

CONSTRUCTION AND MAINTENANCE PROBLEMS ENCOUNTERED
ON THE ALASKA RAILROAD

by

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The first problem encountered on any new railroad after the purpose of the project has been defined is to find the most economical route to serve that purpose. All major transcontinental railroads in the United States encountered this problem. To "go west, open up the resources of the continent" seemed a very fine goal for such railroads, but the problem of where to go and how had to be solved by intensive field exploration and economic planning.

Preliminary information and data on the most favorable route for an Alaskan railroad that would best service the development of the mineral and other resources of the country had been gathered by several government agencies prior to 1914 when, I quote from "The Alaskan Engineering Commission, Service Monographs of the United States Government, No. 4 - Institute for Government Research" as follows:

"Subsequently several bills were introduced in Congress to carry out the recommendation of the commission, and a bill was passed entitled, An Act to authorize the President of the United States to locate, construct, and operate railroads in the Territory of Alaska and for other purposes which was approved March 12, 1914. (38 Stat. L., 305). The President was given full authority to designate, locate and construct the route of the proposed lines of railroad and the necessary telephone and telegraph lines to purchase or otherwise acquire all real and personal property, terminal grounds, right of way, equipment, etc. which were essential to carry out the purpose of the act; to fix or modify rates; to establish all necessary rules and regulations; and in general to perform all things incidental to the success of the undertaking. The only important limitations on the President were that the road was not to exceed one thousand miles in the aggregate, that it was to be located as to connect one or more of the open Pacific harbors on the southern coast of Alaska with the inter or navigable waters and with the coal fields, and that the total expenditure was not to exceed \$35,000,000. The sum of \$1,000,000 was appropriated to be immediately available for carrying out the provisions of the act.

On May 2, 1914 the President directed the Secretary of the Interior to proceed with the surveying of the routes for the railroad, and conferred upon him 'the power and authority to do any and all acts necessary thereto.' For the immediate direction of the work, a commission, designated the Alaskan Engineering Commission was created by presidential appointment composed of Lieutenant Frederick Mears, 'because of his experience as an engineer on the Great Northern under Mr. J. F. Stevens, and later in the construction of the Panama Railroad under Colonel Goethals,' Thomas Riggs, Jr. 'because he had spent many years in Alaska and surveyed the Alaskan Canadian Boundary from the sea to the Arctic Ocean and was familiar with the Alaskan people and conditions under which work can be done in Alaska,' and W. C. Edes, 'because of over 35 years' experience in locating and

constructing railroads in the far west for the Santa Fe, Southern Pacific and other railroad companies.' Formal authorization to begin work was received by this commission from the Secretary of the Interior on May 8, 1914.

"The Commission. The history of the Commission falls into four periods: the period of the survey, the initial period of construction, the period of war-time retardation of construction, and the post-war period of reorganization and full resumption of activities.

"Period of the Survey: As indicated above, the Secretary of the Interior formally authorized the Commission to proceed with its work on May 8, 1914. In general terms, the first problem then facing the Commission was 'to make such surveys and compile such data as would enable the President to decide on the most available route over which to build the railroad.'

"The Commission found at the beginning of its work that:

"In order to accomplish the objectives set forth in the act of Congress, it was necessary to investigate two general routes from the coast to the interior of Alaska; namely, the eastern route starting from Cordova or Valdez and extending northward via the Copper River, Tonsina River, Delta River and Tanana Valley to the vicinity of Fairbanks, and the western route, starting from Portage Bay or Seward and following along the shores of Turnagain and Knik Arm, then northward through the Susitna Valley and over Broad Pass and down the Nenana River to its junction with the Tanana, and thence by one of several routes to the vicinity of Fairbanks.

