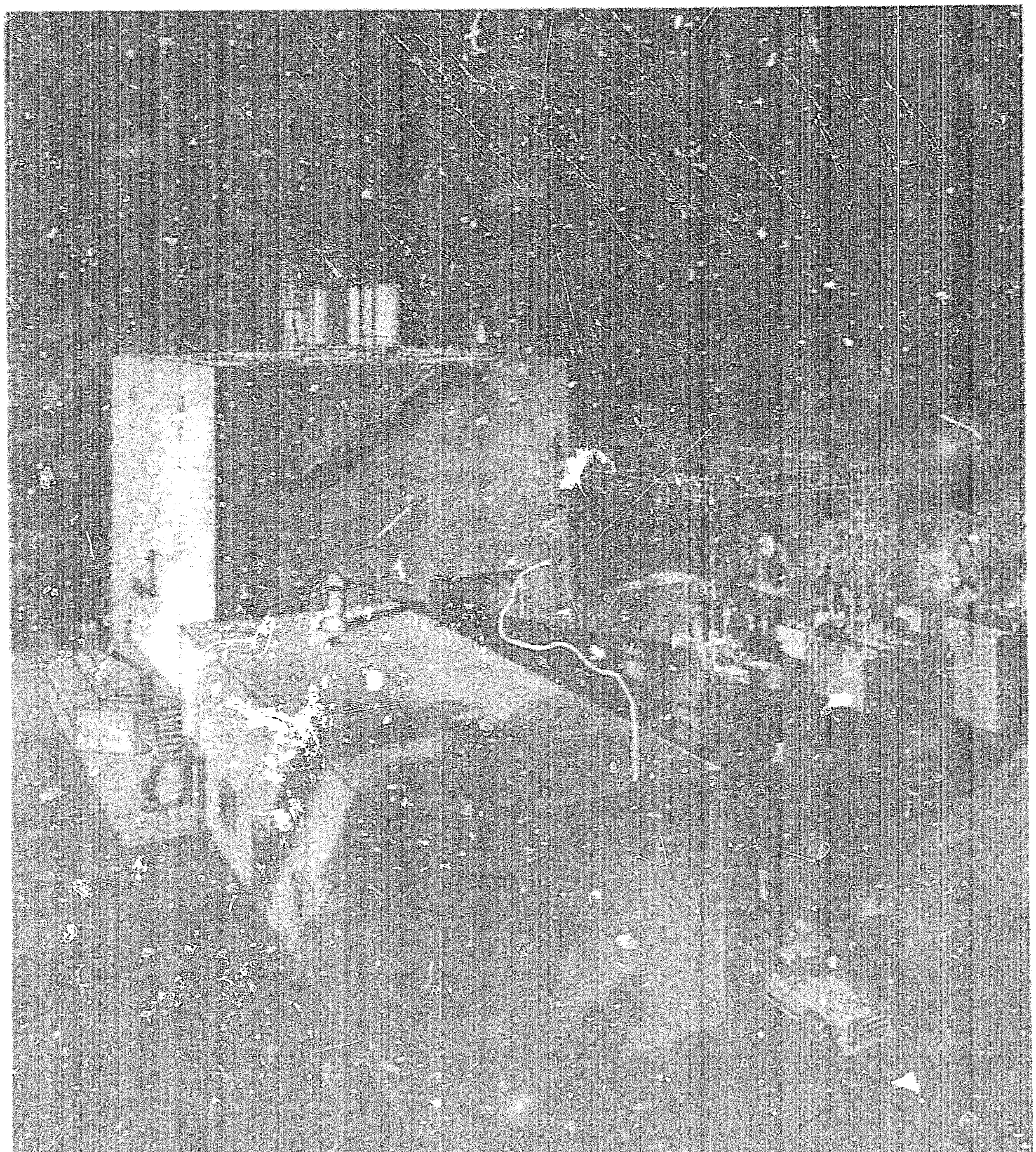
EKLUTNA HYDROELECTRIC PROJECT

PALMER, ALASKA



Alaska Power Administration
U.S. Department of Energy

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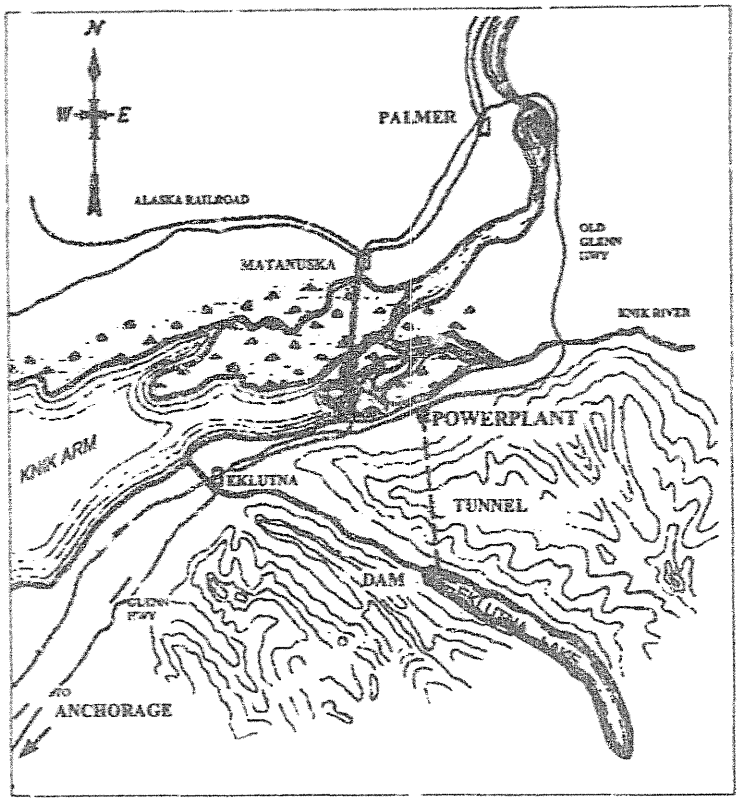
THE EKLUTNA PROJECT: GLACIER ICE TO ELECTRIC LIGHTS

The Eklutna Project has used the energy of melting glaciers to provide electricity for the Anchorage-Palmer region since 1955. Milk-colored water from glaciers flows each summer into Eklutna Lake in the Chugach Mountains northeast of Anchorage. Water pours into a structure on the lake bottom and down a 4.5-mile tunnel that was blasted through the rock of Goat Mountain. The water falls nearly 800 feet in elevation in the tunnel and the penstock, rushes through the Eklutna Powerplant, and enters the Knik River less than 15 feet above the sea level of Knik Arm.

Within the powerplant, the force of the rushing water turns two turbines at 600 revolutions per minute, each developing 25,000 horsepower of energy. Each turbine turns an electric generator that produces 15 megawatts (15 million watts) of electricity. The electricity flows from the powerplant on transmission lines to Anchorage and Palmer, where the energy of melting glaciers is available for uses ranging from heating greenhouses to making ice cubes.

