$$\log. b \left(\frac{a}{b} + 1 \right) = \log. a + \log. \left(\frac{a}{b} + 1 \right) - \log. \frac{a}{b},$$

and

$$\log. b \left(\frac{a}{b} - 1 \right) = \log. a - \left(\log. \frac{a}{b} - \log. \left(\frac{a}{b} - 1 \right) \right)$$

In all cases, $a > b$.

The application of these or other formulas to the solution of the stated problem, by means of the common logarithmic tables, is believed to be now for the first time presented.

LOWELL, MASS., June 1, 1895.

ELECTRICAL SECTION.

Stated Meeting of May 28, 1895.

MR. CARL HERING, President, in the Chair.

TEST OF AN ELECTRIC RAILWAY.

BY A. LANGSTAFF JOHNSTON.

After the interesting and instructive paper we have had on the construction of the ammeter and voltmeter, I have thought it highly appropriate that a few remarks on the practical use of these instruments in electric railway work would be in place.

In the early days of electric railways the data for determining the average amount of current to allow per car could not be had, simply because a road had not been in operation long enough for engineers to make observations on this point.

In 1890 I constructed a line which, for alignment, grades and local conditions, can be classed as a "difficult route," curves 30 feet radius on grades and in narrow streets, grades $7\frac{4}{10}$ per cent., and running over other roads. As the road was operated by one Edison 80 kilowatts generator, driven by one 100 horse-power Ball engine, the equipment consisted of five cars mounted with two 15 horse-power Sprague motors each; all these conditions made it highly favorable

give the general data of one of the tests, and one when the test car was going over the road from the south to the north. The profile shows the location of the other four cars at the very instant the test car was on the centre of the maximum grade ($7\frac{4}{10}$ per cent.), and the table, the data taken on the car and in the power-house during the test.

A study of the table brings out some very interesting points—(1) The maximum amount of current (100 ampères) was at 6.05 P.M., when the test car was on a level and 6,500 feet from the power-house, and using the minimum amount of current (10 ampères). This was caused by the position of the other four cars, the time cards of the observers showing them either on the heavy grades or on the curves. (2) At 5.53 P.M., the test car used the maximum amount of current, and was also on a level and only 300 feet from the power-house; as should be expected, there was no drop in the voltage. It is also seen that the test car, in passing around the curves at Seventh and Perry Streets, Ninth and Arch Streets and Seventh and Arch Streets, took the same amount of current, but with a very large drop in the voltage (80 volts) at Seventh and Arch Streets. At first it was hard to explain this, but by a study of local conditions at this point, I discovered that the motorman had to shut off the current, and did not turn it on until he was in the centre of the curve, when he had to open it up to the seventh notch of the controller to force the car around this 40 feet radius curve, which readily accounts for the large drop that is shown. The same explanation applies to the curve at the Semmes Avenue Bridge; there the car had to cross a narrow bridge at a low speed, on a curve of 35 feet radius. (3) On the maximum grade of $7\frac{4}{10}$ per cent., which was 9,800 feet from the power-house, it took 40 ampères and 440 volts (which was forty volts drop on the line), or $23\frac{1}{2}$ electrical horse-power, to take the test car up the grade at the rate of four miles an hour. The profile shows the test car on this grade, and the location and the direction of travel of the other four cars at this very instant.

These tests show very conclusively the electrical economy that can be gained by a continuous-running motor, which

RECORD OF A TEST MADE OVER THE LINE OF THE RICHMOND AND SOUTHSIDE ELECTRIC RAILWAY, BY A. LANGSTAFF

JOHNSTON, C. E., CHIEF ENGINEER, NOVEMBER 1, 1896.

Instruments placed on Car No. 5, and Car run over the East Track from the South End at Thirty-fourth Street and Semmes Avenue, Woodland Heights, to Seventh and Baker Streets, Richmond.

NORTH TRIP.

