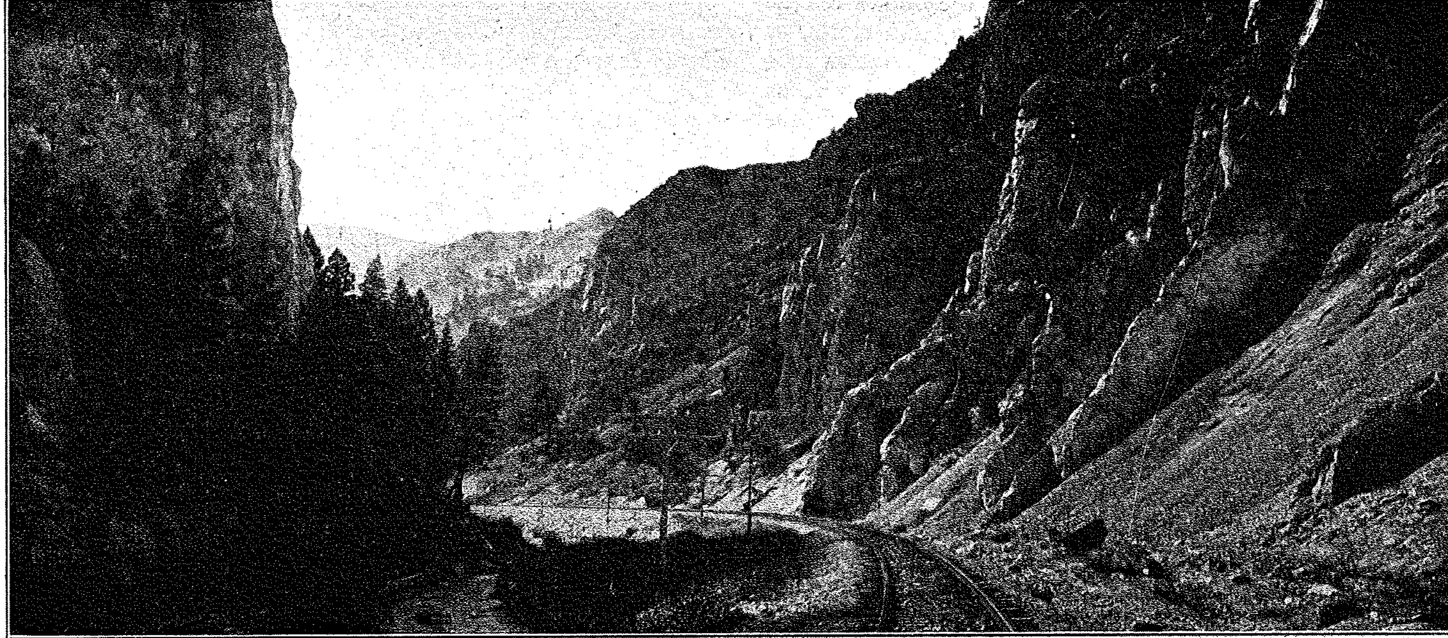


The Montana Canyon as Seen from a St. Paul Observation Car

The Use of Helpers in Electric Train Operation*

Helper Cut in 100 Tons Ahead of Middle and Operated for Braking Over Summit and Down Grade

By W. F. H. Hamilton

Railway Equipment Department, General Electric Company

Operating with helpers is the common method for handling freight trains. The practice on the Chicago, Milwaukee and St. Paul was to put the helper (where only one was used) at the rear of the train just ahead of the caboose. The helper could thus be easily cut off to take water, and could be readily cut in to the train at the start and cut off the train at the summit of the grade. This method leaves one or two cars in the train, at the location where the drawbar stress changes from pulling to pushing, which are very nearly free and can change the slack either way easily. This causes trouble in handling the train and may be termed "floating slack."

It was also the practice with steam power to run helpers from the bottom of each grade to the summit; there they were cut off, turned, and then returned to their original stations, only occasionally being run clear over the hill.

Electric operation was started on much the same basis. The helpers were put at the rear of the trains while ascending the grades but were cut off at the summit and run around to the head-end of the train. There the two locomotives were connected in multiple unit and were used to control the operation down-grade.

This method of operation was tried for a month or so but the results were not entirely satisfactory. Signaling between locomotives was difficult because the trains were longer and the whistles on the locomotives were not as powerful as those on the steam locomotives. The road (leading) locomotive could not slack the entire train, which was necessary in case the helper was not ready to start and, when stopping, the engineer on the helper did not always realize it promptly. This resulted in drawbars being damaged to such an extent that they were pulled out when starting again. Much of this trouble came from the "floating slack" near the middle of the train referred to above, and also because electric locomotives do not slow down as much with the application of load as do steam engines.

