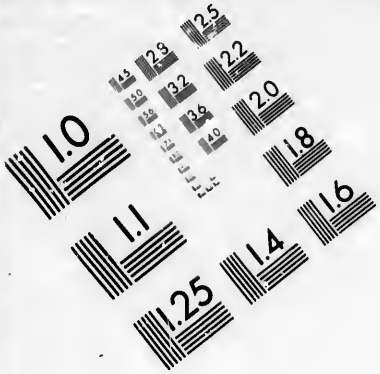

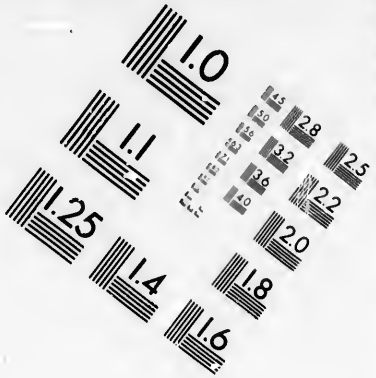

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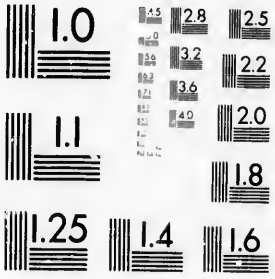

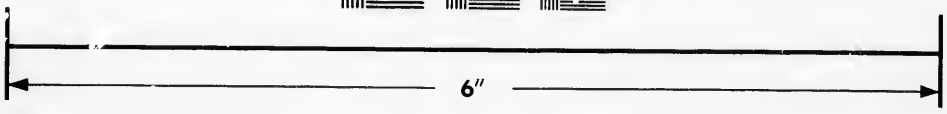

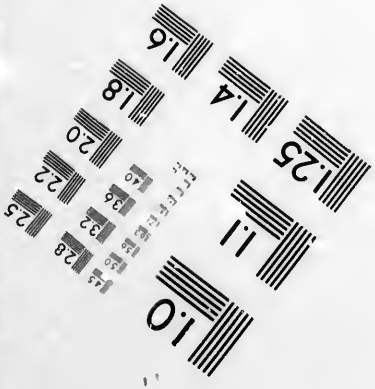

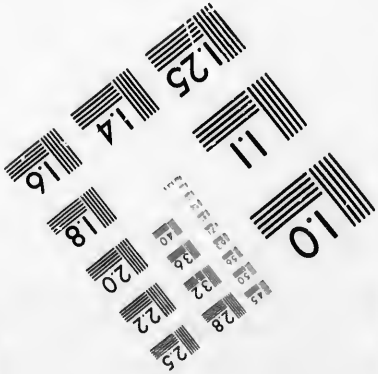

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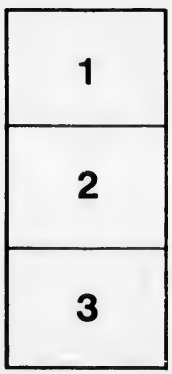

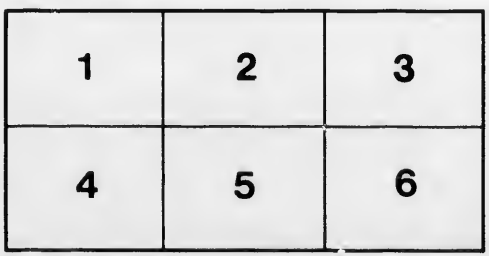

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JAMES AND MACDOUGALL

ON

THE CANADIAN PACIFIC RAILWAY.

Association of Civil Engineers

1884

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Excerpt M

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THE

WESTERN DIVISION

OF THE

CANADIAN PACIFIC RAILWAY.

BY THE LATE

J. C. JAMES AND ALAN MACDOUGALL,
M. INST. C.E., F.R.S.E.

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Excerpt Minutes of Proceedings of The Institution of Civil Engineers.
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SECT. II.—OTHER SELECTED PAPERS.

(*Paper No. 1927.*)

"The Western Division of the Canadian Pacific Railway."[1]

By the late J. C. JAMES and ALAN MACDOUGALL,
M. Inst. C.E., F.R.S.E.

THE first line of railway to cross the American continent was the Union Pacific, completed in May 1869, and the construction of this was justly entitled to the praise meted out to it; it was an undertaking of great magnitude, and, to a large extent, an experiment. The railroad was built at the rate of 1 mile per day in many portions; this rapidity of work not being confined to short sections, but extending over considerable distances. One of the most surprising circumstances connected with its progress was the rapidity with which track was laid. It was an unequalled engineering success at that time. This road was similar in many respects to the Canadian Pacific Railway; it entered an uninhabited and unexplored country, all labour, supplies for man and beast, and track materials had to come from its eastern end; and, as the line progressed, the field of action was always receding from the base of supplies. On these points there is a common comparison between the two systems. During the working season of 1881 the progress of the Canadian Pacific Railway far excelled that of any railway hitherto built; satisfactory as this was, it was completely eclipsed by the progress effected in 1882.

The Canadian Pacific Railway was originally projected by the Government of the Dominion on the Confederation of the Province of British Columbia in 1871, to give an all-rail route on Canadian territory. It had also another and equally important project, namely, the colonization of the extensive tracts of fertile land

[1] Additional information, particularly as to the estimated cost of works, is contained in the following reports which will be found in the Library of the Institution:—"Canadian Pacific Railway; Report of Progress on the Explorations and Surveys up to January, 1874," by Sandford Fleming, Engineer-in-Chief. Also "Report on Surveys and Preliminary Operations up to January 1877;" and Reports 1879 and 1880.

forming the great North-West Territory. Surveys were commenced at once and extended over several years, under the charge of Mr. Sandford Fleming, C.M.G., M. Inst. C.E., who issued several reports on the country and the various projected routes. The line finally determined upon was located 20 miles to the north of what was then called Fort Garry, now the site of the city of Winnipeg, in continuation of the line from Lake Superior. It took a north-westerly direction, passing to the east of Lake Manitoba, and crossing it at the neck of land near its centre; then passing to the west of the lake and south-west of Lake Winnipegoosis, till parallel 52° north latitude was intersected near 101° west longitude. Its route is thence westerly to Fort Edmonton, about 113° 30′ west longitude, 53° 30′ north latitude, till it enters the valley of the River Athabasca, 117° 20′ west longitude, 53° 30′ north latitude; which it follows up to the Yellowhead Pass in the Rocky Mountains, about 118° 45′ west longitude, 52° 50′ north latitude. A good deal of work was done on this track, and the telegraph line erected as far as Fort Edmonton, and operated for several years.