Since considerable information was already available on the eastern route there was planned a careful preliminary survey and estimate of the western route, including a branch therefrom to the Matanuska coal fields, a survey from Chitina on the eastern route to these coal fields and a reconnaissance from the western route into the Kuskokwim and Iditarod districts which had never been gone over in anticipation of railroad construction. Supplementing the work of the locating and surveying parties whose investigations were first hand, an analysis was made of previous surveys of the routes or portions of them, and modifications were made in accordance with the best knowledge then obtainable. At times there was conflicting testimony on important matters, and the Commission then made arrangements for observation and verification by its own representatives. Consequently, through surveys of its own men and through judicious use of former investigations, the Commission was enabled to compile in a relatively short time the facts as to the advantages and disadvantages of alternative routes.

"The act of March 1914 authorized the President: To purchase, condemn, or otherwise acquire upon such terms as he may deem proper any other lines or line of railroad in Alaska which may be necessary to complete the construction of the line or lines of railroad designated or located by him; provided, that the price to be paid in case of purchase shall in no case exceed the actual physical value of the railroad.

"To supply the President with the data necessary to carry out the provisions of this clause, the Commission examined the following three railroads:

	Miles
Copper River and Northwestern Railroad:	
Cordova to Kennicott (standard gauge)	195.0
Alaska Northern Railroad:	
Seward to Kern Creek, a point near the head of Turnagain Arm (standard gauge)	70.8
Tanana Valley Railroad:	
Fairbanks and Chena to Chatanika (narrow gauge)	46.0

"In the case of the Copper River and Northwestern Railroad, which was the most active standard gauge railroad in Alaska, an examination was made of its entire length. Investigation was made of the grades, curvature, bridges, cost of operation, etc. It was found that while, in general, a workable railroad existed, betterments were essential, not only in anticipation of any increased future traffic but also to reduce the cost of operation and maintenance even under existing traffic. It was noted that if economies in operation and maintenance were thus introduced, the handicap on earning power could be removed of the abnormally high rates of 12-1/2 cents per passenger mile and from 3-1/2 to 14-1/2 cents per ton mile as against prevailing rates in the United States of two to four cents per passenger mile and one cent per ton mile.

"The Commission found the condition of the Alaska Northern Railroad much worse than that of the Copper River and Northwestern. It was estimated that to make possible the safe operation of only light trains from Seward to Kern Creek, an immediate expenditure of \$500,000 would be required, including the necessary outlay for snowsheds, determination of which awaited further study of snow conditions.

"In regard to the Tanana Valley Railroad, which was a narrow gauge single track steam railroad, the Commission found that it had suffered a reduction in earnings as the mining industry had decreased, but increased traffic could be anticipated if coal were to be delivered to it from the Nenana Fields. However, even with the existing traffic, the net earnings were more than \$22,000 annually. As to the physical condition of the road, it was found that the equipment was in poor condition and that no heavy grading had been undertaken in the original construction.

"It was also necessary to obtain some estimate of the traffic possibilities on the proposed routes for the government railroad. An independent investigation into the resources of the tributary country was not only obviously beyond the rate of possibility with the limited time and means at hand, but also undesirable if considerable duplication of effort was to be avoided. Personal observation of the members of the Commission was, therefore, supplemented by examination of reports of the various govern-

ment bureaus, data compiled by Chambers of Commerce and statistics furnished by existing transportation companies. It was found that not only was there considerable traffic by water, much of which could be more cheaply handled by such railroads as were then contemplated, but that the creation of cheaper transportation facilities would itself, in all probability, call a large volume of tonnage into existence.

"Since there had been considerable difference of opinion as to the relative merits of various harbors, the members of the commission visited all the harbors under consideration and supplemented their own observations with the information available from the investigations of the Railroad Commission of 1913, the U. S. Coast and Geodetic Survey, Alaskan commercial bodies, and other services. Master mariners were also consulted. It was concluded from the investigation thus made that 'at any of the harbors considered suitable, terminal facilities can be created without excessive cost, and that the question of the most available route for the railroad system to best develop the resources of Alaska is not dependent on the selection of any particular harbor'.

