THE NORTHERN ENGINEER

Volume 8, Number 2

Summer 1976

EDITORIAL

"There is nothing permanent except change." As Gina Brown wrote in her last editorial, she would be leaving *The Northern Engineer* to live and work outside of Alaska. Before she left, she spoke to us, the new Editor, of her pleasure in working with the magazine, of the cooperation she enjoyed from its contributors and her satisfaction in producing an engineering journal of quality. Gina will be missed, but we hope to carry on her high standards and continue to provide our subscribers with a readable, informative and interesting publication.

Many things have conspired to delay timely publication of *The Northern Engineer* during the past year, a condition we hope to remedy. We welcome the suggestions, contributions and opinions of our readers so that we may publish a useful, up-to-date magazine. We look forward to a long and mutually rewarding association with all of you.

Judith Holland
Editor
The Northern Engineer

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COVER PHOTOGRAPH is a montage showing some of the difficulties encountered during construction of the Alcan Highway. The pictures are from Mr. Lyman Woodman's article in this issue on the building of the Alcan Highway.

THE NORTHERN ENGINEER is a quarterly publication of the Geophysical Institute, University of Alaska — Dr. T. Neil Davis, Acting Director. It focuses on engineering practice and technological developments in cold regions, but in the broadest sense. We will consider articles stemming from the physical, biological and behavioral sciences, also views and comments having a social or political thrust, so long as the viewpoint relates to technical problems of northern habitation, commerce, development or the environment. Contributions from other polar nations are welcome. We are pleased to include book reviews on appropriate subjects, and announcements of forthcoming meetings of interest to northern communities. "Letters to the Editor" will be published if of general interest; these should not exceed 300 words. Subscription rates for *THE NORTHERN ENGINEER* are $10 for one year, $15 for two years, and $35 for five years. Address all correspondence to THE EDITOR, THE NORTHERN ENGINEER, GEOPHYSICAL INSTITUTE, UNIVERSITY OF ALASKA, FAIRBANKS, ALASKA 99701, U.S.A.

ICE AND SNOW CONSTRUCTION

by Donald E. Keyes

INTRODUCTION

The construction experience gained on the Trans-Alaska Pipeline Project from 1970 to 1976 can be used in future development planning to reduce environmental disturbances, resource commitments, and capital investment.

The use of ice and snow as construction materials in building temporary workpads, roads, airfields, and bridges has been demonstrated as a workable alternative to more traditional building materials in arctic and subarctic regions.

SNOW PADS

Planning and Site Selection

Project planning for the summer construction season requires consideration for mobilization of men, equipment, and materials over frozen winter terrain. Overland travel during thaw periods through boggy tundra, dense forests, and river valleys is restricted by equipment limitations and possible environmental damage. Water transportation is limited in some areas and non-existent in others. Air access is often difficult because airstrips near a construction site in undeveloped areas and cargo space are limited. Both aerial photos and topographic maps are useful in planning access routes and selecting suitable sites. Verifying topography and soil conditions for a selected site in both summer and winter is highly recommended. A complete site map should be prepared for field use during all phases of mobilization and construction.

Several factors must be considered in designing access routes:

1. All existing drainage patterns should be verified during runoff periods prior to mobilization and development. This is crucial in determining long-term environmental effects. Because construction of trails can cause natural runoff barriers or channels which concentrate water flow, the restoration of natural drainage prior to breakup is most desirable.
2. Projected use of the route will influence ultimate design criteria such as width, grades, cross slopes, and alignment.
3. The topography, gradient, and cross slope control location of the chosen site. Snow pads can generally accommodate only minor adjustments. The thickness of the pad is limited by available snow. Generally, trails should have minimum cross slopes of less than 5% and grades less than 12%.
4. Fill ramps are preferable to disturbing stream banks. Drainages should be crossed at locations requiring minimum disturbance. Snow can be used to build pads in narrow depressions.
5. Final disposition of the site must be considered.

Surveying and Flagging the Right-of-Way

Before work begins, the rights-of-way must be surveyed and flagged to restrict construction to the actual site. Clearing by hand, hydro-ax, or dozer should be completed when the ground is frozen.

Work should not begin until sufficient snow depth exists to protect the vegetative mat from equipment damage.

The vegetative cover should be preserved as protection against thermal or mechanical erosion. This will minimize restoration work and expense while protecting the area from silting or the mass movement of soils.

Snow Ramp

Drainage crossings using snow ramps are most desirable. Larger rivers may require the construction of an ice bridge which is described in detail further on. Damage to existing surface drainage channels can be minimized by restricting activities.

Snow Collection and Compaction

In timbered areas, snow collection is restricted by existing vegetation and the difficulty of operating equipment on an uncleared site. Several techniques are possible in treeless areas where prevailing winds move snow. Snow fences can be effectively used for collection downwind or windrows made by graders can collect additional snow. Compacting snow on the site allows drifts to form in the depressions. The route can be selected to take advantage of land forms as natural snow traps.

Snow must be compacted to provide the necessary support for surface activities and to protect the underlying mat. Construction equipment can be used to densely pack the snow by dragging and leveling the surface. No traffic should be permitted for at least 12 hours to allow sintering (cementing) of the snow crystals. Sintering occurs most effectively at temperatures between -50° and -20° F. During thaw, activity must be scheduled to take into account the stable, early morning period and the weaker surface conditions during the day.

Maintenance

Systematic maintenance is required to keep the pad serviceable. The degree of use, temperature, and blowing snow dictate when maintenance will be required. Prolonged use of an unmaintained pad will result in soft spots and chuckholes. Warmer temperatures cause the pad to weaken and break down under heavy loads and drifting snow makes trails impassable for some types of traffic. Spring maintenance to remove dark surfaces will extend the snow pad's usefulness. Motor patrols, similar to those used on gravel roadways, are recommended.

Putting Trails to Bed

The most important action in protecting the environment is to discontinue use of the trail when it begins to break down from melting temperatures. Restoration by revegetation of the disturbed areas is required to prevent erosion. Some snow berms, ramps, and pads must be breached to allow natural drainage and prevent fish blockages during spring breakup.

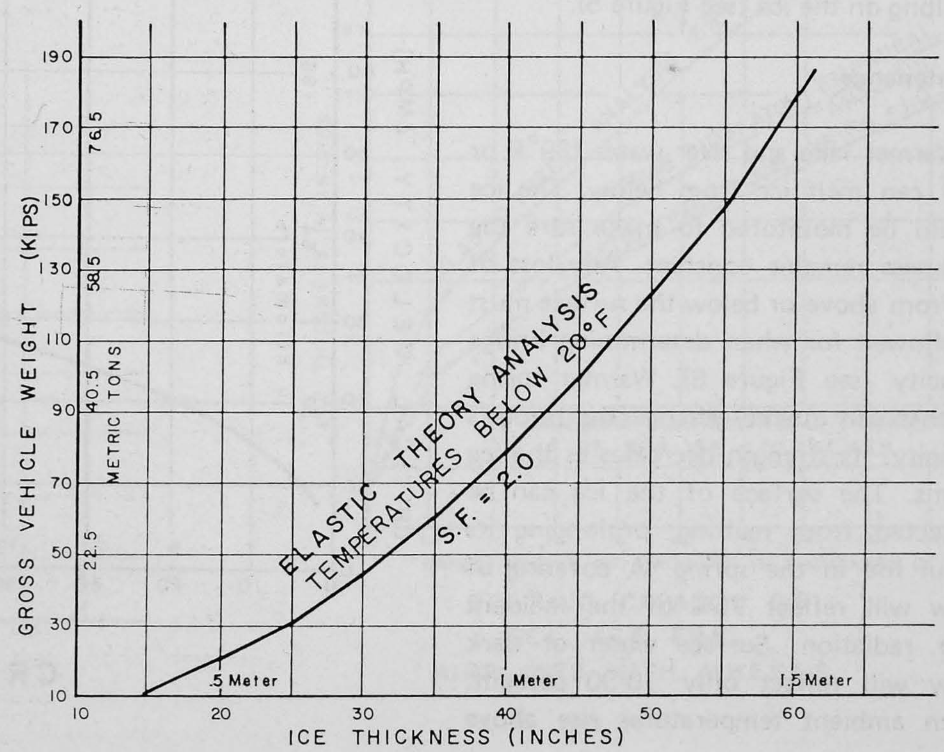
ICE BRIDGES

Ice bridges are constructed by adding thickness to naturally-formed lake and river ice to provide the necessary structural strength to permit winter crossing.

Construction is relatively simple, but depends upon weather and the time needed to freeze water. This time constraint can be minimized by adding thin applications of water to the surface of existing ice which allows rapid freezing. Snow removal will facilitate deeper natural freezing by reducing the heat flow resistance. If natural flooding has occured, the capacity of the bridge must accommodate "white ice" strength which is one-half the strength of clear ice. An approximation of effective ice depth can be made if all white ice layers are considered at one-half their actual thickness. Figure 1 shows a method of determining the ice thickness required to support anticipated traffic assuming a continuous uniform ice sheet. Figure 2 shows the width necessary to develop the capacity of the ice bridges. [Feathering of the surface should extend beyond this indicated width. This is necessary to develop strength for the perimeter of the stress circle.]

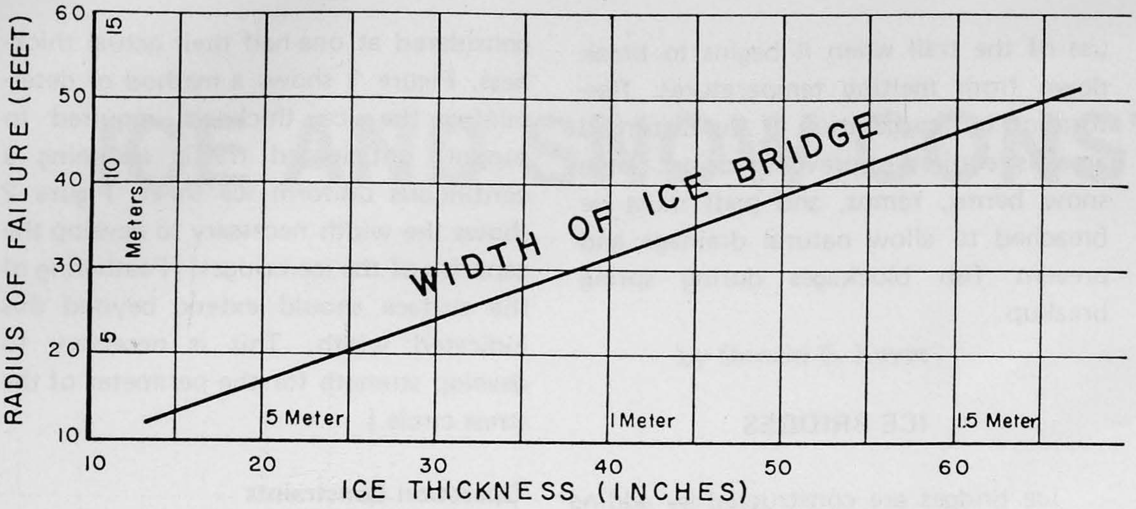
Operation Constraints

The bridges should be posted with recommended load limits for operator safety. Ice acts as a flexible plate and deforms under loading. This deformation results in stress distribution away from the load similar to a continuous beam. At some distance out from the load there is a point of flexture where the bending stress is neutral and reverses. As the load moves across the ice, the point of flexture also moves. Vehicles often move faster than the ice can bend which causes critical stresses in the ice sheet. Posted speed limits, if observed, can prevent potential failure of the bridge (see Figure 3). Maximum recommended speeds depend



FRESHWATER ICE DESIGN LOADING

(FIG. 1)



BRIDGE DESIGN WIDTH

(FIG. 2)

on water depth and are necessary on long lakes or wide rivers.

For vehicles carrying heavy loads, minimum spacing distances between vehicles should be posted (see Figure 4). Two loaded vehicles traveling together are considered one and their combined weight must be allowed for in safety planning. Heavy loads should be restricted to one-way traffic.

Ice is very elastic and exhibits plastic creep under continuous loading. This may result in failures if heavy loads are parked too long on the ice (see Figure 5).

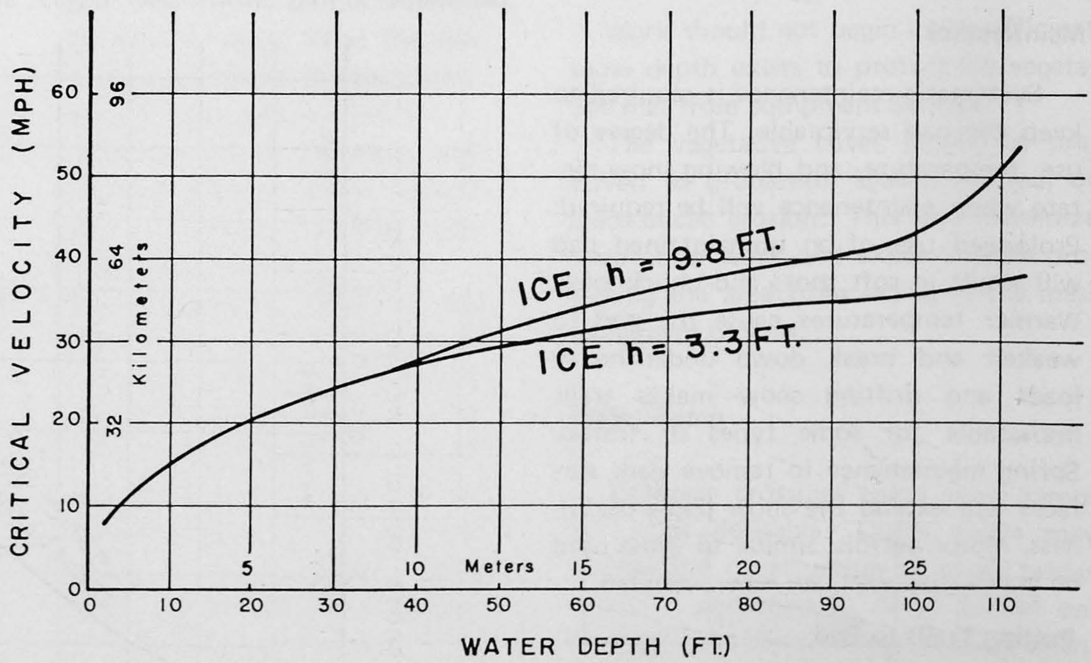
Maintenance

Warmer lake and river water (39°F or 4°C) can melt ice from below. The ice should be monitored to make sure the thickness remains constant. Any loss of ice from above or below the surface must be allowed for when determining bridge capacity (see Figure 6). Warmer spring weather can quickly change the bridge's capacity. Its strength decreases as the ice warms. The surface of the ice can be protected from melting, prolonging its useful life in the spring. A covering of snow will reflect 75% of the incident solar radiation. Surface water or dark snow will reflect only 10-30 percent. When ambient temperatures rise above +15°F (-12°C), the posted load limits must be revised to compensate for weaker ice conditions. Operations should be discontinued at temperatures above 40°F (5°C).

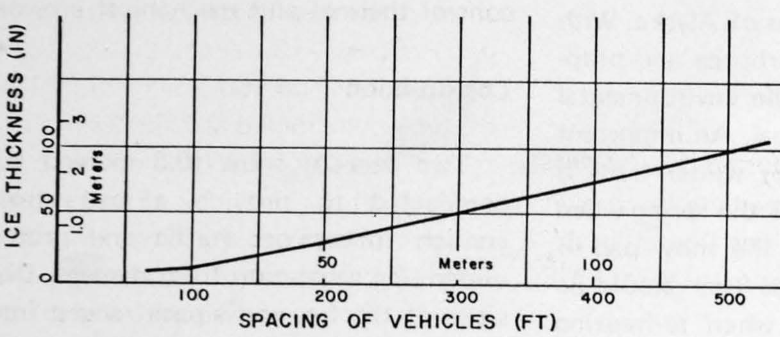
AIRFIELDS

Ice and snow runways can be constructed with minimal environmental disturbance and cost by following the same procedures outlined for ice bridges (see Figures 7 and 8).

Mobilization for the Trans-Alaska Pipeline in 1970 and 1974 required massive air support. With little or no facilities available north of the Yukon River, Alyeska was obliged to design and construct temporary airstrips to move the men, supplies, and support equipment necessary to build permanent gravel runways. An initial overland effort using snow roads was begun with the support of Hercules C-130 aircraft. An ice strip, 5,000 ft long and 150 ft wide (1,500 x 45 m), was constructed at Lake Galbraith on the north side of the Brooks Range (Lat. 68°30′ N), where, by February, the existing natural ice sheet was over 60 in. thick. A motor patrol leveled snow drifts in a few hours and aircraft immediately began using the runway. The only maintenance required was to remove snow drifts when they occured. There were no environmental problems caused by construction of the runway and spring melting obliterated all signs of activity. Associ-

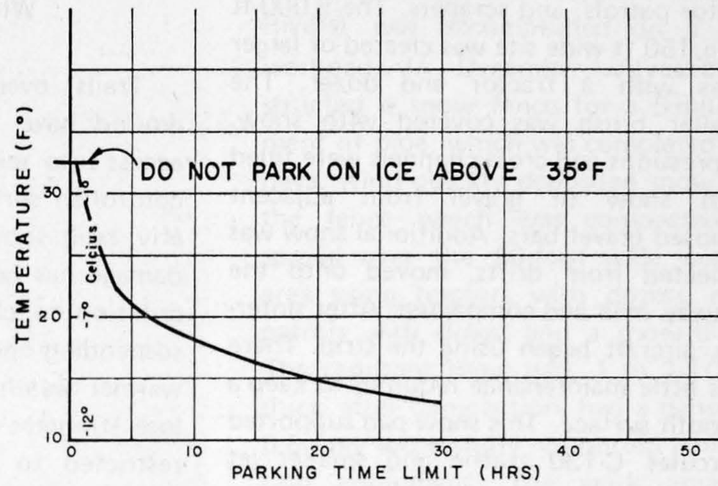


CRITICAL VELOCITY
OF VEHICLES
(FIG. 3)



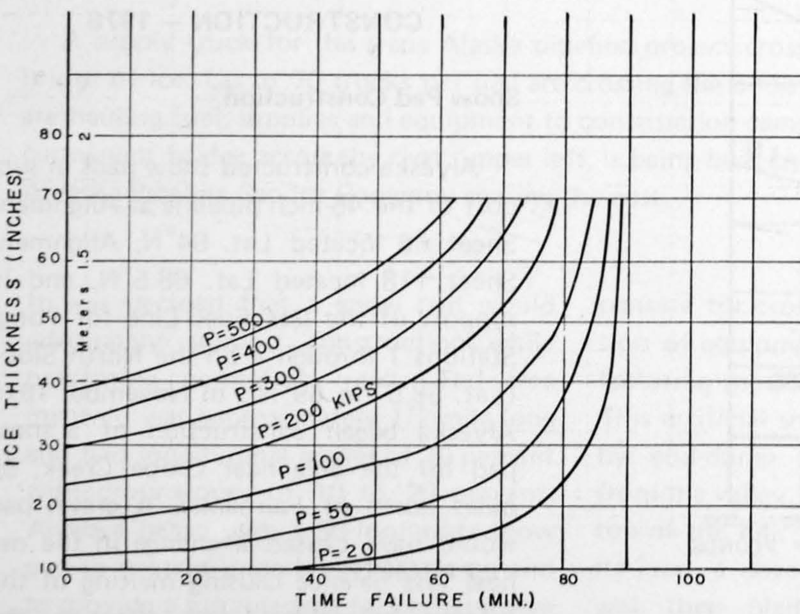
RECOMMENDED TRAFFIC

(FIG 4)



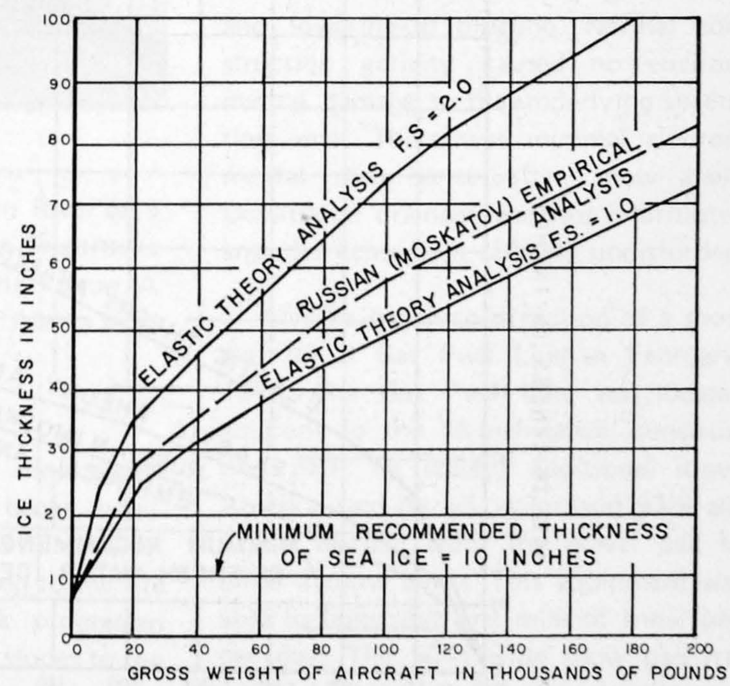
RECOMMENDED PARKING TIME (ANTICIPATED FAILURE)

(FIG. 5)



PREDICTED FAILURE TIME

(FIG. 6)



BEARING CAPACITY OF SEA ICE FOR AIRPLANES WITH WHEELS

(FIG. 7)

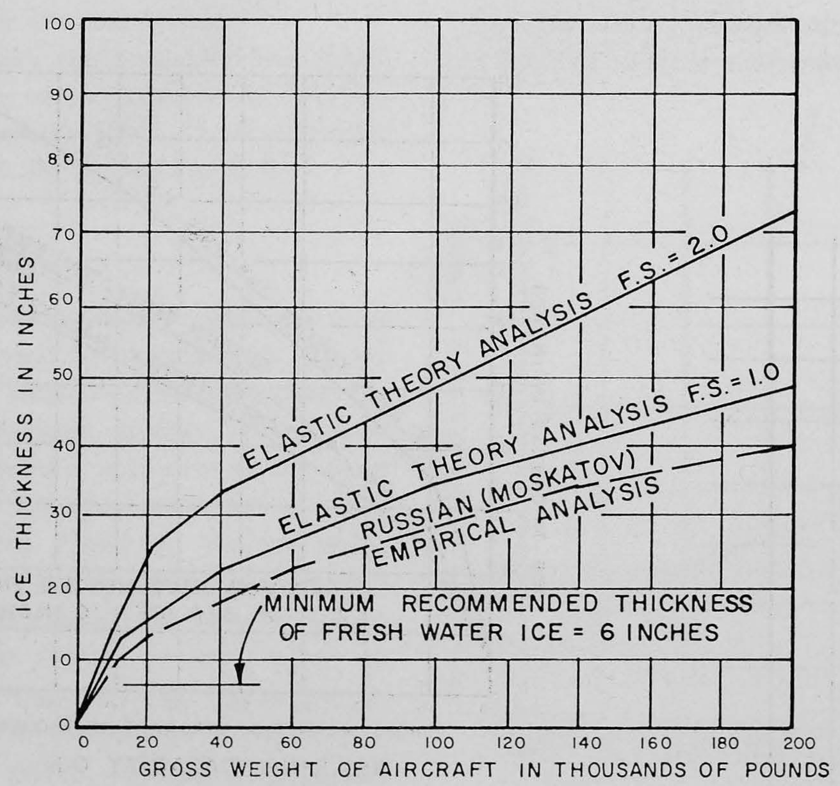
ated activities, however, caused some damage and pollution to adjoining land.

During 1974, APSC required air support at Coldfoot Camp (Lat. 67°N) and a snow pad runway was constructed on the Koyukuk River gravel bars. Construction began in February and was completed in two weeks with a few tractors, dozers, motor patrols, and scrapers. The 5,000 ft long, 150 ft wide site was cleared of larger trees with a tractor and dozer. The smaller brush was covered with snow. Depressions and cross channels were filled with snow or gravel from adjacent exposed gravel bars. Additional snow was collected from drifts, moved onto the runway area and compacted. After sintering, aircraft began using the strip. There was little maintenance required to keep a smooth surface. This snow pad supported Hercules C-130 traffic and smaller jet aircraft.

