THESIS.

INSTALLATION OF AN ELECTRIC LIGHT PLANT

FOR THE

UNIVERSITY OF ILLINOIS.

BY

GEO. W. BLAKESLEY.

For the Degree of B. S. in Electrical Engineering.

UNIVERSITY OF ILLINOIS.

1893.
Six cabinets 4968.60
Belts 86.00
Counter-shaft 36.00
Three pulleys with clutches 100.00
One pulley 16.00
Pulling in boiler 50.00
Cost of pipe connections 40.00
Cost of station building 1000.00
Seventy arc lights 600.00
Cut-outs (30) 15.00
Feed-jump 40.00
Water-heater 36.00
Hard wood cleats 10.00
Molding 40.00
Chandeliers 350.00
Insulating couplings 15.00
Total 7458.60
Cost of labor, wiring, etc: $453.60
Cost of wire: $300.00
Total cost: $753.60
Design of Station House.
Scale $\frac{1}{8}" = 1$ ft.
the cost of the following items would be approximately as follows:

Two T-H incandescent dynamos - $1200.00
One T-H arc dynamo - 1300.00
Foundations for dynamos - 60.00
One Ideal engine - 900.00
Foundation for same - 60.00
Boiler (one) - 1050.00
Three amperes meters - 75.00
Slate switch-board in Place - 75.00
Two volt-meters - 50.00
Six double-pole feeder switches - 39.00
Three main dynamo switches - 57.00
Poles for eight cross arms (13) - 60.00
Incandescent lamps (440) with sockets - 28.60
Snap switches (24) - 24.00

4962.60
All the necessary wood-work, glass, etc., to complete building shall be put in.

The chimney shall be constructed of brick and shall be forty feet high.
It shall have a minimum cross-section of not less than eight percent larger than the grate area of the boiler.
The floor of the station shall be made of concrete.

Estimate of Cost.

Sufficient data could not be obtained to make a very close estimate of the cost of making this installation, but the following approximate estimate has been made.
manufacture have an ample capacity. Both pump and heater shall be properly connected up to supply the boiler.

All steam pipes shall be covered with some incombustable, non-heat conducting material.

Station

A design of the station building is given herewith showing the location of the boiler, engine, dynamos, counter-shaft, switch-board, etc. It shall be a one story structure with walls eight feet high above foundation and shall be made of the dimension given.
appliances such as safety valves, pressure gauges, water columns, etc. It shall be set in masonry in accordance with the standard practice and shall have a good foundation.

A smoke passage to the chimney shall be provided having a cross sectional area of at least five percent greater than the grate area of boiler.

Feed-pump

A feed-pump of the best make, having a capacity of sufficient to give the necessary supply of water to the boiler when at its maximum pressure.

Also a water heater of standard
**Belts**

All belts necessary to drive the dynamos shall be provided; they shall be double leather endless belts and be free from any flaws. They shall be of the length required by the design of station and shall have a width sufficient to transmit the required horse-power at the necessary speed.

**Boiler**

One horizontal, tubular boiler of seventy horse-power. This shall be inspected by a responsible Steam Boiler Insurance Co. and accepted by them. The boilers shall be provided with all the essential
in the concrete.

**Counter-Shaft**

The counter-shaft shall be made of the best material and be of ample diameter to transmit the required horse-power. It shall be placed high enough above the floor to allow six inches between the floor and bottom of largest pulley. It shall be mounted on pedestals containing adjustable self-oiling bearings and be provided with all the necessary pulleys, clutches, collars and key-seats. Each pulley driving a dynamo shall be provided with a friction-clutch. These clutches must be positive in their action and pick up their load without shock or
The foundation shall be made of the best concrete. It shall have a depth of at least six feet and an area at the top equal to that of the capstone, the area at the bottom shall be at least twenty percent larger. The upper surface of the foundation shall be on a level with the floor and shall be surmounted with a capstone which shall have a depth sufficient to give a clearance of twelve inches between the floor and rim of fly wheel or engine. The bolts which hold the engine to the foundation shall pass through the capstone to the bottom of the foundation and must be firmly anchored.
Steam Plant

Engine

The steam plant shall consist of the following apparatus:

One horizontal, simple cylinder, high speed engine to run at three-hundred revolutions per minute and give a sixty brake horse-power. All material and workmanship shall be of the best grade. It shall run noiselessly without any vibration and shall have a high efficiency. The engine shall be provided with all the necessary fittings and be permanently connected with the boiler with the proper pipes and valves.
Back of Switch-board showing wiring.
Design of Switch-board.
These new chandeliers shall be as neat in appearance as the present fixtures. Each fixture shall be insulated from the gas pipe by means of an insulating coupling.