How Helpers Are Now Used

The method was then tried of cutting the helper into the train about 100 tons ahead of the middle. This insures the slack being stretched out on all cars and makes starting easier because each locomotive handles practically its own tonnage. Also it was found practicable to keep the helper locomotive in the train while descending and allowing it to regenerate to assist in holding the train. This method of operation proved successful and has been used ever since.

The helpers all operate out of one station and normally run clear over the hill, returning with the next train in the opposite direction. Occasionally it is necessary on account of traffic movement to cut the helper out at the summit and let the road locomotive take the entire train down the grade. At such times both regeneration and air brakes have to be used in combination as previously described. Operating the helpers out of one station reduced the number of crews and locomotives required.

When ready to start on an ascending mountain grade with a helper in the train, the train brakes are released and the train is held by the independent brakes on the two locomotives. The engineer on the road locomotive "whistles off" and the engineer on the helper locomotive answers if he is ready. These whistles are not always heard, however. When the engineer on the road locomotive hears the helper "whistle off" or after waiting a reasonable length of time, he brings the controller onto the first or second notch and releases the independent brakes. This keeps the locomotive from roll-

*This is the third of a series of three articles on this subject. The first (Railway Age, January 21, 1921), dealt with passenger service requirements and passenger train operation. The second (Railway Age, February 4, 1921), dealt with general requirements of freight train operation.

ing back against the train and as soon as the brakes release the controller is moved out slowly until the train starts, or until the current is as near the wheel slipping point as it is advisable to go. This stretches all the slack in the train as far back as the helper locomotive. The engineer on the helper locomotive watches the drawbar of the car forward of his locomotive and as soon as this stretches out brings his controller onto the first or second notch and releases the independent brakes on the locomotive. As soon as they have released he notches the controller out slowly and carefully until the train starts, or until his locomotive has reached as close to the wheel slipping point as it is desirable to go. After the train has started both engineers watch their ammeters and accelerate as close to the wheel slipping point as desirable until they have reached the full parallel position of the controller.

If, however, the train does not start in what the engineer on the road locomotive considers a reasonable time he notches back his controller slowly and allows the train to drop back gradually against the helper locomotive. This is a signal to the helper locomotive to be ready to start and as soon as the engineer on the road locomotive feels the jolt of the train bunching against the helper locomotive he again attempts to start as before. In cases where several attempts are made to start, this "rolling back" operation is usually repeated with increasing severity each time so that the engineer on the helper locomotive will have no doubt as to what is required. When the latter sees the train dropping back against him as shown by the drawbar of the car ahead, he brings the controller on the first or second notch and releases the independent brakes so as to be ready to start when the leading locomotive pulls the slack out of the train ahead.

In stopping the train, the engineer on the road locomotive notches his controller off slowly. This becomes apparent on the helper locomotive by the ammeters indicating a higher value of current and the helper locomotive engineer noticing this, notches back his controller to hold a slightly lower value of current than was required by the train while running. This process is continued until the train comes to rest when he applies the independent brakes and shuts off the controller. The engineer on the road locomotive does the same and sometimes applies the automatic air brakes to assist in stopping. This process of stopping requires as much or more care than starting and the control must be designed to give the proper steps both when turning off as well as when turning on.

It is really surprising how much information can be obtained from the ammeter on the helper locomotive and from the action of the drawbar of the car ahead. With a little experience and a reasonable knowledge of the profile so as to know where slowdowns may be expected it is possible to tell practically everything that the engineer on the road locomotive is doing.

