Plans, Specifications and Estimates

FOR AN

Electric Street Railway

BY

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THESIS

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

UNIVERSITY OF ILLINOIS.

1895.
An electric railroad connecting the towns Ballarat and Monticello, Pike County, in the state of Illinois, has been frequently talked of, but examination has never been made, to my knowledge, to find out whether such an enterprise would pay.

It would seem to be a favorable location for such a road, for many reasons. There is a traffic over the road connecting the towns, unusually large with respect to the population. This is because they are the largest towns in their vicinity, and because the county seat, as well as the Pike County fair grounds, is located at Monticello. The road is perfectly straight between the two towns, and there are not many hills. The roadway is dirt all the way. Hence there would be no difficult engineering problems encountered in the construction of such a railroad.

Referring to the profile, we see that there are no
very heavy grades, and so very little cutting and filling would be required. The maximum grade is about six per cent, occurring on the south slope of the hill on which is located the Bement Cemetery. This grade is about three hundred feet long.

The population of Bement is stated at fifteen hundred and that of Monticello as about the same. The population is evenly distributed over the area in each town. Each has a system of public works owned by the town.

There is in Bement an incandescent electric light plant, owned by the Bement Electric Light and Power Co. The Westinghouse system is employed, capacity being eight hundred sixteen candle power lights. The streets are lighted by seventy twenty-five candle power Bernstein lamps, run thirty-five in series from the alternator. The contract for these lights was given September fifth, ninety-three, to extend over a period of five years, at the end of
which time we light will probably begin.

The main line of the Wabash Railroad runs through Bement. This line extends from St. Louis and Kansas City on the west to Toledo and Detroit on the east. The Chicago branch of the Wabash system leaves the main line at Bement, running straight north. A feeder of the Wabash runs from Bement south to Alton and Effingham, and is being extended through Paducah, Ky., to Memphis, Tenn. This gives Bement considerable railway advantage.

At present Bement has no manufacturing interests worth mentioning. It is a business town, however, having about thirty five commercial houses, which are in prosperous condition, so the town is the principal trading center for a considerable area of country.

The streets are very level, in fact it may almost be said that there are no grades in the town. There is no
jorin' done as y's. A map is appended, showing Bement and Monticello. The population of Bement is largely distributed over the entire area which is about 10 square miles.

The county surrounding Bement is very flat and is very rich farming land. The principal crops raised are wheat, corn, and oats. Land is worth from seventy to one hundred dollars per acre. The Bement Cemetery is two miles north.

Monticello is seven miles north of Bement. Its population is about fifteen hundred, quite evenly distributed over an area of some twenty square miles. There also there is an electric light plant supplying alternating current for incandescent lights and direct constant current for arc lights. This plant does not give as good satisfaction as the Bement one, and does not pay as well.

There are no manufacturing interests here, and few business houses than at Bement. The county seat is located here, however, and bring a great many people
during construction. The Pottawattamie fair grounds are one half mile north, and bring practically all the county single days there as four miles south of Pleasant, and a great many people from surrounding towns.

The topography of Monticello is not nearly as flat as Pleasant, but could not be called rough. The streets are not paved.

The country around Monticello is quite rolling, especially near the Sangamon River which flows near the town. There is also a great deal of timber land, but to the south and east the land is clear and good farm ground.

This description, together with the maps and profiles will serve to give some idea of the topography and general condition. We will proceed to a consideration of the service which would be required of such a road as the one considered, and then to the design, specifications and estimate.
The service ordinarily required would be two motor cars without trailers. Sixteen feet cars would probably be sufficient. The schedule would probably be such that a car would start from each end of the line every thirty or forty minutes.

An extra session, for example, at the time of the county fair, your motors, each pulling a trailer, could be used to advantage. There would be likely to start almost together from the fair grounds end of the line, all with heavy loads. The probable distribution of this maximum load would be something like this:

One car starting under load, taking 50 amperes...

- On curves or grade...
- Running normally...
- ...25"

Total current required 1 x 5"

This load would not be exceeded, as the motor cars could
be instructed to start successively, and this is the load for which the line should be designed.
Specifications

for

Materials and Labor to be used in the Construction and Equipment of an Electric Railroad connecting the Towns

Bement and Monticello

in

Piatt County, State of Illinois.
General Conditions - Location.

The Carson House and Car Barn will be located as shown in the map of Carson City, at the city water works, on the river. The railroad will run from this point along Robinson Street to Moen, thence north to the end of Main Street, thence north on the road known as the "Monticello road," to the limit of Monticello, thence north on Market Street to Main, thence east on Main to State, thence north on State to the east.