Samps

The contractor shall provide and place in the position indicated on the plans, four hundred and forty incandescent lamps having a voltage of 110 Volts and an efficiency of 3.4% watts per candle-power. Each of these lamps shall be provided with sockets.
the lamp. The drop cord shall be neatly wound around the chandelier and securely fastened.

Where there is no chandelier the lamp shall be suspended by a drop cord or wire pendant from a rosette connector on the ceiling. Each chandelier shall be insulated from the gas pipe by an insulating coupling.

Natural History Building

In the Natural History Building the present gas chandeliers shall be replaced by chandeliers made arranged for both gas and electric light.
that they will not work loose with continued use of the switch.

Joints

All joints shall be soldered and made mechanically and electrically secure and then be so wrapped with insulating tape that their insulation shall equal that of the rest of the wire.

Fixtures

Main Building and Chemical Lab.

In the Main Building and Chemical Laboratory the lamps shall be attached to the gas chandeliers by means of brass connectors insulated from
the floor girders. The molding shall have a neat appearance and be securely fastened to the girders.

Cut-outs

In each building cut-outs shall be placed in the circuit at each change in the size of ceiling. They shall be double-pole mounted on incombustible bases provided with incombustible covers. The rosette above each chandelier shall also be provided with a cut-out.

Switches

All switches shall be double-pole snap switches which are automatic in their action. They shall be securely fastened to the wall in such a manner...
mechanical injury. All wires shall be 98% copper and have the best insulation. The whole system shall test free from grounds and have an insulation resistance of at least one meg-ohm.

The cabinets shall be constructed the same as those in the Main building and shall contain all switches and cut-outs marked on plans.

All wires in this building shall be concealed under a molding. This molding shall be made of wood to match that upon which it is placed. It shall be runs along the lower edge of the vertical side of
by multiple arc.

The fall of potential from the switch-board to the farthest lamp shall be thirteen percent being divided as follows: Ten percent on feeders, two percent on mains and one percent on tap-circuits.

Two feeders shall carry the current from the switch-board. They shall run into the building on the third floor and then run down the inside of the elevator shaft, one to the cabinet on second floor and the other to the cabinet on first floor. They must not interfere with the running of the elevator in any way and shall be protected from
carried from the switch board by pair of one's feeders to the cabinet on the second floor. The insulation of the wire used in this building shall be such that it will withstand acid fumes. In other particulars the specifications for the wiring of this building shall be the same as those for the main building.

**Natural History Building**

The Natural History building shall be wired for 158 incandescent lamps which shall be located in accordance with the plans given. The system of distribution shall
crowding. The wires shall be run under hard wood cleats, securely fastened to the ceiling or wall, placed not more than eight feet apart. The distribution of the current shall be made in accordance with the design given on plans. All wiring shall be free from ground and must give an insulation resistance of one meg-ohm.

Chemical Laboratory

The Chemical Laboratory shall be wired for eighty-five incandescent lamps. The current for these lamps shall be
From the switch-board three feeders shall be carried to the following points: to cabinet located on first floor, to cabinet located on second floor and to cabinet located on fourth floor. From these cabinets the mains shall run to supply the different groups as called for on plans.

These cabinets shall be made of Georgia Pine securely and neatly put together, and shall be provided with hinged doors which can be locked by lock and key. These cabinets shall be of sufficient size to contain the switches and cut-outs marked on plans without
The fall of potential between the switch board and the farthest lamp shall not exceed thirteen percent of the initial pressure, this difference being divided as follows: ten percent on feeders, two percent on mains and one percent on tap-circuits.

All wires used shall be made of the best copper (98%) and shall be insulated with the best insulation. The insulation on all tap circuits shall be white in color. Where wires pass through walls they shall be incased in some kind of an efficient waterproof and incombustible insulating tubing.
twenty feet. These poles shall be squared and painted with two coats of good paint. They shall be set at least four feet in the ground and be provided with cross-arms.

The wires shall be run on glass insulators securely fastened to the cross arms and shall not sag unnecessarily between poles. The distance between poles shall not exceed one-hundred feet.

**Interior Wiring (Main building)**

The main building shall be wired for 197 lamps located as shown on plans. The system of distribution shall be multiple arc.
by soldered joints or by set-screws. These connecting wires shall be separated from the board by an air space of not less than one quarter of an inch.

