lines, on which the controlling grades, except in a few instances, are about 1%, & as we desired to avoid complicating the new method at the outset, by having more than one chart, we have as yet only put in use a chart compiled on this 30% basis. I am well aware that the percentage of additional power required to move the same tonnage in empty as in loaded cars, loaded 2 to 1, decreases as the grade increases. The rolling friction does not increase, while the resistance due to gravity does, &, therefore, the percentage of additional power required is not constant. We have in mind, & I may say in hand, several charts for use on the different sections according to the ruling grades thereon. I think that when we put these in use, we will have overcome the only difficulties that we have encountered in connection with this system. We have found that 30% is too much on grades heavier than 1%, & not enough on easier grades.

Mr. Daly has raised a point as to speed of freight trains on grades. The 7 miles per hour is the speed over summits, & I freely admit that where trains are thick more tonnage can be moved with lighter loads & faster speed than by loading engines to the limit, with resulting long occupation of track, especially on grades. Such conditions are local, & have to be dealt with as you find them. This point, moreover, does not affect the two propositions I have advanced.

As to testing engines, we determined the relative haulage capacity of the different classes of engines, as far as we could, on one grade, using a dynamometer car, not by one, but by a great many tests of each class—not with engines that were all in good condition, with good firemen & good coal, but with engines & men as they came along, & then we took what we thought was a fair average. Having determined the relative haulage capacity of the different classes of locomotives on this one grade we then, by testing one or more classes of engines on the other portion of the line—also with the dynamometer car—were able to fix the haulage capacity of all classes of engines over all parts of the line.

Mr. Chairman, with your kind permission, I will resume my seat, & later on, if I have the privilege, I will say something in explanation of the second portion of the paper respecting the supervision of the loading of engines.

F. POTTER—I would like to ask in what office the comparative figures are kept & what increase of office force is necessary; also what is the increased train load above the old method brought about by the new method?

The CHAIRMAN—Prof. Hibbard, can you favor us with any remarks on this question?

PROF. H. W. HIBBARD—I would like simply to call attention to a paper read before the Northwest Railway Club in Dec., 1895, by H. H. Vaughan, on the hauling capacity of locomotives, the paper being discussed at the Feb. meeting, 1896; I have just been reading over that paper & discussion. Possibly some of the members may have the numbers in their files & would be glad to refer to them.

I notice in the discussion some remarks of J. N. Barr, that I thought were in point. He said: In the midst of all this discussion, about how we could increase our trains hauled & how the motive power department had increased the number & hard-working of its locomotives, all the brunt of increased train loads & cheapening of freight transportation seemed to have fallen upon the motive power department; but if the civil engineering department would do a little something to help out, that little something that they might do would be a very important assistance. He said further: "You talk about hauling your trains up these grades. Why not take out some of those grades? Why not fix up some of those curves, & so on?" It seems to me we need more of co-operation between the civil department & the mechanical department & the department that loads 60,000 lbs. capacity cars with only 20,000 or 30,000 lbs. If all the departments would co-operate we would accomplish more than by simply ourselves bearing all the brunt.