When to Begin.

The work is to be begun immediately after the letting of the contract, and pushed to completion as rapidly as is consistent with good work, and in a manner...
to interfere as little as possible with the use of the streets and roads. The date of completion is not later than

Superintendent.

The Contractor is to give his personal supervision to the work, to furnish all transporting materials, labor, uten-
sils and apparatus necessary to construct and complete the entire road and equipment in the best manner shown by the drawings and specifications.

All materials used are to be of the best description and quality throughout. Should the Con-
tactor introduce any materials different from the sort or quality herein described, or inferior, they shall be removed and made good at the expense of the Contractor at any time during the progress of the work, on recommend-
ation of the Engineer.
The work is to be executed in the best and most substantial and thoroughly unbreakable manner according to the true nature and meaning of these specifications and drawings referred to, which are intended to include everything required and necessary to the final and complete finishing and equipment of the entire road, ready for operation, with the exception of the station building.

Any work drawn and not specified, or specified and not drawn, or not particularly mentioned, necessary to the full completion of the entire road, according to the spirit and intent of the drawings and specifications, is to be done without extra charge.

All work, during progress is to be protected from damage by wind, rain, frost, or other causes, and at completion is to be delivered in a clean and finished condition to the Company. The roadbed and station are to be cleared of all
some material, and the entire course to be in condition for operation.

Superintendence

The Company, with their Engineers, shall have entire superintendence of the work. They will furnish an Inspector or Clerk of Works, who shall remain at the plant during all working hours, to see that all work is faithfully executed. The Inspector will nearly act as the agent of the Company and Engineers, and none of his acts or requirements will be binding, or final, if disapproved by the Engineers, who will general superintendence of the road, and the responsibility of seeing that its erection and construction are properly carried out. All work and materials will be subject to the inspection and approval of the Engineers. Upon his recommendation the work may be stopped at any time if not being executed in the fulfillment of the true intent and purpose of the specifications, and any faulty or defective work shall
be immediately taken out and made good.

Responsibilities
The Contractor will be held responsible for the accurate laying out of all parts of the line, track and station equip-
ment, and its erection in accordance with the drawings
and specification, and he must personally, or by a
competent foreman, look after the work. He
must also see that all the requirements of his contract
are faithfully observed and obeyed by all his sub-contractors,
material-men, and workmen, at all times. He will
see that the sub-contractors commence their work prompt-
ly at the proper time, and carry it on in a manner
that will not delay the works or materials.

The Contractor is to be responsible for all violations of
local ordinances or laws. He must pay all fees, furnish all
supplies, etc. He shall make good any damage to adjacent
properties, keep up lights at night, and provide all other
precaution, for the safety of the public during the erection of the plant.

Any sidewalks or other improvements damaged by the Contractor or any sub-contractor, the Contractor shall make good.

The Contractor will be held strictly responsible for the plant from the date of contract to the final acceptance by the Company, and will be required to make good any and all injuries sustained by the plant arising from any cause whatever. The Contractor will also be responsible for any injury to, or for the death of any person on or about the plant during its construction caused by the acts of himself or any of his employees.

Drawings

The drawings are made in sheets as follows.

Flow plan of Station

Longitudinal section of Boiler Room and part of Engine Room.
Elevations of Switchboard
Map of Berea and Monticello, shown adjacent.

... showing road connecting.
Profile of streets and roads on which track will run.
In all drawings, figured dimensions are to be prepared to scaled size.
The Station.

1. Generators. There shall be 2 - 30 kilowatt Westinghouse horizontal type generators, each capable of running continuously at an output of 60 amperes from 500 to 600 volts without over-heating. These generators are to be compound wound. They shall be per according to drawings and details furnished by the Westinghouse Co., the foundation to extend at least one foot below the cellar floor, to be carried up so that the capstone shall come flush with the floor. Capstone shall be in one piece. The whole foundation to be of hand burned brick or dimensioned stone.
carefully laid in cement morter. Bolts for frame of machine to be flush as specified.

2. Switchboard: shall be constructed as shown in the drawing, of matched hard wood, at least 1" thick. The in- shunt, if to be mounted and connected as shown, there shall be

2. Westinghouse ammeters - 0 & 100 amperes
1 " " 0 " 200 "
1 " " Voltmeter - 0 " 600 Volts
4 " " Circuit breakers 100 amperes
2 - 3 pole switches 400 Volt - 150 amperes
2 - 1 " fuses switches 600 Volt - 150 amperes
4 - Winding now among metal lighting ammeters. Station type.
4 - Inductance coil - 2" soft iron ring, 10" diameter, wound with 5 Chromite wire.
2 Feeder fuses.
1. Contact washer, contact surfaces, etc., contacts shall have faces of marble or marbleized slate, free from metal re-works.

