

DISCUSSION OF "INTERURBAN CAR TESTS," COMMUNICATED BY  
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CAR TESTS ON NORTHERN TEXAS TRACTION COMPANY.

Numerous tests were made by Mr. Bret Harter of the interurban cars which were of three types, namely: (1) Standard interurban passenger car, (2) Larger and special parlor car, and (3) package freight car, with and without trailer; and comparisons are given of the results obtained under different conditions of operation.

A description of the various cars and their equipment is as follows:

CAR.	No. 1 & No. 7.	SAGAMORE.	No. 12.	No. 9
Type.....	Standard closed Interurban Passenger.	Interurban Parlor Car.	Standard Interurban Express.	15-Bench Open Interurban Trailer.
Make.....	Kuhlman.	Kuhlman.	Kuhlman.	Kuhlman.
Length over all....	44' 5"	59' 6"	40' 0"	45' 8"
Width.....	8' 4"	8' 5"	8' 4"	8' 0"
Total Weight in Tons, Car and Equipment.....	25.4	31.0	20	17.4
Number Motors.....	4	4		
Make.....	Westinghouse.	Westinghouse.	Westinghouse.	....
Mfg. No.....	56	76	56	
Gear Ratio.....	32-50	24-58	24-58	
Controllers.....	K 14	L 4	K 14	
No. of Trucks.....	2	2	2	2
Make.....	McGuire.	Brill.	McGuire.	McGuire
Mfg. No.....	35	27	35	40
Dia. of Wheels.....	33"	33"	33"	30"
Wheel Base.....	6'	6'	6'	4' 3"
Make Brake.....	Christensen.	Christensen.	Christensen.	Christensen.
Type.....	Direct Acting Storage Air.	Independent Direct Acting Air.	Independent Quick Acting Automatic Air.	Quick Acting Automatic Air

The dates of the test and weather conditions, etc., were as follows:

Date, 1902....	9/16	9/17	9/17	8/19	9/22	9/24	11/14
Car.....	1	1	1	Sagamore.	12	12 and 9	7
Trip.....	1	1	1	1	1 and 2	1	1 and 2
Direction.....	E & W	E & W	E & W	E & W	E & W	E & W	E & W
Weather.....	Clear.	Cloudy (Rain Dallas end.)	Clear.	Clear.	Rain.	Clear.	Clear.
Temperature..	90°	85°	85°	Warm.		Cool.	Cool.
Rail.....	Dry and clean.	Dry and clean except Dallas.	Dry and clean. Dallas end wet clean.	Dry and clean.	Wet and clean. Cities slippery.	Dry and clean.	Dry and clean.

In Ft. Worth, the interurban cars make a run of approximately 1.8 miles where high speed cannot be made; the terminus being at the court house.

In Dallas there is a distance of 4.1 miles of city track where slow speeds are required, and this is down grade, averaging possibly 1 per cent. Dallas is approximately 200 ft., lower than Ft. Worth.

#### DETAILED LOG OF RUN.

The following is an example of a portion of a log and is presented merely to indicate the general character of the observations made.

Time.	Place.	Track.	Position Con- troller.	Miles per hr.	Amp.	Volts.	Watt hr. Readings	Remarks.
12 32	26.5	S.S. 1	0		0	600	4299600	Coast to
37	24	0%	S		60	575		24
	23.5		S	35	50	575		
38.5	23	0.14% +	S	25	70	570		
	22.3	1.3 % +	S	25	80	525		
41	22	0.17% +	S	28	60	535		
		0.15% +	S	23	50	500		
42.75	21	0.7 % +	S		50	485		
		0.7 % +	S		75	600		
	20.5	0.07% +	0		0	625		Coast to
44.5	G.P.	0.07% +	0	0	0	610	4305000	20.1
45	G.P.	0.07% +	S		80	530		Stop
46	20	0.4 % +	S		80	530		
	19.9	1.0 % -	P					
	19.3	1.6 % +	P	40	175	450		
48	19	0.6 % -	0	0	0	630		Met a
49	19		P		250			regular.
50.5	18.5	0.2 % +	P	35	190	440		

See Tables I, II, III, IV.

Comparing Tables No. 1 and No. 2 it will be noted that the k.w. hours per car mile is greater for the entire run than for the high-speed portion only, and this is due to the greater number of stops in the towns and running on resistance. The average k.w. is less for the entire run than for the high-speed portion and this is due to the slower speed in towns, running on series.

