THE UNIVERSITY OF MINNESOTA

GRADUATE SCHOOL

Report

of

Committee on Thesis

The undersigned, acting as a Committee of the Graduate School, have read the accompanying thesis submitted by Robert Emmet Donahoe for the degree of Electrical Engineer. They approve it as a thesis meeting the requirements of the Graduate School of the University of Minnesota, and recommend that it be accepted in partial fulfillment of the requirements for the degree of Electrical Engineer.

Geo. D. Shepardson
Chairman

W. T. Ryan

F. W. Mann

Date Dec 4 1922

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THE UNIVERSITY OF MINNESOTA

GRADUATE SCHOOL

Report

of

Committee on Examination

This is to certify that we the undersigned, as a committee of the Graduate School, have given Robert Emmet Donahoe final oral examination for the degree of

Electrical Engineer.

We recommend that the degree of

Electrical Engineer.

be conferred upon the candidate.

______________________ Chairman

Oral examination waived in accordance with footnote on page 12 of Graduate School Announcement for the Year 1922-1923

Geo. D. Shepardson

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Date Dec. 4, 1922.

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DESIGN OF AN

ORNAMENTAL STREET LIGHTING SYSTEM

AND AN

ELECTRICAL DISTRIBUTION SYSTEM

FOR THE

GREATER CAMPUS OF THE UNIVERSITY ON MINNESOTA

SUBMITTED IN PARTIAL FULFILLMENT

OF THE REQUIREMENTS FOR THE

DEGREE OF ELECTRICAL ENGINEER

BY

R.E. DONAHOE

1922

CONTENTS.

INTRODUCTION

At present the University of Minnesota has no street lighting system except for a few obsolete lighting posts around the campus knoll and a few pendant-type arc lamps suspended from long iron brackets on wooden posts located at a few of the otherwise dark corners of the campus. The electricity for the light and power in the buildings is furnished partly by the power plant in the rear of the present electrical building and partly by the General Electric Company.

At night the University is both dark and dangerous because its streets are so poorly lighted, and in the daytime the beautiful effect of the well graded and green lawns is spoiled by the unsightly overhead pole lines and by the transformer nests near the buildings. With the present system each new building causes an addition to the pole line and another group of the transformers.

A good ornamental street lighting system and a neat campus are indications of prosperity. They create a psychological impression of thrift and progress as well as attracting favorable publicity.

As the University of Minnesota is in the midst of a large building program, it is an opportune time to improve the campus by replacing the overhead system with an underground distribution system and an ornamental street lighting system. The superintendent of buildings and grounds at the University has taken advantage of this opportunity and has asked the electrical department to help draw up plans and specifications for the two systems which should be fed and controlled at a sub-station to be built at the present heating plant. The author has taken this job as a thesis problem, and the plans and specifications which follow are the results of his effort to design the most up-to-date and efficient ornamental street lighting and electrical distribution systems possible under the present state of the art and science.

The author wishes to thank the following for their helpful suggestions and criticism in designing these systems:

Professor Geo. D. Shepardson

Mr. H. A. Hildebrandt

Professor W. T. Ryan

Also the engineers mentioned later in this thesis.

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DISCUSSION OF PROBLEM

GENERAL

In solving the problem the first step was to study the theses written by former Minnesota students on the subjects of Street Illumination for the University of Minnesota Campus, and an Electrical Distribution System for the University of Minnesota campus, so that their work would not be retraced in the present thesis. After becoming familiar with these theses, the procedure was to obtain all the information possible on modern systems of street illumination and electrical distribution. This information was obtained from books and magazines, (a bibliography of which is given on the last pages of this thesis), also from personal conversation with engineers of the Westinghouse, Western Electric, General Electric, and Minneapolis General Electric Companies and also the street lighting superintendents of the cities of St. Paul and Minneapolis, as well as from the faculty of the Engineering College.

In making the study of modern street lighting it was found that since the advent of the series gas-filled incandescent lamp about ten years ago, great strides have been taken in the development of street lighting units and also in the methods of locating the units and feeding current to them. This development has been so great in the last ten years that the thesis written in 1911 on Street Lighting for the University of Minnesota Campus has been disregarded because the system as recommended therein is entirely obsolete, and the system as specified hereafter has been worked out by the author from modern methods and principles as being the one best suited for the University Campus.

STREET LIGHTING SYSTEM

In designing this system of street lighting for the University Campus, the author has been guided by certain rules which he believes are requirements to be considered in due proportion when designing any ornamental lighting system. These rules are as follows:

1st. The standard should have a pleasing appearance both by day and by night. In fulfilling this requirement it should be remembered that the primary purpose of the post is to support the light unit and it should be as inconspicuous as possible, blending harmoniously with the surrounding architecture.

2nd. The equipment should distribute the light efficiently and without undue brightness in the direction of the eye.

3rd. The system should be safe, simple, reliable and easily maintained at its original effectiveness.

4th. It should give sufficient and uniform intensity on the street and on the sidewalk.

5th. It should be of moderate operating cost.

6th. It should be easily adapted to further development in the art.

The unit selected to fulfill all these requirements is the Arcadian post with an Octagonal Reflectolux top and rippled glass panels, all as manufactured by the George Cutter Company.

A plan drawing of this post is shown on the next page. The drawing on the blue print is somewhat out of proportion be-

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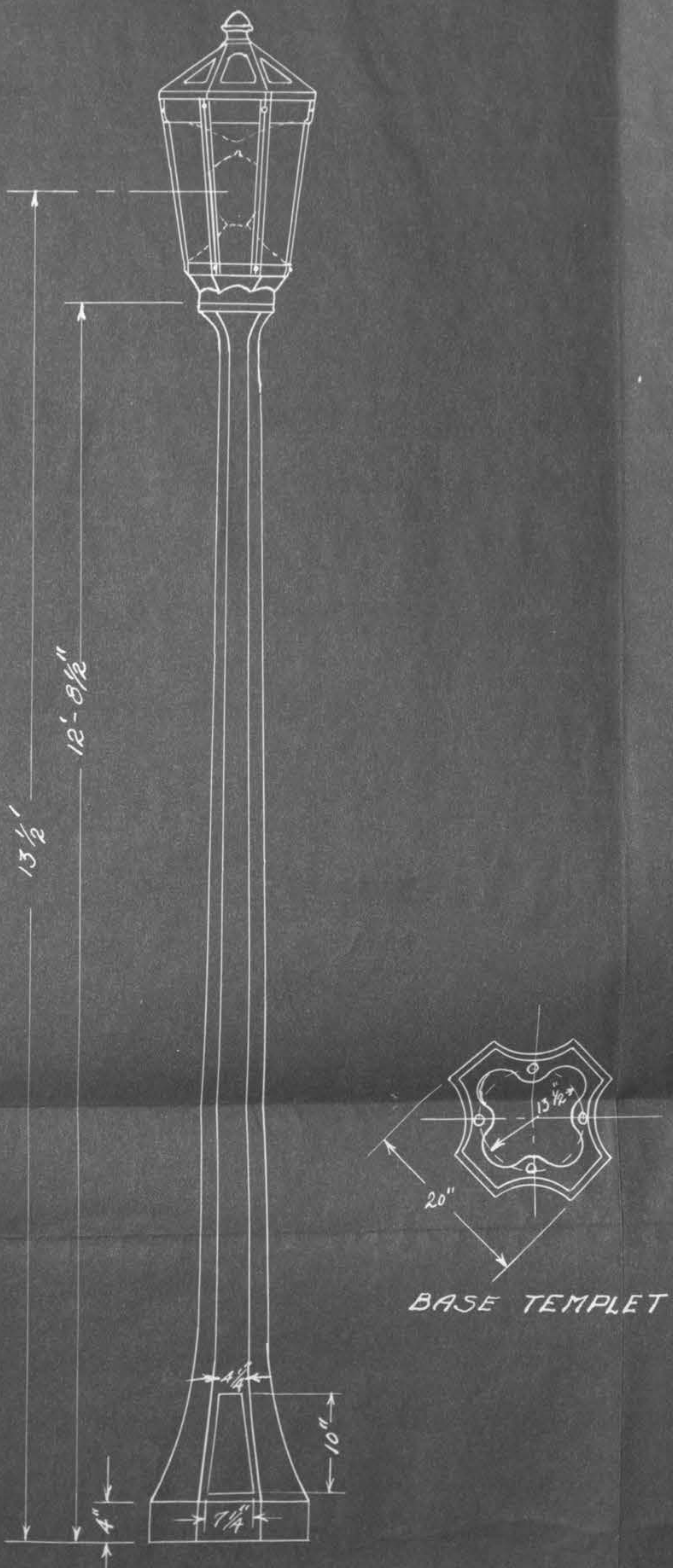

ARCADIAN POST WITH
OCTAGONAL REFLECTO-LUX TOP

cause it shows the top as selected, mounted on a smaller post of the same design, but the dimensions have been altered to those of the post selected.

