THE ANACONDA COMPANY (CANADA) LTD.

BRITANNIA BEACH, B.C.

BRITANNIA OPERATIONS

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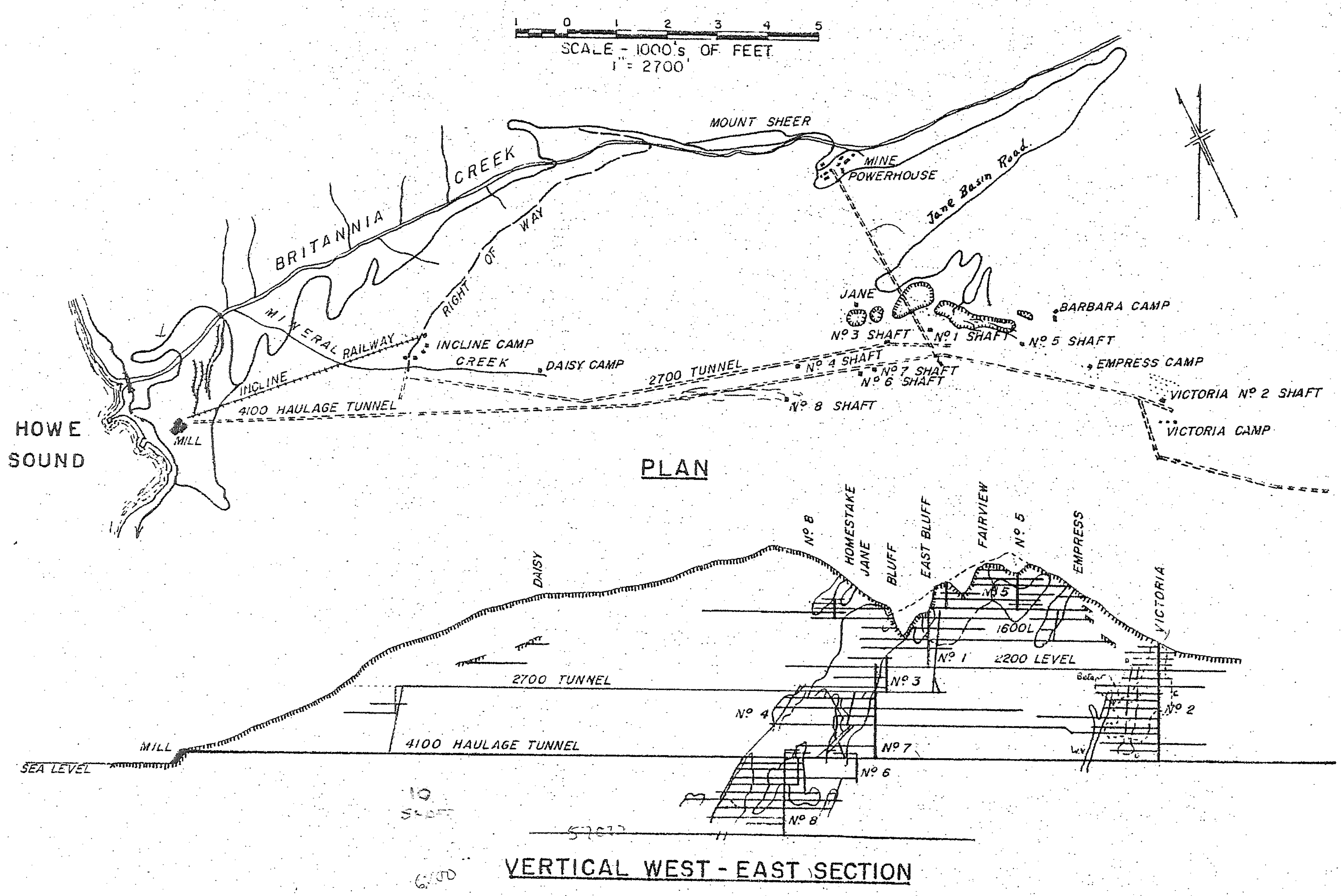
GENERAL RELATIONSHIP OF MINE LEVELS & SURFACE PLANT



RESUMÉ

The Britannia Mine, which is owned and operated by the Anaconda Company (Canada) Ltd., is located about thirty miles north of Vancouver, near the head of Howe Sound. Access to the property is by paved highway, by the Pacific Great Eastern Railway, and deep sea vessels dock right at the plant site.

The original mineral discovery was made in 1888 at an elevation of 4300 feet above sea level. Underground exploratory work disclosed the presence of commercial grade copper mineralization in the early 1900's but production did not start until 1905. Except for short periods of inactivity the mine has been in continuous production. Available records show that total production from 1911 to the present has been 48 million tons averaging 1.24% copper.

As early as 1901 the Jane, Bluff, Fairview and Daisy ore zones were known and ore reserves in that year were estimated to be 1.8 million tons. Reserves were at a maximum of 19 million tons in 1916 and were at a level of 12 million tons between 1930 and 1939. Production over the years has varied between 200,000 and 1 million tons per year but exceeded two million tons between 1929 and 1931 and again between 1937 and 1940. Grade of ore in these years dropped from 1.7% copper to about 1.2%. For the last few years production has been in the 2000 tons per day range with grade varying between 1.1% and 1.4% copper and about 1.0% zinc.

