An Investigation of the Power of the Lewiston Augusta & Waterville Street Railway from Lewiston to Waterville

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POWER OF THE LEWISTON,
AUGUSTA & WATERVILLE STREET RAILWAY

M. L. DAVIS, 1918
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OF THE
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THE LEWISTON AUGUSTA & WATERVILLE
STREET RAILWAY
FROM LEWISTON TO WATERVILLE

A THESIS
SUBMITTED IN PARTIAL FULFILLMENT OF THE
REQUIREMENTS FOR THE DEGREE OF
BACHELOR OF SCIENCE (IN ELECTRICAL ENGINEERING)
BY
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COLLEGE OF TECHNOLOGY
UNIVERSITY OF MAINE
ORONO
MAY 1918
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The Lewiston Augusta and Waterville Street Railway has car lines operating in the cities of Bath, Lewiston, Auburn, Gardiner, Hallowell, Augusta and Waterville. This company is leased by the Cumberland County Power and Light Company of Portland. In this thesis I will subdivide the Lewiston, Augusta and Waterville Street Railway Company into two lines, one operating through Lisbon, Lisbon Falls, Brunswick and Bath. This is called the main line as it was the first interurban line built by this company. The other line is operated from Lewiston through Sabattus, Gardiner, Hallowell, Augusta, North Vassalboro, Winslow and Waterville. This line is known as the Waterville line, and it is this line I wish to discuss in this thesis. I took this line as it was the longest, has the most traffic and needs the most improvements.

The traffic on this road includes both passenger and freight, each kind bringing the company about an equal revenue.

The passenger cars are operated on an hour schedule taking three hours and twenty minutes to make a trip. The freight service is carried on in both day and night.
The cars are equipped with four motors having the series-parallel control.

The Electric Power for running these cars is furnished by two Central Stations, neither of which belongs to the Company. The Power for the Lewiston end is furnished by the Androscoggin Electric Company from their Hydroelectric Station at Deer's Rips, situated about three miles above Lewiston on the Androscoggin River. The Power is generated at 60 Cycles and stepped up to 10,000 volts for transmission. It is sent by two high tension lines to the Lewiston Sub-Station where it is converted into Direct Current. The Alternating Current Voltage is stepped down to 350 volts for running two Rotary Converters, each having an induction motor for starting. These two converters furnish power for Lewiston and Auburn and on the Waterville line for a distance of six miles where a circuit breaker is inserted. The Direct Current is generated at 550 volts and a booster set generating 125 volts is run from a storage battery. This booster set is connected in series with the Bus Bars and the feeder, which gives an output voltage on the Waterville line of 675 volts.
Through the streets of the city to Campus Ave. the line voltage is 550 volts, from Campus Ave. to Sabattus it is 675 volts.

The feed wire is #0000 copper covered with cambric, taps are taken off every half mile to the single trolly wire which is #00 in size.

The Power for the Waterville end is furnished by the Central Maine Power Company from their generating station at Winslow on the Sebasticook River. The average daily power consumed from this station is 13,500 Kilowatt hours.

The Power is generated at 25 cycles, 400 volts stepped up to 19,100 volts for transmission purpose. The High tension line is 38 miles in length passing through Winslow, Vasselboro, Augusta, Hallowell, Gardiner, Litchfield and Monmouth. This line is carried on cedar poles following the car track a great part of the way. It crosses the Kenebec River at Augusta on tripod towers from there it goes to Hallowell. From Hallowell it goes through fields and woods coming back to the car line at West Gardiner and from here it follows the car line to South Monmouth. Wherever it follows the car line it is placed 5 feet higher than the bracket arms, this requires a 35 foot pole. The poles contain one cross
arm at the top. On each side of the cross arm one phase is carried and the other phase is carried by pins bolted to the top of the pole. The insulators used are porcelain tested for 33,000 volts. The phases are transphased every few miles so as to do away with the induction effect on the line.

There are two sizes of wire used on this line. No. 1 stranded copper is used from Winslow to Hallowell and stranded aluminum equivalent to No. 2 copper is used from Hallowell to South Monmouth. This High tension line is well built and gives very little trouble.

Sub-Stations.

On this line there are three sub-stations located at Webber Pond East Vasselboro, Hallowell and Days Corner South Monmouth. One important feature of these stations is that the equipment is the same in each except the controlling switches. The machines are 200 K.V.A., General Electric Company, Synchronous Converters running at 720 R.P.M. generating 650 volts at full load. The armature has 144 slots and contain 288 coils. The voltage is regulated through a reactance box. The transformers used are three single phase General Electric with ratio of
33000/19100/400 connected Delta, taps are brought out from the middle of the secondary for starting. The machines start on half voltage and as soon as the Direct Current begins to build up full voltage of 400 volts is impressed by the means of a knife switch. The lightening arresters are of the multi-gap type connected to the line through choke coils. These arresters give very little trouble outside of the fuse blowing between the multiple and the gap in severe lightening.