The unit selected fulfills these requirements because it is simple in architecture as are the surrounding buildings and campus. The post has smooth lines with no abrupt changes in dimensions and its shape is such that it has greater strength than a round post and will be less liable to break if struck by an automobile or truck. The base and shank of the post are so proportioned that the post looks solid and well able to support the light unit and yet does not appear clumsy.

The corrugated steel post as manufactured by the Union Metal Works was given much consideration when selecting the post because they cost less to repair when broken and if not hit too hard they will save the top from breaking by not allowing it to strike the ground. The theory of the construction of these posts was considered very good, but considering the fact that they are more apt to be broken because the cast iron part of them which is rigidly fastened to the foundation must stand the bumps and is much weaker than that part of the post selected. The architecture of these posts was also not considered as good as that of the post selected.

The concrete post was also considered for this job, but, after considering its merits and seeing several samples of them in different parts of the country, it was decided that they did not compare with the cast iron posts. Their surfaces wear rather fast and the corners chip easily and they soon have a cheap appearance. Any rust that may drip down from the top or soak out from the reinforcing rods causes a stain that cannot be removed.

The external architecture of the post top is also in keeping with the surroundings as well as with the post which was selected for it.

To fulfill the second requirement for a good street lighting system, much care must be taken in the selection of the top. In order that it should be efficient, it should direct all the light possible on the street and as evenly as possible. The Reflecto-Lux Top as selected is equipped with reflectors above and below the lamp which redirect the light from the up and down direction to the street where it is utilized. The over-all efficiency of this top is equivalent to that of any other type, because the light lost behind the corner pieces is made up in the efficiency of the reflectors and panel glass.

With units larger than 400 candle power, the author believes it advisable to use glass refractors for redirecting the light otherwise thrown up and down from the lamp to a direction which will give a more even distribution on the street. For a 250 candle power lamp, a glass refractor is not justifiable when taking into account the increased cost of maintenance from breakages, the higher initial cost and the loss of light in the refractor. For the intensity of light selected, the reflecto-lux top gives an ideal distribution of light, the reflectors directing the light toward the street and the ribbed glass panel diffusing it to reduce the brilliancy in the direction of the eye.

The ribbed glass was selected for the panels because it is clear and absorbs but a small per cent of the light. With the straight ribs it has the effect of giving the rays a spread without changing their general direction. The horizontal spread also eliminates the shadows from the corner pieces.

To get uniform intensity of light on the street, the units should be spaced from seven to eight times their mounting height, or so that the maximum ray strikes the base of the next post. They should be spaced uniformly and not bunched to throw light on certain buildings, because this spoils the even distribution of light, and the appearance of the system as a whole, and it is contrary to modern practice in street lighting. The entrances to buildings should be lighted separately by posts designed for that purpose and located on each side of the entrance and close to the building.

Some engineers say that street lighting units should all be mounted at the same height, regardless of their intensity, to eliminate glare. The author believes that the intensity of the unit used should be a factor in determining the mounting height of any unit, for the following reasons. The size of the lamp should be selected according to the intensity of the light desired on the street which in turn is dependent on the traffic conditions on that street. A top should be selected to give the proper appearance and maximum effiency with that size lamp, It will be found that a large lamp will look best with a large dimensioned top and a small lamp with a smaller top. A small top with a low intensity lamp will not look well on the top of a large high post. Therefore the intensity and size of unit is a factor in determining the mounting height of a street lighting unit.

It can also be seen that the mounting height should be higher for a high than for a low intensity lamp to have the same glare effect on a person walking along the street, and looking in a forward direction, because with a high mounting the maximum ray will strike his eyes when he is at a greater distance from the light than with a low mounting height. Since light intensity decreases with the square of the distance from the source, the high-intensity light should be mounted higher than the low to give the same maximum light intensity on the pedestrians' eyes. The above statements are true when the distribution of light from the lamp is such that the maximum ray falls in a zone of from fifteen to twenty degrees below the horizontal, as it should be for efficient distribution of the light.

For street lighting systems of any size the series system of electrical distribution is used most entirely, because of its flexibility to expansion and alterations and the ease with which it may be controlled. It is also lower in first cost and in cost of operation.

For large systems of street lighting, as on the University Campus, different types of series systems may be used. The system first considered for this job was the group series system. With this system the lights would be fed in groups of about thirty lights each. The lights of each group would be connected in series and fed from an SL-type transformer located in a manhole in the vicinity of the group. The primary of each SL transformer would be connected in series on a constant current

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circuit, fed from a constant-current transformer located at the sub-station. This system would give a comparatively low voltage current in the lamp post and would allow for expansion in full groups, which is liable to be the way this system will be installed.

After comparing the above type of series distribution with the straight series type in which all circuits would be fed directly from the sub-station, it was decided to install the latter because of lower cost and greater flexibility. Calculations were also made to find out whether it would pay to have the lights fed on separate circuits so that part of them could be turned off at midnight or when there is little traffic through the campus. The figures obtained show that the first cost would be about $5000.00 higher, but a saving of about $1,500.00 per year could be obtained by connecting the lights on all-night and on midnight circuits.

With the lights as connected on four circuits and using 250 c.p. lamps, the voltage on any circuit will not exceed 1750 volts, allowance being made for expansion, but a 2500 volt cable has been specified and the transformers are large enough to allow the use of 400 c.p. lamps on the main streets if desired without any change in construction.

As the voltage necessary on any circuit as specified is not exceptionaly high, it was decided to connect each post wiring through a Safety-First Disconnecting Type Pothead and to use series sockets for the lamps. This system was decided in preference to the use of IL transformers in the base of each post, because it gives a saving of about twelve dollars ($12.00) per post on labor and material, or $ 2500 on the first installation.

By withdrawing the plug of the pot-head, any post may be disconnected from the rest of the system without interferring with the rest of the system. In the event of an accidental breakage of any post, the damaged post will be automatically cut off from the lighting circuit. If such a device is not installed, all the lamps on the circuit will be out in case a post gets broken.

With the use of the above pothead and by grounding each post, the safety of the system is well taken care of, both as to operation and danger to persons coming in contact with live wires.

In selecting transformers and control apparatus for this system, the sizes were determined from the number of lights on each circuit and the power in watts required for each. As old established companies, such as the Westinghouse or General Electric Company, can be depended upon to turn out a uniform grade of material and apparatus, it is only necessary to specify that the equipment shall be manufactured by them and give the size and kind desired. This elimiates the procedure of writing detailed specifications for each piece of apparatus used. The station apparatus was therefore selected from that manufactured by a reliable manufacturer.

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ELECTRICAL DISTRIBUTION SYSTEM

In studying the thesis written in 1916 on an Electrical Distribution system for the University Campus it was found that only a small portion of their data could be used, because on checking their loads for the buildings several of them, except those which they actually measured, were far from what they should be. In checking the sizes of cables specified by them, it was found that they had based their calculations for secondary conductors on a voltage of 110 volts instead of 220 volts. For these reasons the most of the calculations for the electrical distribution system herein recommended were made by the author, and in the making of them he has been guided by rules which are considered in good engineer practice.

Before work was begun on the design of the ornamental street lighting system, it was necessary to obtain a plan of the campus showing the proposed layout of the streets and buildings. The University has a plan showing the present layout of the campus, and it has a plan showing the proposed layout of the upper mall area, but it has no plan showing the new proposed layout of the entire campus. For this reason it was necessary to make a tracing of a combination of these two plans to obtain one on which to lay out the new ornamental street lighting and electrical distribution systems.

The work of designing the system was begun by laying out the circuits on the plan of the University Campus as drawn by the author from the two latest proposed plans of the campus. The next step was to determine the maximum load, or maximum demand as it is usually called, for each building on the campus. This maximum is often found by connecting a maximum demand meter in the main feeder circuit to the building and taking readings, according to the design of the meter, over a sufficient length of time during the season of heaviest load, to be sure that the maximum load read is the maximum for any time during the year, and can be used as a basis for figuring the size of feeders to that building. When this system of obtaining the maximum demand is too expensive and in the case of determining the size feeders for a new building to be constructed, they are calculated by multiplying the demand factor for that building by the connected load.

The demand factors for different types of buildings can be found in handbooks, being the ratios of the maximum demands to the connected loads as determined from data obtained by some large power companies.

The connected loads used in calculating the maximum demands can be accurately obtained by adding the wattages of all the lamps in the building, but this system is not generally used because it has been found by large companies and illumination experts that a sufficiently close approximation can be obtained by allowing a connected load of six tenths of a watt of power per square foot of floor area. This figure allows for a good illumination system and any fans or apparatus that may be connected to the light circuit.

After the maximum demands, in kilo-watts, were obtained for each building, they were reduced to maximum ampere loads.

