FRED. H. TIBBETTS
CIVIL ENGINEER

Report No. 416

R E P O R T

to

ANCHORAGE LIGHT & POWER CO.

Anchorage, Alaska

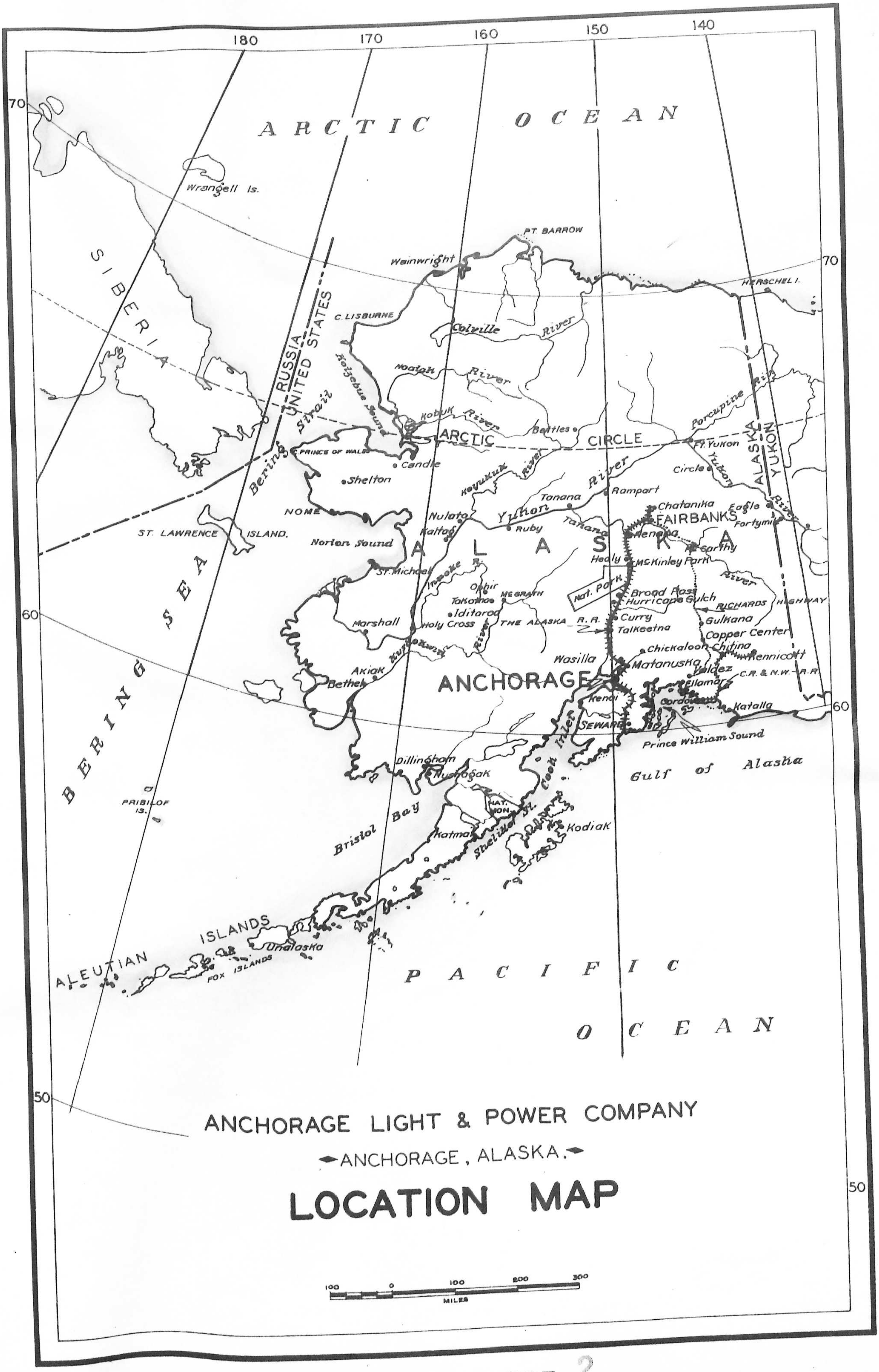
on

EKLUTNA HYDRO-ELECTRIC PROJECT

Project Report No. 5

February, 1929

FRED H. TIBBETTS
CIVIL ENGINEER
San Francisco, California



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SUBJECT ANCHORAGE LIGHT & POWER COMPANY
EKLUTNA RIVER HYDRO-ELECTRIC PROJECT

LETTER OF TRANSMITTAL

February 28, 1929

Anchorage Light & Power Co., Inc.,
Anchorage,
Alaska.

Gentlemen:

This letter of transmittal summarizes in considerable detail the accompanying report on your Company's hydro-electric power project.

1. The Anchorage Light & Power Company is constructing a hydro-electric power project near Anchorage, Alaska, to furnish electric power for the shops and headquarters of the Alaska Railroad, for the town of Anchorage, and, in the future, for a mining and agricultural region to the northward. Anchorage is a town of about 3000 population, located on tidewater, with established fishing, fur trading and commercial enterprises, and favorably situated in a mining, hunting, and probably agricultural, district.

2. The present project was organized in 1923 under the leadership of its present President, Mr. Frank I. Reed. A Federal Power Commission license has been obtained and the project has been financed to the extent of $1,250,000 by Russell-Colvin Company, investment bankers of San Francisco.

3. The project has been designed and is being constructed by the engineering firm of Fred H. Tibbetts, of San Francisco, consisting of -

Fred H. Tibbetts
Ralph G. Wadsworth
Harold I. Wood
Joseph Shaw

Because of the remote and difficult construction work involved, Mr. Wood, has taken personal charge of all construction work in Alaska. The dams and power house are being constructed by Jasper-Stacy Company, contractors of San Francisco, and the construction work on the power line and tunnel is being handled under the direct supervision of Mr. Frank I. Reed, President of the Company. At the date of this report, February, 1929, the construction work is well under way and the system is expected to be ready for service during the coming summer.

4. Although small, the project contains nearly all of the principal physical elements usually found in major developments. The Eklutna River will be regulated for storage purposes by the construction of an earth dam, 15 feet high at the outlet of Eklutna Lake, a natural reservoir with an area of about five square miles, thus producing storage of about 16,500 acre feet, or sufficient to insure a minimum regulated flow of 210 second feet. Seven miles downstream from the lake, water will be raised and diverted by a concrete, variable radius, arch dam about 60 feet high and will pass thence through a tunnel, about 1900 feet long, terminating in an 860 foot steel penstock 54 inches in diameter, which will lead to the power plant, located at approximately tidal elevation and adjacent to the Government Railroad. The effective head will be about 230 feet.

5. Power will be generated, in a modern, reinforced concrete building, by Pelton, horizontal, reaction turbines of 1500 H.P. capacity each, direct connected to General Electric generators of 1000 K.W. each. Power will be transmitted about 26 miles to Anchorage over a 33,000 volt line carried on wooden poles. Transformers, substations and auxiliary equipment are provided at either end of the transmission line.

6. The project is designed for 6000 installed horse power but the

initial installation will include but one of four proposed 1500 H.P. turbine units. Storage regulation at the lake will be sufficient for three units, or a 4500 H.P. installation, while the diversion dam and tunnel will have capacity sufficient for the entire 6000 H.P. installation. Of the two proposed penstocks, each designed to supply two turbines, only one will be installed immediately. The penstock, buildings, substations, and transmission line will be sufficient for two of the proposed units, or 3000 H.P. capacity. The turbine, generator, and transformers in the initial construction will correspond to a 1500 H.P. installation, or one-quarter of the ultimate capacity. The initial capacity can be doubled within a short time and at any season of the year by duplicating, at the power house, which is now being constructed, the mechanical units-- turbine, generator and transformers.

7. The estimated construction cost of the present proposed installation is about $375,000. If the total investment, including financing, organization and legal expenses, should be $450,000, then the average first cost for the initial installation of 1500 H.P. would be $300 per H.P. As soon as the market justifies, however, the installation can be doubled in capacity at an additional expenditure of but a little over $50,000, reducing the cost per installed horse power to about $170, a figure which then compares very favorably with most hydro-electric power installations on the Pacific Coast, and this in spite of the fact that construction costs in Alaska appear to exceed costs elsewhere on the Pacific Coast on similar projects by about 20% to 25%.

8. The town of Anchorage and the Alaska Railroad shops are now supplied with expensive, steam-generated power, furnished by a Government-owned plant. Records of power consumption for the past 5 years are available. The city of Anchorage now uses about 800,000 K.W.H. per year, and the railroad about

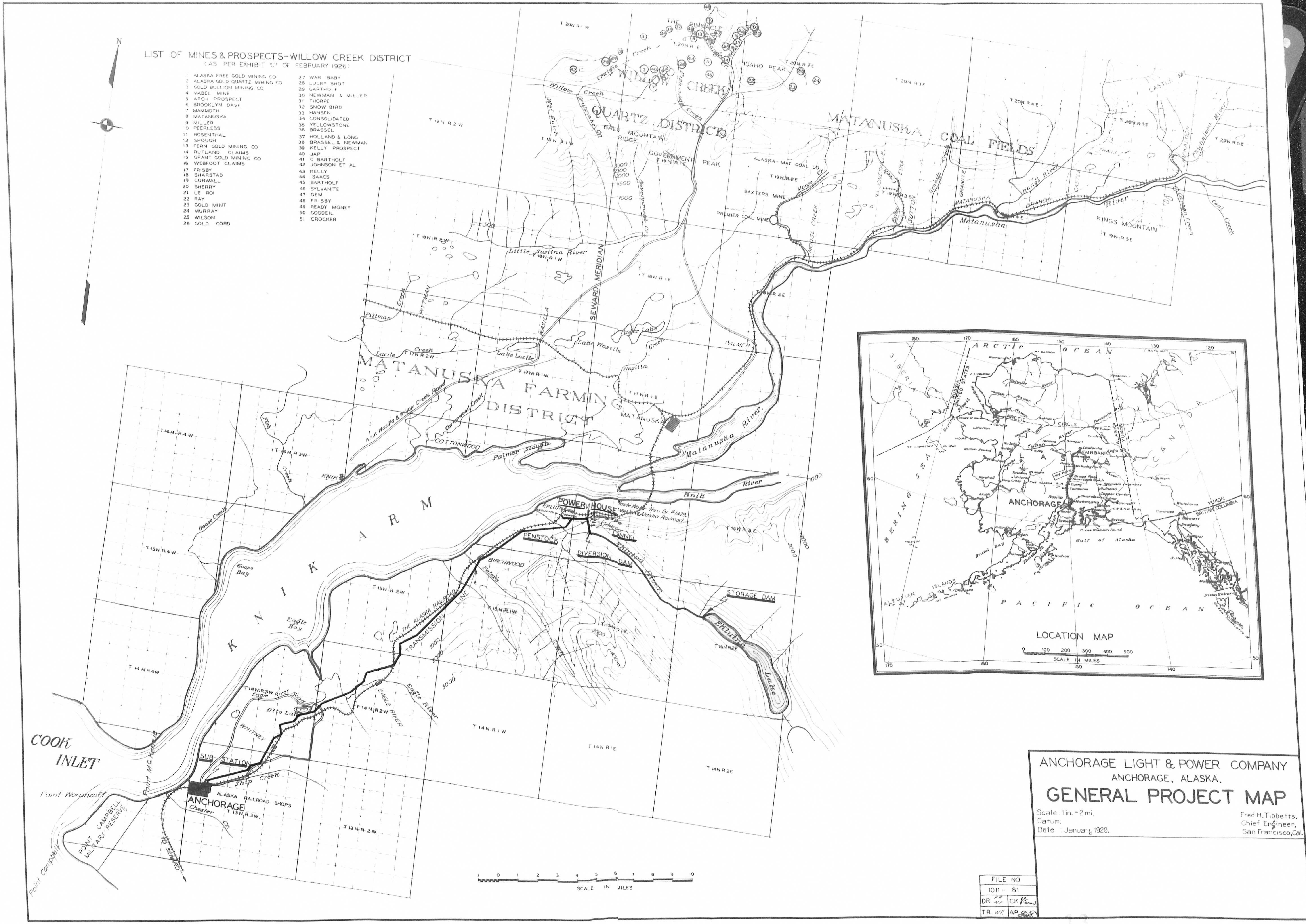
525,000 K.W.H. For this combined load the peak demand is about 575 K.W. The average daily load factor is about 59% and the annual load factor about 28%. It is believed that the natural growth of the town, together with extension of service due to reduced power rates, will result in a steady increase in consumption. Other potential markets are the coal and gold mining districts and the Matanuska agricultural valley to the northeast.

9. The town of Anchorage has contracted to buy wholesale power for the next 15 years at rates varying from 2½c per KWH for heating to 6c per KWH for lighting. It is estimated that annual gross revenues for the first five years of operation from existing consumers including the Alaska Railroad will begin with about $66,000 per year and increase in the five years to about $82,000 per year. The estimated annual operating cost of the system is $19,400 per year, and fixed charges, including depreciation, maintenance, insurance and taxes, are estimated during the first five years at about $19,600 to $21,300 per year. The annual net income during the first five years of operation, as deduced from the above figures, should vary from about $27,300 in the first year, to $41,300 in the fifth year, equivalent to a net yield on the $450,000 investment ranging from 6.1% to 9.2%.

Very respectfully,

Fred. Gibbetts

Chief Engineer,
Anchorage Light & Power Company



LIST OF MINES & PROSPECTS - WILLOW CREEK DISTRICT
(AS PER EXHIBIT "J" OF FEBRUARY 1926)
1 ALASKA FREE GOLD MINING CO
2 ALASKA GOLD QUARTZ MINING CO
3 GOLD BULLION MINING CO
4 MABEL MINE
5 ARCH PROSPECT
6 BROOKLYN DAVE
7 MAMMOTH
8 MATANUSKA
9 MILLER
10 PEERLESS
11 ROSENTHAL
12 SHOUGH
13 FERN GOLD MINING CO
14 RUTLAND CLAIMS
15 GRANT GOLD MINING CO
16 WEBFOOT CLAIMS
17 FRISBY
18 SHARSTAD
19 CORWALL
20 SHERRY
21 LE ROI
22 RAY
23 GOLD MINT
24 MURRAY
25 WILSON
26 GOLD CORD
27 WAR BABY
28 LUCKY SHOT
29 GARTHOLF
30 NEWMAN & MILLER
31 THORPE
32 SNOW BIRD
33 HANSEN
34 CONSOLIDATED
35 YELLOWSTONE
36 BRASSEL
37 HOLLAND & LONG
38 BRASSEL & NEWMAN
39 KELLY PROSPECT
40 JAP
41 C BARTHOLF
42 JOHNSON ET AL
43 KELLY
44 ISAACS
45 BARTHOLF
46 SYLVANITE
47 GEM
48 FRISBY
49 READY MONEY
50 GOODEIL
51 CROCKER
WILLOW CREEK QUARTZ DISTRICT
MATANUSKA COAL FIELDS
MATANUSKA FARMING DISTRICT
KNIK ARM
COOK INLET
ANCHORAGE
POWER HOUSE
PENSTOCK
TUNNEL
DIVERSION DAM
STORAGE DAM
SUB-STATION
TRANSMISSION LINE
THE ALASKA RAILROAD
Eklutna Lake
LOCATION MAP
SCALE IN MILES
SCALE IN MILES
ANCHORAGE LIGHT & POWER COMPANY
ANCHORAGE, ALASKA.
GENERAL PROJECT MAP
Scale 1 in. = 2 mi.
Datum:
Date : January 1929.
Fred H. Tibbetts,
Chief Engineer,
San Francisco, Cal.
FILE NO
1011 - 81

PLATE 1

CHAPTER I

GENERAL DESCRIPTION OF PROJECT

GENERAL PURPOSE

The Anchorage Light & Power Company is constructing a hydro-electric power project near the town of Anchorage, Alaska. It will furnish electric power and electric lighting to the shops and headquarters of the Alaska Railroad and the town of Anchorage, Alaska, and probably in the future to a productive mining region northeast of Anchorage. In the territory served by the power company there are also, particularly to the north, large areas of fertile land which it is hoped in the near future will enable extensive agricultural developments.

Immediately upon completion of the power plant, service will commence to the town of Anchorage and the Government Railroad, which have heretofore been served by a steam plant. By progressive additions of transmission lines it is hoped that service will gradually be extended to the mines and surrounding territory. It is expected that the low rates for power, which the company will be able to offer, will greatly stimulate the use of electric power in the whole area, and thereby promote the development of mining and industries, and cause a substantial acceleration of general progress in the whole community. At the same time the project should become a profitable enterprise for its promoters.

LOCATION

The project is located near the town of Anchorage, at the head of Cook Inlet, the deepest indentation on the southerly coast of Continental Alaska. (See Frontispiece). Knik Arm, an extension of the inlet, runs inland in a northeasterly direction an additional 40 miles with an average width of about 5 miles. (See Plate 1). At the head of the arm two rivers enter, the Matanuska and

Knik, both of which have their origin in glaciers on the northerly slope of the Chugach Mountains, which intervene between the Matanuska Valley and Prince William Sound on the main coast. A number of smaller streams draining the northerly slope of the mountains, also enter Knik Arm between Anchorage and the mouth of the Knik River. All of them emerge from deep canyons at elevations but little above tide water and flow across a plain two to three miles in width, bordering the southerly shore of Knik Arm. The largest of the smaller streams is the Eklutna River, which enters the Arm about 4 miles below its head. This stream has a well sustained summer flow and a rapid fall in its lower reaches, making it particularly favorable for economic power development, and resulting in its selection for the first project to be undertaken by the Anchorage Light & Power Company.

The power plant will have a central location with respect to probable ultimate centers of power consumption. The first transmission line will extend in a southwesterly direction about 26 miles to Anchorage and subsequent lines will extend northeasterly to the Matanuska coal field on the Matanuska River, and northerly to the Willow Creek quartz mining district and the Matanuska agricultural area.

ANCHORAGE, ALASKA

LOCATION & DESCRIPTION

The town of Anchorage, which has already contracted to buy power from the new company, thereby assuring immediate income, is located centrally on the southerly coast line of Continental Alaska. Situated at the head of

Cook Inlet, it is closer to the interior of Alaska than any of the other seaport towns. Its location was originally selected by the Alaska Railroad Commission as the most desirable point for construction of its shops and headquarters when construction of the railroad was undertaken by the United States Government in 1915.

The town is located on a low gravelly plateau on the southerly bank of Knik Arm, near its junction with Cook Inlet. The site has been laid out in rectangular blocks in accordance with a carefully worked out city plan. The streets are wide and the important ones paved.

In 1920, five years after the town was started, the United States census gave its population as 1856. The present population is estimated at 3000, indicating a rapid growth. The development of the town in the past has, of course, been closely related to the construction program of the Alaska Railroad Commission, but the continued prosperity of the community, since active prosecution of the railroad work ceased, indicates that its future prosperity is assured by the industries and natural resources of the region.

TRANSPORTATION FACILITIES

The waters of Cook Inlet are open to navigation most of the year, and a large volume of water borne freight has been handled through the Anchorage docks. Shipping is somewhat hampered by the tides which have an extreme range of about 40 feet. During the coldest months of the winter practically all navigation is discontinued. Although the surface of Cook Inlet

Figure 1
Airscapes of Anchorage, Alaska

Figure 2
Business District, Anchorage, Alaska

Figure 3
Eklutna Lake prior to construction of storage dam.
(Tibbetts and Wood Aug. 7, 1928)

Figure 4
Agricultural Experiment Station at Matanuska.

is never frozen over, due to the heavy tidal flow, navigation is at times made extremely dangerous by the presence of great numbers of blocks of broken ice carried in and out by the tidal current.

Freight and passenger service is maintained throughout the year by the Alaska Railroad which extends 356 miles northerly to Fairbanks, the metropolis of the Interior, and 114 miles southerly to Seward on the main coast, from which port ships sail regularly for Seattle and other southern ports. During the summer, a power boat service, subsidized by the Territory, makes regular trips from Anchorage to other points on Cook Inlet. An air transport company provides regular passenger communication with many points in the interior.

CLIMATE

The climate of Anchorage is typical of northern countries, although temperatures are greatly modified by the proximity of the ocean. The mean temperature in July is about 57°, with an occasional maximum of 80°, while the mean temperature in January is about 9° above zero, with an occasional minimum as low as 36° below. The mean annual precipitation is 14.3 inches, about 2/3 of which occurs in the form of rain during the summer. The winter snow fall aggregates about 75 inches. (See Chapter III for further data on precipitation). During the long days of the summer season, vegetation grows rapidly and cultivation of seasonal crops is remarkably productive. Large quantities of the hardier vegetables and cereals are produced in the farming areas nearby. (See Fig. 4).

INDUSTRIES

Anchorage is a trading center of importance and has a variety of industrial developments, including fish canneries, railroad shops, fur traders headquarters and headquarters for the equipment of sportsmen's expeditions.

The fishing industry on Cook Inlet is becoming of great importance. Two salmon canneries are located at Anchorage with a daily capacity during the season of over 3000 cases. These canneries employ during the season over 200 people, in addition to a large number of fishermen and boatmen.

The headquarters of the Alaska Railroad are at Anchorage, including very large and well equipped repair shops and terminal facilities, as well as the offices of the administrative and operating staffs.

Fur trading is an important business. In addition to the furs of wild animals brought in in large quantities by trappers, there is a well established and going fur farming business, where silver foxes and minks are raised in captivity.

The headquarters of the Alaska Guides Association is at Anchorage and it is here that the best hunters from all parts of the world start on well equipped expeditions in search of moose and the great brown Kodiak bears.

Anchorage is also an important distribution point for mercantile distribution of provisions, supplies, and sporting, mining, trapping, hunting and prospecting equipment.

The Anchorage Hotel is the best known in Alaska and annually entertains thousands of tourists from all quarters of the globe.

SURROUNDING AREA

Immediately tributary to Anchorage is a large mining and agricultural region containing great natural resources. The Matanuska coal fields contain the only accessible deposit of high grade steam and coking coal in Alaska. Seams from 5 to 30 feet in thickness are to be found over an area of about 46 square miles. The willow Creek quarts mining district is rich in minerals, as yet largely undeveloped. Many mountainous areas in sight of Anchorage abound with fur bearing animals for professional trappers, and with bear, moose, elk, mountain sheep, mountain goats, etc., for sportsmen and hunters.

The Matanuska Valley, ten or fiteen miles beyond the power plant, is one of the most promising agricultural prospects in Alaska. It contains a large area of level land of good quality. The Government Agricultural Experiment Station has fully demonstrated the fact that climate and soil conditions are suitable for the raising of wheat, barley, potatoes and other vegetables and for dairying and stock raising. It is confidently expected that this section will, in the near future, have an important agricultural development.

PRESENT POWER SERVICE

At the present time, the town of Anchorage received electric power and lighting service from the steam generating plant built and operated by the Alaska

Railroad. The electrical distribution system was constructed by the railroad and is now operated by the town under lease. Current at 2300 volts is purchased at wholesale rates and distributed to consumers at 12 to 15 cents per k.w.h. The service has apparently been satisfactory but the necessarily high rates for steam-generated power have greatly restricted its use for purposes other than lighting.