The seven orebodies discovered to date are located within a sheared band of apparently steeply dipping metamorphosed sedimentary and volcanic rocks of varying competency that form a roof pendant two miles wide and seven miles long surrounded by granitic rocks of the coast range intrusive complex.

The orebodies are confined to a highly sheared zone measuring over 1000 feet wide and 8000 feet long with thick units of massive competent volcanic flows and sediments to the north and south. The northwesterly striking Britannia shear zone narrows to a few hundred feet in width to the west but continues to be well over a thousand feet in width for at least three miles to the east before dying out as fingers between firm volcanic flow rocks.

Fracturing occurred in the firmer rock units permitting ore solutions to penetrate until conditions were favourable for ore deposition. These favourable conditions varied in the different sections of the mine and resulted in different types of orebodies.

The two principal types of orebodies are veins (Fairview, Empress and Victoria Mines) and disseminated and stringer type mineralization (Bluff, No. 5, Jane and No. 8 Mines).

At present and for the past ten years, production has come from only three orebodies: No. 8 (1000 tons per day), Bluff (700 tons per day) and Victoria (300 tons per day). The Bluff orebody, which is over 1000 feet long and up to 200 feet wide, has been the principal source of ore throughout the life of the mine. It extends from the surface for a depth of over 3000 feet. This orebody and the No. 8 orebody, which was discovered in 1937, lie about two miles east of the camp and are serviced by a tunnel from Britannia Beach. Mining of the No. 8 orebody is being carried on to a depth of 1000 feet below sea level.

The Victoria Mine lies four miles east of Britannia Beach and is reached by the principal low level tunnel which extends for another mile east of the Victoria Shaft. This shaft extends from the surface to a depth of 2400 feet where it connects to the low level haulage tunnel.

Although the principal minerals are pyrite and chalcopyrite (copper sulphide), important concentrations of sphalerite (zinc sulphide) occur in some sections of the mine (Jane, No. 8). The ore is invariably found associated with quartz mineralization.

Throughout the life of the mine all ore has been transported to Britannia Beach for concentration. Overhead tramway, inclined railway, and electric tram line have all been used for transportation from the various ore zones but presently all ore is handled in 20-ton cars through the high speed main haulage level a few hundred feet above Britannia Beach.

Since 1963, when the Anaconda Company purchased the mine from the Howe Sound Company, an aggressive exploration programme has been under way. Although no new large orebodies have yet been discovered, it is considered that the mine is still a fair prospect for the development of ore zones of a type and grade similar to those which have been developed in the past.

RWP

April, 1965

DATES IN THE HISTORY OF BRITANNIA BEACH, B.C.

1859 Captain Richards surveying B.C. coast for British Admiralty named Mountain for 100 gun frigate "Britannia".

1888 Dr. A. A. Forbes - medical doctor stationed at Hopkins, B.C., discovered ore at the 3300 ft. elevation on Britannia Mountain.

1897 Dr. Forbes's discovery turned over to F. Turner who staked claims, established trail and camp and sold part of the property.

1900 Britannia Copper Syndicate organized.

1903 Howe Sound Company organized by Grant B. Schley which purchased the Copper Syndicate.

1904-5 Aerial tram to mine (3½ miles) and mill completed and shipment made to Crofton Smelter. Smelter bought by Howe Sound Company and operated as Britannia Smelting Co. Ltd.

1908 Britannia Copper Syndicate and Britannia Smelting Co. merged into Britannia Mining and Smelting Co. Ltd.

1910 Fairview orebody discovered.

1912 Beach Store and many houses built on the flats.
2200 Tunnel started and Mount Sheer townsite planned.
RR to Top of Incline and Incline finished.

1915 March 21: Upper or 1050 Camp wiped out by a mud slide - 56 lives lost.
Tunnel Camp built up Britannia Creek power development - Tunnel Dam, Utopia Dam and part of Park Lane Dam and connecting pipe lines.
No.2 Mill of 2,000 ton capacity completed.

1920 Operationsstopped except for development of Victoria ore.

1921 In March the idle No.2 Mill burnt down.
October 28: a disastrous flood struck the Beach killing 37 and destroying more than 50 homes.

1923 No.3 Mill completed.

1925 Connection with B.C.E. completed and steam plant dismantled.

1930 Britannia's peak year - reached 7,100 t.p.d. and 44,000,000 lbs. Cu. produced.

1933 Beach Hotel destroyed by fire.

1938 Production after a lull caused by the depression back to 6,000 t.p.d. and 1,224 employees on payroll.

1946 Payroll down to 400 - July 1 to October 21 strike closed operations.

1949 Road connection to Squamish.

1950 Sawmill put up on old mine wagon road beside Mineral Creek.

1952 Road completed to Townsite - later called Mount Sheer.

1956 September: the P.G.E. started regular passenger service to North Vancouver.

1958 March operations suspended because of low copper prices.
August: Seaview Highway to Vancouver was opened.
August: Britannia Mining & Smelting Co. Ltd. was liquidated.