The Eklutna Project was constructed by the U.S. Bureau of Reclamation between 1951 and 1954 at a cost of less than $30 million. The Eklutna Project has produced more than 6 billion kilowatt-hours of energy since it came on line in 1955, and it continues to provide some of the lowest-cost electricity in the region.

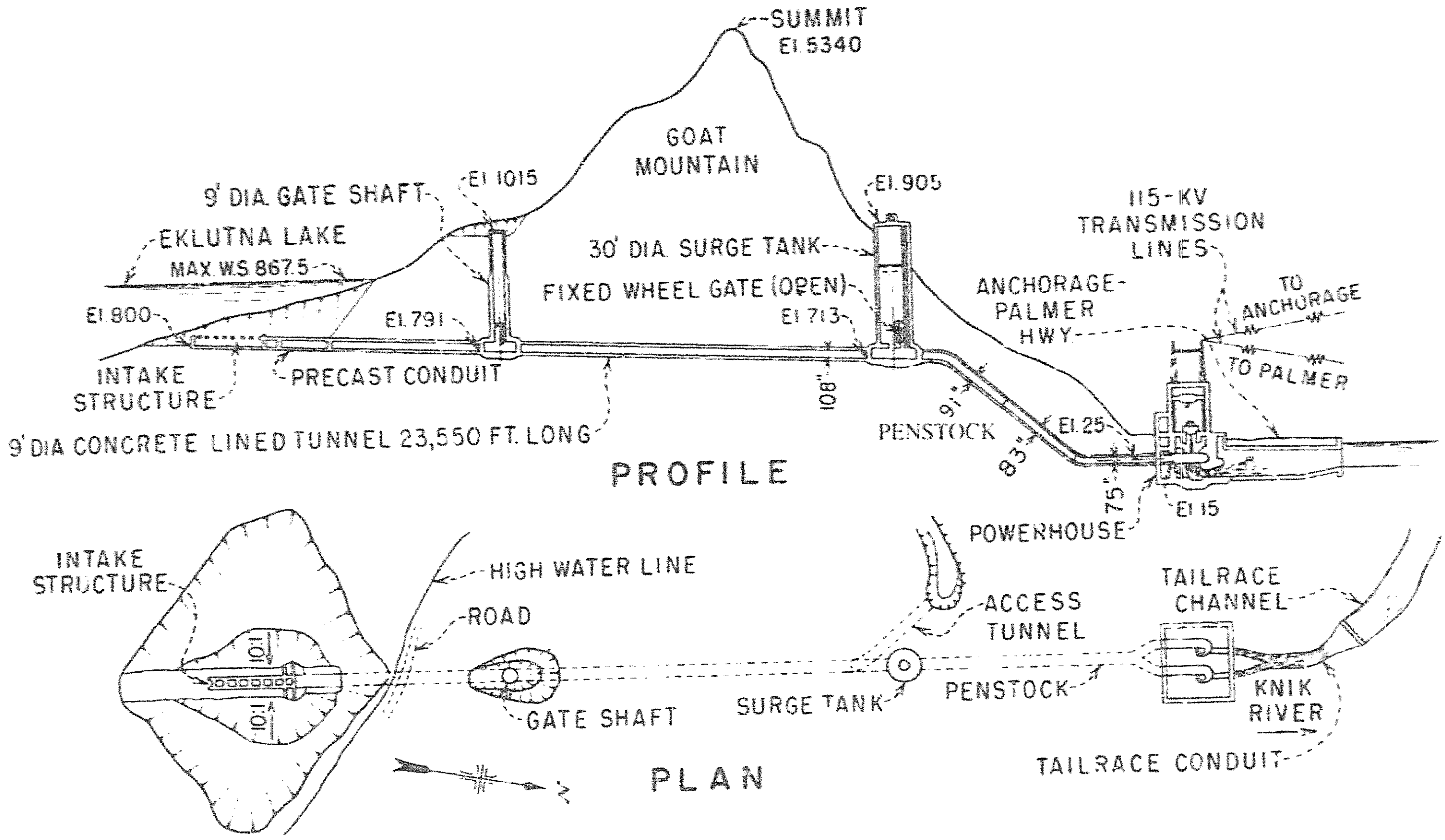
The Eklutna Project has also proven to be extremely durable and dependable. The powerplant returned to partial operation about 30 minutes after the devastating earthquake of March 27, 1964, and within five hours the Eklutna Project was providing critically needed electricity to Anchorage.



The Eklutna Project Powerplant is located about 15 miles south of Palmer and about 34 miles northeast of Anchorage, a. Mile 4 of the Old Glenn Highway.

The Eklutna Project provides benefits to the region beyond generation of electricity. Eklutna Lake is a well-used public recreation area within Chugach State Park. Anchorage can obtain up to 70 million gallons of water per day from Eklutna Lake, by means of a diversion facility attached to the Eklutna Project tunnel near the lake. The Eklutna Salmon Hatchery is located on the Eklutna Project tailrace, where steady outflows from the powerplant provide suitable conditions for releasing and recovering salmon.

FROM GLACIER ICE TO ELECTRIC LIGHTS: MAKING ELECTRIC POWER AT THE EKLUTNA PROJECT



Generating electricity at the Eklutna Project includes operation of three project components: water supply, water delivery, and conversion of the energy of rushing water to electricity.

WATER SUPPLY

Eklutna Creek and other streams bring 'acial melt water and seasonal run-off water into E tna Lake, where the water is stored. The lake is t seven miles long, 3/4 mile wide, and up to 200 feet deep. Total water storage in the lake is 174,800 acre-feet, or about 56 billion gallons of water. The lake was formed behind a natural dike deposited by a glacier, and the storage capacity of the lake is increased as a result of a man-made dam. A dam was built on top of the natural dike in 1929 to help provide dependable water flow in Eklutna Creek for a powerplant downstream from Eklutna Lake. The 1929 dam was improved as part of the Eklutna Project in 1953, and it s severely damaged during the earthquake of March 27, 1964.

The current dam was built in 1965 downstream on Eklutna Creek from the previous dams. It is an earth and rock fill structure 815 feet long and 51 feet high with a concrete spillway at the center of the dam. The 1965 dam raised the maximum surface level of the lake by 3.5 feet. The lake usually reaches its highest level in mid-summer, when glacial melting is at its peak.

WATER DELIVERY

The Eklutna Project powerplant is about 4.75 miles north of Lake Eklutna and about 800 feet lower in elevation. Water from the lake is delivered to the powerplant through an intake structure in the lake, a tunnel through Goat Mountain, and a penstock on the northern slope of the mountain.

Intake Structure

The intake structure lies at the bottom of the lake, about 60 feet below the lake surface. The concrete structure includes trashgates to keep rocks and other debris from entering the tunnel. The intake structure is connected to the tunnel by about 120 feet of concrete pipe. The original intake structure was heavily damaged during the 1964 earthquake and was replaced in 1965.