Restoration entailed providing drainage for spring runoff and regrading the gravel to its original contours. A minimum amount of vegetative undercovering was destroyed. There was very little erosion from subsequent floods and no shifts in river drainage patterns have occurred.

WINTER TRAILS

Trails over snow pads on frozen ground have been used extensively for access into remote areas of Alaska. With controlled surface disturbance and properly built snow pads, the environmental damage has been minimal. An important criterion to consider for winter trails is suspending operations in the spring when warmer weather causes the snow pad to lose strength. Use of the trail should be restricted to evenings when re-freezing has occurred. There is a greater danger of break throughs in the spring, resulting in traffic halts.



BEARING CAPACITY OF FRESH WATER ICE FOR AIRPLANES WITH WHEELS

(FIG. 8)

Alyeska moved equipment over snow pad trails in the winter of 1974-1975 from the Yukon River to Dietrick Camp and to the North Slope. Operations began in late December and by February traffic was moving north on trails opened to Dietrick Camp, a distance of some 200 miles. This trail was rehabilitated and revegation has nearly covered all areas. In a very few locations, trails intercepted drainage and diverted water resulting in hydraulic erosion which required extensive restoration of drainage patterns to control thermal and mechanical erosion.

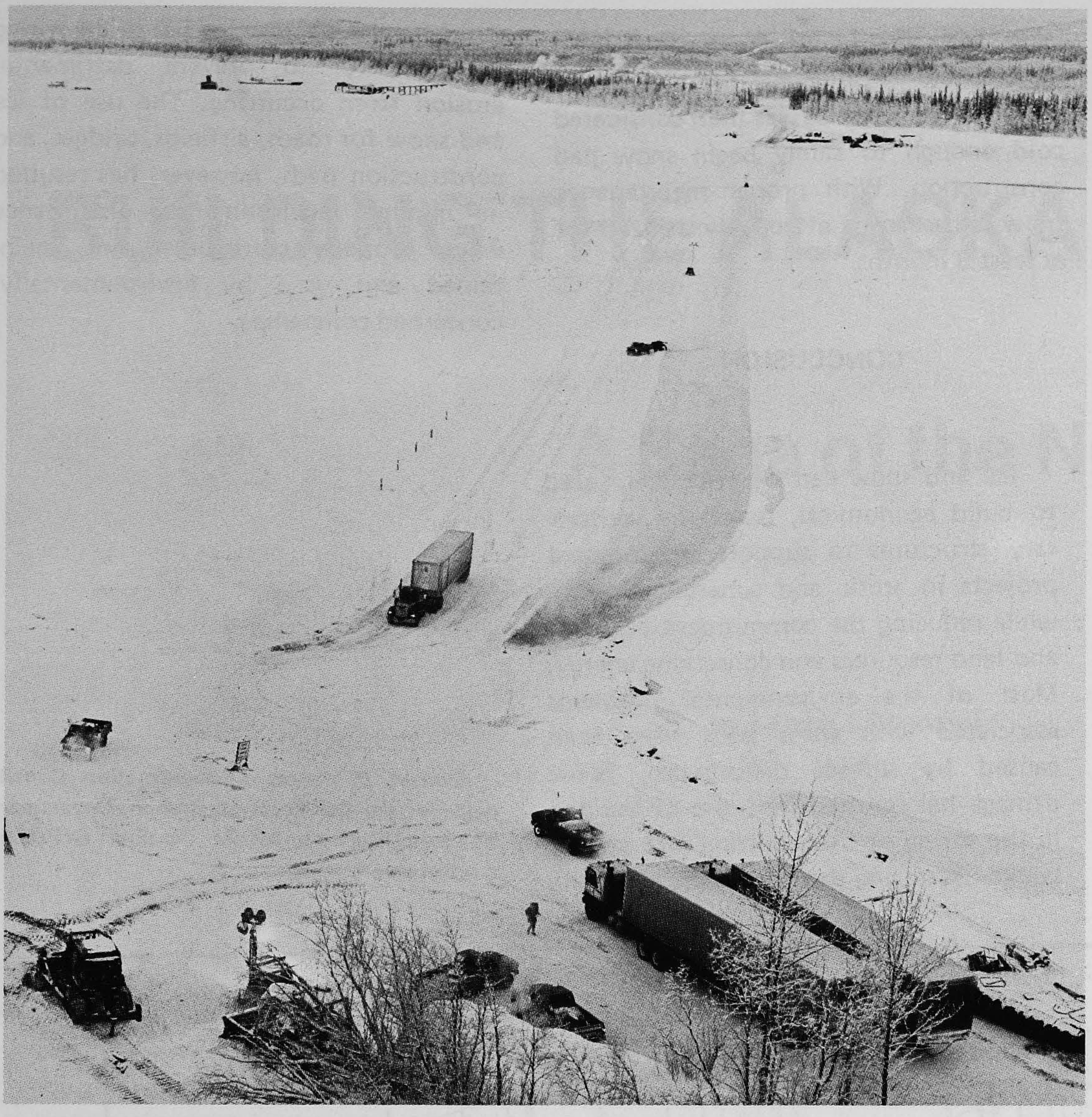
Construction

Two feet of snow (0.6 meters) was compacted to provide a pad strong enough to support traffic and protect underlying vegetation from damage. Densities of the free snow pack ranged from 0.1 to 0.2; the windblown pack ranged from 0.2 to 0.3, and mechanically compacted pads from 0.4 to 0.6. After sintering, mechanically compacted snow will support highway vehicles with tire pressures to 100 p.s.i. and all heavy construction equipment.

TRANS-ALASKA PIPELINE CONSTRUCTION – 1976

Snow Pad Construction

Alyeska constructed snow pads in support of the 48-inch pipeline at Alignment Sheet 66 located Lat. 64°N, Alignment Sheet 118 located Lat. 68.5°N, and in support of the Gas Fuel Line for Pump Stations 1 through 4 on the North Slope (Lat. 68.5° to 69°N). In November 1975 Alyeska began construction of a snow pad for the area near Globe Creek, 50 miles north of Fairbanks. A gravel pad would have caused a change in the net heat loss balance causing melting of the ice-rich permafrost and affecting the integrity of the vertical support members.



A supply truck for the trans Alaska pipeline project crosses the Yukon River on a bridge of ice. Up to 70 trucks per day are crossing the 6-foot-thick bridge. The trucks are hauling fuel, supplies and equipment to construction camps north of the Yukon. A permanent bridge across the river, upper left, is being built by the State of Alaska with Alyeska Pipeline Service Company sharing the cost.

It was decided that a snow pad would adequately support construction while preventing permafrost melt. The area involved was approximately 1/2 mile long and had longitudinal grades of 30 percent with cross slopes of 10 to 20 percent. Alyeska began with a 50-foot wide snow pad to protect underlying vegetation and to provide a suitable area for construction equipment. The snowfall in November was less than 24 inches, insufficient to build a snow pad thick enough to compensate for cross slopes and allow operation of equipment. Alyeska began manufacturing snow at a stream, 3 miles away. This artificial snow was hauled to the site by end-dump trucks. Work progressed from the valley, up the steep slopes to the top of the hill. After each truck dumped its load, a dozer spread the snow, which was then bladed. Equipment activity compacted the snow sufficiently to provide a stable pad. The snow varied in thicknesses from 6 inches to over 5 ft on the lower side of the pad. The actual construction required 3 weeks to complete. Minimal environmental damage occurred after thaw, yet pipeline integrity was preserved.

Approximately 5 miles of construction for the 48-inch pipeline elevated mode on Alignment Sheet 118 (east of Toolik Camp between the Kuparuk and Sag Rivers) was accomplished on a snow workpad. In December, Alyeska constructed a snow fence for a 5-mile segment of pipe, which was completed in 24 days. Wind quickly deposited snow along the fence which was compacted and spread over the 50-foot wide workpad area using tractors with dozers, motor patrols with drags, and a snow blower. The resultant snow pad, 1 to 1-1/2 feet thick after compaction, had a density of 0.6 and successfully supported construction equipment. The work area was generally flat, with minimal side slopes and 0 to 10 percent grades. The work, although not completed, included installing vertical support members, support cross members, and stringing, welding, and lowering-up pipeline. Normal construction activity caused no environmental damage to the underlying vegetation mat. There was minimal environmental disturbance after snow melt. Downslope drainage was not interrupted and the ecosystem remains undisturbed.

Alyeska began construction of a snow pad for a Gas Fuel Line in February, 1976. The Gas Fuel Line was located adjacent to the 48-inch gravel construction pad. To collect additional snow, Alyeska used dozers, drags, and grade-alls which worked from the gravel pad to build a snow berm. This equipment was able to construct one mile of snow pad per day. The 50-ft wide snow pad traversed grades up to 20 percent with cross slopes up to 10 percent. About sixty miles of snow pad were constructed during the winter of 1975-76 and used until May 1. Environmental disturbance has been minimal.

COMPARISON OF CONSTRUCTION ALTERNATIVES

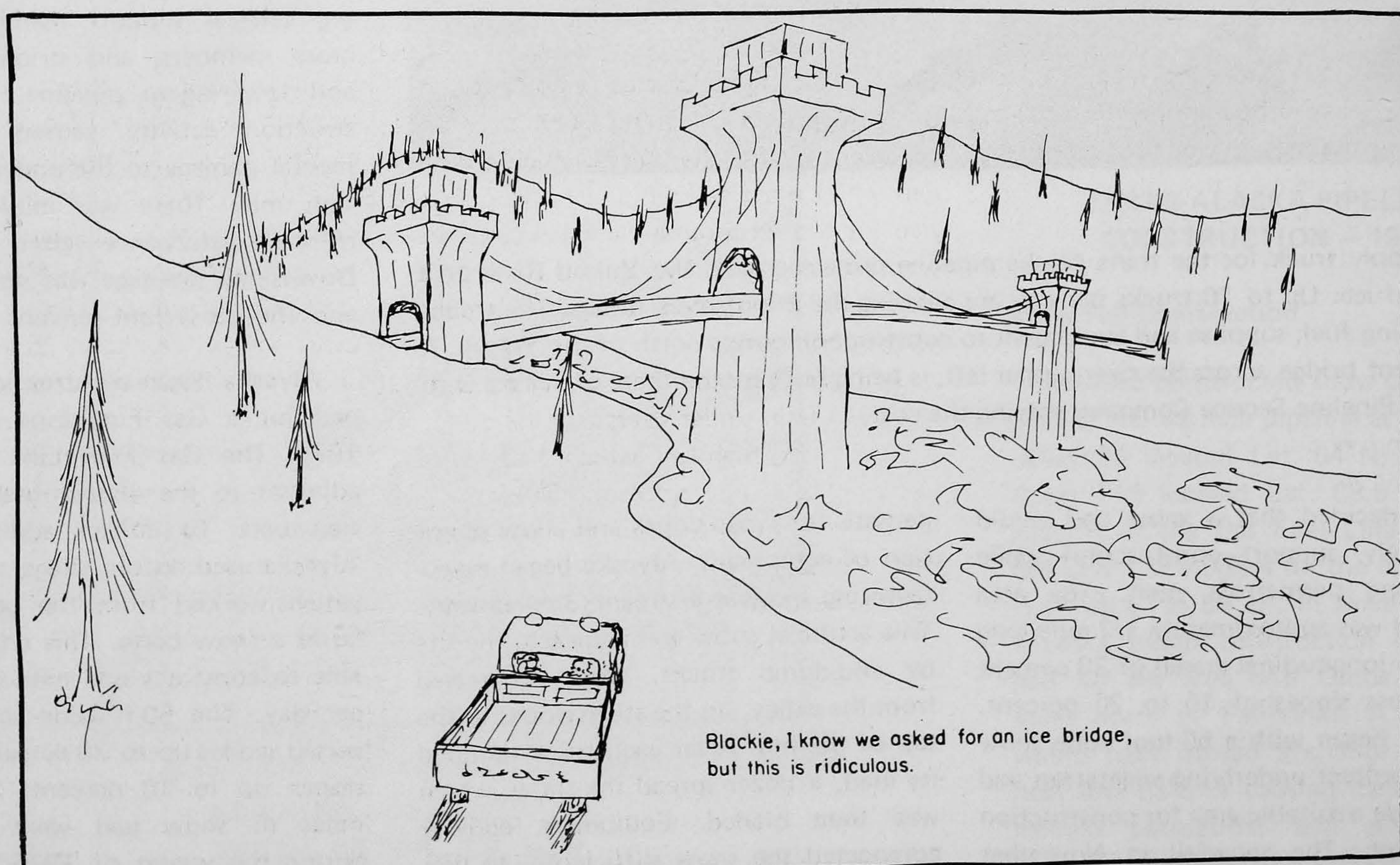
The Trans-Alaska Pipeline also used gravel pads to support year-round efforts. On the North Slope, 5 ft of gravel will not only prevent thermal degradation, but will cause intrusion of the permafrost layer up into the pad itself. On the other hand, 6 feet of gravel in interior Alaska is not thick enough to completely eliminate melting, but will reduce the melt rate to the point that reasonable maintenance can insure a serviceable roadbed.

The snow pad technique requires waiting for colder weather to provide sufficient snowfall for necessary structural depth and surface protection. Measurements made on the North Slope from November 7 to December 2, 1975, revealed most rivers were frozen solid and lakes with depths of 4 to 10 ft (1-3 meters) had ice thicknesses of 2.7 ft (0.8 meters). The weather was then considered cold enough to safely begin snow pad construction. With proper maintenance snow pads can be effectively utilized for at least 3 months.

CONCLUSION

Ice and snow can be effectively used to build economical, functional, temporary structures to support development projects in arctic and subarctic regions, while reducing the commitment of gravel and land resources and conserving energy. Most of the environmental problems associated with snow pads have been caused by surface disturbance. Some damage has resulted from use of the pad in the spring or from cutting into stream banks. Restoring drainage channels in the pad before discontinuing use in the spring is necessary to prevent detrimental erosion from occurring. The use of ice and snow for roads, airfields, bridges, and construction pads, however, has resulted in minimal environmental disturbance when properly constructed and maintained and used by environmentally-concerned companies.

Donald E. Keyes is Construction Coordinator of the Construction Branch, Department of the Interior's Alaska Pipeline Office in Anchorage, Alaska.



(Original source unknown but *TNE* appreciatively acknowledges the anonymous cartoonist.)

BUILDING THE ALASKA HIGHWAY

A Saga of the Northland

by Lyman L. Woodman

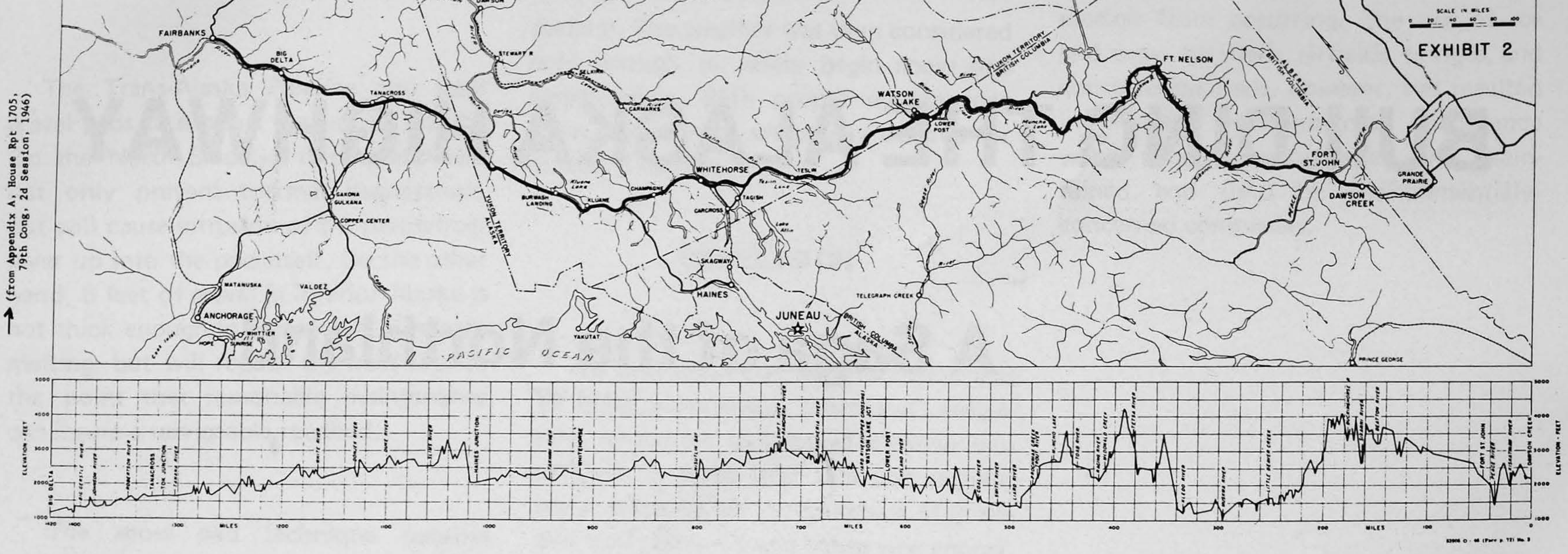
In 1942, ten thousand men from all walks of life who had donned uniform to serve their country in war time received a unique assignment in the subarctic. Inexperienced in construction though they were, and led by only a handful of professional military engineers, they were given a challenging task of tremendous scope and told to complete it in an unbelievably short time under extremely frustrating conditions. Their job — to build a 1,450-mile road through the wilderness from eastern British Columbia to Alaska. And so they did. With selfless teamwork, great ingenuity, and high spirits those tough, fast-learning U.S. Army Engineer troops pushed it through in a remarkable eight months.

Construction of the Alaska Highway — initially called (among other less flattering things) the ALCAN Highway — has been labelled second only to completion of the Panama Canal in the Corps of Engineer's long register of important and difficult projects.[1] It was not only an achievement for the Army which shouldered the main task, but a notable feat also for the six thousand civilian contract workers engaged by the U.S. Public Roads Administration to carry out supplementary work.

Alaska's first land link with "the Outside" was built under stress and the threat of war. The highway which had been contemplated and urged for 13 years was to become a reality after the attack on Pearl Harbor, December 7, 1941, magnified the need for that corridor to our Last Frontier.

Pre-War Efforts

Serious steps leading to a possible highway began in 1929. The idea had been discussed many times by a number of individuals, foremost among them, Alaskan civil engineer Donald MacDonald of Fairbanks. 1929 saw the establishment of organizations dedicated to get action. These were the International Highway Associations (IHA) that MacDonald initiated, with branches in Fairbanks; Dawson City, Yukon Territory; Vancouver, B.C.; and Seattle. These agencies were to stimulate public interest and advocate the project to the Government. Coincidentally, the government of British Columbia initiated inquiries on the subject and an informal exchange of views occurred between Canada and officials of the Territory of Alaska. The IHA plan was endorsed by many associations and commercial bodies in Alaska and the States (particularly Chambers of Commerce in nine cities), auto and mining clubs, the National Highways Association, the American Automobile Association, and the U.S. Chamber of Commerce. The



A map showing the route of the Alcan Highway. This map was used in a report (House Report 1705) to the 79th Congress in 1946.

Alaska legislature adopted a memorial to Congress in 1929 endorsing the project and petitioning that steps be taken to arrange conferences on it between representatives of the United States and Canada.[2]

An Act of Congress in 1930 authorized the President to appoint a Commission "to cooperate with representatives of the Dominion of Canada in a study regarding the construction of a highway to connect the northwestern part of the United States with British Columbia, Yukon Territory, and Alaska with a view to ascertaining whether such a highway is feasible and economically practicable." Follow-up legislation appropriated $10,000 in support of the Commission's study.

The Commissioners were Herbert H. Rich of Detroit (Chairman); Ernest W. Sawyer, Assistant to the Secretary of the Interior; and Major Malcolm Elliott, U.S. Army Corps of Engineers, then president of the War Department's Alaska Road Commission (ARC) and for whom the Elliott Highway was named.

The study group was aided in its collection of facts by information and maps obtained through our Interior and State departments, from cooperating Canadian representatives who had performed aerial and ground reconnaissance in northern B.C. and in the Yukon, and from an international motor caravan organized and conducted by the premier of the province that drove from Vancouver to Hazelton, B.C. The envisioned road was then called the Pacific-Yukon Highway.

In their 1933 report,[3] the Commission concluded that a highway connecting the aforementioned areas "is a feasible project and can be built at a reasonable cost." They estimated up to $2,000,000 for the Alaska section and $12,000,000 for the Canadian portion, with the highway beginning at Seattle and ending at Fairbanks. Some 850 miles of the road already existed between Seattle and Hazelton, leaving 1,374 miles to be built. Financing would be by the two governments in proportion to the construction miles within their jurisdictions. It was suggested that the Alaska section be financed at the 90-to-10 ratio of federal and local funds as then prevailed under the Federal Highway Act in the sparsely settled states.

Two general routes for the highway were found acceptable from the American viewpoint. One would go north through British Columbia from Vancouver via Prince George, Hazelton, Dease Lake and Atlin, and through the Yukon Territory communities of Carcross, Whitehorse, Carmacks, Minto, to Dawson City on the Yukon River. (In part, this covers a portion of today's Cassiar Highway.) From Dawson City it would swing south "ascending some favorable branch of Fortymile River," meet the Richardson Highway in Alaska at McCarty (now Big Delta), and then go about 90 miles northwest to Fairbanks.

There were two possible alternative routes going eastward from Fairbanks toward Canada. One would leave the

Pioneer road about 40 miles south of Watson Lake.

Each pack train taking supplies to the surveying and locating parties at the head of the trail was accompanied by an Indian guide.

Richardson Highway at McCarty and follow the Tanana River practically to its headwaters and go on to Whitehorse. The other route would take off from the Richardson Highway at Gulkana and run almost due east via Nabesna and the White River to Kluane Lake, then on to Whitehorse. Either of these latter courses would miss Dawson, a town the Canadians hoped would some day be linked with Whitehorse.

Appendix E to this 1933 Commission document was an extract from a report by Donald MacDonald (then Locating Engineer of the ARC) of his reconnaissance of the area lying between McCarty and the Canadian border.

The Commission recommended to Congress in May 1933 that intergovernmental negotiations be conducted leading to agreement on a survey and preparation of specifications and cost estimates. They proposed construction of the Fairbanks-Dawson City segment immediately, without waiting for adoption of the whole project.

Eight months later, Alaska's Delegate to Congress, Anthony J. Dimond, introduced a bill for construction of a highway between the United States and Alaska. The War Department, questioned on the military value of such a road, believed they could continue to rely almost exclusively on ships for transporting troops, equipment, and supplies to Alaska. They concluded that, while such a highway might be desirable as a "long-range defense measure," it could be justified "only under low priority."[4]

The significance of a German military study made at about this time came to light rather late in the day. It was an "Alaska Plan" drawn up in Nazi Germany's Geopolitical Institute in Berlin. When that nation and Russia were on friendly terms this plan envisaged the invasion of the United States by way of Siberia, Kamchatka, the Bering Strait and Alaska.[5]

In 1938, and again in August 1940, the Army was queried anew on the road's military value, and the reply was that it was negligible. Alaska's Territorial Assembly urged Congress in 1939 to construct the highway, citing as one reason that "the interest of national defense would be greatly served by this project." In 1940 a Seattle newspaper quoted HOCHI, a Japanese journal, as saying that Japan was greatly disturbed about reported plans for building a military highway from the United States to Alaska through western Canada. Concern was also expressed about a reported string of airbases to be built along the highway.[6]

Delegate Dimond introduced another bill for the highway on February 5, 1941, which also came to nought. But meanwhile, other efforts were being made to secure action in the matter. The Alaskan International Highway Commission, created by Congress in 1938 and chaired by U.S. Rep. Warren G. Magnuson, had rendered a favorable report in April 1940 which President Roosevelt transmitted to Congress.[7] The Canadians would provide the right-of-way for the highway only if the U.S. would assert that it would be militarily valuable. To get this statement, Representative Magnuson provided the Secretary of War with an analysis of two routes through Prince George, B.C., then under consideration; but again, in April 1941, the Department response was negative. In August, Delegate Dimond insisted that "the immediate construction of a highway to Alaska is not only economically justified, but is demanded by considerations of national defense." It was not, however, until October 6, 1941, that the War Department stated that "from the evaluation of the trend of international affairs, the construction of this highway now appears desirable as a long-range defense measure."[8] Two months later the Japanese attacked Pearl Harbor. Said Alaska Territorial Governor Ernest Gruening: "The highway was built in great haste, at great cost, and over a previously unsurveyed route, after the

Construction camps of pyramidal tents heated by small metal wood-burning stoves were the "motels" of the Army Engineers working on the Alaska Highway.