With the maximum amperes and the distance to the transformers, the sizes of service conductors were obtained from the table of current capacities for three conductor cable in the Standard Handbook. The size of these conductors could be calculated but the handbook method is much easier and reduces the mistakes possible in calculations. In determining the size conductors to use, fifty per cent overload allowance was made to take care of any emergency load, which is usually done in engineering practice. Where there were no power loads in large buildings, allowances were made for them figuring on a basis of the current which would be required for a forced air ventilating system. Allowances for the completion of buildings were also made.

After the sizes of feeders were determined, the next step was to determine the size of transformers. In doing this, the buildings were grouped as much as possible, to keep the number of transformers as small as possible. Less transformer capacity is necessary when several buildings are fed from one large transformer than when a separate transformer is provided for each building, because not all of the buildings will require their maximum demand of current at the same time. By using fewer transformers of larger capacity, there is not only a saving in the cost of the transformers, but the constant loses in the transformers are less and for underground systems the cost of building transformer vaults is greatly reduced.

The determination of the size primaries to feed the transformers was the next problem. These were calculated as follows; the load centers for the groups of buildings, and also the loads in amperes to be carried to these centers, were determined. With the loads in amperes and the distance from the distribution point, the ampere-feet for each load were calculated. From the table in the Standard Handbook giving the volts drop per 1000 feet per ampere in each size of three-conductor cable, the sizes of cables were determined for carrying the required loads with not more than one per cent drop in voltage. The size of each one of these cables was increased to take care of any future loads when more buildings are constructed.

Rubber-insulated cable was selected for the secondaries, because it is more flexible and is more easily handled and spliced than paper-insulated cable. Paper-insulated cable was selected for the primaries, because it has greater insulating qualities and has an indefinite life. The approximate life of rubber-covered cable is twenty years. No three-conductor cable larger than #4/0 was selected, because they are too hard to handle and are too easily injured in handling. In specifying cable and transformers, those manufactured by old established companies were used, because their products can be depended upon to be uniform in quality and no detailed specifications are necessary. The data obtained when determining the size of conductors are shown on the following pages.

After selecting the cable and transformers, the next problem was to design the transformer vaults and duct system. Where there are no water pipes, gas mains or other obstructions to contend with in the building of transformer vaults and splice boxes, concrete is considered better than brick for their con-

		Light				Power			
Bldg No	Building	Conn. Load Kw	Dem. Factor %	Max Dem Kw	Size Feeder to Bldg.	Conn. Load Kw	Dem Factor %	Max. Dem. Kw	Size Cond to Bldg.
1	Elliot Hospital	32.4	50	16.2	0	46.0	50	23.0	0
2	Millard Hall	50.9	30	16.6	0	78.3	41	32.3	00
3	Anatomy Bldg.	48.3	25	12.1	2	97.9	40	39.2	000
4	Biology "	49.0	25	12.3	2	18.7	50	9.4	6
5	Main Engr.	54.5	26	14.2	0	43.3	40	17.3	2
6	Expr. Engr	35.5	35	12.4	0	198.0	40	79.0	300,000
7	Electrical Bldg.	60.0	50	30.0	*8	200.0	60	120.0	*6
8	Administration	35.0	35	12.3	2	15.0	80	12.0	4
9	Auditorium	75.0	60	45.0	*6	60.0	75	45.0	*8
10	Pillsbury Hall	20.5	25	5.2	6	15.0	50	7.5	6
11	Armory	24.8	50	12.4	2	20.0	50	10.0	6
12	Minn. Union	34.6	22	7.6	4	16.0	60	9.6	6
13	Folwell Hall	48.6	22	10.7	0	30.0	80	24.0	0
14	Physics	13.1	25	3.3	6	12.0	75	9.0	6
15	Dentistry	23.4	35	8.3	4	24.6	30	7.4	6
16	Mechanic Arts	11.3	22	2.5	8	12.0	60	7.2	6
17	Old Library	23.9	55	13.2	2	25.0	50	12.5	4
18	Shevlin Hall	13.9	50	6.5	4	10.0	80	8.0	6
19	Women's Gym.	24.8	25	6.2	4	14.9	50	7.5	6
20	Law Bldg.	10.5	35	3.7	6	20.0	75	15.0	4
21	High School	14.5	25	3.4	6	20.0	40	8.0	6
22	Mines Exp	21.9	30	6.6	*8	110.0	60	66.0	*6
23	Pharmacognosy	2.8	50	1.4	8	12.7	50	6.4	6
24	Music Bldg	16.2	35	5.7	2	17.9	50	8.9	6
25	Pathology	19.8	22	4.4	6	18.1	75	13.5	4
26	Pharmacy	13.9	22	3.1	6	9.2	60	5.5	6
27	Museum	30.0	80	24.0	6	15.0	80	12.0	4
28	New Library	72.0	35	25.2	*8	60.0	75	45.0	*8

* = Primary feeder to Bldg.

R.E.D.

Bldg No	Building	Light				Power			
		Conn Load Kw	Dem Factor %	Max Dem Kw	Size Feeder to Bldg	Conn Load Kw	Dem Factor %	Max Dem. Kw	Size Cond to Bldg
29	Chemistry	72.0	20	14.4	2	52.2	75	39.0	000
30	School of Mines	45.0	30	13.5	2	78.0	40	31.2	000
31	Todd Hospital	35.0	40	14.0	2	40.0	60	24.0	00
32	Publications Bldg	1.69	60	1.1	8	5.0	100	5.0	8
33	Observatory	.39	100	.4	8	–		–	–
34	Heating Plant	2.5	50	1.23	8	25.0	80	20.0	0
35	Store House (new)	30.0	25	7.29	*	40.0	50	20.0	0
36	Printing Shop	7.2	80	5.6	6	11.9	60	7.2	6
37	Sanford Hall	27.0	60	16.2	0	10.0	80	8.0	6
38	Plant House	6.2	50	3.1	8	12.7	75	9.2	6

R.E.D.

struction. For this reason all the transformer vaults and manholes are designed for concrete construction. The size of each was determined by the size of the transformers and number of cables therein.

Vitrified clay was selected for the conduit because when laid it costs about the same as fiber conduit, and has better qualifications. In case a cable should burn out there is less chance of it affecting the cables in the other ducts of the same run. With fiber duct the cables have been known to become warm and stick so that they could not be pulled out of the duct. There is also no chance of clay ducts bending and pinching the cable as fiber has been known to do. The laying of the duct has been specified according to engineering methods.

Standard switching and measuring equipment has been specified for controlling the circuits at the station.

S P E C I F I C A T I O N S

for an

ORNAMENTAL STREET LIGHTING SYSTEM

and an

UNDERGROUND ELECTRICAL DISTRIBUTION SYSTEM

on the

MAIN CAMPUS

of the

UNIVERSITY OF MINNESOTA

MINNEAPOLIS, MINNESOTA.

R.E. DONAHOE, ENGINEER.

November, 1922.

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DIVISION 1.

GENERAL CONDITIONS.

SCOPE OF WORK.

The work contemplated under these specifications shall be done under two separate contracts. The first shall be for the furnishing of all labor and material, including transformers and switches, necessary for a complete street illumination system, (ready to operate), on the main campus of the University of Minnesota as called for in Div. #2 of these specifications. The second contract shall be for the furnishing of all labor and material necessary for an underground electrical distribution system for light and power to all the buildings on the main campus of the U. of M. as herein specified in Div. #3.

#2 DESIGNATION OF PARTIES.

The word "Owner" as used in these specifications, refers to the State of Minnesota acting through the State Board of Control, Saint Paul, Minnesota.

The word "Contractor" as used herein refers to the successful bidder for either of the contracts.

The word "Engineer" as used herein refers to the party appointed by the State Board of Control to see that the contract is carried out in detail.

#3 FAMILIARITY WITH SITE AND DRAWINGS.

Parties making bids for either portion of the work contemplated under these specifications and plans are expected to familiarize themselves therewith both as regards that portion of the work covered by their bid and such other work as must be carried on or is intended to operate in conjunction therewith in order that the true spirit and intent of these specifications may be fulfilled. It is also expected that they will visit the premises, take their own measurements and familiarize themselves fully as to the extent of the work and the facilities and difficulties in connection therewith.

In case these plans and specifications are in any part deficient or not clearly expressed, the parties making bids should apply to the engineer for the required information before such bids are submitted, as no changes will be allowed in the plans or specifications after the contract has been awarded except as under the conditions named under Article # 17, Div. 1.

It must be understood and agreed that these plans and specifications shall be fulfilled in their true spirit and intent, and that any apparatus or appliance essential to the proper and convenient operation of the system shall be installed without extra charge even though not specifically called for.

#4 PROPOSALS.

Bidders shall submit their proposals on blank forms furnished by the engineer. These blanks are to be filled in completely and in case bidder is a co-partner, the signature shall be of a member of the firm with the names and addresses of each of the other members; if it is a corporation, then an officer of the firm must sign in the corporate name and with the corporate seal attached thereto. A blank copy of each proposal is attached hereto.

#5 CERTIFIED CHECK.

