MASSACHUSETTS INSTITUTE OF TECHNOLOGY

A THESIS

ENERGY CONSUMPTION AND TRAFFIC CONDITIONS OF THE PHILADELPHIA-PAOLI ELECTRIFICATION OF THE PENNSYLVANIA RAILROAD

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PURPOSE OF THE THESIS

The purpose of this thesis is to present a study of the energy consumption and traffic conditions of the Philadelphia-Paoli Electrification of the Pennsylvania Railroad, with a view to economizing energy requirements and car miles.

CONTENTS

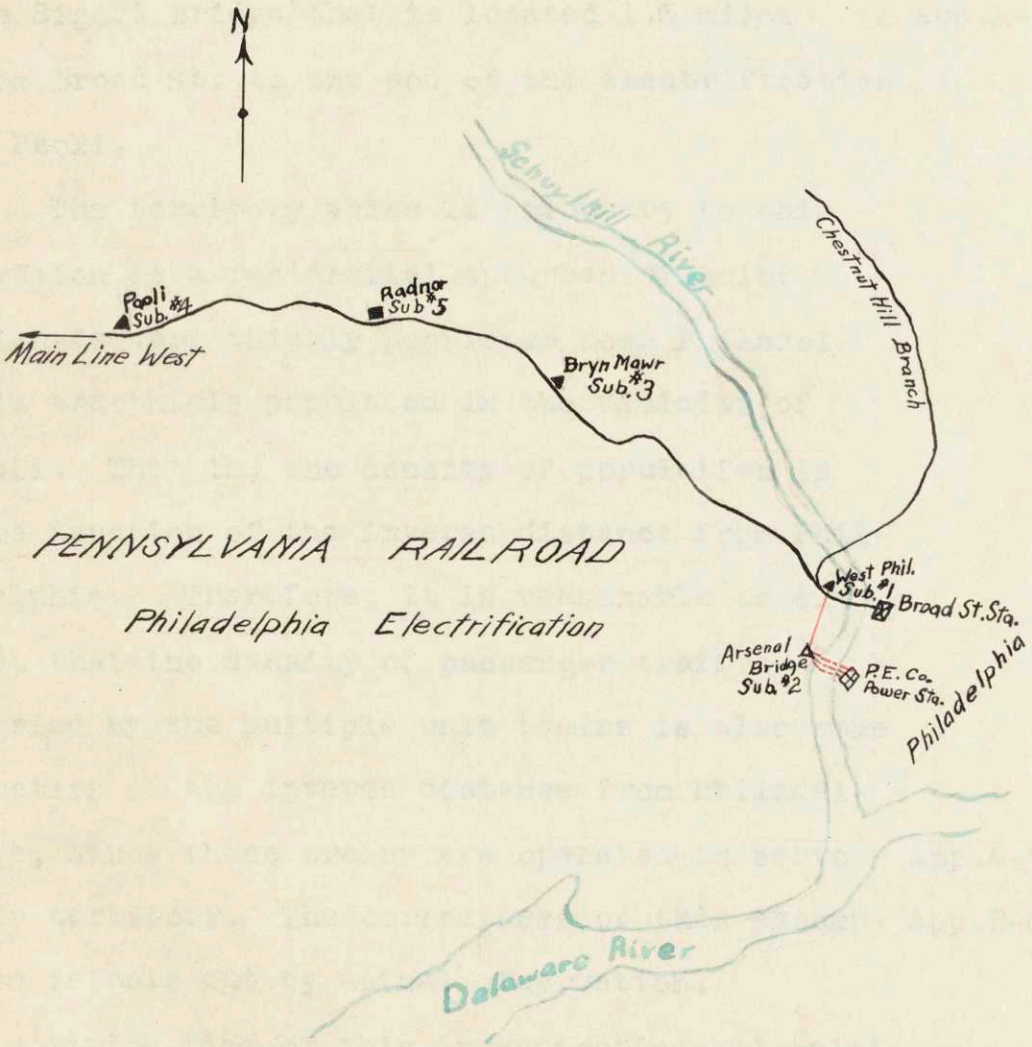
ACKNOWLEDGMENT

This investigation has been made possible by the hearty co-operation of the officials and employees of the Pennsylvania Railroad. We wish especially to thank Professor Dillon for advice and co-operation, Mr. J. T. Wallis, General Superintendent of Motive Power, for permission to make the power tests, Mr. H. K. Lesure, Assistant Master Mechanic Electric Equipment, for assistance in arranging the practical details of the test, and Mr. H. F. Griffith, Foreman of Substations and Transmission, for placing the electrical instruments and carrying out the required electrical switching.

For electrical instruments, we owe thanks to Professor Timbie, The General Electric Company, and The Westinghouse Electric and Manufacturing Company.

SCOPE OF INVESTIGATION

The Philadelphia-Paoli Electrification of the Pennsylvania Railroad extends from the Broad St. Terminal Station in Philadelphia to Paoli, a distance of 20.0 miles. In order to eliminate trains of the Chestnut Hill Branch which also come into the Broad St. Terminal, no data was taken for the Paoli Division trains while they were in the 100 section between Broad St. and West Philadelphia. At West Philadelphia the trains going to Chestnut Hill branch off from the main line. From West Philadelphia there are four tracks going to Paoli. Over these tracks there are operated steam passenger and freight trains and multiple unit electric passenger trains. One electric locomotive is also operated over this division but it was not in operation during the period of our test. The passenger trains are operated over tracks one and four, while the freight trains are operated over the inside tracks. However, this rule is not always adhered to. To sum up, our investigation


N
Schuylkill River
Chestnut Hill Branch
Paoli Sub. #4
Radnor Sub #5
Main Line West
Bryn Mawr Sub. #3
PENNSYLVANIA RAILROAD
Philadelphia Electrification
West Phil. Sub. #1
Broad St. Sta.
Arsenal Bridge Sub #2
P.E. Co. Power Sta.
Philadelphia
Delaware River

covers all multiple unit trains on that portion of the Philadelphia Division which extends from the Signal Bridge that is located 1.3 miles from Broad St. to the end of the electrification at Paoli. App.A-1

The territory which is tributary to this division is a residential suburban district which is very thickly populated near Philadelphia and thinly populated in the vicinity of Paoli. That is, the density of population is some function of the imverse distance from Philadelphia. Therefore, it is reasonable to expect that the density of passenger traffic carried by the multiple unit trains is also some function of the inverse distance from Philadelphia, since these trains are operated to serve this territory. The correctness of this assumption is born out by actual observation. App.A-7&8 App.B-6

At the time of this investigation all multiple unit trains were operated from Broad St. Station to Paoli without any changes in their make-up, and no trains were run a portion of the distance from Broad St. to Paoli. The chief reason for this is the fact that there were no

track facilities at any points intermediate to Broad St. and Paoli, which would make it possible to change the make-up of the trains or to run trains a portion of the distance.

By comparing the statements in the last two paragraphs, it will be seen that if the trains are fully loaded at West Philadelphia, they will be only lightly loaded at Paoli. Now, since the weight of a passenger car is so great in proportion to the load it carries, the power required to propel it will be practically independent of its live load. Therefore, since the passenger load of the car decreases as it approaches Paoli the power required per passenger will be increased. It is evident that if some method of eliminating lightly loaded cars can be devised, a saving in power per passenger will be effected. App.A-8

Two methods of making this saving suggest themselves. First, local trains might be run to and from some station or stations which are near to Philadelphia, while the territory beyond these stations might be served by trains which shall run express from Philadelphia to

to the station or stations to which the locals run and then run local the rest of the distance to Paoli. For instance, locals might be run between Bryn Mawr and Philadelphia while the territory between Bryn Mawr and Paoli might be served by trains which shall run local between Bryn Mawr and Paoli and express between Bryn Mawr and Philadelphia. An obvious disadvantage of this arrangement is the inconvenience which would require passengers desiring to go from some station on one side of Bryn Mawr to a station on the other side, to change trains at Bryn Mawr. However, a small percentage of the trains might be operated in this manner without causing appreciable inconvenience. Another objection to this arrangement is that the number of multiple unit trains is doubled and consequently the already crowded tracks would be congested by the extra trains.

A second method, which will cause no inconvenience to passengers, is to drop cars from each train at certain points on the run from Philadelphia to Paoli and to pick these cars up again on the trip from Paoli to Philadelphia. This method will require track

cross-over and car storage facilities. Since the dropping of cars will cause a certain amount of delay and since the whole distance of the run is only twenty miles, it would be hardly practicable to drop and pick up cars at more than one point. It would appear from consideration of the traffic distribution that the point at which cars should be dropped and picked up should be about half-way from Philadelphia to Paoli. Bryn Mawr is at this point and possesses other advantages which will be described under another heading.

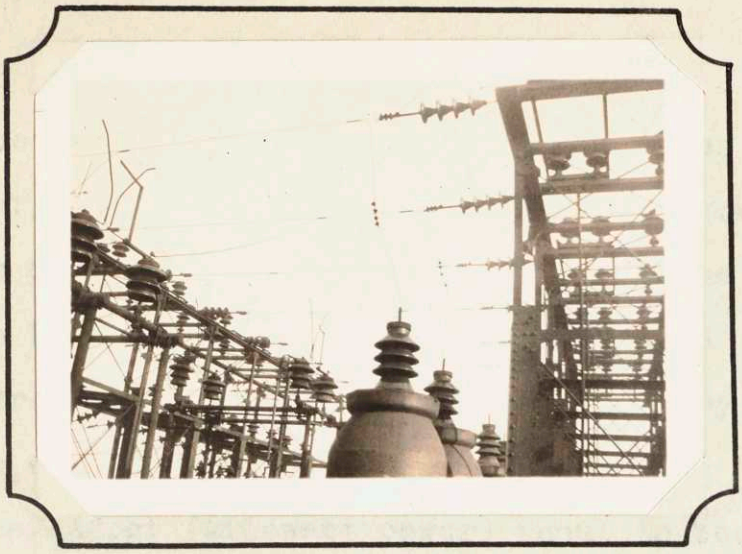
App.A-5 & A-6

DATA REQUIRED BY THE INVESTIGATION

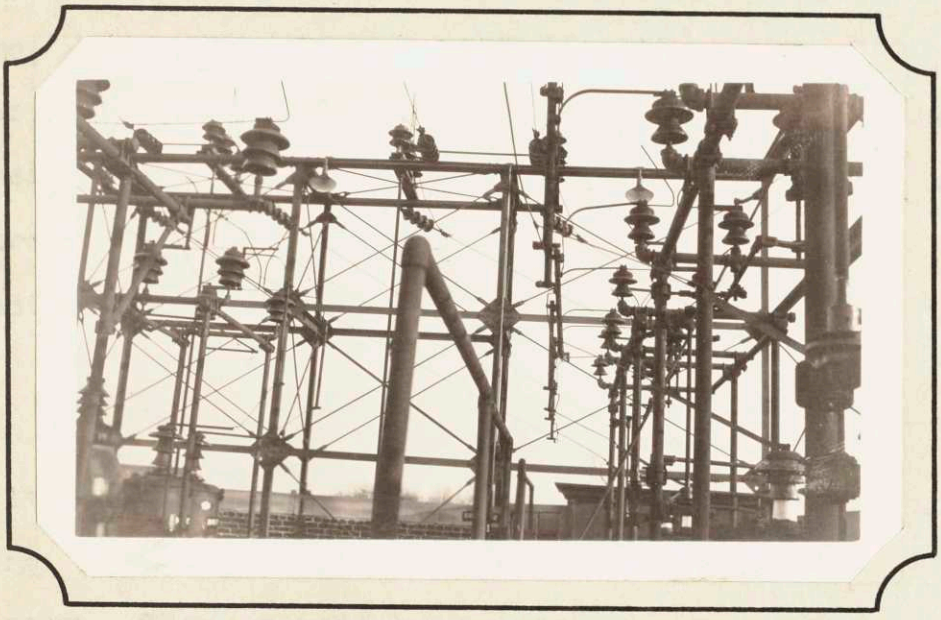
Power Data

In order to find the power saving by making any of the aforementioned changes, it was first necessary to find the present power requirements of the division. Since the point at which it seems advisable to drop cars is halfway from Philadelphia to Paoli and since Bryn Mawr is at this point, it is desirable for the purpose of further comparison to get the ratio of power per passenger mile of that section extending from West Philadelphia to Bryn Mawr to that section extending from Bryn Mawr to Paoli. On diagram No. 10 these two sections are numbered respectively 200 and 300. App.A1 & A2

In order to get the ratio of power per passenger mile in the two sections, it was necessary to obtain power data for each section. To do this, certain changes in the electrical switching were necessary. In the first place it was necessary to separate the trolley wires of the 200 section from those of the 300 section. Since there is a section break at Bryn Mawr which separates the two sections, no change App.A-2



Roof of Sub-Station #1 W. Phila.