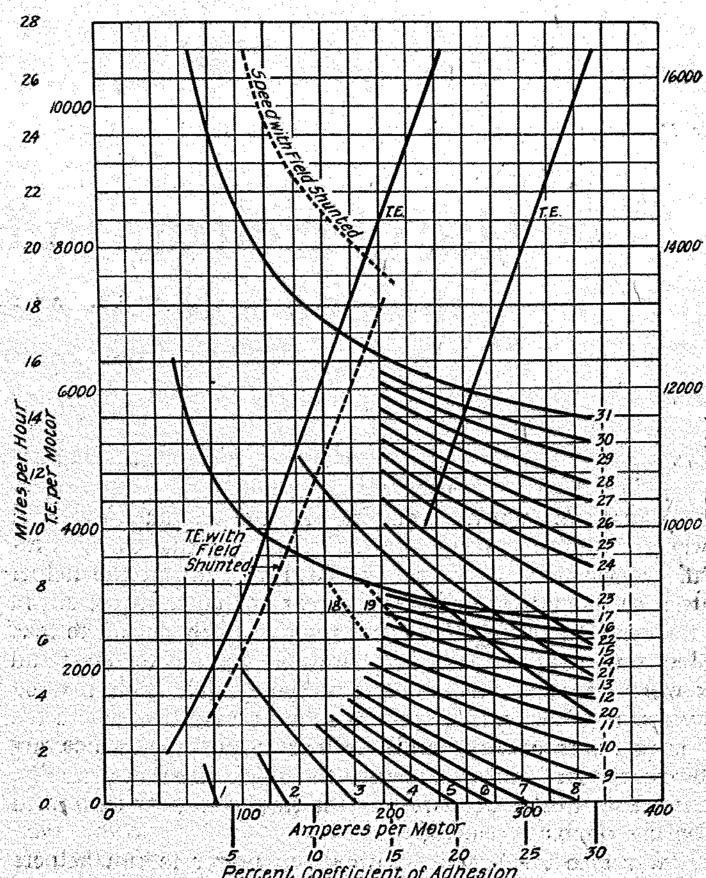
When descending a grade the helper locomotive also regenerates to assist in holding the train. If the start down the grade is made at the summit and the train has to be pulled in order to start it, the helper locomotive engineer commences regeneration when he notices the drawbar on the car ahead shove in. If the start is made from rest on the descending grade he commences regeneration when the first airbrake application is made at the same time as the road locomotive. The helper locomotive is only supposed to regenerate enough so that the road locomotive can readily control the train speed. This means that about 30 to 40 per cent of the load is taken by the helper and 60 to 70 per cent by the road locomotive. In case the helper does not regenerate enough the engineer on the road locomotive makes an application of the airbrakes and releases soon afterwards. The helper locomotive engineer notices this and knows it is a signal to increase the amount of regeneration.

When stopping, the road locomotive engineer makes an application of the automatic brakes and then shuts off his controller when the line current has dropped to about zero. The engineer on the helper locomotive does likewise and both allow their driver brakes to apply. After the train has stopped, the brakes are released on the helper locomotive and the train is held by the independent brakes on the leading locomotive only.

At the bottom of the grade the helper locomotive is cut out. The brake pipe pressure is also dropped from 90 lb. which is carried on mountain grades to 70 lb. A wise engineer applies and releases the brakes on the train twice, making heavy applications each time before starting as otherwise the brakes will stick due to what is virtually an overcharged brake pipe.

Cold Weather May Cause Many Difficulties

The operation of starting on a mountain grade is fairly easy in good weather but in cold winter weather after the train has been standing an hour or so and the oil has con-



Speed-Tractive Effort Curves on Resistance for the Electric Freight Locomotives Used on the C. M. & St. P.

gealed in the journal boxes it is no easy matter. Care must be taken not to apply so much power that a drawbar will be pulled out of some car weaker than the others; this danger is always present in merchandise trains. One is often between "the devil and the deep set," for if enough power is applied to really get the train going in good shape a drawbar or "lung" may come out; if less power is applied the train accelerates slowly and there is the possibility of not being able to accelerate to a running position of the controller before the rheostats overheat.

The friction after the train has been running for an hour or so is about the same as it is in warmer weather but it is very high when starting. Then too there is usually more or less ice and snow on the track which makes the locomotives slip their wheels easily and requires good sanding of the track and careful watching by the engineer. It is possible by notching back a couple of notches to catch wheels that have just started to slip but once they are allowed to spin it is necessary to shut off and start over again. Wheel slipping, especially if it occurs suddenly on mountain grades, is dangerous in that the sudden shifting of load which takes place between the two locomotives is liable to pull out or push in a drawbar. Wheel slipping can usually be detected before it becomes serious by the "fluttering" of the ammeter needle and when this occurs an application of sand must be made promptly. This "fluttering" is noticeable whether the ammeter is in the circuit of the particular motor which is slipping or not.