Difference Between Stations

At Winslow there is a converter but this station can hardly be classed as a sub-station. This machine is run direct from the bus-bars. The machine is so near the generator there is no need of a reactance box as it can be regulated by reacting back on the generator. The machine is started by a compensator. There is a separate panel on the board which controls the High tention line. The Oil switch has an overload relay.

At the Webber Pond Sub-Station there is an incoming and outgoing line, each line is controlled by an oil switch with an overload relay. There are two High Tention panels.
At the Hallowell Sub-Station there are two machines and an incoming high tension line and two outgoing lines. There is also a steam reserve, this consists of two engines which are supplied with steam by four boilers. One of these engines is belt connected to a 200 K.W. Direct current generator while the other is direct connected to a 370 volt alternator. In the same room with the alternator there is a 200 K.V.A. Rotary Converter. This converter is run on the A.C. side by the alternator. The two converters operating from the high tension line are connected in parallel with an equalizer, controlled by a switch mounted on each machine. The direct current side furnishes power at 650 volts.

The reserve supply is great enough to take care of the car service of Gardiner, Hallowell and Augusta in case the Winslow station is forced to close down. The direct current generator belted to the small engine is used when trouble occurs to one of the rotories. Steam is not kept up in this station in fact it does not need to be as with fuel on hand the Direct Current Generator can be started in a short time.
This was demonstrated in July 1917 when lightening burned out rotory No. 2 at 3 A.M. and 5 A.M. the direct current generator was ready to take its share of the load. Of course this small engine does not run as good as when steam is kept up all the time but the cost of the fuel will offset the loss in electrical energy. This station is situated in a very convenient place as it is easily accessible on the Kenebec River and can be reached by rail through the electric track.

The Days Corner Sub-Station at South Monmouth is a large station on the Winslow high tention. This Sub-Station is similar to the Webber Pond Sub-Station both in equipment and building. The high tention enters the brick wall near the ceiling through porcelain insulators. At the entrance lightening arresters are connected through choke coils, then the line goes to the oil switch which is located in oil cells in the back room. The oil switch panel is situated three feet from the direct current board and contains an ammeter.

The wiring is the same for all stations except that Hollowell where two machines are operating in parallel an equalizer is installed.
Operating Expenses

The operating expenses of these stations are not very great. The expense of operating the Winslow machine is less than the other as this machine is operated by the Central Main operator who controls the generating station.

The Webber Pond and Days Corner station are each operated by two men on a twelve hour shift. The cost of operating each station will be $35 per week. At the Hollowell station the cost is greater as three men are required, each working on a shift of eight hours and the operating expenses are about $58 per week.

The question now arises would it be feasible to have these stations converted into automatic stations. The answer is that there is only one station on the line where an operator is not needed for other purposes and this is the only station where the load is off the machine for any time during the day. The equipment for changing this station to an automatic station is already ordered. The other stations could not be profitably changed as at each one an operator is needed to dispatch car orders.
Trolley Construction

The trolley construction consists of bracket arms, except in the cities and on turnouts. From Lewiston to Sabattus the trolley wire is #00 groved, supported by cap and cones on bracket arms, from Sabattus to Gardiner there is double wire #00 groved supported by hangers from bracket arms, from Gardiner to Cony Street Augusta a single #00 groved wire supported by cap and cone on bracket arms a part of the way, and the rest of the way by over head wire construction. From Cony Street to Waterville the construction is the same as from Sabattus to Gardiner.

Method Of Feeding

This line is fed in two ways, one is by direct feeding and the other is by running out feed wire from the station. The Lewiston and Hallowell station feed the line by running #0000 copper wire along the line and taking taps off every half mile or on grades. At Days Corner, Webber Pond and Winslow feed taps are brought direct out and circuit breakers installed so that either section of the line can be isolated from the other, where the circuit breakers are installed
there are feed taps running to each side of the breaker.