The following illustrates this point:

#### T. & P. CROSSING TO OAK CLIFF, INTERURBAN RUN.

Car .....	No. 1*.	Sagamore.	No. 12.	12 & 9	No. 7	No. 7.
Rate of run in m.p.h. . .	29.3	29.3	27.3	22.3	23.5	27.5
K.W. hrs. per mile . . .	2.03	2.07	1.76	2.73	1.91	1.66
Watt-hrs. per ton mile..	75.0	62.7	81.7	64.5	78.5	64.8
Average K.W. ....	59.4	61.	47.8	61.0	45.0	45.8

#### FT. WORTH TO DALLAS, ENTIRE RUN.

Car .....	No. 1†.	Sagamore	No. 12.	No. 12†	12 & 9	No. 7.	No. 7.
K.W. Hrs. per mile . . .	2.16	2.15	1.88	1.81	2.81	1.94	1.76
Watt Hrs. per ton mile.	79.7	65.2	87.2	82.2	66.2	75.7	68.7
Average K.W. ....	48.1	52.7	37.7	42.1	56.4	35.6	36.5

\* No. 1. Average of run of 9/17 Tables 1 and 2.

† 12 - 12 & 9, Average of run. Ft. Worth to Siding 29

## COMPARISON OF RESULTS OF TESTS OF CAR No. 1.

Test of September 16th was with motors in parallel as much as possible, including hill climbing. Obtained high speed but more energy per car mile as compared with subsequent tests made September 17th, when the controller was handled more efficiently, and the car allowed to coast, though the speed was not quite as high.

## CAR No. 7.

Practically the same as No. 1.

The object of the two trips was to note a comparison of the effect of stops. The first trip having a considerable number and the second comparatively few, the result in k.w. per car mile is materially in favor of the second, especially on the west bound trips, where the time of the run is almost the same, but the stops almost three times as many. See Table I.

Also note Table II., which shows the effect of stops on the high speed run, where the result is very marked. Also note Tables III. and IV. Comparing No. 1 and No. 7 and the first test of September 17 of No. 1 and of November 14th of No. 7, there being about the same number of stops, shows that car No. 1 took more k.w. per car mile but the schedule speed was higher, whether the difference is entirely on this account we are not prepared to state, as there were many other circumstances which might affect the results, such as condition of the track, motorman, etc.

## PRIVATE CAR "SAGAMORE."

It will be noted that the "Sagamore" makes practically the same schedule speed as the regular passenger cars, but it could not do this and make as many stops as the passenger cars are capable of making, for the reason that it is not geared for the same high running speed. Gearing for slower speed tends to efficiency of operation, but whether the materially better results obtained for the "Sagamore" in watt-hours per ton mile was entirely due to the gearing, is at least questionable. It will be noted that the k.w. hours per mile was about the same as for Car No. 1 for tests made on the 17th (and comparisons should not be made with tests made on the 16th because of special conditions of such tests). It should be noted, however, that car No. 7 gave better results in this respect than No. 1, and lower actual figures than the "Sagamore," but the watt-hours per ton mile were lower for the "Sagamore" than for No. 1, or even for No. 7, on test of same with the fewest number of stops.

## CAR No. 12.

Car No. 12 is a slightly lighter car than No. 1, and has the same motors as No. 1, and the same gearing as the "Sagamore." The k.w. hours per mile for the total run shown on Table I. was high, and with reference to Table IV., it will be noted that this was especially due to the run in Oak Cliff and Dallas. This car not only has frequent stops, but, owing to the character of the business, namely, taking up and discharging freight, it shifted back and forth at the sidings, etc., so that the results should not be compared on the same basis as obtained by other cars.

TABLE I.

This gives the data obtained from the entire run of interurban cars, including runs in Ft Worth and Dallas.