"After these examinations and investigations had been completed, estimates of cost were prepared based on the information obtained from the field surveys, and an evaluation of the Alaska Northern Railroad was made in anticipation of its possible purchase by the government. On February 11, 1915, the report of the Commission's findings was transmitted to the President. No recommendation was made as to the best route to follow, because:

"This Commission is essentially an engineering one organized to handle the subject along technical lines. In selecting a route other questions besides strictly engineering ones are to be considered. The Commission has understood that their special mission was to collect the evidence and present it in as impartial form as possible, knowing it would be weighed carefully and acted upon wisely.

"On April 10, 1915, about two months after the report had been submitted, the President issued an Executive Order outlining the route which he had selected and directing the Secretary of the Interior to purchase the Alaska Northern Railroad. The order was accompanied by a letter directing the Alaskan Engineering Commission to proceed with the work of construction of the railroad as located in the Executive Order under the supervision of the Secretary of the Interior upon whom was conferred 'full power and authority to do any and all acts necessary thereto.' One member of the Commission was to be designated by the Secretary as its chairman to have power of approval or disapproval of all administrative matters connected with the work in Alaska.

"There was apparently some doubt as to the exact division of authority and responsibility as between the Secretary of the Interior and the Commission, for on April 30, 1915, a letter from the President provided

that: 'All work of the Alaskan Engineering Commission under all orders made by me and the carrying out of all contracts entered into by my direction under authority of said act, be performed under the supervision and control of the Department of the Interior, as directed by the head thereof, in all respects and to all intents and purposes the same as if said work had been placed by law under the jurisdiction and control of the Department of the Interior.'

"Initial Construction Period: Following the above authorization and directions of the President, the Commission prepared itself for the actual work of construction. William C. Edes was made chairman, with headquarters at Seward where it was decided to locate the administrative offices; Frederick Mears was placed in charge of construction of a new line, to begin at a point where Ship Creek enters Knik Arm of Cook Inlet, a locality later known as Anchorage and the third commissioner, Mr. Riggs, took charge of the final detailed location of the line since the general surveys made in 1914 had been aimed merely to supply a basis for the President's decision as to the best general route and were not suitable for actual construction.

"The railroad was to be constructed in a wilderness, so that it was necessary to develop and carry various agencies along with the actual road construction. It was found essential to the project to build ocean docks, towns and camps, machine shops, supply terminals, etc. Railroad rolling stock, construction equipment, and supplies of all sorts had to be transported 1,500 to 2,500 miles from Seattle, which was the nearest Pacific coast port.

"Acquisition of Supplies and Equipment: Under the terms of the act of March 12, 1914, and President Wilson's letter of authorization of April 10, 1915, the Commission was to derive its supplies and equipment for its undertaking in three ways; by transfer from the Panama Canal, by utilization of such materials as were available along the right-of-way and in the reservation lands, and by ordinary purchase.

"In order to make arrangements for assembling and shipping available equipment from Panama, a representative of the Commission was sent to the Isthmus in March 1915. By mid-summer such material and machinery had been overhauled and shipped in chartered vessels from the Canal Zone to Alaska. The Commission was not charged for this equipment but it bore the expense of repair and freight, which arrangement resulted in a saving of from 50 to 60 percent over the cost of new equipment.

"To provide for purchase of supplies, in accordance with the law, a purchasing office was established at Seattle. In 1917, branch offices were established at Portland, Oregon and San Francisco aiming at an extension to the sphere of competition for supplying the requisite supplies and a consequent reduction in costs.

"In addition to purchasing the equipment and materials, the purchasing office arranged for transportation by rail and water except for a single year when a separate agency was created for this and other purposes, described in the next paragraph. Inspection of materials purchased was done under contract with the Commission by a commercial concern. The cost of inspection was .91 of the percent of the invoice price of the materials purchased in 1916 and 1.12 percent in 1917.

"To lower the cost of inspection, to meet the difficulties of transportation, and also to relieve the purchasing office, the office of Engineering Representative was established in Seattle in 1917 to attend to the following matters:

"To examine equipment and material to be applied on the railroad.

"To attend to various technical matters, such as the preparation of standard specifications for track fittings, frogs, switches, etc.

"To employ technical men and labor for Alaskan service.

"To charter vessels and barges for transportation of supplies to Alaska and to supervise the transportation itself.