Loads

Loads on this line are due to the great number of cars, to the grades, and to the curves. The running schedule calls for a car every hour and this brings at times during each hour two cars on the Days Corner machine. When the freight service is operated another car is added and this makes three cars on the machine, thus causing the machine to be overloaded and there is also a large voltage drop in the wire. The above discussion is for any day, but on a Sunday or holiday there are large crowds travelling, thus making it necessary for more cars, so I will now discuss the number of cars on one machine at peak loads. On Sundays in the summer there are three extra cars running to Sabattus and these have to travel on the Days Corner machine about a half mile up a 2% grade besides these, there is an extra car running to Tacoma Inn and another extra running from Tacoma Inn to Augusta so at one time there are five cars pulling on the Days Corner machine through the same wire thus giving a large voltage drop.
At Webber Pond the greatest number of cars on the machine are four and this is only for a short time so the Days Corner station has the worst conditions. Another peculiarity of this road is the grades and curves. The grades and curves are so arranged that cars coming each way are going up grade at the same time and stops are located so that two cars may be starting at the same time. The up and down grade is about the same so the grades will not interfere with the schedule time.

Difficulties Of The System

Under the heading difficulties of the system I will only mention the difficulties in the power. These difficulties can be classed in two kinds, one due to the lack of needed power for every day operation, and the other due to the lack of reserve power. The power required for operation of any road is that power needed when maximum load is thrown on the line and this is called the peak load. Every machine on the road has an ampere rating of 308 amperes and these machines are
required to deliver 500 amperes many times during the
day for periods of fifteen minutes and sometimes for
periods of five minutes a load of 600 amperes. The
circuit breakers are set at 625 amperes both the feed
breaker and the rotary breaker are set so that when
the feed breaker is blown the rotary breaker will go
also thus isolating the other feeder. This is a
disadvantage as a car might be kicking on one feeder,
and blow out the breaker while a car on the other
feeder might be travelling on the flat, with all
current on and before the motorman would discover
that the power was off the line, it would be back on,
catching him with the controller on the last notch,
thus causing injury to the armature.

If the voltage drop was not so great for cars
operating a distance from the station they would have
plenty of power by overloading the machine. This is a
disadvantage of the direct feeding system. If a large
feed wire was used and taps taken off at distant points,
the cars would get more power but they would not get
enough power.
The Days Corner Sub-Station feeds over too large an area, as it feeds ten miles in one direction and eight miles in the other direction.

The Hallowell Station feeds over a larger area but it has two machines and feed wires. In this section there are a great number of cars on the line all the time and the machines stay at a constant load, for when one car is near the station another is a distance away. The load on this station could be increased by extending a feed wire from Gardiner five miles towards Lewiston. There are many steep hills in Augusta and the surrounding country and these grades need a great deal of power to overcome them. The two machines are not large enough to furnish the required power.

Methods Of Improvement

In considering the methods of improvements there is no question but what this line needs more power but the question is how will they get it in the most economical way, for when a company is going to invest
a sum of money they want to invest it in a way where they will get the greatest return.

There are two ways to increase the power, one is by raising the voltage and the other is by putting in more sub-stations.

If the voltage was raised, 13,000 volts would make a good working voltage but there are many financial advantages and disadvantages. The main advantages would be that they could use the same number of sub-stations, the same feeding system, the same wire, and the same number of operators. A 13,000 volt line would give the cars more power to climb grades, make better schedule time, and in the winter they could take care of the snow without the loss of time. There is a great deal of money lost by not giving the public adequate service and this loss would go a great ways towards the cost of more power.

The disadvantages of changing over from 650 volts to 13,000 volts would be in the wiring of the cars for when operated in the city they would have to be capable of operating on 550 volts. These cars at present are
operated on the series-parallel control. The lighting system has five lights in series and if the voltage was raised there would have to be ten lights in series, and another switch for changing to five lights in series for the 550 volt system. The chief disadvantage of changing would be in a car going from the 550 volt system to the 1300 volt system. The motorman might forget to change the light switch thus causing a great increase in the cost of lamps as the lamps would soon burn out on the 1300 volt system. The head lights would have to have two sets of resistance boxes one for the 550 volt system and two boxes connected in series for the 1300 volt system. On the 1300 volt line the machines could be connected in series and the cost of new machines would be greater as it would require two more machines than would be needed in the way to be described later. The whole cost would be a great deal more on this system for it would cost a great deal more to change the cars over, as so many have to be changed. If this was the first building of the road I should recommend the 1300 volt system.
In order to increase the power and keep the voltage the same it will be necessary to put in more sub-stations or put in a booster set in the station at Days Corner and at Hallowell.

If a booster set is used it will be necessary to string a feed wire from each station. If a feed wire was run from Hallowell station, the feeder should run to Greens Hill in West Gardiner; this would require about nine miles of #0000 copper wire. From the Days Corner station a feeder should be run seven miles to Spear’s Corner and another feeder should be run to the Maine Central siding at Sabattus, a distance of eight miles. The material required to run these feeders would be twenty-four miles #0000 copper wire, 1200 porcelain insulators tested for 1000 volts and 1200 pins for the same. At the present time this cost would be very great but this is not the only cost for two booster sets and switch board apparatus will also be needed. If the additional power is supplied by the means of two new stations, the cost of machines and equipments would about equal the cost of feed wire and two booster sets, but these sets would require more
repairs than the new stations.