Pontoon bridge over Little Liard River allowed traffic to move forward while the semi-permanent structure was being built.

Pushing and/or pulling foundered trucks along the muddy pioneer road was a continuing assignment for roving tractors.

United States was at war."[9]

Bomb Burst Reaction

The disaster at Pearl Harbor generated interest among military planners in a new link with Alaska, and the War Plans Division now supported a road to provide an overland emergency supply route to isolated Alaskan outposts. The only direct connection between the States and Alaska was by sea or air. In effect, Alaska was an island rather than a peninsula and it lacked a well-developed internal transportation system as well. Although supplies and equipment that might be brought north by road would still encounter distribution problems within the Territory, a cross-Canada trek would be safe from enemy submarines. And the highway, in the meantime, could supply the string of airfields from Edmonton, Alberta, to Whitehorse which were being built by Canada as part of its contribution to hemispheric defense.

On January 16, 1942, President Roosevelt asked a committee of Cabinet members to study the need for a highway to Alaska, and if construction appeared practicable, to decide on the best route. Heeding the advice of the General Staff, the Air Staff, and Engineer members of the War Plans Division, the committee quickly recommended building the road along the line of the staging fields from Fort St. John to Big Delta, with construction starting at Dawson Creek, the end of the Northern Alberta Railways line 50 miles southeast of Fort St. John. The committee also recommended that the Chief of Engineers be responsible for the work. The staging fields were at Edmonton and Grande Prairie, Alberta; Fort St. John and Fort Nelson in British Columbia; and at Watson Lake and Whitehorse in Yukon Territory. They would constitute the nucleus of the Northwest Staging Route between Alaska and the rest of the United States, and support of that route was the main justification for the ALCAN.[10] In Alaska the air route included Northway, Tanacross, and Big Delta.

On February 2, 1942, the War Plans Division informed Brig. Gen. Clarence L. Sturdevant, Assistant Chief of Engineers in charge of Troops Division, of its decision to build, and directed him to submit a plan for survey and construction. Sturdevant consulted his staff and the head of the Public Roads Administration (PRA), and two days later furnished a two-phase plan for construction of a 1,500-mile highway. First, Army Engineers would push through a pioneer road, then PRA would have civilian contractors transform it into a permanent road. The use of soldiers for the first phase would be faster than trying to assemble and organize a civilian construction force for a big job that needed to be started quickly.

Green Light from FDR

A week later, on February 11, President Roosevelt approved the general plan and on the 14th the Chief of Engineers was given the green light to proceed.[11]

Roosevelt's approval of the road along the Northwest Staging Route was sparked by his concern over a disastrous flight in January when a number of military aircraft crashed on their way to Alaska.[12]

Meanwhile, formal discussions between the governments were taking place on the diplomatic level. The Permanent Joint Board on Defense, Canada-United States (headed by New York's Mayor Fiorello LaGuardia) had earlier been far more in favor of a string of airfields than a road, and by the time they agreed on the need for the road,[13] the Cabinet committee had already decided on it, the President had approved construction along the air route, and the Army had begun work.

The directed air route alignment did not conform to any of the several possible routes that had been under consideration for years. By Donald MacDonald's concept, a road ("coastal route") would have been built between the Coast Mountains and the Stikine Ranges. Route A, favored by the U.S. members of the Alaskan International Highway Commission, was a little east of, and nearly parallel to, parts of MacDonald's line and ran from Prince George via Hazelton to Whitehorse, Kluane Lake, the upper Tanana River, and on into Fairbanks. Both of the routes were susceptible to later connection with several southeastern Alaskan cities. The Canadian Commission favored Route T, still farther east, up the Rocky Mountain Trench. It, too, would start at Prince George, but go to Dawson on the Yukon, thence southwest to Fairbanks. The prairie folks of Canada and the U.S. hoped for Route C, a road east of the Rockies; the famous Arctic explorer, Vilhjalmur Stefansson, advocated another even farther to the west by way of the Peace and Mackenzie rivers.[14] A Congressional committee investigating the highway in 1946 remarked "It is true that there were strong arguments in favor of the selection of other routes, and if a decision had been made in time of peace to construct such an international highway, it is entirely probable that one of several other suggested routes might have been selected for that purpose." The committee concluded, however, "that the construction of the chain of air fields... prior to the construction of the highway itself was sufficient justification for the selection of the route actually used and the committee feels that failure of the two governments...to have selected the route now in use would have been a serious error in judgement and not in consonance with the military requirements of the situation as it then existed."[15]

By February 26, 1942, the Joint Board agreed on certain stipulations regarding highway construction; the Canadian Government approved its recommendations on March 7. President Roosevelt followed suit on March 9, giving his approval a second time. Under the agreement the U.S. would: (1) survey and construct a pioneer road using Army Engineer troops; (2) arrange for the highway to be completed by civilian contractors under the U.S. Public Roads Administration; (3) maintain the road for the duration of the war and six months afterward; and (4) transfer the highway to Canada at the end of the war for integration into the Dominion highway system. Canada would, among other things, provide the rights of way, allow use of local materials for construction, permit U.S. citizens to work on the highway within Canada, and waive various taxes, fees, and import duties.[16] As Canadian Cabinet member Ian Mackenzie was to sum it up later at the highway opening ceremony, "You of the United States provided the toil, we of Canada provided the soil."[17]

One of the major drawbacks to the huge task was the near inaccessibility of the construction route. There were only three approaches and only one settlement which could be called a town on the entire line. The country was a wilderness, some of it barely explored, and nearly all of it lacked adequate maps. The three-pronged advance to the job was by ship to Skagway, Alaska, and over the single-track narrow gauge White Pass & Yukon Route railway to Carcross and Whitehorse; by ship to Valdez and up the Richardson Highway to Gulkana; and by the Canadian railroad from Edmonton to Dawson Creek.

Troops Get Taste of Arctic

The vanguard of American soldiers, a contingent of 90 officers and men of the Quartermaster Corps, arrived in Dawson Creek early on the morning of March 9, 1942. While they were setting up a railhead camp, the first Engineer outfit detrained from their "Sod-buster Express," a combination of passenger coaches and freights carrying food, tents, and motorized equipment. A taste of winter — blowing snow at 30 below zero — greeted Col. Robert D. Ingalls and units of his 35th Engineer Combat Regiment. They fought icy winds in the darkness trying to set up tents. "Tent pegs refused to penetrate the frozen ground, lines finally being tied to logs, boxes, and whatever weighty articles were handy."[18]

With Ingalls was Maj. Alvin C. Welling, executive officer of the task force, who immediately proceeded north 50 miles by way of the provincial road to Fort St. John to establish a command post from which Col. William M. Hoge, the task force commander, could supervise construction of 650 miles of the highway northwestward to Watson Lake. A second command post was to be set up later for control of the rest of the route. Hoge's long experience in military engineering included the Distinguished Service Medal for building pontoon bridges under German shellfire in World War I. Later, in World War II, he gained more fame as the captor of the Remagen bridgehead crossing the Rhine.

No stranger to the north, Major Welling had been in charge of the Corps

Original bridge at Kluane Lake.

of Engineers' flood control and rivers and harbors work in the Territory of Alaska during 1939-40, supervising, among other things, surveying and construction of the Chena River Slough dam near Fairbanks. He also served briefly as Resident Engineer at Ladd Field (now Fort Wainwright) when it was the Army Air Corps Cold Weather Testing Station, and in Anchorage as the Area Engineer for Alaska until early 1941.

Within the first week the remainder of the 35th Regiment, the 648th Topographic Battalion, and 74th Light Pontoon Company joined the advance elements.

Men, vehicles, and supplies moved toward the dismal little settlement of Fort St. John where the Peace River was 1,800 feet wide and there was no bridge. The crossing of the frozen stream was made when the Engineers laid planks on a thick layer of sawdust (to cushion the heavy trucks' wheels) and the 1,200-man organization and its rattling cavalcade of motorized transport eased cautiously over the creaking ice. The 35th Regiment pushed on via an old fur traders' trail blazed by explorer-trader-author Phillip Godsell in 1925-27, forging their way over 265 miles of mostly frozen muskeg, trying to reach Fort Nelson before break-up. From 50 degrees above zero the temperature dropped to 35 below, hardening the winter road. Although the men suffered greatly from the cold, bitter winds, and the roughness of the trail throughout the forced march, the exhausted troops made Fort Nelson by April 10, a few days ahead of thawing which rendered the trail behind them impassable. The Engineers then prepared for their construction task ahead, westward from Fort Nelson.[19]

Hoge was promoted to Brigadier General and early in April set up his second command post in an old Royal Canadian Mounted Police barracks in Whitehorse, the point from which operations over the 850-mile stretch from Watson Lake to Big Delta would be directed. Carcross and Whitehorse were invaded in the next few weeks by friendly

In muskeg areas, layers of timber gave a corduroy road base that was covered with dirt. Plenty of straight timber was found in forests burned years earlier.

forces approaching from Skagway — the 73rd Light Pontoon Company, Company D of the 29th Topographic Battalion, the 18th Engineer Combat Regiment (Lt. Col. Earl G. Paules, commanding), the 93rd Engineer General Service Regiment (Col. Frank M. S. Johnson); and the 340th Engineer General Service Regiment (Lt. Col. R. Russel Lyons). While the 18th had been waiting in Skagway for their lift over the WP&Y line, one platoon unrolled sleeping bags on the floor of the famous old Pack Train Inn, scene of long-ago bar visits by Jack London, Robert Service, and Rex Beach.[20] Yukon steamers, used in 1898, and now pulled high on the riverbank, were used as warehouses.[21]

Though short of equipment, the 18th Regiment began work right away on the wagon trail leading to Kluane Lake. The other regiments had none of their heavy equipment, it having been sidelined on a dock in Seattle awaiting vessel cargo space. After several weeks of frustating delay, General Hoge flew Outside and expedited the movement, getting some gear up from Prince Rupert by barge. The White Pass and Yukon Route was hard pressed to make deliveries from Skagway in May with its meager light rolling stock.

Land Battleships

On their Highway mission, each combat and general service regiment was allotted 20 heavy and 24 medium bulldozer tractors — equipped with winches — "the land battleships of the ALCAN." They usually had at least six 12-yard carrying scrapers, three patrol graders, two 1/2-yard power shovels, from 50 to 90 dump trucks, and many other vehicles, a portable sawmill, two pile drivers, water purification kits, electric generators, and radio transmitters and receivers.[22] The 35th Regiment also had six pulled road graders, six rooter plows, concrete mixers, compressors, gas-driven saws, and electric welding machines.

According to an explorer/author who toured the line in 1944 gathering facts from Army and PRA officials, the Army had more than 3,000 vehicles at work along the road at peak of construction, and the PRA and its contractors as many more. Among the Army vehicles were a thousand powerful six-wheel-drive Studebaker trucks and several hundred 10-ton diesel-driven White trucks. And, of course, there was the ubiquitous Jeep (contrived and manufactured by Willys-Overland with the aid of the Corps of Engineers).[23] It was said later that the greatest array of road-building machinery ever assembled on a single project in the history of American road building was utilized in the construction of the Alaska Highway.[24]

Late in May the 93rd Engineers, with some of their own machinery and two tractors borrowed from the 18th Engineers, began clearing trail eastward from Carcross toward the Teslin River, about 50 miles away. In June, when the 340th Regiment had received enough equipment to go to work, they split up, one platoon staying in Skagway, another going to Whitehorse to do stevedoring, and the rest entraining for Carcross. From there they marched to the Teslin River, then went by boat to Lake Teslin and started hacking out a trail. Work on that route had been started from the Alaska end also.

Early in May, Col. Stephen C. Whipple's 97th Engineer General Service Regiment disembarked at Valdez, having with them only a few items of heavy equipment. Before leaving Seattle they had turned in worn-out trucks and requisitioned new ones. During their first few weeks in the Territory they did maintenance work on the Richardson Highway

Traveling on the pioneer Alcan was always adventurous.

out of Gulkana and on the road toward Nabesna. In a few weeks their equipment arrived, including the same trucks they had turned in, still needing complete overhauling. The 97th pressed on, working on a pioneer road from the village of Slana northeastward toward the Tanana River. (This later became the extension of the Engineer-built Glenn Highway, connecting with the Alaska Highway at Tok.)

Two Commands Formed

General Hoge found it difficult to cover the extensive project by himself, and the Chief of Engineers remedied this by dividing the big undertaking into two independent commands, leaving General Hoge in charge of the Northern Sector and on May 6, putting Col. James A. O'Connor in charge of the Southern Sector. During his 35 years' military engineering service since graduating from West Point in 1907, O'Connor had had many challenging assignments, one being the tunneling of Fortress Corregidor near Manila. After a few months in Alaska, he was advanced to Brigadier General.

In May 1942, the 341st Engineer General Service Regiment (Col. Albert L. Lane), and the 95th Engineer General Service Regiment (Col. David L. Neumann) arrived in Dawson Creek. Both were assigned to work the old fur-traders trail between Fort St. John and Fort Nelson. The 341st bulldozed its way through forests of alder and poplar; the 95th followed close behind, improving and maintaining the open trail, even though neither unit had received much of its road-building machinery. Meanwhile, the 35th Engineer Combat Regiment — the best equipped organization and first on the scene — was unable to make much progress working westward from Fort Nelson because of rain and mud. In this flat country the soil is black, sticky gumbo, similar to that found on the prairies of Canada and the States and in the low tropics of Central and South America. It takes on the consistency of axle grease when wet and though slippery, it clings to boots and wheels, layer upon layer.[25] The 35th Combat Regiment was frequently bogged down. "The sloppy soil conditions near Charlie Lake north of Fort St. John," General O'Connor said in May, "were almost of minor magnitude in contrast with the sloppier conditions near Fort Nelson. Here the soil was in general nothing better than pure mud." And water wasn't always where it was wanted. When troops dug for water in this area they struck gas instead.[26]

Fifty miles northwest of Fort Nelson the 35th encountered what probably was the worst stretch of muskeg on the whole route. At one point they were forced to lay more than two miles of logs crosswise to form a solid corduroy road. Everyone was called out to cut timber — cooks, medics, machine operators, clerks — every available man regardless of rank or job.[27]

General Sturdevant and PRA's Thomas H. MacDonald had worked out a plan whereby the Engineers and the civilian organization would cooperate in building the road. PRA envisioned — in the long-range view — a smooth-surface highway for two-way traffic, with gentle grades and curves, built according to specifications for roads in national forests. Normal width would be 36 feet, but where construction was difficult, the roads could be 20 to 22 feet wide temporarily. Temporary structures made of local material would be succeeded in time by permanent bridges and culverts. Under the agreement, civilians would help with the reconnaissance, but military commanders would have the final decision on location because their mission required opening the road for military traffic as soon as possible.

Route Selection Criticized

Construction had begun before a thorough investigation of the entire route could be made, a situation bitterly attacked by critics of "Route X," as some opponents tagged it. Complaining to the President about the route chosen, the Alaska International Highway Commission called the choice a serious blunder. Others pointed out that along the unsurveyed alignment were many miles of muskeg. Donald MacDonald noted that though the only justification for the route picked was its support of airfields, they were in the wrong place, and the alignment was unnecessarily long. While recognizing that there were political implications, emotional involvements, and perhaps self-serving interests, the Engineers' concern was to get the job done expeditiously, as directed, even though much of it was a "survey-as-you-go" proposition.

There was terrain information at hand on sections in Alaska and the Yukon, and on the portion between Fort St. John and Fort Nelson, but for the remainder of the route, almost all data had to be taken from wrong-scale, incomplete, and contradictory maps, plus on-the-ground confirmation/correction. On this aspect of the project, PRA officials MacDonald, L. I. Hewes and J. S. Bright stated in an article published early in 1943: "Available maps were sketchy. Lakes were out of position and critical elevations almost wholly useless. Indicated mountain passes in one area proved to be in error as much as 3,000 ft. The indicated sources of many rivers were largely schematic. However, there was a corresponding degree of freedom of choice in this wilderness location once the main features of the land began to take form. Right-of-way was not a problem."[28]

Soldiers of the two topographic battalions had more than enough to do during the first few weeks. They and surveyors from PRA dovetailed their efforts so as to incorporate as much of the pioneer road as possible into the highway's final route. Ground survey parties moved through the trees and brush on foot, on tractor-drawn trailers, and early in the project, on dog sleds. To investigate likely river crossings they sometimes used improvised pontoon rafts powered by outboard motors. The pontoon companies had detachments ferrying men and equipment across the many streams.

Colonel Lane, 341st General Service Regiment, has described the road location methods used in his section between Fort St. John and Fort Nelson for which he lacked accurate maps. In his area there was much muskeg, and although visual observations from aerial flights were advantageous as an aid in determining a general route to avoid major streams, lakes, and mountains, many important terrain characteristics were not discernible from the air because of heavy foliage and lack of facilities for detailed study. He found that although aerial photos from 7,000 to 12,000 feet altitude were of great assistance in speeding road location, they were not the absolute solution; ground reconnaissance was also needed.[29] Rolls of 10-inch wide aerial camera film were flown to Spokane nightly for developing and flown back to camp in two days for stereo examination.[30]

"The demand for speed," said Colonel Lane, "made it mandatory to choose a route which would necessitate the least number of stream and swamp crossings and the minimum amount of clearing, rock work, and cutting and felling, and yet preserve direction. Clearing crews must move rapidly in order to provide continuous work for the follow-up elements comprising principally the carryalls and graders, which in order to operate efficiently must be spread out over a considerable distance to avoid bunching up. Furthermore, they must be sufficiently far behind the clearing crew to permit several days' drying out of the cleared areas before they commence to work on it. Therefore, any obstacle such as swamp, river, or ravine which will impede the advance of the clearing cycle should be avoided. To secure adequate drainage, routes along ridge lines are advisable. To provide for exposure to the maximum sunshine in order to insure a dry road, and to afford protection against snowfalls and high drifts in winter, locations along the south or southwest slopes of ridges are desirable. Every effort must be exerted to avoid the muskeg, which requires either complete clearing of the overburden to the clay bed or extensive corduroying over the muskeg. A corduroy road built on muskeg is somewhat spongy and requires considerable maintenance....

Some soldier-bridge builders along the Alcan.

"...As a result of numerous observations from aerial reconnaissance flights between Fort St. John and Fort Nelson, a tentative route was selected and a series of flight photos secured giving as complete a coverage as possible of all the areas that were to be considered in determining the final location. A thorough study of these photos coupled with the best available maps of the region and supplemented by information obtained from qualified Indian guides and trappers, directed the decision as to routes that should be investigated."

More Curves than Hollywood

"All things being equal, the straightest line from one terminus to the other is desirable, however in this particular instance it was found necessary to develop a circuitous route in order to secure the most feasible line, avoiding terrain peculiarities that would impede considerably the rapidity of progress. The pontoon-equipped observation plane was ideally suited for reconnaissance missions since it could be throttled down to about 100 miles an hour, permitting longer and more detailed aerial observation of particular features. Its pontoons permitted landings on numerous bodies of water in isolated regions from which ground reconnaissance parties could make their way to desired points.

"With the general location of the road decided upon and having secured series of flight photographs along the route with 60 percent forward overlap, and affording coverage approximately eight miles on either side of the proposed route, the preliminary work in the field office was ready to commence."

Alternate photos were laid out in a continuous line showing the terminals of the road, or between a terminus and a preselected landmark somewhere along the route. Major control points were established on the photos at 5- to 15-mile intervals. The more important points, such as stream crossings and mountain passes had to be inspected on the ground and related to the photo markings. "The shortest final route," the colonel explained, "would coincide with the general directional route, but experience will show that the final line, though passing through the major control points, deviates from the general directional line principally to overcome obstacles offered by small creeks, swamps, muskeg, and to provide for locating the road along ridge slopes wherever possible."

Their procedure generally was "to examine stereo pairs by means of a good mirror stereoscope and to develop a road location on the photos which is eventually transferred to the ground by field methods."

Of several plans tried, the best plan for use of field units involved the use of location parties comprising an officer and 12 men in addition to the necessary cook, pack train attendants, and a pack-trail clearing crew for the leading party. In proceeding from point A on their aerial photos to point B, with deviations along obviously needed tangents to avoid problem areas, the men oriented their photos, then worked along determined magnetic azimuths, frequently resorting to tree-climbing to check their positions and forward reference points. In the general scheme, an officer and two experienced enlisted men, having a set of photos, scouted out the line ahead, using line rod and compasses. One of the soldiers, using a lensatic compass, followed the azimuth of the line. "The officer using stereovision and counting his strides...follows the photoline. The other soldier, carrying a line rod, helps the compassman stick to the azimuth. In areas of particularly heavy growth where visibility is restricted, the second enlisted man may be spotted on line either by voice or by shaking small trees...."

When the scouts encountered unsuitable terrain, they reconnoitered detours, recording them by compass bearings and on the photos. The NCO in charge of the party's rear element followed the photo line by naked eye stereovision. Men with compass and range pole followed the magnetic azimuth of the line or tangent, and all members checked back and forth to relate photo line goals and scouted ground lines. Distances were checked with 100-foot chains. The NCO concentrated on ground progress with reference to both the guide photos and clear landmarks, and he checked frequently with identifiable features at short distances on either side of the line to verify his position. The actual road line was blazed around obstacles. According to another engineer officer's account of this operation, "...at night the crew would make notes and recommendations concerning the route they had traversed during the day and return these notes to their previous campsite where they could be nailed in a can to a marked tree. The following survey party would pick up these notes and from these suggestions utilize the blazed bearing lying as a reference, select and mark a proposed road centerline. The road stands today with over 90 percent of it built on its original trace — a tribute to the success of this method."[31]

"On several occasions," said Colonel Lane, "in areas of burned-over country that was covered with rather heavy brush in which a few large trees still remained

Representative Tony Dimond (with blowing tie) and his party inspect the highway in 1943. Alaska Secretary of State (later U.S. Senator) Bob Bartlett is in the center of the photograph.

standing, long sections of road were located by climbing a tree on the line, and locating another tree on line by reading the magnetic azimuth. The line was then run in by directing a large dozer toward the distant tree which was visible above the brush to anyone standing on the dozer....It was necessary to climb many trees and trudge many miles in an effort to determine the lay of the country...." Often, under the constant pressure of the all-important speed factor, rather unconventional procedures were used and crude means improvised to overcome unforeseen and unfamiliar obstacles in this strange wilderness environment. Where the line of least resistance was followed, the road, it was said, "had more curves than Hollywood."

More than 10,000 Soldiers

By early June, all Engineer troops scheduled for work on the highway had arrived. O'Connor, in the southern portion, had a combat regiment, two general service regiments, a light pontoon company, and a topographic company, totalling 4,354 officers and men. Hoge, headquartered in Whitehorse, had the same kind of organization, but with an extra general services regiment, his force totalling 5,806. There were altogether some 500 auxiliary troops assigned to the project in signal, quartermaster, finance, and medical units. The 341st Regiment had a pet moose, raised from a calf to horse-size in a few months. The soldiers named it "Moosevelt."

