be of an approved type suitable for the control of the respective lights.

The switches shall be of the tumbler type, top-wired, and totally enclosed as units in bakelite or composition cases. They shall have a 20-ampere, 125-volt rating and shall be suitable for installation in the new or existing outlets according to requirements.

19. Finish Plates. All new convenience and switch outlets shall be provided with new finish plates. These finish plates shall be made of brass not less than 0.06 inch thick. The finish of all plates shall be lacquered bronze.

20. Low-Voltage Wires and Cables. All wires and cables for the low-tension system shall be of the performite grade and otherwise in accordance with Federal Specification J-C-106.

All wires and cables, unless otherwise specified herein or on the contract drawings, shall be rubber covered and shall have single braid on the outside for sizes No. 12 to and including No. 8 and double braid on the outside for sizes larger than No. 8.

No wire smaller than No. 12 B. & S. gauge shall be used for light and power circuits. No. 8 B. & S. gauge wire and larger shall be stranded.

All rubber covered wire and cable for light and power shall be designed for 600-volt service. Loops of not less than 8 inches shall be left at all outlets for the connection of fixtures, wiring devices, etc. Should the insulation be stripped closer than 8 inches from the bushing out of which they extend, taping will not be accepted as sufficient insulation, and new wires shall be furnished in such places by and at the expense of the Contractor.

Frayed ends of wires and conductors at panels, motors, switches, etc., shall be taped.

Exposed wires in distribution panels and main switchboards shall be neatly and symmetrically arranged with multiple wires laced with cord to form cables.

Circuits, feed wires, and cables shall be continuous between outlets. No splices shall be made except at outlets.

All joints in wires or cables shall be carefully soldered and well insulated with rubber and friction tape to build up an insulation electrically equal to that on the wire and cable.

All wires and cables in vertical conduits shall be properly supported in an approved manner, using approved supporting bushings, clamps, or wedges inserted in junction boxes.

All wires and cables run between the sub-basement and the courts shall be lead covered.

21. Grounding. All electrical equipment and apparatus to be installed under this contract in connection with the low-voltage system shall be grounded in accordance with Article 250 of the National Electrical Code.

#### D. CONTRACT DRAWINGS.

The following construction drawings, which, as previously mentioned, formed a part of the contract requirements, are incorporated herein as a part of this thesis. It is believed that these drawings, together with the explanatory notes which follow in the same order, will provide a background sufficient in accuracy and detail to demonstrate thoroughly the character and scope of the project.

1. Elevator Feeder, Switchboard and Panel Schedule	File No. 82.8-144
2. High Tension Equipment Layout	" " 82.8-145
3. Structural Changes	" " 82.8-146
4. Second Floor Plan	" " 82.8-169
5. Feeder Plan	" " 82.8-173
6. Switchboard, Panel and Feeder Schedule	" " 82.8-174
7. Riser Diagram	" " 82.8-175

1. This drawing shows in plan the general arrangement of the first unit of the power switchboard, new elevator feeders, lighting in high-tension, transformer and switchboard rooms, lighting and equipment locations in penthouses, and schedules for switchboard, emergency panel and elevator feeders.

2. On this drawing is shown a general layout of the power switchboard, transformers, high-tension switchgear with incoming primary duct line and manhole, together with necessary sections and details, single line wiring diagram, etc.

3. This drawing shows in considerable detail the structural problems involved, including removal of steam engine base, bridging of pit, new walls, floors, windows, fire doors, louvres and fire dampers.

4. This drawing is selected as the most representative of a typical floor and shows the general rearrangement of the secondary system on this floor, including lighting panels, branch circuit conduit runs, lighting, convenience and switch outlets, emergency lighting, etc.

5. On this drawing are indicated in plan the conduit runs of the main lighting and power feeders to the panels and main riser points; also, main distribution panels and branch circuit conduits to various motors are shown with designation for feeders and branch circuits.

6. This drawing is a complete resume of the requirements for the switchboard, panels and feeders of the entire secondary system, excepting certain work installed under the primary contract.

Data and information shown hereon required much study of conditions and many tedious calculations, and together with the riser diagram constitute the foundation of the secondary electrical installation.

7. On this drawing is indicated diagrammatically the relative arrangement of switchboards, feeders, panelboards and motor branch circuits. In a sense, this diagram represents the skeleton network of the secondary system.