No bid will be considered unless accompanied by a certified check for the sum of 5% of bid figure, payable to the State Board of Control, said check to be forfeited in case the successful bidder shall fail or refuses to enter into contract or deposit with the State Board of Control within five days after date of awarding of contract, the bond required under these specifications.

#6 CONTRACT.

The agreement which the bidders agree to enter into will be the form in use by the State Board of Control, copies of which forms may be seen at the office of the board in Saint Paul.

The agreement, the specification and the drawings with all notes made thereon before the signing of the agreement constitute the contract documents.

The contractor shall under no circumstances assign this contract without the written permission of the owner.

#7 BOND.

The contractor shall furnish and pay for a satisfactory surety bond to the amount of seventy-five per cent (75%) of the contract. This bond to be in such form as will protect the owner against the filing of any lien upon the property because of work done as well as guaranteeing the faithful performance of the contract.

The bond shall provide for additions or omissions to the work to the amount of twenty per cent (20%) of the contract and that such action may be taken without notice to the surety company.

#8 INSURANCE.

The contractor shall keep his own as well as the interests of the owner fully insured against loss by fire or other manner unless otherwise agreed in writing. He shall carry workmen's compensation insurance, and insurance indemnifying the owner against loss or expense incurred on account of claims of third parties arising out of injury to persons or property during the continuance of this contract.

#9 RESPONSIBILITY OF SURETIES.

If at any time it shall appear that the contractor has unlawfully, fraudulently, or through collusion with any representative of the owner in the work, supplied inferior material or workmanship or has departed from the terms of the contract, the final inspection and acceptance of the work shall not be binding upon the owner, and they shall have the right to cause the work to be properly performed and satisfactory material supplied to the extent the engineer may deem necessary at the expense of the contractor and his sureties. They shall have the right to recover against the contractor and his sureties such damage as may be incurred by the owner therefrom, due to such default of the contractor in the premises.

#10 RIGHTS OF SUB-CONTRACTORS.

No sub-contractor or other person furnishing labor or material will be recognized, nor will the owner be responsible in any way for the claims of such persons, beyond taking the bond above mentioned from the contractor; the above mentioned bond covering in part that the contractor shall make prompt payment to all persons furnishing labor or material used in the prosecution of the contract.

#11 EIGHT HOUR LAW.

Attention of the bidder is called to the act of the Legislature limiting the hours of daily service of laborers employed upon Minnesota State work to eight hours in any calendar day.

#12 SUPERVISION.

The contractor shall personally or through an authorized and competent representative constantly supervise the work from its beginning to its completion and acceptance. His supervision shall be efficient and he shall carefully study and compare all drawings, specifications and other instructions and shall report at once to the engineer, any error, inconsistency or omission which he may discover.

#13 INSPECTION OF LABOR AND MATERIAL.

The Owner, the Engineer, and their representatives shall have access to the work at all times, whether it is in preparation or progress and the contractor shall provide proper facilities for such access and for inspection.

If the specifications, the Engineer's instructions, laws, ordinances or any public authorities require any work to be specially tested or approved, the contractor shall give the Engineer timely notice of its readiness for inspection and, if the inspection is to be by another authority than the Engineer, of the date fixed for the inspection. Inspection by the Engineer shall be promptly made. If any such work should be covered up without approval or consent of the Engineer, it must, if required, by the Engineer, be uncovered for examination at the Contractor's expense.

The Contractor shall promptly remove from the premises all material condemned by the Engineer as failing to conform to the contract, whether incorporated in the work or not, and the Contractor shall promptly replace and re-execute his own work in accordance with the contract and without expense to the Owner, and shall bear the expense of making good all work of other contractors destroyed or damaged by such removal or replacement.

If the Engineer deems it inexpedient to correct work injured or done not in accordance with the contract, the difference in value together with a fair allowance for damage shall be deducted, the difference in value and the damage will be determined by the Engineer.

#14 COMPLETION AND CO-OPERATION.

Contractors under these specifications shall commence work as soon as possible after signing of contract and all work shall proceed as rapidly as it is consistent with thoroughness and good workmanship, and shall be completed within one hundred and twenty (120) days from date of contract.

All contractors performing work under this specification are to co-operate with one another to the end that the entire work may proceed with the least amount of conflict, to the best advantage of all concerned, and with due promptness.

#15 DELAYS AND DAMAGES

Time lost due to general strikes, riots, or accidents beyond the control of the contractor shall be added to the time stipulated above for the completion of the work, provided application is made in writing by the contractor at the time such delays occur, giving its nature and extent, such application to be subject to the approval of the State Board of Control.

If the Contractor shall fail to complete his work in the time stipulated above, including time lost through unavoidable delays, if such time has been approved, there shall be deducted as liquidated damages from the contract price, the sum of twenty dollars ($20.00) per day for each and every day the work remains uncompleted after the date set as above.

#16 PAYMENTS.

Payments will be made each month, only on certificate of the Engineer, and as follows:

Eighty-five percent (85%) of the value of the work executed in approved manner, and of the approved material and apparatus installed in place, and seventy-five per cent (75%) of the value of approved apparatus and material delivered on the site but not installed in place; such payments to be based upon the estimated value thereof as ascertained by the Engineer.

In case of apparatus and material delivered at the site and upon which a payment of seventy-five per cent (75%) is made as above, an additional ten per cent (10%) of such apparatus and material will be allowed, together with eighty-five per cent (85%) of the value of the labor involved when such apparatus and material shall be installed in place in approved manner.

Payment of the balance retained fifteen per cent (15%) will be made after the final approval and acceptance by the Engineer of all apparatus, and material and work embraced in the contract.

#17 CHANGES, EXTRAS, ETC.

The owner reserves the right to make any addition to, omission from work or material as called for in the plans and specifications up to the amount of twenty per cent (20%) of the original value of either contract and the additions or subtractions are to be made without notice to surety or sureties on the bond given to secure compliance with the terms of the contract. The unit prices as stated in the contract will be the basis upon which the change in the contract price will be made.

The owner further reserves the right to demand additional security when additions are made, if in its judgment such security is required for the protection of the owner's interests.

#18 CHARACTER OF WORK.

All work contemplated under these specifications shall be executed in a workmanlike and substantial manner; no patched or slovenly work will be allowed.

The labor shall be thoroughly competent and skillful in its line and the Engineer shall have the right to require the removal of any particular workman or workmen on the job, if in his best judgment it shall be for the interest of the work.

All material shall be of the very best quality, shall be of standard dimensions unless otherwise specified, and samples shall be submitted to the Engineer before being used.

#19 GUARANTEE.

The contractor shall make good for a period of one year after the final acceptance of work all defects which develop on account of defective work or material.

#20 PATENTS.

All patented apparatus or material must be furnished by the contractor under guarantee against loss by suits, royalties, or claims of any kind whatsoever, and that loss or damage to the Owner through suits or claims will be made good by said contractor.

#21 SAFEGUARDS AND DEBRIS.

Contractors must provide all necessary safeguards from accidents to persons or property; must keep all passages, entrances, sidewalks, etc., free from debris and incumbrances; and on the completion of the work must remove from the premises all surplus material of every kind and description.

#22 MANUFACTURER'S DRAWINGS.

The Contractor shall submit, with such promptness as to cause no delay in his own work, or in that of any other contractor, two copies of all shop or setting drawings and schedules required for the work of the various trades, and the Engineer shall pass upon them with reasonable promptness. The Contractor shall make any corrections required by the Engineer, file with him two corrected copies and furnish such other copies as may be needed. The Engineer's approval of such drawings or schedules shall not relieve the Contractor from responsibility or deviation from the original plans or specifications, unless he has in writing called the Engineer's attention to such deviations at the time of submission, nor shall it relieve him from responsibility for errors of any sort in the shop drawings or schedules.

#23 RULES AND REQUIREMENTS FOR WORK AND MATERIAL.

All work and material covered by these specifications must conform strictly to the respective requirements of the latest editions of the following:

Rules of the National Board of Fire Underwriters.

Standardization Rules of the A.I.E.E.

Testing Code of the American Society of Mech. Eng.

Standard Specifications of the Am. Society of Test.Mat.

State Laws of Minnesota.

City Ordinances of Minneapolis.

Any conflict between items in the above, between themselves or with these specifications, must be submitted to the Engineer for adjustment, as the prime object desired in any case is to obtain the best quality installation known to the trades, unless otherwise stated.

#24 TESTS.

All work shall be regularly and systematically tested while in the process of construction and any defects shall be immediately remedied.

The final tests shall be made in the presence of the Engineer or his representative, and the right is reserved by the Owner in case any doubt arises as to the fulfillment of the true spirit and intent of the specifications, to demand a test by expert engineers selected as is usual in matters of arbitration, whose decision shall be final on all disputed points, the expense of such tests to be borne equally by both parties unless the apparatus or material shall prove defective, in which case the Contractor shall bear the expense and shall also remedy the defects. He shall also be liable for any loss or damage to the Owner resulting from conditions incident to the remedying of such defects.