HISTORY OF PRESENT PROJECT

ORGANIZATION OF COMPANY

The Anchorage Light & Power Company was organized in 1923 under the laws of the Territory of Alaska by a group of local men under the leadership of Mr. Frank I. Reed, who became its president. Investigations were immediately commenced to determine the possibilities of hydro-electric power on the Eklutna River, which had been selected as the logical stream for the company's initial development, and steps were taken toward acquisition of necessary rights of way and permits needed before construction work could start.

FEDERAL POWER COMMISSION LICENSE

Since a large part of the works of the contemplated project will be located on Government land, it was necessary to obtain a license from the Federal Power Commission, granting rights of way and permitting diversion of the river for power purposes. Application was made to the Commission by Mr. Frank I. Reed, president of the company, and a preliminary permit establishing priority was issued on March 8, 1923. The terms of the permit called for extended investigations of the project by the applicant and the submission within two years of maps, estimates and financing plans sufficient to form a basis for decision as to granting of the license. An engineer, Mr. Robert Howes, of Seattle, was employed to make a field investigation, and prepare necessary preliminary plans and estimates. Mr. Howes made a very thorough study of the power market, prepared a preliminary project map and submitted an excellent report, including cost estimates of the project, all of which were transmitted to the Power Commission in due time. However, certain required data and an acceptable plan of financing were still lacking when the permit period expired. On a showing of reasonable diligence, two extensions of time were granted, one on March 2, 1925, and one in 1926. The license designated "HP 350-Alaska" was finally issued on October 12, 1926.

FINANCING

The financial structure of the organization calls for a capitalization of $1,250,000 made up as follows:

First mortgage, 7% bonds, maturing in 1943	$500,000
Preferred stock, 8% cumulative, $100 par value	250,000
Common stock, $10 par value	500,000
	$1,250,000

For the immediate construction program, it is planned to issue only a portion of the authorized securities.

A large part of the common and preferred stock was subscribed by residents of Anchorage and vicinity. The bonds and a portion of the preferred stock were handled by the Russell-Colvin Company, Investment Counsellors, of

San Francisco, California. Through their connection with the financing, the Russel-Colvin Company has assumed an active interest in the affairs of the corporation.

CONSTRUCTION PROGRAM

GENERAL PLAN

The initial stage in development of the company's project on the Eklutna River will include all of the main elements of the usual hydro-electric development. Storage will be provided by construction of a dam at the outlet of Eklutna Lake, located about 12 miles above the mouth of the river, at which point stream flow will be regulated by a suitable headgate. About 7 miles downstream, and about 5 miles above the mouth of the river, a concrete diversion dam will be constructed to divert the whole or a portion of the flow of the river into a tunnel, which will pass under the ridge separating the river from the shore of Knik Arm. From the outlet portal of the tunnel, two penstocks ultimately will extend down the slope to its inter-section with the plain bordering tide water, where the power house will be located. Water discharged from the power house will be conducted through a channel about one mile long, following a natural water course to its point of entrance into the upper end of Knik Arm. The main features of the development as described are shown on the General Project Map submitted herewith as Plate No. 1 and complete descriptions are contained in Chapter V.

PRELIMINARY WORK

During the fall of 1926, preliminary work was actively commenced with the purpose of starting the principal construction features during the winter. It was necessary to construct the storage dam at Eklutna Lake during the winter so as to be prepared to control the flow of the river during the runoff period in the spring of 1929, when active construction of the diversion dam and tunnel inlet would be under way. It was also desirable to carry on the driving of the tunnel during the winter, since this work would necessarily require several months. The schedule of operations was worked out with the object of completing the project in the summer of 1929.

In order to provide power for driving the tunnel and for other operations at the power house and diversion dam, the transmission line from Anchorage to the power house site was first constructed. Arrangements were made to obtain power from the steam plant at Anchorage and connections were made for conducting it over the new line during the construction period. The transmission line, including temporary substations, was started on September 17, 1928, with company forces under the direction of Mr. Frank I. Reed, and finally completed and tested on December 31, 1928.

On October 3, 1928, a general contract was awarded to the Jasper-Stacy Company of San Francisco, California, covering all work on the project except the transmission line and tunnel. Camps were immediately established at the power house site and at Eklutna Lake. Materials and equipment were obtained for construction of the storage dam and for preliminary work on the diversion dam and machinery and equipment for tunnel driving were installed.

WINTER CONSTRUCTION 1928-29

During the present winter it is proposed to complete the storage dam, to construct the base of the diversion dam, and to drive the major portion of the diversion tunnel, the latter work to be done by company forces. Excavation for the power house and penstock will also be completed.

FIRST STAGE OF DEVELOPMENT

The construction of the power house and penstock and remaining work on the diversion dam and tunnel will be completed in the spring of 1929. The immediate installation will include only one generating unit at the power plant. The building, however, will be constructed to accommodate two units, and the penstock and tail race will also have sufficient capacity to handle the water required for two units of 1000 kilowatts each. The diversion dam and tunnel are designed to provide sufficient water for four units. The transmission line to Anchorage will carry the output of two units, although the sub-station transformers will have sufficient capacity to handle the output of only one.

FUTURE ENLARGEMENT

Enlargement of the plant to double its initial capacity will readily be effected by installing an additional generating unit at the power house and providing additional transformers at the sub-stations bringing the whole installation to 2000 k.w. capacity. This will be accomplished at very moderate expense, due to the fact that most of the construction work, including machinery foundations will already have been completed for the larger installation. For the service of new communities, additional transmission lines are planned, extending in a northeasterly direction toward Matanuska and Willow Creek. It is probable that the first extension of this kind will be undertaken in the latter part of the present year.

When power sales increase to the point where more than 2000 kilowatts are required at the generating plant, it will be necessary to enlarge the power house and put in one or more additional units. At the same time a new penstock will be required extending from the tunnel portal to the power house. No enlargement of the tunnel, intake structure, or diversion dam will be necessary. Some enlargement of the storage capacity at Eklutna Lake may then be required depending upon the results of further investigation of the water supply after additional records are available.

CHAPTER II

POWER MARKET

GENERAL CHARACTERISTICS

During early stages of development of the Eklutna River hydro-electric project, the energy generated will be used principally in the town of Anchorage for lighting, heating, domestic appliances, and operation of machinery in stores and shops, including the large shops of the Alaska Railroad. All of these uses vary widely during the day and from month to month during the year. Fortunately, records of operation of the existing system in Anchorage are available, which give very useful information regarding load variations to be provided for. Summaries of these records are included with the following discussions of the several markets which the Anchorage Light & Power Company will serve.

PUBLIC SERVICE IN ANCHORAGE

POWER CONTRACT WITH TOWN

On July 18, 1927, the Town Council of Anchorage passed Ordinance No. 68, which adopted a contract for purchase of power from the Anchorage Light & Power Company for distribution to consumers in the town and for municipal purposes. The contract provided that service must commence within two years, but a possible extension of one additional year was included to become effective only in case the company had made substantial progress within the two year period. The contract has a life of 15 years, commencing from the date on which actual service is commenced. The main provisions of the contract are summarized below.

Current will be sold to the town at the following rates for various types of service:

Lighting, general	6¢ per K.W.H.
Industrial Power	4¢ " "
Domestic Heating and Cooking	2½¢ " "
Municipal lighting and pumping	4¢ " "

Electrical energy is to be 2300 volt, 3 phase, 60 cycle alternating current. The company agrees to make provision for an auxiliary plant for service in case of failure, shut down, or inadequacy of the hydro-electric system. The town will continue to operate the present distribution system under its existing lease from the Alaska Railroad Commission, the lease having recently been extended to cover the same period of time as specified in the contract with the power company. Delivery of the power will be made at the company's sub-station in Anchorage but payment will be based on meter readings at actual points of use. Transmission losses between the sub-station and points of use are to be borne by the power company up to a maximum of 10%. Losses in excess of 10% will be paid for by the town through an annual accounting and adjustment.

PRESENT MUNICIPAL CONSUMPTION

In addition to the industrial and domestic service, a considerable amount of power is used for the operation of the city pumping plant, which supplies water for domestic use throughout the town. On Plate 2 the lower curve represents the combined monthly power consumption for operation of the pumping plant and for the other uses within the town, during the period from

December 1922 to May 1928 as obtained from existing records. The wide variation between summer and winter shown by the curve is the effect principally of the lighting and heating loads, the pumping plant load being fairly uniform throughout the year. The following tabulation, Table No. 1, shows the annual consumption of power by the town of Anchorage for public service and for pumping plant operation during the four years from 1923 to 1927. The total for each year is shown and, for each of the two services and for the combined total, the percentage change in the total load from year to year is indicated.

TABLE I

CONSUMPTION OF ELECTRICAL ENERGY BY CITY OF ANCHORAGE
Years 1923 to 1927 Incl.

	Public Service		Pumping Plant		Total	
Year	K.W.H.	% Change	K.W.H.	% Change	K.W.H.	% Change
1923	494,000	-	287,000	-	781,000	-
1924	503,000	+ 1.8	283,000	-1.4	786,000	+ .6
1925	474,000	- 5.8	320,000	+13.1	794,000	+1.0
1926	468,000	- 1.3	293,000	- 8.4	761,000	-4.1
1927	482,000	+ 3.0	313,000	+ 6.8	795,000	+4.5

ESTIMATED FUTURE INCREASE

The above figures for power consumption in the town of Anchorage do not indicate any very pronounced trend. A considerable decrease of consumption in 1926 was followed by a similar increase in 1927. Partial records for the year 1928 indicate a total consumption of approximately the same amount as 1927. It would seem likely that, under existing conditions as to rates and service, a maximum rate of consumption may have been reached.

With the reduced rates which should become effective after the delivery of hydro-electric power commences, it is reasonable to expect that there will be a rapid increase in the use of power, particularly for domestic purposes, such as heating and cooking. Based on available information regarding increase of service under similar conditions in other localities, it is believed safe to assume that, during the first five years at least, the consumption of energy for lighting and heating will increase 10% each year. In the case of the current used for the city pumping plant, the increase of consumption will be less rapid, depending largely upon the growth in population. However, the reduced cost of pumping will undoubtedly encourage substantial additional use of water and an annual increase of 5% per year during the initial five year period is considered a conservative estimate. The percentage increases mentioned have been used in estimates of probable income presented in a later chapter.

ALASKA RAILROAD

At the present time the railroad is using for its own purposes somewhat less than half of the total power generated at its steam plant, the balance being sold to the town. The existing plant, located within the railroad yards, is steam driven, coal being used for heating the boilers. Costs of operation have been high, the average cost for 1923 being estimated at slightly over 7¢ per K.W.H. generated.

An agreement has been reached between the railroad management and the Anchorage Light & Power Company, providing for sale of power to the railroad for all of its present uses. This agreement has not been set forth in a formal contract, but is embodied in correspondence between the company and the officials of the railroad. A flat rate of 4¢ per K.W.H. has been set for all power used. It is understood that the present steam plant will be maintained by the railroad in operating condition after the new company commences operation and that it will be available for use in case of interruptions of the hydro-electric service.

PRESENT RAILROAD CONSUMPTION

Plate 2 shows a graph of monthly consumption of electricity by the railroad during the period from December 1922 to May 1928. It will be noted that the annual variation follows closely that of the public service load in Anchorage. The same plate indicates the total monthly output of the railroad steam plant during the same period, this being equivalent to the sum of the consumption curves for the railroad and town plus transmission losses.

The annual consumption of power by the railroad from 1923-27 is indicated in Table 2 below, which also shows in the last column the percentage of increase or decrease each year.

TABLE NO. 2

CONSUMPTION OF ELECTRICAL ENERGY BY THE ALASKA RAILROAD
Years 1923 to 1927 Incl.

Year	K.W.H. Consumed	Percent Change Over Preceding Year
		-
1923	360,000	+27.6
1924	459,500	+31.2
1925	603,000	-17.4
1926	498,000	+ 3.2
1927	514,000	

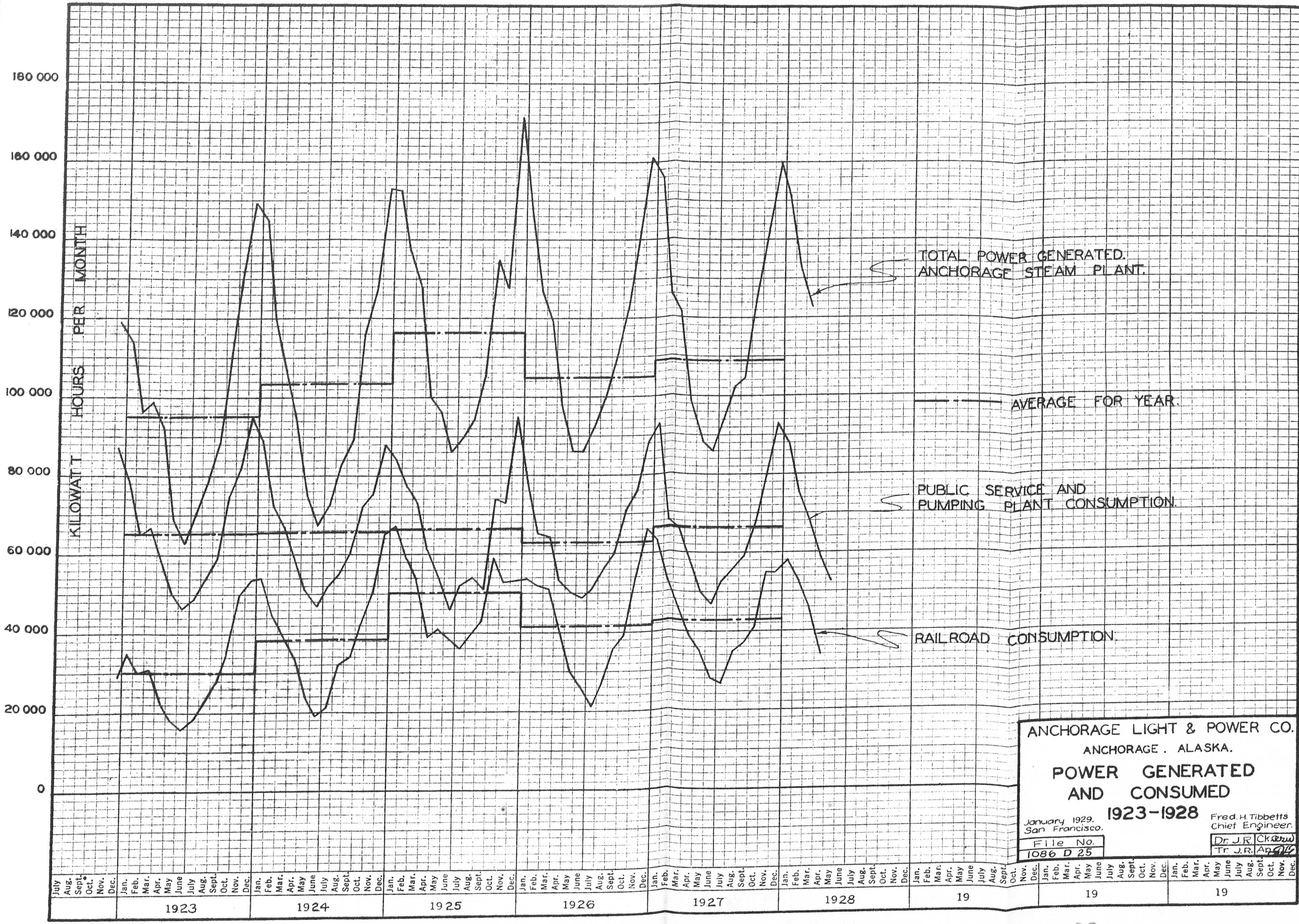

180 000
160 000
140 000
120 000
100 000
80 000
60 000
40 000
20 000
0
KILOWATT HOURS PER MONTH
TOTAL POWER GENERATED. ANCHORAGE STEAM PLANT.
AVERAGE FOR YEAR.
PUBLIC SERVICE AND PUMPING PLANT CONSUMPTION.
RAILROAD CONSUMPTION.
ANCHORAGE LIGHT & POWER CO.
ANCHORAGE . ALASKA.
POWER GENERATED AND CONSUMED
1923-1928
January 1929. San Francisco.
Fred. H. Tibbetts Chief Engineer.
File No. 1086 D 25
Dr. J.R.
Tr. J.R.
July Aug. Sept. Oct. Nov. Dec.
Jan. Feb. Mar. Apr. May June July Aug. Sept. Oct. Nov. Dec.
1923
1924
1925
1926
1927
1928
19

PLATE 2.

The drop in power consumption after 1925 is presumably due to a sharp decrease in construction activity on the Alaska Railroad project.

ESTIMATED FUTURE LOAD

Under present conditions, the above figures indicate that the normal annual consumption of power by the railroad should be about 525,000 k.w.h. per year. Future increases will probably be brought about only by the installation of new equipment in the shops, or by the electrification of some of the steam driven equipment now in use. For example, a steam driven compressor now in service in the shops could readily be provided with an electric motor and a substantial reduction in operating cost effected, under the prescribed rate for power. A change of this kind would result in the use of about 75,000 k.w.h. of additional energy per year. Until the policy of the railroad management toward further electrification is more definitely ascertained, it will be impossible to make an accurate estimate of future increase of consumption, but a total added load, equivalent to that suggested above, would seem to be a reasonable assumption. Adding the additional 75,000 k.w.h. to the present consumption of 525,000 k.w.h. gives a total of 600,000 k.w.h. as the probable uniform annual consumption for use in estimating future income of the power company.

OTHER ACCESSIBLE POWER MARKETS

Within reasonable reach of the proposed power system, a large area to the north and northeast presents a potential market. Within a short distance of the power plant, the Eklutna Industrial School will be served by a branch transmission line already constructed. A rate of 10¢ per K.w.h. and a minimum monthly charge of $100 have been agreed upon.

The town of Matanuska, located about 8 miles northeasterly from the power plant on the opposite side of the Matanuska River, will be a probable consumer of power for domestic use, pumping plant operation, and machinery in a proposed cannery. The Government Experimental Agricultural Station, about two miles from Matanuska, would also be a possible consumer. The Matanuska coal field and Willow Creek mining district, somewhat further away, offer still more promise as future power markets.

MATANUSKA COAL FIELDS

A transmission line about 30 miles in length, extending northeasterly from the power plant, would reach the Matanuska coal fields. Many of the deposits in this area have been opened up and transportation facilities are provided by a branch of the Alaska Railroad, extending from Matanuska to Chickaloon. Government restrictions on mining have prevented extensive development of this coal, but large quantities are shipped for local use in Anchorage and on the lower portion of the railroad. Many uses could be found for electric power in this vicinity, particularly for the operation of coal handling equipment.

WILLOW CREEK GOLD MINES

The Willow Creek mining district lies about 25 miles north of the proposed power plant. In this vicinity there are many small mines utilizing equipment which could be operated by electricity. (See locations and names of mines and prospects on Plate 1). A considerable amount of power is now obtained

from water wheels operated three or four months during the summer when
stream flow is available. If continuous power were made available by ex-
tension of a transmission line to this area, it is probable that a sub-
stantial amount of power could be sold throughout the year and that pro-
duction from the mines would be stimulated by the lengthening of the annual
working season.

CHARACTERISTICS OF POWER LOAD

LOAD FACTORS

The cost of electric energy depends upon the variation of the
load, as well as upon the total quantity of energy consumed. Generating
and transmission facilities must be provided to supply the maximum demand,
although it may be effective for only very short intervals. Thus the
capital investment depends upon the peak load while the annual income depends
upon the average consumption. The important ratio between the average load
on a system during a given period of time, and the peak load occuring during
the same period, is called the "load factor" of the system. The period
referred to may be 24 hours, one month, one year, or any other convenient
period.

DESCRIPTION OF LOAD

The future load conditions on the system of the Anchorage Light
& Power Company will depend largely on the amount of industrial or mining load
which can be obtained. Continuous load at the mines, particularly, would
greatly benefit the system by increasing the amount of continuous power. In
the immediate future, with the Anchorage service predominating, load conditions

will probably remain about as at the present time.

The total load in the town of Anchorage is made up of at least three somewhat different types of service, including lighting, power for machinery, and domestic heating and cooking. The amount of current consumed for lighting depends of course on the season, the short days of winter requiring relatively larger amounts of current. Similiarly, the heating load is greatly increased during the winter months. The power load, however, remains more or less constant throughout the year, including the operation of the city's pumping plant.

The variation of power consumption during a 24 hour period is characterized by heavy load during the day and extremely light load during the night, when both power and lighting requirements are a minimum. The load throughout the day is fairly well sustained, the power load filling in to a large extent the midday gap between the usual morning and evening peaks in the lighting load.