Place .....	Ft. Worth to Dallas.					To Siding.					No. 29 to Dallas				
	9/16	9/16	9/17	9/17	9/17	9/17	9/17	9/17	9/17	9/22	9/24	9/24	9/24	9/24	9/24
Date, 1902.....	1	1	1	1	1	1	1	1	1	12	12	12	12	11	11
Car.....	E	W	E	W	E	W	E	W	E	W	E	W	E	W	E
Direction .....	22	25	20	11	25	35	25	30	30	12	12	12	12	7	7
Passengers .....	1.6	1.9	1.5	0.8	1.9	2.6	1.9	2.2	0.5	2.5	5.0	5.2	5.0	0.3	0.3
Wt. of Pass. or Freight ..	25.4	25.4	25.4	25.4	25.4	25.4	31.0	31.0	20.0	20.0	37.4	37.4	37.4	25.4	25.4
Wt. of Car.....	27.0	27.3	26.9	26.2	27.3	28.0	32.9	33.2	20.5	22.5	42.4	42.6	42.6	25.7	25.7
Total wt. ....	34.3	34.3	34.3	34.3	34.3	34.3	34.3	34.3	34.5	35.1	34.4	34.6	30.5	34.5	34.35
Miles.....	82.0	95.5	89.0	96.0	90.0	96.0	88.5	97.5	99.5	109.5	102.5	121.0	74.7	113.5	113.5
Time.....	25.1	21.6	23.1	21.4	22.8	21.4	23.2	21.2	20.8	19.2	20.1	17.1	24.4	18.2	18.1
Miles per hr. ....	84.6	86.4	70.2	73.2	75.6	77.4	72.0	75.6	58.2	72.6	88.8	98.4	52.4	64.2	69.6
K.W. hrs. ....	2.46	2.52	2.04	2.13	2.2	2.26	2.1	2.2	1.69	2.07	2.58	2.84	1.72	1.93	2.03
K.W. hrs. per mile.....	91.0	92.5	76.0	81.5	80.5	80.6	64.0	66.5	82.5	92.0	61.0	66.5	80.0	72.5	78.9
Watt. hrs. per ton mile.	61.8	54.3	47.3	45.8	50.4	48.4	58.8	46.6	35.5	39.9	52.0	48.8	42.0	33.9	36.7
Average K.W.....															
Stops .....	25	27					24	24	19	14	15*	13*	9	8	15

\*No. 9 Trailer dropped and picked up at Siding 29, Oak Cliff, City Limits.



TABLE III.

This gives the results obtained in Ft. Worth.

Place .....	Ft. Worth Terminal to T. & P. Crossing.																	
	9/16	9/16	9/17	9/17	9/17	9/17	9/17	9/17	9/19	9/19	9/22	9/22	9/24	9/24	11/14	11/14	11/14	
Date .....																		
Car .....	1	1	1	1	1	1	1	1	Sagamore	Sagamore	12	12	12 and 9	9	7	7	7	
Direction .....	E	W	E	W	E	W	E	W	E	W	E	W	E	W	E	W	E	
Passengers .....	22	25	20	11	25	35	35	35	25	30								
Wt. Pass. or Freight.....	1.6	1.9	1.5	0.8	1.9	2.6	2.6	2.6	1.9	2.2	0.5	2.5	5.0	5.2	0.3	0.3	0.3	
Wt of car .....	25.4	25.4	25.4	25.4	25.4	25.4	25.4	25.4	31.0	31.0	20.0	20.0	37.4	37.4	25.4	25.4	25.4	
Total wt. in tons .....	27.0	27.3	26.9	26.2	27.3	28.0	28.0	28.0	32.9	33.2	20.5	22.5	42.4	42.6	25.7	25.7	25.7	
Miles.....	1.8	1.8	1.8	1.8	1.8	1.8	1.8	1.8	1.8	1.8	1.8	1.8	1.8	1.8	1.8	1.8	1.8	
Time.....	13.3	11.5	13.0	14.5	15.0	14.25	14.25	14.25	16.5	13.5	12.5	18.5	15.75	12.0	12.75	17.0	14.25	
Miles per hr.....	8.1	9.4	8.3	7.45	7.2	7.6	7.6	7.6	6.57	8.0	8.64	5.8	6.9	9.0	8.47	6.35	7.58	
K W. hrs. ....	7.2		6.6	9.0	7.2	9.6	9.6	9.6	6.8	9.0	3.6	6.6	6.0	9.0	3.9	6.3	4.8	
K.W. hrs. per mile. ....	4.0		3.66	5.0	4.0	5.34	5.34	5.34	3.78	5.0	2.0	3.66	3.33	5.0	2.16	3.5	2.66	
Watt hrs per ton mile. . .	148.0		136.0	191.0	146.0	190.0	190.0	190.0	115.0	150.0	97.5	162.0	78.5	117.0	84.3	130.0	104.0	
Av. K. W. ....	32.4		30.4	37.2	28.8	40.4	40.4	40.4	24.7	40.0	17.3	21.4	22.8	45.0	18.3	22.2	20.2	
Stops .....			10	14					10	10	6	4	3	3	4	3	5	
																	1	

TABLE IV.

This gives the results obtained in Oak Cliff and Dallas.