### CONCLUSION

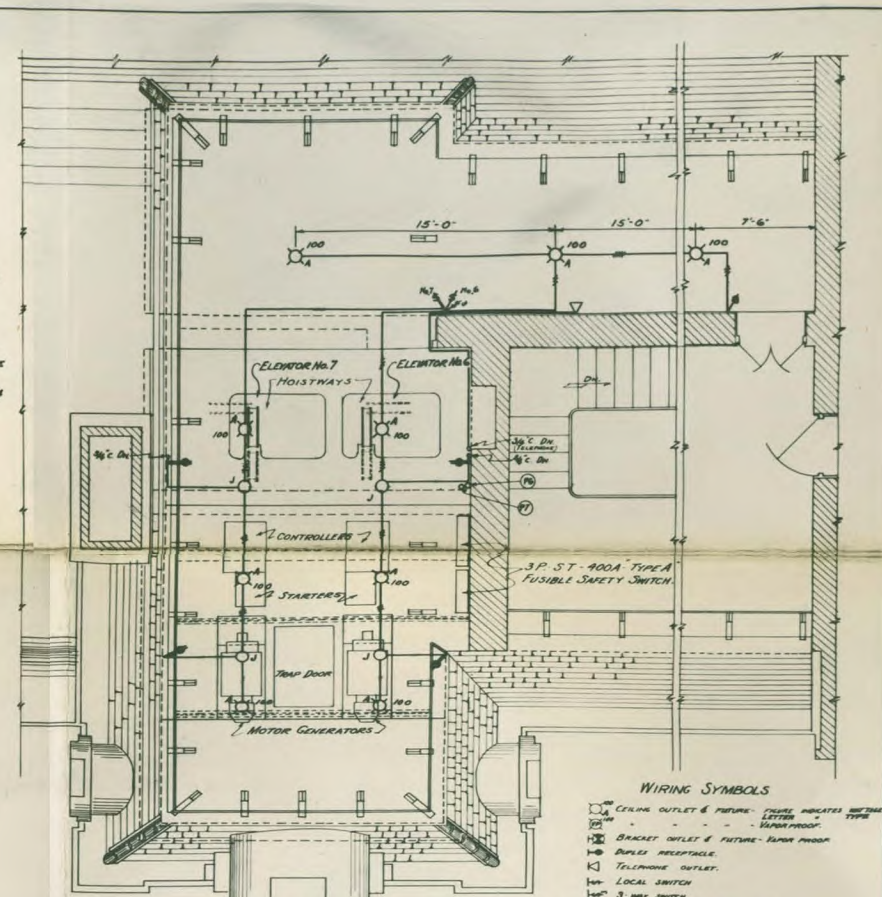
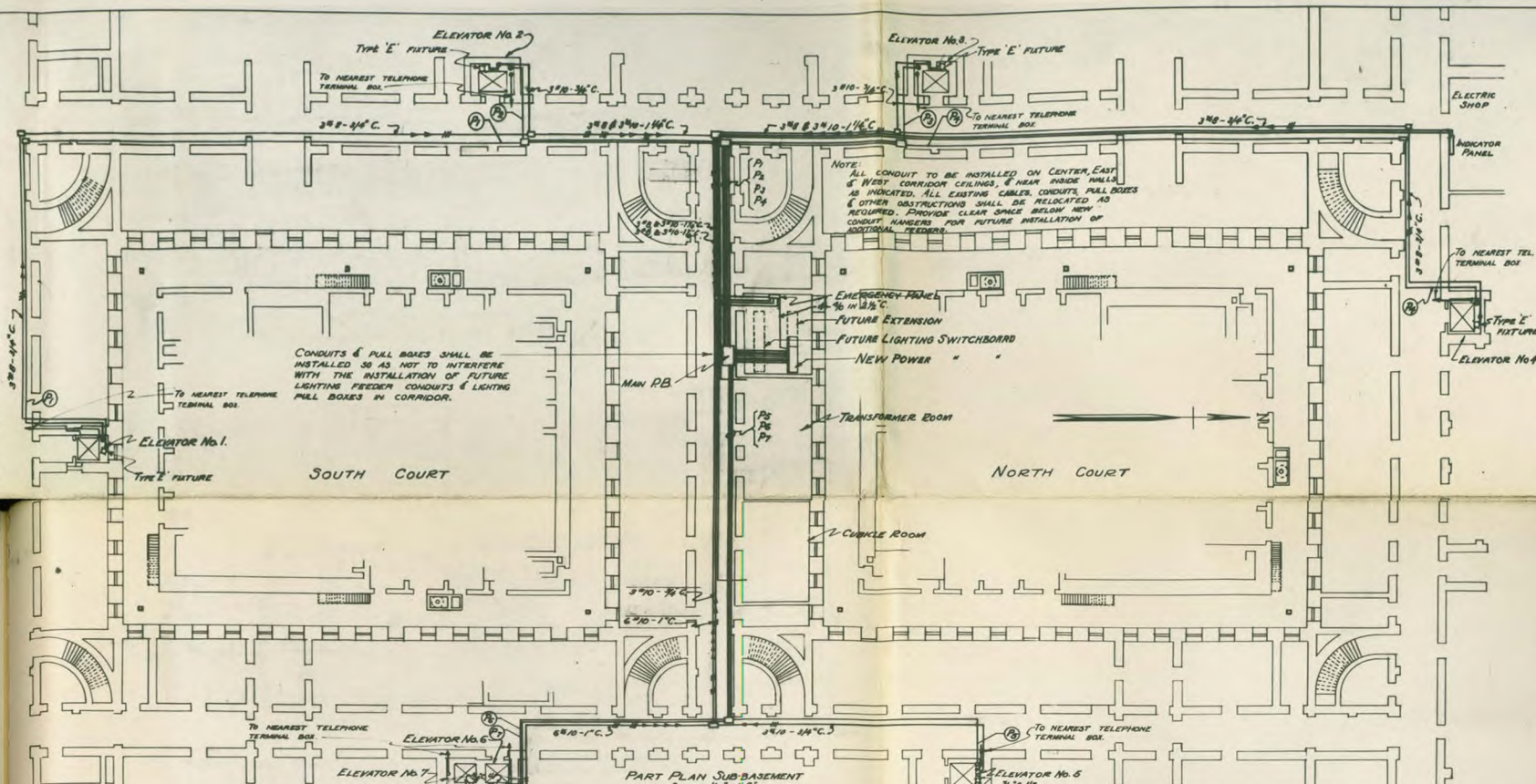
At first glance, it may seem that some of the subjects included were covered in too great detail; however, in view of the fact that an attempt has been made to present all the major features involved, both from a construction as well as a design viewpoint, this has been necessary and essential in order to provide a complete background of the entire project.

Throughout the subject matter presented under the heading "Materials and Construction Specifications", many references were made to Federal Specifications. These specifications describe in considerable detail the particular material or piece of equipment that is being considered, and a direct reference to them eliminates much detailed description from the job specifications. All such specifications are furnished the contractors free of charge and may be purchased by anyone from the Government Printing Office at very small cost.