#25 ACCEPTANCE.

The Owner will assume no liability nor responsibility for any part of the installation until formally accepted in writing and the acceptance of any portion of the work shall not be construed as a final acceptance.

The final acceptance will be given only after the completion of the work contemplated under these specifications according to their true spirit and intent and after the final tests as specified.

The date of the completion of the final tests shall be taken as the date of such final acceptance provided such tests prove satisfactory.

DIVISION 2.

STREET LIGHTING SYSTEM.

GENERAL.

The work included in this part of the contract shall consist of the installation of light posts complete with foundations, cable, transformers, control apparatus and all other material necessary to form a complete street lighting system ready to operate.

The system shall be fed from a power plant or substation to be built as an addition to the present heating plant. The lights shall be fed on four series circuits, two of which shall feed the lights which are intended to burn all night and two of which shall feed the lights which are to burn until midnight. The lights which are to be connected to the different circuits are designated with symbols on the print showing the light locations and the circuits diagrams.

The general conditions as embodied in Division #1 of this contract shall apply to the work specified in this division.

LIGHTING UNITS.

The lighting unit shall be the Arcadian post with an Octagonal Reflecto-Lux top, both as manufactured by the George Cutter Company. Each unit shall be equipped with rippled glass panel, white enameled reflectors and regent sockets.

Before installation each post shall be carefully inspected to see that all material and workmanship is of a grade equal to that of the sample supplied by that company for inspection.

FOUNDATIONS.

The foundations shall be cast in place from concrete of the proportions, one part of cement, to two parts of sand, and four part of a coarse aggregate, all proportions being determined by bulk measurement. The holes for these foundations shall be carefully excavated to conform to the dimensions specified in the drawing, and the bottoms shall be well tamped to a firm condition and leveled to provide an even bearing.

Each foundation shall be provided with four foundation bolts, a pothead support, and two fibre elbows all of which shall be firmly held in place by means of a templet when pouring the concrete.

The foundation bolts are to be 3/4" in diameter and shall extend down into the cement not less than 15".

The fibre elbows are to form the ducts for bringing the cable up to the potheads, and are to have a diameter of 2" and a bend sweep of not less than ten inches.

The top of the concrete in all foundations must be smooth, level, and brought to the level of the adjacent curbing. Where no curbing exists, the top of the foundation must be brought to the level given by the Engineer which shall be that of the curb when one is installed.

The cement used in the concrete for these foundations shall be the best quality Portland Cement and must meet all the requirements of the latest standard specifications for Portland Cement, adopted by the American Society for Testing Material.

The sand used shall be clean and of such fineness that 95% of it will pass through a screen of 1/4 inch mesh and not more than 20% will pass through a screen with 50 holes per inch.

The coarse aggregate shall be clean, durable gravel or crushed limestone and shall be of such sized particles as will pass through an inclined or rotary screen having a one inch mesh.

POST SETTING.

The posts shall be placed on the foundations and set plumb and true. When necessary, metal shims shall be used to secure an even bearing, (no wood shims will be allowed.) When shims are used or where the base of the post does not have an even bearing all around, they shall be grouted in with cement mortar composed of one (1) part Portland Cement and one (1) part sand mixed thin enough to flow easily.

On the University Avenue bridge the posts shall be installed on the sidewalk on the side next to the steel girder. Holes shall be carefully drilled through the concrete slab for bringing the pipe and cable up through and also for the bolts to anchor the posts. Special care should be taken in setting these posts to obtain a solid footing.

POST WIRING.

A Safety-First Disconnecting Type Pothead shall be installed in the base of each light post. These potheads shall be properly mounted on supports set in the concrete foundations.

The cable connections to the potheads shall be care-

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fully made and the potheads filled with "Ajax" splicing compound or a compound of equal grade. In making these cable connections, care must be taken to properly bond the ends of the lead sheath and the steel armor, also to ground the sheath and armor at this point.

The cable connections shall be made as soon as the cable is cut, so that there will be no danger of moisture creeping under the insulation when the ends are exposed.

Connections from the potheads to the lamp sockets shall be made with continuous leads of 2500 volt rubber-covered wire. This wire shall be stranded #8 soft-drawn copper wire and shall be of "Safety" or an equal and approved brand.

GROUNDS.

Each light post shall be well grounded and the sheath and armor of the cable shall be grounded at each post. The grounds may be made by extending one of the foundation bolts on through the foundation for a distance of at least 30 inches, or by extending a #8 copper wire down through the foundation to a depth of at least 4 feet below.

Proper grounds must also be provided for the frames of the transformers and equipment at the sub-station.

PAINTING.

All posts and tops shall be painted with two coats of an excellent grade of acid and rust resisting paint which shall be of a dull black color when dry. The first or priming coat shall be applied before the posts and tops leave the factory, and the second coat shall be applied after they have been installed in place.

CABLE.

The cable shall have a single conductor of #8 B&S guage, soft drawn, annealed copper wire finished with a heavy uniform coating of commercially pure tin without any projections. The wire must be uniform in cross-section and free from flaws, scales and other imperfections. Each conductor must be continuous between posts without weld, splice or joint.

The tinned copper conductor shall be covered with a high grade 30% pure Hevea rubber insulation not less than 8/64" thick and which shall conform to the latest specifications of the American Institute of Electrical Engineers. This rubber insulation shall be covered with a layer of tape not less than 1/64" thick.

After the wire is properly insulated it shall be incased with a commercially pure lead sheath 1/16" thick, which shall have a smooth even surface and shall fit the insulation closely. The cable is then to be passed through a non-hardening bath of preservative compound and served with 5/64" jute yarn wound spirally. It is then to be covered with two galvanized steel tapes ;035" thick and wound in opposite directions. The space between the joining winding shall not be more than 1/16". Each layer of steel tape is to be passed through a bath of non-hardening preservative compound.

After the application of the steel tape the cable shall be thoroughly tarred and completed with the serving of 5/64" saturated jute yarn thoroughly compounded to make a smooth outside finish.

The cable shall show a breakdown test of not less than 8000 volts.

CABLE LAYING.

Where the cable parallels the street, it shall be laid in the boulevard back of the curb, and to a depth of not less than fifteen (15) inches. Where crossing the street or where laid outside of the curb, it shall not be less than eighteen (18) inches below the surface. The ends of the cable shall be brought up through the openings in the post bases and not less than eight (8) inches allowed above the concrete for connection to the pothead. The sod shall be carefully put back in place in as neat a manner as possible. Where paving is taken up, it shall be replaced with that taken up and in a way which will show the repair as little as possible.

Where it is desirable, an iron pipe may be driven under the paving through which the cable can be drawn without injury.

CROSSING BRIDGE.

When crossing the bridge on University Avenue, the cable shall be run in galvanized iron conduit securely fastened to the bridge in a manner satisfactory to the Engineer. Each cable shall be run in a separate conduit. After the conduit has been installed, it shall be covered with at least two coats of a number one grade of rust and acid resisting paint.

REGULATORS.

Four constant current regulators for the purpose of transforming the constant potential power supplied into the constant current power required by the lighting units, shall be installed in an addition to be built to the present heating plant. The constant current regulators shall have a capacity of 17 kilovolt-amperes each, and they shall be of the moving coil, air cooled type for use on 2300 volt, 60 cycle primary circuit. They shall maintain the rated 6.6 amperes within one per cent from no load to full load. The moving element shall be critically damped. They shall successfully stand for a period of sixty seconds, a potential difference of at least 7500 volts (r.m.s. value) between the primary winding and core, and a potential difference of at least 14000 volts (r.m.s. value) between the secondary winding and the core, and between the secondary and primary windings.

CONTROL PANELS.

The contractor shall furnish and install in the distributing station two control panels for connecting the constant current regulators to the power source and to the distributing feeders. The control panels shall be of black marine finished slate, 1.25 inches thick, with 0.25 inch bevel on all front edges. They shall each be of such dimensions as to neatly accomodate the following apparatus:

Two alternating current ammeters, with current transformers, of such a scale range that the 6.6 ampere division is near the middle of the scale. The current transformer shall stand for a period of sixty seconds, a potential difference of 14,000 volts (r.m.s. value) between primary and secondary windings, or between primary winding and the core.

Two 2500-volt, four-pole, single-throw, non-automatic oil switches for connecting the primary winding of the transformers to the buses, and the secondary windings to the feeders with one operation. The oil circuit breakers shall stand for a period of 60 seconds a potential difference of 7500 volts (r.m.s. value) between poles and between each pole and the enclosing case or frame.

These panels shall match those selected for the control of the light and power circuits to the buildings. The apparatus and panels shall be those manufactured by the Westinghouse Co., or of an approved equal grade.

SERVICE.

2300 volt current shall be supplied by the University to the buses back of the switchboard in the distributing station. The Contractor shall make all connections from these buses to the system.

DIVISION 3.

ELECTRICAL DISTRIBUTION SYSTEM.

GENERAL.