G. L. FOWLER—I was speaking the other day with the general manager of a road that probably hauls the largest average net tonnage of any road in the world, & he said that in his original report to his board of directors, when the matter of reducing grades & easing off curves came up, it would be cheaper to put & maintain pushing engines on those grades to help up the hills than it would be to pay the interest on the increased investment required to ease the grades & the curves. And at the risk of repeating perhaps something that you are all familiar with, I will state in regard to this same road, which is the Bessemer Line, from North Bessemer to Conneaut, I had the pleasure recently of going over it very carefully, & noting their tonnage rating & method of operation. They have moguls & consolidation engines hauling their trains, & they have a system of tonnage rating there by which they take a car in units, as they call it. A unit, on their schedule, is 13,000 lbs., which is the weight of the lightest flat car which they have on the line. Of course their traffic is almost entirely conducted in steel cars of 100,000 lbs. capacity. They have a rating for their consolidation & mogul locomotives of 430 & 400 units each. That is, about 40 cars of about 100,000 lbs. capacity. But in their line from Albion to North Bessemer they have six hills, according to my recollection, & on each one of these they put pushing engines. On one of them they put two. Their schedule time for a freight train over the division, which is about 150 miles, is about 12 hours, & they maintain that speed clear through. The work that they do with pushing engines covers 27% of the total mileage of the road, & even on their climb up from Conneaut Harbor, where they have those largest engines in the world, with 24 by 32 in. cylinders, they put 40 cars on behind them & then give the engine a 10-wheel pusher to help up the first hill. But that train goes through practically without any break from Conneaut Harbor to North Bessemer, & their estimate is that they use only about half as many engines to carry the traffic through, using the pushers on the hills, that they would if they left each engine to a tonnage basis which they could carry over the controlling grades & let them go through with the trains without any assistance whatever. That this is a sensible method of operation is evidenced from the fact that, according to their own statement, they have the largest average net paying tonnage of any railway which reports to the Interstate Commerce Commission, & that practically means of any in the world. Their average net paying tonnage is between 900 & 1,000 tons. One month, I remember, it was 949 tons. That includes everything that goes over their lines behind a freight engine. If an engine goes over the road with a caboose car behind it, that is a train with no net tonnage, &, of course, that cuts down the average rate. Their expense of operation is phenomenally low, so low that most railway managers look at them with a good deal of envy. Possibly some of you may be as familiar with this line as I am.

J. S. EATON—May I ask Mr. Fowler a question? He speaks of their having the largest net tonnage. Does he mean per train? If so, does his second engine count for a second train? Does he include the return mileage light of road engines & helpers in computing his train mileage?

G. L. FOWLER—I do not think it includes the return mileage of the helper, but it includes light trains. As I said, if the engine goes over the road with nothing behind it but a caboose, that is a train with no net tonnage, so that if it is averaged up with a train that has 2,000 tons net behind the engine, the average net tonnage would be 1,000, & that

TABLE 5.—CANADIAN PACIFIC RAILWAY,

DAILY REPORT OF HAULAGE CAPACITY OF LOCOMOTIVES AND TONNAGE OF FREIGHT TRAINS OVER RULING GRADES ON HAVELOCK SECTION, NOVEMBER 1ST, 1900. DIRECTION OF BALANCE OF TONNAGE EAST.

TRAIN.	FROM	TO	LOCOMOTIVE.				TONNAGE OVER RULING GRADE.				COAL USED.	REMARKS.
			No.	Schedule Haulage Capacity, Tons.	Class of Rating	Net Schedule Haulage Capacity, Tons.	Contents.	Tare.	Total Actual.	Equivalent Tonnage.		
Extra	Havelock..	Smith's Falls	707	1,008	"A"	1,008	532	416	948	998	6	
54	" ..	" "	739	1,008	"A"	1,008	400	513	913	1,003	6	
56	" ..	" "	725	1,008	"B"	908	382	464	846	922	5	Live stock and Toronto shed freight
50	" ..	" "	723	1,008	"A"	1,008	427	487	914	1,004	5	
Way freight extra	" ..	" "	705	1,008	"A"	1,008	480	473	953	1,020	6.5	
52	" ..	" "	709	1,008	"B"	908	297	513	810	918	5	Dressed beef and provisions.
Extra	" ..	" "	743	1,008	"A"	1,008	537	423	960	1,007	6.5	
				7,056		6,856	3,055	3,289	6,344	6,872	40	

Percentage of Total Equivalent Tonnage taken to Net Schedule Haulage Capacity over Ruling Grades, 100%.

NOTE.—Under the old "actual tonnage" method of loading engines, these engines would each have been scheduled at "A" rating to take 913 actual tons through over the section, or a total for the seven engines (2 at "B" rating), of 6,209 tons—whereas under the new method they brought 6,344 tons through over the section—a gain of 135 tons, or 19.3 tons per train.

If the proportion of tare had been one-third on each train, this power would have taken 6,856 tons through over the section—or 512 tons more than it was able—owing to large proportion of tare—to bring through.