The variation of the average hourly load on the Anchorage steam plant on two typical days of 1928 is shown on Plate No. 3. A study of these curves indicates only a slight difference in total consumption in the middle of the day, that is from 8 a.m. to 3 p.m. The principal difference occurs between 3 p.m. and 10 p.m., when the heavy lighting load occurs in the winter time. The usual peak, which occurs on most systems when the lights are turned on in the evening, can be observed on the diagrams, occurring between 4 and 5 o'clock in January, during which time it coincides with the power load, and

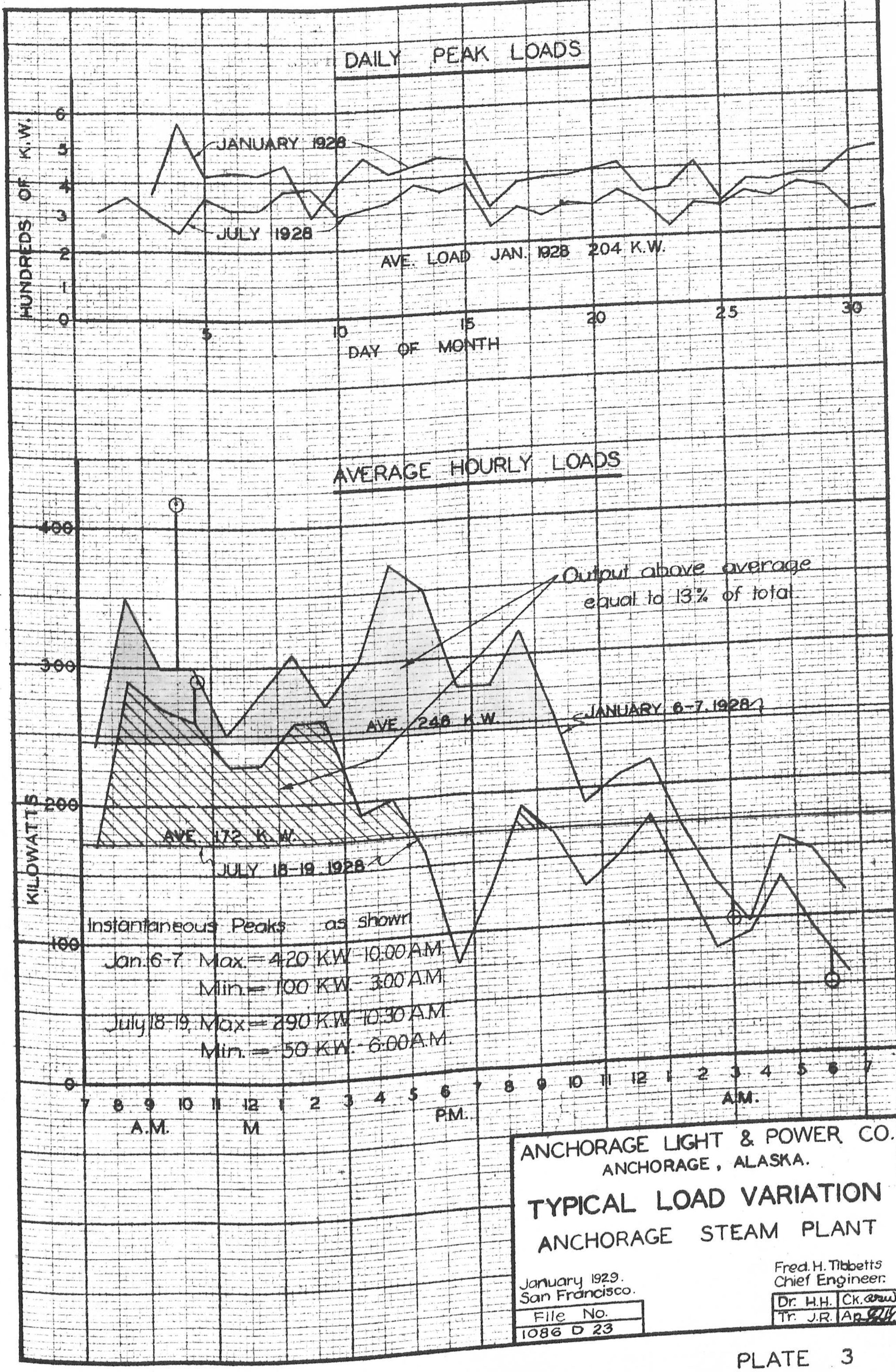

DAILY PEAK LOADS
HUNDREDS OF K.W.
JANUARY 1928
JULY 1928
AVE. LOAD JAN. 1928 204 K.W.
DAY OF MONTH
AVERAGE HOURLY LOADS
KILOWATTS
Output above average equal to 13% of total
AVE. 248 K.W.
JANUARY 6-7, 1928
AVE. 172 K.W.
JULY 18-19, 1928
Instantaneous Peaks as shown
Jan. 6-7 Max. = 420 K.W. 10:00 A.M.
Min. = 100 K.W. 3:00 A.M.
July 18-19, Max. = 290 K.W. 10:30 A.M.
Min. = 50 K.W. 6:00 A.M.
A.M.
M
P.M.
A.M.
ANCHORAGE LIGHT & POWER CO.
ANCHORAGE, ALASKA.
TYPICAL LOAD VARIATION
ANCHORAGE STEAM PLANT
January 1929.
San Francisco.
Fred. H. Tibbetts
Chief Engineer.
File No.
1086 D 23
Dr. H.H.
Tr. J.R.

PLATE 3

occuring between 8 and 9 o'clock in the summer time, after the shops have closed. The deep depression in the curve for July 18th between 6 and 7 p.m. indicates the interval of daylight between the close of the shops and the beginning of darkness.

The upper curves of Plate 3 indicate the daily peak loads on the Anchorage steam plant during January and July of 1923. They apparently show a wider fluctuation of the peak load in January than in July.

ANNUAL LOAD FACTOR

The peak load on the Anchorage steam plant under present conditions is about 575 k.w. (See upper curve, Plate 3), and the average output for the year about 160 k.w. The annual load factor is therefore the ratio of 160 to 575 or about 28%. This is a rather low ratio compared with the corresponding load factor obtained on larger systems with more diversified loads, but for the type of local service to be rendered at Anchorage, it is about what must be expected. The significance in the present case of the load factor indicated is that while equipment must be installed to supply at least 575 k.w., the income during the year is based on the sale of an average amount of only 160 k.w. This demonstrates the great desirability of obtaining for the system additional uniform load, such as would be furnished by the mines, in order to raise the average output.

MONTHLY LOAD VARIATION

The variation of the average load from month to month is indicated on Plate 2. It will be noted that the load during the period of maximum use in December and January exceeds by about 100% the load during May and June. This is a high but not excessive variation as compared with other power systems. In California the maximum monthly load of the Pacific Gas & Electric Company is about 50% in excess of the minimum monthly load, and on the San Joaquin Light & Power Company system the maximum is about 78% in excess of the minimum. In the latter cases, however, the maximum occurs in July and August during the irrigation period.

DAILY VARIATION

The daily load variation is, of course, even greater than the monthly variation, as shown by the lower curves on Plate 3. The maximum hourly output on January 6-7 was over 200% in excess of the minimum. During the 24-hour period shown, the peak load was 420 k.w., occuring at 10 a.m. and the average load for the period, 246 k.w., giving a load factor of 58.7% for the day. On July 18-19, the maximum hourly output exceeded the minimum by about 400%, the peak load was 290 k.w., the average load 172 k.w., and the load factor for the day, 59.3%. On the basis of the record of these two typical days, representing both summer and winter conditions, it is believed that a daily load factor of 60% can be assumed.

STAND-BY SERVICE

During the first few years of operation of the hydro-electric system of the Anchorage Light & Power Co., plenty of capacity will be available to take care of any possible peaks in the power demand. There will, therefore, be no need of steam stand-by service so long as satisfactory operation of the hydro-electric plant is continuously maintained. It is certain, however, that in the operation of the completed system, involving complete co-ordination of its several widely scattered parts, including regulation of the stream flow, operation of the generating units, and maintenance of service over the transmission line, occasional interruptions will necessarilly occur. At the power plant inspection and adjustment of bearings will at times be necessary. Severe ice conditions at the tunnel intake may require cutting off of the flow of water for short periods, and violent storms during the winter are certain to cause an occasional interruption of service over the transmission line.

To insure continuous service to consumers, it is therefore, essential that definite arrangements be made for promptly bringing power from the railroad steam plant at Anchorage into the system when necessary. In addition to the electrical connection between the two systems as already provided, this requires that some plan be worked out whereby actual generation of power at the steam plant can be commenced on short notice. This will necessitate keeping steam on the boilers and the attendance of an operator capable of putting the plant into immediate operation.

CHAPTER III

WATER SUPPLY

WATERSHED

The watershed of the Eklutna River, which produces the water supply for the present project, occupies the northwesterly slope of the westerly extremity of the Chugach Mountains, which separate the Matanuska Valley region from Prince William Sound on the main sea coast. This mountain area has not been completely mapped but the summits reach to an elevation well over 5000 feet. Several large glaciers are found near the summit, including the great Knik glacier at the head of the Knik River, which enters Knik Arm a short distance above the Eklutna River.

The Eklutna watershed has a transverse width of about 5 miles at the point where it emerges from the canyon on to the wide flat bordering Knik Arm. Its length up the mountain slope, and its width at the upper extremity can only be roughly approximated from existing maps, but it is apparent that the total area probably exceeds 100 square miles. The head waters are fed by a glacier, which may possibly connect with the Knik glacier on the adjoining watershed.

About midway of its course the Eklutna River passes through Eklutna Lake, located at an elevation of about 872 feet above sea level. (See Figure 3). The lake is about 8 miles long and has an area of about 5.2 square miles. It is clearly of glacial origin, as evidenced by the gravel moraine occupying the river bed below the present outlet.

A short distance above the mouth of the canyon, a small branch stream enters the river from the south. It apparently has a length of some 10 miles and drains an area of perhaps 20 square miles. Its watershed lies at comparatively low elevation and occasional inspections indicate that it produces very little runoff. For this reason its effect on the runoff of the stream, as measured at the mouth of the canyon, has been neglected.

PRECIPITATION

The United States Weather Bureau maintains a number of observation stations in the vicinity, including Anchorage and Matanuska in the valley region, and Seward and other ports on the main sea coast, and records of precipitation have been published for several years. The Anchorage station is located at an elevation of 149 feet above sea level and the Matanuska station at elevation 150. There are no records of precipitation on the higher levels of the surrounding mountains.

MEAN MONTHLY PRECIPITATION

The following tabulation shows the mean monthly precipitation at Anchorage, Matanuska, and Seward, as summarized from records of the United States Weather Bureau for the years indicated.

TABLE NO. 3

MEAN MONTHLY PRECIPITATION
In Inches

MONTH	ANCHORAGE 1917-1927	MATANUSKA 1917-1927	SEWARD 1911-1925
January	1.06	0.81	3.43
February	0.67	0.54	4.59
March	0.44	0.52	3.12
April	0.38	0.54	4.17
May	0.35	0.48	2.56
June	0.58	1.03	2.39
July	1.70	1.84	2.84
August	2.61	2.60	6.20
September	2.74	2.58	10.05
October	2.00	1.69	11.60
November	0.83	0.54	6.63
December	0.97	1.04	6.86
Annual Mean	14.33	14.21	64.44

The mean monthly precipitation at Matanuska is also indicated graphically on Plate 5, which appears with the discussion of runoff which follows.

PRECIPITATION AT HIGHER ALTITUDES

The above tabulation clearly indicates the wide difference between precipitation on the main coast at Seward and in the interior valley. It is evident that storms passing northward from the coast drop most of their moisture on the top and slopes of the Chugach Mountains before reaching the valleys beyond. In the absence of records, it is impossible to make any approximation of the probable precipitation on the mountains, but it would probably equal or exceed the amount recorded for Seward.

RUNOFF

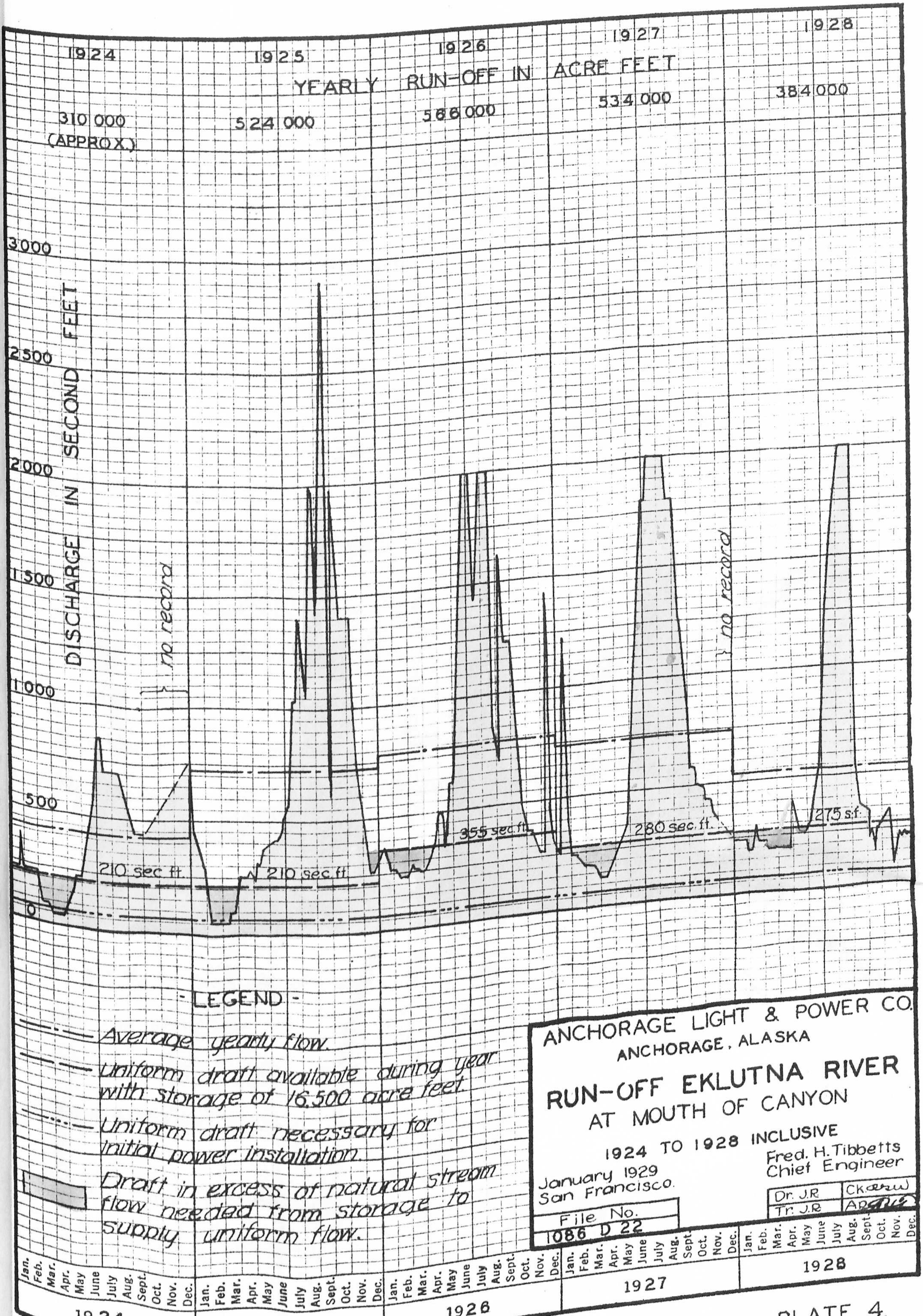
RECORDS

The Anchorage Light & Power Company commenced a series of observations on the flow of the Eklutna River in October 1923. A gage was established at the mouth of the canyon about half a mile above the railroad crossing and close to the point where the newly constructed transmission line crosses the stream. The early records were taken weekly and showed the width of the stream and the depth of the water as indicated by the gage reading. The record has been continuous up to the present time with the exception of the last three months of 1924 and the month of December 1927. The absence of any record for the latter part of 1924 is unfortunate since that year was apparently one of sub-normal runoff.

In the fall of 1928, when active preliminary construction work commenced, a gaging station was installed by the Anchorage Light & Power Company at the mouth of the canyon, in accordance with standards of the United States Geological Survey. A water stage register was installed at that time to give thereafter a continuous record of the water level. A number of current meter measurements of the flow have been taken from time to time, thereby permitting the construction of a rating curve, establishing the relation between gage height and discharge. Further measurements will add to the accuracy of this curve.

Upon completion of the proposed diversion dam on the Eklutna River, which will be located about 3.5 miles above the mouth of the canyon, the gaging station will be moved to the dam, which will provide a more stable control section than exists at the present station. The new location will have the further advantage that small amounts of runoff entering the river through branch streams, including the branch which enters just above the canyon mouth, will be eliminated, and future records will indicate, without question, only the runoff applicable to the present project.

The present gaging station has been referenced to the original staff gage on which all past observations have been taken and it is therefore, possible to compute a continuous record of flow by aid of the rating curve, since the commencement of the observations. The record thus obtained has been plotted as shown on Plate 4, which indicates the flow of the river in second feet from January, 1923, to December, 1928, inclusive, a period of 5 years. The two short gaps in the record have been filled in by approximation. The computed total annual flow for each of the years of record is indicated on the plate and also shown in the following tabulation:



1924
1925
1926
1927
1928
YEARLY RUN-OFF IN ACRE FEET
310 000 (APPROX.)
524 000
566 000
534 000
384 000
DISCHARGE IN SECOND FEET
3000
2500
2000
1500
1000
500
0
no record
no record
210 sec. ft.
210 sec. ft.
355 sec. ft.
280 sec. ft.
275 s.f.
- LEGEND -
Average yearly flow.
Uniform draft available during year with storage of 16,500 acre feet
Uniform draft necessary for initial power installation.
Draft in excess of natural stream flow needed from storage to supply uniform flow.
ANCHORAGE LIGHT & POWER CO.
ANCHORAGE, ALASKA
RUN-OFF EKLUTNA RIVER
AT MOUTH OF CANYON
1924 TO 1928 INCLUSIVE
January 1929
San Francisco.
Fred. H. Tibbetts
Chief Engineer
Dr. J.R.
Tr. J.R.
File No.
1086 D 22
Jan. Feb. Mar. Apr. May June July Aug. Sept. Oct. Nov. Dec.
1924
1925
1926
1927
1928

PLATE 4.

TABLE NO. 4

ANNUAL FLOW OF EKLUTNA RIVER
In Acre Feet

Year	Annual Runoff	Percentage of Mean
1924	310,000 (Approx.)	67
1925	524,000	113
1926	566,000	122
1927	534,000	115
1928	384,000	83
MEAN ANNUAL	464,000 Ac.Ft.	

The runoff records presented above are based on measurements taken at the mouth of the canyon as already described. It has not been possible to make an accurate estimate of the proportionate parts of the total which probably pass the proposed diversion dam site or the Eklutna Lake outlet, located respectively 3.5 and 10.5 miles upstream. Inspection of the small, lower tributaries, however, indicates that they produced very little runoff and measurements at Eklutna Lake indicate roughly about the same discharge as is measured at the outlet of the canyon. In view of the uncertain extent of the upper portions of the watershed and the known light precipitation at low elevations, it is assumed in the present study that the runoff shown by the records can safely be considered as available for diversion at the proposed diversion dam site.

AVERAGE AND MINIMUM FLOW

As shown on Plate 4, the annual discharge of the Eklutna River has varied, during the short period of record, from 67% to 122% of the mean, the low flow being that of 1924, which is somewhat uncertain. The minimum flow recorded in this period was 50 second feet and the average for the whole period, 640 second feet. The maximum discharge recorded was 2930 second feet in September 1925.

The mean annual discharge of 464,000 acre feet, if applied to the estimated water shed area of 100 square miles, represents a runoff of 4,640 acre feet per square mile, or an annual depth of runoff of 87 inches. This, of course, is far in excess of the annual rainfall in the interior valley and somewhat greater than the rainfall at Seward, but no comparison is possible with the actual rainfall on the upper portion of the watershed, no records being available. Whether the apparently high rate of runoff indicates extremely heavy precipitation in the mountains or a much greater extent of watershed than assumed, is left an open question until further data are available.

DISTRIBUTION OF RUNOFF

As indicated by Plate 4, there is a wide variation of stream flow during the year, the maximum occurring in July and August, and the minimum in the early spring. Plate 5 shows a curve representing the distribution of the mean annual runoff during the months of the year, the vertical ordinate of the diagram indicating for each month the percentage of the annual flow. It will be noted that 37% of the annual flow occurs during July and August and that 61% occurs during the 4 months from June to September.

To show the relation of the runoff to other factors, Plate 5 shows

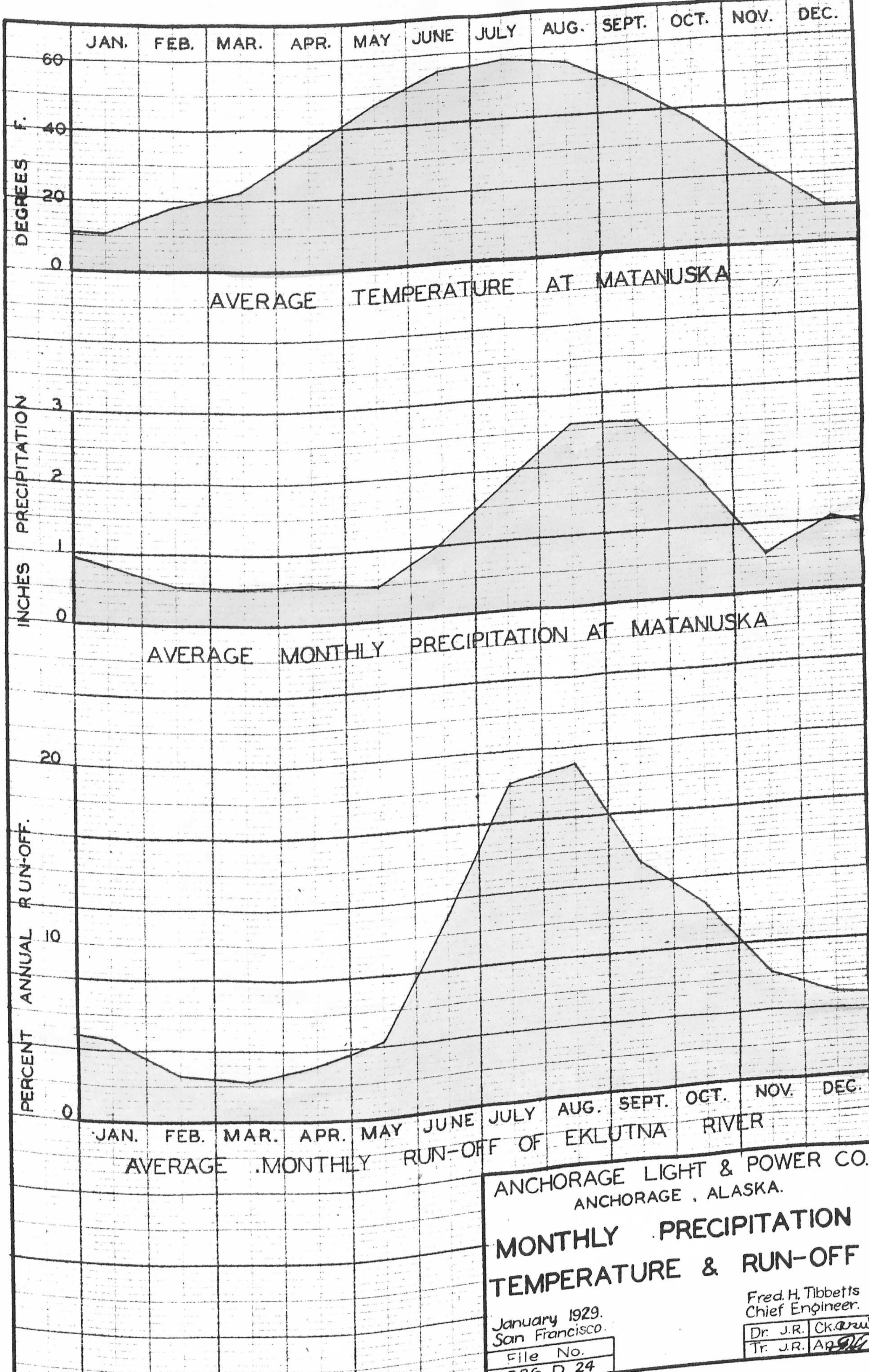

JAN.
FEB.
MAR.
APR.
MAY
JUNE
JULY
AUG.
SEPT.
OCT.
NOV.
DEC.
DEGREES F.
60
40
20
0
AVERAGE TEMPERATURE AT MATANUSKA
INCHES PRECIPITATION
3
2
1
0
AVERAGE MONTHLY PRECIPITATION AT MATANUSKA
PERCENT ANNUAL RUN-OFF.
20
10
0
AVERAGE MONTHLY RUN-OFF OF EKLUTNA RIVER
ANCHORAGE LIGHT & POWER CO.
ANCHORAGE, ALASKA.
MONTHLY PRECIPITATION
TEMPERATURE & RUN-OFF
Fred. H. Tibbetts
Chief Engineer.
January 1929.
San Francisco.
File No.
1086 D 24
Dr. J.R.
Ck.
Tr. J.R.
Ap.