This part of the contract shall be for the furnishing of all labor and material necessary for the complete installation of an underground electrical distribution system for light and power to all the buildings on the main campus of the University of Minnesota.

The general conditions as embodied in Division 1 of this contract shall apply to the work specified in this division.

The system shall be of vitrified clay conduit with lead covered cables feeding distribution transformers located in manholes on different parts of the campus. The buildings shall be fed with the secondary current from the transformers. There shall be four primary cables, two for power and two for lights which shall be fed from current furnished to a switch board located in a power house or sub-station built onto the present heating plant.

CONDUIT.

The conduit shall be single duct Vitrified Clay. It shall be of the best grade obtainable and made by a reliable manufacturer.

A dimensioned diagram of a length of duct is shown on an attached drawing. These dimensions may vary slightly from those given, but in no case shall they be less.

CONDUIT LAYING.

The number of ducts and the arrangement in laying shall be as shown on the attached drawings.

The trenches for the conduit shall be excavated to a grade sloping toward the manholes at the rate of 1/8" per foot or more. They shall be of such width as will accomodate the ducts and concrete specified for each and they shall be of such depth that the top of the concrete incasement shall be not less than fifteen inches below the ground surface at any point.

Loose dirt on the bottom of the trenches shall be tamped solid previous to placing the concrete, and any sharp stones or rocks which are encountered in the bottom of the trenches or filling dirt shall be removed.

The sides of the trenches must be vertical, and wherever required the sides must be shored to prevent caving. The trenches must be kept free from any water during the laying of the conduit. On the bottom of the trench, shall be laid a three inch layer of concrete. This layer of concrete shall be brought to a smooth compact even surface and before it begins to harden, conduit of the number and arrangement of ducts shown on the attached drawing for the respective locations, shall be placed on the concrete and embedded in so that it shall be supported throughout its entire length. The ends of all the ducts shall be staggered and a mandrel not less than four and one half feet long should be pulled through as the conduit is laid to insure a smooth fit in the joints and to scrap out any concrete that may have come through them.

As soon as the ducts are laid properly, concrete shall be placed over the top and sides in the specified amounts.

BACK FILLING.

After the conduit has been properly laid and the concrete allowed to harden enough to withstand the work of tamping, the earth shall be replaced in the trenches in layers not more than four inches in thickness, and each layer shall be well dampened, and tamped into an unyielding condition with a tamper having an area of not more than twenty-five (25) square inches and weighing not less than fourty (40) pounds. The earth shall be brought to the height of the sub-grade of the superstructure where the conduit lies under the pavement or sidewalks, and where the conduit lies in the parking, the earth backfill shall be brought to the surface of the adjacent ground.

Where excavations occur through pavement or sidewalks, the pavement or sidewalks shall be relaid of the same quality of materials and of the same thickness as the original pavement. The contractor shall guarantee the pavement or sidewalks relaid to be in good condition at the end of one year.

MANHOLES.

Manholes shall be constructed of the respective type, shape and dimensions and at the locations shown on the attached drawings. They shall be of concrete with reinforced concrete roofs. The forms shall be erected in a workmanlike manner so as to leave a smooth even surface to the concrete when they are removed.

Before the floor is laid, a piece of one inch galvanized iron conduit shall be driven into the earth about five feet and the end shall be allowed to extend up through the floor of the manhole. The object of this conduit is to form a means of grounding the transformers and cable in the manholes.

The floors should be laid before the wall forms are installed and care should be taken to get the proper slope toward the end with the drain pipe. The upper surface of the floors shall be finished with a half inch layer of cement mortar composed of one part by bulk of cement and two parts by bulk of sand. The surface shall be finished with a trowl.

Where the manholes are not located more than forty (40) feet from a sewer line, the drain pipes should be connected to a sewer with three inch sewer pipe in which there is a trap to prevent gas coming up into the manhole.

Where the manholes are located more than forty feet from a sewer, at least four cubic feet of crushed stone or coarse gravel must be placed just outside the manhole at the drain end as shown in the drawing to give a large surface for drainage.

The covers and lids shall be of the shape and dimensions shown on the attached drawings. They shall be made of the best quality of soft grey iron without the admixture of any inferior materials.

Each manhole shall be equipped with enough cable racks of an approved make to properly support the cable around the walls.

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CONCRETE.

The concrete used in the manholes shall be of the mixture of one part of cement, two parts of sand and four parts of a coarse aggregate, all proportions being determined by bulk measurement.

The cement used in the concrete shall be the best quality Portland cement and must meet all the latest requirements of the standard specifications for Portland cement adopted by the American Society for Testing Materials.

The sand used shall be clean and of such fineness that 95% of it will pass through a screen of 1/4 inch mesh and not more than 20% will pass through a screen with a mesh of fifty holes per inch.

The coarse aggregate shall be clean, durable gravel or crushed limestone and shall be of such sized particles as will pass through an inclined or rotary screen having a one inch mesh.

The concrete for conduit shall be the same as that used in the manholes except that the coarse aggregate shall be of such size as will pass through an inclined or rotary screen with a one half inch mesh.

REINFORCING STEEL.

The reinforcing steel shall be of the size, and spaced as shown on the attached drawing, and shall be of the best quality reinfotcing steel, rolled from new billets. (No re-rolled stock will be allowed.) It shall also be free from excessive rust and oil. All bars shall be cut to the required length, as no splicing will be permitted. The steel shall be placed on the forms in such a manner that the center of the bars are two inches from the bottom of the slab.

CABLE.

The cable used shall be three conductor in sizes up to number four ought (#4/0) and shall be single conductor in sizes larger than four ought (#4/0). The sizes to be used are shown on the attached blue prints.

All cable used on this job shall be of the best grade manufactured by the General Electric Company or an equal and approved grade.

The primary cables carrying current at twenty three hundred volts pressure shall be paper insulated and thirty volt current shall be rubber insulated.

CABLE PULLING.

In pulling the cable into the conduit, no length of over five hundred feet shall be pulled at one time. All cables shall be thoroughly greased as they are pulled into the conduit. They shall be protected from injury as they enter the conduit by suitable leather or lead cable protectors placed in the mouth of the duct. The ends of the cable shall be hermetically sealed with solder immediately after cutting. Sufficient slack shall be left in all manholes so that the cable may be carried around the sides of the manholes on the cable racks or hooks, properly spliced and connected to transformers. During installation no cable shall be bent on a radius less than ten times its diameter. The cable shall be carefully protected at the mouth of the duct, and shall not be left hanging loosely or laying on the manhole floor.

If any unsealed cable is exposed to moisture, it shall successfully stand the electrical tests for cables of its kind before being connected as an integral part of the system. The expense of removal, test and replacement of the cable shall be borne by the Contractor.

The cables from the heating plant to the manhole near Sanford Hall shall be placed on cable racks in steam tunnel running to that building. In this case the cables should be located as far from the steam pipes as possible.

No splice nor joint will be permitted in any underground cable except in a manhole or pullbox. All splices and connections shall be made by expert workmen, experienced in this work, and the latest approved methods shall be employed.

TRANSFORMERS.

All transformers shall be Westinghouse type SM or General Electric type H for underground distribution, and shall be of the sizes shown on the attached blue print. They shall be wound for 2300 volt primary and 110/220 volt secondary service, and shall withstand all tests in accordance with the rules specified in Division 1 of these specifications.

ELECTRICAL EQUIPMENT IN MANHOLES.

Transformers of the size and kind specified above shall be installed in the respective manholes as shown on the attached drawings.

The transformers shall be set firmly on the floor of the manhole, metal shims being used if necessary.

The cables connected to the transformers shall be carried around the wall of the manholes in the hooks provided therefore in a neat manner. In each primary lead to a transformer there shall be properly installed a subway type of fused cutout of the design made by the manufacturer of the transformers. All cable connections to the cutouts and transformers shall be waterproof by connecting the cable to the brass nipple with a wiped joint.

All transformer cases and cable sheaths shall be permanently and effectively grounded with connections to the pipe installed for that purpose when building the manholes.

CONTROL PANELS.

The Contractor shall furnish and install in the distributing station, two control panels for connecting the power and light feeders to the buses in the station. The control panels shall be of black marine finished slate, 1.25 inches thick, with 0.25 inch bevel on all front edges. They shall each be of such dimensions as will neatly accomodate two manually-operated, single-throw, three-pole oil switches with automatic over-load trips.

The Contractor shall also install with each of these panels, a sub-panel with an integrating watt-hour meter mounted on it. The above meter shall be suitable for measuring the power delivered to both the circuits controlled on the panel above.

