

## SOME WONDERFUL ENGINEERING FEATS ACCOMPLISHED IN AMERICA

Imagine a rocky coast line with an estuary stretching miles inland to where two glaciers rear their icy faces 300 feet above the water. On either side and inland as far as the eyes can see are ragged mountains cleft by canyons of sickening depth. In winter all is buried beneath a dozen feet of snow; in summer it is a place of chill fogs and rushing streams that often double their depth in a single day.

Such is the site of the Copper River Railroad in Alaska. As a feat of engineering this railroad today stands absolutely alone. Its builders faced problems never before met by any other engineers. They started the great work with prophecies of failure ringing in their ears. In a land of such cruel winters and such sudden climatic changes it seemed as if those who risked fifteen million dollars on the line were fools as well as dreamers. But they won the stake and how they won is an inspiring story.

To begin with, the Copper River Railroad is only 193 miles long, but it cost \$70,000 a mile to build it. The discovery of rich deposits of anthracite coal and copper in the northwestern part of Alaska made such a road necessary unless the new treasure house that had been opened up was to be allowed to keep its good things forever locked up from man. The only possible route carried the tracks across the Copper River. This stream is the outlet for the melted waters of the great Miles and Childs glaciers and it stretches from the foot of the ice of the Behring sea.

Across this, almost at the base of the glacier, it was necessary to erect a 1,150 foot bridge. In that arctic land literally hundreds of miles from any base of supplies there is today one of the finest railroad bridges in America. It is built on concrete piers that defy both fies and icebergs. In fact one of the piers is itself set in a base of glacial ice which in that climate is as unchanging as stone.

The contract called for the completion of the road in two years. This meant that the tracks would be laid east and west from the river at the same time that the bridge was being built. But a great many reputable engineers were not at all sure that the bridge could ever be finished. Its location was salmost in the shadow of those two frowning cliffs of ice. In spring and summer great pieces were constantly breaking off and crashing down into the water, there to rush toward the sea in the form of icebergs, sweeping away anything that got in their path. The river was hardly ever free from fies, and in winter the ice sheet was seven feet thick. During the spring floods the river had been known to rise twenty feet in a single day. Had this been clear water it would not have been discouraging. But remember, this water always carried with it ten upon ton of ice with here and there a towering berg that seemed large enough to crush any bridge that was ever built.

If the bridge should fall the rest of the line would be useless and its entire cost of \$15,000,000 would be lost.

The plans called for a four-span steel bridge resting on concrete piers forty feet above normal water level to allow for floods and the passage of ice. Also several barriers were to be built between the bridge and the glacial wall to intercept as much ice as possible.

Were it not for the fact that the Miles and Childs glaciers split long before they reach the sea into two separate walls of moving ice, each presenting a face three miles long, the

Copper River Valley would be impassable, as indeed it was considered for many years. To get material and supplies across the water that washed these two cliffs of ice was the first problem the engineers faced. A temporary bridge was not to be thought of. The first flow of ice would have carried it away like a house of cards. It was finally decided to establish a ferry. A heavily timbered boat was brought up from the coast.

On this clumsy craft, stationary engines, construction locomotives and cars, as well as ties and tracks, were transported across the river, often at great risk of life.

Of course, none of the heavy material for the bridge could be brought there until the track had been finished from the east to the edge of the river. But before this was done material was desired for the building of the line from the western bank of the stream. This was brought in up the river from the coast in heavy river boats, each handled by a crew of fifteen hardened rivermen and guides. It was impossible to paddle or sail any great part of the way, and during most of the journey the boats had to be towed along the shore by the men themselves.

The boatmen were often forced to wade for miles through water waist deep and as cold as ice could make it. In winter it would seem to have been an easy task to bring the supplies up the frozen surface of the river on sledges. But this was not so simple as it sounds. Even in winter the climate in that portion of Alaska is below zero one day and melting the next. Here there will be a solid mass of ice and just over the next rise there may be five feet of water. Thousands of tons of brush were laid on the surface of the ice in an effort to maintain a passable sledge road, but at best it was terrifically hard going.