PLATE 5.

also the monthly distribution of the annual precipitation at Matanuska and the mean monthly temperatures at the same point. A comparison of these curves indicates that the rainfall and runoff occur during the same part of the year, but that the runoff slightly precedes the rainfall. This would seem to show that the major portion of the runoff is not the direct result of precipitation, but is rather due to the melting of snow and ice at the head-waters of the stream. This theory is further corroborated by the relation between the runoff and temperature curves.

EFFECT OF EKLUTNA LAKE

The runoff of the Eklutna River is somewhat affected by the presence of Eklutna Lake, about 10.5 miles above the gaging station. The lake has a narrow outlet, with a rather well established crest elevation, which tends to restrict the natural flow during periods of high runoff, thereby reducing the peak flows. During the winter months, it is probable that the lake also has some affect in maintaining the low flow, by permitting the seepage of impounded water through the gravels which, in part, form the natural dam at its outlet.

EFFECT OF ARTIFICIAL STORAGE

PROPOSED STORAGE AND REGULATION

The Anchorage Light & Power Company proposes to construct a dam at the outlet of Eklutna Lake, which will raise the water level 5 feet above the normal low water level. This will create artificial storage subject to control amounting to about 16,500 acre feet. Regulation will be afforded by a head gate structure incorporated in the proposed spillway. This will permit the release of stored water as required during the period of low stream flow in order to maintain a desired minimum flow for power purposes farther down the stream.

REGULATED FLOW

Based on the records of runoff previously described, an estimate has been made of the minimum regulated flow which would have been obtained each year had the proposed storage at Eklutna Lake been available. Releases would have been made during 2 to 5 months each year, depending on the season. The following table shows for each of the years of record the actual unregulated minimum flow and, in the last column, the regulated minimum flow which would have resulted from the use of the proposed storage at Eklutna Lake.

TABLE NO. 5

NORMAL AND REGULATED MINIMUM STREAM FLOW-EKLUTNA RIVER
In Second Feet

Year	Normal Minimum Flow	Regulated Minimum Flow
1924	50	210
1925	50	210
1926	230	355
1927	145	280
1928	95	275
ANNUAL MEAN	114	266

As shown above, the proposed storage at Eklutna Lake would have produced a regulated flow of at least 210 second feet during the years of low runoff. This is approximately the uniform flow required for an installation of 3000 k.w. at the proposed power plant of the Anchorage Light & Power Co.

COST OF REGULATION

The proposed dam at the outlet of Eklutna Lake is estimated to cost about $33,000, giving a unit cost of only $2.00 per acre foot of storage, a remarkably low price compared with usual storage projects. On this basis, the cost of producing one second foot of regulated stream flow can be estimated. An increase of one second foot throughout the year will, in an average year, require reservoir releases of that amount for about 5 months, depleting storage by 306 acre feet. At the price indicated above, this would require an investment of $612 per second foot of regulated flow. Assuming that annual costs, including fixed charges and operation, would amount to 10%, the annual cost of one second foot of regulated flow is found to be $61.20.

ADDITIONAL FUTURE STORAGE

The proposed dam could readily be raised an additional 10 feet in height at a cost for additional storage which probably would not exceed the unit price indicated for the present reservoir. At least 35,000 acre feet of additional storage would be obtained in this manner. In 1924, the year of lowest recorded flow, the presence of this additional amount of storage would have made it possible to increase the minimum stream flow to about 350 second feet.

MAXIMUM RATE OF RUN-OFF

As previously mentioned, the maximum rate of run-off shown by records so far obtained for the Eklutna River, was 2930 second feet. The record period of only 5 years is too short, however, to permit of drawing conclusions as to the probable maximum which might occur over a long period of years.

No continuous records of stream measurements are available for similar streams in the vicinity of the Eklutna River. On the assumption that the run-off might bear some relation to average summer temperatures, a comparison of run-off and temperature has been made for the short period of the run-off records. While not very conclusive, the comparison seems to indicate that high annual run-off coincides in general with high summer temperatures. The mean July temperature at Anchorage during the past 12 years has varied from about 54.5° to 59.5°. The mean July temperature in 1926 was 59.0 or within 0.5° of the maximum, and this was also the year of maximum run-off. This would indicate the probability that over a period of 10 or 15 years the maximum so far observed might be exceeded only slightly. It is considered safe to assume that the probable maximum under ordinary conditions would be about 4,000 second feet.

It is certain, however, that over a long period of years a much higher maximum might occasionally occur as a result of unusually hot weather, local rainfall in conjunction with rapidly melting snow, or a possible breaking of the glacier at the head of the stream, which might release considerable volumes of impounded water. To provide for these contingencies, it is considered desirable to double the indicated ordinary maximum, thereby providing for a possible maximum of 8,000 second feet in the design of dams and spillways.

CONCLUSIONS

The following conclusions may be drawn from the records and estimates presented above.

1. That, with the proposed immediate storage, the dependable minimum flow will be about 210 second feet.

2. That, by raising the proposed storage dam an additional 10 ft., the dependable minimum flow could be increased to 350 second feet.

3. That the cost of storage and regulation is so low that, so far as other portions of the project are concerned, the water supply, within reasonable limits, can be considered unlimited, additional supply costing only about $61.20 per year per second foot.

4. In the present development, 1 second foot produces about 15.3 K.W. at a price then of $4.00 per K.W. of water supply. The present or initial development, however, utilizes only about 27% of the total available fall between Eklutna Lake and tidewater.

5. In an average year the maximum rate of run-off in Eklutna river below, the lake will probably not exceed 4000 second feet. The maximum occurring at long intervals may be as high as 8000 second feet. Important storage or diversion structures on Eklutna River should be so designed that they will not be permanently injured by such a maximum rate of discharge.

CHAPTER IV

DESIGN OF MAIN ELEMENTS OF HYDRO-ELECTRIC PROJECT

CAPACITY OF INSTALLATION

IMMEDIATE AND ULTIMATE REQUIREMENTS

Selection of the desirable capacity for a power installation depends primarily on the anticipated maximum demand or peak load. The maximum load shown by available records of operation of the present power system in Anchorage is about 575 K.W. With the probability of a rapid increase of service, resulting from lower rates, a conservative policy requires immediate provision for at least 1000 K.W. With the further probability that the load will rapidly increase as the power market is extended to outlying areas during the first five years of operation, it is believed that the major portions of the project should provide for the installation of about 2000 K. W. In the case of the tunnel and diversion dam, which cannot readily be enlarged, it is desirable to plan for still further future growth, and provide still greater initial capacity. A capacity of 4000 K. W. has been selected as the probable ultimate development of the present project and the tunnel and diversion dam have been designed accordingly.

NUMBER AND SIZE OF UNITS

In any generating plant, and particularly on a system with widely varying load, it is desirable to have more than one unit, in order to permit of operation close to conditions of greatest efficiency, and also to permit of adjustments and repairs without complete interruption of service. It is also desirable to have units of identical design so that parts will be interchangeable. In the present case it is planned to employ identical units of 1000 K. W. capacity each. Units of this size will conform nicely to a program of progressive enlargement and two or more units will give the desired flexibility of operation. Four units will ultimately be required.

CAPACITY OF PROPOSED IMMEDIATE CONSTRUCTION

The various parts of the system have been designed to permit of enlargement in progressive increments corresponding to 1000 K.W. each, as mentioned in Chapter I. The initial capacity of each of the main elements of the project as planned for immediate construction is shown in the following table.

TABLE NO. 6

CAPACITY PROVIDED BY IMMEDIATE CONSTRUCTION

Item	Capacity In Equivalent K.W.
	3000
Storage Reservoir	4000
Diversion Dam	4000
Tunnel	2000
Penstock	2000
Power House	1000
Generating Equipment	2000
Sub-stations (excluding transformers)	1000
Transformers	2000
Anchorage Transmission Line	

The principles and methods used in the design of the main elements of the system are discussed in the following paragraphs of this chapter.

STORAGE DAM

The storage dam at the outlet of Eklutna Lake will consist of a simple earth structure across the present opening and a spillway channel around one abutment, with fixed entrance weir and a narrow regulating gate structure. The design of the dam follows standard practice in providing stable side slopes and a tight up-stream face with cut-off at the toe.

The spillway weir and channel was designed to pass a flow of 4000 second feet with the regulating gate closed and with the water surface 2 feet below the crest of the dam. With all flash-boards removed from the regulating gate, the flow, with the same depth of water, would be increased to about 5800 second feet. A possible maximum flood of 8000 second feet would raise the level of the water passing over the spillway weir and would encroach on the nominal free-board of the dam, but no permanent injury would be done the structures if reasonable precautions were taken to assure its maintenance.

As mentioned in Chapter III, the proposed dam will provide 16,500 acre feet of storage above the present low-water level of the lake, which will produce a regulated water supply for a power installation of about 3000 K.W. The regulating gates will have a minimum capacity of 200 second feet, sufficient for a 3000 K.W. installation.

Timber was selected for the lining of the spillway channel partly because of the necessity of rapid construction during the winter and partly to permit of re-location or enlargement at moderate cost when future enlargement of the reservoir becomes necessary. With careful maintenance, it should have a life of ten years, within which time raising of the dam and spillway crest are likely to be desirable.

DIVERSION DAM

LOCATION

The diversion dam on the Eklutna River will be constructed in a deep rocky gorge favorably situated with respect to the proposed diversion. The general location was selected after a careful inspection of the river channel in the general vicinity of the proposed tunnel, the exact position finally being fixed on a map prepared from an accurate field survey of the selected vicinity.

TYPE OF DAM

The solid rock forming the canyon at the dam site is of a hard, tight nature which clearly indicated that a concrete dam would be the most suitable type of structure. The inaccessibility of the site, however, made it necessary to keep the volume of material, particularly the cement, to a minimum. Comparisons were made of costs of various types of concrete dam, including gravity, constant radius arch, and variable radius arch, which demonstrated conclusively the desirability of the last type. The details of the structure are outlined in the next chapter and are shown on Plate 7. The following paragraphs outline the methods followed in the design. Elevations mentioned are referred to the Alaska Railroad datum, which has been adopted throughout the project.

ARCH DESIGN

The arch was designed at 10 foot vertical intervals for full water load, each section being considered as a true arch ring fixed at the ends.

All stresses were computed by the revised formulae (including shear) of Professor William Cain, as presented in the Trans. Am. Soc. C. E., Vol. LXXXV, 1922, on Pages 233 and 264. The stresses for the arch rings at elevations 250 and 240 were computed for the primary arches as shown on the design, while below elevation 240 stresses were computed for secondary arches lying entirely within the primary arches. The final computations show a maximum compressive stress of 401.8 pounds per square inch, this being at the abutment at elevation 210. Stresses are compressive at both extrados and intrados for both crown and abutment at all elevations with the exception of a very negligible amount of tension at the abutment for elevation 240. The non-overflow section above the elevation of the overflow crest is designed as a cantilever transmitting the water load to the arch rings just below the crest where the arch stresses are low and the additional load can readily be carried.

Since this dam is a diversion dam only, there will be practically no variation in the operating level and only slight temperature variations are anticipated. It is proposed to grout all contraction joints under pressure at a time when the temperature is low, and thus eliminate all possibility of stresses due to temperature decreases and shrinkage. Any stresses due to a rise in temperature would be in the opposite direction from the arch stresses, due to water load, but would be of insufficient magnitude to reverse the water load stresses, and were therefore neglected in the design.

The arch stresses for full water load as computed by the above method are as follows:

TABLE NO. 7

STRESSES IN ARCH DAM

Pounds per Square Inch

Elev.	Upstream Radius	Thickness	Central Angle	Crown Stress Extrados	Crown Stress Intrados	Abutment Stress Extrados	Abutment Stress Intrados
250	68.8	5.2	92°	+77.4	± 31.4	+10.7	+99.9
240	64.8	5.9	87°	+135.9	+ 37.7	- 6.4	+184.6
230	53.2	4.4	90°	+217.9	+ 75.9	+12.2	+287.6
220	40.5	3.4	93°	+283.1	+105.3	+26.0	+370.0
210	31.05	3.1	97°	+302.1	+101.3	+12.0	+401.8
200	21.85	2.7	107°	+292.6	+ 97.4	+14.6	+387.8

ICE PRESSURE

The possible effect of ice pressure on a dam depends on the depth and solidity of freezing and on the degree of lateral constraint of the frozen sheet and is always difficult to estimate. In the present instance, the effect is minimized by three features of the location and design as follows: (1) The canyon upstream from the dam is long and comparatively straight, thus presenting no obstacle to free expansion of the ice in that direction. (2) The walls of the canyon have an appreciable though moderate slope, which will permit the ice to slide upward, thus relieving the lateral pressure. (3) The crest of the dam has been sloped back in the downstream direction to deflect the ice sheet upward and over the top. To take care of any residual thrust that might become effective at the top of the dam, the crest will have a safe resistance by arch action equivalent to an ice pressure of 9000 lbs. per lineal foot.

SPILLWAY PROVISION

Provision is made in the design for a maximum spillway capacity of 8000 second feet with the water level one foot below the concrete abutments at the two ends. Still greater discharge could be passed in an occasional emergency by a still further increase of depth over the dam and the abutments. The capacity selected for the spillway is over 170% in excess of maximum recorded discharge of the river. The future discharge of the river will, of course, be considerably reduced by the proposed storage reservoir. Based on an approximate watershed area of 100 square miles, the spillway capacity will be equivalent to about 80 second feet per square mile.

FOREBAY REGULATION

When the ultimate installation of 4000 K.W. is reached, conservation of the water supply will require regulation of the flow at the tunnel intake to conform to the fluctuating daily load. The maximum water supply for 4000 K.W. will be about 300 second feet. If the system then operates under the same daily load factor as at present, namely 60%, the average water demand will be 180 second feet or 360 acre feet per day. Present typical daily power consumption curves, as shown on Plate 3, indicate that the consumption above the daily average amounts to about 13% of the daily total. Therefore, when forebay regulation becomes necessary, there will have to be storage capacity at the diversion dam of about 13% of 360 acre feet or 47 acre feet. The pondage above the diversion dam will have an area of about 10 acres and consequently the depth required for forebay regulation will be about 5 feet.

This is one of the elements which determine the elevation of the tunnel entrance with respect to the crest of the dam. A second element affecting diversion into the tunnel is the possible presence of ice on the surface of the forebay. With continuous flow in the stream and a fluctuating water level, it is not certain that ice would form to any great depth but, to be conservative, a thickness of 4 feet has been assumed and forebay regulation of the required depth has been provided below the ice. This has resulted in placing the top of the tunnel section at an elevation 9 feet below the crest of the dam, fixing the floor of the tunnel at 17.0 feet below the crest of the dam, or at elevation 236.0 Alaska Railroad datum.

ECONOMIC HEIGHT

The costs of the diversion dam, tunnel and penstocks are so closely related that determination of the height to which the dam should be built must depend on a careful economic study of the combination of all three elements. An increase in the height of the dam shortens the tunnel, lengthens the penstocks and reduces the quantity of water required for a given amount of power, while a decrease in height lengthens the tunnel, shortens the penstocks, and increases the quantity of water. Only by estimating the total cost of various combinations can the most economical design be obtained.

The topography at the dam site indicated a probable desirable maximum height of about 68 feet and preliminary estimates on that basis were made of the total cost of dam, tunnel and penstocks. For comparison, similar estimates were made for dam heights of 58 feet and 50 feet. For the lower elevations, the construction cost was increased by an amount equivalent to the value of the additional water required to produce the same amount of power as the first combination, the value of the water being computed as already described in Chapter III.

A study of the totals thus obtained indicated a substantial reduction in total cost by reducing the height of the dam from 68 feet to 58 feet but only a slight reduction by further lowering to a height of 50 feet. As a result of this study the 58 foot height was finally selected, putting the elevation of the spillway crest at elevation 255.0.

TUNNEL

DIMENSIONS

The diversion tunnel passing through the ridge on the north side of the river will penetrate a ground formation that probably will require only a small amount of lining. Since the flow of water for the ultimate installation will not exceed about 300 second feet, it is found that the smallest tunnel which can economically be driven will have sufficient capacity with permissible loss of head. The adopted section was designed to conform to the dimensions of the equipment proposed for use in driving and is expected to give the minimum cost per foot as compared with sizes either larger or smaller. The maximum velocity of flow will be about 6.0 feet per second.

COMPUTATION OF FLOW

In estimating the head loss through the tunnel, the neat section was used and a friction co-efficient of .035 applied. A greater degree of roughness, possibly resulting from irregular breaking of the rock, will be compensated for by the increase of the cross-sectional area over the prescribed neat section. Computation of head losses should therefore prove conservative.

TUNNEL LINING

Lining where found necessary will be placed inside the lines of the net rock section, thereby reducing the area. The increased smoothness of the surface, however, will compensate for reduction of area, thereby keeping the friction loss per foot at about the same value as for unlined sections.

PENSTOCKS

NUMBER AND CAPACITY

Penstock capacity is to be provided immediately for two generating units, requiring a flow of about 145 second feet. A single pipe for the whole flow is found to be more economical than two pipes of half the total capacity. The single line will fork close to the power house, a branch leading to each unit. When more than two units are required, a second penstock similar to the first can be laid alongside.

MATERIAL

Penstocks are usually constructed of steel or wood, although reinforced concrete and cast iron are occasionally employed. For low head developments not exceeding 150 feet the woodstave pipe is usually the most economical. For higher heads, the use of steel pipe has become standard practice. At the lower heads, the use of steel is not ordinarily economical due to the necessity of providing a certain minimum thickness of metal, regardless of the stress imposed by the water pressure. Under the rigorous climatic conditions of Alaska and the distance from points of manufacture of pipe, it has been concluded that the penstocks for the present project should be of steel throughout. In accordance with standard practice, the minimum thickness of plates has been set at 1/4 inch.

ECONOMIC DIAMETER

The determination of the diameter of a steel penstock ordinarily requires an economic study involving the quantity of water, the head, the allowable stress in the metal, the cost of the pipe in place per pound, the rate for annual fixed charges, and the net value of power at the power house. Several formulas have been developed which permit of direct calculation of the most economic diameter when the various factors are known.

One of the more important of the elements entering into the solution is the value of the power gained or lost by variation of the penstock size. Ordinarily this value would be based on market price less cost of production. In the present case, however, with a very cheap water supply, practically unlimited in amount, this method does not apply. To make up for friction losses in smaller sized penstocks, it is only necessary to supply more water. The value of the power involved in varying the penstock diameter cannot, therefore, exceed the cost of furnishing the corresponding additional water supply. With 1 second foot of water costing only $61.20 per year, as described in Chapter III, and producing, through a drop of 230 feet, about 134,000 K.W.H., the cost of the water is found to be only about .046¢ per K.W.H. of power produced. This figure, equivalent to $3.00 per H.P. year, was used in computations of penstock diameter.

For use in the same computation and also to determine proper thickness of metal, working stress of 18,000 lbs. per square inch for the steel was adopted, this being about 60% of the elastic limit for high-grade open-hearth steel. This was believed to be a safe stress to apply in connection with the maximum possible pressure which might occasionally occur in the penstock. The assumed maximum pressure was based on the total possible static head at the power house plus an allowance for water-hammer effect, resulting from closure of the valves, amounting to 15%, which has been guaranteed as the maximum requirement by the manufacturer of the turbine selected for installation. To the minimum thickness of metal as determined under the above conditions, 1/16 inch additional thickness was added to allow for possible corrosion of the metal.

Using the figures mentioned above for value of power, working stress in metal, and total head, together with estimated values for other elements involved, a solution of the various existing formulas, gave a resulting economic diameter varying from 51 to 55 inches. As a result of this study, a penstock diameter of 54 inches was finally selected. This will give a velocity of about 9 feet per second, with the flow of 145 second feet which will be required to operate two units at the power house. This resulting velocity conforms satisfactorily with standard practice. For modern plants of low head not exceeding 250 feet, the usual penstock velocity varies from 6 to 18.5 feet.

POWER HOUSE

TAIL RACE

In designing the tail-race, into which the turbines will discharge, it was necessary to determine the most economic water surface elevation. The possible upper limit was fixed by the natural ground surface at about elevation 21.0. The minimum possible elevation was that which would assure sufficient slope to carry the discharge of the turbines to tide-water, a distance of about one mile, through a channel of reasonable size. It was found that the highest water level recorded on Knik Arm was 16.4, which occurred in 1921 when a flood in Knik river, caused by breaking of the Knik glacier, coincided with an extremely high tide. Adding one foot to this maximum height to provide necessary slope for the tail-race channel gave a minimum possible tail-race elevation of 16.4. The final selection between the upper and lower limits of 21.0 and 16.4 was based on a study of the cost of excavation and the value of power produced by increased head. The normal water level was finally fixed at elevation 18.0.

EFFECTIVE HEAD

The normal static head on the power plant will be the difference in elevation between the crest of the diversion dam (253.0) and the tail race water level (18.0) or 235 feet. The head lost through friction in the tunnel and penstocks will vary with the quantity of water flowing through these conduits. The net or effective head at the power house for the various stages of the proposed progressive installation, is shown in the following tabulation:

TABLE NO. 8

EFFECTIVE HEAD AT POWER PLANT

Installation	Flow Sec. Ft.	Effective Head Feet
Immediate installation, 1000 K.W.		
At full load	72.5	230.4
At 60% load	43.5	232.0
2000 K.W. Installation		
At full load	145	223.2
At 60% load	87	229.4
4000 K.W. Installation		
At full load	290	210.0
At 60% load	174	220.3

REQUIRED TURBINE OUTPUT

The above tabulation indicates the quantity of water required at full and 60% load for each of the three proposed stages of power installation. These quantities were based on an estimated over-all efficiency of turbine and generator amounting to 77%, including an estimated loss of 17% for the turbine and 6% for the generator. The power output required from the turbine on this basis to drive a 1000 K.W. generator will be approximately 1065 K.W. or 1430 H.P. To conform to manufacturers standards it was found desirable to select for the installation a turbine having a rated output of 1500 H. P.

TYPE OF UNIT

The available head of about 230 feet as shown in Table No. 8 requires the use of a water wheel of the reaction turbine type. Either vertical or horizontal arrangement would be suitable, the vertical type usually being preferable due to reduction of area of building and foundations. In the present case, however, the selection of the horizontal type is imperative in order to permit the installation of a fly wheel between the turbine and the generator. This is made necessary by the rapid fluctuation of power demand in the town of Anchorage during certain times of the day, as indicated on Plate 3 herewith. The presence of the fly wheel aids the governor mechanism in maintaining constant speed and voltage when rapid changes in the power load occur. The generator will be of standard construction to produce 3 phase, 60 cycle current at 2300 volts and will be direct connected to the turbine.

TRANSMISSION LINE

The Anchorage transmission line was designed to transmit 2000 K.W. a distance of 26 miles at 33,000 volts with a power loss not exceeding 10%. No. 4 hard-drawn copper wire with a breaking strength of 1964 pounds was selected for the conductors. The spacing of the poles was so fixed as to give a maximum sag of 7.5 feet and to limit the tension in each conductor to one-half the breaking strength, or 982 pounds. It was necessary to take into account the wide range of temperatures which occur in the vicinity of Anchorage, a minimum of 40° below zero and a maximum of 100° above zero being assumed. In computing the sag and tension, allowance was made for a half inch thickness of ice and a horizontal wind load of 6 pounds per foot. Under these conditions it was found that, for a span of 240 feet with limiting stress on the wires, the sag would be 7.24 feet at a temperature of 40° below zero. A computation for a temperature of 100° above zero indicated a sag of 7.0 feet, and a stress of 135 pounds. A normal spacing of 240 feet or 22 poles to a mile was therefore adopted.