Power Tunnel

The power tunnel through Goat Mountain is 23,550 feet long and 9 feet in diameter. The tunnel is lined with concrete, and some portions of the tunnel also have steel beam reinforcement. The southern end of the tunnel meets the intake structure at the bottom of Lake Eklutna. The tunnel slopes gently downward to the north dropping about 85 feet in elevation from the intake structure to the north end of the tunnel. The tunnel has a capacity of 640 cubic feet of water per second, and the water can travel more than 10 feet per second.

The power tunnel was blasted through mostly solid rock, and it was not damaged during the 1964 earthquake. Shifting and collapse of the intake structure allowed a large amount of rock and silt to enter the tunnel, however. The tunnel was cleaned in 1965, and screens were installed to keep debris from travelling through the tunnel to the powerplant turbines. The power tunnel is not accessible to the general public.

Tunnel Gate Shaft

The power tunnel extends about 700 feet from the intake structure to a gate that can be used to shut off water flow through the tunnel. The gate is at the bottom of the tunnel gate shaft, which is 9 feet in diameter and about 200 vertical feet from ground surface to the tunnel. The tunnel gate shaft also provides access to the southern portion of the power tunnel, and it was used extensively for tunnel-cleaning operations after the 1964 earthquake.

Surge Tank

The surge tank protects the penstock and generating station from damage from rapid surges in water pressure in the power tunnel. The surge tank is a reinforced concrete cylinder 181 feet tall and 30 feet in diameter, with walls at least 18 inches thick. Most of the surge tank is within a shaft cut through rock above the power tunnel. A gate in the surge tank allows the penstock and powerplant to be drained of water for inspection or repair.

Penstock

The penstock is welded steel pipe encased in concrete that carries water 1,088 feet from the surge tank to the powerplant. Most of the water pressure or "head" that drives the powerplant turbines is developed in the penstock. As the pipe descends 864 feet at an angle of 53 degrees, it decreases in diameter from 91 inches to 75 inches. Before entering the powerplant, the penstock divides into two pipes to provide water to each of the turbines.

Tailrace

The tailrace conduit is a 209-foot-long concrete structure that carries water from the powerplant, under the Old Glenn Highway, to the tailrace channel. The tailrace channel to the Knik River was rebuilt after the 1964 earthquake.

GENERATING ELECTRICITY

The powerplant is the heart of the Eklutna Project, where the energy of rushing water is converted to electricity and sent by transmission lines to Anchorage and Palmer.

Water under tremendous pressure enters the powerplant in two penstock tubes and passes through "butterfly" valves that can control the volume of water entering the turbines. Each of the tubes joins a spiral scroll case that directs the water flow downward and around a turbine, which is a steel wheel with fans or blades mounted on a steel shaft. High pressure jets of water enter the turbine through vents in the scroll case, striking the turbine blades and causing the turbine shaft to spin at 600 revolutions per minute. Eklutna Project's turbines were built by the Newport News Ship Building and Dry Dock Company, and each turbine is rated at 25,000 horsepower.

An electric generator is mounted on the upper end of each turbine shaft. The generator consists of two principal parts: a circle of powerful electromagnets and a spinning rotor at the center of the electromagnets. The electromagnets create strong magnetic fields. Driven by the turbine below, the rotor crosses the magnetic fields, causing electric current to flow. Eklutna Project's generators were built in Switzerland by the Pacific Oerlikon Company of Zurich.

The electric current flows from the generators to transformers on the south side of the powerplant, where it is "stepped up" to 115 kilovolts for efficient transmission to Anchorage and Palmer. Substations at those locations "step down" the current for distribution to service areas. Electricity from the Eklutna Project contributes to a grid that provides power to much of south-central Alaska.

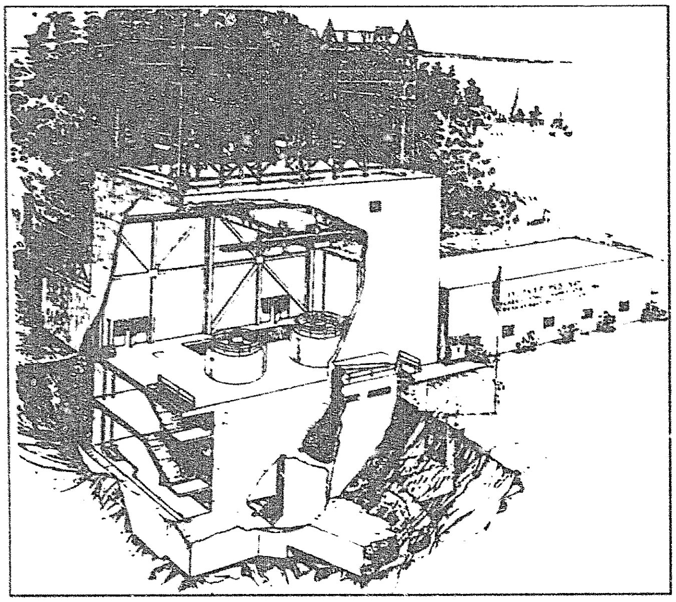
BUILDING THE EKLUTNA PROJECT

Anchorage was established in 1915 as a marine shipping port and the headquarters of the Alaska Railroad, but it remained a small town until World War II. During the 1930s, federal agencies resettled hundreds of families from the lower 48 states on small farms in the Matanuska Valley near Palmer, but the region as a whole had only sparse and scattered settlement.