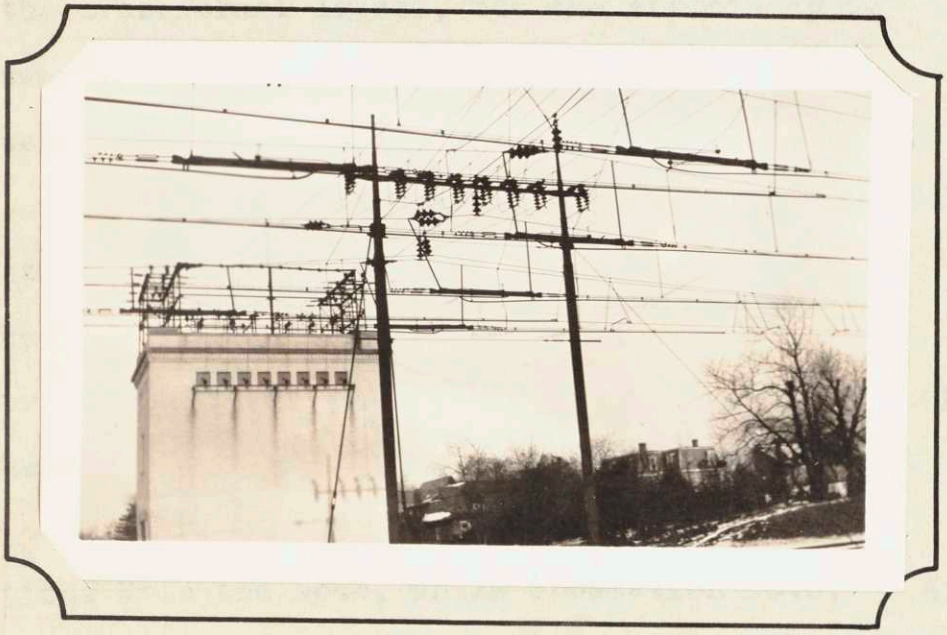


Roof of Sub-Station #3 - Bryn Mawr

was necessary in this instance. Also it was necessary to separate the 100 and 200 section trolley wires. This was done by opening the section break switches on signal bridge 1.3 miles from Broad St. Next, it was necessary App.A-2 to make changes in the substations in order that the energy (kilowatt power) input to each section might be measured in the substation. Substations No.1 and No.3 feed the 200 section. App.A-1

Substation No.1 feeds the 200 section thru feeders 204 T and 201 T. In order to measure App.A-1 the output thru these two feeders it was necessary to install a watt-hour meter for each App.A-1 feeder. These two watt-hour meters, then, measured the input of Substation No.1 to the 200 section. App.D

To get the input of Substation No.3 to the 200 section it was first necessary to have switch FF in the 11000 volt bus open. However, App.A-1 since this is normally open, no change was necessary. Then, a watt-hour meter was installed to measure the input to transformer No.3, and it can be seen from the diagram that it consequently measures the total output of the substation App. D



Sub-Station №3 - Bryn Mawr

Showing Trolley Section-Breaks

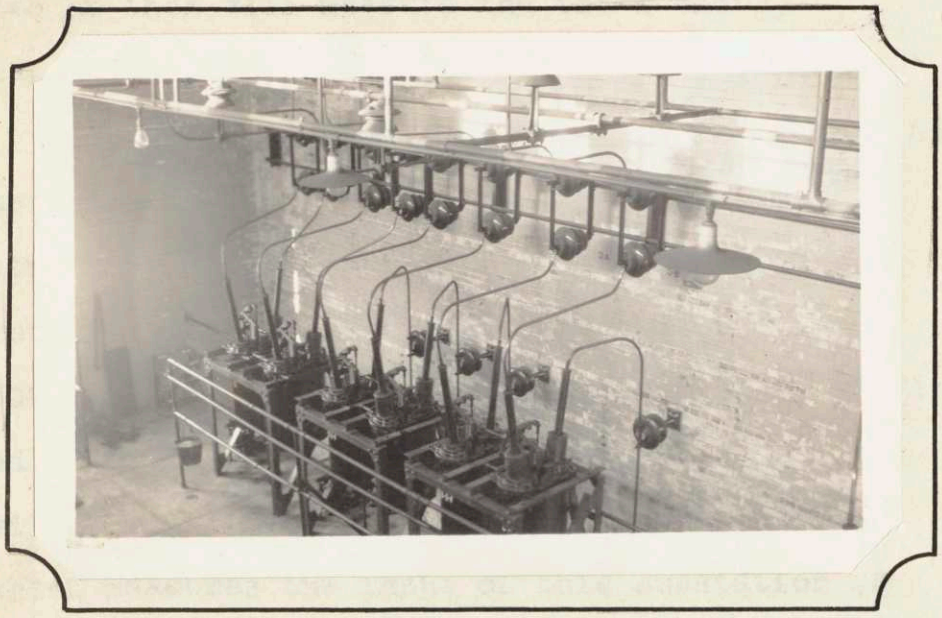
Sub-Station №4 - Paoli

Paoli Yards in the Background

to the 200 section. Of course, this includes the transformer losses, but the efficiency is so high that the small resulting error will be well within the precision of the final results.

To sum up, the two watt-hour meters installed in Substation No.1 and the one watt-hour meter installed to give the input to transformer No.3 in Substation No.3 will together give the total input to the 200 section. App. D

The 300 section is supplied by Substations No.3 and No.4, while Substation No.5, which is a synchronous condenser substation, is tied into the trolleys of this section. App.A-1 & A-2 This substation contains two synchronous motors which are run at no load for the purpose of power factor correction. Since they improve the power factor on the whole system, it is not reasonable to charge the power required to run these motors to the 300 section. Therefore, it is necessary to subtract the energy taken by these two motors from the total input to the 300 section. Since, in this substation there are two watt-hour meters, each measuring the input to one motor, the App.A-1



Oil Switches in Sub-Station No 3

Bryn Mawr Station and Sig. Tower "WH"
Sub-Sta. No 3 To left of Signal Bridge

two of them will measure the total energy taken by the station.

The total output of substation No.3 is measured by a watt-hour meter which is installed with its current coil in the rail bus. Therefore the input of this substation to the 300 section will be the kilowatt-hours measured by this meter in the rail bus less the kilowatt-hour measured by the watt-hour meter which measures the input of this substation to the 200 section. App.A-1 App. D

The measuring of the input of Substation No.4 to the 300 section presents certain complications. In the first place this substation supplies the Paoli Yard with power. In order to eliminate the power taken by the yard, it was found necessary to measure the actual input to the yard. This was done in the following manner: Switches PA5 and PA1 were opened. Inside the substation, switch FF in the 11000 volt bus was opened and the switch in trolley feeder 302 was opened. This arrangement left conditions so that transformer No.3 supplied power to the yard and the power house. A watt- App. A-1 App.A-1 App. D App.A-1

ABOVE:
RADNOR CONDENSER SUB-STATION.

RIGHT:
M-U. TRAIN PASSING OVER RADNOR TRACK-TANKS.

hour meter in the power house gave the power supplied to the power house by transformer No.3, while a watt-hour meter was installed to measure the input to transformer No.3. Thus the difference of the readings of these two watt-hour meters gave the input to the yard. A watt-hour meter is installed with its current coil in the rail bus in such a manner that it measures the input of the sub-station to the yard and the 300 section, but does not measure the input to the two 2200 volt lines running to the power house. Therefore, the input of this substation to the 300 section will be that measured by this watt-hour meter less the input to the yards.

The total net input to the 300 section will be the sum of the input of substations No.3 and No.4 to this section less the energy taken by Substation No.5, the condenser sub-station. App. D

Period of Taking Power Data.

With regard to the period over which readings should be taken, it is obvious that the longer the period the better the results.

But since one week was all the time that was available for taking readings it was necessary to limit the period to one week. In order to minimize the effect of electrical failures on the system and the consequent nullifying of results due to necessity for changing the electrical switching set up outlined above, readings of all watt-hour meters were taken every day. Thus, if anything went wrong on any particular day, that day's readings could be rejected without affecting those for the other days. During the test there was one instance of this; namely, the day of December 30. Furthermore, it will be noted that the readings for January first and second are combined. This is due to the fact that the reading of the two meters in Substation No.1 were not taken during the interval between January first and second. App.D-2

Obviously the best time to take readings is at that time of night when no multiple unit trains are operating. This was done. To take readings at any other time would require the simultaneous reading of all meters, which is

impracticable.

By referring to the data in the appendix, it will be seen that the kilowatt hours consumed in each section are presented for the days of December 26, 27, 28, 29, 31, and combined January 1 and 2. This includes one Sunday which naturally shows a marked difference from the other days of the week.

App. D
App. E-2

Passenger Data:-

It was not possible to get the distribution of passenger traffic in the two sections from any existing records. In order to obtain this data, it was necessary for one man to ride on a train between West Philadelphia and Paoli and count the number of passengers on the train after it had made a stop. The ideal way of obtaining this data would have been to have a man on every train for every day that power readings were taken. But the number of men required to do this was so large as to make it impracticable. Since only one man was available for this purpose, it was necessary to assume that the distribution of passengers was the same for each day of the week. Furthermore, it was impossible for this man to obtain data for the passenger distribution on every train, so it was necessary to make the further assumption that the figures for trains on which he did obtain data will, when summed up, give a distribution which is representative. Since about 50% of the trains were covered it is seen that the error from this

App. B

App. A-8

source will not be large when it is also remembered that the trains covered were distributed evenly over each day and the whole week.

Since the same assumptions hold for both the 200 and 300 sections, it will be seen that the resulting error in the ratio of power per passenger mile for the two sections will be small.

Car Data:-

Fram data taken by every conductor on every train for every day during which power readings were taken, it was possible to find the total number of car miles in both the 200 and 300 section for each day of the test. This data taken by each conductor, and obtained by us from the Superintendent of Car Service, consisted of the number of cars on each train. Thus by multiplying the number of cars by the known distances which they travelled the number of car miles is obtained.

App.A-5
App.A-6

App. C

Since from the power readings the energy consumption in each section is known for each day, it is possible to find the energy consumption per car mile in each section. As no assumptions are made here, the figure for

App.E-2

App.E-2

the energy consumed per car mile will be exact within the limits of meter accuracy, which is so high that it makes no difference. However, it must be remembered that the energy consumed per car mile is measured at the substations and so includes the losses in the trolley wires.

The cost of maintenance per car mile was obtained from records of the car maintenance department. App. E-3

INDICATIONS GIVEN BY DATA

Power Data:-

By taking the average of the daily ratio of kilowatt-hours for the 200 and 300 section, it is found that the 200 section takes 1.30 times as much power as the 300 section. This figure in itself has no particular significance with reference to the problem in hand. It is only useful in connection with the passenger distribution and car mile data. App.E-2

Passenger Distribution:-

A curve has been drawn which gives the number of passengers which are on a train at each station in terms of the per cent of the maximum number of passengers on a train during a trip. This curve is not for one particular train but is an average for all trains, both inbound and outbound. It is seen that the maximum number of passengers occurs between 52nd St. and Overbrook. Fifty-second St. is the next station west of West Philadelphia. At Bryn Mawr, which is half way between West Philadelphia and Paoli, 42.7% of App.A-8 App. B

the maximum number of passengers are on a train, while at Paoli 14.7% of the maximum are on a train. In general the curve is concave upward, showing that the per cent change in the number of passengers on a train at any one station, is less the nearer the train is to Paoli.

From the data taken it appears that on about one-third of the trains no passengers were taken on or discharged at Strafford or Daylesford. From this fact it seems advisable to make Strafford a flag stop as well as Daylesford for certain trains. App.A-7 & 8

Maintenance Data:-

The cost of car maintenance is $.0473 per car mile. Since the cost is independent of the number of passengers on a car the cost of car maintenance per passenger mile will be higher where the cars are lightly loaded. Consequently any change which reduces the number of lightly loaded cars will reduce the cost of maintenance per passenger mile.