While these explorations were being carried on, the route from Thunder Bay, on Lake Superior, to Selkirk, the point north of Winnipeg already mentioned, was determined, and the contracts were let. Work has been continuous on this division for six or seven years, and this portion of the line is now open for traffic. There are very heavy works and numerous engineering difficulties on this division.

The Pembina branch, which connects Winnipeg with the American railway systems, originally commenced at Selkirk, and follows the right, or east bank, of the Red River to the international boundary in 49° north latitude. By this arrangement Winnipeg would have been on a branch. The works on this branch are very light; it was graded for its entire length in 1875, but, owing to some difficulties amongst the promoters of the St. Paul, Minneapolis and Manitoba Railroad, the track was not laid till 1878, being completed for that distance in December, and trains commenced to run over it in the spring of the following year. Both these divisions have been built by the Dominion Government, and are to be handed over on completion to the Syndicate as part of their contract.

The Government in 1880, finding the construction of this enormous system too heavy a burden, advertised for tenders for its construction. In the month of August the final arrangements were completed with the present syndicate, and at a meeting of

Parliament in the following month, called together specially for this purpose, the terms were ratified.[1]

As soon as the present Direction obtained possession of the road, they diverted the alignment, taking it much farther to the south. Its general direction is now west for 150 miles from Winnipeg, a little to the south of 50° north latitude; it then runs towards the forks of the Red Deer and South Saskatchewan rivers, about 110° west longitude, 50° north latitude; thence it passes nearly due west to 114° west longitude, where it enters the valley of the Bow River. It follows this valley for 115 miles, and traversing Kicking Horse Pass in the Rocky Mountains, about 117° west longitude, 51° 30′ north latitude, enters the province of British Columbia. This location was adopted to obtain lighter works than those on the Government line, and to open up lands equally good and fertile as those on the other line, and also to strike a new pass in the Rocky Mountains considerably to the south of, and which has a much lower elevation than, Yellowhead Pass. It may here be remarked that a line has been successfully located through this pass, and a junction effected with the Government lines in British Columbia.

As a matter of necessity the whole route of the new lines had to be explored and located ahead of the graders. The length constructed in 1881 was 160 miles, which included the building of an air-line from Winnipeg to Portage-la-Prairie, 55 miles, and the extension of the main line to 30 miles beyond the town of Brandon. These works were under the charge of General Rosser, a Southern engineer.

In 1882 the main line had again to be explored and located ahead of the labourers, during the working season, as it is not practicable to keep survey parties in camp on the prairies in winter. It is the progress of these works the Authors wish to bring under the notice of the Institution, as they believe they are unequalled and unexampled in the history of railway building. General Rosser having resigned in the spring of 1882, Mr. J. C. James was appointed Chief Engineer, and operations were carried on under his direction. During the season, extending from the 1st of June to the 1st of December, embracing a period of one hundred and fifty-seven working days, 411 miles of main line were built, 388 miles of track laid and opened for traffic; or, with

[1] "The Canadian Pacific Railway. Contract between the Government of the Dominion of Canada and the Canadian Pacific Railway Company; also the Consolidated Railway Act (1879), and the Act of 1881 amending it." 8vo. Ottawa, 1882.

side tracks, 418 miles of track were laid, and a branch 114 miles long was also built and opened for traffic. Between the 1st of April and the 1st of December survey parties located 620 miles on the plains. The distances from Winnipeg to the—

	Miles.
End of located line	840
„ grading	633
„ track-laying	555
Crossing River Saskatchewan . . .	661
End of 500-mile contract	667

A length of 15 miles more was graded in various places between the end of the continuous grade and the River Saskatchewan.

Location.

The general feature of the North-West Territory is a great undulating plain, divided into steppes, or plateaus. The first steppe extends from Winnipeg to Moose-Jaw Creek, 388 miles; here the ascent to the second plateau begins, and the country rises 275 feet in 7 miles. From this point to the crossing of the River Saskatchewan, a distance of about 224 miles, there are numerous difficulties. The pitches in the Coteaus are very rapid and irregular, especially so in the Missouri Coteau, where the country rises ridge upon ridge, like miniature mountains, and falls into deep and abrupt valleys. Had cuttings been possible there would have been less difficulty of location, and lighter works; but these are not practicable, as it is a matter of great importance to keep the grade in filling (or embankment), to avoid blockade by snow; this added greatly to the difficulty of location. The dryness of the season in winter pulverises the snow, and makes it like very fine sand. It drifts before the wind much more freely than in the eastern provinces, and packs so solid that a horse and sleigh can pass over it, leaving scarcely any impression. A drift of this very fine snow, 6 inches deep, during a "blizzard," will bring to a dead stop the most powerful engine. The snow has very little consistency, the wheels crush it on the rail, on which it forms a coating of ice, and effectually bars the way of the locomotive. A drift 3 feet deep in the eastern provinces can be charged and cleared, but such a drift on the line here would have to be dug out.[1]

[1] A large number of cuttings were also made in the rough country between the eastern line of the Missouri Coteau, and the Saskatchewan River; but all of these have, during the past season (1883), been practically eliminated as far west as Swift Current, by the grading away of the higher ground on either side,

The limitations of curvature are to 4° curves (1433 rad.), and of these only three have been used between Winnipeg and the crossing of the River Saskatchewan. Grades are limited to 40 feet to the mile (1 in 132); but it was found necessary to increase this limit to 50 feet to the mile (1 in 105·60) in ascending the Missouri Coteau. Grades are compensated for curvature, at the rate of 0·05 foot per 100 feet for each 1° of curvature.[1] No hindrances occurred in setting out the line, and the graders were never delayed an hour.

The locating-parties were kept ahead of the graders all the season, and were an independent staff to those employed on construction. They had to explore an unknown country, and, in addition to exploration, had to align the permanent location, the constructive staff doing no locating, only putting in grade-pegs, and attending to monthly measurements. In the season of two hundred and thirty-nine working days, 840 miles were permanently located, being an average of 3·51 miles per day. Including trial locations, many camps made a daily progress exceeding 6 miles.