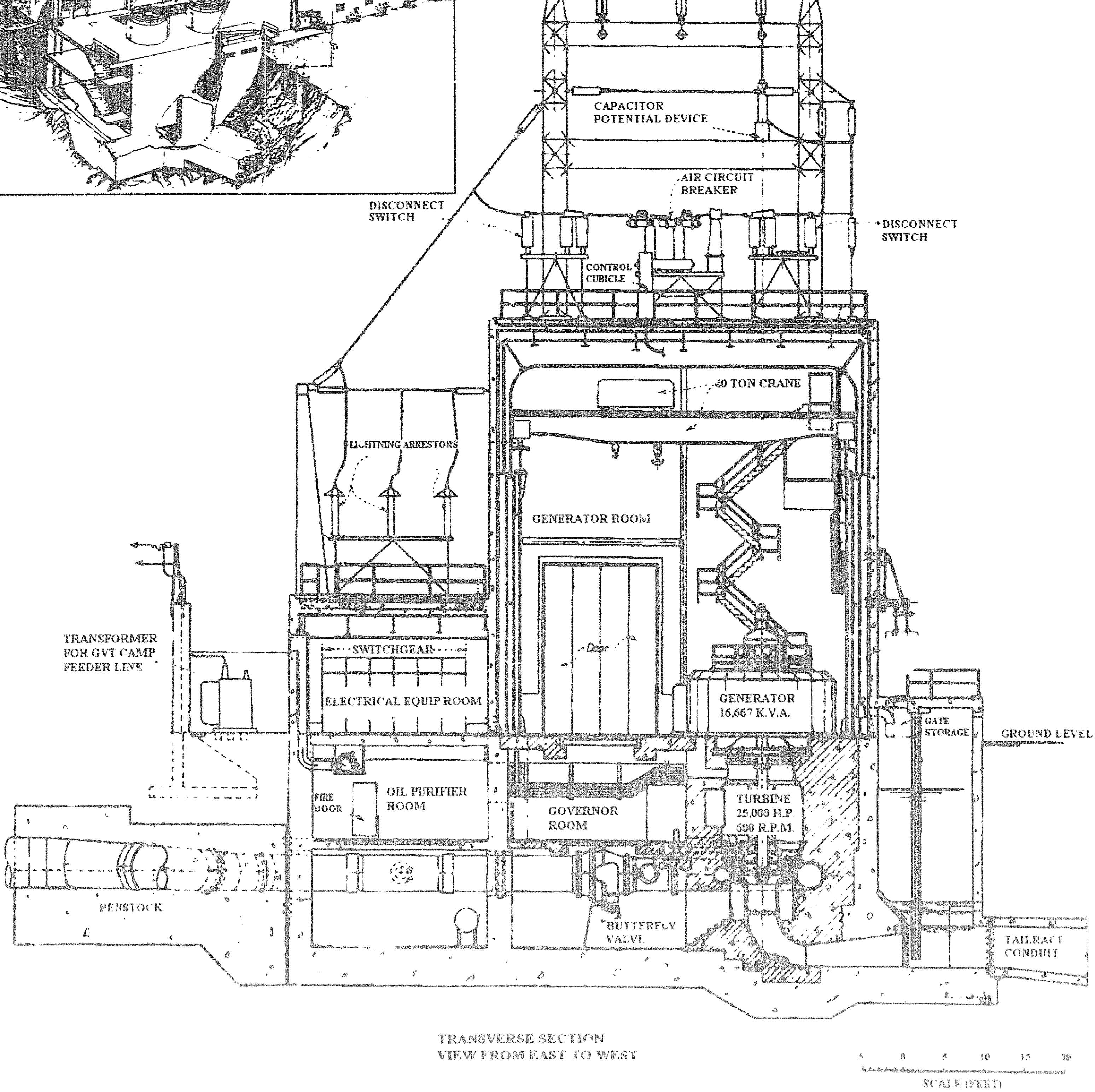
Recognizing the strategic importance of Alaska, the U.S. Army began construction of Fort Richardson outside Anchorage in 1939. Workmen and their families poured into Anchorage, and the village continued to grow rapidly during and after World War II. Anchorage was critically short of electricity by 1948, and neither the municipal government nor private power companies had sufficient resources to meet the area's current or future electrical demand.

The federal Bureau of Reclamation concluded in 1948 that the area's power needs could be provided by a powerplant near Knik Arm that would use water from Eklutna Lake. The powerplant would generate 15 times as much electricity as an existing powerplant that had been built on Eklutna Creek in 1929. The "Old Eklutna" powerplant would remain in operation until the new project became operational, but thereafter it would not have dependable water power for its turbines.

Congress authorized the Eklutna Project in 1950, and the project was designed in Bureau of Reclamation offices in Denver. Preliminary surveying and site location were accomplished in 1950 and 1951. A contract for $17,348,865 for construction of the tunnel and improvements to the dam was awarded in September 1951 to Palmer Constructors of Omaha, Nebraska. Rue Contracting Company of Fargo, North Dakota was awarded a $2,579,607 contract to build the powerplant.



EKLUTNA POWERPLANT



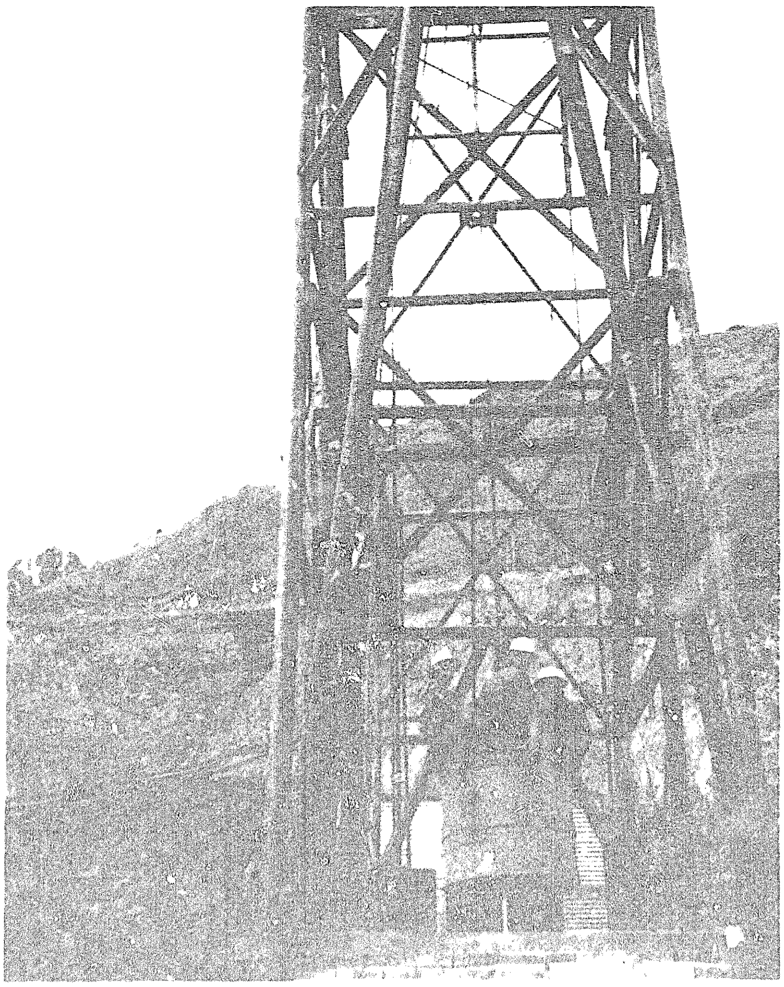
TRANSVERSE SECTION
VIEW FROM EAST TO WEST