With the 40 foot poles planned for standard construction of the line, the maximum sag permitted will give a clearance above the ground of about 23 feet, this occurring only during occasional periods of extreme temperature. Special insulation to take care of the moist atmospheric conditions in the vicinity of Anchorage was provided by using a special type of insulator rated at 40,000 volts. Metal cross arms were used to reduce the cost of pole erection and the transportation charges to the job.

Figure 5
Eklutna Lake storage dam under construction. Nov.21, 1928. Looking north from lower end of spillway channel toward

Figure 6
Penstock site, indicated by cleared strip on hillside. Crane and boiler house in foreground. Nov.20, 1928

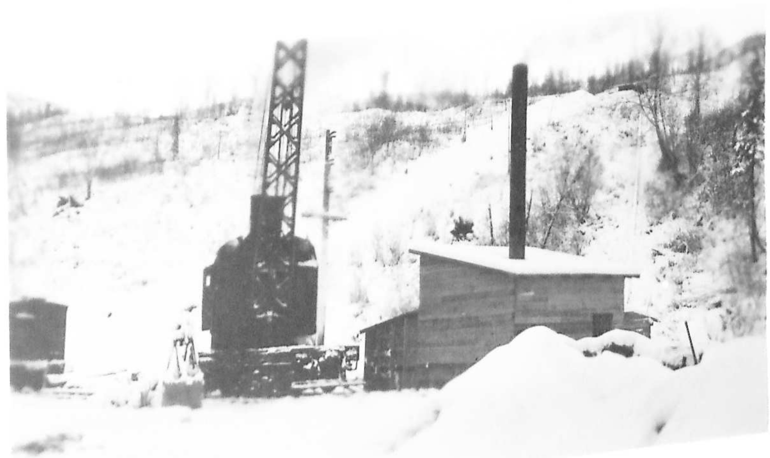


Figure 7
Power house site. Construction camp in foreground. Nov.20, 1928

Figure 8
Anchorage transmission line under construction. Oct.30, 1928

CHAPTER V

DESCRIPTION OF PROPOSED CONSTRUCTION WORK

GENERAL TYPE AND LOCATION

In accordance with the principles and methods outlined in the preceding chapter, all of the main portions of the project have been completely designed. A high type of permanent construction has been adopted throughout and effort has been made to provide equipment which will require a minimum of attention and repairs.

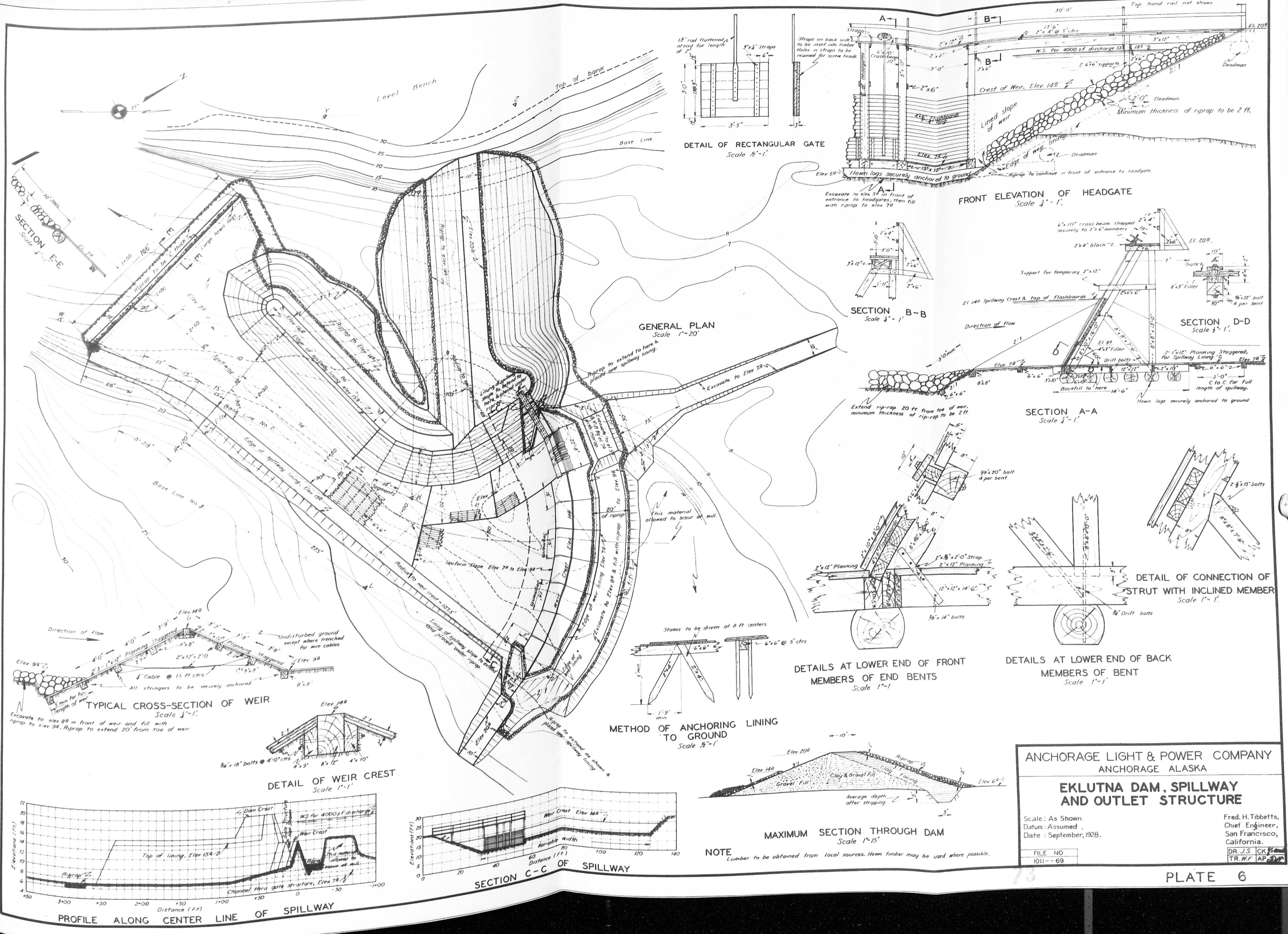
The locations of the various parts of the project are shown on the General Project Map (Plate 1), and also on the Transmission Line Location map (Plate 10). The following paragraphs in this chapter give details of the design of the various elements and outline methods of construction.

STORAGE RESERVOIR

(See Fig. 5 and Plate 6)

LOCATION

Storage will be provided by the construction of a dam at the present outlet of Eklutna Lake on the Eklutna River about 12 miles above its mouth and about 10.5 miles above the point where the river emerges from the canyon on to the plain bordering Knik Arm. The outlet of the lake is about 120 feet wide at the narrowest point, with banks sloping rather steeply upward. The formation consists of a comparatively tight clay and gravel


GENERAL PLAN
Scale 1"=20'
DETAIL OF RECTANGULAR GATE
Scale ½"=1'
FRONT ELEVATION OF HEADGATE
Scale ¼"=1'
SECTION B-B
Scale ¼"=1'
SECTION D-D
Scale ½"=1'
SECTION A-A
Scale ¼"=1'
SECTION E-E
Scale ¼"=1'
Extend rip-rap 20 ft from toe of weir, minimum thickness of rip-rap to be 2 ft.
Minimum thickness of riprap to be 2 ft.
Crest of Weir, Elev. 14.9
Hewn logs securely anchored to ground
Excavate to elev 5.9 in front of entrance to headgates, then fill with riprap to elev 7.9
DETAILS AT LOWER END OF FRONT MEMBERS OF END BENTS
Scale 1"=1'
DETAILS AT LOWER END OF BACK MEMBERS OF BENT
Scale 1"=1'
DETAIL OF CONNECTION OF STRUT WITH INCLINED MEMBER
Scale 1"=1'
METHOD OF ANCHORING LINING TO GROUND
Scale ½"=1'
Stakes to be driven at 8 ft centers
TYPICAL CROSS-SECTION OF WEIR
Scale ¼"=1'
Excavate to elev 8.9 in front of weir and fill with riprap to elev 9.9. Riprap to extend 20' from toe of weir.
Direction of flow
Undisturbed ground except where trenched for wire cables
All stringers to be securely anchored.
DETAIL OF WEIR CREST
Scale 1"=1'
MAXIMUM SECTION THROUGH DAM
Scale 1"=15'
Clay & Gravel Fill
Gravel Fill
Clay Facing
Riprap
PROFILE ALONG CENTER LINE OF SPILLWAY
SECTION C-C OF SPILLWAY
Weir Crest Elev 14.9
Variable width
Distance (Ft)
Elevations (Ft)
NOTE
Lumber to be obtained from local sources. Hewn timber may be used where possible.
ANCHORAGE LIGHT & POWER COMPANY
ANCHORAGE ALASKA
EKLUTNA DAM, SPILLWAY AND OUTLET STRUCTURE
Scale: As Shown.
Datum: Assumed.
Date: September, 1928.
Fred. H. Tibbetts, Chief Engineer, San Francisco, California.
FILE NO
1011--69
DR. J.S.
TR. W.F.
PLATE 6

with some indication of bed-rock near the lower end of the outlet channel.

DAM

The dam will consist of an earth fill, 15 feet in height above the lowest point of the stream bed. It will have a 10 foot crown and side slopes of 3 horizontal to 1 vertical on both sides. The upstream half of the fill will be constructed of a mixture of local clay and gravel in proportions to give maximum density. The downstream half will consist largely of gravel porous enough to drain readily. Water tightness will be provided by placing a thick layer of clay on the upstream face terminating, at the bottom, in a cut-off trench excavated about 5 feet below stream bed and back-filled also with clay. Erosion of the clay facing will be prevented by a layer of rip rap for the full height of the upstream face, constructed of boulders and large gravel, which are available in quantity close to the dam site. A training wall will be constructed of earth which will form one bank of the spillway and which will protect the downstream toe of the dam. The total volume of fill in the dam and training wall will be about 3,700 cubic yards.

SPILLWAY

The spillway will have a simple weir crest 145 feet long, set at an elevation 8 feet above stream bed, or 5 feet above normal lower water level. This crest will be formed by cutting into natural ground and will be lined with timber, with a level top and side slopes of 2 horizontal to 1 vertical. The timber facing will be placed directly on undisturbed earth extending well into the ground and will be protected with rip rap at the upstream toe. Water passing over the weir will pass into a channel excavated around the easterly end of the dam and discharging into the stream well below the down-stream toe. To protect the spillway channel from scour, it will be completely lined with hemlock sheathing thoroughly anchored to the foundation. The outlet will be flared laterally to reduce the velocity and will be protected by rip rap. The total spillway excavation will be about 4,100 cubic yards.

HEAD-GATE

Regulation of reservoir releases will be provided by a head-gate structure in the end of the spillway crest nearest the main dam. It will consist of a well-braced timber frame, carrying inclined supports for flash boards. The opening will have a total net width of 21 feet divided up into three 7 foot panels by intermediate frame bents. For close regulation of the flow, two slide gates will be provided in the central panel, each with a net width of 3.0 feet, and a clear height of 2 feet. The slide gates will be operated with hand wheels mounted on a runway passing across the top of the head-gate opening. The floor of the head-gate will be at approximately the level of the natural stream-bed, so as to permit of drawing the reservoir down to approximately the level of the bottom of the present outlet channel.

DIVERSION DAM

(See Plate 7)

LOCATION

The diversion dam will be located in the Eklutna River at a

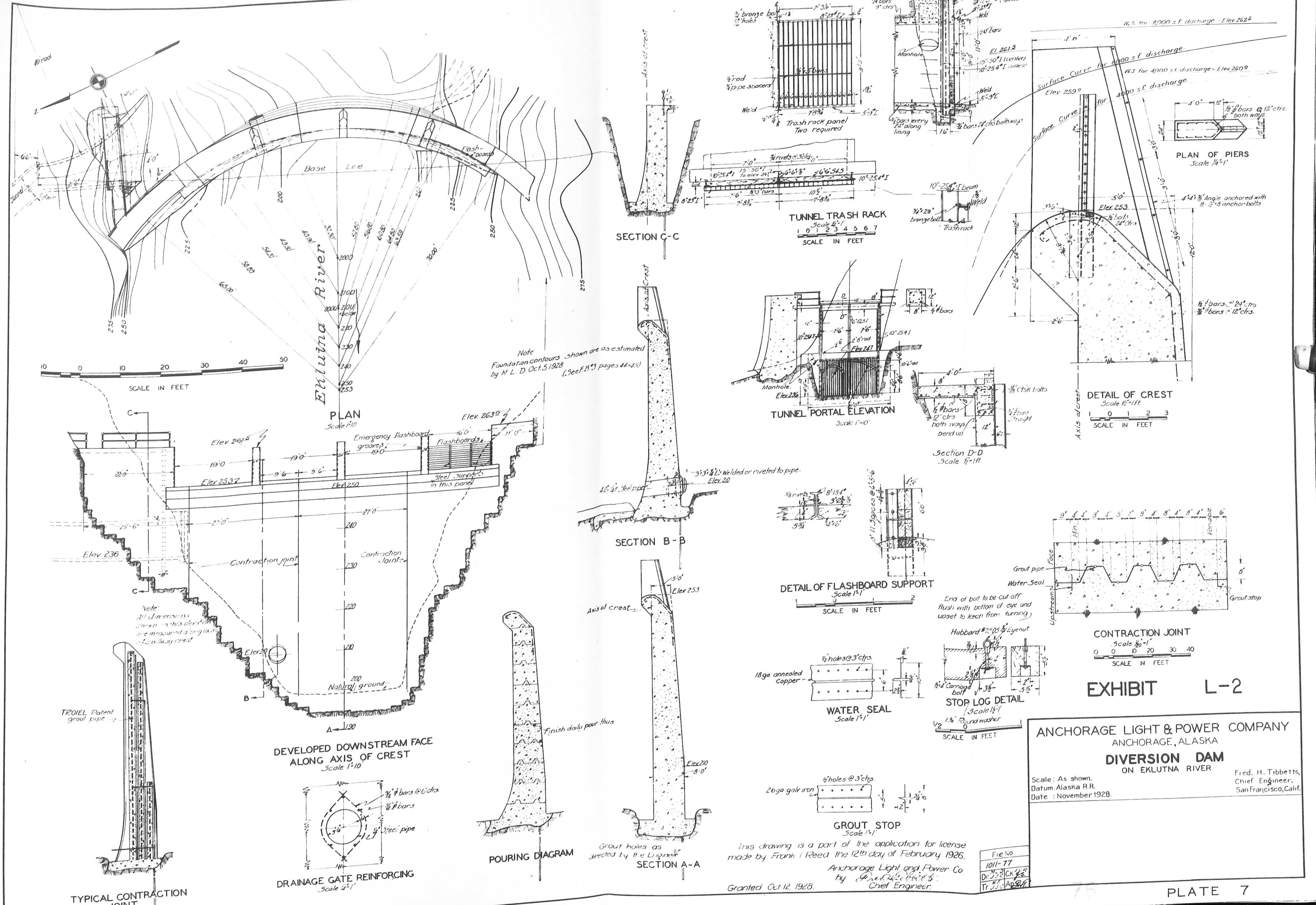


EXHIBIT L-2

ANCHORAGE LIGHT & POWER COMPANY
ANCHORAGE, ALASKA

DIVERSION DAM
ON EKLUTNA RIVER

Scale: As shown.
Datum: Alaska R.R.
Date: November 1928.

Fred. H. Tibbetts,
Chief Engineer,
San Francisco, Calif.

This drawing is a part of the application for license made by Frank I. Reed the 12th day of February 1926.

Anchorage Light and Power Co
by [signature]
Chief Engineer.

Granted Oct 12, 1928.

File No 1011-77

PLATE 7

point about 7 miles below the storage dam, where the river passes through a narrow gorge. At this location the river is separated from the southerly margin of Knik Arm by a narrow ridge, which will require only a short tunnel for diversion to the power house site.

DESCRIPTION

As previously described, the dam is designed as a variable radius concrete arch with overflow crest. The total length along the crest will be 112 feet, and the total height above bed rock, about 65 feet. The overflow will be confined to the central portion of the crest by a solid abutment at one end and by an abutment and a set of removable flashboards at the other end. The net length of the crest, with flashboards in place, will be 57 feet, and with flashboards removed, 73 feet. The crest will be placed at elevation 253.0, Alaska Railroad datum. The abutment walls extend up to elevation 260.0 at either end. The maximum thickness of the arch at the crown is 8 feet and the minimum thickness, 5 feet.

SPILLWAY PROVISION

With the flashboards removed, the spillway capacity will be 4000 second feet with the water level standing at elevation 259, or one foot below the concrete abutments. The overflow will be aerated by three reinforced concrete piers 19 feet apart along the crest. The crest has been designed with an overhang and sloping face on the upstream side, and the piers have been provided with steel reinforcement to insure the passage of ice and heavy drift over the top without damage.

OUTLET GATE

To make it possible to drain the water impounded above the dam down to a level below the proposed tunnel portal, a drainage gate 42 inches in diameter has been provided at elevation 210.0, or 43 feet below the crest. The gate will be operated by a shaft extending through the body of the dam diagonally upward to a convenient operating point near the north abutment. This will permit operation of the gate even though water should be spilling over the crest of the dam. The gate will have a capacity of 405 second feet with the water level at the crest of the dam and 314 second feet when the water level has been drawn down to the level of the tunnel floor.

DIVERSION TUNNEL

DESCRIPTION

The tunnel will extend from the north abutment of the diversion dam in a northerly direction through the ridge separating the river from Knik Arm. It will have a total length of about 1880 feet and a cross sectional area of 50.2 square feet unlined, and 37.5 square feet lined. It will be built on a descending grade of 8.5 feet per 1000 feet and will always be under slight pressure. The net unlined cross-section will have a 7 foot bottom, 4.5 foot side walls, and a semi-circular top with 3.5 foot radius. Where the rock formation is found to be soft or unstable, concrete lining will be placed, the lined cross-section having a 5.6 foot bottom, 4.5 foot side walls, and a semi-circular crown with 2.8 foot radius.

INLET PORTAL

The inlet portal will adjoin and be connected with the north abutment of the diversion dam. The opening will be flared to give a net area about double that of the normal tunnel cross section. For protection against drift, a permanent heavy steel grillage will be provided on reinforced concrete supports. A concrete walkway overhead will serve as a working platform for the removal of accummulated debris. A man-hole will be provided through walkway to give access to the tunnel. Supports for stop logs will be included in the structure to permit of emergency closure if required. Special provision will be made to prevent the accummulation of needle ice on the grillage bars.

TUNNEL OUTLET

At its lower end the tunnel will terminate in a concrete head wall where connection will be made with the penstocks. At the head wall the portal cut will have a depth of 24 feet.

PENSTOCKS

(See Fig. 6)

ARRANGEMENT

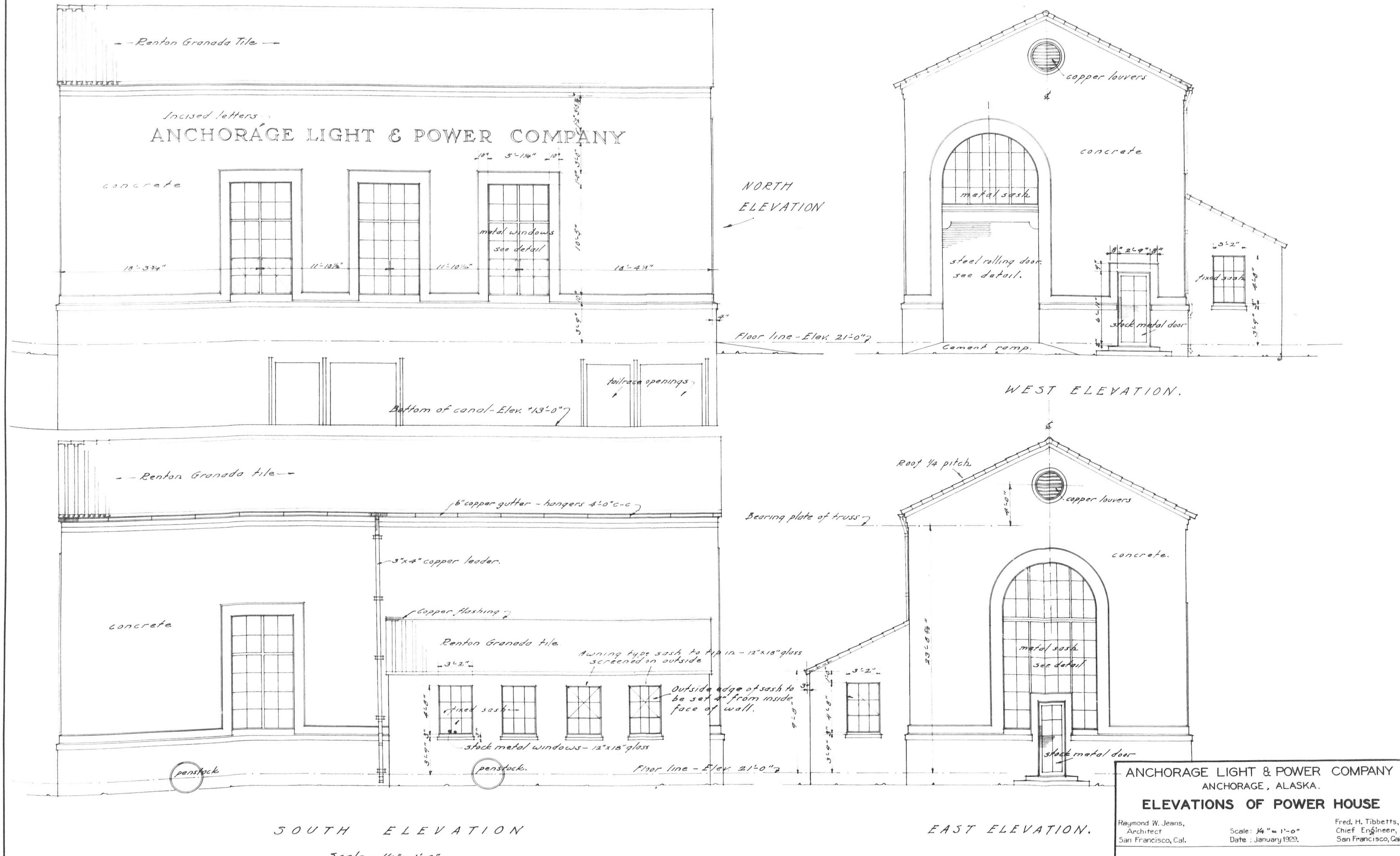
The ultimate development of the project will require two penstocks commencing at the tunnel portal and extending down the hill in a northerly direction to the power house location, a distance of about 860 feet. Provision will be made at the tunnel portal for the installation of both penstocks but only one will be installed during the initial construction period. The average slope along the penstock line will be about 23½%. To conform to the contour of the ground four small vertical angles of approximately 10°, 8½°, 5° and 5° respectively will be required on theslope and one larger angle at the foot of the slope where the profile of the line flattens out to enter the power house. At the latter angle point, a steel Wye will divide the pipe into two branches, both of which will taper down to fit the turbine intake. Since only one generating unit is to be installed at the present time, one branch of the penstock will be closed off at the Wye with a blind flange.