Camps of Supply.

The engineering staff consisted of five divisions, having charge of a length of 30 miles each. Each divisional engineer had three assistant engineers under him, to each of whom a length of 10 miles of construction was allotted. His camp consisted of a rod-man, axe-man, and cook. As his section was completed, he was shifted farther west; and so the staff was kept moving all the season. Supply-camps were 20 miles apart, and carts were kept on the road during continuance of work, distributing supplies. The contractor's supply-camps were 25 miles apart, and as stores were brought up by the teams they were freighted forward in trains of from thirty to forty teams. A "team" consists of a pair of horses and large four-wheeled wagon, and was used in preference to the Red River cart. These famous carts are two-wheeled vehicles constructed entirely of wood, the wheels not even being tired with iron. Long strings of these, drawn by cayuses (native ponies), used constantly to be met going east and west with supplies for the Hudson Bay forts and Indian reserves. The contractors had four trains on the road all the season.

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or by raising the track: and all the remaining cuttings will be treated in the same way during the coming season (1884), with, perhaps, one or two exceptions, where it will be impracticable. W. C. Van Horne, General Manager, C.P.R.

[1] Minutes of Proceedings Inst. C.E., vol. lxiii., p. 133.

There were three camps of supply, which usually covered 100 miles; the farthest off was 75 miles from the track, and this supplied the line for the remaining 25 miles. More than four thousand men, and seventeen hundred teams of horses and mules were employed by the contractors constantly during the season; and the Company had a large force at the rear, finishing up the work. Two-thirds of the number of teams consisted of mules, it being found that they did as much work as the horses, stood hardships better, and their cost of keep was about two-thirds of that of a horse, as they could subsist better on the prairie grass than horses freshly imported from the province of Ontario. The Montana ponies are also very hardy, and stand an immense deal of work. Water was usually plentiful; but in some places during the dry season it was scarce, and had to be carted long distances. It was not always practicable to sink wells, as camps were moved so constantly, and the sub-strata did not permit of Abyssinian or other tube-wells being employed. As illustrative of the commissariat arrangements necessary, it may be mentioned that 75,000 bushels of oats were consumed monthly, and in one particular month as much as 95,000 bushels.

Construction.

The contract for the whole work, including grading, bridge-building and tracklaying, was let to Messrs. Langdon, Shephard, and Co., under contract to complete and have ready for traffic in twelve months 500 miles of railway. This contract was rigidly enforced by the directorate, and they found in the contractors energetic and willing assistance. It may be contended that on the plains, with works so generally light, there should be no great difficulties in building a large mileage in one season. It is not easy without a large map and numerous drawings to explain the magnitude of the undertaking, and to convey a proper estimate of the difficulties to be overcome in the construction of this line. In the first place, the country into which the railway was entering was unexplored, and uninhabited; and arrangements were required to be made to send out surveyors for explorations, to be followed by engineers for construction; the workmen had all to be gathered from different parts of Canada and the United States, and forwarded; and there were the enormous commissariat organisations necessary for men and beasts. This was no mean task of itself. Added to which there had been a large immigration into Winnipeg in the spring, and the resources of the city were taxed to their utmost to afford accommodation to the incomers; all these people

had to be moved out west in the spring, at the same time that preparations were being made for beginning the work. And as they settled and formed small towns and villages, the requisite station-buildings, side-tracks, &c., had to be put up. The materials for tracklaying had also to be hurried forward, as the track was a considerable distance behind the graders.

When the spring opened, the country was visited with very heavy floods, which affected the whole valley of the Red River for 250 miles south of Winnipeg. Such floods had not been known for more than a quarter of a century; not only did they destroy large portions of the railroads south and north of Winnipeg, but they flooded the whole country for miles along the valleys of the Red River and its principal tributary, the Assiniboine. The destruction to the railroads was so great that the freight was blocked on the side-tracks for hundreds of miles, and it was not until the month of May that the lines became clear. The wash-outs had to be repaired before any traffic westwards could begin, or supplies be brought in from the south. The difficulties of this season's work were not therefore confined to construction on the plains; they embraced the permanent engineering staff for the repairs on the track, the constructive staff, and the freight-staff for forwarding passengers to their destinations, and supplies of all kinds to the working parties. All this had to be moved over a single track. Keeping these facts in mind, the progress of the undertaking this season is justly entitled to be ranked among the highest engineering successes of the day. The mode of construction of this and other lines on the American continent being different to that employed in Great Britain, and, so far as the Authors are aware, never having been brought under the notice of the Institution, they venture to describe it somewhat in detail.

Station Work.

This consists of letting short portions of the line in lengths of 100 feet, called "stations," to gangs composed of from one to four labourers, who throw up the bank from side-ditches. It has the advantage of employing local labour, as settlers between times of cropping and harvesting are enabled to earn a little ready cash; and it gives employment to numerous half-bred settlers, whose mode of life prevents them from taking long engagements, and who are also unfit for other work. This class of work is also very much in vogue amongst the Swedes and Norwegians here, who make it their regular business; they are excellent workmen, neat,

correct, and expeditious. The Authors have never met any navvies who can approach them for power of endurance, and for neatness in the execution of their work. A Swede or Norwegian will cast in 25 cubic yards a day as an average day's work, and if pushed, or labouring in easy-going stuff, will put in 50 cubic yards a day, and keep it up for several days. No plant is required, the embankments being cast up in all cases, a few planks and barrows are sometimes necessary in very wet places.

Scraper Work.