BUILDING THE EKLUTNA PROJECT

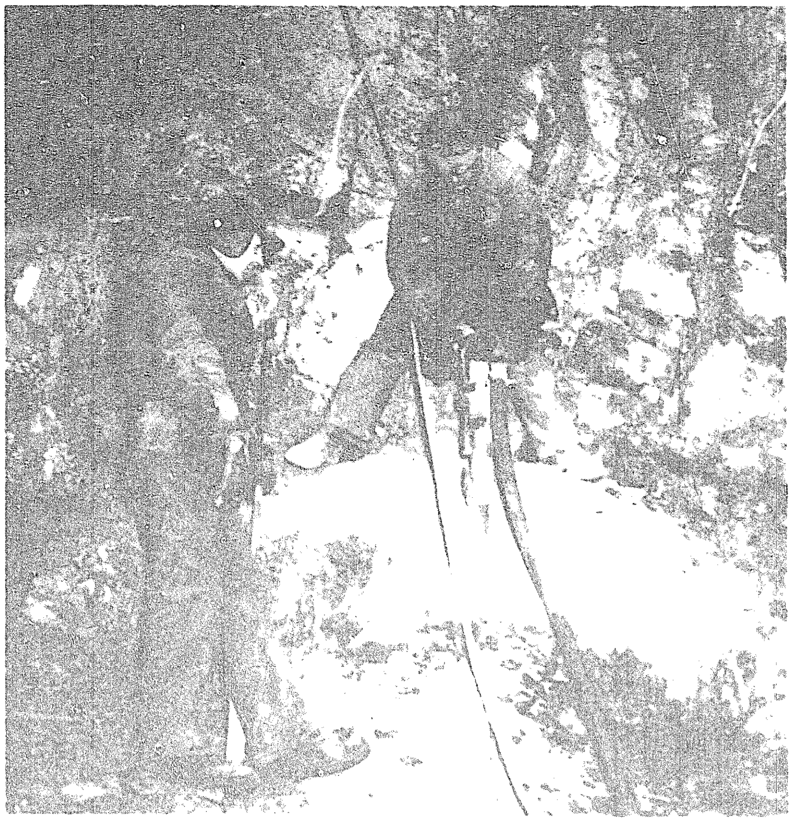
Excavation of the tunnel began near the north and south ends in October 1951. Neither end of the tunnel could be easily built; the south end would lie under Lake Eklutna and the north end would be more than 700 feet up the steep slope of Goat Mountain. Near the south end, the tunnel gate shaft was dug down about 200 feet to the level of the tunnel. The tunnel was then cut through rock under the lake and lined with concrete. A watertight bulkhead was installed near the lake end of the tunnel so that the intake structure could be attached without flooding the tunnel. The tunnel was then driven northward from the gate shaft. Men and machinery could only enter the south end of the tunnel through the 9-foot diameter gate shaft, and all of the rock excavated in the tunnel was removed through the gate shaft.

At the northern end of the tunnel, a road was constructed up the side of Goat Mountain, and a portal tunnel was excavated to the depth of the main tunnel. The portal tunnel was closed several times by cave-ins and landslides. The first mile of the main tunnel was also built through unstable rock that contained water-bearing channels. Tunneling was suspended in November 1952 after a major cave-in. Water seepage into the tunnel had reached 10,000 gallons per minute by the time of the cave-in, and water flow from the tunnel would reach a peak of about 16,000 gallons per minute. A pipeline was built in the main and portal tunnels to remove the seepage water.

The tunnel was excavated by drilling 26 to 40 holes about 9 feet into the rock, exploding 160 to 170 pounds of blasting powder in the holes, and removing the loose rock or "muck." Each such blast advanced the tunnel about 8 feet. Tunnel construction proceeded from the north and south ends simultaneously, and the two headings were "holed through" on October 15, 1953.



Workmen being lowered into tunnel gate shaft, June 1952

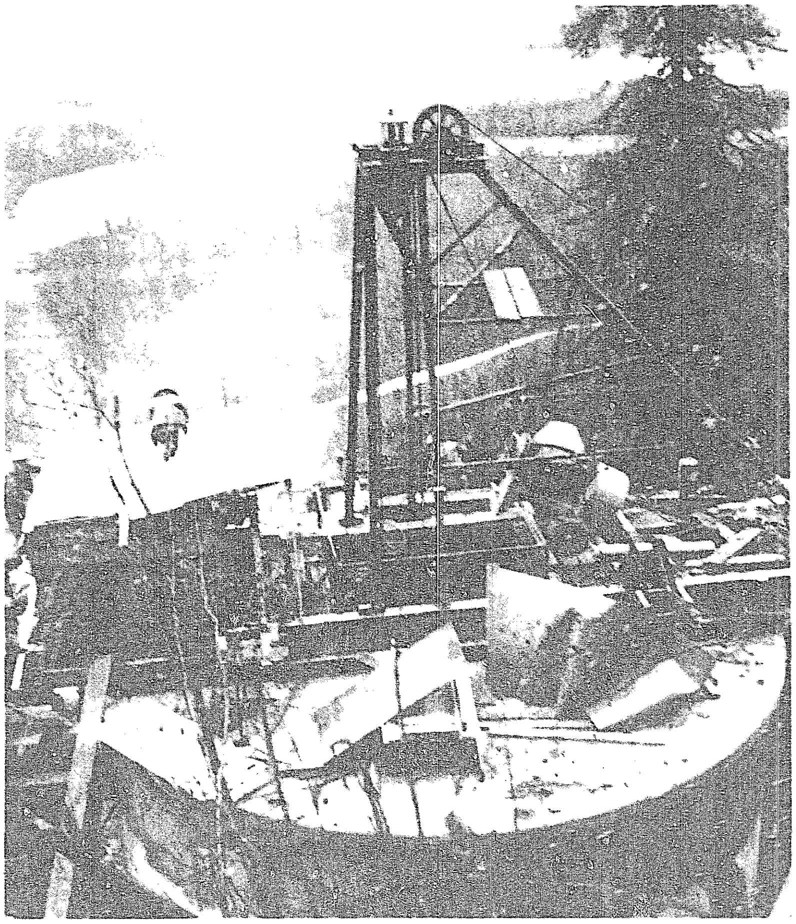


Drilling holes for blasting charges in tunnel

Engineer peering through hole between north and south tunnel headings, October 15, 1953

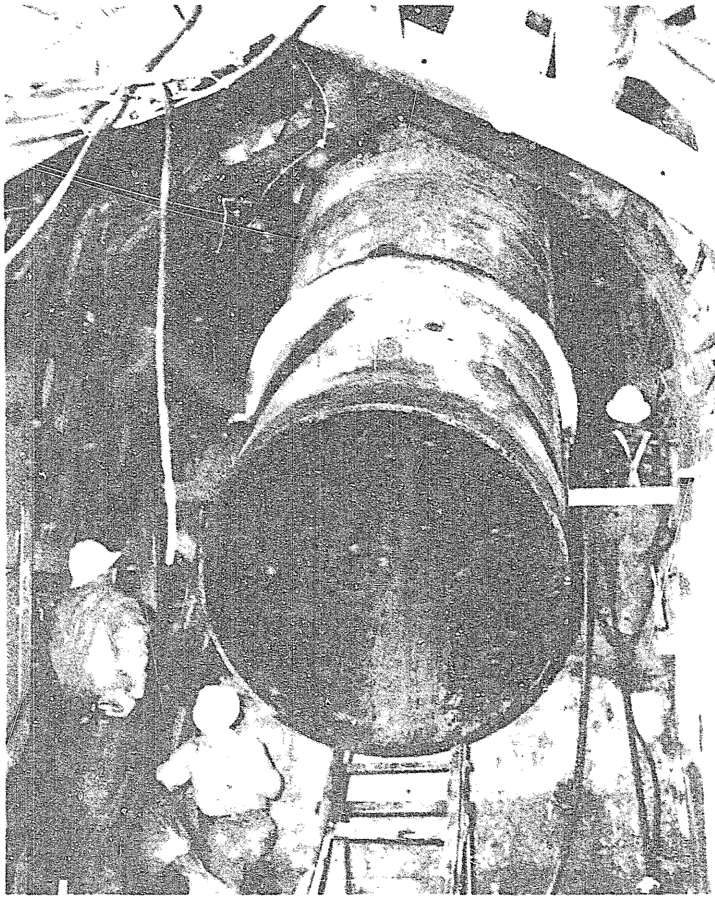
U-shaped steel supports were installed in about 70 percent of the tunnel, but stable rock in the rest of the tunnel allowed construction without the steel supports. The entire tunnel was lined with poured concrete, which was mixed in the tunnel and hauled by rail car to its placement location. Portable rail sidings and switches allowed three trains to operate at the same time, and the concrete mixing point was moved so that it was always near the point of concrete placement. Dry materials for the concrete were lifted by tram from the contractor's facility at the base of the mountain to the north portal, and then the materials were taken by train to the mixing point.