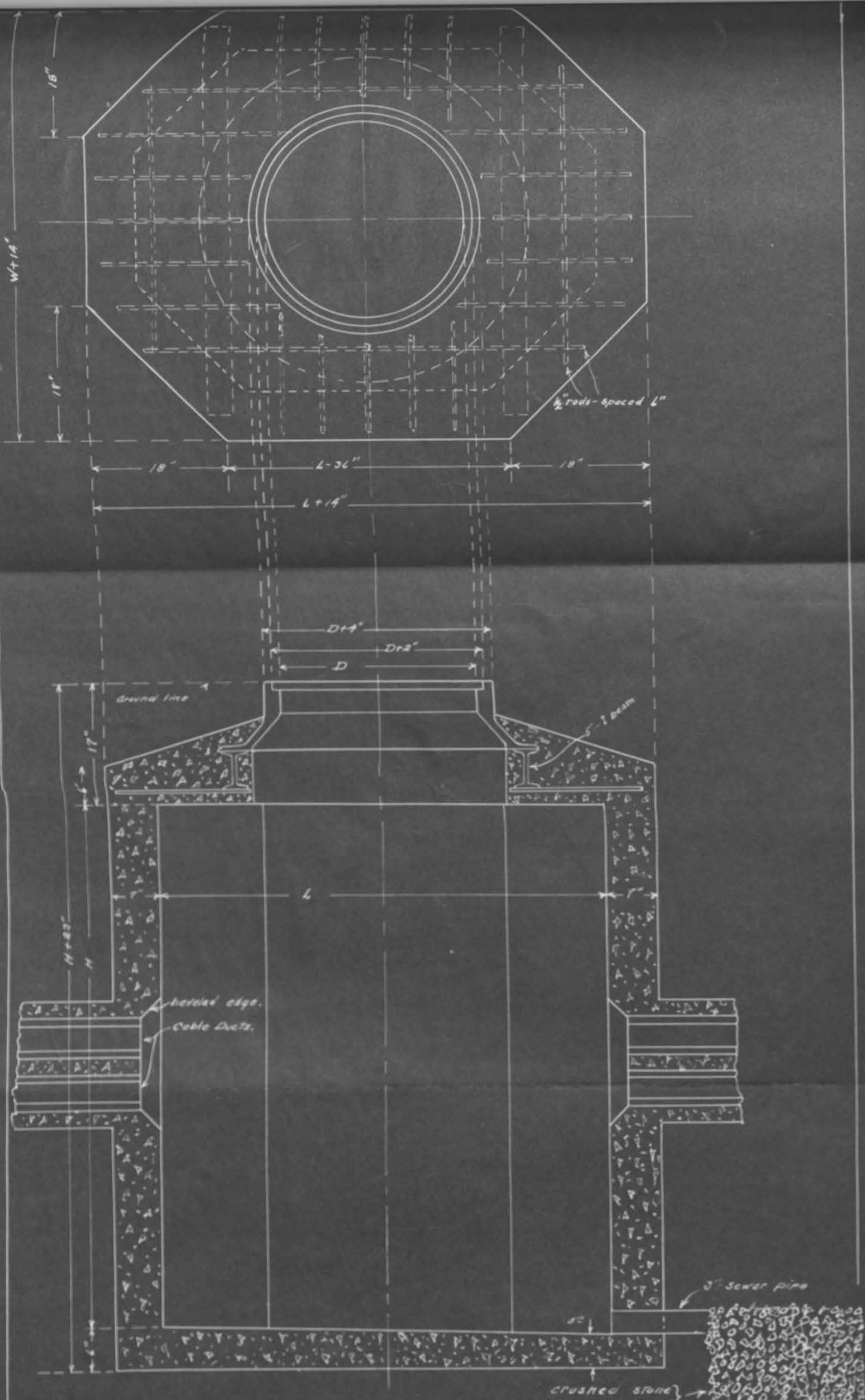
The above equipment shall be that manufactured by the Westinghouse Company or an approved equivalent.

The above apparatus shall be connected in such a way that the two power feeders shall be controlled on one panel and the two light circuits on the other.

SERVICE.

Current at 2300 volts and 60 cycles shall be furnished to the buses of the sub-station switch board by the University.

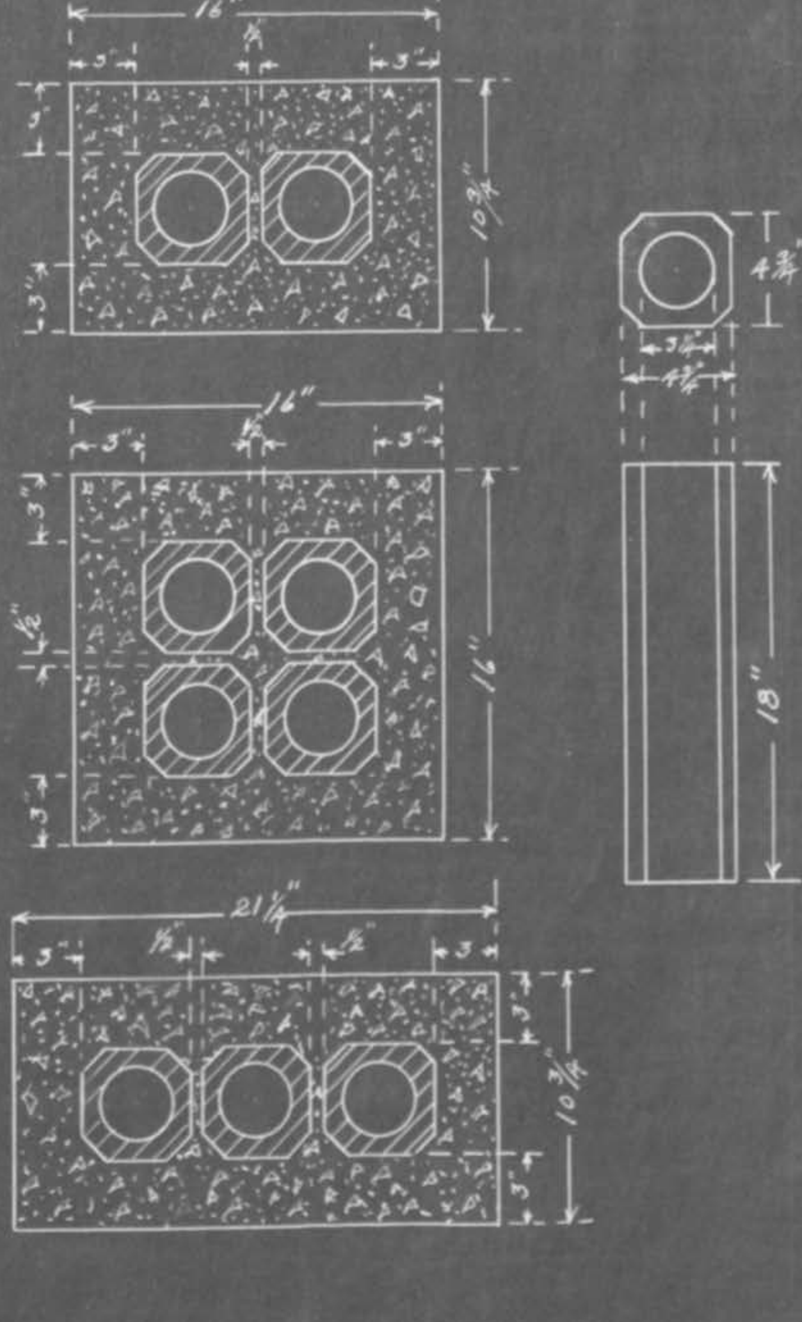
The Contractor shall furnish all material and make all connections necessary to control the respective circuits from these buses.



Plan of Manholes.

Manhole Dimensions					Transformers in Manholes.				
					Light			Power	
M.H. No	L	W	H	D	No + size	Cable No	Phase	No + size	Cable No
1	4	3	5	24					
2	7½	6	6	30	1-25	3	A	3-15	4
3	4	3	5	24					
4	7½	6	6	36	1-37½	3	B	3-15	4
5	5	4	6	24					
6	4	3	5	24					
7	7½	6	6	36	1-25	3	A	3-10	4
8	4	3	5	24					
9	Base. of Auditorium				1-75	1	A	3-25	2
10	4	3	5	24					
11	4	3	5	24					
12	6½	5	6	30	1-15	1	C	3-5	2
13	Base of New Physics				1-25	1	B	3-15	2
14	"	"	"	Electrical	1-37½	1	C	3-50	2
15	5	4	6	30					
16	9	7	6½	36	1-37½	1	B	3-37½	2
17	4	3	5	24					
18	4	3	5	24					
19	7½	6	6	30	1-25	1	A	3-10	2
20	4	3	5	24					
21	Base. of New Library				1-50	3	B	3-15	4
22	9	7	6½	36	1-25	3	C	3-25	4
23	3	3	4	24					
24	6½	5	6	30	1-2	7	C	3-5	8
25	9	7	6½	36	1-37½	1	C	3-25	2
26	6½	5	6	30	1-15	1	B	3-5	2
27	Base. of New Store House				1-25	3	A	3-10	4
28	Base. of Mines Exp.				1-15	5	C	3-37½	6

R.E.D.



Plan for Laying Conduit

P.E.D.