The airbrakes give a great deal of trouble in weather colder than 10 deg. F. The hoses freeze stiff, usually when the train is standing more or less bunched; when it is stretched out again they leak badly or open up entirely. This often causes the brakes to stick and their action is uncertain at best. When the brake pipe is leaky the feed valve chatters because of the large volume of air passing through it and this is not only very disagreeable to one who has to listen to it continuously but the valve usually manages to freeze up in time and must be thawed out. Sometimes it freezes shut, in which case the brakes apply at once due to the leaks in the brake pipe; sometimes it freezes open and admits main reservoir pressure to the brake pipe. This means that the brakes will stick after it has been thawed because of the brake pipe being overcharged. In such cases it is best to attempt to keep the train moving, although it is sometimes necessary to shut the controller off in case the additional load due to the brakes dragging causes the current to go too high.

When an application of the automatic airbrakes is made on a long train, there is first a high pitched whistle which is caused by the air exhausting from the equalizing reservoir and this is followed, in maybe a second or less, by the deep roar of the air exhausting from the brake pipe itself. With a very leaky brake pipe the leaks may draw down the pressure faster than the equalizing valve in the brake valve can. In such cases only the first high pitched whistle is heard. This usually means a damaged drawbar before the train is stopped as in such cases the brakes apply hardest at the rear of the train and the train is stretched out. To counteract this an effort is made to draw down the brake pipe pressure faster at the brake valve by making as heavy an application as possible without actually going into emergency.

Train Slack

Train slack is very peculiar and in a long train seems to give trouble in three sections; the head, middle and rear. The cars in these sections seem to run closely bunched together with considerable slack between the sections and this more or less free slack is always ready to start trouble. This is especially the case on lighter grades or nearly level stretches. There was a certain station on the C. M. & St. P. where there was a sag in the track with about 2,000 ft. of not over .4 per cent grade on each side of the sag. When running through this sag the controller had to be moved back to series in order to prevent too high a speed being attained, but still power was being applied to the train. Twice while the writer was instructing on this particular section of the road trains broke-in-two near the middle while passing through the sag. Apparently the rear end speeded up enough to overtake the head or middle portion and some cars came together enough to either uncouple, or else when the train stretched out again as it started to ascend the grade there was enough of a shock to pull out a drawbar or break a knuckle. These two cases happened within a short time of each other and give some idea of the unforeseen and unavoidable incidents which happen in freight train handling.

There was a certain canyon on the St. Paul where there were many curves on about an .8 to 1 per cent grade—just enough so that the train had to be held back a little at times when descending and yet not enough to require heavy applications of the airbrakes. Application less than 8 to 10 lb. usually mean that the brakes will stick more or less after releasing so that with steam locomotives more or less trouble was experienced in taking trains through. With the electric locomotives regeneration is used instead and the need of the light applications is eliminated and operation is thus made easier.

Locomotive Design

To meet the conditions of train handling, as outlined above, successfully the control equipment of the locomotives must be carefully designed so that sufficient rheostat steps and ample rheostat capacity will be provided. The acceleration curves on resistance of the C. M. & St. P. freight locomotives are shown on the chart. It will be noted that the change in tractive effort between notches when accelerating to a maximum of 25 per cent coefficient of adhesion is about 21,000 lb. for the total of 8 motors on a locomotive. The rheostats are designed to allow an acceleration at an average value of 210 amp. corresponding to about 16 per cent coefficient of adhesion for 25 minutes and 300 amp. corresponding to 25 per cent for 15 minutes. These capacities have proven ample in service but are not too large for winter work. It will be noted, too, in examining the curves that the steps are close together from the fourth notch to the eighth, inclusive, and are then spread out more. This provides steps close together at the most critical time in starting a heavy train. The increments in tractive effort between steps have always been satisfactory so that it may be assumed that the proper increment to use with this size locomotive is about 20,000 lb. to 25,000 lb. per step after the train is in motion.

The field shunting position gives about 50 per cent shunting which is about the maximum which can be used on account of the commutation of the motors.

It is necessary that the traction motors be so designed that they can have currents up to 20 to 25 per cent coefficient of adhesion applied for about five minutes with the locomotive stationary without injury to the commutator. This is often required in starting heavy trains. No trouble from this cause was ever experienced on the C. M. & St. P. locomotives.

Direct current locomotives using series motors for freight service have a great advantage as far as this work is concerned in that the tractive effort developed depends only on the current input and does not vary with the voltage. Therefore, variations in voltage do not affect the ability to pull the train or the current input but simply change the speed. There is some increase of heating due to slower speed of the blowers but this can be neglected for short periods. In case of reduction of voltage for any reason the trains can still be kept moving. The auxiliaries were designed to operate at a minimum of one-half normal voltage (1,500 volts) and some will operate as low as 1,000 volts, although at this voltage the air compressors will not pump up a long train. This feature is also made use of by the power limiting system which was described in the April 9, 1920, issue of the *Railway Age*.