Dropping Cars at Bryn Mawr:-

As previously pointed out it seems ad-

visable for west-bound trains to drop cars at Bryn Mawr and for east-bound trains to pick them up there, because Bryn Mawr is half way between Philadelphia and Paoli. But, still more important is the fact that the Pennsylvania Railroad Company owns land adjoining the right of way at Bryn Mawr where it is possible to lay tracks for storage of cars dropped at Bryn Mawr.

By dropping cars at Bryn Mawr, the following savings will be effected. First, there will be a saving in power which would otherwise be used to take the cars from Bryn Mawr to Paoli and return, and to make the intermediate stops. Secondly, there will be a saving in car maintenance, because of the car miles saved by dropping cars at Bryn Mawr. Lastly, the dropping of cars at Bryn Mawr will serve to lessen the peak load, which is an important item.

App.A-5
App.A-6

RESULTS OF CALCULATIONS

Ratio of Energy per Passenger Mile.

By taking the total number of passengers that rode between each two adjacent stations and multiplying by the number of miles between the respective stations, the number of passenger miles between each two adjacent stations was obtained. The sum of the passenger miles between all stations in the 200 section gave the total number of passenger miles in the 200 section. Going thru the same procedure for the 300 section gave the total number of passenger miles in the 300 section. App.B-6 App.B-6 App.B-6

The number of passengers used in this calculation is that counted during the week of the test. Therefore, the number of passenger miles in each section has no particular significance. But their ratio will have a real significance, which can be seen by remembering the manner in which the passengers were counted. This ratio is 2.92; that is, there are 2.92 times as many passenger miles in the 200 section as in the 300 section. App.B-6

By dividing this ratio by the ratio of energy used in the 200 section to that used in the 300 section, the resulting ratio is 2.24 and is the ratio of energy per passenger mile in the 300 section to that in the 200 section. Thus between Bryn Mawr and Paoli, it requires 2.24 times as much energy per passenger mile as between Bryn Mawr and West Philadelphia.

Since this ratio is quite large it is evident that there is considerable opportunity for improvement and any reduction of the ratio will be worth while.

Energy per Car Mile.

As the number of car trips for each day of the test is known, the number of car miles for each day in both the 200 and 300 section can be found. Also, since the total energy used in each section is known for every day of the test, the energy required per car mile in each section can be found for each day. The average of these values is 8.45 kw.-hr. per car mile in the 200 section and 5.91 kw.-hr. per car mile in the 300 section. The chief reason for this difference is the heavier

App. C

grades in the 200 section.

Saving by Dropping Cars at Bryn Mawr.

The Pennsylvania Railroad engineers who have been working on this problem estimate that 50 cars may be cut off per day at Bryn Mawr. This gives a saving of 986 car miles per day. Now, the cost of energy is $.005 per kw.-hr., which with 5.91 kw.-hr. per car mile gives an energy cost of $.0295 per car mile. Since the maintenance cost is $.0473 per car mile, the total cost of energy and maintenance is $.0768 per car mile. On a basis of 986 car miles per week day and half as many on Sunday, the saving in cost of maintenance and energy is $25,600 per year by dropping cars at Bryn Mawr. This is a gross saving from which must be subtracted the interest and depreciation on the yard facilities at Bryn Mawr. The cost of the yard at Bryn Mawr is estimated by the Company's engineers at $94,000. With interest at 6% and depreciation at 5% the cost of the yard is very nearly $10,300 per year. Then, the net saving is $15,300 per year by dropping cars

App. E-3

App. E-3

App.E-3

at Bryn Mawr. This, of course, includes the saving in energy and maintenance alone.

As previously stated, 42.7% of the maximum number of passengers are on a train at Bryn Mawr, or in other words 57.3% of the car capacity is unused when a train leaves Bryn Mawr in the direction of Paoli. Therefore, theoretically it ought to be possible to cut off 57.3% of the cars at Bryn Mawr. But there are certain practical considerations which prevent this. From a general standpoint, no cars should be cut off a two car train, one car should be cut off a three car train, two cars off four and five car trains, and three cars off six and seven car trains. Making generous allowance for this, it seems reasonable to state for purposes of calculation that 40% of the cars might be cut off at Bryn Mawr. This is nearly 20% less than the theoretical 57.3%. App.A-8

The average number of cars making the trip from Bryn Mawr to Paoli and return per day is 170 with half as many on Sunday. Cutting off 40% of them would be 68 cars per week App. C

day and 34 on Sunday. This is 18 more than estimated by the Company's engineers. Using this figure of 68 instead of 50, the gross saving in energy and maintenance costs is App.E-4 $34,800 and the net saving is $24,500.

Another saving that might result from the dropping of cars at Bryn Mawr is in train crew or platform charges. But this item is too indefinite to be calculated within reasonable limits. Still another and more important saving is in the peak load charge which is $1.25 per kw.-hr. for the average of the three highest peak hours of a month. This rate holds at $1.25 up to where the peak load hour consumption becomes 12,000 kw.-hr. From 12,000 to 15,000 kw.-hr. for the peak load hour consumption, the charge is fixed at $15,000 per month. After the peak load hour consumption reaches 15,000 kw.-hr. the charge becomes $1.00 per kw.-hr. for the average of the three highest peak hours of the month.

Peak Load Hour Saving.

By cutting off cars at Bryn Mawr in the manner previously stated, it is found that

that 159.6 car miles will be saved during the peak load hour. This means a saving of 942 kw.-hr. Thus the peak load hour consumption is reduced by 942 kw.-hr. But at the present time, this will mean no saving in the peak load charge, because the peak load hour consumption is now between 13,000 and 14,000 kw.-hr., and the charge is constant at $15,000 per month when the peak load hour consumption is between 12,000 and 15,000 kw.-hr. Therefore, the peak load hour consumption would have to be reduced to the limiting value of $12,942 kw.-hr. before any saving in peak load charge would begin to be affected. However, there are a few months in the year when the peak load hour consumption does fall considerably below this value and then a very material saving would come into effect. App.A-5 & 6

CONCLUSION

In conclusion, we recommend that at least 68 cars per week day and 34 cars per Sunday be cut off at Bryn Mawr. Also, we recommend that Strafford, as well as Daylesford, be made a flag stop for a number of trains.

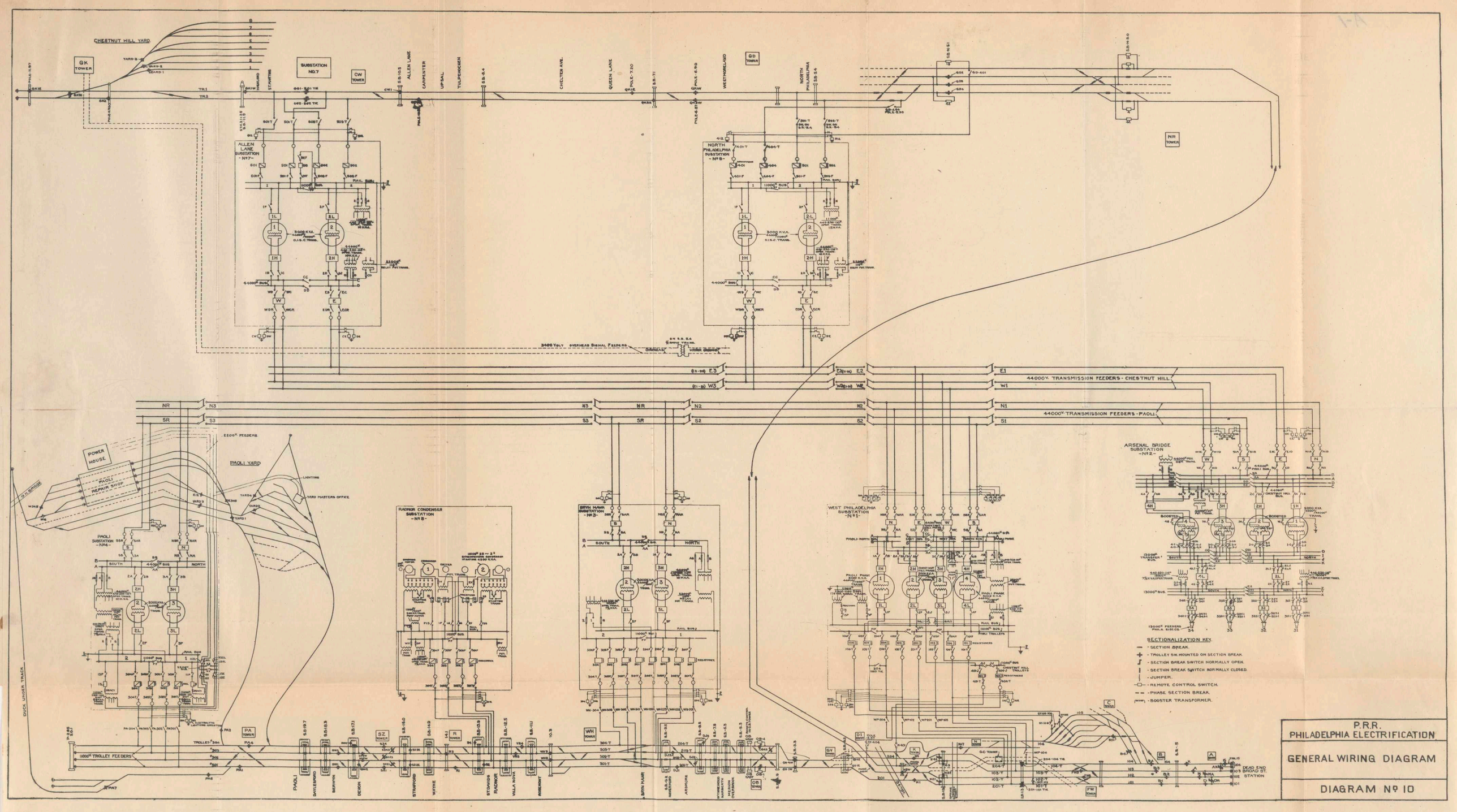
Appendix A

This appendix consists of diagrams only. The first, on page A-2, is a general diagram of the sections tested. W indicates a watt-hour meter, the large numeral following indicates the station in which the meter is installed and the subscript numeral is the meter number in the station. "W-H" section breaks are the dividing line between the 200 and 300 sections.

Pages A-3 and A-4 are straight line time-tables for the 300 section during the morning and night rush hours.

Pages A-5 and A-6 show the car densities at present and as proposed during the same two hours as the preceeding plots.

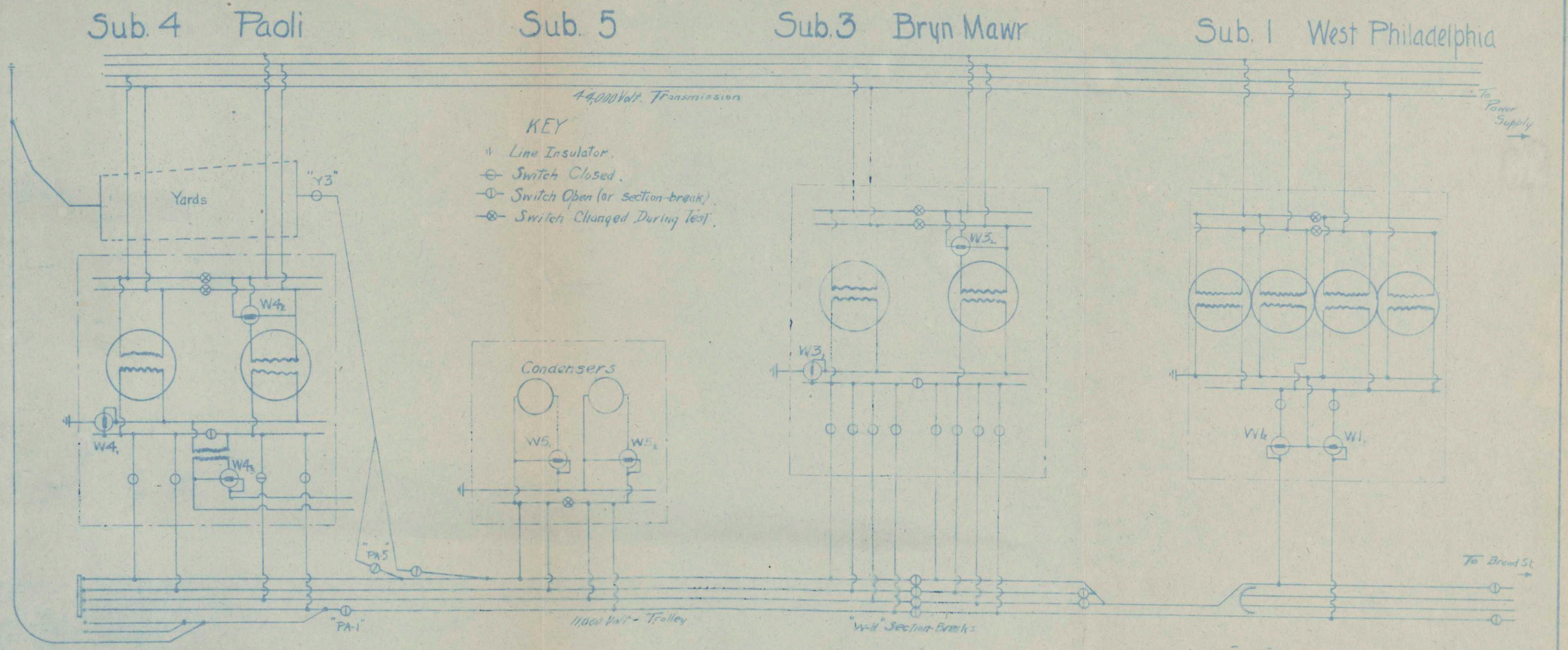
On A-7 and A-8 are plots of passenger density against distance. Page A-7 is that as obtained from ticket sales from Broad St. Station and does not include passengers riding between intermediate stations. Page A-8 is plotted from data obtained by actual count of passengers on trains but does not include every train of a day. However it does give a very good idea of what the passenger density really is.