3. Conductors. The conductors from the machine to the switchboard shall run through the floor at molding using glass floor tubes, and in the cellar shall run in glass conduits to switchboard, using glass floor tubes in coming through floor. In same way run feeders in cellars, from switchboard to power of heating station as indicated in plan. All conductors in station shall have not less than 1200 circular miles for copper, and where insulated, shall comply with section 1 of these specifications.

4. Engines. Install 2 9\( \times \)10\( ^{\text{th}} \) belt engines, as shown in plan. Foundations are to be of the most substantial type.
Carry up from 2' below cellar floor, using hard burned brick, laid in pure cement mortar, and use cap stone in a single piece. Cap stone to come flush with floor. Engage one 6' long 48" pulleys and run 33 1/3 revolutions per minute.

5- Belts- Use 10" light double endless leather belts, of same size tanned leather, cut from short laps of the solid part of the hide.

6- Boilers- Install 2- 66''x16'' horizontal return tubular boilers. These shall be 7 3/4'' bar flange steel, and shall conform throughout to the specifications of the Hartford Steam Boiler Insurance Co. They shall be set and connected in the best possible manner with all necessary appliances.
7. Piping. All steam, water and drain lines are to be of the sizes indicated in the drawings and their specifications, and to be run in the best manner, located approximately as shown in drawings.

- Pipe from well pump to tank: Run 1½" pipe close to wall and floor as shown as far as cool line wall, then run up close in corner, 2½ feet, or high enough to clear tank, then through wall at opposite tank, down west to tank.

- Pipe from tank to boiler feed pumps: Run 2" pipe. Cut short nipple in bottom of tank, then run close to wall, drop down close against wall and run close to floor as shown to boiler feed pumps. Cut globe valve in this pipe close to pumps.

- Pipe from boiler feed pumps to heater: Run close to wall and floor straight through cool wall.

- Conducts: Put in wood conduits, 12" square inside, 2" lumber just below floor. Run as shown. Run Shelter and feed water pipe in this.
This conduct is to run from heater throughout all between boiler room and cellar. A branch conduct ending near outside pipe to about an inch through floor back of boiler. This branch is to be 2" square inside, 2.5" square. Also run conduct of the same description ending thus as far as pipe and discharging pipe from injector. These conduct to be well made, and cut tight. The tops to be secured on, so as to be easily removed. Run all conduct as tops are just below bricks in floor.

Steam feeding pipe: Run 1½" pipe from heater in conduct and around end of boiler as shown. Come up through floor just before feed pipe branches to boiler #2. This pipe to be coated with magnesium or other approved covering. Put in check valve and globe valve in branch-return boiler, putting globe valve next to boiler. Put globe valve in this pipe just north of white pipe from injector joins on.

Steam pipe: Main pipe connecting boiler to be 2" Riser.
from done each 4" with stop valve. Steam pipe to engine 1/2".

Branches from this to each engine 2 1/2" Aramg and injector.

Steam pipe 1 1/2" tapping on & done. Run a branch over from done to wall, shop done & injector and boiler feed pump. Tap off 1" connecting to well pump as shown. All the pipes to be covered throughout with magnesium or other approved covering.

2" Aramg exhaust pipe. Run 3/8" pipe in conduit mentioned and show from boiler feed pump to exhaust pipe.

Run 1 1/2" pipe from well pump in conduit mentioned and show to exhaust pipe. These pipes to be covered throughout with magnesium or other approved covering.

4" Exhaust exhaust pipe. Run 3" pipe from engine to exhaust branch. This to be 3" main to exhaust main as shown in cellar. Run any convenient height above ground.

Exhaust main & belt, run as shown. In cellar run any convenient height above ground to well, shop done as at
Run no condensate heater. All this pipe to be covered throughout with magnesia or other approved covering. Put an asphalt oil separator in cellar close to boiler room wall. Connect to drain.

2. Blow off pipe. Run 2½" pipe from blow off connection as shown, dropping under floor 1' in line from boiler setting and connect to drain. Tap on blow off connection for boiler #1 as shown just inside ell. Put plugged cock in each blow off connection.