"With the diminution of activity in 1918, the office of Engineering Representative was abolished on June 1, and all its activities transferred back to the General Purchasing Agent. The work accomplished by this office for the brief period of its existence is described in the section on transportation. There was no other change made in the purchasing office thereafter, even in the reorganization of November 1919.

"From the third source of supply, material along the right-of-way and in reservation lands, coal and wood were obtained. Various timber reservations were made in order to retain control of timber suitable for railroad construction. The field service of General Land Office worked in cooperation with the Commission in handling this reservation timber. At first, wood was obtained only for piling and culvert timbers and for ties, while lumber for general building purposes and for bridge construction was imported from Puget Sound. Gradually, however, as sawmills were erected along the route, lumber for snowsheds and other structures became available. Coal was first obtained for the Commission's use in the summer of 1916, when a small mine, located at a point one-half mile from the Matanuska branch of the railroad at Moose Creek, was opened. A contract was entered into for 2,000 tons of coal at \$6.00 per ton. Before this mine was opened, the Commission was paying about \$16.00 per ton for coal from Puget Sound.

"Sufficient coal was produced at this time to meet the needs of the Commission and the town of Anchorage for the summer and fall of the year. In April 1917, a mine operator who had been granted a coal leasing unit at Eska Creek ran into serious faults in the mine and the production

became less than thirty tons per day. The annual requirement of the Commission was then about 40,000 tons, and since neither the operator nor his associates had sufficient funds to develop the mine with the obstacles being encountered, the Commission paid \$15,650 for the improvements that had been made and began operation of the mine on June 18, 1917. A total of 18,198 tons were produced during the year, 6,000 tons of which were mined prior to June 18 under private operation.

"Transportation of Supplies and Equipment: Because of the long haul involved, the transportation to Alaska of supplies and equipment, most of which was purchased in the States, became an important problem even at the beginning of the construction project, but the demoralization of the world's shipping facilities which followed the outbreak of the World War caused special difficulties. The importance of this factor in the cost of construction is shown by the fact that of all expenditures made by the Commission up to April 1, 1920, one-eighth was for transportation costs from Seattle to Alaska.

"As already indicated, all matters relating to transportation were handled by the Seattle Purchasing Office except for the brief period when the office of Engineering Representative was in existence. For handling all freight and passengers arriving by steamers, a receiving and forwarding department was established in the Anchorage Division. In anticipation of a congestion of freight on the ordinary commercial ships which would follow the demand for tonnage by the railroad construction project, arrangements were made with the War Department in 1916 to repair and operate the transport Crook from Seattle to Anchorage at the expense of the Commission. Since commercial rates for water carriage were advancing rapidly owing to war demands for tonnage, the saving which resulted from the utilization of this army transport was reported 'more than sufficient to meet the cost of operating the vessel, plus the cost of extensive repairs which it was necessary for the Commission to incur to place the Crook in commission.' The transportation facilities thus made available were supplemented by seagoing tug and barge, operated between Seattle and Anchorage via the Inside Passage; a collier placed at the disposal of the Commission by the Navy Department to carry a cargo of rails, and several chartered commercial vessels.

"It was found that dependence upon commercial steamers placed the Commission practically at the mercy of the steamship companies in matters of delivery and cost. Accordingly, in 1917, the office of Engineering Representative at Seattle, to which were assigned the duties previously under the jurisdiction of the Purchasing Office of chartering vessels and barges and the general supervision of transportation itself, attempted both to lower costs and to expedite delivery. Arrangements were made for specially chartered barges at less than commercial rates, and a special tariff agreement was made with the White Pass and Yukon Railroad providing for transportation at 60 percent of the regular rates. Consequently, out of a total of 70,000 tons of supplies shipped during the year, only about 11,000 tons went by commercial steamers at commercial rates.

"Distribution of Supplies and Equipment: The method by which supplies and equipment were distributed to the zones of operation under the peculiar conditions existing in Alaska merits some attention.