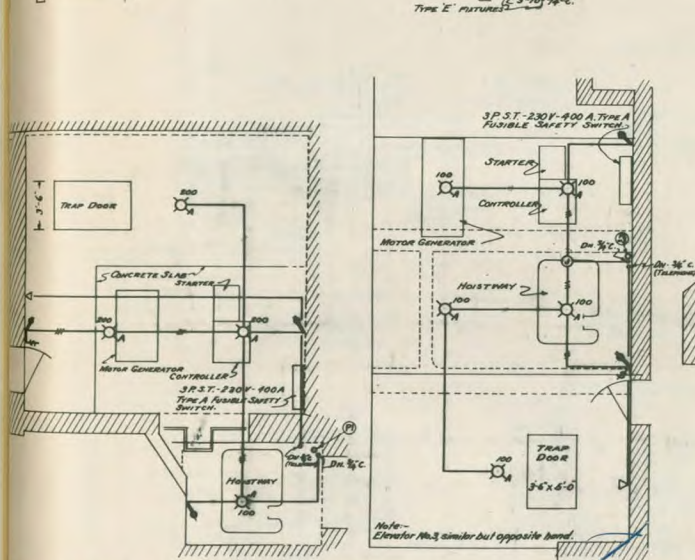
No attempt has been made to analyze the reasons for selecting equipment or materials to meet a particular requirement. It is pointed out, however, that during the process of design, each type of equipment and material specified was analyzed and selected according to its own merits to fulfill a particular need and perform the functions desired. It is believed that a study of conditions and requirements, together with the corresponding material or equipment specified, will reveal the fundamental reasons for the choice that was made.

In conclusion, it is desired to emphasize that the primary object of the thesis has been to present the complete scope of the entire project in all its different yet related aspects, including its justification and need, major features of design, construction problems involved, and responsibilities involved in carrying a project of this scope and character through to a successful completion.

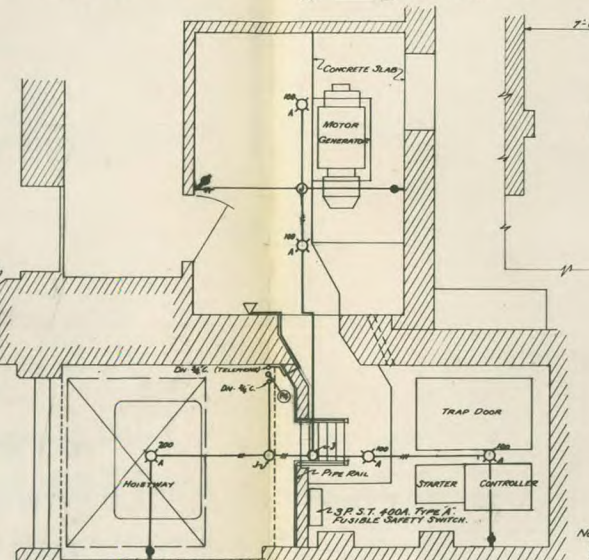




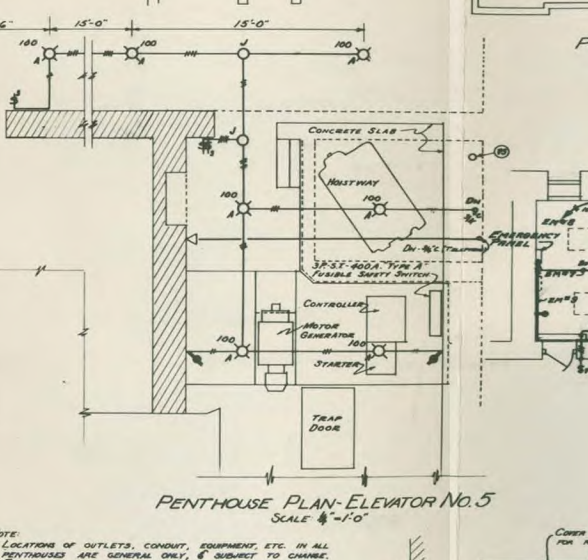
- WIRING SYMBOLS**
- CEILING OUTLET & FUTURE - THREE INDICATES DIFFERENT TYPES
  - BRACKET OUTLET & FUTURE - FLUSH PROOF
  - ◇ DUPLEX RECEPTACLE
  - TELEPHONE OUTLET
  - LOCAL SWITCH
  - 3 WAY SWITCH
  - LOCAL SWITCH & FUSE LIGHT
  - SAFETY SWITCH
  - MOTOR STARTER
  - NEW CONDUIT, EXPOSED AT CEILING



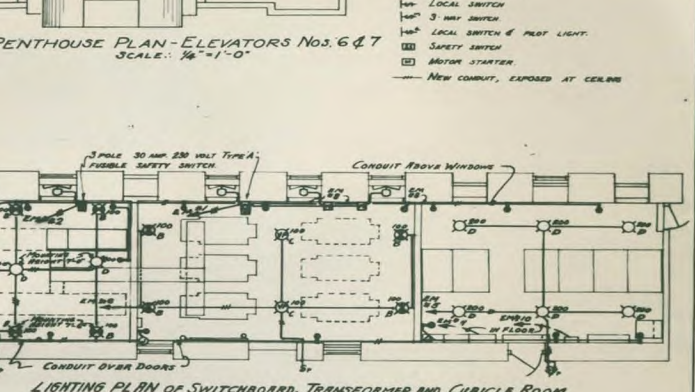
PENTHOUSE PLAN - ELEVATOR No. 1  
SCALE: 1/4" = 1'-0"