They also have an advantage in that the speed during regeneration can be varied over quite a wide range especially if the train weight is below the maximum. This allows the lighter trains to make faster time and helps in getting trains over the road. When operating full tonnage trains on the mountain grades, practically only one speed is available ascending or descending, but there are usually stretches of lighter grades or nearly level track between mountain grade sections where it is desirable to use higher speeds.

Freight service in mountain railroading is far more fascinating than passenger service although, of course, it involves much longer and harder hours. It requires at times the greatest skill, patience and resourcefulness on the part of the engineer, and this is not always appreciated by those who have not followed the work on the road, particularly in winter.

The writer would like to express his thanks to the engineers and others on the C. M. & St. P. with whom he was associated, particularly in the early days of the electrification, who worked out many of the methods described in this article and who also showed him many practical "kinks" in train handling that in considerable measure made the writing of this article possible.

Freight Car Loading

WASHINGTON, D. C.

FREIGHT CAR LOADING during the week ending February 12 continued to decrease, showing a reduction of over 15,000 cars as compared with the week before, according to the weekly report of the Car Service Division of the American Railway Association. The total number of cars loaded with revenue freight was 681,627, as compared with 786,633 in the corresponding week of 1920, and 687,128 in 1919. The summary follows at the bottom of the page.

The number of surplus freight cars continues to increase and for the week of February 15 averaged 392,550. There were also scattering shortages amounting to 388 cars.

The Car Service Division announces that effective March 1, 1921, the district embargo zones with headquarters at Atlanta, Boston and Philadelphia will be consolidated into one zone with headquarters at Washington, D. C., under the supervision of the Car Service Division as district representative. The following will thereafter constitute the district embargo headquarters:

District embargo headquarters	Representative	Address
1. Washington, D. C.	Car Service Division	718 18th street, N. W.
2. Montreal, Que.	C. P. Riddell, District Embargo Chairman.	263 St. James street.
3. Chicago, Ill.	J. J. Pelley, Chairman, Car Service Committee.	431 So. Dearborn street.
4. Winnipeg, Man.	E. J. Stone, District Embargo Chairman.	Union Station.
5. Ft. Worth, Texas	R. L. May, District Embargo Chairman.	11 Touraine Building.

To minimize the expense incident to the present method of handling embargoes, some of the smaller roads which heretofore received embargo notices from district embargo headquarters at the points mentioned have been assigned to a designated trunk line connection for the purpose of *receiving* embargo information issued by other roads. There will be no change in the present method of *placing* embargoes by the roads affected. Where a road is shown as being assigned to a trunk line connection that road will receive all notices of placement of embargoes, modifications, extensions or cancellations direct from the designated trunk line connection which will promptly transmit such embargo information in the manner provided for in Circular CSD-87 and Supplement No. 2 thereto, due regard being given to the utilization of railroad wires where facilities are available.

NO SITUATION CAN POSSIBLY arise to excuse lack of good manners on the part of any employee. Courtesy is due every patron with whom we come in contact, rich or poor, well dressed or poorly dressed, no matter who he is. You will find that good treatment on your part to the patron will bring good treatment on the patron's part to you. He will treat you as well as you treat him. Courtesy always brings big dividends. It pays you, and it pays the company. It pays you, because it makes friends for you and saves complaints against you by patrons, thus raising your standing with the company. It pays the company, because the company is always judged by the conduct of its employees. Courtesy is simply the exercise of kindness and helps make life go smoothly. Nothing makes so many friends as kindness. Nothing adds so much to our own equipment and character. We can all be kind if we choose. It is true that kindness never fails of its reward. It is also true that discourtesy toward a patron under any circumstances is a betrayal of the company's interest. Practice courtesy, not some of the time, but all the time. Your record will speak for itself, should you be reported for some seeming grievance by a patron. If you are courteous to all patrons, the company will soon hear of it, because the public, as a rule, will find pleasure in praising your work. If your manner is discourteous, the public takes equal delight in doing all it can against you, and then the company's interests, as well as your own, suffer. Look above the weaknesses of individuals in the crowd and meet discourtesy with courtesy, impatience with patience. We can do much towards educating the public by example.—*E. E. Nash, general manager, Minneapolis & St. Louis.*

PENNSYLVANIA RAILROAD STOCKHOLDERS on February 1, 1921, numbered 134,743, an increase of 1,675, compared with that of January 1, and of 14,434, compared with the totals of February 1, 1920.