At this time two gaps remained in the construction layout. One was at the extreme north end, a 100-mile segment between Big Delta and Tanacross and the other ran about 50 miles southeastward out of Whitehorse. It was planned to assign those stretches to PRA contractors.

It soon became evident that the North had a secret weapon against the builders — permafrost — and until the Engineers learned how to deal with it, that peculiar material baffled the troops. At the outset, soldiers would shovel away a foot or so of soil and find "a solid roadbed of ice." Gravel dumpers and road gangs spread a filler over it; the sun came out and the road sank. They soon found that the more they dug, the more the frozen ground melted. Then they started treating it like muskeg, piling on heavy layers of brush, corduroy, and gravel to make a protective blanket.

In all sections the pioneer road was pushed through in more or less the same manner. As stretches were located, surveyed, and blazed, clearing crews, driving 23-ton D-8 tractors with bulldozers, smashed a corridor through brush and woods. While the lead dozer (sometimes a pair, side-by-side) opened a path, other dozers widened the clearing and shoved aside falled trees and debris. The long daylight of summer made it possible to work two or three shifts every 24 hours. Working around the clock crews could clear three to four miles a day.[32]

The Alcan takes shape amid rugged Alaskan scenery.

Culvert gangs followed the dozers, cutting timber to build rectangular culverts, cinching them with iron driftpins or wooden pegs. Carryalls pulled by more tractors moved hills into dales. Then came the ditchers and graders to finish grading. When dry, the result in fair weather was a loose, soft-surface road soon chewed up by cargo trucks, converting the dirt into deep talcum-fine dust that penetrated everything and obscured driver vision.[33]

Invasion Spurred Workers

On June 7 and 8, 1942, Japanese troops landed at Atu and Kiska Islands far out on the Aleutian Chain and pressure to expedite completion of the highway became even stronger. Alaska had been invaded, and the Americans were inspired to even greater efforts, manipulating their "land battleships" with increased vim as they bent to the task of building "the Burma Road of the North."

The week of the invasion, Delegate Bartlett introduced legislation aimed at construction of a highway north from Prince George on the A Route, connecting with the ALCAN at Whitehorse. The intent was to shorten the supply line by tieing in Seattle more directly to Alaska, a goal sought for many years by Tony Dimond and Donald MacDonald.[34]

General Sturdevant came from Washington in July to check on progress. He inspected the entire route by airplane and traveled 500 miles by car over completed sections and those under construction. He observed that the soldiers were building a fairly well-drained, graded highway instead of a rough access trail. This was because the road was the only line of supply they had with their bases. Sturdevant noted also that the pioneer road could serve not only as an access route for PRA contractors, but could support the airports during the coming winter.

In theory, Army engineers were to build a rough trail or haul road which contractors would use in building a finished highway. But thousands of men and thousands of machines require a constant flow of enormous quantities of supplies, and no simple trail through the northern forest could carry such traffic. Once they pushed back the wilderness the men and machines had to build well or starve, hence the tote road was drained, graded, bridged and surfaced in many sections to supply the advancing working points. Furthermore, as the summer of 1942 wore on it became clear that war in the Pacific might not wait for a superhighway to Alaska; it became a question of now, or perhaps never, so the haul road became the highway.[35]

The invasion, and the threat of approaching freeze-up, called for new ways of expediting the job. Not only must the road be finished that year, but in order to make it usable in all seasons it needed a telephone system, construction rest camps, and fuel supply depots. Sturdevant changed the Army/PRA operating plan, arranging in August for the troops and the contractors to merge forces to quicken the work. Up to that point, contractors had been concentrating on setting up camps and gathering their equipment. Soon PRA's Thomas MacDonald established offices in Gulkana, Whitehorse and Edmonton. PRA engaged four engineering firms to act as management contractors, and they in turn controlled 47 American and Canadian construction companies working under cost-plus-fixed-fee contracts. The management team consisted of C. F. Lytle Company and Green Construction Company of Sioux Falls, Iowa; Dowell Construction Company of Seattle; R. Melville Smith Company of Toronto; and Okes Construction Company of St. Paul.[36] In addition, the Seattle firm of E. W. Elliott Company was engaged to handle transportation and camp construction.[37]

Above the improved road in foreground is the line of the pioneer road at Soldiers Summit.

In August some of the civilian workmen began to clear sections which had been assigned to PRA for construction, while others moved up close behind the troops, widening, improving and gravelling the roadbed. The 47 contractors used equipment with a new value of $10,750,000; about 35 percent of the equipment was government-owned.[38]

During late summer and fall, PRA contractors finished sections connecting Big Delta with Tanacross, and from Whitehorse southeastward to Jake's Corner. The 35th Combat Regiment, which had been struggling for months westward from Fort Nelson, achieved 209 miles by August 20. Soon they were aided by the 341st and 95th Regiments which had been working south of Fort Nelson and had turned that section over to the civilians to finish. The 93d Regiment meanwhile had blazed a trail eastward out of Carcross (on the WP&Y rail line) to Teslin.

Road Segments Join

At the close of September, two regiments came together near Watson Lake as bulldozers of the 340th General Service Regiment working east from Whitehorse touched blades with those of the 35th Combat Regiment heading west from Fort Nelson. The 13th Regiment, operating pile drivers from opposite banks of Slim's River at the southwest end of Kluane Lake, erected a bridge there in six weeks. Timbers for it were hewn by soldier axemen, and decking was cut in portable sawmills, the logs being snaked to them by tractor chains. The lake shore was muddy, and had quicksand spots, and the men used 110 cases of dynamite blasting out the road in the face of a cliff. Supported 400 feet above the water by lifelines, the soldiers wrestled heavy jackhammers to drill holes in which the charges were placed. The crest of the rocky ledge was named Soldiers Summit.[39]

There was one major connection yet to be made, and the initial contact was near the Alaska-Yukon border on October 25 when men of the 97th Regiment, which worked north from Slana to Tanacross, then headed east, met the 18th

Combat Regiment coming northwest from Kluane Lake. When, on November 20, they completed the last link – the bridge over White River – the *pioneer* form of the Alaska Highway was completed. Its cost has been estimated at $27,745,000 with $17,548,000 being the Army portion, and the balance Public Roads Administration.[40]

Ceremony at Soldiers Summit

That same cold day (the previous week it had been 35 below zero) the highway opening ceremony was held amid dramatic and colorful conditions. It was carried out on a picturesque stretch of the road 1,500 feet above the icy blue reaches of Kluane Lake at Soldiers Summit. Here, 100 miles east of the Alaska-Yukon border, surrounded by lofty white peaks, glaciers, and "dark crags that towered like silent sentinels into a sky of beaten copper," as one writer portrayed it, Canadian and American officials and a few score bundled-up spectators met to commemorate the historic event.

It was colorful in several ways, as General O'Connor's aide, Lieutenant (later U.S. Senator from Oregon) Richard Neuberger described the scene in a letter to Tony Dimond. There were the eight Royal Northwest Mounted Police constables standing at attention in their scarlet and gold tunics and bright leather boots. There were the snow-whitened mountains and blue lake in the background. There was the blue of Col. R. B. Bush's hands as the general's chief of staff removed his gloves to read congratulatory messages. It was all tied together nicely by the narrow red, white and blue ribbon that figured in the ceremony.

Un-named Canadian and American officers greet at the highway opening ceremony, Soldiers Summit, Kluane Lake, Y.T.

Speeches over, Alaska Secretary of State (later Delegate and U.S. Senator) Bob Bartlett presented an Alaska flag sent by the Fairbanks chapter of the DAR, whose president was Mrs. Donald MacDonald. Bartlett and Ian Mackenzie of the Canadian cabinet together clipped the ribbon, using a pair of scissors specially engraved in Alaskan gold by William Osborne of Juneau. Holding the ribbon for them were a master sergeant, two corporals, and a private representing the thousands of soldiers who had labored so long and diligently toward this goal.

"In the cold gloom of the Arctic morning," said Neuberger, "an American Army band struck up 'God Save the King,' and then the strains of the 'Star Spangled Banner' filled the snowy air....A great cheer went up. The first truck bound for Fairbanks, driven by Cpl. Otto Gronke of Chicago and Pvt. Bob Rowe of Minneapolis, rolled forward as the band played 'The Maple Leaf Forever' and "The Washington Post March.' "[41] The next day the first vehicles from Dawson Creek entered Fairbanks.

Connecting Roads Added

Although the pioneer road was finished there were many tasks yet to complete during the fall, winter and coming spring. Several connecting roads were built, including one from Fort Nelson to Fort Simpson on the Mackenzie River to be used as a supply route for the CANOL (Canadian Oil Line) Project, another huge wartime undertaking in which U.S. Army Engineers played an important role. There was also the Haines Cut-off connecting the seaport of Haines with the Alask Highway at Champagne, west of Whitehorse. Bridges required major effort, and the Engineers built a number of long structures during the fall, including a 1,270-ft pile-bent structure across the Liard River 209 miles west of Fort Nelson, and a pile bent bridge 750 ft long over the same stream near Watson Lake.

Under PRA contract, Okes Construction Company put in a 2,200-ft timber structure across the Peace River at Fort St. John, finishing it in three weeks. A sudden thaw in November hurled huge ice floes onto it, tearing out a 200-foot section, but the gap was closed and traffic resumed in a few days. The 340th Regiment and civilian workers together erected a 2,300-ft-pile-trestle bridge across Nisutlin Bay, driving many of the piles through the ice.[42]

During the previous summer, the troops had slept on the ground in tents, but by fall better quarters became available as hundreds of demountable buildings that had been in use in 40 Civilian Conservation Corps (CCC) camps in the States were taken down, hauled north and re-erected all the way from Dawson Creek to Whitehorse, and from Gulkana to the Canadian border.

Discontinuance of the CCC Program in June 1942 made available to the PRA great quantities of equipment to supplement that of their contractors. Among the major items were 300 tractors fitted as scrapers, bulldozers, or trail-builders; 1,000 trucks, 125 air compressors with drilling accessories; 55 power shovels; 200 light plants; 65 portable repair shops; mixers, rollers, pumps, and trailers, as well as kitchen gear.

For water transportation, the PRA had the use of five steamships, a motor ship, five yachts, 14 barges, and 10 tugs. Many of their engineers and the construction company workers moved north by sea, train, and truck; 1,200 of them were flown to the northern end of the project (Gulkana and Big Delta) to establish living quarters, shops, warehouses, and other operating facilities. The 6,000-man PRA/contractor combination was the largest civilian force ever put to work on a single highway job — and Commissioner MacDonald called it the most effective.[43]

Unbelievable Cold

The winter of 1942-43 was a terror, especially for the men from southern climes, many of whom had never experienced ice or snow. With the cold, the "bush bombers" (mosquitoes) departed, but as days became shorter and darker and much colder, new problems arose.

"For three weeks," Neuberger reported later, "the temperature never got above 50 degrees below zero. On three consecutive days it was 60 below. Along the Donjek River, two Engineer regiments reported an unbelievable minus 71....At those temperatures the grease in engines will solidify until it is as hard as the steel it is supposed to lubricate. Whiskey will freeze in the bottle."

Along the WP&Y line "...800 soldiers of the 770th Railway Battalion shoveled snow 24 ft deep and endured cold to 60 below, trying to keep the little engines and boxcars moving. Bulldozers were started with roaring bonfires beneath the treads and engines."[44] Under the circumstances PRA truck drivers were not overpaid at $1.40 an hour for their first 48 hours and $2.10 an hour thereafter.

Reminiscing in a letter to the Alaska

Early culverts were rectangular tunnels built with green timber cut and trimmed nearby. They were replaced later with planks or metal sections.

District Engineer years later, a former office manager for one of the construction contractors revealed that his group lived in tents at Teslin while building the bridge over Nasutlin Bay when it was about 70 below zero for three days. "I was hospitalized; the Prestone froze."[45]

Most of the winter efforts were centered on keeping the pioneer road open in order to move the seemingly endless quantities of supplies and equipment needed for future operations. Water from underground springs glaciating across the road was a continuing problem. At very low temperatures diesel fuel would not flow and gasoline lines froze. Often, re-starting a stopped engine was impossible, and at one time 1,600 trucks were deadlined.[46] "Cans of undiluted antifreeze were found to have frozen in a stock pile at Kluane Lake."[47]

Troops Leave for Other Assignments

Engineer units started to leave Alaska for other war tasks in January and February 1943, leaving highway improvements to the contractors. During the spring, temporary trestles and portions of the pioneer road were destroyed by flooding rains and repeatedly had to be repaired. Expecting this, contractors had stockpiled replacement timbers at bridge sites and made repairs with minimum loss of time. Despite unfavorable conditions, the ALCAN Highway was serviceable as a military road during the winter and spring.[48]

In retrospect, one can see that with the entrance of the United States into the war, the Northwest Staging Route assumed great importance. Because of it, the ALCAN was built, a most spectacular example of international collaboration. The principal role of the highway was to facilitate the building and improving of airfields and as a guide path for flyers. Whether that purpose was essential to the defense of the continent is another question, but it should not obscure the fact that the highway and the Staging Route amply fulfilled their principal roles.[49]

Along the Alaska Highway were 133 bridges 20 ft or longer, 8,000 culverts, and a roadway 25 ft between ditches. At the highest point, Summit Lake, it was built at 4,250 ft elevation. It was a fantastic 1,428-mile road-building achievement by 10,000 soldiers and 6,000 civilian workmen in 8 months and 12 days.

By exchange of notes between the governments of the United States and Canada on July 19, 1943, the agreed-upon name for the road was "Alaska Highway" as it is still officially called.[50]

The 1946 Congressional investigating committee said: "The construction of the Alaska Highway and its feeder facilities by the Corps of Engineers and the private construction firms operating under the direct supervision of the Public Roads Administration constituted one of the construction epics of modern times. It was a gigantic task performed under great pressure where the elements of nature put man and machinery to the ultimate test of performance."[51]

A big 6x6 truck was the first vehicle to make the run from Dawson Creek to Whitehorse along the pioneer road.

FOOTNOTES

[1]U.S. Army, Alaska, pamphlet 360-5, Fort Richardson, 1972.

[2]Pubn No. 474, Dept of State, Conference Series No. 14, May 1933.

[3]*Ibid.*

[4]ALCAN file, Engineer Historical Div., Washington, D.C.

[5]Godsell, Philip H., *The Alaska Highway*, London, 1946, p. 102.

[6]*Ibid.*, p. 115.

[7]House Doc 711, 76th Cong., 3rd Session.

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[10]Conn, Stetson, and Byron Fairchild, "The Framework of Hemisphere Defense," In *United States Army in World War II*, Off Ch of Mil Hist, Washington, 1960, p. 398.

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[14]*Ibid.*, p. 393.

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[17]Letter, 3 Mar 43, Capt Richard L. Neuberger, Northwest Service Comd, to U.S. Rep Warren Magnuson.

[18]Godsell, *op. cit.*, p. 130.

[19]Dod, *op. cit.*, p. 301.

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[24]House Rept 1705, *op. cit.*, p. 29.

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[28]MacDonald, Thomas H.; L. I. Hewes, and J. S. Bright, "Alaska Highway—Organizing $30,000,000 Job," *Western Construction News*, Feb 1943.

[29]Land, Col. Albert L., "The ALCAN Highway, Road Location and Construction Methods," *Military Engineer*, Oct 1942.

[30]Godsell, *op. cit.*, p. 139.

[31]Eschbach, A. M., In *CH2M Reports*, Summer, 1969.

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[33]Rainey, *op. cit.*, p. 154.

[34]HR 7284, 77th Cong. 2nd Session, 23 Jun 42.

[35]U. S. Army, Alaska, pamphlet 360-5, p. 81.

[36]Congressional Record, 27 Nov 1942, p. 9184.

[37]House Rept 1705, *op. cit.*, p. 42.

[38]MacDonald, Hewes, Bright, *op. cit.*

[39]Sheldon, *op. cit.*, p. 21.

[40]House Rept 1705, *op. cit.*, p. 22.

[41] Letter of 29 Nov 1942 in Cong. Record, Appendix p. 4274, 14 Dec 1942.

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[48]Dod, *op. cit.*, p. 317.

[49]Conn and Fairchild, *op. cit.*, pp. 389 and 398.

[50]House Rept 1705, *op. cit.*, p. 3.

[51]*Ibid.*, p. 12.

Photographs Courtesy of U.S. Army.

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by H. J. Coutts and R. K. Turner

RESEARCH ON PRACTICAL METHODS OF REDUCING AUTOMOTIVE ICE FOG

INTRODUCTION

In recent years, as the urban population in Fairbanks, Alaska has increased, ice fog has created serious problems for people who attempt to live comfortably in this climate. The most obvious problem is lowered visibility during the dark winter months. It hinders commercial traffic by closing airports and increasing vehicle accident rates. Ice fog, when capped by atmospheric thermal inversions, increases the ambient levels of other problem pollutants, for example, lead compounds and toxic gases such as nitrogen and sulfur oxides, aldehydes, and halogenic acids.

SOURCES

Three major sources of ice fog are: (1) evaporation from cooling ponds and other open water bodies, (2) exhaust from domestic heating furnaces and large power plants, and (3) automobile and truck exhaust.

The relative impact of the ice fog emanating from each source depends on your point of view. When driving in heavy traffic, automobiles appear to be the most important source. While this article will consider only automotive-produced ice fog, it is important to remember that other sources continue to remain a significant problem.

The ice fog emitted from motor vehicle exhaust is formed by the oxidation of the hydrogen in the hydrocarbon fuels. Automobile exhaust is also rich in other pollutants, some of which are absorbed into the ice fog particles.

To the daily commuter, the most significant source of ice fog is the motor vehicle. Vehicles emit ice fog along the roads resulting in greatly reduced visibility. In addition, ice fog tends to concentrate at intersections where obscuring conditions are especially hazardous. This reduced visibility forces the operators to drive more slowly, thus increasing fuel consumption, which in turn produces more ice fog. The only compensating effect is that residents often try to drive less during extremely cold periods when ice fog is very dense.

FUEL ECONOMY AND ICE FOG EMISSION

The three most common types of automotive fuels used in the Fairbanks area are propane and gasoline for the spark ignition engine and fuel oil for the diesel engine. Historically, the light duty diesel engine yields better fuel economy than the gasoline engine for passenger vehicles. Table 1 is an ice fog emission comparison constructed by assuming a fuel consumption rate of 6.8 km/liter (16 mi/gal) for the gasoline-powered vehicle. Using the same motive energy requirement and efficiency for propane yields 4.7 km/liter (11 mi/gal). The diesel engine with the same motive energy requirement, but higher efficiency, would yield 11 km/liter (16 mi/gal). Table 1 shows that a gasoline-powered vehicle at 6.8 km/liter creates more ice fog than a diesel; propane creates more than gasoline. This is directly related to the fuel economy figures which are shown in the first column of Table 1. Now consider a gasoline engine in a lighter vehicle which has the same fuel economy as the diesel in a heavier vehicle. The diesel would then emit more ice fog than the gasoline engine because fuel oil contains more hydrogen per gallon than gasoline. Fuel economy as it relates to gross vehicle weight or passenger comfort is not considered here.

In comparing emissions for any one fuel type, the water vapor (ice fog emission) is directly related to fuel economy. For example, a vehicle yielding 17 km/liter (40 mi/gal) will emit only half as much ice fog as a vehicle yielding 8.5 km/liter (20 mi/gal) and one-quarter as much ice fog as a vehicle attaining only 43 km/liter (10 mi/gal).

TABLE 1

EFFECT OF FUEL ECONOMY ON AUTOMOTIVE ICE FOG (H_2O) EMISSION

	ASSUMED MILAGE		RESULTANT EMISSIONS	
FUEL	km/liter	mi/gal	gm H_2O/km	(lb H_2O)/mi
Diesel (Fuel Oil)	11	(26)	90	(0.32)
Gasoline	11	(26)	79	(0.28)
Gasoline	6.8	(16)	130	(0.46)
Propane	4.7	(11)	180	(0.63)

ICE FOG CONTROL TECHNIQUES

With existing vehicles, ice fog emissions can be reduced by limiting the number on the road or by applying control devices. Reduction of vehicular traffic would require traffic controls and mass transit. Consideration of these techniques is not within the scope of this article.

Many possible techniques to control ice fog from automobile exhausts exist and may be applied either to the exhaust water vapor or to the resultant ice fog. The latter method requires the use of such large gas handling equipment to capture the fog that it is not considered practical. Two common methods can be applied to the exhausted water vapor; both involve capture before it becomes ice fog. One method is to absorb the water in some type of a desiccant such as a glycol solution. The other is to cool the exhaust gases down below the dew point and remove the water vapor as a condensate, i.e., liquid water.

Desiccants are chemicals which actively absorb water vapor from humid gases. Typical desiccants are calcium chloride and ethylene glycol. The exhaust gas stream must contact the desiccant either in a dry bed as with calcium chloride or in a gas-to-liquid contractor as with the glycol solutions. The spent desiccant requires regeneration (drying) before reuse. Regeneration can best be accomplished after the vehicle has stopped. The procedure requires the use of a stripping column and heat energy to drive the water vapor out. Exhaust contaminants such as mineral acids, lead compounds, and soot tend to contaminate the desiccant which makes regeneration difficult; thus, the desiccant would require continuous partial replenishment. Also, disposal of spent desiccants would replace the air pollution problem with a solid waste problem.

The most practical method is to cool the hot exhaust gases to well below the dew point, thus removing the fog-creating water vapor as a liquid. This method involves only a heat exchanger, a coolant, and a coalescer. During ice fog episodes there is ample cold air to act as a coolant. Because these heat exchangers cool the exhaust and condense the water vapor, they are called *cooler-condensers*. Most cooler-condensers are tube types in which the hot exhaust gas flows inside the tubes and cold air flows outside the tubes.

All cooler-condensers convert the water vapor into liquid water. Experience has shown a portion of this liquid water ends up as fine mist droplets and, if allowed to escape to the atmosphere, would form ice fog crystals. A coalescer

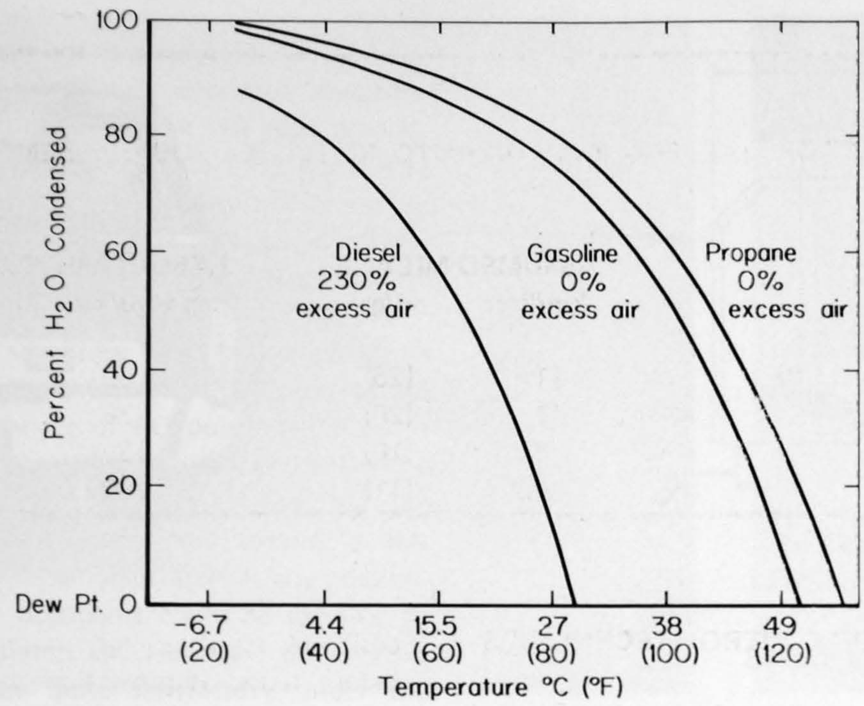

Fig. 1 Percent of exhaust gas water vapor condensed vs. exhaust temperature.

will cause these fine droplets to form into a liquid stream.