PENTHOUSE PLAN - ELEVATORS Nos. 2 & 3  
SCALE: 1/4" = 1'-0"



PENTHOUSE PLAN - ELEVATOR No. 4  
SCALE: 1/4" = 1'-0"



LIGHTING PLAN OF SWITCHBOARD, TRANSFORMER AND CUBICLE ROOM  
SCALE: 1/8" = 1'-0"

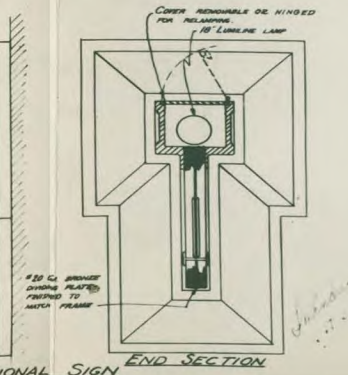
- NOTES**
1. TELEPHONES: CONTRACTOR SHALL INSTALL CONDUIT SYSTEM FROM NEAREST TELEPHONE TERMINAL BOX IN SUB-BASEMENT UP EACH HOISTWAY TO OUTLET IN PENTHOUSE. A TRAVELING CABLE TAKE OFF BOX SHALL BE INSTALLED IN EACH HOISTWAY AS DIRECTED BY CONTRACTING OFFICER. WIRING WILL BE INSTALLED BY OTHERS.
  2. CONTRACTOR SHALL INSTALL A TRAVELING CABLE TAKE OFF BOX IN EACH ELEVATOR HOISTWAY IN LIGHTING RISER CONDUIT, AT LOCATION DIRECTED BY CONTRACTING OFFICER.
  3. ELEVATOR DIRECTIONAL SIGNS: CONTRACTOR SHALL INSTALL ELEVATOR DIRECTIONAL SIGNS TO BE CONFINED IN PANEL ABOVE DOOR AT EACH SAMPLE ELEVATOR OR ELEVATOR BANK ON THE BASEMENT & FIRST FLOORS. CONNECT TO HOISTWAY LIGHT CONDUIT. PROVIDE PRE-TYPE LOCAL SWITCH AT SUB-BASEMENT FLOOR FOR EACH ELEVATOR OR BANK. EXACT LOCATIONS OF THE SIGNS & SWITCHES TO BE AS DIRECTED BY THE CONTRACTING OFFICER.

**EMERGENCY PANEL SCHEDULE**

CIR. NO.	WIRING	PHASE	SETTING	WIRING	SUPPLYING
1	30	20	250	3/16"	Transformer Room Con.
2	30	20	250	3/16"	Switchboard Room Con.
3	30	20	250	3/16"	Spares
4	30	20	250	3/16"	Spares
5	30	20	250	3/16"	Spares
6	30	20	250	3/16"	Spares
7	30	20	250	3/16"	Spares
8	30	20	250	3/16"	Spares
9	30	20	250	3/16"	Spares
10	30	20	250	3/16"	Spares
11	30	20	250	3/16"	Spares
12-13	30	20	250	3/16"	Spares
14-15	30	20	250	3/16"	Spares
16-17	30	20	250	3/16"	Spares
18-19	30	20	250	3/16"	Spares
20-21	30	20	250	3/16"	Spares
22-23	30	20	250	3/16"	Spares
24-25	30	20	250	3/16"	Spares
26-27	30	20	250	3/16"	Spares

**POWER SWITCHBOARD**

FEEDER NO.	POLES	SETTING	WIRING	SUPPLYING
1	3	4000	4000	3/16"
2	3	600	600	3/16"
3	3	600	600	3/16"
4	3	600	600	3/16"
5	3	600	600	3/16"
6	3	600	600	3/16"
7	3	600	600	3/16"
8	3	600	600	3/16"
9	3	600	600	3/16"
10	3	600	600	3/16"
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97	3	600	600	3/16"
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99	3	600	600	3/16"
100	3	600	600	3/16"



CONTRACT NO. 1-IP-12901  
UNITED STATES DEPARTMENT OF THE INTERIOR  
NATIONAL PARK SERVICE  
BRANCH OF ENGINEERING

STATE DEPARTMENT BUILDING  
WASHINGTON, D.C.

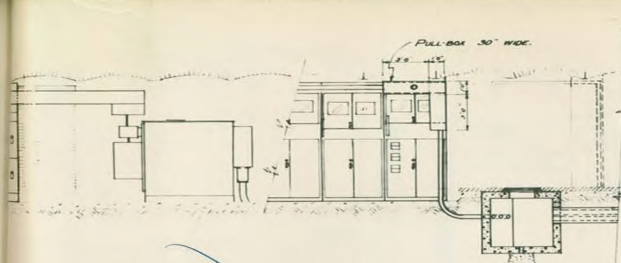
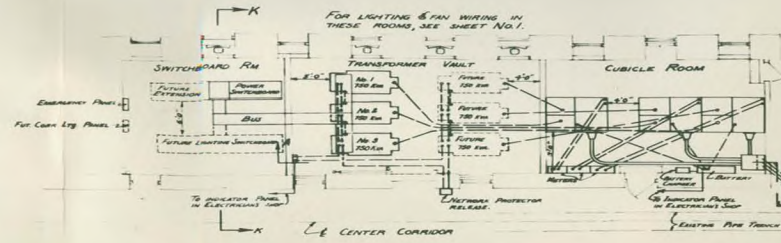
D.C. A.C. CHANGEOVER - PRIMARY SYSTEM  
ELEVATOR FEEDER AND PENTHOUSE LIGHTING PLAN  
POWER SWITCHBOARD AND EMERGENCY PANEL SCHEDULES  
Scales As Shown

Designed: T.L.B.  
Checked: T.L.B.  
Drawn: R.J.T.  
Traced: R.S.M.M.