P.R.R.
PHILADELPHIA ELECTRIFICATION

GENERAL WIRING DIAGRAM

DIAGRAM Nº 10



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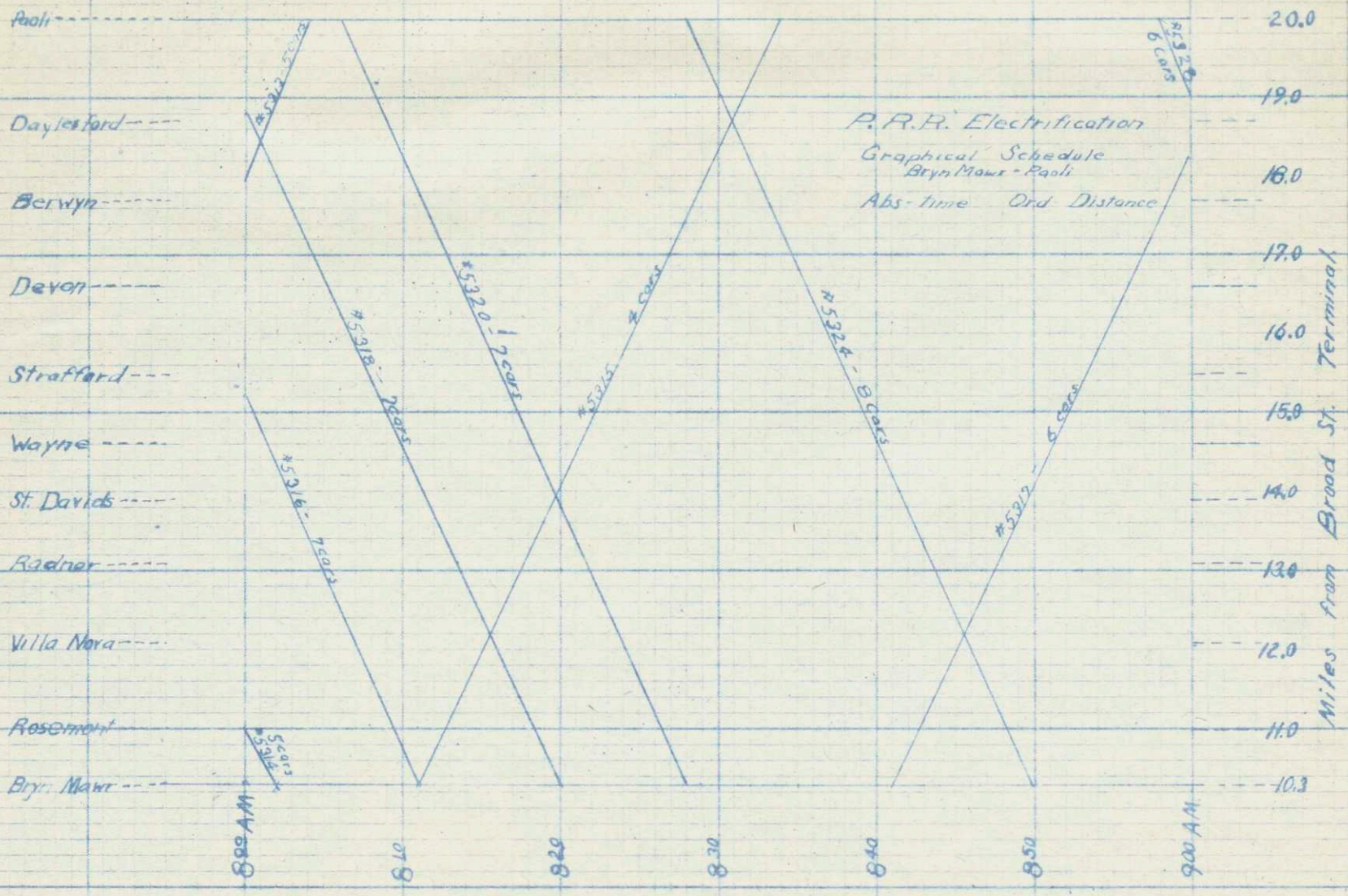
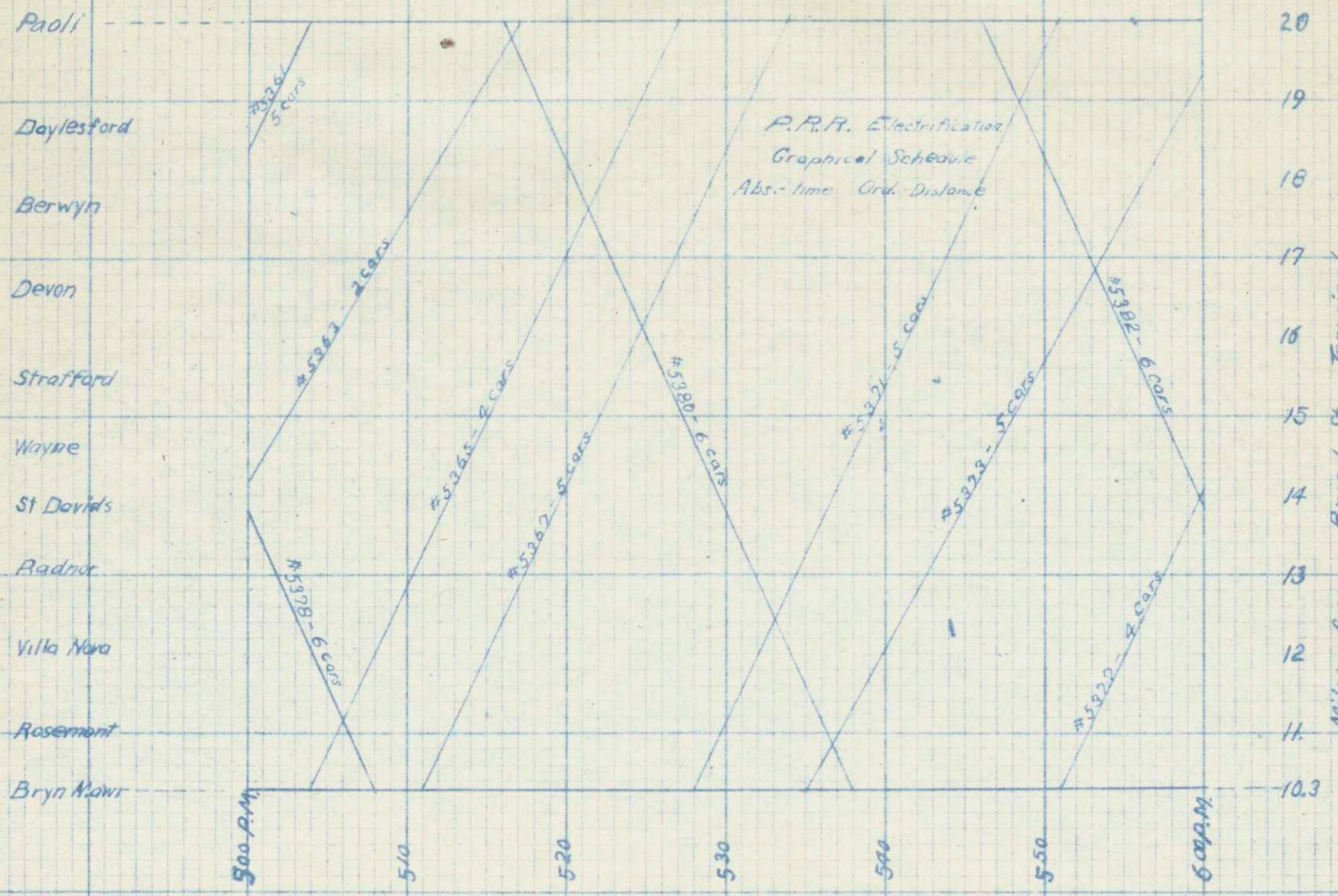
Schematic Diagram
Penna. R.R. Electrification