On most automobiles and light duty trucks, the exhaust gas temperature ranges from about 600° to 1200°F at the muffler inlet. An ice fog removal device such as the cooler-condenser must cool the exhaust gas down to the dew point and from that point on must condense water. More water will be condensed as the temperature is lowered from the dew point (see condensation curves in Figure 1). The engineering challenge is to design the cooler-condenser with enough heat transfer surface to accomplish the task, but not allow the outlet temperature to drop so low that the condensate freezes in the tubes and plugs the system. From a design perspective, it appears that the easiest type of exhaust gas to handle is from the propane-fueled engine since this exhaust would have to be cooled to only 39°C (102°F) to condensate 60 percent of the water vapor. The exhaust from gasoline combustion requires cooling to 35°C (95°F) and exhaust from diesels must be cooled to 14°C (58°F) to obtain 60 percent water vapor condensation.

The diesel is the only piston engine that normally operates with excess air. This excess air results in a lower exhaust water concentration, hence, a larger fraction of water will remain in the vapor phase at any given temperature when compared to exhausts with no excess air.

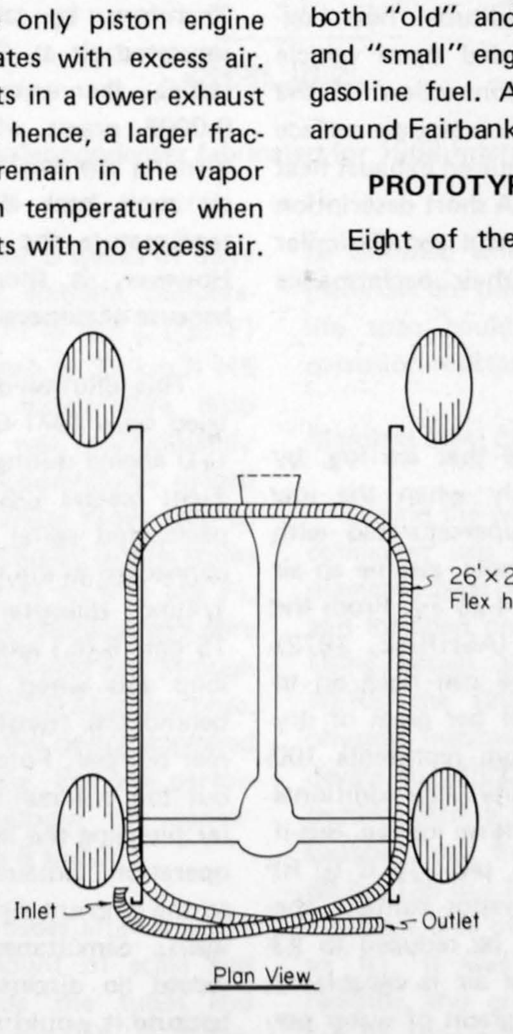

Fig. 2 Exhaust gas diluter on 1971 GMC Jimmy.

The concept of cooling engine exhaust to well below the dew point and condensing out the water vapor to reduce motor vehicle ice fog has been known for some time. A few individuals have successfully modified their personal vehicles. In those cases, the cooler-condenser was made from 2- or 3-inch thin wall copper tubing or, in the case of a small foreign vehicle, from another vehicle radiator. Generally these devices appear to work, but quantitative performance information is lacking. During the winters of 1974-75 and 1975-76 the USEPA Arctic Environmental Research Station (AERS) sponsored 12 research projects on 9 different vehicles to validate the effectiveness of the cooler-condenser device in controlling automotive ice fog. Seven devices were constructed by the AERS staff; the other five by independent contractors. The vehicles selected for evaluation represent both "old" and "new" models, "large" and "small" engines, and diesel as well as gasoline fuel. All were operating in and around Fairbanks, Alaska.

PROTOTYPE INSTALLATIONS

Eight of the cooler-condensers were

Fig. 3 Exhaust visibility with ice fog control device.

Fig. 4 Exhaust visibility without ice fog control device.

constructed as finned-tube heat exchangers which depended upon vehicle velocity for forced convection of the coolant air. Some had inadequate surface area to transfer the required exhaust heat at 64 km/h (40 mi/h). A short description of the five most successful and dissimilar control devices and their performance follows:

Exhaust Gas Diluter

It must be realized that ice fog, by definition, occurs only when the low temperature air is supersaturated with water vapor. For example, assume an air temperature of -32°C (-25°F). From the psychrometric charts (ASHRAE, 1972) air at this temperature can hold up to 0.0002 grams of water per gram of dry air. The 0.0002 gm/gm represents 100 percent relative humidity. Any additional water vapor input will form ice fog. But if the air is warmed to say, -18°C (0°F) with the same water vapor content, the relative humidity will be reduced to 23 percent. At -18°C the air is capable of holding up to 0.0008 grams of water per gram of dry air before ice fog will form. Therefore, by taking 1.0002 grams of saturated air at -32°C and warming it to -18°C, the warmed air could accept 0.0006 grams of water vapor before forming any fog. Theoretically, when the air cools back down to the prevailing temperature the ice fog would reform. However, it should be much thinner because of dispersion.

This dilution-dispersion principle was tried on a 1971 GMC Jimmy with a 250 CID engine during the winter of 1975-76. Eight meters (26 ft) of 2-inch diameter perforated spiral wound flex hose was connected to the tail pipe. The holes were 1/4-inch diameter spaced approximately 15 cm (6 in.) apart (Figure 2). The hose loop was wired to the frame members behind the transfer case and under the rear bumper. Forcing the exhaust to flow out the 1/4-inch holes was accomplished by plugging the hose end. During vehicle operation, exhaust heat was transferred to the ambient air through the metal hose walls. Simultaneously, moist exhaust would be dispersed into this warm air because it would now accept more water vapor before becoming saturated and showing visible fog behind the vehicle. Also, during extreme cold, -34°C (-30°F) or colder, some of the exhaust water vapor condensed out and dripped from the perforated metal hose. Several ice stalagmites 10 to 15 cm (4 to 6 in.) high formed on the ground under the perforated hose when the vehicle was left idling for 15 minutes at -40°C (-40°F). Little, if any, water vapor was condensed while driving. Therefore, the overall ice fog reduction is probably negligible but the visible vehicle plume is reduced.

The hose was wired below the rear bumper so that it could easily be slipped on or off the tail pipe for comparison purposes. The device performance is best displayed by the with- and without-photos (Figures 3 and 4). Both photos were taken within 5 minutes of each other at an ambient temperature of -29°C (-20°F). In both cases the vehicle was idling at 1100 rpm. The diluter-air heater hose can be seen slipped over the tailpipe below the left tail light. Without the device the person standing at the left of the vehicle is almost completely obscured. The visual effect during driving is similar but not as spectacular.

In one winter's operation the hose rusted through at the tail pipe connection. Accurate costs for the perforated hose could not be determined since this hose was from salvage. The estimated new replacement cost with stainless steel spiral wound flexhose is about $75.

The advantage of this system is its comparatively low cost. The disadvantage is the danger of CO poisoning. Because most of the exhaust is released under the floorboards, some of it leaks into the vehicle. Therefore, this system is not recommended when there is any possibility that occupants could be exposed to contaminated air. However, this system would be quite satisfactory under the open cargo bed of a truck.

EMT Cooler-Condenser

A cooler-condenser was designed by Borghorst (1975) to meet the requirements for a 1968 IHC Scout equipped with a 266 CID-V8 engine. It was fabricated from 23 one-half inch diameter EMT (electrical metallic tubing — thin wall conduit) tubes each 76 cm (30 in.) long in a single pass arrangement. For simple construction, there was no welding or machining of parts (Figure 5). The condenser was designed so that the outlet header could be removed to allow for easy cleaning and removal of deposits inside the tubes. Mounting was simple — bolting the condenser onto the front bumper and running a 5-meter (15 ft) piece of spiral wound flexhose from the tail pipe to the inlet header.

Air flow across the tubes was controlled from the inside cab by a mechanical cable attached to six adjustable louvers in front of the tubes. Freezing of the two bottom tubes became a problem which was solved by blocking the air flow across them.

Materials for the condenser cost approximately $85. About 40 hours were required for fabrication and installation.

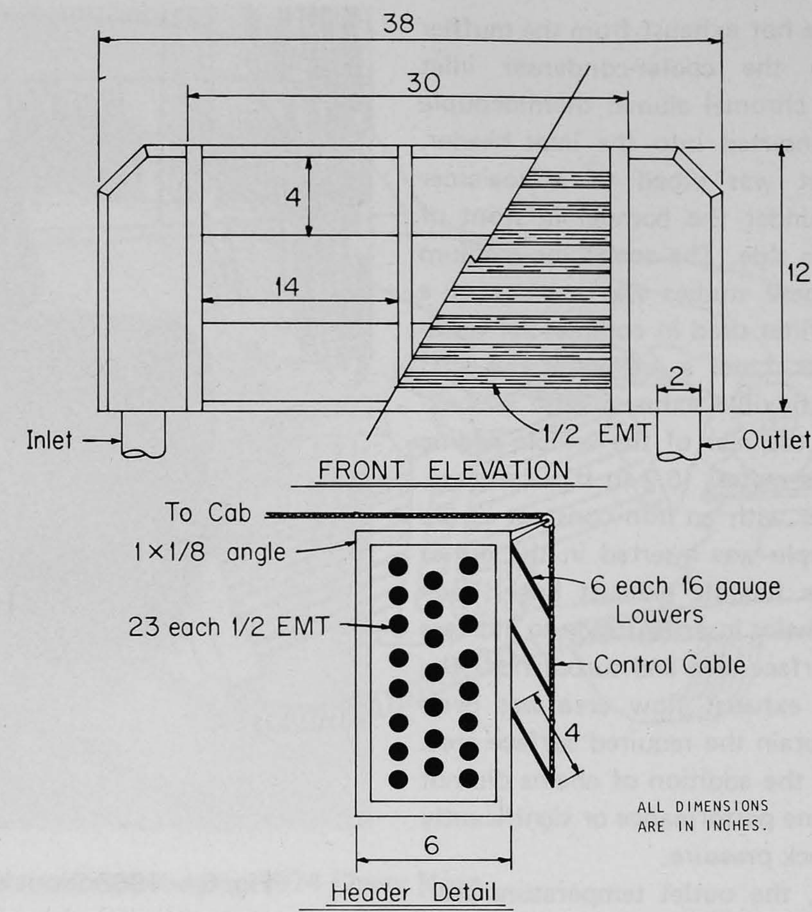

Fig. 5 EMT cooler-condenser fabricated for 1968 International Scout.

The unit was tested for 5 weeks of daily routine traveling. At ambient temperatures from -7°C (20°F) to -37°C (-35°F) and at speeds from zero to 72 km/h (45 mi/h), the average temperature drop across the condenser was approximately 28°C (50°F). Inlet temperatures ranged from 54°C (130°F) under heavy load to 37°C (98°F) at idle. Outlet temperatures were from 19°C (84°F) to 6°C (42°F), respectively. Low inlet temperatures were explained in part by the heat loss through the 5 meters (15 ft) of exhaust flex hose. Based on these data, the device appeared to operate best at idle. For idle performance, with and without the cooler-condenser, see Figures 6 and 7.

Inspection of the tubes after 5 weeks revealed a small amount of scale and powder residue inside the tubes and headers. Because of corrosion, an anticipated life of three to four seasons could be assumed when the most inexpensive materials are used. A considerably longer life span could be expected by using corrosion-resistant alloys.

Stainless Steel Cooler-Condenser

During the winter of 1975-76 a cooler-condenser was fabricated using 1/2-inch diameter type 409 stainless steel tubing and installed on a 1974 Chevrolet Nova. Using design and tubing furnished by AERS, the University of Alaska, Geophysical Institute Machine Shop built the device for $600. The tubing ends were beaded with a parker beading tool and swagged into the headers. The unit was 89 cm (35 in.) long with 25 tubes, giving a surface area of 0.85 square meters (9.1 sq ft). It was mounted between the radiator and grill on the front of the vehicle (Figure 8). A 2.6 meter (8.5 ft) length of flexible exhaust hose was used to pipe the hot exhaust from the muffler inlet into the cooler-condenser inlet header. A chromel alumel thermocouple was also inserted into the inlet header. The outlet was piped to a coalescer mounted under the bumper in front of the driver's side. The coalescing medium used in these studies was a piece of a fiberglass filter used in commercial ventilating ducts. Later a 4.4 meter (14.5 ft) length of flexible exhaust hose was extended to the rear of the vehicle adding 0.58 square meters (6.2 sq ft) of surface. A coalescer with an iron constant in the thermocouple was inserted in the outlet end of the flexible exhaust hose. Each tube had chains inserted inside to increase internal surface area and turbulence. The exchanger exhaust flow area was oversized to obtain the required surface area. Therefore, the addition of chains did not affect engine performance or significantly increase back pressure.

At idle, the outlet temperature averaged 10°C (50°F) with inlet temperatures of 180°C (350°F). At speeds of 64 km/h (40 mi/h), output temperature averaged 21°C (70°F). For idle emission comparison with and without the cooler-condenser, see Figures 9 and 10. Back pressure at idle was 3-10 cm (1-4 in.) of water. At 64 km/h (40 mi/h) it was 76 cm (30 in.) of water. Normal back pressure without the cooler-condenser was 51 cm (20 in.) of water.

Condensation efficiency decreased with decreasing temperatures. It was found that some ice film formed in the tubes at temperatures below -25°C, thus restricting exhaust flow and increasing back pressure.

Tube and Shell Cooler-Condenser

Students in the University of Alaska mechanical engineering program designed and fabricated an air-cooled shell and tube cooler-condenser from 16 EMT tubes, 1-1/2 inches x 15 in. (38 cm), enclosed in a 12 in. (30 cm) x 15 in. (38

Fig. 6 1968 Scout exhaust after passing through cooler-condenser.

Fig. 7 1968 Scout exhaust without ice fog control.

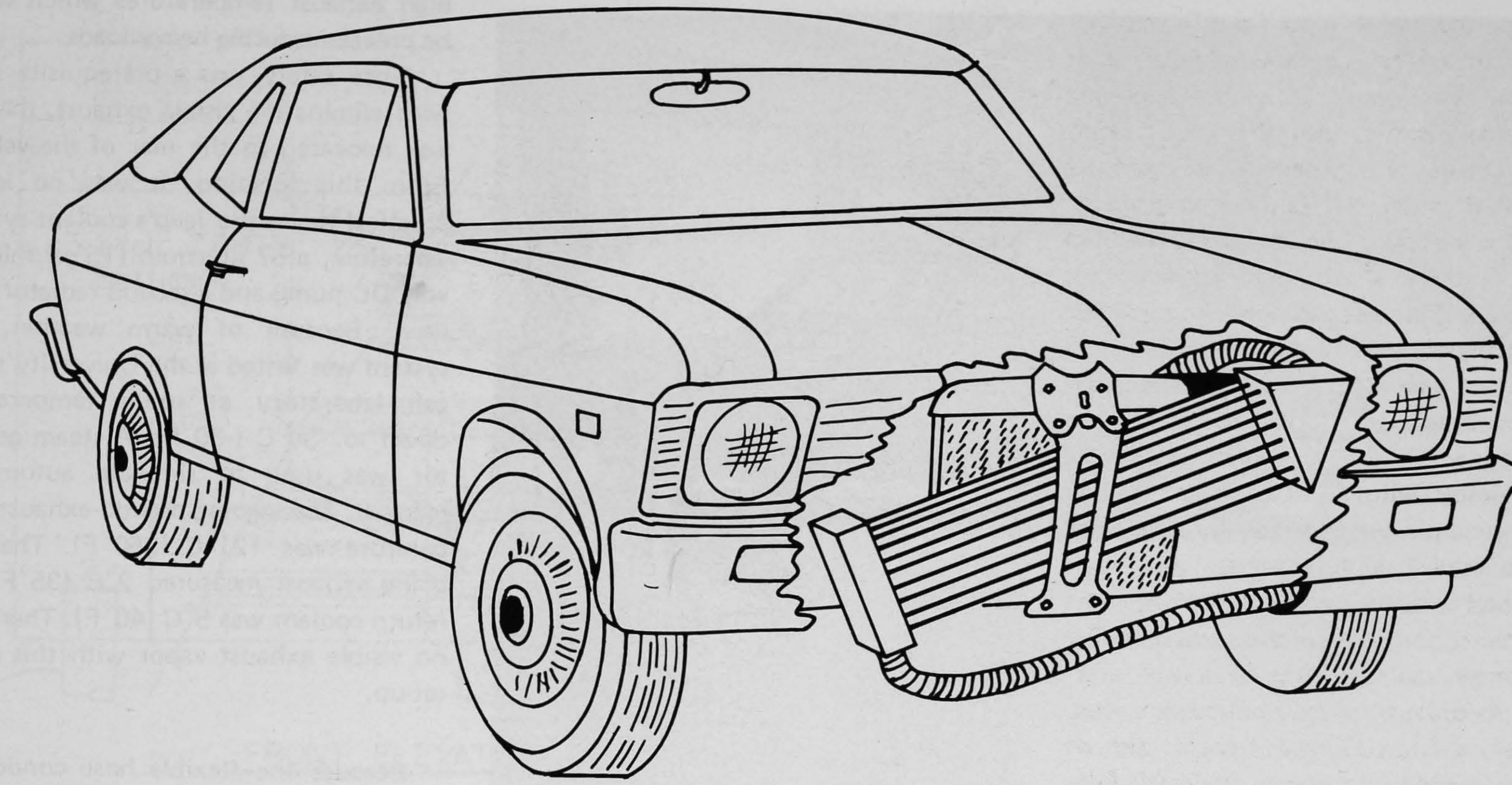

Fig. 8 Cooler-condenser mounting on 1974 Chevy Nova.

cm) x 8 in. (20 cm) sheet metal box (Schmidt, R.) A 12 VDC fan was mounted at one end to draw ambient air through each tube to maintain a continuous air flow. This cooler-condenser was mounted on the rear bumper of a 1970 Volvo 144S (Figure 11). Exhaust gas at a temperature between 93°C (200°F) and 150°C (300°F) flowed into the shell and was baffled around the tubes. To some extent, this baffling caused mist coalescence by impingement. The exhaust gas outlet was then recirculated through the tubes, mixing with the heated ambient air being drawn by the fan. Outlet temperature was about 5°C (40°F) indicating 95 percent water vapor condensation. This device prevented any visible ice fog from being released into the atmosphere. The condensed water remained liquid and drained out of the condenser through the seams, freezing when it made contact with the road. For comparative road performance, see Figures 12 and 13.

Material costs can be itemized:

Sheet metal	$15.50
Conduit	12.00
Fan and Motor	20.00
Miscellaneous	4.00
	$51.50

Considering the corrosion factor, this system had an anticipated life of not more than three seasons.

Antifreeze to Gas Cooler-Condenser

Another group of mechanical engineering students (Schmidt, G) designed a liquid-cooled cooler-condenser which was expected to be more efficient than the air-cooled exchangers because of the greater surface area. It consisted of an enclosed radiator mounted on the front of a 1968 Jeep Wagoneer. The coolant antifreeze solution was connected in series with the vehicle's cooling system. The exhaust gases were routed through a sheet metal shell encasing the radiator (Figure 14). The outgoing gases were then directed at the vehicle's radiator which re-evaporated all mist droplets not removed in the condenser. This procedure proved undesirable because of the possibility of drawing poisonous exhaust gases into the vehicle cab. At ambients near -1°C (30°F), the exhaust temperatures going into the condenser ranged between 93° and 150°C (200° and 302°F) while the incoming coolant was about 27°C (80°F). The outgoing coolant and exhaust gases measured approximately 38°C (100°F).

During colder weather large icicle formations accumulated at the lower seams where the condensed water seeped out into the cold atmosphere. These icicles broke off and fell onto the roadside. This cooler-condenser was not tested with the

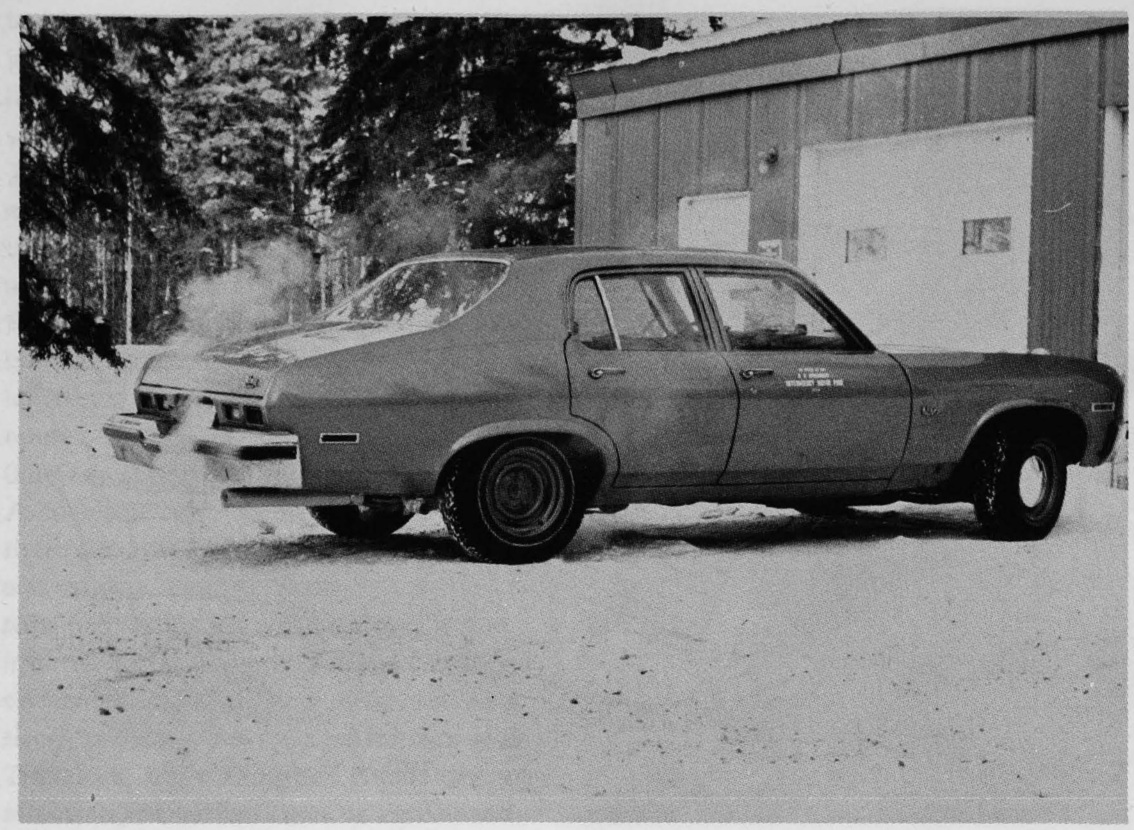

Fig. 9 1974 Nova with cooler-condenser outlet through rear coalescer. (-30°F ambient)

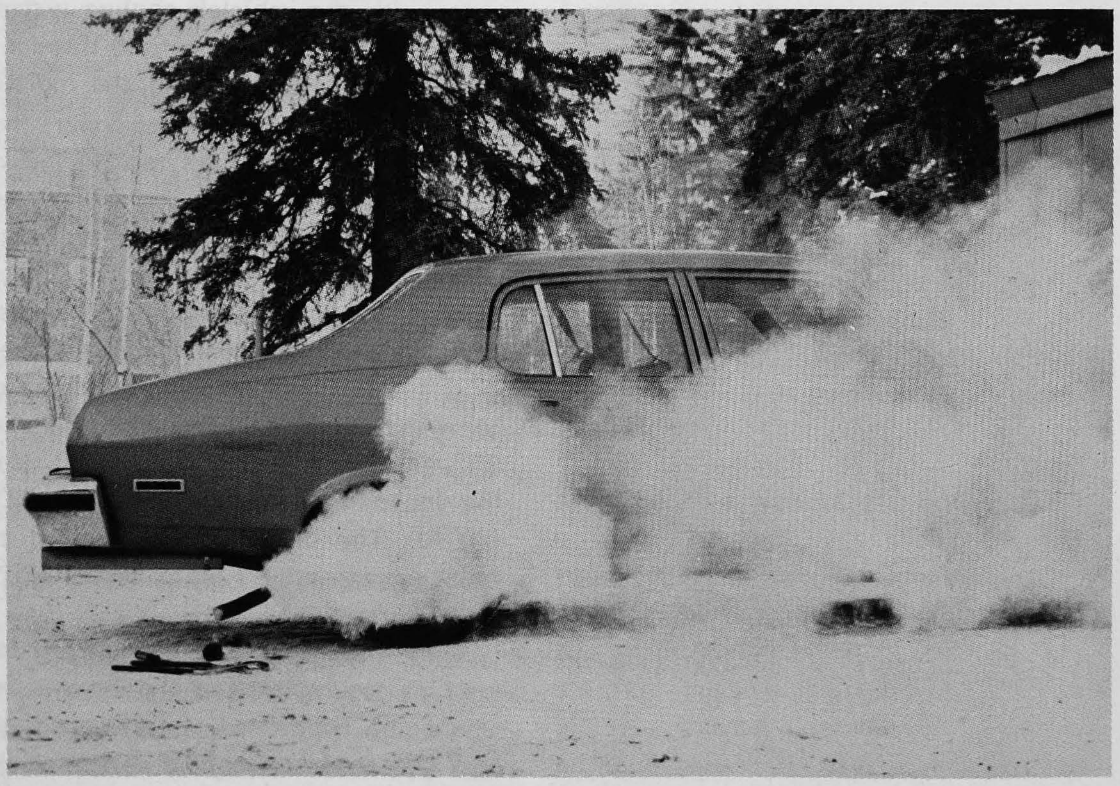

Fig. 10 1974 Nova with cooler-condenser bypassed. (-30°F ambient)

high exhaust temperatures which would be prevalent during heavy loads.