The surge tank was constructed by drilling a small hole from the ground surface down to the tunnel. The hole was used as a chute for removing rock as the hole was enlarged to accommodate the surge tank's 30 foot diameter, and the rock was taken out the north portal tunnel. Steel H-beam support rings were installed at 4-foot intervals in the entire height of the surge tank. Concrete for lining the 18 inch thick walls of the surge tank was pumped from the portal entry to the base of the surge tank and then lifted in the interior of the shaft by a winch mounted at the top of the tank.



Winch headframe and workmen completing construction of surge tank, fall 1954

Construction of the penstock began with an open trench between the bottom of the inclined portion and the powerplant. The inclined portion was built in a tunnel dug at a 53 degree slope from the south end of the open trench to the main tunnel above. The bend sections of steel pipe at the bottom of the slope were installed, reinforced with steel beams, and encased in concrete. Pipe sections above these bends were lowered into place from the tunnel above and were encased in concrete. Pipe sections from the bends to the powerplant were installed in the open cut and encased in a concrete anchor block that was supported by steel pilings driven to bedrock.

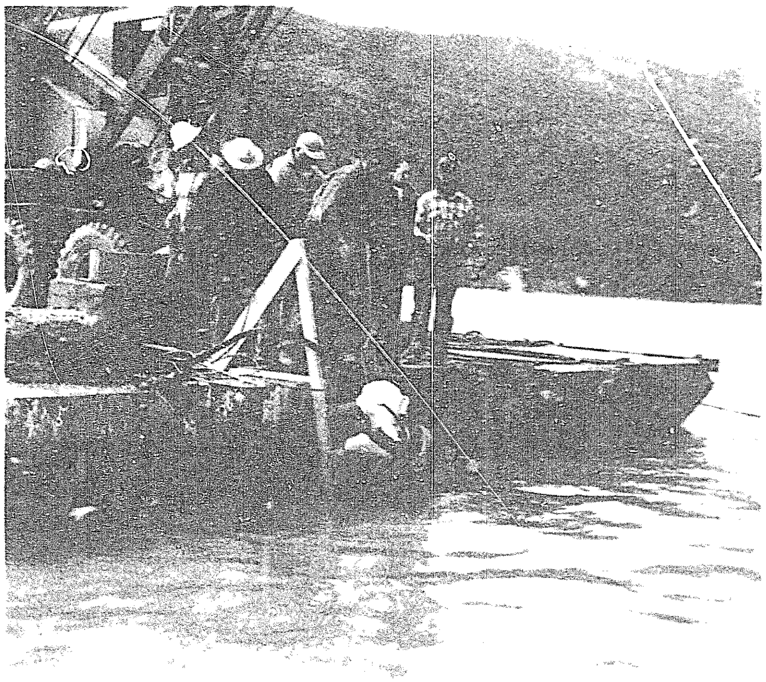


Installing penstock pipe, 1954

The final piece of the water delivery system, the intake structure in Eklutna Lake, was perhaps the most difficult construction task. The intake structure consisted of 225 feet of 9-foot diameter concrete pipe, a bulkhead structure, a transition section, and a trashrack water intake section, all of which were installed about 70 feet below the surface of the lake. Dredging of about 410,000 cubic yards of rock and hard-packed glacial "flour" on the lake bottom was accomplished by blasting the material loose and removing it by means of a specially designed floating dredge.

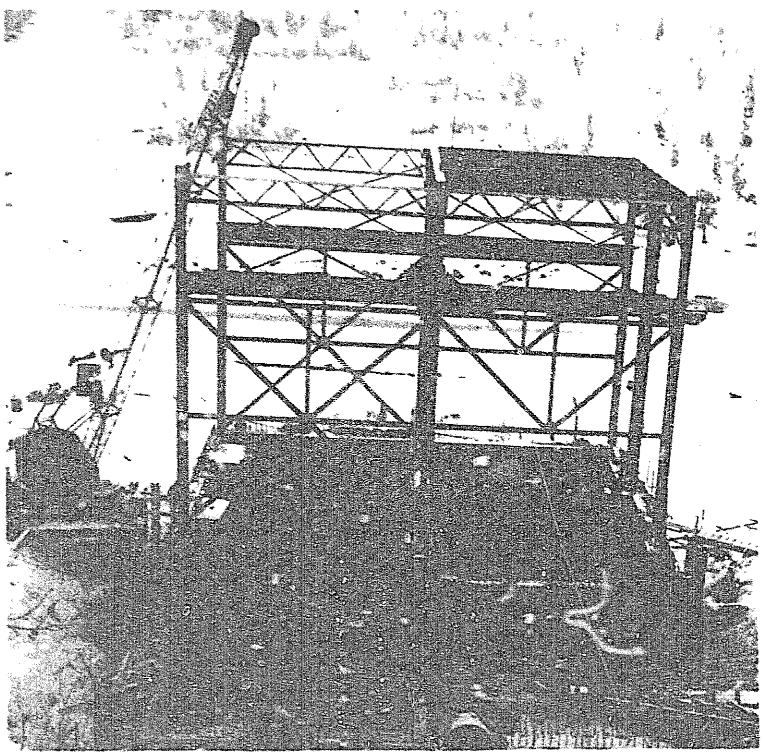
The concrete pipe sections were made in California and transported by ship to Anchorage, and the other portions of the intake structure were built at Eklutna Lake. All sections were moved by gantry crane from the lake shore to shallow water and then were moved into place by a floating crane and installed by divers.

The first two sections of concrete pipe were installed to make connection with the end of the main tunnel, which had been completed earlier, and the remaining sections of the intake structure were extended into the lake. The intake structure was completed in November 1954 when divers removed a steel bulkhead and allowed lake water to flow into the main tunnel.