DESCRIPTION OF PIPE

The pipe line will be of riveted steel, with a 54 inch diameter down to the Wye, and tapering to 36 inches in diameter below the Wye. The metal will have a thickness of 1/4 inch from the upper end at elevation 220.0 down to elevation 93. From that point to the Wye the thickness will be 5/16 in. The Wye will have a thickness of 3/8 in., and the branches, 1/4 in. Longitudinal joints will be standard double lap riveted and circumferential joints single lap riveted. All pipe will be dipped in hot asphalt at the factory and then provided with a soil proof wrapping of felted fabric saturated with bituminous compounds and applied under tension. The penstock will be buried for its full length to a depth of about three feet below natural ground surface.

ACCESSORIES

At the upper end of the penstock, a 54 in. butterfly valve will be provided to permit unwatering of the penstock without draining the tunnel and also to provide control of the water back of the valve in case of a break in the penstock. Air relief and vacuum valves will be provided below the butterfly



ANCHORAGE LIGHT & POWER COMPANY

ANCHORAGE, ALASKA.

ELEVATIONS OF POWER HOUSE

Raymond W. Jeans, Architect, San Francisco, Cal.

Scale: 1/4" = 1'-0"
Date: January 1929.

Fred. H. Tibbetts, Chief Engineer, San Francisco, Cal.

FILE NO	
1011 - 84	
DR. R.W.J.	CK.
TR. R.W.J.	AP.

81

PLATE 8

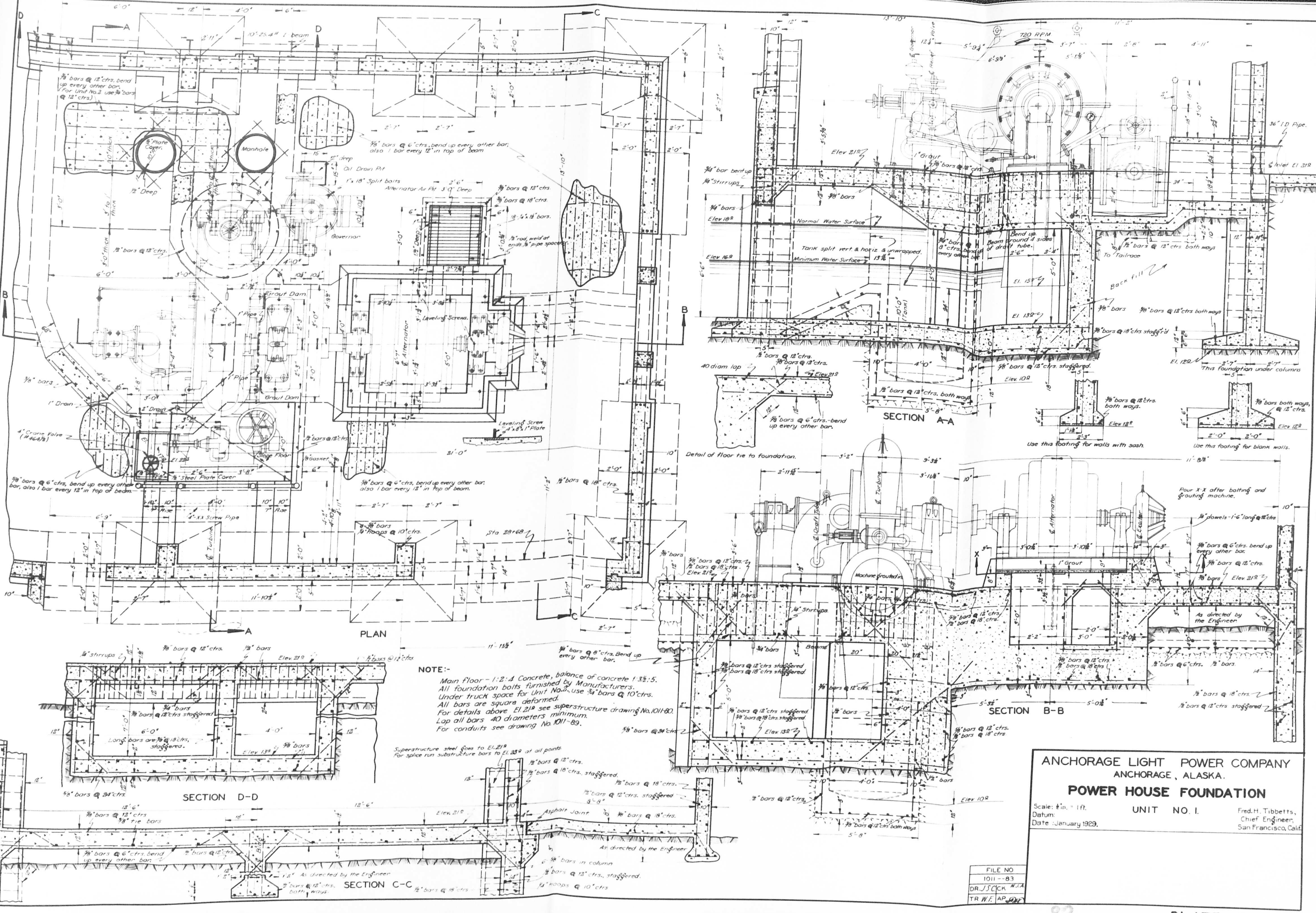

PLAN
SECTION A-A
SECTION B-B
SECTION C-C
SECTION D-D
NOTE:-
Main floor - 1:2:4 Concrete, balance of concrete 1:3½:5.
All foundation bolts furnished by Manufacturers.
Under truck space for Unit No.2, use ¾" bars @ 10" ctrs.
All bars are square deformed.
For details above El. 21.9 see superstructure drawing No. 1011-80.
Lap all bars 40 diameters minimum.
For conduits see drawing No. 1011-89.
Superstructure steel goes to El. 21.9
For splice run substructure bars to El. 23.9 at all points.
Detail of floor tie to foundation.
Use this footing for walls with sash.
Use this footing for blank walls.
ANCHORAGE LIGHT POWER COMPANY
ANCHORAGE, ALASKA.
POWER HOUSE FOUNDATION
UNIT NO. 1.
Scale: ⅛ in. = 1 ft.
Datum:
Date: January 1929.
Fred. H. Tibbetts,
Chief Engineer,
San Francisco, Calif.
FILE NO
1011--83

PLATE 9

valve to admit air when the penstock is being drained, so as to avoid possible collapse. At the angle points in the line, heavy concrete anchors will be constructed to resist the resultant force due to change of direction of the water. A flexible expansion joint will be provided in the 36 inch branch of the Wye to accommodate any possible settlement of the power house.

POWER PLANT BUILDING

(See Plates 8 & 9)

PLAN AND ARRANGEMENT

The power plant building will be constructed on the flat ground at the base of the hill with its long dimension running in an easterly and westerly direction parallel to the toe of the slope. (See Fig. 7). The main portion of the building, containing the generator units, will be 27 feet 4 in. wide by 61 feet 1 in. long outside. At the rear or southerly side, near the southeast corner, a lean-to structure 9 ft. 6 in. wide by 30 ft. long will provide space for the switching gear and tools and supplies. The transformers will be located also at the rear of the building but at the opposite end from the lean-to structure.

SUB-STRUCTURE

The building will be constructed entirely on the flat ground near the base of the hill. The rock underlying the slope of the hill dips rapidly at the foot of the slope and is over-laid with a deep deposit of alluvial material, consisting largely of gravel and clay. The foundation of the building will rest entirely in this material at a depth of about 8 feet below natural ground level. Footings will be provided under all portions of the structure of sufficient area to give a uniform bearing pressure of slightly less than 3/4 ton per square foot.

All portions of the foundation will be carried down to the same level. Under the turbines, dividing walls will be constructed to form individual conduits for conducting the water separately from the draft tubes and relief valves to the tail race channel at the north side of the building. The foundation will be of heavily reinforced concrete throughout.

SUPERSTRUCTURE

The house will be of simple but pleasing architectural design, with large windows and tile roof. (See Plate 8). The walls and columns will be of reinforced concrete. Steel trusses will support the roof. The main entrance, at the west end of the building near the northwest corner, will be of sufficient size to permit ready movement of large pieces of equipment in or out and will be closed by a steel rolling door. Smaller doors for ordinary use will be provided at each end of the building. Ventilators will be installed in the end walls near the gable to carry off warm air accumulations in the upper portion of the main generating room. The windows will be built of metal sash with movable panels. The structure will be fire proof throughout.

TAIL RACE

Water passing from the draft tubes or relief valves of the turbine will be discharged separately through short concrete conduits into an open concrete lined channel at the north side of the building. The lined portion of the channel will terminate beyond the building line in a weir designed to maintain the water level at the draft tubes at elevation 18.0, and will discharge into an excavated canal extending westerly and thence northerly to an outlet into Knik Arm. This channel will follow a fairly well defined natural water course for most of its length and will cross beneath the main line of the Alaska Railroad at existing bridge number 1429.

POWER PLANT EQUIPMENT

TURBINE

The main generating unit to be installed immediately will consist of a 1500 H.P. turbine, direct connected to a 1250 K.V.A. generator. The turbine, already under construction by the Pelton Water Wheel Company of San Francisco, will be of the reaction type, with horizontal shaft, single runner, and single discharge. It is designed to operate at a speed of 720 r.p.m. under an effective head varying from 220 to 232 feet. Maximum efficiency will be obtained at an effective head of 222 feet and is guaranteed to be not less than 85%. The turbine runner will be of bronze and the shaft of high grade forged steel. On the generator end, a fly wheel will be provided to supply the necessary inertia to produce, in combination with the inertia of the generator rotor, the required speed regulation under changes of load. The unit will have one main bearing and one outboard bearing, the latter provided with a double acting thrust bearing of the Kingsbury type, of ample capacity to carry the maximum possible unbalanced thrust in either direction which may be imposed by the water wheel.

For speed control there will be provided a standard Pelton oil pressure, hydraulic governor of ample capacity for the required duty. This governor will be of the self-contained type having enclosed centrifugal element, self-contained oil sump, pressure tank, belt driven gear oil pump, automatic unloading valve, emergency shut down device, mechanical self-locking hand control mechanism and all necessary adjustments for complete control of the turbine.

For the protection of the penstock and to aid in close speed regulation under all load conditions, a Pelton governor-operated relief valve will be provided. This relief valve has an adjustable dashpot mechanism by means of which it can be made to act either as a water economizing device, or as a synchronous bypass. It is planned to use the relief valve in the latter way for the initial installation, which will result in practically a uniform flow of water in the penstock. The relief valve will have sufficient capacity to discharge the full flow of water required by the turbine when operating at full load.

A main inlet butterfly valve having an annealed cast steel body and disc and adjustable bronze ring will be provided for manual control of the water entering the turbine.

GENERATOR

The generator, to be furnished by the General Electric Company, will be of standard modern construction, to generate 2300 volt, 3 phase, 60 cycle alternating current at a speed of 720 r.p.m. It will be provided with a direct connected exciter and necessary rheostat. It will be designed to withstand a maximum run-away speed of 1300 r.p.m. under no load conditions.

SWITCHBOARD

The switchboard will consist of three panels for mounting the circuit breakers for the generator and exciter, and the Anchorage and Eklutna transmission lines. Voltmeters, ammeters, watt-hour meters, synchroscope,etc. will be mounted on the face of the board and current and potential transformers, and other miscellaneous equipment will be placed at the rear. The switchboard will stand in an enclosure provided for it in the east end of the lean-to structure, where there will also be sufficient space for an office for the convenience of the power plant operator, as well as for the future installation of additional panels. Glass partitions will be installed on the side facing the generator room to give the operator a complete view of his machinery. The complete enclosure of the switchboard room will permit of economical heating during the winter.

SYNCHRONIZING EQUIPMENT

The unit will be provided with a governor-actuating motor and a synchroscope so that it can be properly synchronzied for connection to the transmission line at times when the latter is already energized from another source. While this equipment is not absolutely essential until the second unit of the power plant is installed, it will nevertheless be very valuable when it becomes necessary to make use of the Anchorage steam plant for emergency operation. In switching the load from the steam plant back to the hydro plant, interruption of service will be completely avoided by making use of the synchronizing equipment to bring the latter on to the line before taking the former off.

AUXILIARIES

The plant will have, mounted on crane rails at the top of the side walls, a traveling crane of sufficient capacity to lift and transport the heaviest pieces making up the generating units. Miscellaneous small equipment, including house transformers, compressor, oil tanks, etc., necessary for operation and lighting of the plant will be provided in the main room or store room.

POWER HOUSE SUB-STATION

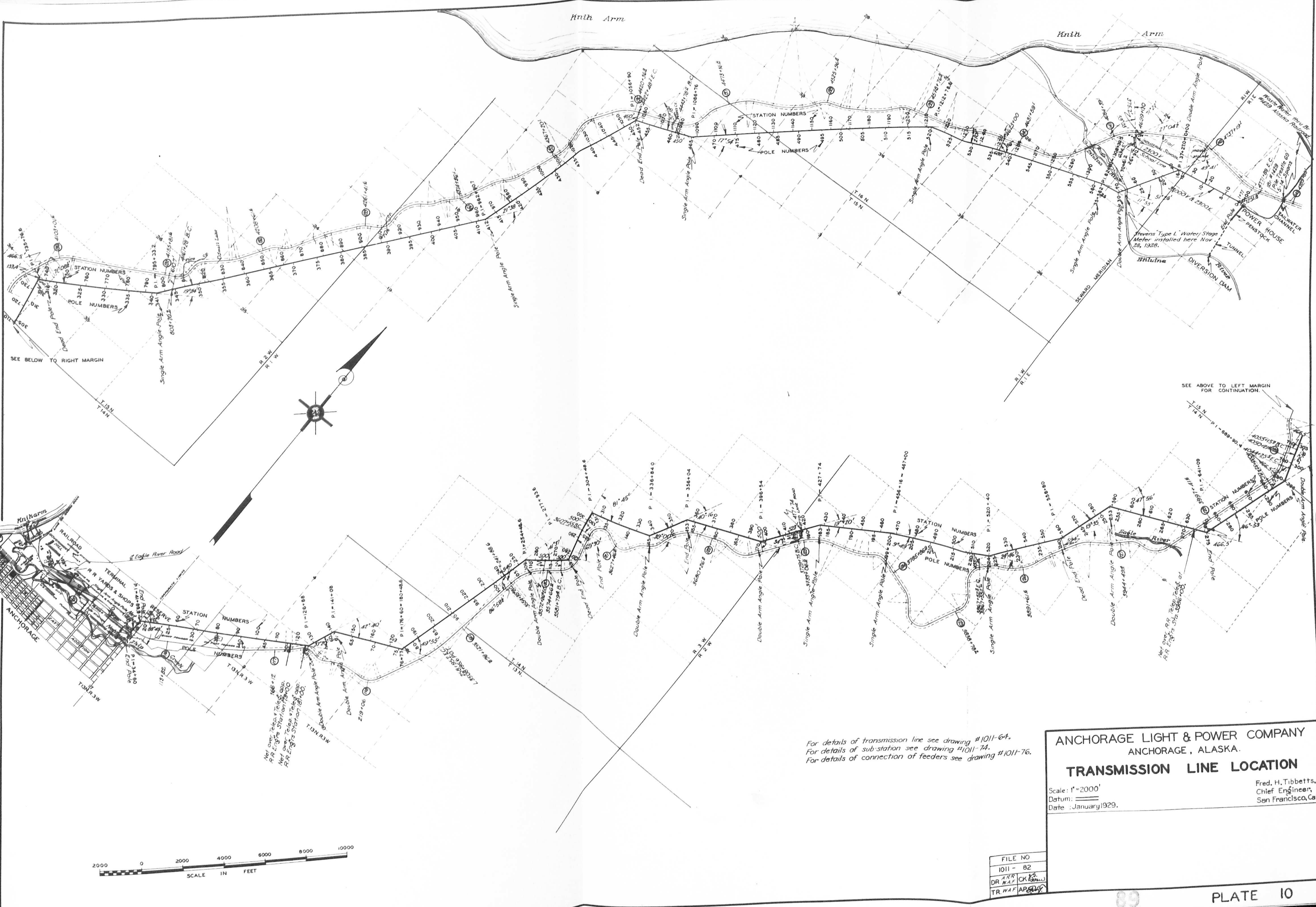
For transforming the plant output from generator voltage of 2300 volts to transmission line voltage of 33,000 volts, a set of 3 transformers connected in delta formation will be installed outside the building near the southeast corner. For the immediate installation, transformers with a capacity of 400 K.V.A. each will be used giving a combined capacity of 1200 K.V.A. or about 1000 K.W. at 80% power factor. The transformers will rest on a concrete foundation. Conductors and outdoor switching equipment will be mounted on a wooden frame work, which will also support lightning arrestors, choke coils and fusible disconnects. Electrical conductors from the power house switchboard will be carried to the transformers in conduits placed underground. All equipment in the sub-station except transformers will have a capacity of 2000 K.W.

TRANSMISSION LINES

(See Fig. 6 and Plates 10 & 11)

ANCHORAGE TRANSMISSION LINE

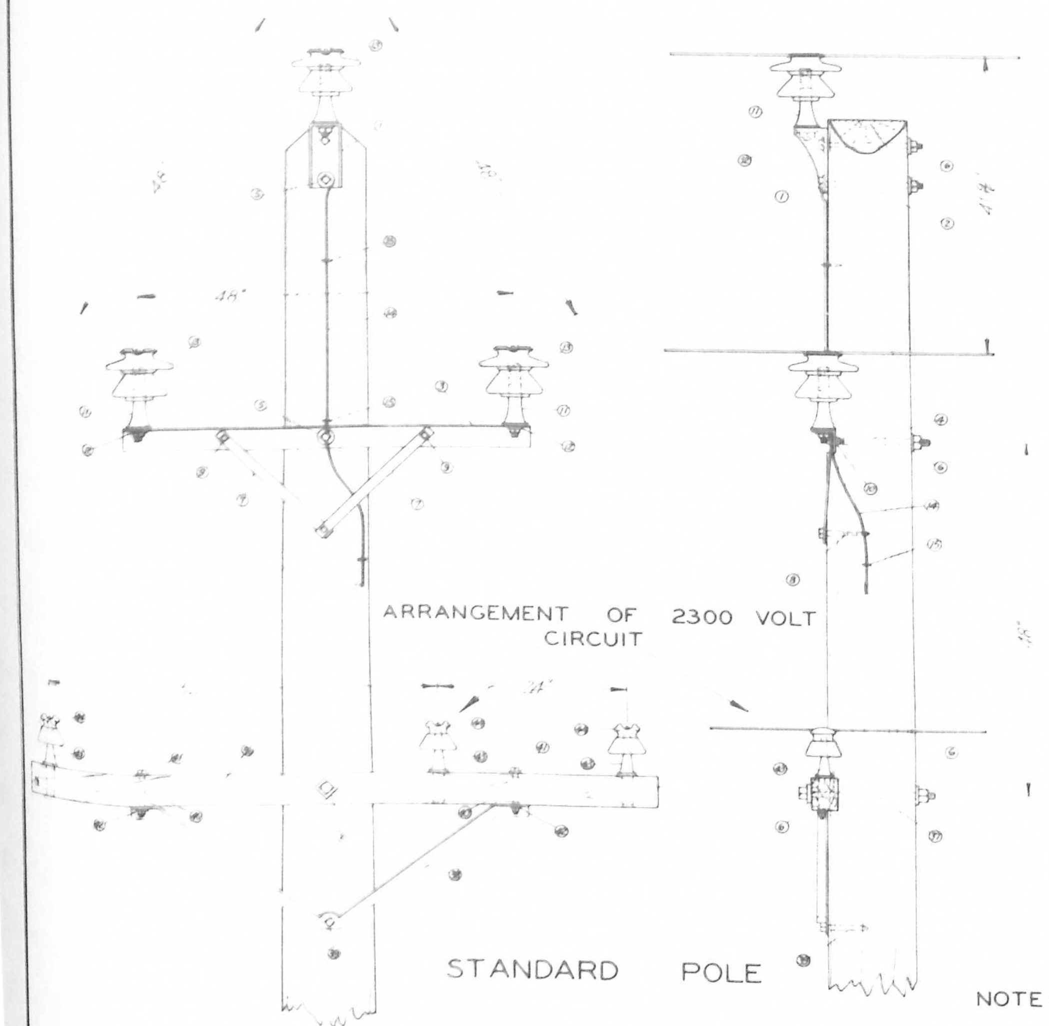
The Anchorage transmission line, 26.3 miles in length, has


Knik Arm
Knik Arm
STATION NUMBERS
POLE NUMBERS
Dead End Pole
Single Arm Angle Pole
Double Arm Angle Pole
End Pole
SEE BELOW TO RIGHT MARGIN
SEE ABOVE TO LEFT MARGIN FOR CONTINUATION.
POWER HOUSE
PENSTOCK
TUNNEL
DIVERSION DAM
TAILWATER CHANNEL
Stevens' Type L Water Stage Meter installed here Nov. 28, 1928.
SEWARD MERIDIAN
T 16 N
T 15 N
T 15 N
T 14 N
T 14 N
T 13 N
R 2 W
R 1 W
R 1 W
R 1 E
R 3 W
R 2 W
T 13 N R 3 W
Eagle River
Eagle River Road
ANCHORAGE
RAILROAD TERMINAL
R.R. YARDS & SHOPS
Ship Creek
Knikarm
For details of transmission line see drawing #1011-64.
For details of sub-station see drawing #1011-74.
For details of connection of feeders see drawing #1011-76.
ANCHORAGE LIGHT & POWER COMPANY
ANCHORAGE, ALASKA.
TRANSMISSION LINE LOCATION
Scale: 1"=2000'
Datum:
Date: January 1929.
Fred. H. Tibbetts,
Chief Engineer,
San Francisco, Cal.
FILE NO
1011 - 82
SCALE IN FEET
2000 0 2000 4000 6000 8000 10000

been designed for a capacity of 2000 K.W. with a line loss not exceeding 10%. Bare copper wire, No. 4 gauge, was used for the conductors. Insulators of the pin type with cemented metal thimbles are mounted on steel pins, and are rated for 40,000 volt service. The conductors are placed at the corners of an equalateral triangle, with a spacing of 4 feet, the upper pin being carried on a pole-top bracket and the two lower ones on a galvanized angle iron cross arm. Poles are spaced about 240 feet apart and have an average length of 40 feet. About half of them were cedar poles with 3/8 inch guaranteed penetration Permex treated butts obtained from Seattle, the balance being obtained from local sources. For protection against decay the local poles were treated with Anaconda Wood Preservative applied at the time the poles were set. This preservative, which is granular in texture, is largely composed of arsenic, together with compounds of lead, copper and zinc, and is highly toxic to wood destroying organisms. Special construction was provided at sharp angles in the line and at dead ends, as shown on Plate 11. Nets will be provided under the conductors wherever the transmission line crosses the railroad or telephone and telegraph lines.