This is the regularly recognised mode of construction, and is the most effective. The side-ditches, or surface of the ground in cuttings, where the haul does not exceed 50 yards, is first ploughed, and the material is then hauled to the bank in an iron box scraper, which holds about $\frac{1}{3}$ cubic yard. The outfit required is one plough-team and driver to five scrapers in ordinary soil; each scraper has a team, driver, and scraper-holder; every scraperful has to be hauled on to the dump, consequently it is well trodden down and consolidated, and shrinks very little. As this system can be adapted for embankments up to 10 feet in depth, and no expensive outfit is necessary, it is peculiarly well adapted for public work in a sparsely populated country. Here again the settler can obtain employment for his horses, either for the plough or for the scraper. An average day's work is 60 to 100 cubic yards, according to material. In the opinion of the Authors this is much better than the system of wheeling in shallow dumps with barrows, or laying temporary rails and tipping from a wagon; for even in cases where a cutting has to be taken out, a long farmer's cart, having the bottom and sides removable, can be substituted, and every layer thoroughly worked down by the horses. Where leads are too long for slush-scrapers or the dumps too high, wheel-scrapers are used. They are iron boxes, hung on an axle between two wheels, and are drawn by a horse in trams like an ordinary cart. They are easily tipped, and hold $\frac{1}{2}$ cubic yard.

Grading Machines.

Within the last few years a machine has been invented for grading roads, railways, and other public works in the prairie regions in the North-West Territories of the United States and Canada. It is a cumbrous-looking affair, with a great deal of complicated machinery; still it works well and needs but little

looking-after and repairs. The chief cost is in oiling the parts; breakages are comparatively few. It can be described as a large frame on wheels; the front wheels are geared into a series which work an endless elevated band placed across the centre of the frame. This elevator is capable of being raised and adjusted; one end is close to the ground, alongside of the plough, and the other is 4 feet above, and is capable of being raised 4 feet. Opposite to the lower end of the elevator is the plough, which has a heavy beam placed over it for weighting it. The director (or ploughman, if he may be so termed) stands immediately over the plough, and has a brake-wheel for raising and lowering it—an almost constant operation.

In the centre of the frame, in front of the elevator, is a large horizontal geared wheel for raising the elevating arm. The grader is drawn along the side-ditch by four teams of horses, two abreast, and two more are attached in rear to a carriage very much like the English timber carriage, or janker. As the plough progresses, the earth is turned on to the elevating band and dropped into position by it; after the turf has been taken off by the plough, and drawn out and levelled in the bank, nothing more need be done to the soil, as it drops from the band till the dump is finally dressed up. It is usual to plough long strips on each side of the line, say ½ mile long, to save turning; the grader goes up one side, and comes down the other. It is claimed by the inventors and makers of these machines that they can place from 900 to 1,000 cubic yards into a dump in a day. The record of several used on the works during the season is from 800 to 930 cubic yards per day, and the daily average in one case was 1,000 cubic yards for the season, whilst 1,260 cubic yards were put in daily for a week. With careful management they can be used for a whole season without requiring serious repairs. The amount of subsidence from scraper-work is 10 per cent., and from station and grader-work from 15 to 18 per cent.

Bridging.

The only large bridge west of Brandon will be the one over the south branch of the River Saskatchewan. It will be 1,000 feet long, in five spans of 200 feet each. The piers and abutments will be of stone, and the girders of wrought-iron. A temporary bridge has been erected. Openings for water-courses, *coulées*, and drainage of the land, consist of four bents of pile-work, with four piles in each bent. Two pile-drivers were brought to the

ground and used on each bridge. As soon as a bent was piled the framers commenced to cut the piles and put on the caps and stringers. It was no uncommon thing for the framers to be up to the pile-drivers as the last pile was driven, with the track-layers entering the bridge as the last stringer was laid. The stringers are laid two under each rail in one span, and three under each rail in the alternate span; they are respectively 9 inches by 15 inches, and 6 inches by 15 inches, laid to rest 12 inches on each cap-piece; they are drift-bolted down to the cap, and bolted together horizontally with splice-plates 24 inches by $2\frac{1}{2}$ inches by $\frac{1}{2}$ inch.

Stations.

The stations are 16 miles apart, with passing-places halfway between. They have a station-building, with the necessary offices, agent, and section-boss' houses, platforms 200 feet long, well, pump-house, and frost-proof tank. The passing sidings are 2,000 feet long, and each station has one side-track 2,000 feet long, and one 1,000 feet for general traffic.

The wells are 10 feet in diameter, 25 feet deep, with a drill-hole sunk through the sub-stratum into the rock, from 150 to 250 feet deep. These drill-holes are lined with iron piping 5 inches in diameter. Water is pumped into the tanks by steam, time not permitting of wind-engines being erected, as they take some time to put up. Several wind-engines are in use on the eastern and southern portions of the line. These engines and frost-proof tanks were described in a Paper read before the Royal Scottish Society of Arts by Mr. Macdougall.[1] The tanks hold 50,000 gallons each, and the supply of water is abundant.

The station-buildings were erected by a series of gangs of workmen following one another. The first gang put up the framing, joisting, and rafters, &c.; the second put on the sheeting, flooring, and roofing, and they were followed by the plasterers, joiners, and painters. As each gang finished its particular class of work it moved westward; by which arrangement four or five stations were being built at the same time, and each gang got through its own division of labour in time to allow the next one to come on. There were no delays or hitches in the work. The station-house gangs began work 125 miles behind the track-layers, and caught them up at the end of the season. Two hundred and

[1] This Paper does not appear to have been printed in the Transactions of the Royal Scottish Society of Arts.

fifty men were employed throughout the season; they built twelve station-houses, twelve section-houses, sixteen temporary and ten permanent water-tanks.

The sub-grade (or formation) is 14 feet wide, with side-slopes of $1\frac{1}{2}$ to 1. A berm 4 feet wide is left between the foot of the slopes and the side-ditches. The banks are 3 feet deep on the average in the plains, or prairie. Ground was broken towards the end of May, but work did not really commence till the 1st of June. It progressed very rapidly, till, at the close of the season, 6,102,210 cubic yards had been shifted, as detailed in the following Table :—

	Cubic Yards.
1882 June	737,170
,, July	1,054,326
,, August	1,387,169
,, September	1,386,500
,, October	1,237,847
,, November	299,198
	6,102,210

The number of men was reduced on the 8th of November; a sufficient number being kept on during the winter to complete the grading to the crossing of the River Saskatchewan, and have it ready for the track-layers in the spring.

Track-laying.