Jan 1916

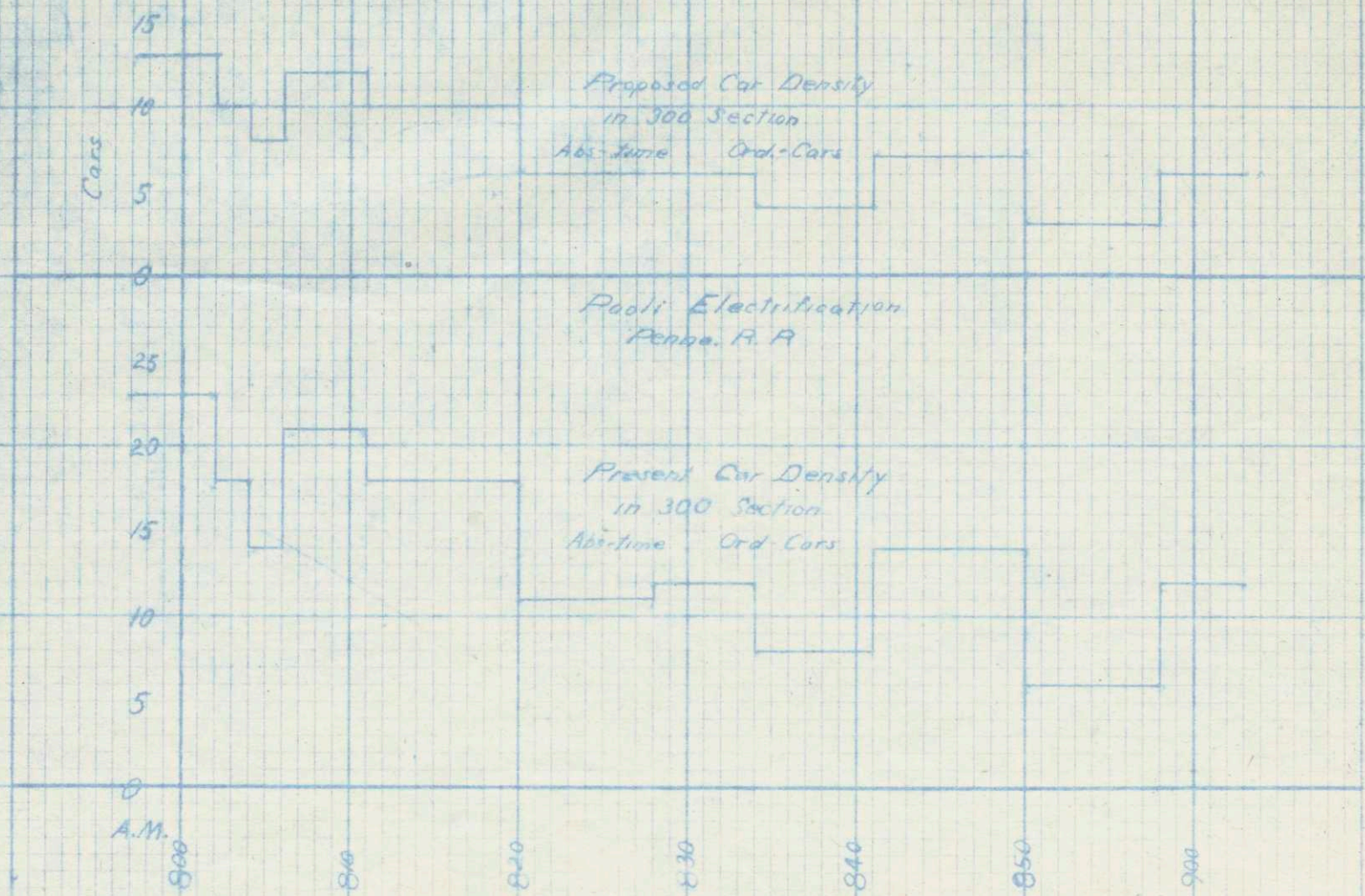
1

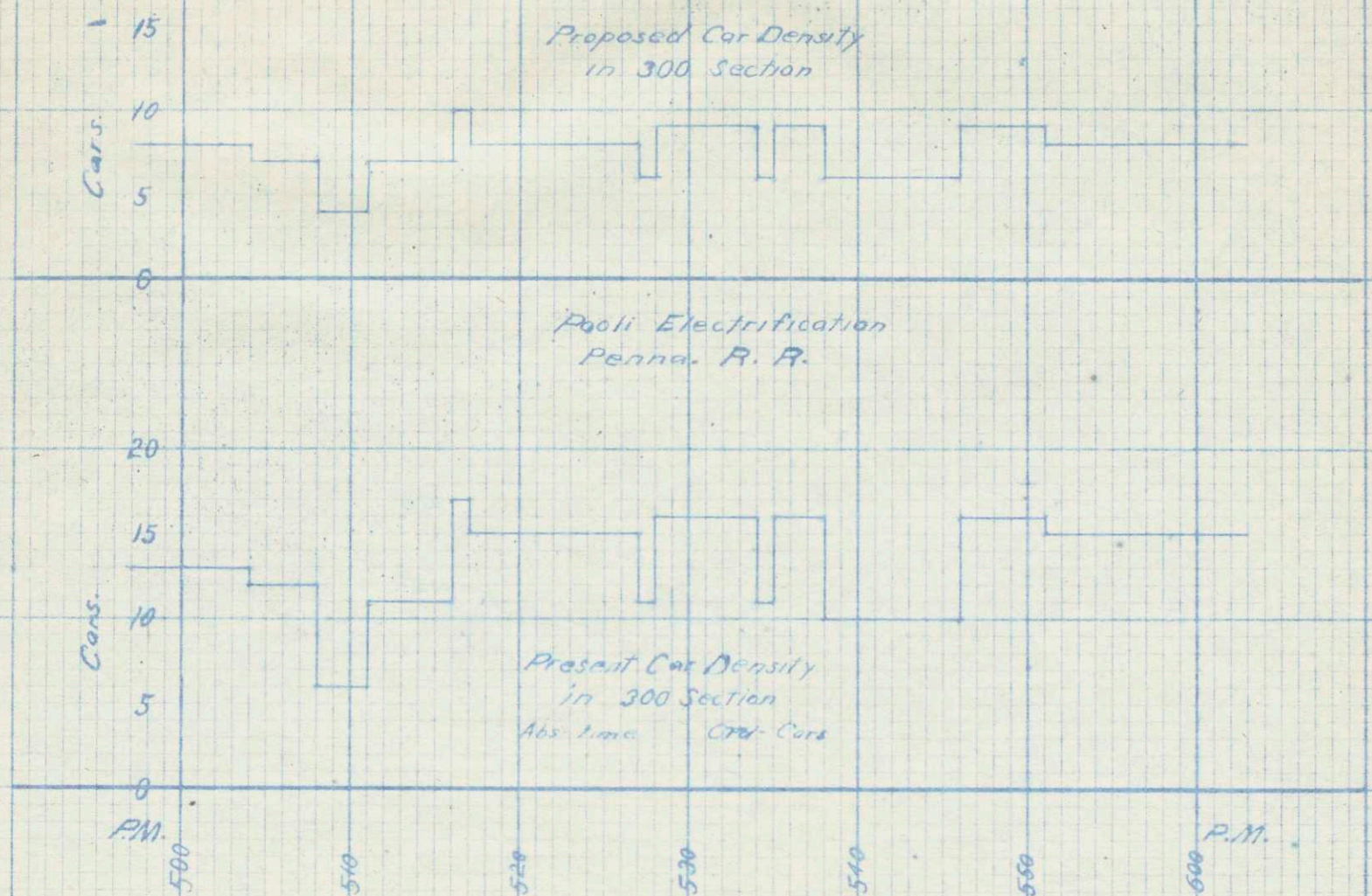

Paoli
Daylesford
Berwyn
Devon
Strafford
Wayne
St. Davids
Radnor
Villa Nova
Rosemont
Bryn Mawr
#5312 - 5 cars
#5318 - 2 cars
#5320 - 12 cars
#5316 - 7 cars
#5315 - 4 cars
#5324 - 8 cars
#5312 - 5 cars
#5312 - 6 cars
5 cars #5316
8.00 A.M.
8.10
8.20
8.30
8.40
8.50
9.00 A.M.
20.0
19.0
18.0
17.0
16.0
15.0
14.0
13.0
12.0
11.0
10.3
Miles from Broad St. Terminal
P.R.R. Electrification
Graphical Schedule
Bryn Mawr - Paoli
Abs-time Ord Distance

A-3

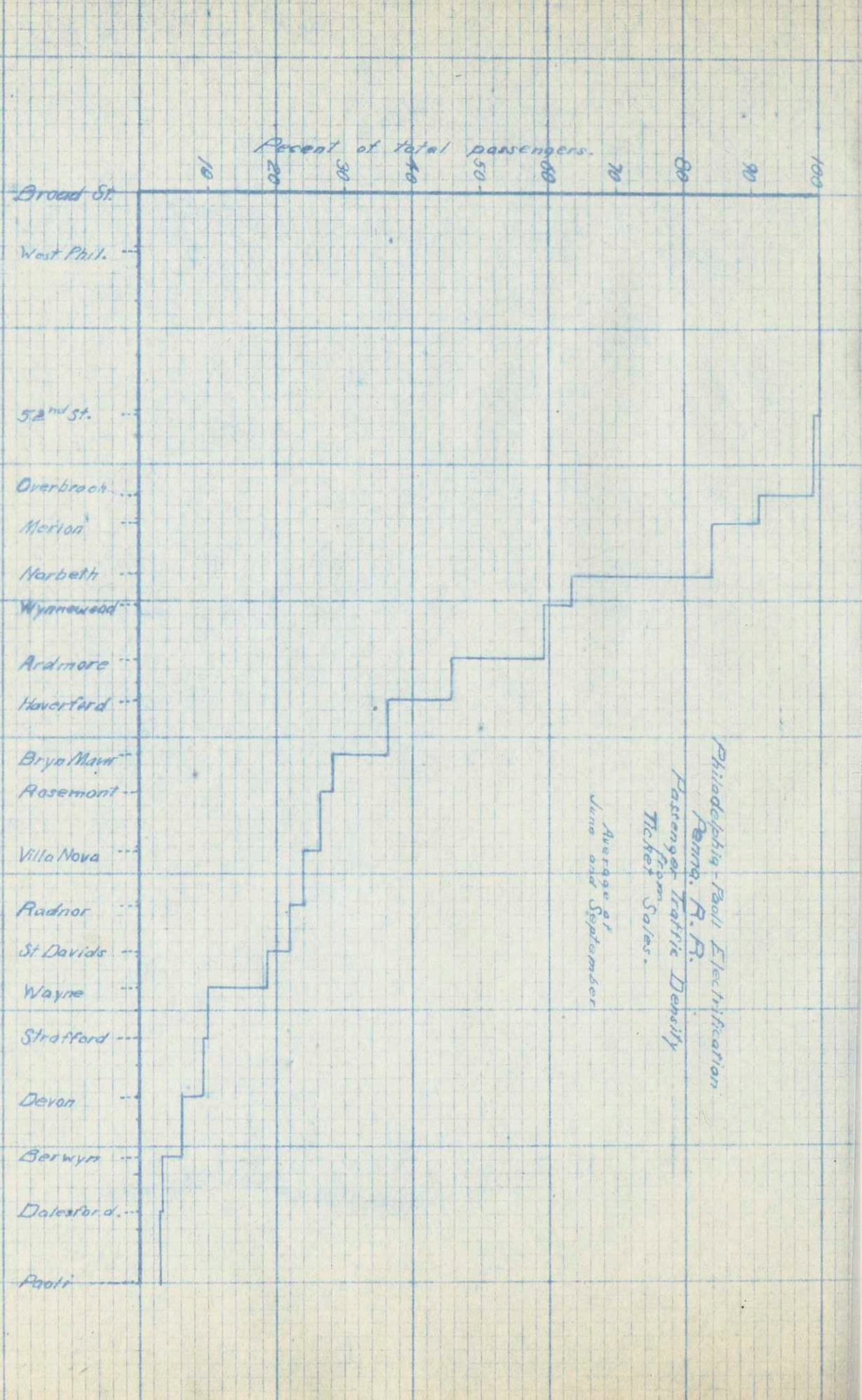

Paoli
Daylesford
Berwyn
Devon
Strafford
Wayne
St Davids
Radnor
Villa Nova
Rosemont
Bryn Mawr
20
19
18
17
16
15
14
13
12
11
10.3
Miles from Broad St. Terminal
P.R.R. Electrification
Graphical Schedule
Abs.-time Ord. Distance
#5366 - 5 cars
#5363 - 2 cars
#5365 - 4 cars
#5362 - 5 cars
#5378 - 6 cars
#5380 - 6 cars
#5324 - 5 cars
#5323 - 5 cars
#5382 - 6 cars
#5322 - 4 cars
5:00 P.M.
5:10
5:20
5:30
5:40
5:50
6:00 P.M.