All wire connections with arc lighting dynamos shall pass directly through the board and shall be thoroughly insulated. All joints made shall be soldered in such a way as to insure good contact and avoid heating.

Wiring

All exterior wiring both for arc and incandescent dynamos systems shall be done on poles which shall have a height of not less than
Three main dyna.m.s switches
Eight six feeder switches
Two voltmeters
Three amperemeters
Eleven double-pole fusible cut-outs
Sixteen lightning arresters
and any other necessary apparatus.

All the switches shall be double-poleknife switches and shall be of a sufficient size to safely carry their current.

All switches shall be mounted on incombustible bases and be securely fastened to the switchboard.

All wiring done on the outside of switchboard shall be with bare wire, all connections being made
holding dynamo.
This wooden frame shall be firmly bolted to the foundation and the bed plate of the dynamo in turn securely bolted to this wooden base. The woodwork must be painted with a water-proof compound so that the dynamo is thoroughly insulated from the ground.

Switch-board

The switch-board shall be made of slate neatly finished and shall be securely held in place. It shall be set out not less than three feet from the wall. There shall be placed upon this switch-board the following apparatus:
with proper care of the commutator and correct adjustment of the brushes. They shall be provided with a belt tightening and must be so mounted that they will run at the required number of revolutions. The armature shall not vibrate when run at full speed.

Each machine shall be provided with an efficient oiling device and shall not heat at the bearings.

Foundations

The foundations shall be constructed of brick laid in the best German Portland cement and shall extend to a depth of at least three feet below the floor. They shall have a cross-section equal to the area of the wooden frame
Specifications

The contractor shall provide and erect the following apparatus and material.

Dynamics

Two direct current T-11 incandescent dynamos with spherical armatures, having a capacity of two-hundred 110 volt incandescent lamps.

One direct current T-11 dynamo for arc lighting having a capacity for twenty arc lights of two thousand candle power.

The workmanship on these dynamos shall be first class in every respect. They shall have an efficiency of at least ninety-two percent and shall not spark.
\[ c = \text{the current required for one lamp} \]

then (1) may be written:

\[ \text{cur. mils} = N \times \Pi \times \frac{21.6 \times c}{E} \]

where \( E \) = the lost volts.
The formula by which the size of wire was computed was developed as follows:

The resistance of 1 mill-foot of good copper wire = 10.8 ohms

hence the resistance of any good copper wire of any length

\[ R = \frac{10.8 \times \text{length}}{\text{cross section}} = \frac{10.8 l}{\text{cir. mils}} \]

but \[ R = \frac{E}{C} \]

\[ \therefore \frac{E}{C} = \frac{10.8 l}{\text{cir. mils}} \] or \[ \text{cir. mils} = \frac{C \times 10.8 l}{E} \] (1)

Let \( \Pi \) = the average distance of the lamps in feet

\[ \Pi = \frac{1}{n} l \]

\[ N = \text{the number of lamps fed by wire} \]
and this system has been selected. All the information which could be obtained on Electric light installation has been carefully consulted and the design of wiring and specifications, have been made to conform as nearly as possible, to the principles learned in this reading.

A design is provided giving the dimensions of the station house, and showing the location of the engine, dynamos, boiler and switch-board. A detail drawing of this switch-board is also given, showing the location of switches and instruments and the manner of making connections for same.
In each building the lamps have been divided into groups in the most convenient manner. Each floor is provided with a cabinet containing switches by which the lamps may be turned on or off as groups, without affecting the brightness of the lamps in the other groups. The lamps have been placed only in such places where they would be an advantage. These plans also give the location of all cabinets, switches, and fuse boxes, and the length, weight, and size of wire needed. The only system of wiring which was found at all convenient for inside wiring was the multiple arc
buildings will soon be built south of the present buildings. If these changes are made before a plant is installed, they would in all probability alter any design which could be made at the present date.

These changes indicate that the center of the university grounds will move some distance south. For this reason the station-house which should have as near a central location as possible has been located six hundred feet south of the Chemical Laboratory.

Plants are given which shows the location of the lamps, and the manner of distributing the current.
Installation of an Electric Light Plant for the University of Illinois

This thesis shall consist of plans and specifications for lighting the buildings and grounds of the University of Illinois with electric light. The subject shall be treated more for the amount of information that may be gained in regard to electric lighting, than for the purpose of making an acceptable design in case a plant should be installed. If the present plans of the university trustees are carried out, several needs