Since safety was a prerequisite along with eliminating visible exhaust, the unit was relocated to the rear of the vehicle. From this location, it was no longer practical to use the Jeep's coolant system. Therefore, a 57 liter/min (15 gal/min) 12 volt DC pump and a second radiator were used. Because of warm weather, this system was tested at the University's cold cell laboratory at room temperatures down to -34°C (-30°F). A steam generator was used to simulate automobile exhaust. The ingoing pseudo-exhaust temperature was 121°C (250°F). The outgoing exhaust measured 2°C (35°F) and return coolant was 5°C (40°F). There was no visible exhaust vapor with this mock set-up.

Because the flexible hose conducting the exhaust from the tailpipe to the cooler-condenser proved susceptible to corrosion and attack by acidic condensate, it was considered the weakest part of the system. However, the sheet metal shell is equally affected by acidic condensate. The anticipated life of the hose and shell was not more than two seasons.

Material costs for the first device, including antifreeze, totaled $169. Cost of additional parts for the second device was $135. Total overall material cost for this project was approximately $300.

DISCUSSION

All the techniques discussed successfully reduced automotive ice fog. The only difference among the cooler-condensers were the cooling media (ambient air is the final medium) and the flow considerations. In cooler-condensers where the air absorbs heat from the exhaust gas, the exhaust can flow either through the tubes or through the shell (outside the tubes). If the exhaust gas flows through the tubes, they must be large enough to compensate for ice accu-

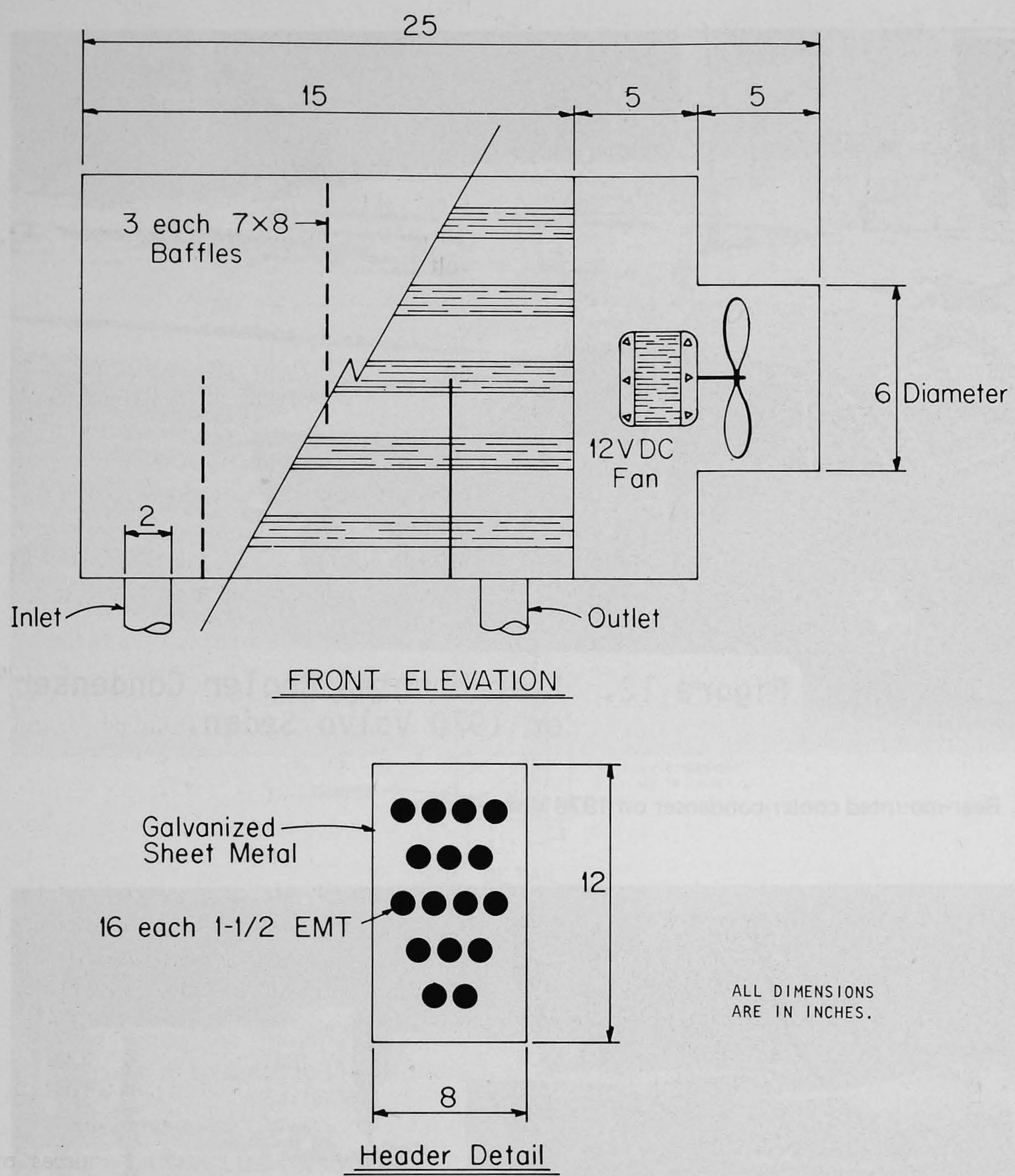

Fig. 11 Tube 8 shell cooler-condenser fabricated for 1970 Volvo sedan.

mulation or the cooling air flow must be regulated to reduce ice formation. The tubes must also have sufficient flow area to maintain low back pressure. If the exhaust gas is on the shell side, the freezing and back pressure problems are reduced because of the large flow area. However, construction of a baffled shell and the addition of a fan (for forced convection), as was done on the 1970 Volvo, make this type of cooler-condenser more expensive.

Because of the large flow area, the antifreeze-to-exhaust gas cooler-condenser has a low back pressure and little opportunity for ice plugging. If automotive radiator solders, which soften at about 200°C (400°F), can withstand the high exhaust temperatures on one side and cold antifreeze on the other, then economical cooler-condensers could be fabricated by adding baffles to an auxiliary radiator as was done on the 1968 Jeep. The standard equipment automobile radiator would cool the antifreeze before being pumped into the cooler-condenser (baffled radiator). The main disadvantage of this system is the increased vulnerability to the engine cooling system. The extra hoses and connections to the anti-freeze system increase the possibility of leaks or total loss of coolant.

The condensation process also serves as an excellent gas scrubbing process. Therefore, it is believed that some of the toxic combusion products such as nitrogen and sulfur oxides, hydrocarbons, halogenic acids, and soot and lead compounds would be captured in the condensate. Since carbon monoxide is not appreciably soluble in water, the carbon monoxide concentration in the vehicle exhaust gas would probably not be affected by the condensation process. By removing these compounds in the condensate, the toxic materials would be deposited onto the road instead of being inhaled.

Disposal is the other problem that must be faced when creating a condensate. For a cooler-condenser that is condensing over 90 percent of the water vapor, the theoretical yield is about 0.8 gallon of condensate per gallon of gasoline consumed. By design, this condensate has been allowed to drip from the coalescers onto the road surface. It then freezes to form an ice surface. Preliminary calculations for some of the heavier-traveled routes show that if all the vehicles condensed their exhaust water vapor and discharged it onto the road, the volume would amount to about 20 percent as much ice as Mother Nature normally deposits on the roads from November through February. Normal precipitation falls as snow which may be easier to remove than ice. However, most of the condensate would fall upon the road surface as liquid water and then freeze into rime ice. Where traffic is heavy, tires

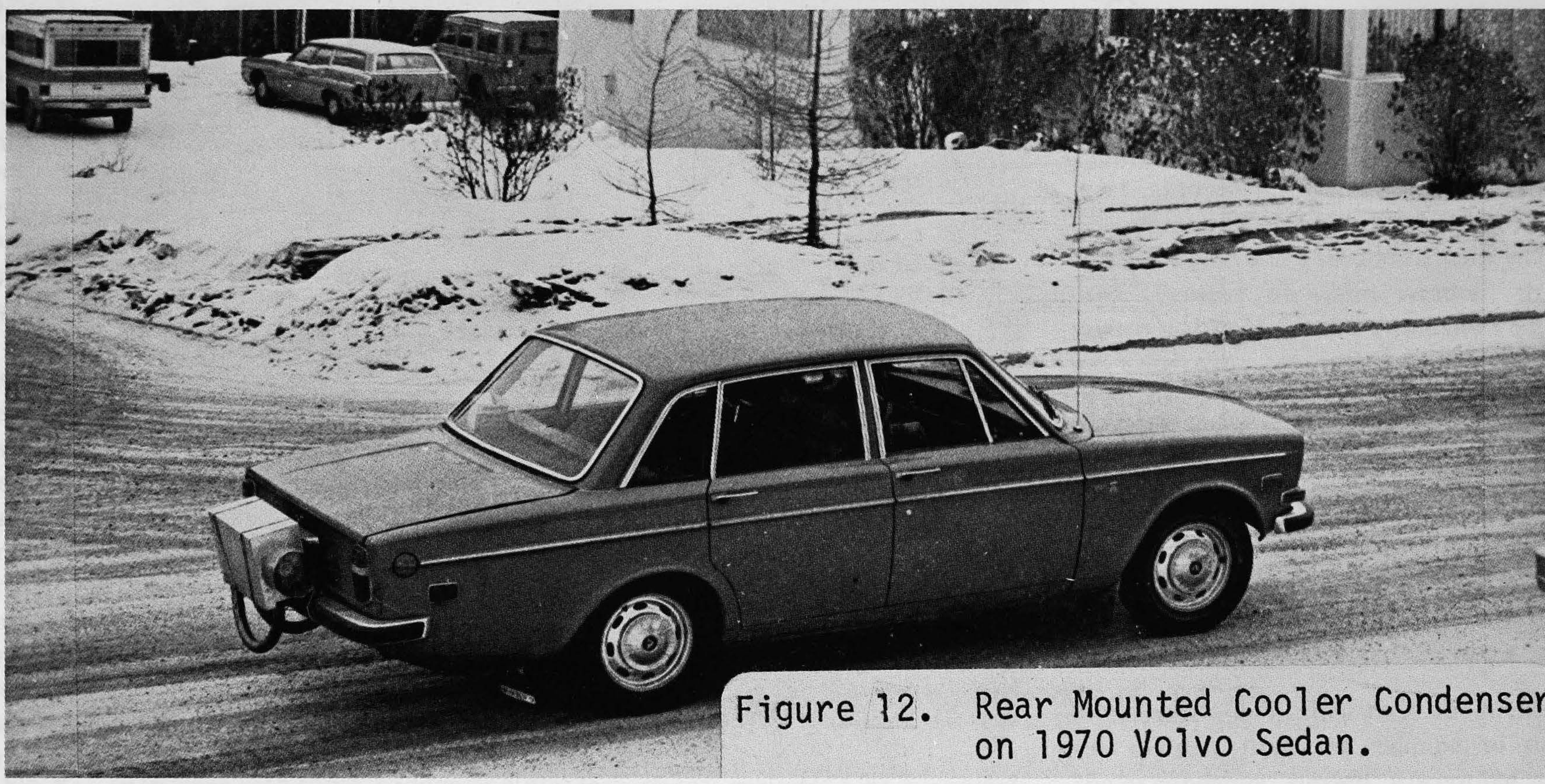

Fig. 12 Rear-mounted cooler-condenser on 1970 Volvo sedan.

Fig. 13 Cooler-condenser in operation. Note: No visible exhaust compared to passing truck.

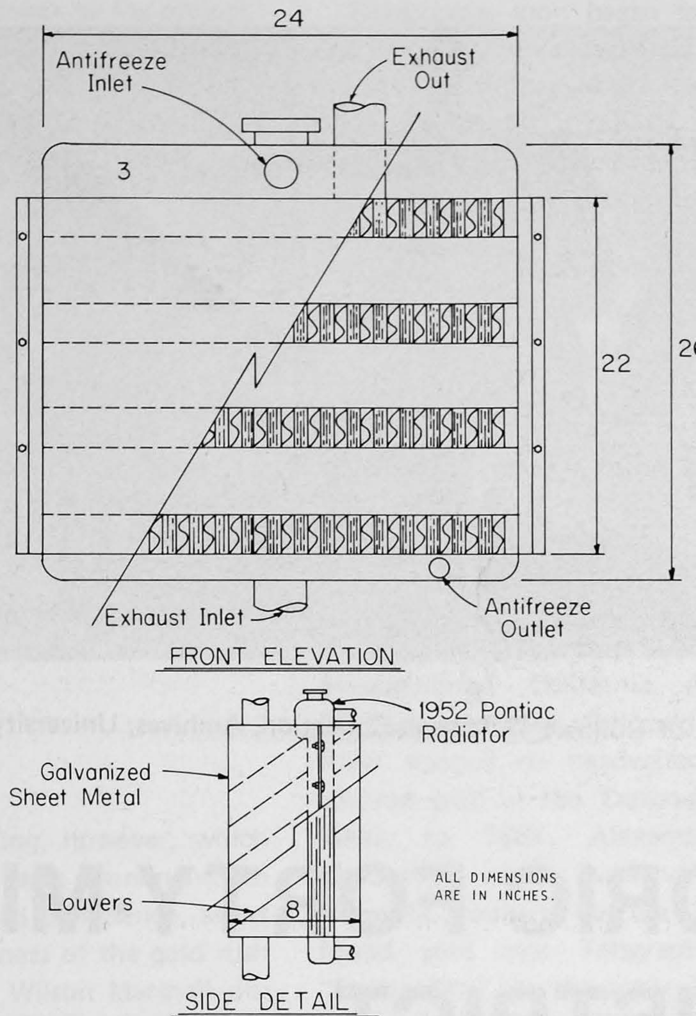

Fig. 14 Antifreeze to gas cooler-condenser. Fabricated for 1968 Jeep Wagoneer.

would erode the forming ice, causing much of it to be swept to the roadside.

CONCLUSIONS AND RECOMMENDATIONS

Ice fog is a continuing hazard for people living in cold regions. Ice fog created by automobiles is most offensive because it creates a visibility and safety problem on the road network, especially at traffic intersections. Vehicular ice fog emissions can be drastically reduced; however, there are some added costs and inconveniences to the vehicle operator.

The individual cost of automotive ice fog control would probably range between $100-$500 per vehicle if the devices were commercially manufactured and installed. Several of the devices tested were much less costly because they were manufactured from locally available materials using home construction techniques.

The next logical step in the effort to solve the motor vehicle ice fog problem is to establish an evaluation-demonstration program. The AERS research effort has provided adequate design criteria to facilitate definitive prototype engineering for such a program. This evaluation should be performed on one of the many vehicle fleets (20 or more vehicles) that routinely operate in the dense ice fog areas. This type of evaluation would better quantify the overall economics: cost vs. benefits. The outcome could be used by authorities to determine if, in fact, automotive ice fog controls would be a practical solution to the problem.

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Authors' Note: The USEPA's Arctic Environmental Research Station expects to issue a more complete report on the *Research with Techniques for Control of Automotive Ice Fog* in the winter of 1976.

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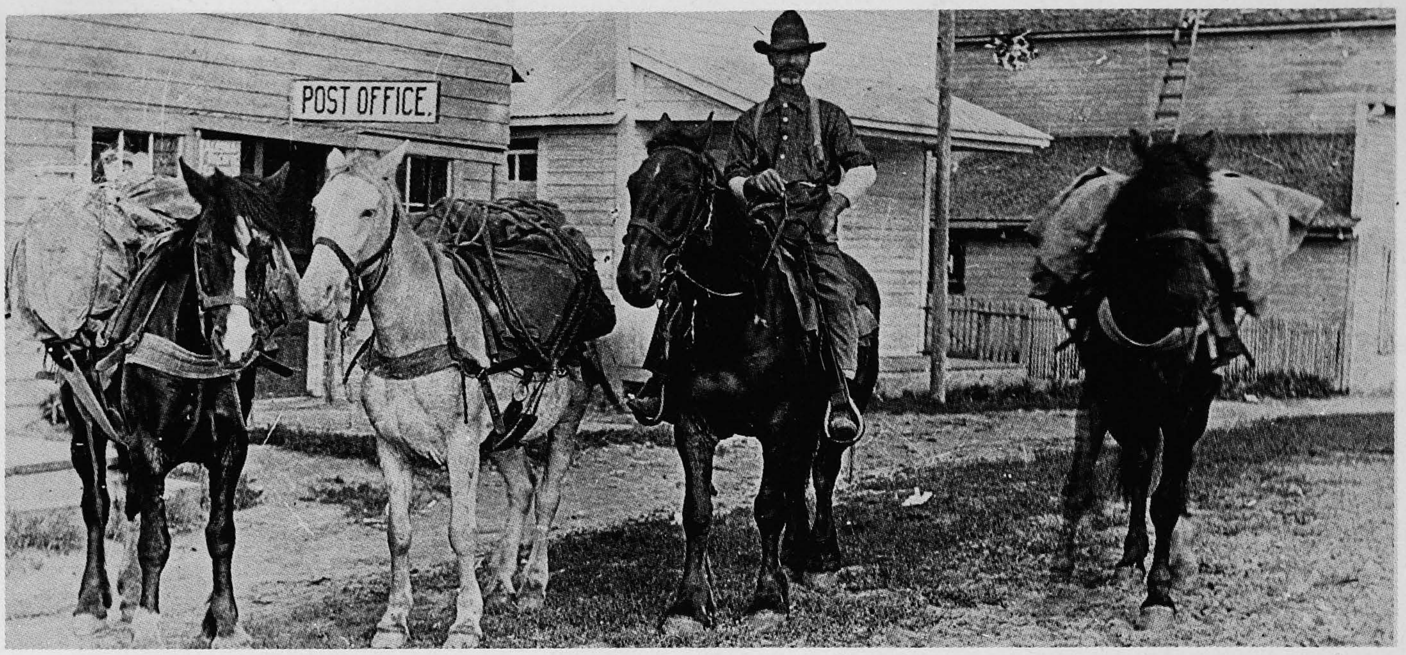
by Claus-M. Naske



(Courtesy of Guilbert Thompson Collection, Archives, University of Alaska, Fairbanks.)

THE HISTORIC FORTY-MILE DISTRICT

The oldest mining area in the interior of Alaska, the Fortymile district, is roughly seventy miles long and approximately thirty miles wide, 64°, 30' North and 141-142°, 20' West. The Fortymile River, the largest stream within the district, drains a fairly large area and receives several large tributaries. It joins the Yukon about thirty miles above the international boundary, the mouth of the river lying in the Canadian Yukon. The drainage basin lies, for the most part, on the Alaskan side.[1] Notwithstanding the Fortymile's abundance of water, the swiftness and shallowness of this river make it difficult to navigate. All the streams in the area, except for the Fortymile, can be forded on foot at ordinary water stages. Water levels vary greatly because of the direct relationship which exists between the amount of water carried and rainfall. Since most of the ground is permanently frozen, runoff occurs very quickly. A few days of dry weather quickly lower the water level and render mining difficult.

The area has a typically Arctic climate, with warm summers and severe winters. Extended periods of fifty to sixty degrees below zero temperatures are fairly common and minus seventy-five has been recorded. Summers are warm and temperatures reach the eighties and even nineties each year. Yet, despite high summer temperatures, diurnal variations may be extreme and freezing temperatures may and have occurred in each month of the year.

The many valleys in the area have been shaped by the streams which flow through them, and the narrow, deeply-cut appearance of the Fortymile Valley is repeated in the lower valleys of its tributaries. Vegetation consists of spruce trees of considerable size which dominate the valleys and creep up the slopes to the treeline. Aspen and birch are also common and thickets of alder and willow line many of the stream banks. The higher ridges are covered with a thick carpet of moss.[2] Precipitation occurs mostly in the normal form of convection showers, and snowfall, which averages approximately forty-five inches per year. Because of the cold temperatures, snow accumulation on the ground approaches this average as well.

From prehistoric times to the present, Athabascan-speaking Indians of various tribes occupied areas along the Yukon, Porcupine, and Tanana Rivers. As far as can be ascertained, however, the Fortymile area itself does not contain any old native settlements, although the area was traversed often in search of game.[3] In 1930, a geologist for the United States Geological Survey reported Kechumstuk, on Kechumstuk Creek near its junction with the Mosquito Fork of the Fortymile, as a native village. He gave no population figures, but reported that a white man had a cabin at Kechumstuk, and a homestead farther up Mosquito Fork where he put up hay in the summer for the use of his own and other stock at Chicken during the winter.

THE RUSH IS ON

It was gold mining, however, which made the Fortymile area prominent. An historian can, in good conscience, assert that the whole madness of the gold rush started when James Wilson Marshall discovered gold on the South Fork of the American River in California on January 24, 1848. Marshall, employed by John Sutter to build a sawmill, noticed bits of yellow metal in the millrace. He showed some to Sutter and together they tested the find and convinced themselves that it was gold. Despite attempts to keep it a secret, the news spread rapidly and before long the first great gold rush began.

Actually gold was not unique to California. North Carolina had produced some as early as 1792, and five states along the Appalachian Mountain Range had produced the precious metal as well. Yet the entire United States production between 1792 and 1847, the eve of the California rush, had amounted only to some 1,525,000 fine ounces with a value of $31,521,750. In 1849 alone, 1,935,000 fine ounces were mined worth some $39,996,450.[4]

Prospectors soon began to look high and wide for the yellow metal and ranged extensively throughout Nevada and Colorado, the Dakotas, Montana, Washington, Idaho and northward into British Columbia. Small gold finds had been reported from both the Yukon and Kuskokwim Rivers in Russian America before Marshall's California find. It was Peter Doroshin, a graduate of the Imperial Mining School at St. Petersburg, who, in 1851 or 1852, washed out some gold along the Russian River, a tributary of the Kenai River.

In 1857, prospectors found gold at the confluence of the Fraser and Thompson Rivers in British Columbia. By that time, disappointed California miners had flocked northward, followed the Fraser River toward its headwaters, and discovered gold in the Caribou District in 1860. In 1861, Alexandre "Buck" Choquette came overland from the Ominella country to the Stikine and found gold near Telegraph Creek at "Bucks Bar." In the early 1870's, gold was also discovered in the Cassiar and from there miners filtered into southeastern Alaska, since acquired by the United States from Russia in 1867 and renamed. This movement of men eventually led to the discovery of gold in Siver Bow Basin and the founding of Juneau in 1880.