"Before leaving Seattle in April 1915, the Commission spent about \$40,000 in the purchase and shipment of equipment, material, and supplies essential for initiating construction. To provide for transferring this cargo to the shore at Anchorage a 1,000 ton barge and three lighters were purchased at Seattle for delivery at Anchorage as well as material for 200-ton barge which was to be put together there. No wharf could be constructed at which deep draft steamers could dock until the channel was dredged. To meet this difficulty:

"A very serviceable dock was constructed on the north bank of Ship Creek near the mouth. In front of the dock was constructed a gridiron, over which the barges were floated at high tide and on which they safely rested at low tide, thus avoiding any difficulty in unloading. A 15-ton derrick, operated by hoisting engine, was equipped for unloading the barge.

"Several towboats which had been employed in the engineering survey of the previous year were also utilized as well as some gasoline boats belonging to private individuals in order that the heavy demurrage charges of the ocean steamers might be avoided. After the first shipload of supplies and materials had been unloaded, a large warehouse was constructed at the dock for storage of commissary supplies and a track was laid from the dock to storage yard, a half-mile distant, to which point lumber and construction material were taken. Some flat cars were taken from the stock of the Alaska Northern Railroad at Seward and brought by steamer to Anchorage for the handling of construction material.

"As soon as work began on the line from Anchorage, supply camps were established at various points along the line, supplied by barges working on Knik Arm and by freight teams. Bridges were not erected until they were reached by the newly constructed railroad track to avoid the expense of hauling the necessary material by teams, but the bridge timbers were hauled by construction trains to the various sites. In 1916 large quantities of material, equipment, and supplies were distributed ahead, over the uncompleted work. Transportation facilities provided by the ice of rivers and snow roads over frozen swamp lands made this distribution comparatively easy and cheap in some regions. In others distribution was a greater problem and required special labor and cost. For example, for use on the Susitna River above Croto, a special type of boat called a 'river tunnel boat' was designed to meet the difficulties due to many gravel bars and low water.

"Construction: In the construction of the railroad, there were two general classes of work; the first included the clearing of right-of-way, grubbing, grading, excavation, etc., comprising a kind of labor that could be standardized and for which unit prices could be established; and the second covered the buildings of bridges, laying of tracks, building of snowsheds, etc., where no such standardization was possible. The greatest portion of the first type of work was let out to 'station men' under a system described by the commission in the following language.

"A number of men associate themselves together as partners, taking short

pieces of work at a certain price per cubic yard for grading, or per acre for clearing or grubbing. Each man signs the contract for doing the work and becomes equally interested in it as co-partner or small contractor. Each man receives his separate check for doing his portion of the work. The amount received depending upon the amount of work done, the men are spurred to exert their best efforts. Scarcely any capital is necessary to take a station contract, as the Commission furnishes the necessary equipment at a moderate rental.

"In 1917 the Seward Division was created, to carry out the work of rehabilitation and operation of the Alaska Northern Railroad as well as the construction of 8-1/2 miles of new track. By the end of the year, 174.88 miles of standard-gauge track and 26.5 miles of sidings, spurs, and yard tracks had been laid. In addition, there were 76.8 miles of the line graded and 70.8 miles cleared but not graded.

"Purchase of Alaska Northern Railroad. A problem somewhat distinct from the general construction program was the purchase, rehabilitation, and operation of the Alaska Northern Railroad. The act of March 12, 1914 required that the government railroad terminate in an ice-free harbor on the south coast of Alaska. It was necessary, therefore, to start at the town of Seward, located at the head of Resurrection Bay. Since the Alaska Northern in general followed the most feasible route toward the interior, only two courses were open; the purchase of this railroad or the construction of a new line paralleling the old. A careful field physical evaluation by the commission, described above, verified by experts of the Interstate Commerce Commission, demonstrated that the price requested by the private owners of the Alaska Northern was not in excess of its value. It was, therefore, considered the wiser policy to purchase. Once having made this decision, the Commission deemed it better to negotiate with the owners and agree on a reasonable price than to enter into condemnation proceedings.