COST ESTIMATE

OF

ORNAMENTAL CAMPUS LIGHTING SYSTEM

FOR

UNIVERSITY OF MINNESOTA, MINNEAPOLIS, MINNESOTA.

57,000 ft.	No. 8, 2500 volt single-conductor steel taped underground cable @ $158.00 per 1000 ft.	$ 9006.00
5,600 ft.	No. 8, 2500 volt single-conductor rubber covered, double braided wire @ $20.00 per 1000 ft.	112.00
26,500 ft.	Trenching for cable, laying cable and resurfacing @ 7¢ per ft.	1855.00
206-	Labor and material to install concrete foundations, including sett-bolts, conduit elbows and pothead supports @ 6.50	1339.00
412-	Conduit elbows @ 60¢.	247.20
824-	3/4" x 18" foundation bolts @ 40¢	329.60
206-	Arcadian Posts complete Octagonal Reflectolux tops, with regent sockets Syenite panels, and potheads @ 46.50	9579.00
	Carried Forward	22467.80

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	Brought Forward	$ 22467.80
206-	Labor to erect posts, including wiring, installing lantern tops, sockets glass panels and lamps @ 2.75	566.50
206-	Labor to install potheads, including cutting cable, wiring and filling potheads with compound @ 2.00	412.00
206-	Labor and material to paint posts @90¢	185.40
4-	17 kva. Moving Coil Station Type constant current regulators @ 350.00	1400.00
2-	Control panels with apparatus as specified @ 125.00	250.00
	Labor to install regulators, control panel and station wiring	200.00
206-	2500 Lumen (250 C.P.) 6.6 Ampere Mazda "C" Street Series Lamps @ $2.35 less 21%	382.44
	Tape and Miscellaneous supplies	100.00
	Insurance	250.00
	Miscellaneous freight and draying	500.00
	TOTAL.....$	26417.14

TOTAL COST OF COMPLETE INSTALLATION....$ 26,417.14

AVERAGE COST PER POST INSTALLED... ....$ 129.20.

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C O S T E S T I M A T E

O F

ELECTRICAL DISTRIBUTION SYSTEM ON CAMPUS

O F

THE UNIVERSITY OF MINNESOTA, MINNEAPOLIS, MINNESOTA.

8600 ft.	Double duct conduit complete including conduit, excavation, refilling, removal and replacement of pavement @ $1.60/ft.	$ 13,760.00
1680 ft.	Four duct conduit complete as above @ $2.20 per ft.	3,696.00
9-	4' x 3' x 5' manholes complete, including excavation, refilling, tops etc. @ $55.00 each	495.00
4-	7-1/2' x 6' x 6' manholes complete as above @ $135.00 each	540.00
2-	5' x 4' x 6' manholes complete as above @ $95.00 each	190.00
3-	6-1/2' x 5' x 6' manholes complete as above @ $120.00 each	360.00
3-	9' x 7' x 6-1/2' manholes complete as above @ $170.00 each	510.00
9-	5 kva 2300/220 volt subway trans.@ $110.	990.00
9-	10 kva ditto @ $161.50.	1453.50
	Carried Forward	21994.50

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		Brought Forward	$	21994.50
15-	15 kva 2300/220 volt subway Trans.		@$204.	3060.00
16-	¢25 kva	ditto	@ $282.	4512.00
10-	37-1/2 kva	ditto	@ $363.	3630.00
4-	50 kva	ditto	@ $428.	1712.00
1-	75 kva	ditto	@ $538.00	538.00
3100 ft.	# 2/0 - 3 cond. 2300 volt, paper insulated lead covered power cable @ 97¢			3007.00
5150 ft.	# 1/0	ditto	@ 93¢	4789.50
900 ft.	# 2	ditto	@ 60¢	540.00
2600 ft.	# 4	ditto	@ 41¢	1066.00
650 ft.	# 6	ditto	@ 38¢	247.00
2850 ft.	# 8	ditto	@ 35¢	997.00
900 ft.	# 10	ditto	@ 32¢	288.00
1850 ft.	# 10 - 2 conductor, 2300 volt, paper insulated, lead covered cable @ 20¢			370.00
450 ft.	300,000 c.m. 1 conductor, rubber insulated, lead covered cable @ 50¢			225.00
400 ft.	#3/0 - 3 conductor, rubber insulated, 600 volt, lead covered cable @ 98¢			392.00
		Carried Forward		47368.50

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			Brought Forward	$ 47368.50
1150 ft.	#1/0 - 3 conductor, rubber insulated, 600 volt, lead covered cable		@ 82¢	943.00
700 ft.	# 2	ditto	@ 52¢	364.00
2000 ft.	# 4	ditto	@ 37¢	740.00
2200 ft.	# 6	ditto	@ 34¢	748.00
800 ft.	# 8	ditto	@ 28¢	226.00
25700 ft.	Pulling in cable @ 4¢ per foot			1028.00
64-	Setting and connecting transformers @ $9.00 each			576.00
4-	Marine finished slate panels with equipment as specified @ $85.00			340.00
	Miscellaneous labor and material			600.00
	Insurance			500.00
			TOTAL	$ 53433.50

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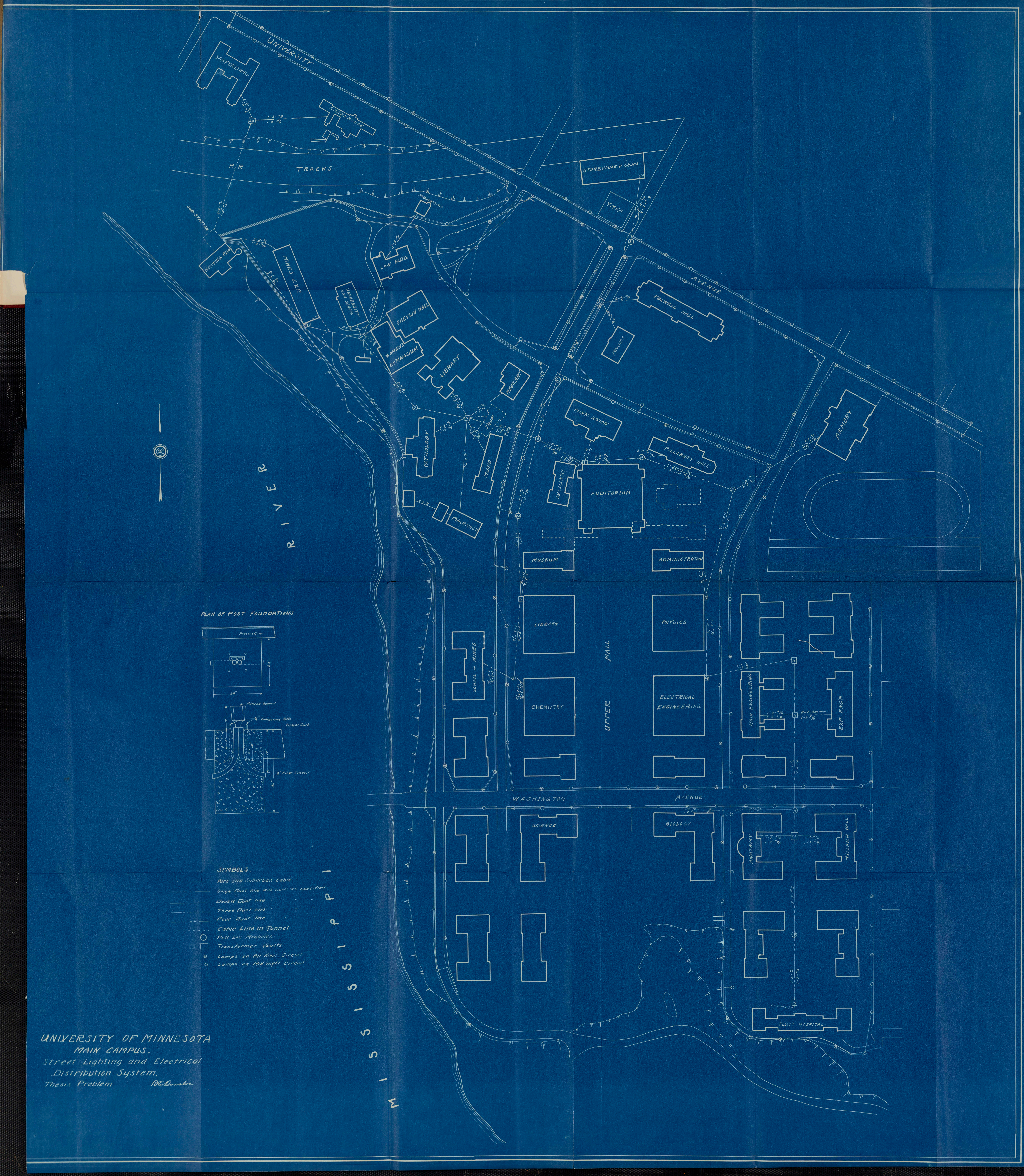
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