In a Paper on "The Platelaying of the Jacobabad or Broad-gauge Section of the Kandahar Railway," by Mr. George Moyle,[1] it is stated that sixteen hundred men were employed, twelve hundred for track-laying and four hundred for lifting, lining up, &c.; that the average rate of progress was $1\frac{3}{8}$ mile per day; that the greatest length laid in any one day was $2\frac{3}{4}$ miles; and that the best record for laying 1 mile was two hours. Among the Abstracts[2] a statement is given of the force necessary to lay 1 mile of track per day upon a line in Texas. This is stated to be one hundred and twenty-eight men, exclusive of the force necessary for lifting and finishing the road. The average daily force employed on this railway was two hundred and fifty men, besides one hundred and fifty surfacers, or four hundred in all, against sixteen hundred on the Kandahar Railway, and the rate of progress was nearly twice as great.

[1] Minutes of Proceedings Inst. C.E., vol. lxi., p. 289.
[2] *Ibid.*, vol. lxix., p. 445.

Track-laying was begun on the 1st of June, and on the 1st of December 388 miles had been laid on the main line, and 30 miles of side tracks. This had all been laid on the new works west of the town of Brandon, and does not include any of the side tracks put in at the various stations between that town and Winnipeg. The rate of progress was :—

Month.	Working Days.	Length.	Rate per Day.
		Miles.	Miles.
1882 June	26	68·70	2·64
„ July	26	63·56	2·44
„ August	27	86·86	3·22
„ September	26	71·25	2·74
„ October	26	59·38	2·28
„ November	26	38·30	1·47

The greatest length laid in any one day was 4·10 miles, and on three occasions in August 4 miles per day were laid. The best record was ½ mile in thirty-five minutes. Details of this work are given in the Appendix. The Authors regret they are unable to furnish any details of the cost. Meanwhile they can state that it will compare very favourably with those referred to, or with any work of this kind ever executed.

As the track had to be laid so rapidly it would not have been possible to have camps for the track-layers. Instead of this large boarding cars were built in two stories; in the upper the men slept, and in the lower they lived and messed. Each car is capable of affording sleeping accommodation for eighty men. These cars, with the necessary cooking, inspectors, and workshop cars, were the permanent portion of the train, and were always left at the front. The construction train brought up the materials from the nearest side-track; the trains were usually of flat cars, the ties came in loads of three hundred to a car, the rails were laid on the cars, thirty pairs to a car, on which were five boxes of spikes, weighing 112 lbs. each, sixty pairs of fish-plates, and one box of bolts. The ties (or sleepers) were loaded into carts and carted ahead on the dump, distributed, spaced, and lined for a considerable distance ahead of the track-layers. When the rails were unloaded the train was backed up to the farthest point and the

rails thrown off the cars in equal lots on each side; the engine then went ahead, and a trolly drawn by horses was run up, on which fifteen pairs of rails, with the necessary fish-plates, bolts and spikes were put. When the trolly reached the last laid rail a pair of rails was dropped, gauged, and the trolly run forward. A gang followed, linking on the fish-plates, and was in turn succeeded by the spikers; the first gang spiked the ends and the centre, and the rest followed, spiking each third tie till the whole rail was secured. While this was being done the remaining bolts were put in and the fish-plates fastened securely. By the time the last rail was thrown off the length was completed; a second trolly brought up another load, the first being thrown off the rails to let it pass. By this arrangement the men were never idle, and the work progressed rapidly.

The ties are 8 feet long, 6 inches thick, and average 8 inches on the face; there are two thousand six hundred and forty to the mile. The rails are of steel, flat-bottomed, 56 lbs. to the yard, and 30 feet long; they were rolled in England. The fish-plates are 23 inches long; the ordinary suspended fish-plates weigh 17 lbs. to the pair. In the summer of 1882 an angle-bar was introduced; fish-plates of this pattern weigh 34 lbs. per pair. The bolts are 1 lb. and $1\frac{1}{4}$ lb. each, the heavier ones are used on the angle-bar fish-plates. These make the best joint, as they are notched at each end, which enables the spikes to be driven into two ties, instead of all being driven into one tie directly under the joint.

A train consisted of twenty-one flat cars; it was backed up by the engine; the train had never to go a greater distance for supplies than 8 miles. In ascending, and on the second plateau, two engines were used all the time, in consequence of the grades, as the trains frequently stopped on an ascending grade. Water was readily obtained from the side-ditches and swampy places; no very long runs had to be made. The tenders were filled by means of steam siphons with india-rubber hose attached. It took from twenty-five to thirty minutes to raise 10,000 gallons.[1]

Surfacing.

No ballast was used in 1882. After the rails had been lined and lifted, the ties were packed with the material in the bank, and the berms beyond the ties were taken off, the material being thrown in between the rails to a height of 2 inches above the ties,

[1] Minutes of Proceedings Inst. C.E., vol. lxxi., p. 383.

forming a regular convex surface which sheds the water perfectly. This is known as surfacing. The rails keep a good surface, over which trains travel at 25 to 30 miles an hour. One hundred and fifty men were employed on the surfacing, and they kept close to the track-layers all through the season.

Telegraph.

A gang of telegraph operatives worked alongside of the track-layers, and every evening the end of the track was connected with head-quarters in Winnipeg. About one hundred and fifty men were employed on this work.

Snow-Fences.

Fences of ⅄ shape, in lengths of 12 feet, have been put up where considered necessary. These are removable, and will be taken down in summer. Double board-fences, 8 feet high and 12 feet apart, are also to be put up where the experience of the winter's storms may show them to be desirable.

South-Western and Pembina Mountain Branch.

The work of 1882 also included the construction of a Branch into South-Western Manitoba, 114 miles long, on which the track was laid for its entire length. This branch was opened for traffic on the 12th of December. It was built in the manner already specified.

General features.

It is noticeable that all the prairie land is free from stones. For great distances along the line, 1 bushel of stones could not be gathered in 50 miles. In the neighbourhood of Brandon the soil is gravelly, and there are some large boulders which are striated in an east and west direction; these are the only boulders to be met with for 400 miles from Winnipeg.

The absence of earth-worms and slugs is a marked feature of this soil. When dry it is hard to work; during summer it can scarcely be ploughed; when wet it adheres so hard to carriage-wheels and boots, that it can only be removed by being scraped off. A very little moisture produces this state. It is very difficult to work in this condition, as it can scarcely be cast off the shovel or the scraper; with 20 per cent. of moisture it somewhat resembles half-set mastic or glue. The most adhesive qualities of this soil

are termed "gumbo." When "gumbo" dries, it bakes too hard to be ploughed; on several occasions it was taken out with picks, in large blocks, and laid by hand in the dump. In its worst condition of moisture, it will hold the hoofs of horses working in it and pull their shoes off; this has occurred repeatedly, and within one hour of their having been set. The Authors kiln-dried and soaked some of it, and found it would absorb 72 per cent. of moisture before becoming "slurry."