By 1880, a few white men were known to be on the upper Yukon. Some had reached the region overland from the Mackenzie River, others had shipped out to St. Michael at the mouth of the Yukon River and ascended the river from there. Still another route began at the head of Lynn Canal and crossed Chilkoot Pass. This was an ancient trade route between the coast and the interior, jealously guarded and monopolized by the Chilkat Indians. As early as 1869, Alaskan military commander General Jefferson C. Davis had dispatched mail from Sitka to Captain Raymond and his expedition at Ft. Yukon by way of the Chilkoot Pass. No conflict ensued because the general had the foresight to employ Chilkat Indians as mail carriers and he had not tried to open the route for white traffic.

The Forty-Mile Hotel and Restaurant with its watchful guardian on duty. (Courtesy of Clara Rust Collection, Archives, University of Alaska, Fairbanks.)

In 1875, George Holt apparently crossed Chilkoot Pass and found some gold on the Yukon. Finally, with the help of Lt. E. P. McClellan of the *Jamestown*, a party of some nineteen miners under the leadership of Edmund Bean crossed the Chilkoot Pass at the end of May, 1880. This event marked the official opening of the Pass.[5]

Each year from 1880 onward, men crossed the divide in increasing numbers. Arthur Harper, a prospector turned trader, came overland from the Mackenzie Valley in the 1870's, and together with Al Mayo and LeRoy Napoleon McQuesten, the trio helped open up the Yukon Valley for an increasing number of prospectors. They built a trading post and named it Ft. Reliance. This supply post quickly became the nucleus of future river settlements, and several neighboring tributaries of the mighty Yukon took their names from the distance which separated them from Ft. Reliance, i.e., the Fortymile River as well as the Twelvemile joined the Yukon that distance downstream from Ft. Reliance. The Sixtymile was located that distance upriver from the fort. Later on, the settlements which grew at the mouths of these rivers took the same names.

A decade later, a fourth trader, Joseph Ladue, joined the others. These four men, by establishing trading posts along the Yukon, enabled prospectors to systematically explore the river country.

By 1886, some 200 miners had gradually worked their way 300 miles down the Yukon to the mouth of the Stewart River. There McQuesten and his partners built a trading post. That winter, Arthur Harper convinced two prospectors to explore the waters of the Fortymile River which joined the Yukon 100 miles farther downstream. They found gold later in the season and a minor stampede followed.[6]

Gold was discovered that same year on the bars of the Fortymile River at Franklin Creek which was named after Howard Franklin, its discoverer. The Fortymile became a steady, if not spectacular, producer until the 1950's. In 1887, prospectors found gold placers in Franklin Gulch, and in the spring of 1888, discoveries were made on Davis Creek, a headwater tributary of Walker Fork. In the following years, miners struck pay dirt on Poker Creek, another headwater tributary, as well as the main Walker Fork. Further discoveries in 1892, east of the international boundary on Miller and Glacier Creeks, attracted numerous miners. This new influx of men brought additional discoveries, and mining activities began on Dome Creek in 1893, while the placers of Wade Creek were first located in 1895, and those of Chicken Creek in the spring of 1896. In short, most, if not all, of the valley's productive placers had been located within ten years after the minor stampede of 1893. Prospectors apparently thoroughly examined the Fortymile district in the 1890's, because few additional deposits have since been found.

In 1886, certain that news of gold would spread more widely the following year, Harper decided to ask McQuesten, by then the agent of the Alaska Commercial Company and wintering in San Francisco that year, for an increase in the supply shipment. George Williams, a former river captain, volunteered to carry the letter over the Chilkoot Pass to tidewater. After many hardships, Williams and his Indian guide reached Taiya where Williams died from the effects of the exposure he had suffered. The letter, however, got through.

In 1887, gold was found in Franklin Gulch, also named in honor of the discoverer of Fortymile. The settlement of Fortymile sprang up on a high bank at a point where the Fortymile River joins the Yukon. During the first year miners took out an estimated $4,000 worth of gold.

In the spring of 1888, gold was discovered on Davis Creek and men flocked to the new site. Other gold finds followed rapidly. In 1889, Poker Creek and the headwaters of Walker Fork were staked by eager miners. In 1892, O. C. Miller staked Miller Creek, its whole length located in the Yukon Territory. In 1893, miners opened many additional claims, and it was estimated that some 80 men took out $100,000 worth of gold. Miller Creek, although prospected before, had not been worked because the gravel was so deep that the labor needed to strip the top layers made it unprofitable. Miller Creek rapidly became the largest producer for a considerable time.

In 1893, the creeks in the Fortymile district, including Fortymile, Davis, Nugget, Piker, Franklin Gulch, and Bettle's Mine were occupied by some 116 miners who produced some $98,000 worth of gold. By 1894, gold production in the Fortymile area had risen to $400,000. Miller Creek, with a population of some 80 men, still yielded the largest output, although Franklin Gulch and Napoleon and Glacier Creeks made good showings.[7]

In the summer of 1893, two miners named Pitka and Sorresco, who had previously worked the Fortymile, discovered gold on Birch Creek. The news of the strike encouraged many men in the Fortymile to seek their fortunes in the new district. Some 80 miners left and went down the Yukon where they built cabins along the river and wintered. In the spring, the Yukon overflowed its banks and swept away some of the cabins. The men then moved to higher ground twelve miles downriver and built the settlement of Circle City. By 1895, the center of the footloose mining population had shifted from Fortymile to Circle City which quickly became the most important settlement in the interior with an estimated population of 700 as compared to the 600 left at Fortymile. In the same year, the area's gold production had fallen to $300,000, a decline of $100,000 from the previous year. By 1896, the Fortymile, despite a six-week summer drought which idled many men and made it impossible to run the sluices in most of the gulches, had somewhat recovered. Some 700 men worked the gulches and bars and produced approximately $460,000 worth of gold. Despite the temporary recovery, the Fortymile continued to lose population as miners were lured to new locations. In the latter part of August, 1896, this trend accelerated when they heard of rich new placers on the Klondike River. As a consequence of the new strike, Fortymile was almost deserted during the winter of 1896-97.[8]

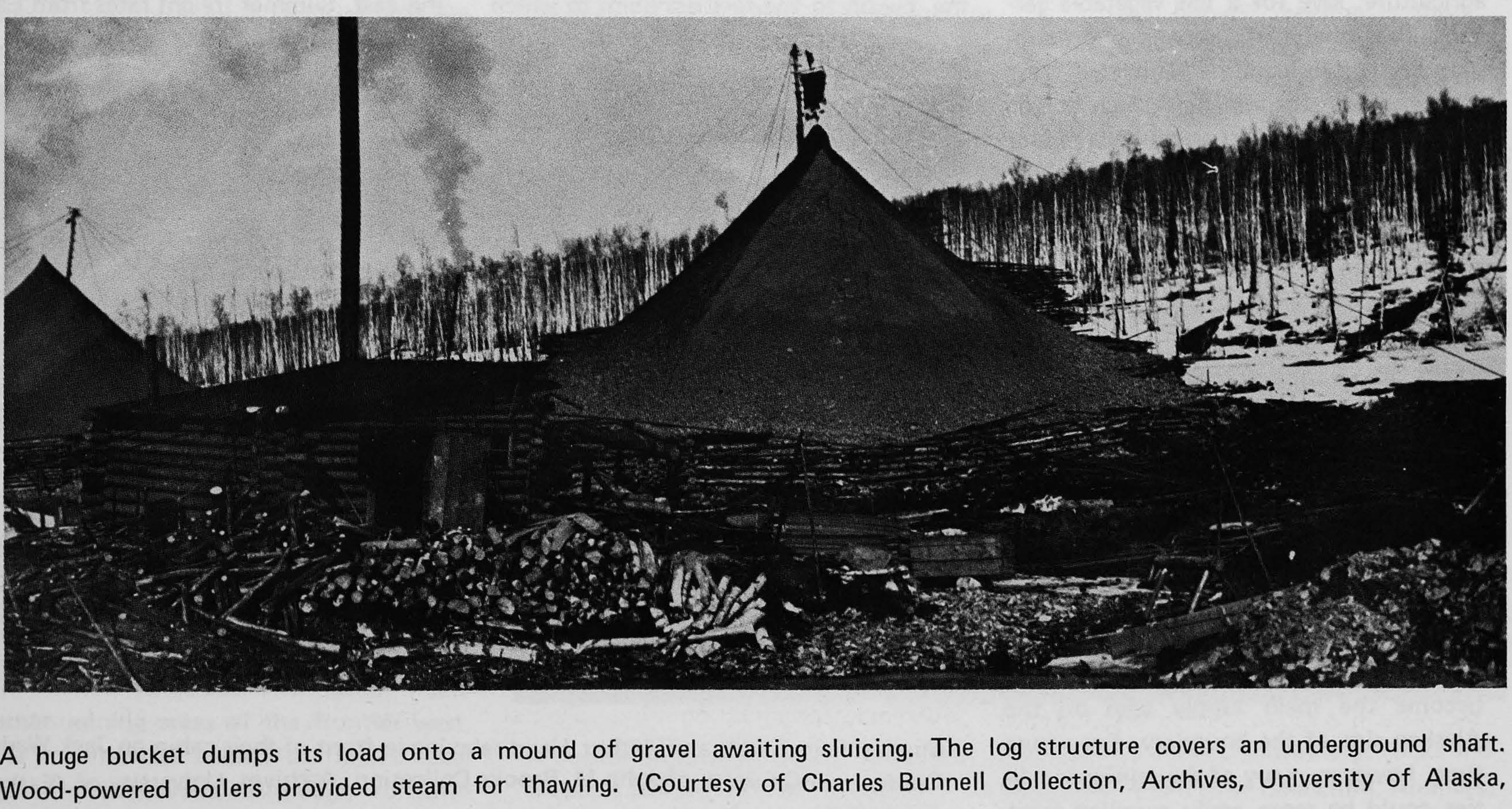
THE METHODS IN THEIR MADNESS

By the mid-1890's, most miners had come to fully realize the difficulties of mining in Alaska. Short summers and long, cold winters imposed severe restrictions on the length of the mining season. With breakup occurring approximately in the middle of May, miners were hard at work by the first of June, soon after the end of the flood season. Winter came early at the end of September. The ground, as well as the creeks and rivers, froze and most work had to be suspended.

A number of ways of extracting the gold from the ground were utilized. In the bar diggings, gold-bearing material consisted largely of coarse, round pebbles as well as finer materials, all of which had to be removed from the heavier gold. This was done with water employed in various ways or by air applied by bellows.

The gold pan, operated by hand, was the simplest device used to cull the gold from the gravel. The cradle, a more sophisticated tool, consisted of a long, narrow box with an upper and a lower compartment. The floor of the upper one was usually constructed of metal and riffled with holes of the proper size. Miners shoveled pay dirt into the upper end, and the cradle was moved back and forth upon the rockers up on which it was mounted. This movement sifted the gravel. The finer material passed through the holes into the lower compartment, while the coarser, containing little or no gold, passed out of the box as "tailings." The floor of the lower compartment consisted simply of an inclined plane. The surface, roughened in various ways, such as by the use of cleats, wooden riffles or corrugated metal sheeting, caught the fine gold. The lighter material was washed out of the box in streams of water.

In the gulches, conditions were quite different from on the bars. Gold usually occurred in a small channel at the bottom of the gulch, in gravel between three or four feet to a few inches thick. Often the bedrock at the bottom of the gravel contained gold as well. The pay dirt, after it had been uncovered, was loaded into a



A huge bucket dumps its load onto a mound of gravel awaiting sluicing. The log structure covers an underground shaft. Wood-powered boilers provided steam for thawing. (Courtesy of Charles Bunnell Collection, Archives, University of Alaska, Fairbanks.)

sluice, a long, slightly inclined trough constructed of boards, and the water in the gulch was diverted into this device. The gravel was washed out while the heavy gold sank to the bottom of the sluice and was captured by the slats or riffles built into the last few boxes.[9]

By the mid-1890's, miners had also learned to utilize the cold months of the season productively. They thawed the frozen ground by building fires fed by timber. By burning and drifting the men sank shafts until they hit pay dirt. Once there, they hauled the rich gravel to the surface and stored it until water again became available and the winter's accumulation could be washed out.

A MINER'S LIFE. . .

Miners not only had to contend with a harsh climate and isolation, but with an extremely high cost of living as well. Since the area generally did not support agriculture, save for a few vegetable gardens, the inhabitants depended on supplies brought in from the "Outside." Vast distances, with accompanying high freight rates as well as the virtual absence of any competition, drove prices to ridiculous heights. Wages, as high as $10 and even $12 for a ten-hour day in the more remote gulches, hardly compensated for inflated prices. During the cold season, wages generally declined to approximately $5-$8 for a six-hour day. In short, it was difficult for a laborer to make ends meet under the best of circumstances. Often, failure of supplies to arrive during the open season forced most miners to hunt uncertain game to fend off literal starvation.[10]

By the first decade of the 20th century, Eagle, on the Yukon River, had become the main supply base on the Alaskan side of the boundary. For a long time, however, many of the mining localities could be more easily supplied from Dawson in the Yukon. Most of the Fortymile miners bought their outfits in Dawson and horsedrawn sleighs sledded them up the frozen Fortymile where they were delivered to the more remote creeks and tributaries. During the winter of 1906-07, several hundred tons of dredge parts were shipped via this route and assembled on Walker Fork, about a mile above the mouth of Franklin Gulch. During the same year, another dredge was constructed on Pump Bar of the Fortymile, about two miles below the mouth of Franklin Creek; still another dredge operated on the Fortymile at Boundary, and yet another worked Sourdough Bar of the Fortymile about four miles above its mouth, in Canadian territory.

The freight rate to Franklin Creek amounted to approximately $70 per ton. During the summer months supplies were delivered by poling boats, a slow and laborious method because long stretches of quiet water were separated by bedrock riffles where the water was swift and shallow. Rates from Fortymile Post on the Yukon to the farthest point to which supplies were freighted, Chicken Creek, came to 25 cents per pound in 1907.

From Dawson to Glacier, a distance of approximately 60 miles, a summer wagon road existed over which supplies were carried to creeks on the Alaskan side of the boundary. Additionally, the road commission had surveyed a government wagon road from Eagle to the Fortymile country and by 1907 had completed about nine miles, from Eagle to American Creek. Mail was carried from Eagle to Valdez by way of the Fortymile country. Pack-trains were used during the summer, but because of the large mail-order business from the miners, the mails were always overtaxed.[11]

Mining in the Fortymile area developed around six separate areas; Dome, Steel, Wade, Franklin and Chicken Creeks, and at the headwaters of Walker Fork of the Fortymile River. Miners utilized three approaches to the district — from Eagle to the north; from Fortymile to the northwest; and from Dawson to the east. Summer freight rates from Eagle

Charley Pennycook and Arthur Hand relaxing in front of their cabin on Jack Wade Creek. (Courtesy of John M. Brooks Collection, Archives, University of Alaska, Fairbanks.)

to Steel Creek, Jack Wade, and Chicken during the late 1920's were, respectively, 15, 20 and 25 cents a pound, while the corresponding winter rates amounted to five, six and seven cents. Winter freight delivered to Jack Wade and Chicken from Fortymile in the Yukon Territory cost four and a half to five cents per pound, but only three and a half cents per pound to Walker Fork.

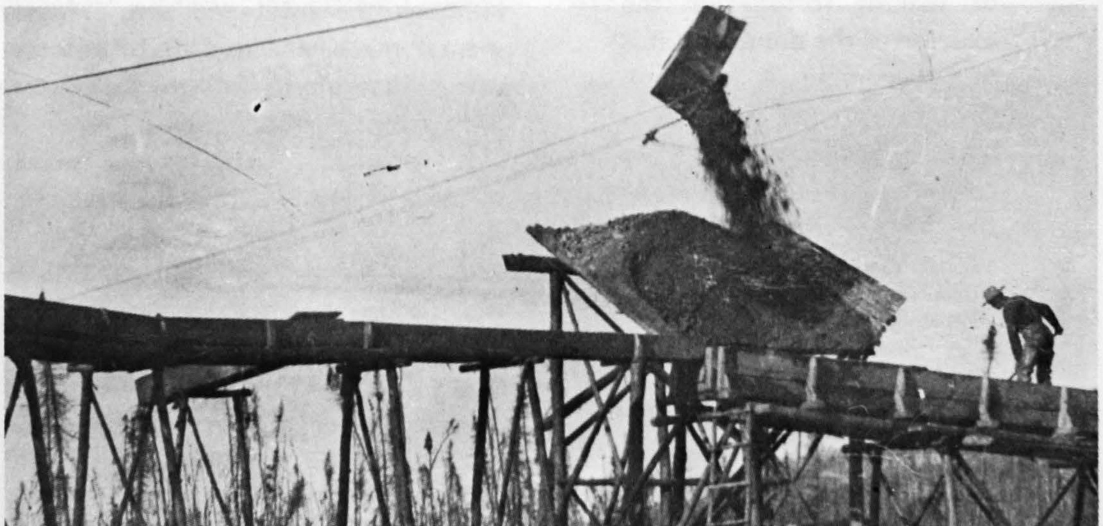
During the same period, the late 1920's, a small airfield was constructed at Chicken, and in case of emergencies passengers could be flown from there to Fairbanks or elsewhere in Alaska. Post Offices had also been established at Steel Creek, Jack Wade, Franklin, and Chicken, with mail service three times monthly. But the Walker Fork area, situated near the international boundary east of the main mail route, received its mail by private carrier from Steel Creek. Communication from the Fortymile, however, was slow at best since the area did not possess any telegraphic facilities, and the nearest wireless stations were at Eagle and Dawson, some distance away.[12]

An example of hydraulic mining as used in the Forty-Mile; great jets of water were used to strip away the overburden. (Courtesy of J. S. Norwood Collection, Archives, University of Alaska, Fairbanks.)

"MINERS' MEETING"

The need for some sort of rude order was manifest by the late 19th century. The "miners' meeting" organizations of Juneau, the Fortymile and various other localities represented examples of the more advanced forms of civic structures created by settlers before any legal base for local government existed. The miners' law was designed to bring some semblance of order to the affairs of prospectors, claimants and mine operators. Although extra-legal, the Organic Act of 1884 explicitly recognized such law and the miners' organizations. As in many other mining areas of the frontier west, the miners' law helped to fill the local governmental void. Although romanticized by some observers, the effectiveness of the miners' meetings in Alaska, and elsewhere, should not be exaggerated since the practice in American mining towns often tended more toward mob rule than justice. Moreover, because it was only an expedient arrangement for the adjudication of mining disputes, the miners' meeting had a very limited application and lasted only as long as the mining enterprise did. In 1897, one observer of the Alaskan scene, Harold B. Goodrich, has this to say:

> The miners' meeting is the only government in the interior of Alaska, but it



A bucket dumps gravel into an elevated sluice where a miner removes large rocks and prepares the pay dirt for sluicing. (Courtesy of Clara Rust Collection, Archives, University of Alaska, Fairbanks.)

Steam pipes, heated by a wood-fired boiler, are driven into frozen ground to thaw it for digging. (Courtesy of Charles Bunnell Collection, Archives, University of Alaska, Fairbanks.)

> appears nearly to have outlived its usefulness, and with the growth of the country and the introduction of a class of nonproducing adventurers, attracted by the hope of making fortunes at the expense of the producers, it is fast becoming a mockery. The better class of miners have already objected to having disputes occurring in the gulches settled in town, for the greater preponderance of the disreputable class in the latter makes it almost impossible ot obtain justice there. Again, while perfectly well intentioned, the miners are often not the ones best fitted to decide cases impartially.[13]

Goodrich was entirely correct in his observations. The growth of mining towns and districts revealed the inadequacy of the miners' meeting. There was a need for a more substantial form of government to insure peace and order, to guarantee local justice, and to provide the services needed by communities. Congress responded in part when it passed an act in 1899 which gave Alaska a criminal code, although the local and district governmental machinery needed to enforce it was still lacking.[14] With the passage of an "Act making further provisions for Civil Government. . ." in 1900, Congress began to deal seriously with the problem of structuring a governmental system for Alaska. Yet the North Country was much too remote and its population far too small and transient to worry Washington overly much. The structures provided were minimal, and from that time on, until the achievement of statehood in 1958, Congress passed a series of measures which provided for – but concurrently also imposed special restrictions on and rigid definitions of – the form, powers, and functions of government at territorial and local levels. Nevertheless, a body of municipal law accrued during this period which proved very durable, and, among other things, took care of the miners' needs.

PRODUCTION AND PROFITS

With the influx of a greater number of miners, especially after the great rush to the Klondike in the late 1890's, gold production rose steadily, not only in the Yukon but in Alaska as well. In time, most creeks in the Fortymile were prospected by the restless gold-seekers and rapidly came into production. Gold production from the Fortymile district between 1886, the year of discovery, to 1903 amounted to approximately $4,000,000 and between 1904 and 1909, another $1,282,000 worth of gold was produced. Dredges were introduced in 1907, and by 1909, two had operated throughout the season, one on Walker Fork and the other on the South Fork of the Fortymile River. In the winter of 1908-09, some 34 claims on Walker Fork, Jack Wade and Chicken Creeks were worked by 80 men who produced $35,000 worth of the yellow metal. During the summer of 1909, some 95 men worked 25 claims on Walker, Jack Wade, Chicken, Franklin, and Canyon Creeks and produced some $116,000 worth of gold. In addition, Ingle Creek and Lilling Gulch, a small tributary of the former, were also mined by drifting and open-cut work. On Napoleon Creek both drifting and open-cuts were employed. A total estimated value of $225,000 was taken from the Fortymile in 1909, a gain of some $75,000 over 1908, chiefly due to improved mining methods.[15]

In 1910, gold production sank to $200,000, a loss of $25,000 from the previous year. Experts attributed the decline to the extremely dry summers and the resulting inadequate water supply during the 1910 season. In addition, although five different dredges had been operating on the Fortymile and its tributaries, they generally had not been as successful economically as had been hoped. Exactly why was difficult to pinpoint. One of the main reasons for the poor showing seemed to be a lack of proper prospecting to determine the gold content of the available ground before the installation of the dredges.

There were exceptions. The dredge on Walker Fork near Poker Creek had a good season. Men worked ahead of the dredge and stripped the ground of overburden. The operators hoped that the stripping would aid in the thawing process and ready the ground for future dredging. The Walker Creek dredge was steam-powered, its energy produced by wood. The rapacious appetite of the dredge, however, had quickly depleted the supply of readily available wood which, in 1910, had to be hauled several miles, a distinct economic disadvantage. Around 1910, the owners of the small Walker Fork dredge moved it to a new location on the Fortymile River just below Franklin Creek. The operators derived a good profit from the "Mulvane Dredge," as it was known in its new location. Once the dredge passed the mouth of Franklin Creek and worked upstream on the Fortymile River, however, gold production fell off sharply because Franklin Creek had been the source of the gold feeding into the Fortymile River. The dredge rapidly became unprofitable and was shut down in 1914.[16]

About six or seven men did considerable work on both Davis and Poker Creeks during the 1910 season. They recovered gold by ground-sluicing and shoveling into sluice boxes, but no winter work had been done. Two men spent the summer prospecting Walker Fork below Cherry Creek to determine the possibilities for moving in a dredge, and some prospecting took place on Cherry Creek itself.

On Canyon Creek, approximately three miles below Squaw Creek, a one-half-yard capacity steam scraper, drawn by a forty-five horsepower boiler connected with a double-drum hoist, operated during the latter part of 1910. This piece of machinery allowed the movement of roughly 150 cubic yards of gravel in a ten-hour workday and employed about eight men. In the early part of the season, a smaller scraping plant operated just below the mouth of Squaw Gulch, and on the gulch itself, three or four groups of one to three men each mined by open-cut methods during that summer.