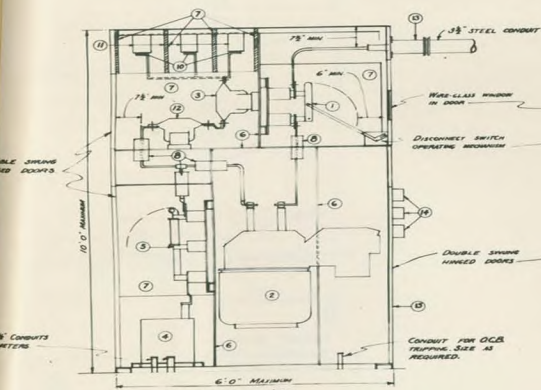
Approved: [Signature]  
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DATE: FEBRUARY 13, 1939  
SHEET 1 OF 3  
FILE NO. 828-144

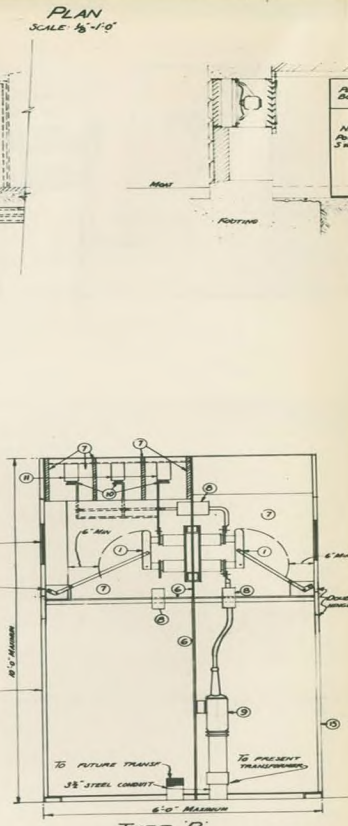




PART SECTION ON LINE AA  
SCALE 1/8"=1'-0"

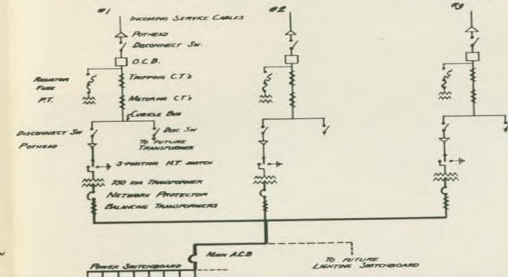


TYPE A' OCB CUBICLE SECTION  
SCALE 1/8"=1'-0"  
3 REQUIRED



TYPE B' DISCONNECT CUBICLE SECTION  
SCALE 1/8"=1'-0"  
3 REQUIRED

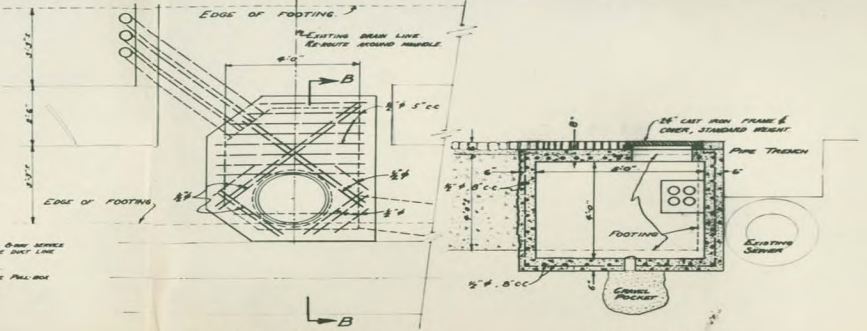
SECTION K-K  
SCALE 1/8"=1'-0"



SINGLE LINE DIAGRAM OF SYSTEM

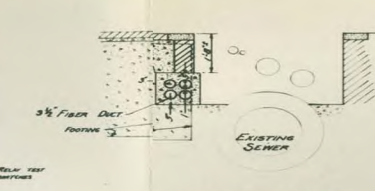
ITEM	DESCRIPTION
1	GANG OPERATED DISCONNECT SWITCH - 600 AMP, 15,000 VOLT, 3PST
2	OIL CIRCUIT BREAKER, 600 AMP, 15,000 VOLT, 250,000 A.M.P.S.T.
3	CURRENT TRANSFORMERS FOR METERING FURNISHED BY REPCO
4	POTENTIAL TRANSFORMERS FOR METERING FURNISHED BY REPCO
5	COMBINED RESISTOR, DISCONNECT SWITCH & FUSE FURNISHED BY REPCO
6	STEEL BARRIER
7	INSULATING BARRIER
8	INSULATING BARRIER
9	3 CONDUCTOR POTHEAD 15,000 VOLT
10	INSULATED BASINS 15,000 VOLT
11	BUS - INSULATED 6000 VOLT
12	CURRENT TRANSFORMERS FOR TRIPPING OCB AUTOMATICALLY RETURNED
13	POTHEAD - 15,000 VOLT FURNISHED BY REPCO
14	O.C.B. RELAYS
15	STEEL CUBICLE

SYMBOLS (IN PLAN)  
RIGID CONDUIT IN FLOOR  
EXPOSED

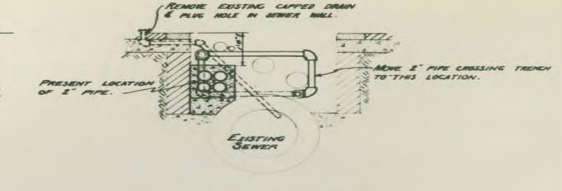


PLAN OF MANHOLE  
SHOWING REINFORCING OF ROOF  
SCALE 1/8"=1'-0"