The frost penetrates the ground to a considerable depth. In the excavations for the main sewer in Winnipeg some years ago, a layer of frozen clay, 12 inches thick, was found 8 feet below the surface in the month of August. The presence of frost in the lower layers of the subsoil is not prejudicial to the growth of the crop. The soil does not heave when the frost leaves it in spring, which is a marked difference to the clay subsoils of the eastern provinces. Houses can be built on sills laid on the surface of the ground; foundation-walls, or piles, have to be carried down 8 feet. Frost has a beneficial effect on the earthworks, crumbling down the "gumbo" and causing it to fall like fine garden soil. It also consolidates the embankments.

As already mentioned, Messrs. Langdon, Shephard, and Co., are the contractors for all the works on the main line. The contractors on the South-Western and Pembina Mountain Branch were Messrs. Preston and McDonald, Scoble and Denison, and John Stewart. Messrs. Ross and Grant laid the track on the branch. All the works have been carried out under the personal superintendence of the late Mr. J. C. James, the Chief Engineer. The construction on the main line was under the charge of Mr. W. D. Barclay, Assistant Chief Engineer, and the whole of the locations under Mr. J. H. E. Secretan. Mr. Alan Macdougall, M. Inst. C.E., was Divisional Engineer, on construction, on the South-Western Branch.

MEMORANDUM by MR. C. W. VAN HORNE, GENERAL MANAGER of the CANADIAN PACIFIC RAILWAY.

In 1883 grading was recommenced at the end of March, and track-laying on the 18th of April; and from that date, until the track reached the end of the Prairie Section, at the crossing of the Bow River, near Calgary, the daily record was as given in Appendix II.

At Calgary the line enters the Bow River Pass, and begins the ascent of the eastern slope of the Rocky Mountains. On the 27th of November the track had reached the summit, 122 miles west of Calgary, and 962 miles from Winnipeg.

The three seasons' work on the Western Division of the main line have been as under:—

	Miles.
1881	165·50
1882	419·86
1883	376·78
	962·14

The sidings, which aggregate 66 miles in length, are not included in any of the figures given.

It will be observed that in seven weeks, ending September 17th, 1882, or in forty-two consecutive working days, 134·88 miles of main track were laid, or an average of 3·21 miles per day, exclusive of sidings. Large as was this average, it was exceeded in 1883, when, for the eight weeks ending August 5th, embracing forty-eight consecutive working days, 166·88 miles of main track were laid, or an average of 3·46 miles per day, exclusive of sidings.

In order to preserve the rails from injury, and to provide a good track over which the enormous quantity of materials and supplies could be moved with certainty and despatch, the lining and surfacing gangs were kept well up to the track-layers.

It must not be supposed that because the work was so quickly done it must have been poorly done, or that the track was merely stretched out on the surface of the ground. On the contrary, the entire line is thoroughly well built of the best materials, and everything has been done to make it a first-class railway in every respect, and with a view to the greatest economy in operating. The average amount of earthwork from Winnipeg to the foot hills of the Rocky Mountains has been 16,300 cubic yards to the

mile. This high average in a prairie country is accounted for by the fact that while, to guard against snow, the grade line is elevated well above the surface of the ground, so as to almost entirely avoid cuttings, long planes and tangents and very low grades have been secured.

With the exception of one short length at the crossing of the Saskatchewan River, the maximum gradients between Winnipeg and a point 4 miles below the summit of the Rocky Mountains, a distance of 958 miles, are 40 feet to the mile, equivalent to 1 in 132.

The steel rails used are all of English and German manufacture; about one-half come from the works of Krüpp, at Essen, in Prussia.

The ties, or sleepers, were brought from the forests about the Lake of the Woods, east of Winnipeg.

The grading of the last 650 miles of the prairie section was done by Messrs. Langdon, Shephard, and Co., who also laid the track from Oak Lake to Calgary. They commenced at Oak Lake in April 1882, and finished at Calgary fifteen months later. In that time, notwithstanding a winter's interruption, they laid 677 miles of main track and 48 miles of sidings, and moved about 10,000,000 cubic yards of earthwork, a feat unequalled in the history of railway construction.

It should be mentioned in this connection, that in order to keep the grading out of the way of the track-layers, the work had to be manned long distances ahead, in some cases nearly 200 miles, and that in a wild country without roads or means of supply, except from the end of the track.

The transportation department was charged with the delivery of all the materials and supplies at the end of the track, and when the quantity of these, and the great distances they had to be transported, are considered, it will be thought no small feat to have moved them to the front day after day and month after month with such regularity that the greatest delay experienced by the track-layers, during two seasons' work, was less than three hours.

Divisional points with train-yards, engine-sheds, coal-sheds, &c., are placed at intervals of 120 miles, and at the alternate divisional points repairing shops are provided. The company owns the telegraph line, which is at all times kept abreast of the track-layers.

During the rapid construction yards were established at intervals of 100 miles, whence all materials and supplies were assorted and forwarded to the front in train lots, each train taking an accurately-adjusted lot of rails, ties, fastenings, telegraph material, and other

necessary items, so that no material was scattered along the line. The headquarters of the construction department were situated at these material-yards, the offices and houses making quite a village; but all the houses were portable, and of such size as to be readily moved on flat cars, and when, as the track advanced each 100 miles, it became necessary to move on to a new point, the change could be made in a day, and without delay to the work.

During the year 1883 two more branches were built by the company in the north-west, one from Winnipeg to Selkirk, on the west bank of the Red River, 22 miles, and another from Emerson to a connection with the Pembina Mountain branch, 23 miles, long.

The whole of the line between Winnipeg and Lake Superior was transferred by the Government to the company in May 1883, and is now in operation, giving the company an independent outlet eastward by way of the Great Lakes during the season of navigation.