"The investigation of the Commission demonstrated that the Alaska Northern Railway had cost the original owners and builders \$5,250,000. The Interstate Commerce Commission reported a total investment in road and equipment of \$3,616,800.81 to June 30, 1912. The purchase price of \$1,157,339.49 was slightly below the physical value of the property as estimated by the engineers of the Commission and as certified to by the valuation experts of the Interstate Commerce Commission. The Commission acquired not only the terminals and physical properties of the railroad, but also very considerable value in the work which had been done by the former Alaska Northern Railway Company, at various points along Turnagain Arm and by having the benefit of the studies, maps, and profiles which they had prepared as a result of their field surveys from Seward to Fairbanks over the entire present adopted route of the government railroad and of the Matanuska branch line.

"An initial installment of \$500,000 and interest was paid on August 25, 1915, when litigation over the title had ceased, and the final payment of \$650,000 was made on June 30, 1916, on which date the government came into full possession."

AN OBJECT OF CONTROVERSY

Like all new ventures, The Alaska Railroad had its opponents as well as its boosters. Considerable ill feeling was developed and fostered by the residents of Seward because the Commission had made the Railroad headquarters at Anchorage instead of Seward. Many employees, though they were making their livelihood from the railroad, joined with the dissenters. One extra-gang foreman, for instance, could see no other purpose for the railroad tracks than a well-defined dog trail. When the gandy dancers were filling up between the ties, he instructed his men thus: "Put the small gravel in the center, boys, make it easy on the dogs' feet."

These workers accomplished a tremendous amount of work under almost unbelievable living conditions. Robert Service aptly described the attitude of the early railroad builders in "Spell of the Yukon," when he referred to "the hardships that nobody reckons."

RUGGED LIVING CONDITIONS

Tents without floors, pole bunks covered with wild hay for mattresses and no bedding (you packed your own) were the accommodations then available. There was no smiling assistant camp steward to direct the new arrivals to their quarters. The new arrivals generally had to provide and build their own. At some locations along the access winter trails or tote roads, crude log houses chinked with moss were hastily constructed. Roofs on such houses were made of strong poles laid with very little pitch, then covered with bark, hay, and moss and capped with an overall covering of two or three feet of topsoil or earth. Door hinges were ingeniously made out of bent nails, or leather from old boot tops and homemade wooden latches held the doors shut (Alaska was then a land without locks or policemen). Flour sacks covered the opening where windows should have been. Such trail accommodations were a combination cook house, storeroom, dining room, social hall and bunk house. The bunks were built out of poles in tiers across both ends of the room, similar in arrangement to post office boxes. They usually were four feet square and eight feet in depth and were known as "muzzle loaders" (the extra two feet was for duffle storage). It was no uncommon sight to find four tiers of such bunks, six bunks wide at each end of the room. Two coal oil lamps suspended from the ceiling provided illumination to the group which gathered around the central heating stove or climbed up and down the crude ladders to and from their muzzle loading bunks. One should not claim to be a real sourdough unless he has spent at least one night in an Alaska muzzle loading bunkhouse.

It may be revealing to know that the men who did this hard work were mostly European immigrants who had not yet attained U.S. citizenship status. The major railroads built across the American continent were the products of the Irish shovel stiffs. In a similar manner, it was the Scandinavians, the Russians, the Greeks, the Slovenians, and the Irish, who with their axes, mattocks, hammers and drills, spike mauls and gauges did the real and actual work of building this present transportation route.

Associated with, and by no means a minor factor in the overall railroad construction program, was the problem of bridging the numerous streams and rivers. It is astonishing to realize that eight and one-half miles of the 470 miles of main line extending from Seward to Fairbanks are still on bridges.

Most of the original spans were wood structures, although the major river crossings such as Gold Creek, Hurricane, Riley and Tanana Rivers, required specially designed steel structures. These steel bridges are still in service and are monuments to the ingenuity and ability of the men who designed and erected them.