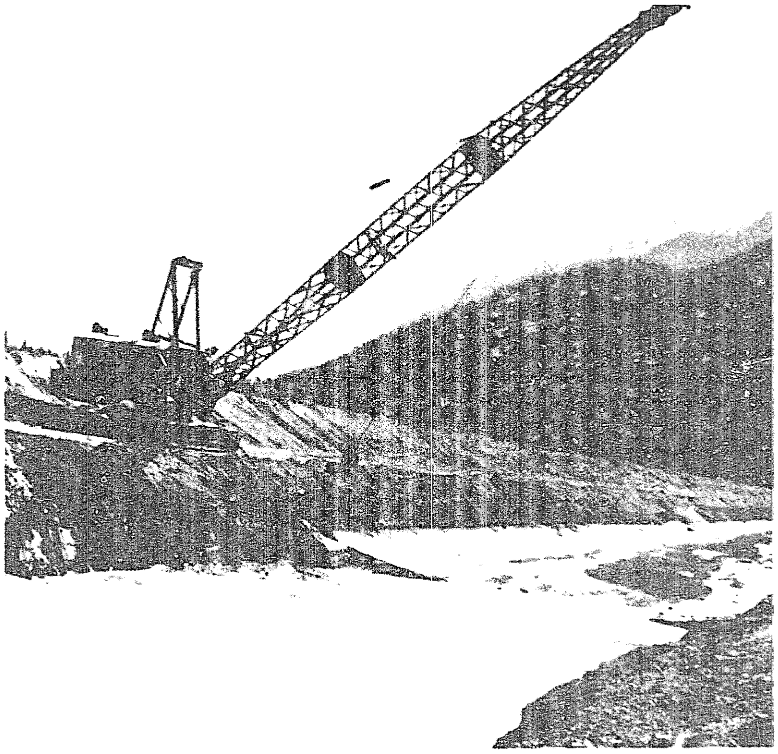


Diver working during excavation for intake structure on Eklutna Lake bottom

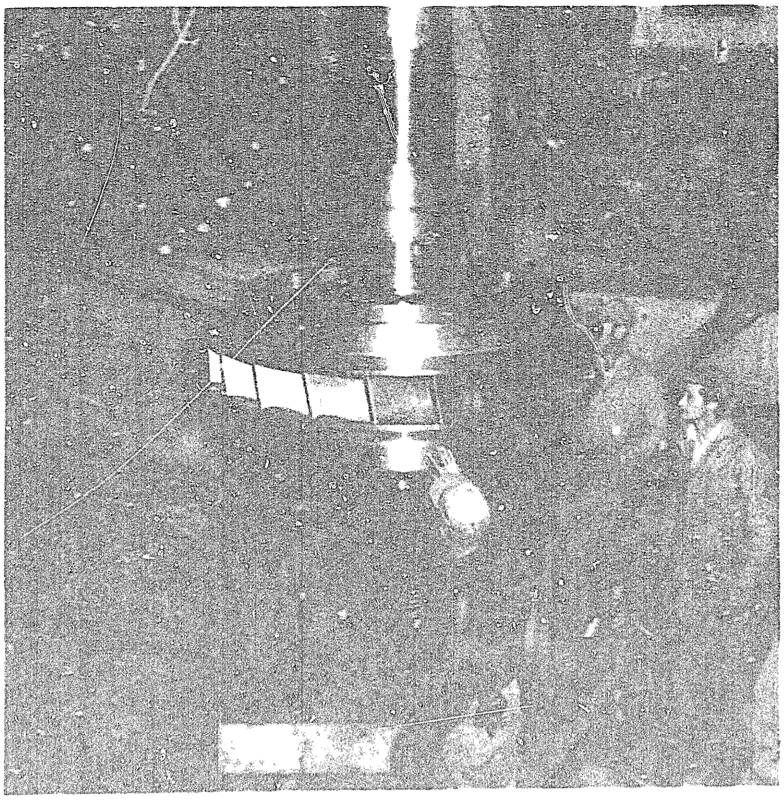
Rue Contracting Company began building the powerplant and spillway 81 days before receiving official notice to proceed. Construction generally proceeded on schedule, except for delays in receiving the turbines and butterfly valves. Excavation was completed in 1952 and 1953, and construction of the powerplant began in 1953 with driving of steel pilings into solid bedrock. Embedding of turbine parts in concrete began in June 1954, and installation of generators began in July 1954. The first generator was started for testing on December 31, 1954, and the second generator was started on March 26, 1955. Both generators were ready for full operation on April 1, 1955.



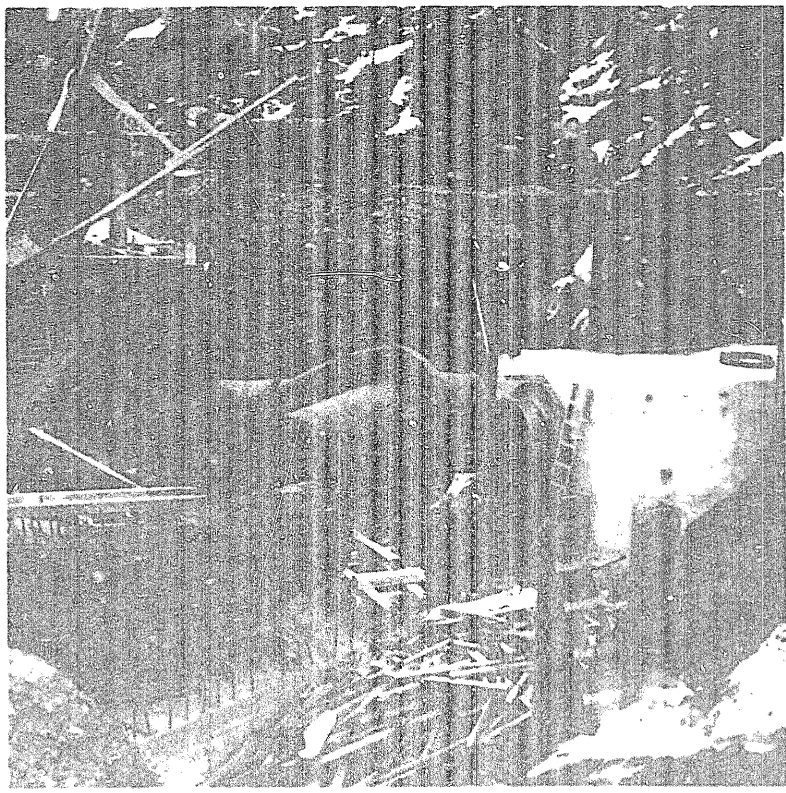
Powerplant construction, 1954. Partly installed turbine draft tubes are shown at bottom center of photograph.



Excavating tailrace channel, 1954. The bottom of the channel is below the ground water table, resulting is seepage into the channel.



Installing turbine runner for Unit 2, August 1954. Water pushing against the runner blades causes the turbine to spin.



Installing penstock wye at powerplant, 1954. The wye splits water in the penstock into two streams, one stream for each turbine.