Place .....	Oak Cliff City Limits to Dallas Terminal.													
	9/16	9/16	9/17	9/17	9/17	9/17	9/17	9/19	9/19	9/22	9/22	9/24	9/24	9/14
Date .....	1	1	1	1	1	1	1	Sagamore	E	12	12	12 and 9	7	7
Car. ....	E	W	E	W	E	W	E	E	W	W	E	W	E	W
Direction .....	22	25	20	11	25	35	25	30						
Passengers .....	1.6	1.9	1.5	0.8	1.9	2.6	1.9	2.2		2.5	5.0	5.2	0.3	0.3
Wt. of Pass. or Freight ..	25.4	25.4	25.4	25.4	25.4	25.4	31.0	31.0		20.0	37.4	37.4	25.4	25.4
Wt. of car .....	27.0	27.3	26.9	26.2	27.3	28.0	32.9	33.2		20.5	42.4	42.6	25.7	25.7
Total wt. in tons .....	4.1	4.1	4.1	4.1	4.1	4.1	4.1	4.1		4.1	4.0	4.3	4.1	4.1
Miles .....	15.5	25.5	16.5	24.0	16.5	24.5	15.5	24.0		14.75	27.5	14.0	23.5	31.0
Time .....	15.9	9.65	14.9	10.2	14.9	10.0	15.9	10.2		16.7	10.5	17.1	13.6	7.94
Miles per hr. ....	5.4	10.8	6.0	10.2	6.6	10.8	4.2	9.6		5.4	15.0	6.4	4.5	9.3
K. W. hrs. ....	1.31	2.64	1.46	2.49	1.49	2.64	1.02	2.34		1.32	3.13	1.6	2.23	1.46
K. W. hrs. per mile. ....	48.5	97.0	54.5	95.0	44.5	94.5	31.0	71.0		64.0	139.0	37.8	52.7	88.3
Watt hrs. per ton mile. ....	20.9	25.4	21.8	25.5	22.2	26.4	16.2	24.0		22.0	32.8	27.4	15.0	18.0
Av. K. W. ....			6	5			5	5		6	5	7	4	6
Stops .....														4

NOTE.—It should be noted that the results in Table No. 4 are included in those given in Table No. 1, and also that, at the time of the tests, the Oak Cliff Line was in poor condition as to track, bonding and overhead work. This was an old line, which has since been rebuilt.

The effect of adding a trailer on the k.w. hours per mile and the watt hours per ton mile is very marked, both on the entire run as given by Table I. and for the portions of the run as given by Tables II., III. and IV. the reduction in watt-hours per ton-mile being very considerable.

In connection with the above it should be noted that the average k.w. for the entire run (see Table I.) for the regular passenger cars is less than 50 k.w. (omit test of September 16th, which was intentionally made under uneconomical conditions). Therefore, if the average efficiency of the motors was 75 per cent., the average output of the motors was slightly less than one-quarter of their rating and it should also be noted that this does not include time for lay-over, which gives opportunity for cooling. Each motor is rated at 55 h.p.

[COMMUNICATED AFTER ADJOURNMENT BY MR. A. H. ARMSTRONG]

In commenting upon the very admirable paper brought out by Messrs. Goldsborough and Fansler, one point strikes me as rather inconsistent, and that is the elaborate methods taken to secure and make use of the square root of the mean square current per motor. As the chief object of the tests seemed to be to obtain this value, it is interesting to note what use is made of it. To this end Mr. Goldsborough has constructed a new term which he calls the "running-factor," this being the ratio of the square root of the mean square current per motor to the kilowatt hours per car mile. The term has no rational reason for existence, as obviously this "running-factor" or ratio will vary widely, depending upon the kind of service and will in no way serve as an indication of whether the proper motors are used, whether the gearing is correct, etc. It is obvious that the kilowatt hour per car mile depends largely upon the gear ratio used, and the rate of acceleration chosen for a given schedule and frequency of stops. With the series-parallel controller, a service calling for much series running will considerably affect the kilowatt hours per car mile without in any way affecting the square root of the mean square current. For long runs there may be some similarity in the values obtained for this "running factor," but the results cannot be used in any comparative sense, have no direct bearing upon the fitness of the equipment for the work, and not in any way indicate the heating of the motors. The term seems to me to complicate an otherwise rather simple problem without in any way furnishing additional accuracy. The use of the "running-factor" term ignores the possible efficiency of acceleration of the motors. This efficiency of acceleration is the ratio of work done by the motors to the energy input of the car or train, and will vary from 40 per cent. to as high as 75 per cent. or 80 per cent. on the longer runs. The square root of the mean square current is not at all affected by the efficiency of acceleration of the motors, and hence any conclusions drawn from the ratio of square root of the mean square current to the kilowatts per car mile input



must necessarily show considerable variation, due to the variable efficiency of acceleration of different lengths of runs.

Mr. Goldsborough noted a considerable variation in energy consumption on the shorter runs. I believe this was largely due to the fact that the method of taking ampere time curves was not well adapted to very short runs when the accelerating current forms the greater part of the total ampere input. Some time ago at Schenectady we were met with this same difficulty and some of our engineers advised a recording voltmeter and ammeter which gave the current reading at every instant, thus eliminating the personal element of the observer and giving much more accurate results than can be obtained with either two second or five second readings.