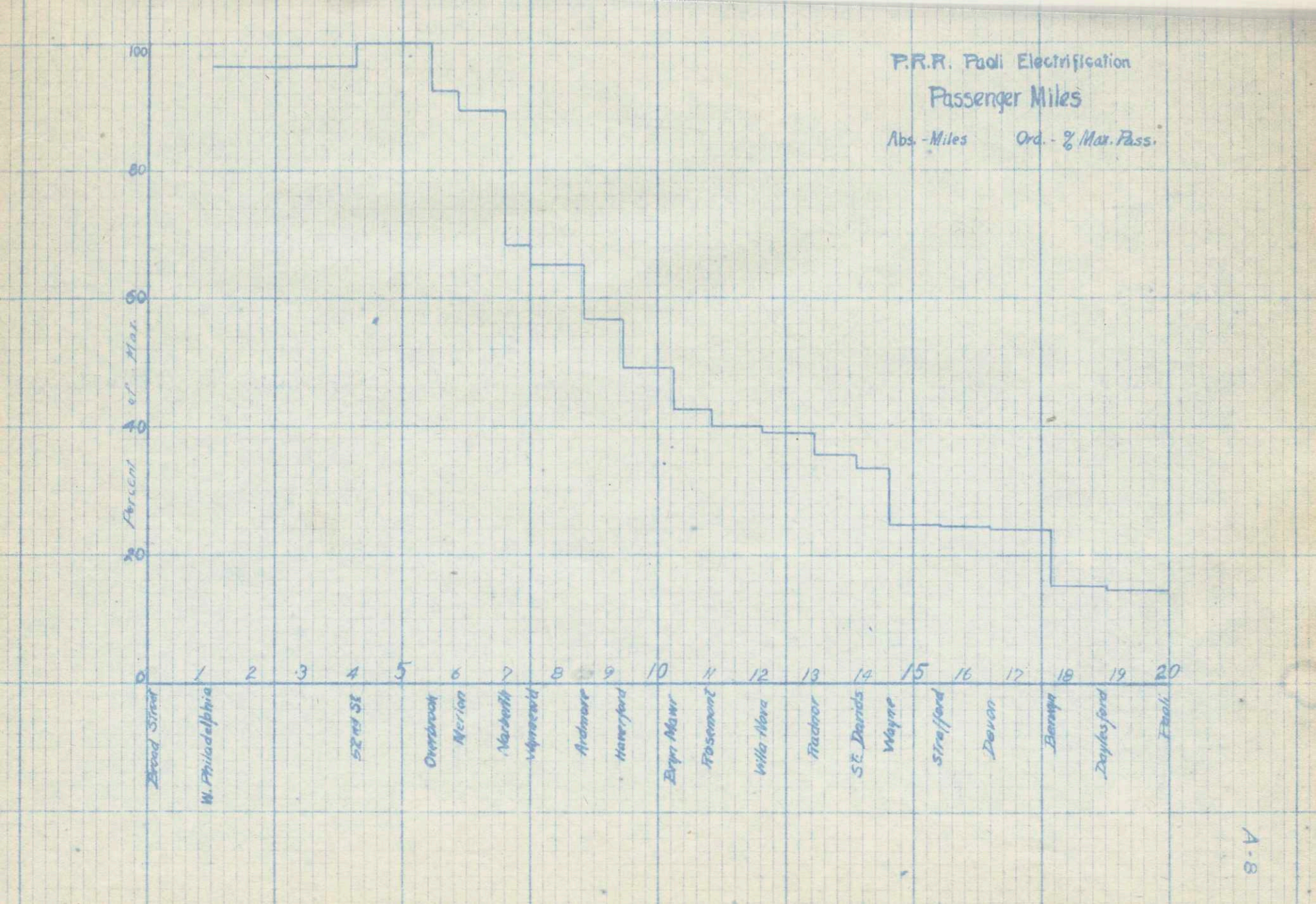
A-4


Proposed Car Density
in 300 Section
Abs-time Ord.-Cars
Cars
15
10
5
0
Paoli Electrification
Penna. R. R
Present Car Density
in 300 Section
Abs-time Ord Cars
25
20
15
10
5
0
A.M.
800
810
820
830
840
850
900


Proposed Car Density
in 300 Section
Cars.
15
10
5
0
Paoli Electrification
Penna. R. R.
Present Car Density
in 300 Section
Abs. time
Cars
Cars.
20
15
10
5
0
P.M.
500
510
520
530
540
550
600
P.M.

A-6


Percent of total passengers.
10
20
30
40
50
60
70
80
90
100
Broad St.
West Phil.
52nd St.
Overbrook
Merion
Narberth
Wynnewood
Ardmore
Haverford
Bryn Mawr
Rosemont
Villa Nova
Radnor
St. Davids
Wayne
Strafford
Devon
Berwyn
Daleford
Paoli
Philadelphia - Paoli Electrification
Penna. R. R.
Passenger Traffic Density
Ticket Sales.
Average of June and September


P.R.R. Paoli Electrification
Passenger Miles
Abs. - Miles
Ord. - % Max. Pass.
Percent of Max.
100
80
60
40
20
0
1
2
3
4
5
6
7
8
9
10
11
12
13
14
15
16
17
18
19
20
Broad Street
W. Philadelphia
52nd St
Overbrook
Merion
Narberth
Wynnewood
Ardmore
Haverford
Bryn Mawr
Rosemont
Villa Nova
Radnor
St. Davids
Wayne
Strafford
Devon
Berwyn
Daylesford
Paoli

A-8

PASSENGER TRAFFIC DATA (by count)

Explanation: This data represents the number of passengers on a train between each station as found by actual count. Each column of figures is headed by the train number and day on which the figures below them were obtained. The letters represent stations between which the passengers rode, and stand for stations as follows:

WP	West Philadelphia	RO	Rosemont
52	Fifty Second St.	VN	Villa Nova
OV	Overbrook	RA	Radnor
ME	Merion	SD	St. Davids
NA	Narberth	WA	Wayne
WY	Wynnewood	ST	Strafford
AR	Ardmore	DE	Devon
HA	Haverford	BE	Berwyn
BM	Bryn Mawr	DA	Daylesford
		PA	Paoli

PASSENGER TRAFFIC DATA (by count)

Train No:	5311	5312	5313	5314	5320	5321	5331
Date	29	29	30	31	30	27	24
WP - 52	87	394	134	238	264	79	192
52 - OV	120	359	230	238	264	99	193
OV - ME	118	330	234	238	264	100	172
ME - NA	110	322	216	238	264	101	185
NA - WY	118	168	128	238	264	89	140
WY - AR	113	158	118	238	264	92	136
AR - HA	53	119	107	113	202	81	112
HA - BM	46	110	81	114	156	67	112
BM - RO	28	110	65	86	139	46	114
RO - VN	23	98	53	77	130	39	112
VN - RA	20	117	47	68	118	35	101
RA - SD	23	100	47	66	113	30	88
SD - WA	21	114	39	54	100	28	81
WA - ST	23	97	21	29	46	31	82
ST - DE	25	95	17	27	44	36	79
DE - BE	29	89	16	21	36	38	76
BE - DA	23	70	15	9	15	29	58
DA - PA	23	69	15	8	13	29	51

PASSENGER TRAFFIC DATA (by count)

Train No:	5338	5339	5340	5345	5347	5350	5351
Date	24	27	27	1	24	24	29
WP - 52	328	424	239	61	269	98	136
52 - OV	377	378	231	64	282	101	120
OV - ME	372	364	213	60	250	96	112
ME - NA	350	365	205	55	242	93	94
NA - WY	206	288	161	51	183	77	88
WY - AR	200	281	155	50	175	70	84
AR - HA	178	276	134	42	135	64	72
HA - BM	145	250	108	31	108	59	60
BM - RO	128	222	85	21	89	49	44
RO - VN	120	202	79	20	89	51	39
VN - RA	115	196	82	19	87	49	35
RA - SD	112	181	66	18	79	48	38
SD - WA	110	174	59	17	69	41	30
WA - ST	60	120	43	15	47	28	22
ST - DE	57	116	42	16	47	28	23
DE - BE	34	102	37	14	46	33	18
BE - DA	14	43	28	8	39	23	15
DA - PA	13	42	28	8	36	23	15

PASSENGER TRAFFIC DATA (by count)

Train No:	5372	5374	5375	5378	5380	5381	5388
Date	29	27	30	1	24	27	29
WP - 52	118	87	422	142	93	191	99
52 - OV	134	96	395	156	123	169	115
OV - ME	124	93	234	168	118	116	108
ME - NA	113	87	206	114	110	100	104
NA - WY	92	78	90	100	110	65	61
WY - AR	90	82	85	95	104	60	55
AR - HA	81	55	64	79	103	38	39
HA - BM	72	45	55	66	89	23	37
BM - RO	68	32	47	57	74	19	33
RO - VN	62	28	44	56	70	19	29
VN - RA	53	28	42	48	68	18	28
RA - SD	56	28	37	42	68	18	19
SD - WA	51	28	32	29	68	15	17
WA - ST	40	30	22	14	58	8	12
ST - DE	42	30	18	14	55	10	12
DE - BE	44	32	11	15	51	9	11
BE - DA	48	26	5	10	38	8	14
DA - PA	48	24	5	6	36	6	14

PASSENGER TRAFFIC DATA (by count)

Train No:	5390	5719	5734
Date	27	28	28
WP - 52	192	87	93
52 - OV	222	127	119
OV - ME	191	127	116
ME - NA	182	127	116
NA - WY	103	102	92
WY - AR	102	106	92
AR - HA	77	108	86
HA - BM	65	105	88
BM - RO	54	104	82
RO - VN	51	99	74
VN - RA	43	98	78
RA - SD	34	93	79
SD - WA	31	91	73
WA - ST	42	78	50
ST - DE	42	86	55
DE - BE	26	72	54
BE - DA	21	72	23
DA - PA	19	72	24

PASSENGER TRAFFIC DATA (by count)

SUMMARY

Stations	Miles	Passeng.	Pass-Miles
WP - 52	3.0	6418	19254
52 - OV	1.5	6605	9908
OV - ME	0.5	6148	3074
ME - NA	0.9	5861	5275
NA - WY	0.6	4531	2719
WY - AR	1.0	4380	4380
AR - HA	0.7	3653	2547
HA - BM	1.0	3178	3178
Total for 200 section			50335
BM - RO	0.7	2722	1905
RO - VN	1.1	2543	2797
VN - RA	1.0	2456	2456
RA - SD	0.8	2285	1828
SD - WA	0.7	2136	1495
WA - ST	0.9	1535	1382
ST - DE	1.1	1526	1679
DE - BE	1.1	1464	1610
BE - DA	1.0	937	937
DA - PA	1.3	892	1160
Total for 300 section			17249

Ratio $\frac{200}{300}$:

$\frac{50335}{17249} = 2.92$

CAR RECORD

Explanation: The following data was obtained at the office of the Superintendent of Car Service, Philadelphia, and contains the train "make-up" for each and every train on each day the test was run. All trains, including mail, express, and extras are in this list. Cognizance is taken of three types of car: the scheduled passenger coach, the scheduled combination passenger and baggage car, and the "Non Pass." which includes all other cars, either mail, express, or deadhead as well as extras for railroad workmen (i.e. cars not carrying revenue passengers). Only electric trains are included.

The totals at the bottom of each sheet are for that sheet only.

See Appendix "E" for summary.

CAR RECORD December 26, 1919

Train No.	Coaches	Non Pass.	Comb.	Total
5302	3	0	0	3
5303	3	1	0	4
5304	4	0	1	5
5306	6	0	0	6
5311	3	1	0	4
5312	6	0	1	7
5313	4	0	0	4
5314	5	0	0	5
5315	3	0	1	4
5316	7	0	0	7
5317	6	0	0	6
5319	5	0	1	6
5320	7	0	0	7
5321	6	0	0	6
5324	6	1	1	8
5325	5	0	1	6
5327	0	2	0	2
5328	5	0	1	6
Totals	84	5	7	96

CAR RECORD December 26, 1919

Train No.	Coaches	Non Pass.	Comb.	Total
5331	6	0	1	7
5332	5	0	1	6
5338	4	0	1	5
5339	4	0	1	5
5340	5	0	0	5
5341	3	0	0	3
5343	0	2	0	2
5345	3	0	1	4
5346	4	0	0	4
5347	3	0	1	4
5348	0	2	0	2
5350	3	0	0	3
5351	2	0	1	3
5352	4	0	1	5
5355	5	0	1	6
5356	4	0	0	4
5357	4	0	0	4
5358	4	0	1	5
Totals	63	4	10	77

CAR RECORD December 26, 1919

Train No.	Coaches	Non Pass.	Comb.	Total
5360	4	0	0	4
5361	5	0	0	5
5363	0	2	0	2
5364	3	0	0	3
5365	4	0	0	4
5367	5	0	0	5
5368	0	2	0	2
5370	4	0	0	4
5371	6	0	0	6
5372	3	0	1	4
5373	7	0	0	7
5374	5	0	1	6
5375	5	0	1	6
5377	6	0	0	6
5378	4	0	1	5
5379	6	0	1	7
5380	5	0	1	6
5381	5	0	0	5
Totals	77	4	6	87

CAR RECORD December 26, 1919

Train No.	Coaches	Non Pass.	Comb	Total
5382	4	0	0	4
5384	4	0	1	5
5385	3	0	1	4
5387	3	0	0	3
5388	4	0	0	4
5389	3	0	0	3
5390	4	0	0	4
5391	3	0	0	3
5393	3	0	0	3
5394	3	0	0	3
5395	3	0	0	3
5398	4	0	1	5
5400	3	0	0	3
5402	4	0	0	4
5405	5	0	1	6
5408	5	0	0	5
5409	4	0	0	4
	62	2	4	68

CAR RECORD December 26, 1919

Train No.	Coaches	Non Pass.	Comb.	Total
5410	4	0	1	5
5411	5	0	0	5
5415	3	0	0	3
Extras	0	11	0	11
PA to OB	0	1	0	1
	0	1	0	1
	12	13	1	26

CAR RECORD December 27, 1919

Train No.	Coaches	Non Pass.	Comb.	Total
5302	3	0	0	3
5303	2	1	1	4
5304	3	0	1	4
5306	6	0	0	6
5311	4	1	0	5
5312	6	0	1	7
5313	4	0	0	4
5314	5	0	0	5
5315	3	0	1	4
5316	7	0	0	7
5317	6	0	0	6
5318	7	0	0	7
5320	6	0	0	6
5321	6	0	0	6
5324	6	1	1	8
5325	5	0	1	6
5327	0	2	0	2
5328	5	0	1	6
Totals	84	5	7	96