Production on Wade Creek was greatly hampered by inadequate water supplies. Forty-one men worked 18 claims during the winter, and 24 men utilized open-cut methods on ten claims during the summer. Chicken Creek and its tributaries also suffered from a lack of water and most operations were suspended for the better part of the season. For short periods during the season, two outfits, employing six men each, drifted and eleven men performed open-cut work on four claims. In the same area, three men each worked ten different claims, and divided their work roughly between winter and summer. On Myers Fork, seven men mined on three claims at different times of the year. Ingle, Franklin and Napoleon Creeks employed approximately 13 men. Other streams and creeks in the district, such as Hutchinson and its two tributaries, Confederate and Montana Creeks, as well as bars on the Fortymile River near the mouth of Twin Creek, employed another 12 to 15 men.[17]

The 1911 season proved to be a discouraging one for many of the smaller operators in the Fortymile because of the continued shortage of water. Dredges and larger operations were more successful. Two dredges operated on the headwaters of the Fortymile River and employed many of the men thrown out of work by the continued drought and the army's abandonment of Ft. Egbert at Eagle. On Dome Creek, the Auburn Gold Mining Company had built extensive ditches preparatory to hydraulic mining in order to develop the higher placer grounds along the creek. During the 1911 season, a small ditch was worked and company officials planned an extension which was to eventually yield the entire flow of Dome Creek. Future plans called for a five-mile ditch with a 22-foot capacity. Other ditches for hydraulic work were either in the construction or planning stages on Dennison Fork and Franklin and Twin Creeks.

The Copper Mountain mining camp during winter operation. (Courtesy of John M. Brooks Collection, Archives, University of Alaska, Fairbanks.)

That same summer, J. V. Anderson built a several-hundred foot ditch to tap a small creek. During the spring runoff in 1912, he expected to wash out the gold in the bench lands on the right bank of Dennison Fork near its mouth. On Walker Fork, the upper Mulvane dredge completed a successful season, although for about three weeks in August there was hardly enough water to float the dredge.[18]

In the 1912 season, approximately 143 miners worked the Fortymile district. Geologists with the U.S.G.S. expected these men to produce some $230,000 worth of gold, up slightly from the $200,000 the district had yielded in 1910 and 1911.

Although prospectors had found gold quartz on Mosquito Fork and copper ore at the headwaters of Kechumstuk Creek, no development work took place, primarily because of the remoteness of these localities from transportation facilities. Three dredges operated in the Fortymile basin on the American side of the boundary, and one on the Canadian side, while the Canadian Securities Company, Ltd., operated two dredges on the lower part of the Fortymile. The heavier one worked well on the Canadian side, but the American one, about a half mile below Moose Creek, was too small and light for the large boulders found. It broke down frequently which meant an unprofitable operations.

On a claim below Baby Creek, six men operated a bottomless steam scraper of three- quarter-yard capacity, powered by a 40 horsepower boiler. The miners sluiced off the muck and thawed between two to six feet of gravel with steam points. They then scraped the last one and one-half feet of gravel next to the bedrock up an incline to a platform about 20 feet high and dumped it into sluice boxes. With this very efficient method, approximately 200 yards of wet, or 250 yards of dry, gravel were processed per day using about one cord of wood for fuel. Approximately 11,520 square feet of bedrock were cleaned in this way.

Although open-cut and drifting methods were still employed, dredging accounted for the bulk of gold production in 1912. Most mining operations closed down for the winter of 1912-13, although some activity continued on Chicken and Wade Creeks. In addition, workmen dismantled the Walker Fork dredge at the end of the season preparatory to moving it over the divide to Miller Creek in the Yukon Territory where it was to be operated on the claims of the North American Transportation Company.[19]

Again water problems hampered the 1913 season. Nevertheless, 25 mines operated throughout the winter and about 15 during the summer. The Atwater dredge worked on the south fork of Franklin Creek. In addition, there were reports that an unnamed syndicate was negotiating for a large number of bench claims on the Fortymile River and planned to develop the necessary water supply to extract gold.[20]

By 1914, the United States Geological Survey reported that dredges had ceased operations after the 1913 season, probably because the ventures had been too small to be profitable. Operating costs remained high because of inadequate transportation facilities. Some operators considered the possibility of developing electrical power at a mine on Coal Creek in the Canadian Yukon. A power plant already existed at the mine, about 20 miles from where the Fortymile River crossed the international boundary. Dredges were to utilize the electricity for their operation.

BURNED-OUT BONANZA?

Although several companies contemplated the development of large mining ventures, actual mining decreased. Whereas some $100,000 worth of gold came out of the district in 1913, this amount had decreased to an estimated $60,000 in 1914. Nearly all mining operations in 1914 were small, and between 75-100 men worked approximately 25 claims during the summer season. Miners performed some winter work on Wade, Lost Chicken, and Chicken Creeks. Winter clean-up of about 10 claims on Wade Creek yielded approximately $9,000 and summer work brought roughly an additional $7,000. With a yield of about $15,000-$25,000, Chicken Creek ranked as the largest producer. Some mining also took place on Walker Fork, Squaw, Buckskin, Ingle, and various other creeks in the district. A dozen men mined the bars of the Fortymile River with rockers during low water, and prospectors worked Mosquito Fork for larger placer deposits.[21]

By the late 1920's, the Alaska Consolidated Gold Corporation placer mined on the north bench of Dome Creek. Operations began in 1922 and steadily extended downstream. The company used hydraulic methods and had built an eight-mile ditch to supply the necessary water. In 1928, each square foot of gravel yielded about 35 cents worth of gold.

The Walker Fork Gold Corporation employed about 20 men who were housed in a camp near the southeastern part of the Fortymile quadrangle. A good 25-mile ridge trail provided access from Steel Creek, and a trail from Walker Fork wound its way some 12 miles eastward to Glacier Creek on the Canadian side where it connected with a wagon road to Dawson.

The corporation owned some 14 miles of claims on Walker Fork and mined ten-foot thick gravel near the slopes which decreased to approximately six feet thick in the center of the valley, all under about one or two feet of overburden. Each square foot of gravel yielded between 18 to 36 cents worth of gold.

An example of the type of gold dredge operated in the Forty-Mile district. This method was much more profitable than panning and sluicing. Note the ridges of tailings in the foreground. (Courtesy of Mike Erceg Collection, Archives, University of Alaska, Fairbanks.)

The corporation used a combination of hydraulic and steam-shovel methods. It placed elevated sluice boxes at one side of a cut. A Bucyrus steam shovel with a 50-foot boom then lifted the gravel and bedrock into the boxes where a hydraulic nozzle moved the gravel from the far edge of the cut inward to where it could be reached and handled by the wood-powered steam shovel. This shovel boasted a bucket with a maximum capacity of one and a quarter cubic yards and could move about one cubic yard of gravel per minute into the sluice boxes. There were nine sluice boxes, but most of the gold was recovered from the first four.

Two ditches on the north side of the valley furnished the necessary water. The upper ditch stretched for two miles and supplied water for the hydraulic nozzle, while the lower ditch furnished sluice water and also picked up seepage from the upper ditch.

By the late 1920's, mining on Wade Creek had been going on for over 30 years. Operators worked most of the claims by drifting in winter and sluicing the gravel dumps in spring. Charles Martin conducted the biggest operation at a hydraulic plant on claim No. 14, above Discovery, and extracted approximately 20 cents worth of gold from each square foot of gravel. Martin brought the necessary water from Wade Creek, about a mile upstream from his outfit. Three men operated the plant, in day and night shifts, during the 1928 season. Martin had worked the operation since 1920, originally with a scraper plant which had not been successful.

In 1929, two men ground-sluiced preparatory to the installation of a small hydraulic plant on No. 23 claim at the confluence of Gilliland and Wade Creeks.

The original discovery on Franklin Creek in 1886 was still producing gold 43 years later. Miners worked the six mile creek in 1928 employing the "shoveling-in" type of operation.

Chicken Creek wound its way roughly west to south and entered Mosquito Fork of the Fortymile River about a mile above the confluence of Mosquito and Dennison Forks. Stonehouse Creek and Myers Fork, two sizable tributaries, joined Chicken Creek from the northwest and made the upper valley wide and open, while the lower part was flat and gradually merged into the wider valley floor of Mosquito Fork. It was here that an airfield had been built. The town of Chicken was nestled about one mile above the mouth of Chicken Creek. No miners worked the location in the 1928 season, although some drift mining was done during the 1927-28 winter on claim No. 5-1/2 and some prospecting in the summer of 1928. In that same year, a large company had taken options on the producing ground on Chicken Creek and planned to install a dredge in the near future.

MINING BECOMES BIG BUSINESS

By 1933, it had become apparent to most observers that profitable placer mining had developed into a big enterprise, using expensive equipment such as dredges, utilizing relatively low grade deposits, and requiring careful cost control.

Two hydraulic plants operated on Myers Fork in 1928, and obtained approximately 30 cents worth of gold from each square foot of gravel processed. A two-mile-long ditch above the mouth of Stonehouse Creek supplied the water.

By 1929, the Walker Fork Gold Corporation, with its dragline scraper, had emerged as the largest operator. That same year, the Alaska Consolidated Gold Corporation, under the management of Lee Steele, acquired large holdings on Dome and Chicken Creeks with plans for large-scale hydraulic mining. Smaller operators worked the Fortymile and Chicken Rivers, Franklin Gulch and Napoleon Creek and various other locations.[22]

In 1934, when the Federal Government raised the price of gold from its previously fixed price of \$20.67 to

$35.00 an ounce, Alaska's mining industry received a tremendous stimulus. This became quickly apparent as mining activity increased. From 1935 on, gold production increased each year as more and more dredges were installed.

In the Fortymile district, parts for the planned-for Walker Fork Gold Corporation dredge finally arrived early in 1934. Quickly assembled, it began production by September 1st.

In 1934, about one-seventh of the placer production came from drift mines, while dredges, hydraulic and open-cut mining produced the rest, reflecting the consolidation of mining ventures. However, the district continued to provide opportunities for the individual enterpreneur equipped solely with the primitive, but time-honored rocker.[23]

Gold production in 1935 amounted to more than double the amount of 1934. This sharp increase was partly due to the increase in the price of gold and the fact that the Walker Fork Gold Corporation dredge had worked its first full season. Even smaller operations had been stimulated by the New Deal's gold price increase. Over 50 one- or two-man outfits worked most of the creeks in the district. Preparations were also underway for the Alaska Gold Dredging Corporation to install another dredge on Mosquito Fork.[24]

During the spring of 1935, North American Mines, Inc. of Boston, bought the old "Mulvane Dredge" and moved it from its location on the Fortymile River to Jack Wade Creek. The new owners replaced the hull timbers and installed a new bucketline. Transporting the new buckets, each weighing some 700 pounds, proved to be tricky. Brought from Cordova to Chitina on the Copper River and Northwestern Railroad, they were then taken by truck to Chistochina and from there a Travelair plane flew them, one at a time, to Lassen Field near Jack Wade, the present Walker Fork campground. North American Mines, Inc. operated the dredge until 1938 when the company sold out to the Yukon Placer Company, owned jointly by Chuck Herbert, Harold Smith, Leonard Stampe, Early Elingen and Fred Parker.[25]

In 1936, three dredges and approximately 48 one- to two-man outfits extracted some $158,500 worth of gold from the Fortymile district, an increase of $37,500 over the preceding year. The smaller outfits, however, barely made more than modest grubstakes. In 1938, two dredges, the newly-installed one on Canyon Creek which belonged to the Boundary Dredging Company and the North American Mines, Inc. dredge on Jack Wade Creek, accounted for the bulk of gold production. The dredges of the Alaska Gold Dredging Company on Mosquito Fork and the Walker Fork Dredging Company on Walker Fork were idle in 1938 and 1939. Both companies had encountered financial difficulties and the Northern Commercial Company had taken over their holdings in November-December of 1938.[26] In 1940, the Wade Creek Dredging Company replaced the old steam engine with a diesel. In 1941, the digging ladder broke, was repaired, broke again and finally caused the dredge to shut-down. In 1942, the Federal government forced the company to lease its bulldozers to contractors for the war effort.

During its active years, the Wade Creek dredge required only a crew of three – a winchman, oiler and fireman – who each received approximately seven dollars a day. Before the installation of the diesel engine, however, some 30 men busily cut 12 cords of wood a day to feed the voracious appetite of the boiler. The dredge usually operated from June through September and required about 1,500 cords of wood for which the operators paid approximately $6 per cord. During the season, the dredge operated round the clock for roughly 10 days. Then the sluice boxes were cleaned up and the gold removed. The owners considered a $30,000 return on a 10-day run as good; $20,000 was closer to average.[27]

Not only did gold production decline sharply from a high of $341,000 in 1939 to $276,000 in 1940, but a number of other changes also occurred. The Wade Creek Dredging Company, on Jack Wade Creek, operated on under its new owners. In addition, the Fairbanks Department of the United States Smelting, Refining and Mining Company acquired holdings near the junction of Chicken Creek and North Fork which had formerly belonged to the Alaska Gold Dredging Company, and immediately began to prepare the ground for dredging in the 1941 season.

In addition to the Jack Wade dredges, three or four other placer operators also worked on the creek. Of these, the Central Development Syndicate reported the largest production.

As usual, small operators and individual sourdoughs made a modest living.[28] Two men were open-cut placer mining on Stonehouse Creek. One man "shoveled in" creek gravel and further upstream, still another man mined bench gravel on the east side of the valley. Each square foot of gravel yielded 40 cents worth of gold. During that same summer, three men operated a hydraulic plant on Lost Chicken Creek, mining two cuts approximately four miles long.[29]

THE WAR YEARS

In 1941, Alaska stood on the brink of tremendous social, economic and political upheaval. In early summer, large defense construction programs began in various places throughout the territory. High wages paid even to unskilled workers began to lure men from many occupations, including miners. As a consequence, mines considerably scaled down their operations throughout Alaska.

When the Japanese attacked Pearl Harbor on December 7, 1941, America suddenly found itself at war. In the summer of 1942, enemy forces invaded and occupied Attu and Kiska in the Aleutian Chain. America's pride was hurt. The United States sent 10,000 soldiers, divided into seven army engineer regiments and supported by 6,000 civilian workers under the direction of the United States Public Road Administration, to start construction of the ALCAN (Alaska-Canadian Military Highway). The highway was completed with incredible speed, and in November of 1942, was formally opened for traffic.[30]

While the ALCAN Highway rapidly took shape, thousands of other American soldiers came to Alaska to participate in its defense and prepare for the recapture of Kiska and Attu. Civilian workers toiled practically round the clock to build bases at various locations in Alaska. At the end of May, 1943, after fierce fighting, Attu Island fell again into American hands. On August 15, 1943, American troops made an amphibious landing on Kiska but discovered that the enemy had left the island at the end of July by submarine.[31]

The war and the changes it brought about adversely affected mining activities. Construction needs diverted much of the mobile equipment, such as the draglines, tractors and grading machines used in the mines. In October of 1942, the War Production Board delivered what amounted to a deathblow to the gold mining industry when it declared that, with few exceptions, gold extraction was regarded as nonessential to the war effort. The WPB called for the rapid suspension of gold mining and hurried the process when it deprived operators of further priorities for supplies and equipment. Most of the larger operators promptly quit. Geologists now stepped up their efforts to locate strategic materials. Despite all this, the Fortymile still yielded $218,000 of gold in 1941 and $205,000 in 1942, most of it produced by the two dredges in the district.[32]

By 1944, the effects of the war had become fully apparent. The total value of Alaska's mineral output had dropped to $7,032,000, about what it had been at the turn of the century. Gold mining, for so long Alaska's leading industry and which, in 1906, had yielded over a million ounces, had declined to 49,296 ounces, valued at $1,725,360, by 1944. For all practical purposes, the gold mining industry had become a war casualty despite the fact that a few of the dredges had continued to operate.

The old Steele Creek Roadhouse, built in 1899. (Courtesy of John M. Brooks Collection, Archives, University of Alaska, Fairbanks.)

By the end of 1944, hope existed that gold mining would resume in the not-too-distant future and once again become an important factor in Alaska's economy. Nine floating, connected-bucket dredges operated in 1944, two more than in 1943. The War Production Board issued permits to about 70 placer-mining and eight or ten lode-mine operators. They also authorized the employment of about 775 miners, and small mines did not even require a license to start work.[33]

By 1945, mineral production had increased to $10,210,000. Some 13 dredges and 16 draglines operated at least part of the season, among them the Wade Creek Dredging and Mining Company which could now be reached via a new caterpillar road winding its way north from the Alaskan Highway at Tanacross to the Fortymile district. The war-connected upsurge in wages and the fixed price of gold, however, had made profitable mining extremely difficult even though the Federal government had rescinded the War Production Board Limitation Order on July 1, 1945. Despite these and other difficulties, gold had regained its predominant position in the Alaska mining industry by 1946. Some 226,781 fine ounces of gold brought $7,937,335, a substantial amount of money, though far short of prewar gold production.[34]

POSTWAR PROGRESS

In the Fortymile district, some 19 placer mines were operated in 1946. The two largest producers, the Yukon Placer Mining Company on Walker Fork Creek and the Wade Creek Dredging Company on Jack Wade Creek, recovered 3,156 ounces of gold, 474 ounces of silver and

2,091 ounces of gold and 469 ounces of silver, respectively.

Only 18 placer mines operated in 1947, and the Yukon Placer Mining Company and the Wade Creek Dredging Company again emerged as the largest producers with 4,839 ounces of gold, 712 ounces of silver, and 3,169 ounces of gold and 685 ounces of silver, respectively, a total of 8,008 ounces of gold and 1,397 ounces of silver for the two companies out of a district grand total of 10,953 ounces of gold and 1,980 ounces of silver.[35]

In 1948, some 25 placer mines produced 4,980 ounces of gold and 909 ounces of silver worth $175,123. The Yukon Placer Mining Company worked with bulldozers and sluice boxes on Walker Fork and bucket-line dredges on Poker and Canyon Creeks; the Wade Creek Dredging Company used bulldozers and sluice boxes and the Uhler Creek Mining Company used dozers and hydraulic equipment on Jack Wade Creek. George E. King mined on Turk Creek and Attwood and Granger operated bulldozers and hydraulic equipment on Stonehouse Creek. There were numerous smaller outfits also mining gold in the district.[36]

Despite a general decline in gold production for the second consecutive year in 1949, gold still continued to rank first in value among all mineral commodities. Despite the decrease, the total mineral production of Alaska amounted to $15,302,000 to which gold contributed some $8,029,560. Most gold mine operators battled the increasingly difficult task of balancing the high cost of mining, labor and supplies against the fixed price of gold, unchanged since 1934. Despite readily available labor, the narrowing margin between high operating costs and the fixed price of $35 per ounce allowed only the most efficient enterprises to continue working.[37]

The conditions of the gold mining industry had become precarious by 1951. Gold production continued to decline, constituting some $8,387,295 out of a total mineral production value of $19,569,000. Only eight placer mines worked the Fortymile district in the 1951 season. Although the Wade Creek Dredging Company ranked first in total output, it discontinued operations at the end of the season and planned to move into Canada where conditions were more favorable. The Franklin Mining Company worked draglines, bulldozers and hydraulic equipment on claim 2 below Discovery on Chicken Creek and ranked second in production. Other operators who recovered 100 or more ounces by using a combination of equipment were, in order of their production:

Uhler Creek Mining Company, on Stonehouse Creek
Squaw Creek Mining Company, on Squaw Creek
William Meldrum, on Chicken Creek
Purdy Brothers, on claim 2 on Myers Fork.[38]

In 1953, gold again temporarily topped the list of minerals mined in Alaska, amounting to $8,882,405 out of a total mineral production of $24,252,000. Coal ran a close second with a value of $8,451,452, while sand and gravel ranked third at $5,079,681. Various other minerals made up the difference.

Little had changed in the Fortymile district, except that the United States Smelting, Refining and Mining Company had begun to strip at Chicken in preparation for possible dredging operations. The Franklin Mining Company produced the largest amount of gold. Bulldozers and a hydraulic giant delivered gravel to the sluice boxes, while a dragline removed and stacked the tailings. Other smaller operators who used dragline-bulldozer-hydraulic combinations in 1953 were, in order of production:

Purdy Brothers, on Myers Fork and Atwater Bar (South Fork of the Fortymile River)
George F. Robinson, on Wade Creek
William Meldrum, on claim No. 1 on Stonehouse Creek
Jack Wilkey, on Squaw Gulch
Vern Weaver and John Rambaud, on Napoleon Creek
Frank Barrett, on claim No. 5 above Discovery on Stonehouse Creek
Jack LaCross, on Turk Creek.[39]

In 1955, gold still occupied first place with $8,725,290 out of a total mineral production of $25,412,000. But the year's big news involved the accelerated tempo of exploration activities, particularly for petroleum and natural gas. In the Fortymile district, the LaCross Mining Company on Walker Fork, consisting of the partners Jack LaCross and Fred Whitehead, emerged as the season's largest producer with 965 ounces of gold and 137 ounces of silver derived from approximately 20,000 cubic yards of gravel. The company used three hydraulic giants to remove the overburden and two TD-18 bulldozers to deliver the gold-bearing gravel to the sluice boxes. Other operators in the district, in order of productivity, included:

The Vern Weaver and John Rambaud partnership, on Napoleon Creek
Engbret Johanson, on the Gold Hill claims at Ingle Creek
William Meldrum, on Chicken Creek
Chicken Hill Mines, Inc., on Lost Chicken Hill
Squaw Creek Mining Company, on Canyon Creek
Purdy Brothers, on Myers Fork
Dan Manuske, on Ingle Creek
Robert McComb at the South Fork of the Fortymile River

George F. Robinson, on Jack Wade Creek.[40]

In 1959, gold still led Alaska's mineral production with a value of $6,262,000 out of a total of $20,495,000. Coal came next with a value of $5,869,000. The United States Smelting, Refining and Mining Company was the leading gold producer in the Fortymile. The company had moved its Pedro Creek dredge over the Alaska Highway by truck from Fairbanks to a new location. The move took place on July 4, 1959 and dredging operations began toward the close of that same season. Nine mines produced 1,625 ounces of gold and 310 ounces of silver, worth $57,156. The lion's share was produced by the United States Smelting, Refining and Mining Company's new dredge. Other producers in the district quickly became unimportant by comparison.[41]

END OF A GOLDEN DREAM

While still constituting some $5,887,000 out of a total mineral production of $21,860,000 in 1960, gold had become rather insignificant by 1961. Petroleum and natural gas production took first place in 1961, with a value of $17,647,000; coal ranked second with $5,868,000 while gold, with a value of $3,998,000, ranked behind even sand and gravel with a value of $4,185,000. Although five outfits produced some 5,869 ounces of gold and 1,256 ounces of silver worth $206,576 in the Fortymile district, the U.S.S.R. and M. Co.'s dredge again washed the largest amount of gold.

Gold production continued its steady decline and in 1966, with a value of just under one million dollars, had reached a 77-year low. In 1967, the United States Smelting, Refining and Mining Company had become the only major gold dredge operator left in Alaska. In its annual report to stockholders in that year, the company reported that:

> Normal operating conditions and costs were experienced at both Hogatza and Chicken Creek; however, production underruns occurring at Chicken Creek made further dredging at that location economically unfeasible. Accordingly, dredge operations at Chicken have been discontinued and the dredge was put in dry-dock.

With that rather dry and factual announcement, gold mining, for so many years the major component of Alaska's mining industry and the stuff of which romance was made, for all practical purposes, had died.[42]

An unusual Y-shaped sluice; "arms" were built onto the sluice to divert tailings as needed. (Courtesy of Selid-Bassoc Collection, Archives, University of Alaska, Fairbanks.)

FOOTNOTES

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[9]*Ibid.*, pp. 389-392.

[10]*Ibid.*, pp. 118-133.

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[15]Brooks, Alfred H., *et al., Mineral Resources of Alaska: Report on Progress of Investigations in 1909*, USGS Bull. No. 442, GPO, Washington, 1910, p. 244.

[16]"Jack Wade Dredge, Mile 87 Taylor Highway, Fortymile Resource Area," notes supplied by the Fairbanks District Office of the US Bureau of Land Management, April, 1973.

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