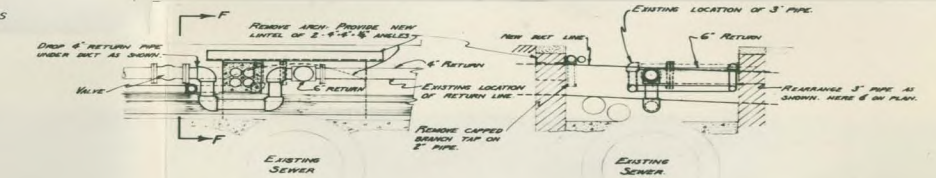
SECTION B-B  
SCALE 1/8"=1'-0"



SECTION C-C  
SCALE 1/8"=1'-0"

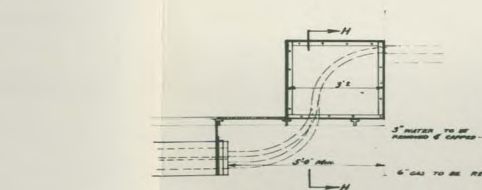


SECTION D-D  
SCALE 1/8"=1'-0"

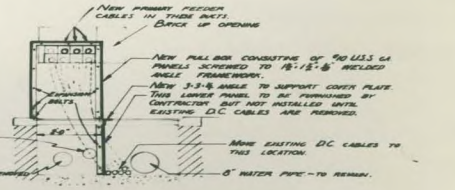


SECTION E-E  
SCALE 1/8"=1'-0"

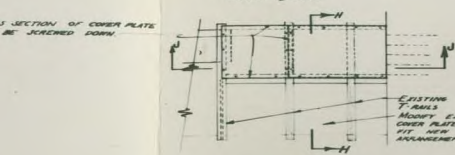
SECTION F-F  
SCALE 1/8"=1'-0"



SECTION G-G  
SCALE 1/8"=1'-0"



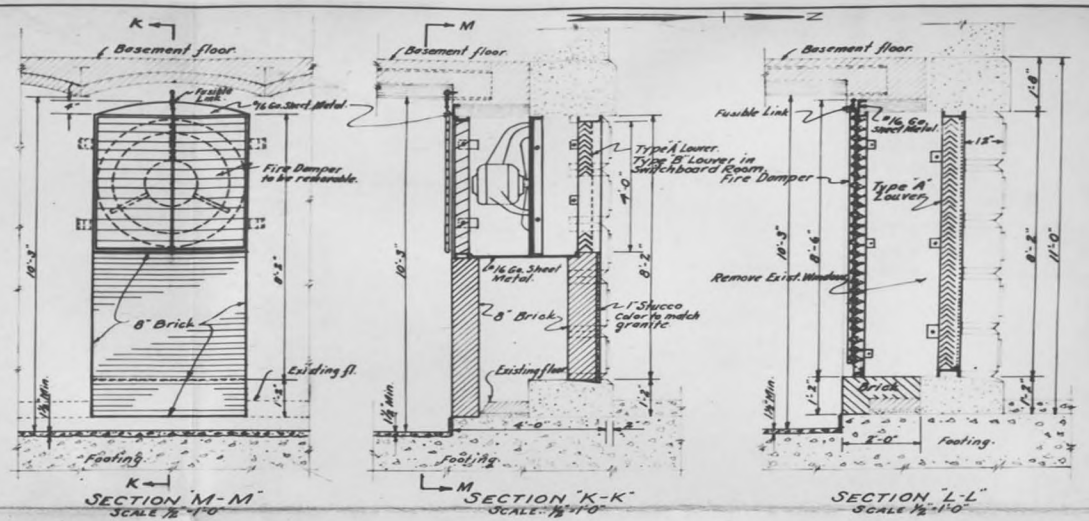
SECTION H-H  
SCALE 1/8"=1'-0"



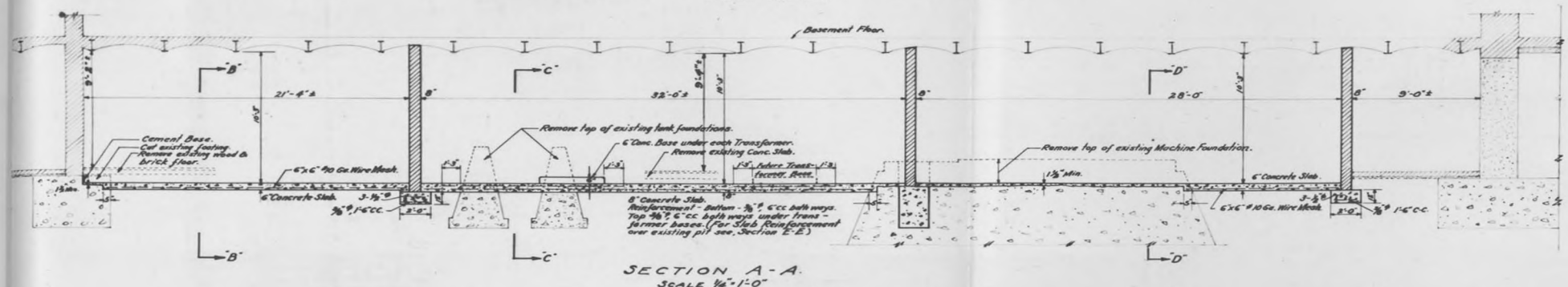
PLAN OF ENTRANCE PULL BOX  
SCALE 1/8"=1'-0"