On many miles of the original construction where fill material was not readily available to make the required embankments across deep swamps and long hollows, temporary pile trestles were built out of native lumber obtained from the forests near the job sites. These trestles were later filled by train-hauling the required embankment material from more convenient borrow locations. Pile driver and bridge erection crews were exceptionally competent in those times. Scotty Parks, with a pendulum type pile driver, drove and capped sixteen five-pile beats in one single eight-hour shift, in comparison to three similar beats per day with modern pile driver crews and equipment.

In the period between the official completion of the line in 1923 and 1947, only minor improvements and repairs were made on the roadbed and drainage structures. The original 70-pound rail laid on untreated crossties, plus a sprinkling of ballast, over a subfoundation of tundra, had become so warped and battered by the extra traffic of the war years that a thorough rehabilitation of the entire line, plus many improvements, was deemed a prime necessity in order to continue operations and to meet the growing demands of our present defense programs.

Such contemplated work was ineptly called a "rehabilitation program." It should have been called a "reconstruction program," since it has involved the replacement of the old 70-pound rail with new 115-pound steel, the replacement of old ties with treated ones, the extension of sidings, the building of terminal yards, reconstruction of bridges and terminals, and, in many places, the relocation of the line to permit greater speed and safety of train operation.

Associated with this reconstruction program has been an overall attempt to eliminate winter frost heaving of the roadbed by raising the entire trackage on a deep, wide bed of clean gravel ballast, plus a general elimination of the short sags and hollows, which necessitated the raising of the track from three to five feet and the placing of millions of cubic yards of select borrow material which, on sections such as between Nenana and Fairbanks where suitable material for such purposes could not be found, required average train hauls of 40 miles or more.

As the original grade builders made no attempt to clear away the tundra or glacial muck, and in many places succeeded only in laying the track on top of these deposits by placing miles of corduroy or puncheon covering, the construction of a stable and solid roadbed superimposed on this poor

foundation has been an extremely difficult and expensive undertaking. It has been found that the normal winter penetration of frost in ordinary bank run gravel having 25 percent of air voids is from two to five feet, depending on its compaction and the bank infiltration of moisture from underlying deposits. Where the tundra or glacial deposits of muck and clay lie closer to the surface, frost action expands them in proportion to their water contents and, as the only course of free expansion is upward, the overlying railroad tracks become warped and buckled, necessitating the insertion of wood shims between the cross ties and the base of the rails to level up the tracks for the safe passage of trains. We have found only one solution which prevents such frost heaving - digging out the underlying deposits of tundra and glacial muck, backfilling with clean gravel and, of course, providing such backfilled sections with plenty of drainage.

The upper part of the line between MP 343.0 and Healy (MP 350.1) is over permafrost foundation in the Nenana River Canyon. The removal of the already thawed gravel and glacial deposits and the consequent alteration of the natural or old drainage channels during the construction of the line has created new thaw areas, especially in the gumbo-filled hollows, thereby causing long sections of the subgrade to settle and slide toward the river. Numerous unsuccessful attempts have been made to stop this thawing and sliding. Large maintenance crews are continually there jacking up and backfilling the tracks on these settled sections.

From Healy to Fairbanks, where the winter temperature sometimes reaches 72 degrees below zero, and 25 degrees below zero is considered a fairly warm day, the line passes through rolling valley country, most sections of which are underlaid with permafrost and ice lenses. The average depth of summer thaw is only a few feet. Consequently, embankments of gravel or earth placed on top of these permanently frozen areas are always settling during the hot summer season when the thermometer climbs to plus 98 degrees or better.

The gravel ballast and embankments warm up under the almost constant summer sun and act like hot poker placed on top of ice cakes. Hundreds of thousands of cubic yards of backfilling and grade-raising material have been used, and the settlement of the tracks partially stopped in this section. Icing of the tracks caused by creeks overflowing during the winter has to be taken care of also and watched continually, especially during the extreme cold periods.

In conclusion, I wish you to note that I have merely touched some of the construction and maintenance problems which we have encountered. There are many other delaying and recurring factors we are constantly trying to combat which I have not mentioned. It is my earnest desire to record the accounts of our previous attempts and effort and so to broaden the basic understanding of the overall conditions that caused or created them.

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2/14/64