The work of the Company for the year 1883 may be summarised as follows:—

	Miles.
Extension of main line, west, from Sturgeon River	100
Extension of main line, east, from Port Arthur	101
Extension of main line, west, to the summit of the Rocky Mountains	376
Algoma branch	96
Ontario and Quebec Railway	200
Selkirk Branch	22
Emerson Branch	23
Making for the year a total of	918

The lines owned and operated by the company at the end of the year were:—

	Miles.	Miles.
Eastern Division.		
Main line	445	
Branches	199	
		644
Western Division.		
Main line	1495	
Branches	244	
		1,739
Ontario and Quebec Railway		200
Credit Valley Railway and branches		184
Toronto Grey and Bruce Railway and Branches		196
Total		2,963

MEMORANDUM by MR. JAMES ROSS, GENERAL MANAGER of the NORTH AMERICAN RAILWAY CONTRACTING CO.

The North American Railway Contracting Co. took a contract to complete the construction of the railway in the end of February, 1883. Mr. James Ross was appointed manager of construction and of all work west of Winnipeg, succeeding the late Mr. J. C. James, whose untimely death occurred on the 27th of February. The company awarded a contract to Messrs. Langdon, Shephard, and Co., for the grading, bridging, track-laying, and surfacing from the end of the track to Calgary, a distance of 255 miles; besides the completion of the last season's work from Swift Current, a farther distance of 76 miles, which included building culverts, finishing bridges, dressing up, and surfacing the track. The engineering staff consisting of nine locating parties and fourteen construction parties left Winnipeg early in April. Some of the former travelled more than 500 miles over the prairies in carts, and over the mountains on pack-horses, before they reached the scene of their operations. Surveys in the Selkirk Range were not commenced until the 10th of July. A special system was organised for keeping the general manager of construction informed of what was going on in the immense district under his charge, and especially for communicating with locating parties. This was the perfecting and extension of last year's courier mail service.

The Railway Company determined to reduce the grades from the top of the west bank of the River Saskatchewan to a point near the summit of the Rocky Mountains, to 40 feet per mile instead of the maximum grade of 52·80 feet per mile used in 1882. At the same time they wished the track to reach the summit of the mountains in the current season. On the located line of 1882 the most suitable gradient had been applied, involving very heavy mountain-work and a tunnel ½ mile long. No information was available as to other parts of the country, and Mr. Ross and many of his staff had never been so far West before. Shortly after the engineering parties had left the end of the track, 555 miles west of Winnipeg, the courier service was organised to run a distance of 280 miles, extending the service westwards as the track-laying advanced. Each courier was equipped with a pony-saddle and mail-bag. One man was assigned to every 40 miles; the time allowed to cover this distance was eight hours; and at

each station a fresh courier was ready to continue the journey. By this arrangement the entire distance of 280 miles was covered in three and a half days.

The engineering camps were 13½ miles apart, every camp was numbered, and each division lettered. A system of way-bills was established, by which any lost letters could be traced, similar to that adopted by railway companies to trace lost freight. The benefits arising from this were inestimable, changes in location were perfected, construction pushed on, no delays were incurred, and the staff at head-quarters were always fully informed of all that was going on. As an example, two locating parties were sent to change the line between the River Saskatchewan and Calgary for a distance of 181 miles; one party went ahead to determine the practicability of the route, for the grade of 40 feet to the mile, and the second party to locate the permanent line. Though these two parties started from a point 74 miles west from the end of the track, had three weeks' start of the graders, and were able to locate 4 to 5 miles a day, yet the graders were many times in sight of their back picket-man. The same can be said of the work west of Calgary, with the exception that the location was slower, more preliminary surveys having been required.

The organisation required for supplying the men and teams was much the same as that already referred to in the account of the previous season's work. Different plant was required west of Calgary, and the difficulties were much increased owing to the great distance from the base of supplies, the summit in the mountains being 963 miles from Winnipeg. The number of men and horses to be fed made this a question of continual anxiety. The greatest number of men employed was five thousand, and nineteen hundred teams; the cost of feeding them was $100,000 (roundly £20,000) per month.

From the end of the track to Calgary the character of the work was similar to that of the previous year. Messrs. Langdon, Shephard, and Co., completed their contract on the 15th of August, the day specified by their contract. From Calgary westwards the line is being constructed by the North American Railway Contracting Co.

Calgary is at the eastern base of the foot hills of the Rocky Mountains, the mountains proper begin at "the Gap" 56 miles farther west. The summit of the mountains, the objective point of this season's operations, is 67 miles west of "the Gap," or 123 miles west of Calgary. The line follows the Bow River for nearly the entire distance, and in order to retain the grade of 40

feet per mile, several heavy cuttings and embankments had to be undertaken. For some miles the average earth- and rockwork was 70,000 cubic yards per mile, besides a large amount of bridging.

Taking into consideration the class of the work, heavy rock, cemented gravel, and hard-pan cuttings, some of them containing 50,900 cubic yards, and the amount of bridging intervening, the rapidity of work on this section will equal that on the prairies.

A length of 123 miles was completed in eighty days.

The amount of earthwork and rock shifted each month during the season 1883, east of the summit, was—

	Cubic Yards.
April	47,187
May	1,357,398
June	1,261,878
July	1,104,685
August	895,474
September	488,421
October	331,526
Total	5,486,569

Besides the grading, bridging, and track-laying, the Contracting Co. finished all buildings, wells, tanks, telegraph lines, &c., and handed over to the Railway Company a completed railway ready for operation.

The large bridge over the River Saskatchewan is under construction. It is 1,000 feet long, is 45 feet above the river-bed to the rails, and consists of three spans of 217 feet each, two spans of 30 feet each, and a draw-span of 300 feet. The piers and abutments are of limestone from the quarries near Winnipeg. The material for a temporary bridge, which was put up, was freighted along the prairie from the end of the track, a distance of 66 miles.

On the section between Calgary and the summit there is a length of 2 miles and 3,000 feet of bridging, which includes eight crossings of the Bow River averaging from 400 to 800 feet each; one crossing of the Kananaskis, three crossings of Devil's Head Creek, and one trestle work 250 feet long by 80 feet in height. The rapidity of these streams made the construction of temporary bridges slow and difficult.

Three large division-yards for storing materials, with sidings, round-houses, coal-sheds, water-supply, &c., have been constructed, as well as twenty double-section men's houses, and twenty water-tanks and water-supply stations.