EKLUTNA TRANSMISSION LINE

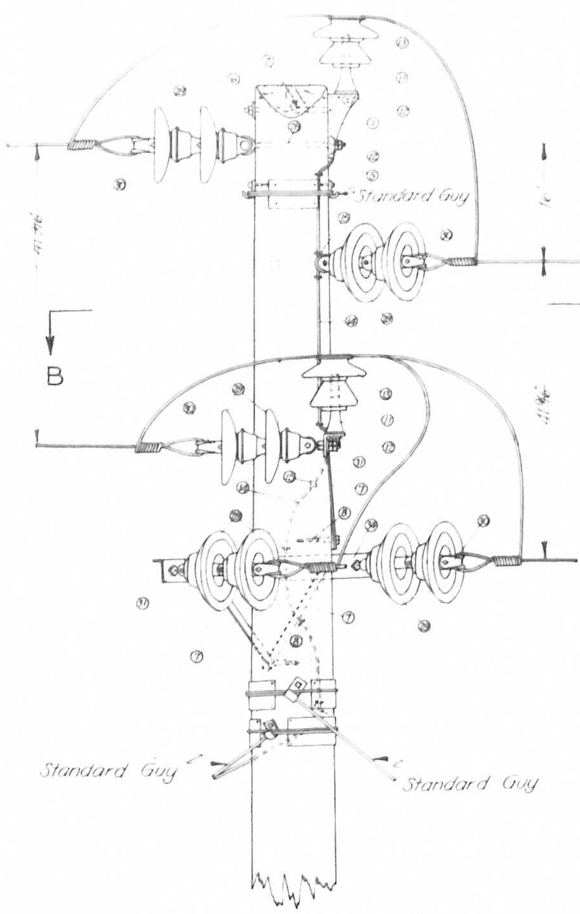
A second transmission line has been constructed from the power plant to serve the Industrial School at Eklutna. This line will operate at 2300 volts and will be carried for the first 0.71 miles on the poles of the main transmission line. It will then branch off for a distance of 0.63 miles to Eklutna.



ARRANGEMENT OF 2300 VOLT CIRCUIT

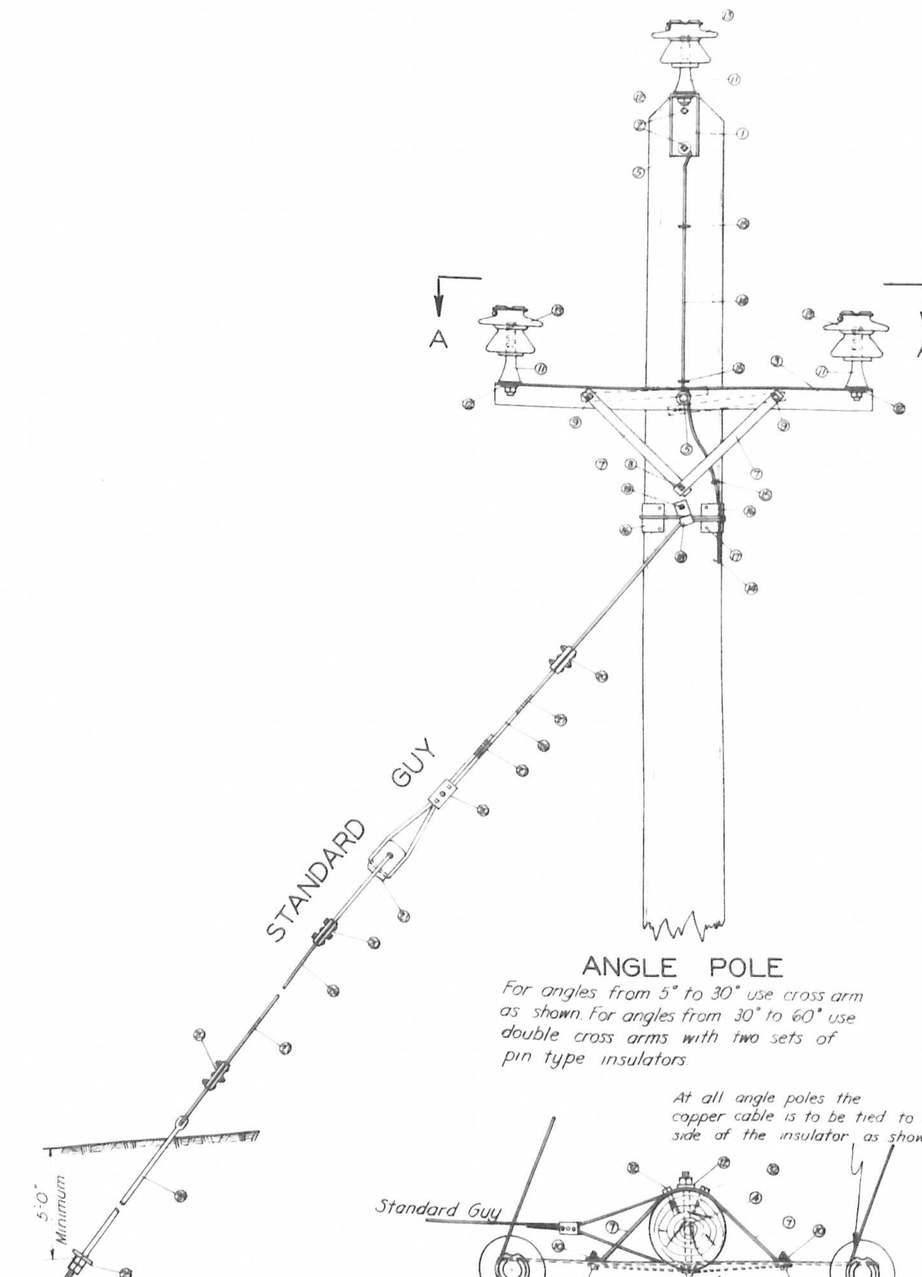
STANDARD POLE

NOTE (FOR 2300 VOLT CIRCUIT)
For construction of end poles and at junction of 2300 V with 33,000 V lines use double cross arms with double arming bolts and strain insulators.



DEAD END POLE

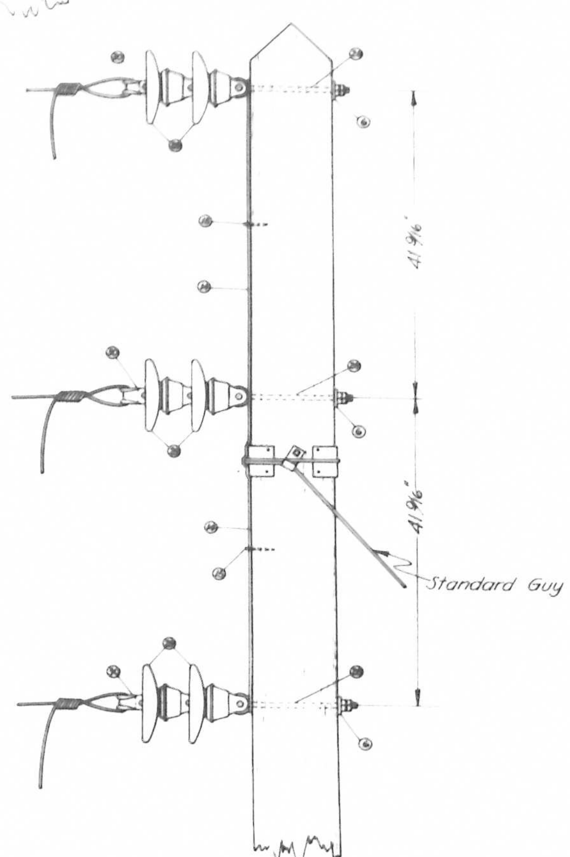
5 such poles to be placed within the transmission line, and located, if convenient at the maximum angle points



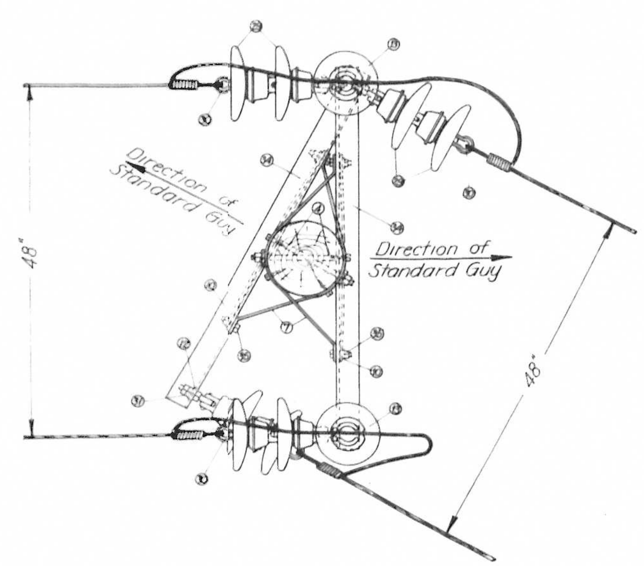
Note Deadman to be of treated timber buried

ANGLE POLE

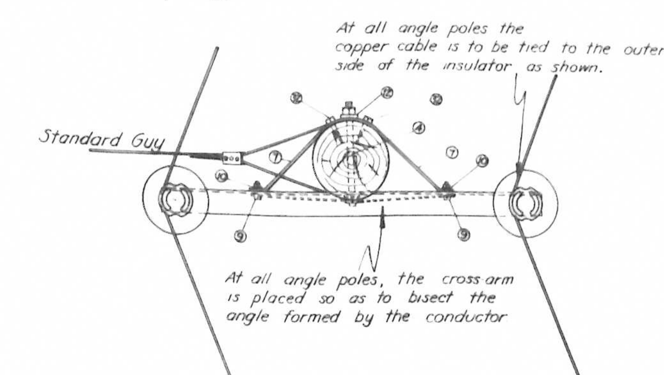
For angles from 5° to 30° use cross arm as shown. For angles from 30° to 60° use double cross arms with two sets of pin type insulators



END POLE
(At transmission line ends and for angles over 60°.)



SECTION B-B



SECTION A A
(Maximum angle shown)

NOTES:
Place cross arms on alternate sides of adjacent poles.
Recommended depth of setting of poles in soil:
40' poles - 6.0 ft. depth.
45' poles - 6.5 ft depth.
50' poles - 7.0 ft depth.
In the total line, make three rotations of the set of conductors, each rotation to be 120°.

ANCHORAGE LIGHT & POWER COMPANY EKLUTNA POWER PROJECT	
TRANSMISSION LINE DETAILS	
Scale: 1" = 1'.	Fred. H. Tibbetts, Chief Engineer, San Francisco, California.
Date: August 1928.	
FILE NO. 1011 - 64	DR. J.S. CK. — TR. WF AP. —

ANCHORAGE SUB-STATION

(See Plate 12)

The main transmission line will terminate at a sub-station to be built by the company in the town of Anchorage. A location as shown on Plate 10 has been selected close to the railroad yards and adjoining one of the local roads. The transformers and out-door equipment will be similar to those provided at the power plant sub-station. For the switchboards and indoor equipment, a small concrete building will be provided conforming in general appearance to the power plant building. It will be about 14 feet long by 12 feet wide. Connections will be made from the sub-station to the present steam plant operated by the railroad, and also to the two transmission lines serving the town of Anchorage and the city pumping plant. The connections will permit current to be drawn from the steam plant for delivery to the city lines in case of a shut-down of the hydro-electric plant and meters will be provided to measure the power delivered to or drawn from the steam plant.

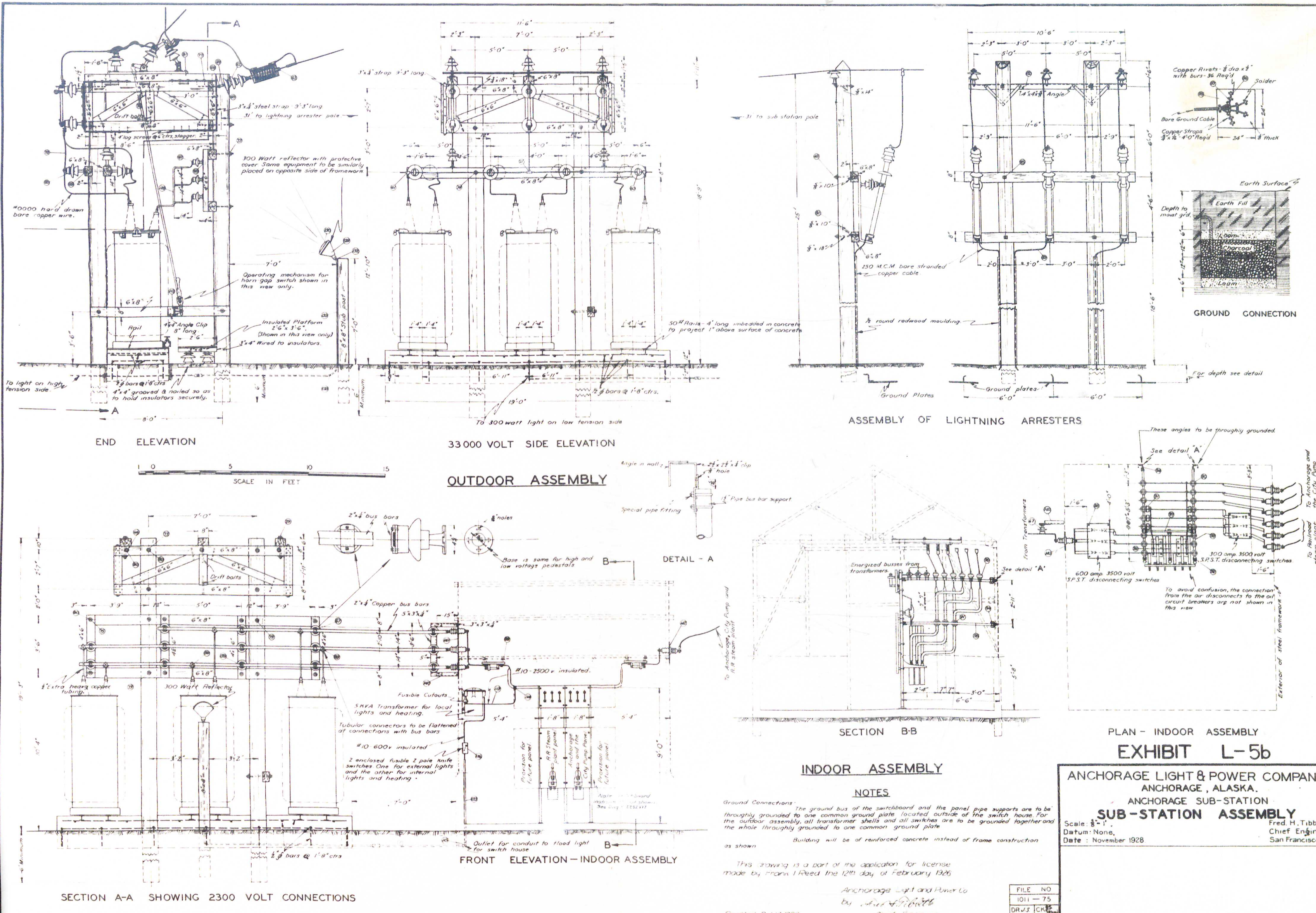


EXHIBIT L-5b

INDOOR ASSEMBLY

NOTES

Ground Connections - The ground bus of the switchboard and the panel pipe supports are to be throughly grounded to one common ground plate located outside of the switch house. For the outdoor assembly, all transformer shells and all switches are to be grounded together and the whole throughly grounded to one common ground plate.

Building will be of reinforced concrete instead of frame construction as shown.

This drawing is a part of the application for license made by Frank I Reed the 12th day of February 1926

Anchorage Light and Power Co
by [signature]
Chief Engineer

Granted Oct 12 1928

ANCHORAGE LIGHT & POWER COMPANY
ANCHORAGE, ALASKA.
ANCHORAGE SUB-STATION
SUB-STATION ASSEMBLY

Scale: ⅛" = 1'.
Datum: None.
Date: November 1928

Fred. H. Tibbetts
Chief Engineer
San Francisco, Calif.

FILE NO
1011 — 75

93

CHAPTER VI

COST ESTIMATES

UNIT PRICES

Construction work on the initial development of the Anchorage Light & Power Company project has already progressed far enough to demonostrate with reasonable accuracy the unit prices which will apply to many parts of the work. With the transmission line completed and the Eklutna Lake storage dam well along toward completion, the costs of these features are fairly well established. In addition, exdavation work so far completed for the diversion dam, penstock, power house, and tunnel portal has already given a fair indication of the probable final cost of that item. Prices for work not yet started have been based on experience with similar construction on numerous other projects with suitable allowance for Alaskan conditions. Prices used for machinery and materials are based on actual manufacturers quotations and transportation charges are based on quoted rates.

Costs of construction materials will generally exceed Pacific Coast States prices by freight costs from Seattle to Anchorage, these being for carload lots for copper wire - 1.35¢ per lb. or 7.8% of cost at Seattle

Portland cement-	0.75¢ "	" 100.0%	" " "	
Structural Steel-	1.35¢ "	" 27.5%	" " "	
Lumber	0.74¢ "	" 68.0%	" " "	or Ketchikan, Alaska

Labor costs at Anchorage are probably about 50% higher than in California and Washington, but skilled mechanics or tunnel men are very difficult to obtain. Altogether, costs on a job of this sort will exceed costs for a similar job in the Pacific Coast States by about 20% to 25%.

The following table indicates the unit prices adopted for the main elements of the proposed construction work.

TABLE NO. 9

UNIT PRICES

Excavation	Spillway of storage dam	$3.00 per c.y.
	Solid rock - diversion dam	4.75 " "
	Solid rock - power plant	3.50 " "
	Loose rock - power house	1.00 " "
	Common - tailrace canal	.60 " "
	Common - penstock trench	2.00 " "
Fill in storage dam		1.00 " "
Concrete	Diversion dam	27.00 " "
	Power house foundations and penstock anchors	19.00 " "
	Power house superstructure	24.00 " "
	Tail race canal lining	0.40 " sq. ft.
Lumber	Storage dam spillway stringers	75.00 per M.B.M.
	" " " lining	100.00 " "
Rip-rap	at storage dam	3.00 per c.y.
Tunnel (7' x 8')	Unlined section	38.00 per lin.ft.
	Lined section	50.00 " "
Structural steel	Trash rack and diversion dam	0.15 per lb.
Steel pipe for penstock	f.o.b. San Francisco	0.04 3/4 per lb.
	Erection on saddles	0.80 per 100 lb.
Window sash for power plant building		0.35 per sq. ft.
Russett #8 Shale clay tile for power plant roof		0.19 " " (Seattle)
Freight	Depends on type of material	Alaska S.S.quotations
Electrical and mechanical equipment		Manufacturer's "

ESTIMATED CONSTRUCTION COSTS

Complete cost estimates are included herein for the initial development of the project as previously described and also for the probable second stage of construction.

Table No. 10 presents in complete detail the estimated construction costs for the various elements making up the initial development and is followed by Table No. 11 which is a summary of the same costs with an indicated percentage added to cover over-head expense. As shown, the total estimated cost of the initial development is $374,300 for construction work. Nothing is included in these estimates for rights of way, interest during construction, legal expense, or preliminary financing or promotion expenditures.

The construction work estimated above provides a complete installation for a 1000 K.W. system; and includes as well a power-house, penstock, and transmission line sufficient for an additional 1000 K.W.; storage works sufficient for an additional 2000 K.W.; and river diversion works sufficient for an additional 3000 K.W. In other words, 85% of the total cost applies to works having a capacity equivalent to 2000 K.W. and 47% applies to works having a capacity of 4000 K.W.

Following the summary of costs for the initial development, Table No. 12 presents an estimate of the cost of additional equipment and installation necessary to increase the output of the whole system to 2000 K.W., assuming that the additional output will be transmitted to Anchorage. This includes, principally, the second unit at the power plant and additional sub-station equipment. It does not include any of the proposed extensions of the transmission system to the proposed future power markets lying to the north of the power plant, although it is possible that this work may precede the enlargement of the capacity of the Anchorage line. As shown in Table No. 12 the cost of increasing the initial system to a capacity of 2000 K.W. will be about $51,580.