CAR RECORD December 27, 1919

Train No.	Coaches	Non Pass.	Comb.	Total
5331	6	0	1	7
5332	5	0	1	6
5338	4	0	1	5
5339	6	0	1	7
5340	5	0	0	5
5341	6	0	0	6
5343	0	2	0	2
5345	4	0	0	4
5346	7	0	0	7
5347	4	0	1	5
5348	0	2	0	2
5350	3	0	0	3
5351	3	0	1	4
5352	7	0	1	8
5355	6	0	1	7
5356	4	0	0	4
5357	4	0	0	4
5358	4	0	1	5
	78	4	9	91

CAR RECORD December 27, 1919

Train No.	Coaches	Non Pass.	Comb.	Total
5360	4	0	0	4
5361	5	0	0	5
5363	0	2	0	2
5364	3	0	0	3
5365	4	0	0	4
5367	4	0	0	4
5368	0	2	0	2
5370	4	0	0	4
5371	4	0	0	4
5372	6	0	1	7
5373	7	0	0	7
5374	7	0	0	7
5375	5	0	1	6
5377	4	0	0	4
5378	6	0	1	7
5379	7	0	0	7
5380	5	0	1	6
5381	5	0	0	5
	80	4	4	88

CAR RECORD December 27, 1919

Train No.	Coaches	Non Pass.	Comb.	Total
5382	3	0	0	3
5383	3	0	1	4
5384	0	2	0	2
5385	3	0	1	4
5387	3	0	0	3
5388	3	0	0	3
5389	3	0	1	4
5390	5	0	0	5
5391	3	0	0	3
5392	3	0	0	3
5393	3	0	0	3
5395	3	0	0	3
5398	3	0	0	3
5400	3	0	0	3
5402	3	0	0	3
5405	4	0	1	5
5408	5	0	0	5
5409	5	0	0	5
	58	2	4	64

CAR RECORD December 27, 1919

Train No.	Coaches	Non Pass.	Comb.	Total
5410	2	0	1	3
5411	5	0	0	5
5415	4	0	0	4
5451	4	0	0	4
Extra	7	0	0	7
	0	1	0	1
	0	1	0	1
	22	2	1	25

CAR RECORD December 28, 1919

Train No.	Coaches	Non Pass.	Comb.	Total
5702	2	0	1	3
5704	3	0	0	3
5705	2	1	1	4
5706	3	0	0	3
5707	2	0	1	3
5708	3	0	1	4
5711	3	0	0	3
5712	6	0	0	6
5714	5	0	1	6
5715	3	0	0	3
5716	3	0	0	3
5719	2	0	1	3
5720	2	0	1	3
5723	2	0	1	3
5724	3	0	0	3
5725	3	0	0	3
5726	2	0	1	3
5727	5	0	0	5
	54	1	9	64

CAR RECORD December 28, 1919

Train No.	Coaches	Non Pass.	Comb.	Total
5728	4	0	0	4
5729	2	0	1	3
5732	4	0	1	5
5733	4	0	0	4
5737	4	0	0	4
5739	2	0	1	3
5740	3	0	1	4
5742	3	0	0	3
5743	3	0	0	3
5744	4	0	0	4
5745	3	0	0	3
5746	3	0	0	3
5747	2	0	1	3
5750	4	0	0	4
5753	4	0	0	4
5754	4	0	0	4
5755	3	0	0	3
5760	4	0	0	4
	60	0	5	65

CAR RECORD December 28, 1919

Train No.	Coaches	Non Pass.	Comb.	Total
5762	3	0	0	3
5763	5	0	0	5
5764	3	0	0	3
5765	3	0	0	3
5767	4	0	0	4
5768	3	1	1	5
5769	3	0	0	3
5773	3	0	0	3
	27	1	1	29

CAR RECORD December 29, 1919

Train No.	Coaches	Non Pass.	Comb.	Total
5302	3	0	0	3
5304	3	0	1	4
5306	6	0	0	6
5311	3	0	1	4
5312	6	0	1	7
5313	3	1	1	5
5314	5	0	0	5
5315	3	0	1	4
5316	6	0	1	7
5317	6	0	0	6
5318	7	0	0	7
5320	7	0	0	7
5321	6	0	0	6
5324	6	1	1	8
5325	5	0	1	6
5327	0	2	0	2
5328	5	0	1	6
5331	5	0	1	6
	85	4	10	99

CAR RECORD December 29, 1919

Train No.	Coaches	Non Pass.	Comb.	Total
5332	5	0	1	6
5338	4	0	1	5
5339	5	0	1	6
5340	5	0	0	5
5341	3	0	0	3
5345	0	2	0	2
5346	4	0	0	4
5347	3	0	1	4
5348	0	2	0	2
5350	3	0	0	3
5351	2	0	1	3
5352	4	0	1	5
5355	5	0	1	6
5356	4	0	0	4
5357	4	0	0	4
5358	4	0	1	5
5360	4	0	0	4
5361	5	0	0	5
	64	4	8	76

CAR RECORD December 29, 1919

Train No.	Coaches	Non Pass.	Comb.	Total
5363	0	2	0	2
5364	3	0	0	3
5365	4	0	0	4
5367	5	0	0	5
5368	0	2	0	2
5370	4	0	0	4
5371	6	0	0	6
5372	5	0	1	6
5373	7	0	0	7
5374	7	0	0	7
5375	5	0	1	6
5377	6	0	0	6
5378	5	0	1	6
5379	7	0	0	7
5380	5	0	1	6
5381	5	0	0	5
5382	3	0	0	3
5383	4	0	1	5
	81	4	5	90

CAR RECORD December 29, 1919

Train No.	Coaches	Non Pass.	Comb.	Total
5384	0	2	0	2
5385	3	0	1	4
5387	3	0	0	3
5388	5	0	0	5
5389	3	0	0	3
5390	4	0	0	4
5391	3	0	0	3
5393	3	0	0	3
5394	3	0	0	3
5395	3	0	0	3
5398	4	0	1	5
5400	3	0	0	3
5402	4	0	0	4
5405	4	0	1	5
5408	5	0	0	5
5409	4	0	0	4
5410	2	0	1	3
5411	5	0	0	5
	61	2	4	67

CAR RECORD December 29, 1919

Train No.	Coaches	Non Pass.	Comb.	Total
5415	3	0	0	3
*	4	0	0	4
*	3	0	0	3
Extras	6	0	1	7
PA to 52	0	1	0	1
	0	1	0	1
	16	2	1	19

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* The train numbers corresponding to these train make-ups were illegible on the conductors Car Record Sheet.

CAR RECORD December 31, 1919

Train No.	Coaches	Non Pass.	Comb.	Total
5302	3	0	0	3
5303	2	1	1	4
5304	3	0	1	4
5306	6	0	0	6
5311	3	1	0	4
5312	6	0	1	7
5313	4	0	0	4
5314	5	0	0	5
5315	3	0	1	4
5316	7	0	0	7
5317	6	0	0	6
5318	7	0	0	7
5320	7	0	0	7
5321	6	0	0	6
5324	6	0	1	7
5325	5	0	1	6
5327	0	2	0	2
5328	5	0	1	6
	84	4	7	95

CAR RECORD December 31, 1919

Train No.	Coaches	Non Pass.	Comb.	Total
5331	5	0	1	6
5332	5	0	1	6
5338	5	0	0	5
5339	5	0	1	6
5340	4	0	0	4
5341	3	0	0	3
5343	0	2	0	2
5345	3	0	0	3
5346	4	0	0	4
5347	3	0	1	4
5348	0	2	0	2
5350	3	0	0	3
5351	2	0	1	3
5352	4	0	1	5
5355	5	0	1	6
5356	5	0	0	5
5357	4	0	0	4
5358	4	0	1	5
	64	4	8	76

CAR RECORD December 31, 1919

Train No.	Coaches	Non Pass.	Comb.	Total
5360	4	0	0	4
5361	5	0	0	5
5363	0	2	0	2
5364	3	0	0	3
5365	4	0	0	4
5367	4	0	1	5
5368	0	2	0	2
5370	3	0	1	4
5371	6	0	0	6
5372	5	0	1	6
5373	7	0	0	7
5374	6	0	1	7
5375	5	0	1	6
5377	6	0	0	6
5378	4	0	1	5
5379	6	0	1	7
5380	5	0	1	6
5381	5	0	0	5
	78	4	8	90

CAR RECORD December 31, 1919

Train No.	Coaches	Non Pass.	Comb.	Total
5382	4	0	0	4
5383	4	0	1	5
5384	0	2	0	2
5385	3	0	1	4
5387	3	0	0	3
5388	4	0	0	4
5389	3	0	0	3
5390	3	0	0	3
5391	3	0	0	3
5394	4	0	0	4
5395	3	0	0	3
5398	4	0	1	5
5400	4	0	0	4
5402	5	0	0	5
5405	4	0	1	5
5408	5	0	0	5
5409	4	0	0	4
5410	2	0	1	3
	62	2	5	69

CAR RECORD December 31, 1919

Train No.	Coaches	Non Pass.	Comb.	Total
5411	5	0	0	5
5415	6	0	0	6
Extra	7	0	0	7
	18	0	0	18

CAR RECORD January 1, 1920

Train No.	Coaches	Non Pass.	Comb.	Total
5302	3	0	0	3
5303	1	1	1	3
5304	2	0	1	3
5306	1	2	0	3
5311	3	1	0	4
5313	3	0	0	3
5315	2	0	1	3
5316	7	0	0	7
5317	2	1	0	3
5318	7	0	0	7
5321	4	0	0	4
5324	6	0	1	7
5325	5	0	0	5
5327	0	2	0	2
5328	5	0	0	5
5331	5	0	1	6
5332	5	0	1	6
5338	3	0	1	4
	64	7	7	78

CAR RECORD January 1, 1920

Train No.	Coaches	Non Pass.	Comb.	Total
5339	5	0	0	5
5340	6	0	0	6
5341	3	0	1	4
5343	0	2	0	2
5345	3	0	0	3
5346	6	0	0	6
5347	5	0	0	5
5348	0	2	0	2
5350	6	0	0	6
5351	3	0	0	3
5352	4	0	1	5
5355	3	0	1	4
5356	4	0	0	4
5357	5	0	0	5
5358	4	0	0	4
5360	4	0	0	4
5361	4	0	0	4
5363	0	2	0	2
	65	6	3	74

CAR RECORD January 1, 1920

Train No.	Coaches	Non Pass.	Comb.	Total
5364	3	0	0	3
5367	4	0	0	4
5368	0	2	0	2
5370	4	0	0	4
5371	4	0	0	4
5372	3	0	1	4
5374	4	0	0	4
5375	3	0	1	4
5378	3	0	1	4
5380	3	0	1	4
5381	5	0	0	5
5382	4	0	0	4
5384	0	2	0	2
5385	3	0	1	4
5387	5	0	1	6
5388	3	0	0	3
5389	7	0	0	7
5390	5	0	0	5
	63	4	6	73

CAR RECORD January 1, 1920

Train No.	Coaches	Non Pass.	Comb.	Total
5391	3	0	0	3
5392	4	0	0	4
5393	4	0	0	4
5395	3	0	0	3
5398	3	0	1	4
5400	3	0	0	3
5402	4	0	0	4
5405	5	0	0	5
5408	3	0	0	3
5409	5	0	0	5
5410	3	0	0	3
5411	8	0	0	8
5415	10	0	0	10
	58	0	1	59

CAR RECORD January 2, 1920

Train No.	Coaches	Non Pass.	Comb.	Total
5302	3	0	0	3
5303	2	2	0	4
5304	3	0	1	4
5306	6	0	0	6
5311	4	1	0	5
5312	6	0	1	7
5313	4	0	0	4
5314	5	0	0	5
5315	3	0	1	4
5316	7	0	0	7
5317	6	0	0	6
5318	7	0	0	7
5320	7	0	0	7
5321	6	0	0	6
5324	6	2	0	8
5325	5	0	1	6
5327	0	2	0	2
5328	5	0	1	6
	85	7	5	97