Between the River Saskatchewan and Calgary water for the engines is more difficult to obtain than on any other section of the line owing to the character of the sub-strata. Two large well-boring machines, with outfits, were prepared and used continuously night and day. Tubing has been sunk to the depth of 2,000 feet in some places with satisfactory results in obtaining water.

Track-laying commenced on the 18th of April; very little grading was done in that month. The best day's track-laying was made on the 7th of July, when 6 miles and 100 feet of main line, and 1,800 feet of side-track were laid. All the track was full-spiked, bolted, and tied (sleepered).

APPENDIX.

I.—Detailed statement showing Daily Progress of Track-laying for 1882.[1]

Day of the Month.	June.	July.	August.	September.	October.	November.	December.
	Miles.	Miles.	Miles.	Miles.	Miles.	Miles.	Miles.
1		2·80	3·86	3·35	S.	2·55	2·05
2		S.	3·60	3·64	0·68	2·55	1·00
3		2·10	4·00	S.	1·80	2·75	0·51
4		2·24	3·50	3·37	0·68	1·10	2·01
5		2·10	3·30	2·30	..	S.	..
6		1·62	S.	2·30	2·14	2 70	..
7		2·10	3 10	3·17	2·56	1·10	..
8		3·47	3 00	3·75	S.	2·00	1·86
9	53·20	S.	2·90	3·17	2·90	0·90	1·06
10		..	2·60	S.	2·75	..	S.
11		1·80	2·54	3·50	2 75	.	..
12		2·17	2·90	3·26	2·56	S.	0·80
13		2·00	S.	3·00	1·60	0 50	..
14		2·00	3·35	3·05	2·75	1·50	0·28
15		1·62	3·10	3·36	S.	2·10	0·51
16		S.	2·75	3·30	3·00	0 80	0·44
17		2·30	3·00	S.	1·75	1·00	0·57
18		3·07	1·60	3·55	3·66	2·00	1·12
19	2·42	2·74	4·10	2·30	2·75	S.	1·78
20	2·00	1·90	S.	1·60	2·95	2·10	1·50
21	1·12	3·07	3·36	..	2·55	2·00	1·52
22	.65	2·35	2·95	2 60	S.	1·90	1·70
23	.52	S.	2·95	2·30	2 80	1 90	1·44
24	..	3·16	3·26	S.	2 85	2·00	1·00
25	S.	3·16	3·54	2·40	2·75	1·75	1·14
26	1·65	2·00	3·00	2·23	3·10	S.	1·74
27	0·82	3·23	S.	2·50	2·55	0·50	1·52
28	2·06	3·06	3·50	2·75	1·25	..	1·31
29	1·26	3·00	4·05	2·50	S.	0·60	1·08
30	2·00	S.	3·50	2·00	2·75	2·00	1·66
31	..	3·50	3·55	..	2·50	..	S.
..	68·70	63 56	86·86	71·25	59·38	38·30	30·30

In addition to the foregoing, 1·95 mile of main track was laid on the 1st, 2nd, and 3rd of January, 1883, when heavy snow storms brought the season's work to an end, the grading having been stopped by frost on the 13th of November.

[1] The statement for December 1882 and January 1883 has been supplied by Mr. C. Van Horne; and that for April to November 1883 by Mr. James Ross.

II.—Detailed statement showing Daily Progress of Track-laying for 1883.

1883.	April.	May.	June.	July.	August.	September.	October.	November.
	Miles.	Miles.	Miles.	Miles	Miles.	Miles.	Miles.	Miles.
1	..	1·17	..	S.	3·09	1·78	2·03	1·40
2	..	..	..	2·78	3·28	S.	2·58	1·78
3	..	..	S.	4·68	3·31	1 93	2·21	1·74
4	..	..	..	3·63	3·24	1·80	1·00	S.
5	..	2·16	..	3·63	S.	1·70	..	1·60
6	..	S.	..	3·90	3·30	..	..	1·52
7	..	2·50	1·64	6·02	2·93	..	S. 1·78	2·21
8	..	2·50	2·63	S.	1·70	0·78	1·06	2·14
9	..	1·60	1·60	3·90	..	S. 0·86	1·02	1·17
10	..	2·58	S.	3·79	..	1·46	2·15	2·20
11	..	2·06	3·22	3·07	3·09	1·78	1·42	S.
12	..	2·84	3·50	3·75	S.	1·62	2·05	2·37
13	..	S.	3·35	3·67	..	1·44	1·60	2·12
14	..	2·63	3·79	4·34	0·37	1·87	S.	1·29
15	..	2·96	3·24	S.	1·57	1·34	1·67	2·01
16	..	2·78	3·24	2·91	0·81	S.	2·05	2·08
17	..	2·31	S.	3·77	..	2·14	0·81	1·52
18	0·51	2·87	3·07	1·17	..	1·76	0·70	S. 1·50
19	1·36	3·13	3·79	..	S.	2·24	2·10	0·66
20	1·31	S.	4·00	3·24	..	1·52	2·08	..
21	1·69	3·69	2·91	4·11	1·90	2·14	S.	0·64
22	S.	3·07	3·70	S.	1·60	2·34	2·18	..
23	1·57	3·20	3·67	3·60	0·68	S.	1·36	..
24	2·10	3·01	S.	3·71	..	1·50	1·67	..
25	2·16	0·65	3·60	2·50	..	..	1·78	..
26	1·57	..	3·45	3·86	S.	..	1·68	..
27	1·10	S.	3 33	2·88	..	..	1·70	..
28	1·06	2·95	3·48	6·38	..	..	S. 1·36	..
29	S.	1·91	2·61	S.	1·21	..	1·67	..
30	2·14	..	3·13	3·66	1·27	S.	1·69	..
31	..	..	..	3·40	1·68	..	0·25	..
..	17·57	51·97	66·95	92·35	41·23	32·00	43·65	26·87
Side-tracks	1·05	2·15	5·47	5·11	4·55	1·40	2·48	3·08
..	18·62	54·12	72·42	97·46	45·78	33·40	46·13	29·95

Selected Papers.

for 1883.

November.

Miles.
1·40
1·78
1·74
S.
1·60
1·52
2·21
2·14
1·17
2·20
S.
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