TABLE NO. 10

ESTIMATED CONSTRUCTION COSTS
INITIAL DEVELOPMENT

STORAGE DAM

Camp and trail		$2,000	
Excavation spillway	4,000 c.y. @ $3	12,000	
Lumber, spillway	27 M.B.M. @ $75	2,025	
spillway	50 M.B.M. @ $100	5,000	
gates	7.2 M.B.M. @ $100	720	
Fill	3,700 c.y. @ $1.00	3,700	
Rip-rap	600 c.y. @ $3	1,800	
		$27,245	
Incidentals, 10%		2,725	$29,970

DIVERSION DAM

Concrete, 1,190 c.y. @ $27	32,150	
Rock excavation, 642 c.y. @ $4.75	3,050	
Outlet gate and pipe in place	600	
Hoist for outlet gate	500	
Reinf. steel in place 4740 lbs. @ 5¢	237	
Structural " " " 1043 " @ 15¢	157	
Grout pipe, water stop, etc.	500	
Grouting and water proofing	750	
Eklutna River gaging station	306	
	$38,250	
Incidentals 10%	3,830	42,080

TUNNEL

Lined section - 470 ft. @ $50	23,500	
Unlined section 1410 ft. @ $38	53,580	
Inlet structure: Exc. 124 c.y. @ $6	744	
Concrete 33 c.y. @ $27	891	
Trash rack 8635 lb. @ 15¢	1,295	
Heating of trash rack	1,190	
Outlet structure (considered as inlet portion of penstock)	0	
	$81,200	
Incidentals 10%	8,120	89,320

PENSTOCK

Excavation - intake	1200 c.y. @ $2		$2,400
trench	1930 " @ $2		3,860
anchors	50 " @ $3		150
Backfill over penstock	1480 " @ $1		1,480
Concrete	1 surge tank base - 40 c.y.		
	4 anchors @ 14.5 - 58 "		
	98 c.y. @ $19		1,860
Steel pipe 54" diam. 1/4" and 5/16" thick			
Tunnel to elev. 93, 1/4", 658 ft. @ 155.3#		102,200#	
Elev. 93 to Wye 5/16", 141 ft. @ 196.4#		27,700	
Wye 5/16", 5 ft. @ 393#		2,000	
Branch (36" dia.) 1/4" 60 ft. @ 105.2#		6,300	
Bends (54" dia.) 15 ft. @ 155.3#		2,300	
Stiffeners, etc. @ 5% of above weight		7,000	
		147,500#	
@ 4 3/4¢ f.o.b. San Francisco			7,000
Valves: 1 butterfly valve and flanges f.o.b. S. F.			3,250
8" By-pass system around butterfly valve, including 8' steel pipe, 2 elbows, 6 flanges, 1 gate valve and 2 saddle flanges			250
Air relief and vacuum valves, 2-6" and 2-6" gate valves			317
Penstock flanges, 2-36" and 1-54"			700
Blind flange on unused 36" branch of wye			100
Expansion joint 1400# structural steel @ 20¢ - $280			
1100# machined steel @ 20¢ - 220			
Bolts, flax, etc. 20			520
Freight on above materials 155,000# @ $2.00 per 100#			3,100
Soil proofing of steel pipe (to be done in factory before shipment) 900 ft. at 81¢			729
Installation of above material			
Penstock pipe 147,500# @ 80¢ per 100#			1,180
Valve and by-pass			300
Flanges, air relief valves, expansion joint, etc.			300
			$27,496
Incidentals 10%			2,754
			$30,250

POWER HOUSE BUILDING

Excavation including tail race conduit and channel to R.R. bridge				
Loose rock	448 c.y.	@ $1.00	....	$ 448
Common	5320 "	@ 0.60	....	3,192
Concrete				
Substructure	256 "	@ $19.00	....	4,864
Superstructure	190 "	@ 24.00	....	4,560
Lining of tail race 1190 sq. ft. @ 40¢			....	476
Concrete drops in tailrace channel				150
Structural Steel				
Fabrication -	11,450 lbs.	@ 6½¢	....	745
Freight	11,450 "	@ $2 per 100#	....	229
Placing	11,450 "	@ 2¢	....	229
Crane - 4 ton capacity			....	750
Freight	3,300 lbs.	@ $2 per 100#	....	66
Placing	3,300 "	@ 2¢	....	66
Railing	120 ft. in place		....	120
Sash	580 sq. ft. in place @ 35¢		....	203
Tile Roof				
Russett #8 Shale clay 2,263 sq. ft. @ 19¢....				430
Freight	2,263 x 14# x $1.35 per 100#		.....	428
Placing	2,263 sq. ft. @ 10¢		....	226
Rolling door, 8' x 10' in place			....	300
Doors 3 @ $12 in place			....	36
Toilet, wash basin, plumbing, etc.			....	150
Lockers			....	50
Bench			....	20
Office fixtures			....	150
Operator's cottage			....	1500
				$19,378
		Incidentals, 10%	...	1,932
				$21,310

POWER HOUSE EQUIPMENT

Turbine, 1500 H.P., 720 R.P.M.		17,243
Generator, 1250 K.V.A.,80% P.F., 720 R.P.M.		5,550
Switchboard and accessories		520
Wiring and conduits for 2300 volt conductors		420
3" Conduit - 300 ft. @ 75¢	$225	
300 M.C.M.cable insulated 500' @ 22¢	110	
Eklutna feeder conduits & cable	85	
Lighting for power house and cottage		300
Heating for power house and cottage 8-5 K.W. heaters with wiring and conduits		615
Telephones - 3 installed and connected with R.R.cir.		100

POWER HOUSE EQUIPMENT (Continued)

Transformers for local Service 2-25 K.V.A. .... $ 400

Transportation of all of above materials
Generator East to Seattle 360
Seattle and S.F. to Eklutna
78,000# @ $1.60 /100 1,250 1,610

Installation and initial operation of equipment
Pelton representative 90 days @ $20 plus
trans. and living expenses 2,400
Assistants, 360 man-days @ $7 2,520
Switchboard, transformers, telephones, wiring,
etc.... 1,000
$32,678
Incidentals, 10% 3,262 $35,940

POWER HOUSE SUB-STATION

Outdoor framework and foundation 420
Poles - 6 @ $25 $150
Timber 1000 ft. @ $100 100
Misc. bolts, nuts, etc. 50
Concrete, 4 c.y. @ $30 120

Outdoor electrical materials 5,349
Transformers, 3 @ $1400 4,200
Fusible disconnects 98
Gang oper. switch & choke coil 248
Lightning arresters 333
Insulators 170
Misc. wiring, grounds, etc. 300

Installation of outdoor elect. materials,
including hauling from R.R. 500

Indoor electrical materials 908
2 panel switchboard with all necessary
instruments, circuit breakers, pipe supports,
bus bars, etc. ....

Installation of indoor electrical materials 500

Lighting system chargeable to sub-station 150

Miscellaneous testing apparatus (50% chargeable to
P.P. Sub-sta.)
Megger testing set $500
Oil filter press 540
Portable oil tester 176
Blotting paper 20
$1,236 x 50% 618

Freight on above materials 891
East to Seattle, 20,000# @ $2.50/100 - $500
Seattle to Anchorage 27,000# @ $1.65/100 - $391

POWER HOUSE SUB-STATION (Continued)

Temporary assembly during construction period ...		304	
Fencing around outdoor assembly		200	
		$9,840	
Incidentals (Omitted)		-	$9,840

TRANSMISSION LINES

Labor at Anchorage		22,700	
Materials purchased at San Francisco			
Estimate #1 Pole line hardware		2,459	
Estimate #2 Copper conductors		10,629	
Estimate #3 Erection tools, poles & hardware		5,509	
Estimate #4 Insulators, copper, etc. ...		3,783	
Materials purchased at Anchorage			
Contract #1, Poles		5,540	
Misc. materials (no record in S.F.)		3,000	
Estimated rental of outfit cars		4,000	
Freight on above materials shipped to Alaska			
135,000# @ $1.60 per 100#		2,160	
260,000# @ .60 " "		1,560	
Feeder connections to steam plant, etc.		500	
Auxiliary 2,300 v. line to tunnel intake trash rack		500	
		$62,340	
Incidentals - lump sum ...		3,000	$65,340

ANCHORAGE SUB-STATION

Outdoor framework and foundation		420	
Poles - 6 @ $25	$150		
Timber-1000 ft. @$100 per M.	100		
Misc. bolts, nuts, etc.	50		
Concrete, 4 c.y. @ $30	120		
Outdoor Electrical Materials		5,347	
Transformers, 3 @ $1400	4,200		
Fusible disconnects	98		
Gang operated switch and choke coil	246		
Lightning arresters	333		
Insulators	170		
Misc.wiring,ground plates,etc.	300		
Installation of outdoor elect. materials including hauling to site		500	
Switch House		880	
Concrete 22.5 c.y. @ $24	540		
Tile roofing 350 sq.ft.@ 40¢	140		
Windows and doors in place	200		

ANCHORAGE SUB-STATION (Continued)

Indoor Electrical Materials:
2 Panel switchboard with all necessary instruments, circuit breakers, wall bushings, pipe supports, bus bars, insulators, etc. $1300

Installation of indoor elect. materials 500

Lighting system 270
Transformers, 5 K.V.A. $120
Conduits, conductors, reflectors, switches, lamps, etc. in place 150

Miscellaneous Testing Apparatus (50% chargeable to Anchorage sub-station)

Megger testing set	500
Oil filter press	540
Portable oil tester	176
Blotting paper	20
	$1236 x 50% ... 618

Freight on above materials 945
East to Seattle 20,000# @ $2.50/100 $500
Seattle to Alaska 27,000# @ 1.65/100 445

Temporary switch house during construction period 250

Fencing around outdoor assembly 200

$ 11,230

Incidentals (Omitted) - $11,230

SPUR TRACK 2300 feet 5,000

TABLE NO. 11

SUMMARY OF COST ESTIMATES

INITIAL DEVELOPMENT

Item	Construction Cost	Overhead and Engineering 10%	Total Cost
Storage Dam and Spillway	$29,970	$3,000	$32,970
Diversion Dam	42,080	4,210	46,290
Tunnel including inlet structure	89,320	8,930	98,250
Penstock including inlet structure	30,250	3,030	33,280
Power plant building and cottage	21,310	2,130	23,440
Power plant equipment	35,940	3,590	39,530
Power plant sub-station	9,840	980	10,820
Transmission Lines	65,340	6,530	71,870
Anchorage sub-station	11,230	1,120	12,350
Spur track	5,000	500	5,500
TOTALS	$ 340,280	$34,020	$374,300

TABLE NO. 12

ESTIMATED COST OF COMPLETING SYSTEM TO 2000 K.W. CAPACITY

Penstock - second branch of Wye		$700
Power House Equipment		
Turbine	$17,243	
Generator	5,550	
Switchboard and accessories	1,000	
Wiring, etc.	300	
Freight on above	1,600	
Installation..................	4,500	
	$30,193	
Incidentals 10%	3,017	$33,310
Power House Substation		
Outdoor Enlargement	400	
Transformers	4,200	
Wiring, etc.	200	
Installation	400	
Freight	700	
	$5,900	
Incidentals 10%	590	6,490
Anchorage Sub-Station (Same as power house sub-station)		6,490
		$ 46,890
Overhead 10%		4,690
TOTAL		$ 51,580

CHAPTER VII

ANNUAL INCOME, CHARGES AND EARNINGS

GENERAL STATEMENT

The Anchorage Light & Power Company is fortunate in having an immediate market for its initial power output under contracts already arranged. With prices already fixed, it is possible to estimate with a fair degree of accuracy the immediate income and to estimate the probable increase in income from the present market for several years in advance. It is also possible to estimate accurately the probable operating costs and fixed charges, and thus determine the earnings of the company during the same period.

In addition to immediate service in the town of Anchorage, however, the company has other very promising potential markets, requiring only additional transmission lines to bring them in. The available information regarding the additional markets is sufficient at this time to warrant only a general statement that they will clearly provide income greatly in excess of the cost of service. Power earnings on extensions of the distribution system will very quickly amortize the cost of constructing the new lines and pay a substantial and increasing profit besides. No attempt is made in this report to estimate the amount of such probable earnings. The following discussion of income, operating charges and earnings applies therefore only to the immediate installation serving the vicinity of Anchorage and Eklutna.

ANNUAL GROSS REVENUE

ANCHORAGE PUBLIC SERVICE

Records of operation of the present system in Anchorage indicate a present annual consumption for public service of about 482,000 K.W.H. On the assumption that the low rates offered by the new company will probably effect an immediate increase in service, it is assumed that the consumption during the first year of operation of the new system should be about 530,000 K.W.H. Assuming that about 70% of the total would be used for electric lighting, and that the balance would be distributed between industrial power, domestic power, and municipal lighting, the annual income from this source using the rates specified in the contract with the town, would be as shown in Table No. 13 below.

TABLE NO. 13

ESTIMATED ANNUAL REVENUE DURING FIRST YEAR
FROM ANCHORAGE PUBLIC SERVICE

Type of Service	Wholesale Rate per K.W.H.	Consumption %	K.W.H.	Estimated Annual Revenue
Electric lighting	6¢	70	371,000	$ 22,260
Industrial and commercial power	4¢	15	79,500	3,180
Domestic power	2½¢	10	53,000	1,320
Municipal lighting	4¢	5	26,500	1,060
Total		100		$27,820

For subsequent years, as previously mentioned, it is estimated that annual consumption and consequently annual revenue would increase about 10% each year.

ANCHORAGE CITY PUMP

The probable income from the sale of power to the town of Anchorage for use at its pumping plant is based on consumption of 330,000 K.W.H. during the first year, giving, at the prescribed rate of 4¢ per K.W.H. an income of $13,200. The annual increase of revenue resulting from increasing use of water is estimated at 5% per year.

ALASKA RAILROAD

Records of power consumption by the Alaska Railroad in its shops and offices indicate a present annual use of about 525,000 K.W.H. With a probable increase of consumption due to cheaper power and possible electrification of additional equipment, it is assumed that the total would probably reach about 600,000 K.W.H. in the near future and remain at approximately that figure for several years. At the agreed power rate of 4¢ per K.W.H. the resulting annual income would be $24,000.

EKLUTNA INDUSTRIAL SCHOOL

The present agreement with the Eklutna Industrial School calls for a rate of 10¢ per K.W.H. and a monthly minimum charge of $100. It is probable that the actual consumption during the first few years will not greatly exceed the amount covered by the minimum charges. The annual income is therefore estimated on the basis of 12 months at $100 or $1200 per year.

SUMMARY

The total annual revenue during each of the first five years of operation of the new system, estimated in the manner described above, is shown in the following table.

TABLE NO. 14

ESTIMATED ANNUAL REVENUE

FIRST FIVE YEARS

Year	Anchorage Public Service	Anchorage Pumping Plant	Alaska Railroad	Eklutna School	Total
1st	$27,820	$13,200	$24,000	$1,200	$66,220
2nd	30,600	13,860	24,000	1,200	69,660
3rd	33,660	14,550	24,000	1,200	73,410
4th	37,030	15,280	24,000	1,200	77,510
5th	40,730	16,040	24,000	1,200	81,970

ANNUAL CHARGES

OPERATING COSTS

The principal operating costs will consist of wages of operators and linemen, salaries of a superintendent and office assistants, and necessary supplies and material for operation of the system and the administrative offices. It will be necessary to have an operator on duty at the power house at all times but, under usual operating conditions, a 12 hour shift will be practicable, requiring two operators regularly stationed at the plant. The Anchorage sub-station would also require attendance. It is assumed that one man could take care of this station continuously if sleeping accommodations be provided in or near the sub-station building. A telephone and possibly certain alarm devices would be needed to make this plan of operation safe. To provide relief for the station operators in case of temporary disability or absence, it would be advisable to provide a fourth operator who could serve at either the power plant or the sub-station and could perform needed repair or maintenance work when not required for operation. This man would also be available for duty at the Anchorage steam power plant.

The administration of the system would be simple, and it is assumed that a superintendent with the assistance of a good clerk could handle all the necessary work. Office space and miscellaneous office supplies, such as stationery, bill heads, etc., would be needed.

The estimated costs of operation are shown in Table No. 15 below.

TABLE NO. 15

ESTIMATED ANNUAL OPERATING COSTS

Administration		
Superintendent of System	$4,000	
Stenographer and clerk	1,000	
Rent of office	600	
Stationery, printing, etc.	1,000	$6,600
Power Plant Operation		
2½ operators @ $200 per mo.	6,000	
Outside work and patrol - equivalent of one man entire year	1,500	
Oil, waste and miscellaneous supplies	200	7,700
Sub-station and Steam Plant Operation		
1½ operators @ $200 per mo.	3,600	
Outside work and transmission line patrol	1,500	5,100
Total Annual Operating Cost		$19,400

ANNUAL FIXED CHARGES

Fixed charges include those portions of the annual expense which depend mainly on the amount of money invested and on the degree of permanence of the construction work. The principal items are depreciation reserves and maintenance expenditures. Taxes and insurance are also usually included. In general the fixed charges depend only to a slight extent on the volume of business done.

Depreciation: In order to assure continued life for an operating concern, it is essential that funds be set aside each year to provide for replacement of property or equipment when it becomes worn out or obsolete. The amount which should be set aside each year for any particular element of the project depends upon its probable useful life. The latter varies greatly for different types of equipment or construction. The diversion dam and tunnel of the present project, for instance, have practically unlimited life and for estimating purposes 100 years has been adopted. The power plant building has been assigned a life of 50 years, the penstock 25 years and hydraulic and electrical equipment 20 years. The storage dam proper will have practically unlimited life but the spillway lining and headgate structure will require occasional renewal. For this reason, the timber construction at this dam has been assigned a life of 10 years.

Having the estimated cost of each item of the project, and having determined for each the probable life, the average useful life of the entire property is readily found, computations in the present case giving an average of 20.6 years. For simplicity, a life of 20 years has been adopted.

Since funds set aside for depreciation would, theoretically at least, be placed in a fund drawing interest, it is only necessary to deposit such a sum each year as would be necessary to amount with interest at the end of 20 years to the total construction cost. To provide the sum of $374,300, estimated as the construction cost for the present project, at the end of 20 years, with interest accumulating at 5%, requires an annual reserve of 3.024% of the total cost, or $11,300.

<u>Maintenance</u>: Maintenance expenses include all amounts expended to keep the system in satisfactory operating condition. Due to the high standards adopted for all design work on the present project, maintenance costs will be low, varying from a minimum of about .5% per year for the concrete structures, to a maximum of about 3% for the cottage at the power plant. A careful estimate of the probable maintenance cost for each of the various items of the project indicates a total annual expenditure of $3,135, or about 0.8% of the total cost.

<u>Taxes</u>: Annual taxes collected by the Alaska Territorial Government will amount to about 0.4% of the gross annual revenue. In addition an income tax of 12% of the net annual revenue will be collected by the United States Government. In estimating these taxes it has been necessary to carry through a preliminary approximation of the gross and net revenues to serve as a basis for computing the taxes.

Insurance: Fire insurance premiums have been estimated at a rate of $1 per year per $100 average depreciated value of those portions of the property subject to fire hazard. Workmen's compensation and liability insurance would amount to about 4% of the annual pay roll for operators and about 0.1% of the pay roll for office employees.

Summary: The following table shows the amounts estimated for annual fixed charges during the first five years of operation of the new company, including separately the amounts for depreciation, maintenance, insurance and taxes.

TABLE NO. 16

ESTIMATED FIXED CHARGES

FIRST FIVE YEARS OF OPERATION

Year	Depreciation	Maintenance	Insurance	Taxes	Total
1st	$11,300	$3,135	$1,095	$4,025	$19,555
2nd	11,300	3,135	1,095	4,460	19,990
3rd	11,300	3,135	1,095	4,885	20,415
4th	11,300	3,135	1,095	5,310	20,840
5th	11,300	3,135	1,095	5,730	21,260

ANNUAL NET EARNINGS

The annual net earnings are readily obtained from the above estimates by deducting from the gross revenue the operating and fixed charges. The figures for each of the first five years of operation are shown in the following table. The last column of the table indicates the percentage return on the original investment for construction work.

TABLE NO. 17

NET ANNUAL INCOME
FIRST FIVE YEARS OF OPERATION

Gross Revenue	Annual Expenses Operating	Fixed	Total	Annual Net Income	Return on Orig. Cost
$66,220	$19,400	$19,555	$38,955	$27,265	7.3%
69,660	19,400	19,990	39,390	30,270	8.1%
73,410	19,400	20,415	39,815	33,595	9.0%
77,510	19,400	20,840	40,240	37,270	10.0%
81,970	19,400	21,260	40,660	41,310	11.0%

The percentages shown in the last column of the above table are based on an estimated construction cost of $374,300. This of course does not include all of the capital investment of the corporation. Certain amounts will have to be paid for permits and rights of way, preliminary investigations, organization, legal work, and financing. If the total of such expenditures should amount to $75,000, giving a total investment of approximately $450,000, the percentage as indicated above would be reduced to about 6.1% for the first year, and 9.2% for the fifth year, still indicating a substantial return.

The above tabulation presents a conservative estimate of the dependable income which can be expected from the operation of the initial development of the project. Extension of service to other markets will undoubtedly produce sufficient revenue to pay the cost of the additional facilities provided and at the same time greatly increase the return on the original investment. The possible revenue from additional markets has been estimated as high as $45,000 by persons well qualified to form an opinion. Large increases of profits over the minimum dependable amounts shown in the tabulation above will depend only on the success of the corporation in developing the surrounding potential market.

$250,000

Anchorage Light and Power Company

First Mortgage Sinking Fund 7% Gold Bonds

Dated August 1, 1928 — Due August 1, 1943

Interest payable February 1, and August 1. Redeemable, either in whole or in part, on August 1, 1931, or any interest payment date prior thereto, at 106 and interest, and thereafter at 106 and interest, less 1/4 per cent for each expired six months between August 1, 1931 and August 1, 1943. Coupon Bonds in denominations of $1,000 and $500. Registerable as to principal only.

Normal Federal Income Tax 2% Paid.
California Personal Property Tax paid up to six mills.

Trustee: THE SEATTLE NATIONAL BANK, Seattle
Co-Trustee: THE BANK OF ALASKA, Anchorage
Paying Agent: WELLS FARGO BANK & UNION TRUST CO., San Francisco

COMPANY: The Anchorage Light and Power Company is erecting a modern hydro-electric power generating and transmission plant in Southern Alaska, near the City of Anchorage. Construction is now in progress and includes lake control works, concrete diversion dam, tunnel, penstocks, power house, high-tension transmission line, substations and some distributing lines. The City of Anchorage itself leases and operates a fully completed distributing system built and owned by the United States Government, and has contracted to purchase electricity at very satisfactory rates from the Anchorage Light and Power Company for a period of fifteen years.

The territory served includes the shops (valued at $7,000,000) and headquarters of the Alaska Railroad, which are now utilizing steam-generated electricity. This will be entirely supplanted by the hydro-power of the company, and the present steam plant will be maintained as a stand-by. Rates for domestic and power purposes will be substantially reduced below rates now being charged, and consumption of electricity for both domestic and industrial uses will increase considerably. The population served will be approximately 3,000.

The engineering firm of Mr. Fred H. Tibbetts, San Francisco, has complete supervision over all construction work of the company.

SECURITY: These Bonds will be secured, in the opinion of counsel, by an absolute first mortgage lien upon all the physical properties now owned or hereafter acquired by the company, including Federal Power Permits, Rights of Way, Contracts and other tangible assets, valued in excess of $500,000. The First Mortgage Bonds will take precedence over $100,000 par value Preferred Shares and 50,000 shares of $10.00 par value Common Stock.

SINKING FUND: Commencing June 10, 1931, and yearly thereafter, the company will pay to the Trustee in cash, as and for a sinking fund, not less than fifty per cent of its annual net earnings remaining after payment of bond interest, to provide for the retirement of outstanding bonds of this issue. It is estimated that this fund will be sufficient to retire the entire outstanding issue of bonds considerably before their maturity.

INTEREST PAYMENTS: The Mortgage provides that the company will pay to the Trustee in cash each month, commencing with February 15, 1930, a sum equal to one-sixth of the amount of semi-annual interest due on the bonds each succeeding interest payment date.

MORTGAGE PROVISIONS: Bonds authorized but unissued may in part be issued for completion of construction and in part reserved in escrow under careful restrictions against the cost of future property acquisitions or construction when net earnings are equal to two and one-half times annual interest charges on bonds outstanding and to be issued.

EARNINGS: Conservative estimates of net earnings, based upon present actual volume consumption of steam-generated electricity, indicate earnings of not less than two and one-half times annual bond interest charges, and sufficient to retire entire bond issue before maturity out of earnings.

CAPITAL STATEMENT

(Upon Completion of Present Financing)

	Authorized	To be Issued
First Mortgage 7% Bonds 1943	$500,000	*$250,000
Preferred Stock 8% Cumulative	250,000	**100,000
Common Stock	500,000	500,000

* Remaining $250,000 par value reserved for future issuance under restrictions.
** Remaining $150,000 par value reserved for future construction purposes and general corporate uses.

These bonds are offered when, as and if issued, substantially as above, and accepted by us subject to the approval of our attorneys, Messrs. Orrick, Palmer and Dahlquist, San Francisco.

Price 100 and Interest to Yield 7.00 Per Cent

RUSSELL-COLVIN COMPANY

Investment Counselors

MILLS BLDG., SAN FRANCISCO — CENTRAL BANK BLDG., OAKLAND

MEMBER
SAN FRANCISCO STOCK EXCHANGE
SAN FRANCISCO CURB EXCHANGE

All statements made herein are derived from official sources, and while not guaranteed by us, are believed to be correct.