P. M.	Time taken on Test Car.	LOCATION OF CAR ON LINE.	Weight of Car and Passengers, Pounds estimated.	Rate of Grade per cent.	Length of Grade.	Distance of Test Car from Power House (Feet).	Kind of Rail passed over.	Read- ing of Meters on Car.		Horse-power delivered at Power House.	Horse-power developed by Motors in Moving Car.	Drop in Voltage on Line.	Radius of inside Rail of Curve.	REMARKS.
								Ampères.	Volts.					
5:45		Thirty-fourth and Semmes Ave.	8,000	+ 1.5	310	5,500	T.	20	460	60	480	12.3	—	Grades opposed to car going north, marked thus +
5:50		Semmes Ave. bet. Power house and 22d St.	8,000	+ 2.3	1,600	1,000	T.	20	480	80	480	20	35'	Grades opposed to car going south, marked thus =
5:53		Curve at Semmes Ave. bridge	8,000	—	—	300	T.	45	480	—	480	26.9	—	Grades are given in feet per 100 (per cent. %).
5:54		Curve at Cowardin and Perry	8,000	—	—	1,100	T.	30	460	80	480	18.5	—	Each car equipped with two 15 h. p. motors (Sprague).
5:55		Fifteenth and Perry, Pass No. 2	8,200	—	—	1,500	T.	40	460	80	480	24.6	—	Maximum grade.
6.		Curve at Perry and Seventh	8,200	—	—	4,000	T.	40	460	20	480	20	39'	
6:01		On Seventh bet. Perry and McDonough	8,200	+ 3	360	4,200	Tram.	30	480	12.9	19.3	60	—	
6:03		South end free bridge, Pass No. 3	8,200	—	—	5,600	Tram.	10	445	—	5.9	35	—	
6:05		On free bridge	—	0 0	—	6,500	Tram.	40	460	64.3	24.6	20	—	
6:06		Curve at Ninth and Arch	—	—	—	7,700	Tram.	40	460	—	5.9	35	—	
—		Curve at Seventh and Arch	—	—	—	8,500	Tram.	40	460	—	21.4	20	40'	
—		Seventh between Arch and Byrd	—	+ 5.2	300	8,700	Small grove.	40	460	—	11.7	40	—	
6:10		Seventh between Main and Cary	—	+ 7.4	300	9,800	Small grove.	40	460	96	480	23.5	—	
—		Seventh between Franklin and Main	—	+ 2 0	300	10,400	Small grove.	15	444	57.9	8.9	36	—	
—		Seventh between Franklin and Grace	8,000	+ 6 9	300	10,800	Tram R. I. P.	20	460	—	—	35	—	

a great many attempts have been made to put in practical operation, but so far without success, and is a line on which inventors can work and experiment in the hope of a large reward, if successful; for it is evident, with a continuous revolving armature there would be only a small drop in the counter E. M. F., whereas, now, every time the motor is started it has to build up, and particularly in cities where the regulations require the cars to come to a full stop at each street crossing, the distances between stops are so short that the armature is revolving at a velocity to be of very little effect for only a few seconds, and really amounts to nothing.

From the profile and table the members of the Section can readily see many other interesting points, but the most important one shown by this test is the necessity of the electrical engineer to study the local conditions in proportioning the feed system of an electric railway, making use of the data given him of former work by his volt- and ampère-meters.

CHEMICAL SECTION.

Stated Meeting of May 21, 1895.

DR. W. C. DAY, President, in the Chair.

[The President announced the paper for the evening, and introduced the speaker.]

THE CITRATE METHOD OF PHOSPHORIC ACID DETERMINATION, WITH SPECIAL REFERENCE TO INSOLUBLE PHOSPHATES.

BY F. BERGAMI.

The molybdate method of phosphoric acid determination has always been regarded as a very safe and accurate method, and its general applicability surely imparts to it an inestimable value as a gravimetric method.

Although some doubts have lately arisen as to its absolute infallibility, for some not yet fully explained reasons,