I believe the most economical way to supply more power would be by building two more sub-stations but now the question arises where would these stations be placed. One station should be placed at Trafton's Siding, midway between Days Corner and Gardiner. By placing the station here it would be in a good location to overcome the load that would be brought on it by two cars crossing at the siding. It is very evident that this place and Spear's Corner a few miles nearer Lewiston, at the present are very week places on the line owing to the grades. It often occurs that when one car is going up the hill at Spear's Corner a car approaching another hill will have to stop until the first car gets up the hill.

The equipment for a station at Trafton's should be the same as used at Days Corner, that is a 200 K.V.A., General Electric, Synchronous Converter. The reason for using this kind of a machine is that it is plenty big enough to take care of the load. In putting a station here they would not need to have any more high tention
as a line passes right by it. The only inconvenience would be in acquiring the land and this difficulty could be easily overcome. This location would ideal for it is near a siding and would be a great help in dispatching car orders.

The location for a station between Days Corner and Lewiston will need a little more thought, for Litchfield Turn furnishes a location midway between the grades but it would not be a good place for car dispatching. A better location would be in the village of Sabattus as the company owns land and runs a waiting room and post office. Back of this building there is room enough for a station. With a station here the operator could look after all the company's business thus reducing the expenses. Another point that makes this place good for a station is that in the summer on Sundays there are as high as eight cars on the line between Sabattus and Lewiston thus making a large load on the Lewiston station and by a station at Sabattus a large load could be taken from the Lewiston machines. At Sabattus there is a ten degree curve and a 2% grade
and this requires a great deal of power to overcome. With reduced voltage it is hard to climb the grade, but with full voltage the cars could climb the grade without the loss of time. With a station at Sabattus it would be necessary to extend the high tension line from Days Corner. This cost would be very large as the poles that are used for the trolley are thirty feet high, while a high tension line on a trolley pole should be thirty-five feet high. This difference could be overcome by setting new poles but this would be a very large expense. A cheaper way to overcome this would be by pieceing out the poles, either by using wood or steel props with cross arms of the same. The line could be strung on thirty foot poles, but this would be dangerous and cause considerable trouble. I would recommend that the line be strung five feet above the trolley bracket arm and the poles topped out with steel towers having steel cross arms.

The material needed for this construction would be twenty-seven miles of stranded aluminum wire #6.
copper equivalent, 450 steel extension towers with cross arms, 1350 insulators tested for 33000 volts, and 1350 pins. The reason for using aluminus wire is that the first cost would be cheaper and the wear would be just as good. The 33000 volt insulators are used instead of the 19100 volts so that at any time this line should be changed to 33000 volts the line would not have to be disturbed and this is very likely, as the transformers that are now in use are built for 33000 volts and the transformers to be used in these new stations are of the same type. The machine to be used in the Sabattus station will be a 200 K.V.A., General Electric, Synchronous Converter with full equipment including, three single phase transformers, oil switch, two circuit breakers capable of holding 650 amperes with overload relay and one circuit breaker capable of holding 650 amperes with overload and reverse current relay.

In the Hallowell Station there are two General Electric type, 200 K.V.A., Synchronous Converters. These do not supply power enough and more power can be obtained by using
the 650 volts direct current generator which is now belted to a steam engine. This generator is used only when one of the converters are under repair. More power can also be obtained by putting in another converter as there is plenty of room for it but it would cost a great deal. The best way would be by belting a Synchronous Motor to this generator and the cost of the motor would be much less.

There is plenty of room between the steam engine and the generator, for a motor. In case trouble occurred on the high tension line the belts could be changed and the generator be driven by the steam engine as is done at present. The best motor for this work would be a three phase 300 horse power, 400 volt Synchronous Motor with grids for starting. The fields could be excited from the bus bars of the other machines, by putting enough resistance in series with it to cut the voltage down to 125 volts. The equipments required for the motor would be three single phase transformers having the required reactance with a ratio of 33000/19100/400, a compensator
and two new switch boards, one panel for starting with the necessary instruments and a generating panel with an ammeter, wattmeter and voltmeter plugs. There is plenty of room for two new panels along side the other panels. By the addition of another motor the generator that now lies idle a greater part of the year could be put in use thus making the station more efficient.

With all these new stations the car service would be increased and the freight could be increased and the increase in revenue would yield a good interest on the money invested. In case of accident to any one of the machines the public would not notice it as the other stations could run at overload. By having the transformers and machines all of the same type, a spare transformer and an armatur could be carried in stock thus taking care of delays in repair.