CONTRACT No. 11P-12901  
UNITED STATES DEPARTMENT OF THE INTERIOR  
NATIONAL PARK SERVICE  
BRANCH OF ENGINEERING  
STATE DEPARTMENT BUILDING  
WASHINGTON, D.C.  
DC-AC CHANCEOVER-PRIMARY SYSTEM  
HIGH TENSION EQUIPMENT LAYOUT  
SCALE AS SHOWN  
DESIGNED: T.L.B.  
CHECKED: T.L.B.  
APPROVED: T.L.B.  
FEBRUARY 15, 1933  
SHEET 2 OF 3  
CONTRACTING OFFICER  
FILE NO. 828-145

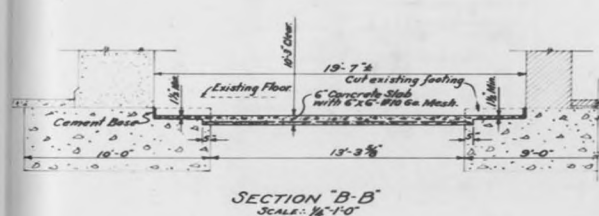




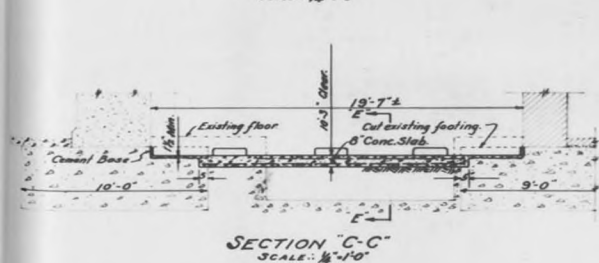
PLAN OF SWITCHBOARD, - TRANSFORMER, - AND CUBICLE ROOMS.  
SCALE:  $\frac{1}{4}" = 1'-0"$



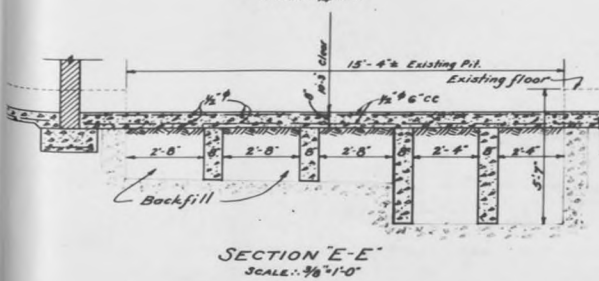
SECTION A-A.  
SCALE  $\frac{1}{4}"=1'-0"$



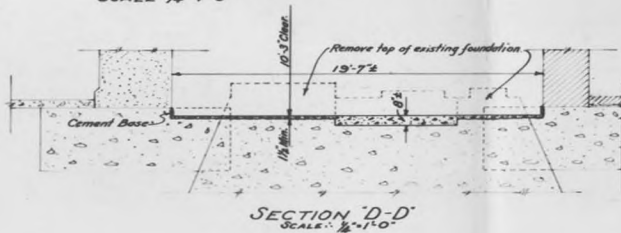
SECTION "B-B"  
SCALE: 1/4"=1'-0"



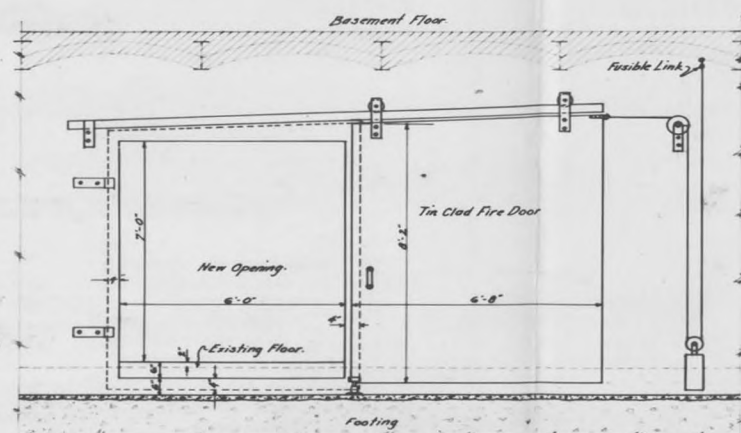
SECTION "C-C"  
SCALE: 1/4"=1'-0"



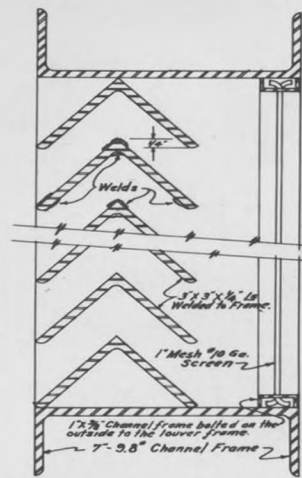
SECTION "E-E"  
SCALE: 3/8"=1'-0"



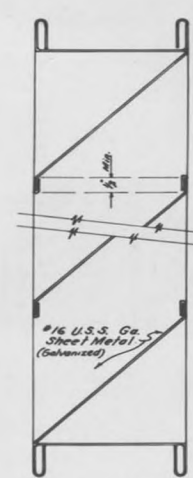
SECTION "D-D"  
SCALE: 1/4" = 1'-0"



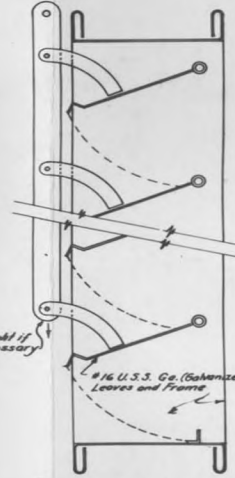
ELEVATION OF FIRE DOOR TO TRANSFORMER VAULT.  
SCALE:  $\frac{1}{2}" = 1'-0"$