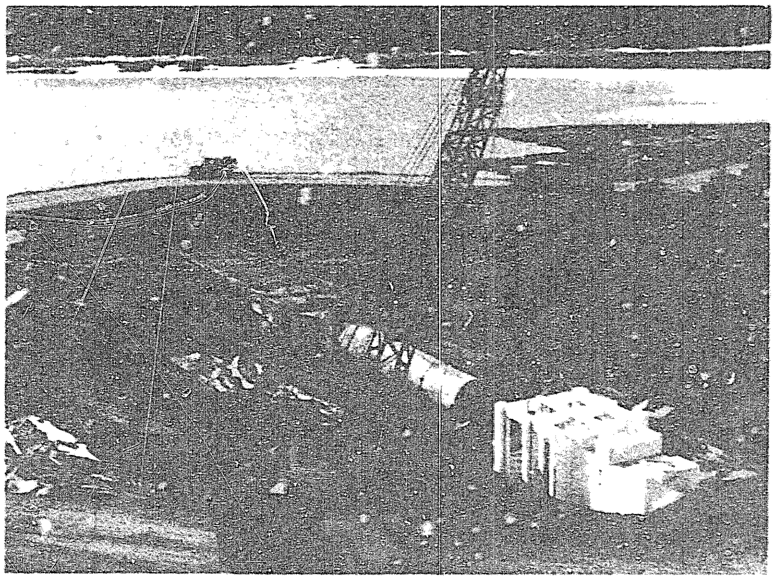
EKLUTNA PROJECT AND THE EARTHQUAKE OF 1964

At 5:36 p.m. on March 27, 1964, a magnitude 8.4 to 8.6 earthquake struck the Anchorage area. The earthquake devastated parts of Anchorage, ruptured natural gas lines, and almost entirely cut off electric service to the city.

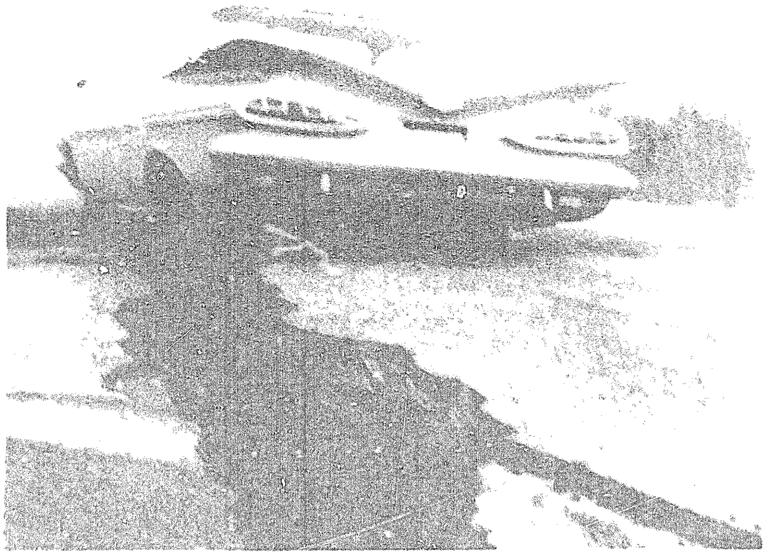
At the Eklutna Project, the earthquake severely damaged two circuit breakers, and a snowslide destroyed about 7,500 feet of the Palmer transmission line to the east of the powerplant. The generators went off-line when the earthquake hit, but damage to the generating units was not apparent after the earthquake. One generator was restarted about 30 minutes after the earthquake, and electricity was flowing to Anchorage within 5 hours

However, the earthquake had damaged the intake structure under Eklutna Lake, which allowed rock and other debris to enter the tunnel and damage one of the turbines. The powerplant was kept running as much as possible to provide critically-needed electricity during the initial rescue and recovery operations in Anchorage.

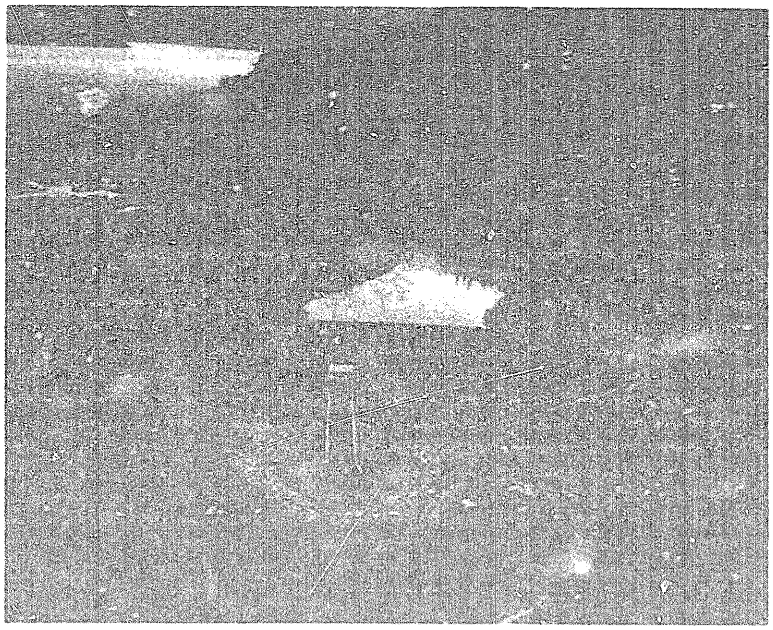
Workmen inspected and repaired the water delivery system in 1964, including removal of debris from the tunnel. The dam at Eklutna Lake had been seriously weakened by the earthquake, and a new and higher dam was constructed in 1965. The intake structure and tailrace channel were also reconstructed in 1965.



Rebuilding the intake structure, 1965. A temporary coffer dam was built to allow dry access to trashgates, concrete conduit pipe, and bulkhead structure.

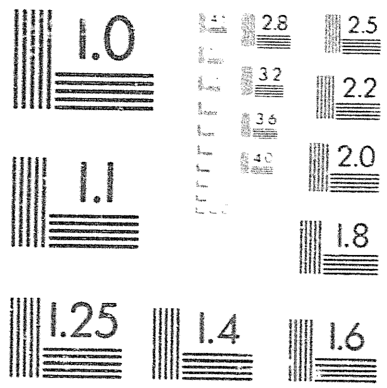


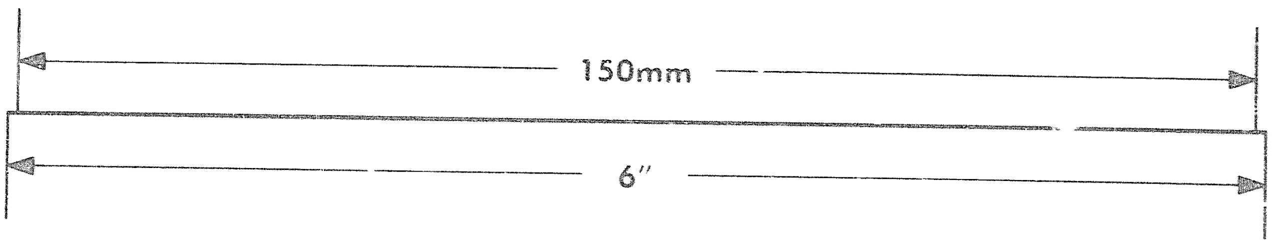
Earthquake damage to highway near powerplant



Eklutna dam, constructed 1965. Remains of old dam are above the new dam, at left edge of photo.

IMAGE EVALUATION TEST TARGET QA-3





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