3. Other piping. Run feed pipe from injector down just below floor, then across and tap on feed pipe from heater. This pipe to be covered with magnesia or other approved covering. Run a 2" pipe from bottom of tank to sink as shown. Run 1" pipe from engine, injector, pumps and sinks to drain pipe. Engines, injectors, pumps to be supplied with all necessary appliances, as lubricators, stop valves, air cocks, cylinder cocks, etc.
8. City water connection. Run 2" pipe from city main as shown, running inside corn barn close to well and for tap off fire plug as shown, each to be supplied with stop valve, approved, hard steel or brass, and approved cotton hose and nozzle. Run 1½" pipe up well 24', through well and to tank as shown. Put a globe valve 8' above corn barn floor.

8. Water supply. Drill a 6" tubular well to permanent water supply (about 200') feet as shown in plan. Put in a "Dean's Horizontal Engine", with 6" x 16" steam cylinder. Put in a cylindrical water tank, 6' x 24', of 2½" tank iron, treated as shown in plan and elevation. This is to be supported by 4" Wrought iron strap, 3½" x ½", to 8-½" I Beams, built in the walls.

Put in a 250 horse power boiler located as shown under coal bunkers.

10. Coal supply - The coal bunkers will be located as shown in plan and section. Those with the car for burning coal will be furnished by the building contractor.

11. Conveyer tracks - locate as shown 4 tracks. These to conform to specifications for track, paragraph.

12. Transfer table - locate track for transfer table as shown, across middle of tracks. Put in an attachment transfer table capable of carrying a 10 ton car.

13. Pit - Construct as per as shown. 6 ft deep from rail to bottom. Rails to be supported on heavy 12" Carnegie I beams. Line pit, bottom and sides, with concrete. Construct stages as shown.
14 Track construction

Position. Within city limits, locate track in center of street. At the two masonry bridges near Monticello, locate track as near the west wall as practicable; at all other points, the west rail is to be about 15' from outer line of road as near as may be.

15 Maximum grade. No grade shall be steeper than 5%, and none longer than 300' shall be steeper than 4%. 

16 Rails. Within city limits, at road crossings, and on bridges, use 60# steel rail. At all other points, use 50# steel rail. Make track standard gauge.

17 Ties. To be not less than 5x8", and under rail joints 6x12", of white oak, or other approved wood.
11. Method of laying. This to be 27" center to center. In the cases where 50" rail is specified, track must be laid so that it can be driven over. Where 50" rail is specified, this is not necessary. The ties shall be strongly bunged, especial care being given to those under rail joints. Use good grade ballast. Strike rail directly 18" toe.

17. Curves. Make radii as long as possible, especially at ends of curves. In no case shall a curve have a radius of less than 60'. Elaborate on the rail from 6 to 2'. Second rails are to be used on all curves.

20. Turnouts. To be located as shown in maps and profiles. Use approved frogs and switch.

21. Bridges. As the 2 main line bridges mentioned above, no extra construction will be required. As all other streams and
ditches bridge shall be constructed which shall be capable of safely transporting a 20 ton car. These bridges to be in the line of the track, and need not be wide enough for the track. To be of the style of ordinary railroad bridges.

22. Bonding. Every rail joint shall be bonded with the Phusston RailBond #0000. This bonding shall be carefully done with the tools made for the purpose, so as to reduce the resistance of the rail joints as much as possible. Track to be cross bonded every 5th rail with #0000 copper wire.

At intervals of about a mile the track shall be thoroughly earthed by copper plates or approved substitute buried in permanently wet earth, preferably in the bottom of a ditch. The line has an air station to be connected to track and earthed on the well pumps.
Line Construction

23 Trolley - To be #0 B and 5 gauge, No lead drawn copper, with a conductivity not less than 98% that of pure copper. Joints are to be made with approved splicing bars and in the best possible manner, so as not to interfere with the smooth and even running of the trolley. solder all connections with rosin. Do not use blow lamp when it can be avoided. use half and half solder.

24 Feeder - To be #0000 soft drawn copper, conductivity not less than 98% that of pure copper. To be covered with insulating material that shall have properties as follows.

1. Shall not soften on each side exposed to the severest changes of temperature which it is likely to encounter.
2. Shall adhere firmly to conductor.
3. Shall not fray by friction nor be easily impaired.
by running on tension.

4. Shall show an insulation resistance in water at
70° after one week's submerging of not less than 100 megohms per
mile, with a potential of 1000 volts, after 15 minutes electrification.


25. Suspension - Within city limits and as turn out,
span wire suspension shall be used. In the country, use
bracket suspension. The suspension through out is to be
done in the very best manner, using approved brackets,
span wire, insulators, bars, clamps, etc.