REVENUE FREIGHT LOADED AND RECEIVED FROM CONNECTIONS

SUMMARY—ALL DISTRICTS, COMPARISON OF TOTALS THIS YEAR, LAST YEAR, TWO YEARS AGO AND FOR WEEK ENDED SATURDAY, FEBRUARY 12, 1921

Districts:	Year	Grain and grain products	Live stock	Coal	Coke	Forest products	Ore	Merchandise L.C.L.	Miscellaneous	Total revenue freight loaded: This year 1921	Corresponding year 1920	Corresponding year 1919	Received from connections: This year 1921	Corresponding year 1920	Corresponding year 1919
Eastern	1921	4,492	2,877	42,605	959	8,434	844	45,521	53,381	159,113	.....	.....	183,665	.....	.....
	1920	4,949	2,848	49,524	3,952	6,090	1,994	24,950	77,239	.....	171,546	160,610	.....	216,214	187,121
Allegheny	1921	1,856	2,867	46,327	5,265	3,248	2,642	32,676	46,710	141,591	.....	.....	98,536	.....	.....
	1920	2,698	3,055	49,738	3,204	4,024	2,416	33,495	62,534	.....	161,164	144,412	.....	116,145	119,632
Pocahontas	1921	167	94	13,957	139	1,451	51	2,460	4,897	23,216	.....	.....	12,867	.....	.....
	1920	176	99	20,041	731	1,864	302	156	9,614	.....	32,983	26,400	.....	18,309	19,315
Southern	1921	3,184	1,796	21,830	660	12,866	942	36,664	29,464	107,406	.....	.....	60,998	.....	.....
	1920	3,904	2,454	24,682	321	16,709	2,524	20,151	55,205	.....	125,950	108,939	.....	79,893	64,989
Northwestern	1921	10,042	8,214	5,856	1,617	18,735	1,136	24,245	27,633	97,478	.....	.....	43,587	.....	.....
	1920	10,006	7,804	13,518	1,166	20,464	1,582	20,274	39,934	.....	114,748	103,199	.....	61,731	47,640
Central Western	1921	8,937	9,817	16,557	290	2,934	2,078	27,374	28,796	96,783	.....	.....	42,369	.....	.....
	1920	9,872	9,969	23,764	463	5,630	2,798	22,082	43,440	.....	118,018	94,074	.....	67,290	55,616
Southwestern	1921	4,201	1,791	4,654	96	6,214	401	15,952	22,731	56,040	.....	.....	46,961	.....	.....
	1920	3,974	2,553	7,104	140	6,931	567	16,469	24,486	.....	62,224	49,494	.....	50,749	42,796
Total, all roads	1921	32,879	27,456	151,786	9,026	53,882	8,094	184,892	213,612	681,627	.....	.....	488,983	.....	.....
	1920	35,579	28,782	188,371	9,977	61,712	12,183	137,577	312,452	.....	786,633	.....	.....	610,331	.....
	1919	33,839	33,369	140,999	.....	57,120	14,882	.....	406,919	.....	.....	687,128	.....	.....	537,109
Increase compared	1920	.....	.....	.....	.....	.....	.....	47,315	.....	.....	.....	.....	121,348	.....	.....
Decrease compared	1920	2,700	1,326	36,585	951	7,830	4,089	.....	98,840	105,006	.....	.....	.....	.....	.....
Increase compared	1919	.....	.....	10,787	9,026	.....	.....	184,892	.....	.....	.....	.....	48,126	.....	.....
Decrease compared	1919	960	5,913	.....	.....	3,238	6,788	.....	193,307	5,501	.....	.....	.....	.....	.....

L.C.L. merchandise loading figures for 1920 and 1919 are not comparable as some roads are not able to separate their L.C.L. freight and miscellaneous of 1919. Add merchandise and miscellaneous columns to get a fair comparison.

February 5	36,875	31,277	155,917	10,381	54,066	8,501	182,221	217,759	696,997	762,680	692,614	495,860	599,454	551,312
January 29	39,830	32,368	162,652	9,749	53,677	7,693	179,123	214,844	699,936	803,332	718,297	489,184	589,838	577,709
January 22	46,695	35,255	168,453	11,177	49,159	7,991	176,581	207,804	703,115	804,866	734,293	491,640	589,000	608,751
January 15	44,861	35,125	183,228	10,483	45,241	9,590	173,500	207,860	709,888	840,524	758,609	509,708	627,293	609,260