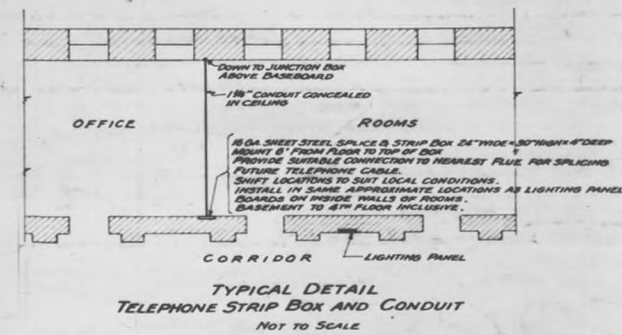
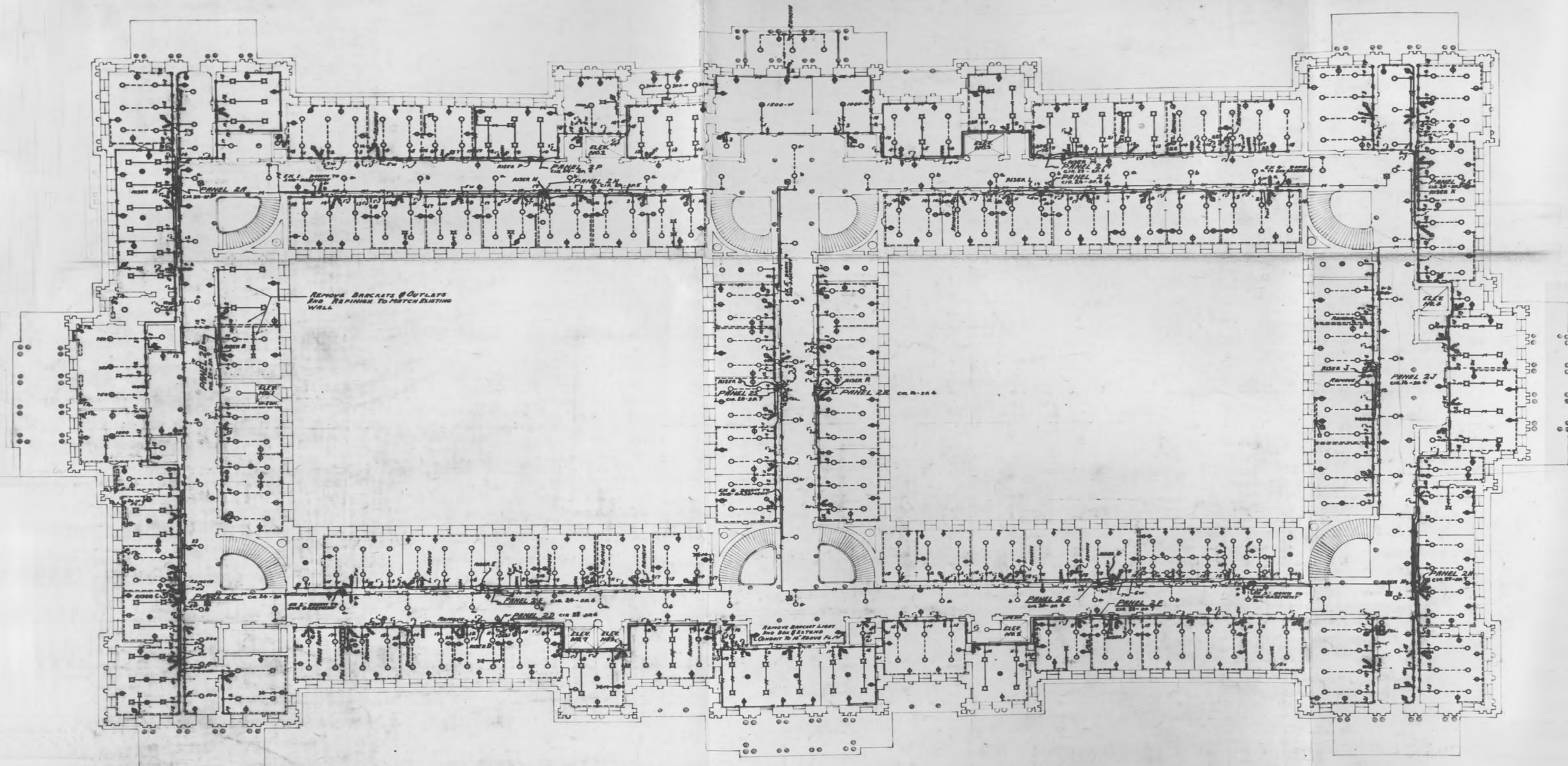
TYPICAL DETAIL  
TYPE "A" LOUVER  
SCALE: HALF SIZE.



TYPICAL DETAIL  
TYPE "B" LOUVER  
SCALE: HALF SIZE.



TYPICAL DETAIL  
FIRE DAMPER  
SCALE: HALF SIZE



FOR GENERAL NOTES AND SYMBOL LIST SEE  
DRAWING FILE NO. 82.8-174, SHEET 9.

CONTRACT No. I-1P-15202	
UNITED STATES DEPARTMENT OF THE INTERIOR	
NATIONAL PARK SERVICE	
BRANCH OF ENGINEERING	
STATE DEPARTMENT BUILDING	
WASHINGTON, D.C.	
REWIRING OF DC-AC CHANGEOVER	
SECOND FLOOR PLAN	
SCALE 1/8"=1'-0"	
DESIGNED: T.L.B.	APPROVED: [Signature] SHEET 4 OF 11
CHECKED: T.L.B.	APRIL 21, 1939
DRAWN: R.M.L.	CONTRACTING OFFICER
TRACED: R.M.L.	