The bridge piers, three of which were in deep water, were built in the dead of winter. This work had to be done through holes cut in ice seven feet thick. The molds for the concrete were then sunk from forty to fifty feet through the water and the river bottom to bed rock. These molds were heavily timbered boxes, their outsides armored with a succession of eighty-pound railroad rails. Above the molds ice barriers of rails were also sunk.

The engineers knew that if they could get the molds and piers down before the spring break-up they would be safe. For the river is tame only when held in its winter prison. In spring and summer it is a savage, ice-filled torrent. But one night, before the work was half done, the water suddenly burst forth from the depths of the glaciers and the river rose twenty feet. The great sheet of ice seemed ready to pull the molds and half finished piers out by the roots, but the work held and soon the temperature dropped again and the ice sheet solidified.

When the steel workers arrived on the first train that came through along the new tracks from the east they found that the temporary foundations between the piers had been made ready for them by driving one thousand piles fifty feet into the bottom of the stream. So well had the whole thing been timed that within an hour after that first train arrived with its welcome load of metal, which had been six months in coming from the mills, the first big girder was in place and the riveters had started their race to beat the spring thaw.

Day and night the workers faced the danger of having the results of their labor and suffering—for they did suf-

fer in a climate that was frequently twenty-five below zero—swept away by the ice that was growing less stable every hour. Also the time of the contract would terminate with the coming of spring, and when the first bolt was placed a margin of only six weeks was left.

Span No. 3, which was 450 feet from pier to pier, was the most difficult, for it was in the direct line of the greatest current and the heaviest flow of ice. By the bare space of an hour this span was saved from complete destruction. While the uncompleted steel work still rested on the temporary pile foundation it was discovered that it had slipped an inch out of alignment. This meant that the ice was moving. The break-up had started. In a few days the river would be a mass of churning ice and great bergs. Unless the span then rested solidly on its permanent concrete foundations, it would be swept away.

The first day's slippage of an inch increased next day to two, then to three, to four, and finally the whole span was fifteen inches out of line. The river was also rising. It climbed twenty-two feet while the men unbolted and shifted beams and girders to get them out of harm's way. If the pile foundations could be saved the bridge would be safe. As a last desperate resort every "donkey engine" boiler on the job was fired up and steam from scores of feed pipes was turned on the ice to keep it clear of the temporary bases. For days every man worked eighteen hours in the damp cruel weather of an Alaskan spring to save the bridge.

Heavy anchorages were built into the ice upstream and by means of block and tackle the slipping span was literally dragged back into its proper alignment. When this was done the iron workers set with frantic haste to bolt the steel parts together, for the piles could hold but a few days longer. Just an hour after the last bolt was placed, the last block knocked out and the span dropped upon its safe bed of concrete, the ice broke up with an angry roar and the temporary foundations went downstream like so much driftwood. But the bridge had been built. It defied the glaciers.

There is not space here to detail the hardships of the men who laid the tracks across the rugged surface of the land east and west. Washouts and avalanches were almost of daily occurrence. Once a rotary snowplow, pushed by two locomotives, started out to clear the twenty foot drifts from the tracks to the base of supplies fifty miles away. It disappeared in a white wave and was not seen until a month later. It had taken thirty-one days to travel the fifty miles and its crew had eaten their last bit of food the day before it steamed into the station.

The man who carried this great work through to completion gave up his life for it. Erastus Hawkins was his name and he has left a worthy monument behind. When he returned to New York after the completion of the bridge he was so broken in health from hardship and exposure that he never recovered his strength and died a few months after the first train crossed the Copper River.

### Colorado.

On Friday the Colorado debaters will meet their final opponents of the debating contest for the year. This debate against Utah will determine whether or not Colorado shall have three victories out of five intercollegiate debates held this year. Colorado now stands two and two, having lost to Kansas and Oklahoma, and won over Missouri and Texas. The question of these debates is, "That boards of arbitration with compulsory powers should be established to settle disputes between employers and employees." Colorado is confident of victory over Utah.

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