Rope feeder in approved glass insulator made especially
for this purpose.

The entire wire shall have an insulation resistance
of not less than 50 megohms, under electrification of 1000
volts.
Poles to be set not less than 6' deep. A tc all poles in concrete of portland cement, sand and broken stone. Toply to be 1½' above truck. No pole to be less than 8" diameter at small end. Span and guy wire to be of steel galvanized and of size suited to the conditions, and to have approved circuit break insulator inserted.

26. Anchorages. At each end of long curve and tangent, and at intervals of not more than 1000' on the straight track, construct double anchorages of approved design.

27. Summits. All summits shall have pgs of such a design as to afford a sure path for the trolley. Use cow suspension.

28. Curves. Pull off poles shall be of hard quality, set 15' deep in the concrete mentioned in paragraph , and shall
have a rake of about 10° and shall be thoroughly grouted.

24. Lightning protection. Connect a Wurtz wire along railway lightning arresters of pole type to the line at intervals of ½ mile, grounding on rails and ground plate in moist earth.

30. Car equipment

Motor cars. Supply & equipped as follows.

A. Trucks to be built of Magnane, with 7' wheel base, wheels and cars to be as specified for motors.

B. Motors to be 2-15 Horse Power W.C. Thomas motor

C. Each motor car.

D. Controllers. 2 W. T. H. Series Parallel controllers to be supplied to each motor car.

E. Connections are to be made throughout the car in the most thorough manner, and all motor cars to be supplied with 2 lamp switches.
1. Lightning arrestor - Can type
2. Cutout - 60 ampere fuse
3. Circuit breaker - 80 amperes
4. Pilot lamps
5. 3 light cluster
6. 10 ampere branch switch for lights
7. Apparatus electric heater, trolley and base, and sanding devices

- Car bodies - Supply 3 closed 14' bodies for motor cars and 2 open 14'...

31. Trailer cars - Supply 4 trailer bodies, Bill of Lading, with 7' wheel base.
3-1/2' closed trailer bodies.
3-14' open...

All trailers to be equipped with lighting circuits of a 3-light cluster, with bells for connecting to motor.
Both motor and trailer cars are to be neatly up-
labeled and painted, and any letters, figures, or design
which the Engineer may desire shall be painted on
them.
Specifications for building.

The plans and specification for the building should be gotten up by an architect and approved by the Engineer. The building should be designed on the lines indicated in station plans and sections. It should be a substantial brick structure, with braced roof. The roof, if of metal, must be lagged on the underside, or the double with air spaces between, to prevent condensation of moisture. The floor should be of tiles, neatly laid on a wood backing. The floor should be designed to allow for the foundation for machines, and be entirely independent of them.

The entire station is intended to be of fire proof construction, and the architect should keep this in mind. The wall separating the boiler room from engine and dynamo room is intended to be absolutely fire proof and should have iron doors at the opening.

The building should have as many windows as possible and should be wired for 100 volt incandescent lights.
Estimates on approximate cost of plant, exclusive of building.

<table>
<thead>
<tr>
<th>Description</th>
<th>Cost</th>
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<tbody>
<tr>
<td>2-9x10ierce engines</td>
<td>$600</td>
</tr>
<tr>
<td>2-30kw Generators</td>
<td>$1,000</td>
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<tr>
<td>Switchboard</td>
<td>$100</td>
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<tr>
<td>Belt</td>
<td>$80</td>
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<tr>
<td>2 Boilers</td>
<td>$800</td>
</tr>
<tr>
<td>Tank and Piping</td>
<td>$500</td>
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<tr>
<td>Boiler feed pump</td>
<td>$100</td>
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<tr>
<td>Well pump</td>
<td>$200</td>
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<tr>
<td>Trucks and car lines</td>
<td>$700</td>
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<tr>
<td>Total cost of station</td>
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Track and line construction:

<table>
<thead>
<tr>
<th>Description</th>
<th>Cost</th>
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</thead>
<tbody>
<tr>
<td>Tracks, laid and loaded</td>
<td>$6,000 per mile</td>
</tr>
<tr>
<td>Trolley wire</td>
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<tr>
<td>erection of same</td>
<td>$300</td>
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</tbody>
</table>
Poles: $3.00 per mile

Feeder, 4000: 975

Erecting of same: 100

Total cost of line and back: 8000 - $70,000.

Car equipment:

4 motor cars complex:  @ $3200: $12,800

4 trailers:  @ $1500: $6,000

Extra Steel specified: 4500

Total Car equipment: 23,700

Estimated total cost of plant: $100,500