CAR RECORD January 2, 1920

Train No.	Coaches	Non Pass.	Comb.	Total
5331	5	0	1	6
5332	5	0	1	6
5338	4	0	1	5
5339	5	0	1	6
5340	5	0	0	5
5341	3	0	0	3
5343	0	2	0	2
5345	3	0	0	3
5346	4	0	0	4
5347	3	0	1	4
5350	3	0	0	3
5351	2	0	1	3
5352	4	0	1	5
5355	5	0	1	6
5356	4	0	0	4
5357	4	0	0	4
5358	4	0	1	5
5360	4	0	0	4
	67	2	9	78

CAR RECORD January 2, 1920

Train No.	Coaches	Non Pass.	Comb.	Total
5361	5	0	0	5
5363	0	2	0	2
5364	3	0	0	3
5365	4	0	0	4
5367	5	0	0	5
5368	0	2	0	2
5370	4	0	0	4
5371	5	0	0	5
5372	5	0	1	6
5373	7	0	0	7
5374	7	0	0	7
5375	5	0	1	6
5377	6	0	0	6
5378	6	0	1	7
5379	6	0	0	6
5380	5	0	1	6
5381	5	0	0	5
5382	4	0	0	4
	82	4	4	90

CAR RECORD January 2, 1920

Train No.	Coaches	Non Pass.	Comb.	Total
5383	4	0	1	5
5384	0	2	0	2
5385	4	0	1	5
5387	3	0	0	3
5388	4	0	0	4
5389	3	0	0	3
5390	4	0	0	4
5391	3	0	0	3
5392	4	0	0	4
5393	3	0	0	3
5395	3	0	0	3
5398	4	0	1	5
5400	3	0	0	3
5402	4	0	0	4
5405	4	0	1	5
5408	5	0	0	5
5409	4	0	0	4
5410	2	0	1	3
	61	2	5	68

CAR RECORD January 2, 1920

Train No.	Coaches	Non Pass.	Comb.	Total
5411	5	0	0	5
5415	3	0	0	3
Extra PA to 52 -	0	1	0	1
	0	1	0	1
	0	1	0	1
	0	1	0	1
PA to OB -	0	1	0	1
	0	1	0	1
	0	1	0	1
	16	6	0	22

POWER DATA

Explanation: On page "D-2" are given the actual meter readings of each meter for each day. The significance of numbers and letters as meter designation is as follows:

S1	West Philadelphia	Sub-Sta. #1
S3	Bryn Mawr	Sub-Sta. #3
S4	Paoli	Sub-Sta. #4
S5	Radnor, Condenser	Sub-Sta. #5

The figures or word following signify location in that sub-station. "200" means section from West Philadelphia to Bryn Mawr.

On the following pages are the calculations of the energy supplied by each sub-station to each section.

POWER DATA METER READINGS

Date	S1 201	S1 204	S1 "PA"	S3 200	S3 Rail
Dec 26	000.47	000.73	13288.3	002.06	11458.75
: 27	000.655	001.05	13327.5	002.91	11494.4
28	000.890	001.395	13365.7	003.700	11529.35
29	000.98	001.52	13382.5	004.17	11547.0
30	001.175	001.815	13421.4	005.11	11584.8
31	001.330	002.050	13455.9	006.22	11625.1
Jan 1	001.545	002.345	13488.7	007.01	11659.35
3	001.85	002.82	13565.8	008.88	11728.65

Date	S5 #1	S5 #2	S4 Rail	S4 Yrd	S4 Sig
Dec 26	04211.4	01737.4	06519.6	000.84	33042.3
27	04213.4	01739.85	06541.25	001.95	33056.9
28	04215.9	01742.6	06561.3	002.956	33071.0
29	04215.9	01746.3	06571.4	003.47	33077.7
30	04218.35	01749.0	06590.4	004.27	33091.9
31	04220.3	01751.85	06608.75	005.02	33105.8
Jan 1	04222.3	01754.8	06627.8	006.01	33123.2
3	04225.8	01760.1	06660.10	007.79	33137.8

POWER DATA ENERGY

December 26

300 Section:

Meter	Multip.	Diff.	Kw-hrs.	Net to Section
S3 Ra	1000	035.65	35,650	
S3 200	16,000	000.850	13,600	
				22,050
S5 #1	1000	02.0	2,000	
S5 #2	1000	02.45	2,450	
				-4,450
S4 Ra	1000	021.65	21,650	
S4 Yrd	16,000	01.105	17,680	
S4 Sig	10	014.6	146	
				4,120
Traction energy used 300 section:				21,720

POWER DATA ENERGY

December 26

200 Section:

Meter	Multip.	Diff.	Kw-hrs.	Net to Section
S1 201	24,000	000.185	4,440	
S1 204	24,000	000.320	7,680	
S3 200	16,000	000.850	13,600	
Traction energy used 200 section:				25,720

West Philadelphia Yards and Broad Street Station:

Meter	Multip.	Diff.	Kw-hrs.	Net to Section
S1 "PA"	1000	039.2	39,200	
S1 201	24,000	000.185	4,440	
S1 204	24,000	000.320	7,680	
Traction energy used this section:				27,080

POWER DATA ENERGY

December 27

300 Section:

Meter	Multip.	Diff.	Kw-hrs.	Net to Section
S3 Ra	1000	034.95	34,950	
S3 200	16,000	0.79	12,640	
				22,310
S5 #1	1000	002.5	2,500	
S5 #2	1000	002.75	2,750	
				-5,250
S4 Ra	1000	020.05	20,050	
S4 Yrd	16,000	001.011	16,176	
S4 Sig	10	014.1	141	
				4,020
Traction energy used 300 section:				21,080

POWER DATA ENERGY

December 27

200 Section:

Meter	Multip.	Diff.	Kw-hrs.	Net to Section
S1 201	24,000	000.235	5,640	
S1 204	24,000	000.345	8,280	
S3 200	16,000	000.79	12,640	
Traction energy used 200 section:				26,560

West Philadelphia Yards and Broad Street Station:

Meter	Multip.	Diff.	Kw-hrs.	Net to Section
S1 "PA"	1000	038.2	38,200	
S1 201	24,000	000.235	5,640	
S1 204	24,000	000.345	8,280	
Traction energy used this section:				23,280

POWER DATA ENERGY

December 28

300 Section

Meter	Multip.	Diff.	Kw-hrs.	Net to Section
S3 Ra	1000	017.65	17,650	
S3 200	16,000	000.470	7,520	
				10,130
S5 #1	1000	000.00	-	
S5 #2	1000	003.7	3,700	
				-3,700
S4 Ra	1000	010.1	10,100	
S4 Yrd	16,000	000.514	8,224	
S4 Sig	10	006.7	67	
				1,940
Total energy used 300 section:				21,080

POWER DATA ENERGY

December 28

200 Section:

Meter	Multip.	Diff.	Kw-hrs.	Net to Section
S1 201	24,000	000.09	2,160	
S1 204	24,000	000.125	3,000	
S3 200	16,000	000.470	7,520	
Traction energy used 200 section:				12,680

West Philadelphia Yards and Broad Street Station:

Meter	Multip.	Diff.	Kw-hrs.	Net to Section
S1 "PA"	1000	016.8	16,800	
S1 201	24,000	000.09	2,160	
S1 204	24,000	000.125	3,000	
Traction energy used this section:				21,960

POWER DATA ENERGY

December 29

300 Section:

Meter	Multip.	Diff.	Kw-hrs.	Net to Section
S3 Ra	1000	037.8	37,800	
S3 200	16,000	000.94	15,040	
				22,760
S5 #1	1000	002.45	2,450	
S5 #2	1000	002.70	2,700	
				-5,150
S4 Ra	1000	019.0	19,000	
S4 Yrd	16,000	000.80	12,800	
S4 Sig	10	014.2	142	
				6,340
Traction energy used 300 section:				22,950

POWER DATA ENERGY

December 29

200 Section:

Meter	Multip.	Diff.	Kw-hrs.	Net to Section
S1 201	24,000	000.195	4,680	
S1 204	24,000	000.295	6,080	
S3 200	16,000	000.940	15,040	
Traction energy used 200 section:				25,800

West Philadelphia Yards and Broad Street Station:

Meter	Multip.	Diff.	Kw-hrs.	Net to Section
S1 "PA"	1000	038.9	38,900	
S1 201	24,000	000.195	4,680	
S1 204	24,000	000.295	6,080	
Traction energy used this section:				27,140

POWER DATA ENERGY

December 31

300 Section:

Meter	Multip.	Diff.	Kw-hrs.	Net to Section
S3 Ra	1000	034.25	34,250	
S3 200	16, 000	000.79	12,640	
				21,610
S5 #1	1000	002.0	2,000	
S5 #2	1000	002.95	2,950	
				-4,950
S4 Ra	1000	019.05	19,050	
S4 Yrd	16,000	000.99	15,840	
S4 Sig	10	017.4	174	
				3,480
Traction energy used 300 section:				20, 140

POWER DATA ENERGY

December 31

200 Section:

Meter	Multip.	Diff.	Kw-hrs.	Net to Section
S1 201	24,000	000.215	5,160	
S1 204	24,000	000.295	7,080	
S3 200	16,000	000.79	12,640	
Traction energy to 200 section:				24,880

West Philadelphia Yards and Broad Street Station:

Meter	Multip.	Diff.	Kw-hrs.	Net to Section
S1 "PA"	1000	032.8	32,800	
S1 201	24,000	000.215	5,160	
S1 204	24,000	000.295	7,080	
Traction energy used this section:				20,560

POWER DATA ENERGY

January 2

300 Section:

Meter	Multip.	Diff.	Kw-hrs.	Net to Section
S3 Ra	1000	069.30	69,300	
S3 200	16,000	001.87	29,920	
				39,380
S5 #1	1000	003.5	3,500	
S5 #2	1000	005.3	5,300	
				-8,800
S4 Ra	1000	032.3	32,300	
S4 Yrd	16,000	001.78	28,480	
S4 Sig	10	014.6	146	
				3,970
Traction energy used 300 section				34,550

POWER DATA ENERGY

January 1 - 2

200 Section:

Meter	Multip.	Diff.	Kw-hrs.	Net to Section
S1 201	24,000	000.305	7,320	
S1 204	24,000	000.475	11,400	
S3 200	16,000	001.87	29,920	
Traction energy used 200 section:				48,640

West Philadelphia Yards and Broad Street Station:

Meter	Multip.	Diff.	Kw-hrs.	Net to Section
S1 "PA"	1000	077.1	77,000	
S1 201	24,000	000.305	7,320	
S1 204	24,000	000.475	11,400	
Traction energy used this section:				58,280

GENERAL

Explanation:

Page "E-2" contains a tabulated summary of data acquired.

On page "E-3" is figured the charge per year for the changes necessary and the saving resulting from cutting off 50 cars per day at Bryn Mawr (as suggested by the Committee of the General Manager).

On page "E-4" the saving is calculated for our recommended cutting of cars (68).

TABULATED DATA

Date		26	27	28	29	31	1-2
K.W.H.	200 Sect.	25720	26560	12680	25800	24880	48640
	300 Sect.	21720	21080	8370	22950	20140	34550
	Paoli Yds.	17534	16035	8157	12658	15666	28320
	Broad St.	27080	23280	21960	27140	20560	58280
Car Trips		354	364	158	351	348	639
Car Miles	300	3490	3590	1560	3460	3430	6300
Car Miles	200	3120	3210	1392	3090	3060	5630
Kwhr/Car Mile	300	6.22	5.88	5.36	6.62	5.87	5.48
	200	8.24	8.26	9.09	8.34	8.15	8.64

	300	200
Average Kwhr/car mile by averaging daily values	5.91	8.45
by using totals	5.89	8.42

Ratio Passenger Miles 200 sect. / 300 sect. 2.92

COST AND EARNING POWER

Cost:

Necessary Facilities for Bryn Mawr Yard $ 94,000
Assuming depreciation at 5%
Assuming interest at 6%
Total yearly charge 11%, or $ 10,300

Saving:

Assuming cutting off 50 cars a day at Bryn Mawr
Week-day saving 986 car miles per day
6 week-days 5916 car miles
1 Sunday 493 car miles
Total saved per week 6409 car miles
Total saved per year 333,000 car miles

Operating car cost per car mile power $ 0.0295
maintenance 0.0473
Total operating cost per car mile $ 0.0768

Gross saved per year $ 25,600
Net saved per year $ 15,300

Maximum number of cars that could be cut off at Bryn Mawr is 68.

Giving total yearly saving of 453,000 car miles.

Using same cost data as above:

Gross saving per year	$ 34,800
Net saving per year	$ 24,500