1959 In January operations were resumed on a curtailed basis.

1963 In January The Anaconda Company (Canada) Ltd. purchased all the Britannia properties of the Howe Sound Company.

1964 Employees went out on strike on August 11th.

1965 On March 2nd, settlement of strike, with the assistance of The Minister of Mines, the Honorable D. Brothers.
Resumption of operations on curtailed basis.

A HISTORY OF BRITANNIA BEACH and SURROUNDING AREA

The Britannia property is situated about 20 air miles north of Vancouver on the east shore of Howe Sound, and is accessible by P.G.E. railroad, by car or bus on the paved Seaview Highway, and, of course, by boat.

The history of Britannia is well documented in government reports, mining magazines, and some ocurrences have made world news. Between 1925-30, Britannia was rated as the largest copper mine in the British Empire. To the end of 1965 it has produced 1,212,186,654 pounds of copper.

Only recently has the Beach been the seat of mining operations on the property, though from the start in 1905, it has been the base of all milling operations. In mining this billion lbs. of copper, 48,102,645 tons of ore were dug out of Britannia Mountain and hauled to the concentrator at the Beach where it was crushed, ground, milled and the valuable minerals separated out. Besides copper, a quarter billion pounds of zinc, over five million oz. of silver, over 450,000 oz. of gold and more than 700,000 tons of pyrite were extracted. The rejected waste rock was poured into the sea. Lately, even that has found a small market, for use in the making of cement.

In getting out all this metal, the mountain has been riddled with tunnels, and other mine headings; some 140 miles of development workings, extending from the top of the mountain, 4350 feet above sea level, to our lowest present workings 1300 feet below sea level. In the past, the men who did all this work lived in several camps located close to the orebodies which lie in a general easterly direction from the Beach. Now all workers either live at the Beach or commute daily from Vancouver.

EARLY HISTORY:

Captain Richards, surveying the B. C. Coast in 1859, for the British Admiralty, named the mountain situated behind the actual townsite, Britannia, after the 100 gun frigate in his command.

The original mineral discovery was made by Dr. A. A. Forbes in 1888. Dr. Forbes was a medical practitioner stationed near Hopkins Landing. He travelled to Britannia Creek in a small boat accompanied by a fisherman named Granger. The doctor later bought the fisherman's share in the discovery in exchange for a small boat. He returned to his discovery the following summers, prospected, did a small amount of development work and tried to interest capital. Five years later he moved up the coast and made another discovery on Texada Island.

While showing this to F. Turner of Vancouver in 1897 he described his Britannia discovery. This led to the serious development of the prospect. Turner met O. Furry (after whom Furry Creek was named) and in 1898 they staked five claims. Incredibly, these original claims have produced the bulk of Britannia ore. Turner then made a deal with Bascovits & Sons, of Victoria, and sold a half interest for $10,000.

In 1899, these claims were surveyed with two fractions added to make a solid group. A pack trail was built from the Beach, and a camp established on Jane Flats. Prospecting was done and a 150 foot tunnel was driven. Turner now managed to sell a 7/10 interest in the property for $35,000 to Walters of Libby, Montana, and the balance to G. Robinson of Butte, Montana for $53,000. (Notice how even before 1900, it was American capital that was interested). The property also included one lot of 75 acres at the Beach.

In 1900 the property was visited by W. M. Brewer of the Engineering and Mining Journal, who must have been something of a prophet, gifted with second sight. After touring the snow covered rocky hills, he reported that "If the property was worked under careful management, with a sufficiently large capital to install necessary machinery, and with a large force of men, Britannia ought to develop into a producing mine of great capacity.

At this date, January, 1900, Britannia Copper Syndicate was organized to develop the property. Robinson bought out Walters' share, gained control of the Syndicate, and increased its capitalization. He took on the active direction of the company. In 1904, an aerial tram was built from the dock at the Beach to the Halfway, 11,800 feet) and from the Halfway to the terminal at the main camp, (8000 feet). A pole line carrying power, alongside the tramway, was erected, and water licenses on Britannia Creek obtained. An upper tram terminal, where the ore could be crushed and sorted, was built, along with a concentrating plant at the Beach. Then an office, stores, hotel, and some houses added - also at the Beach.

Robinson now interested a New York banker, Grant B. Schley in the venture. He organized the Howe Sound Company under the laws of the State of Maine, and it became the holding company for the Britannia Copper Syndicate in 1903.

By 1905, the Mine, tram, and mill were operating and a shipment was made to the Crofton Smelter on Vancouver Island. This smelter, and a lease on the Mount Andrew Mine on Prince of Wales Island, were bought by the Britannia Smelting Company.

There is little to report for several years. The company did not do very well. Its mill was unable to make a satisfactory product and the mine was slow in developing good ore. In 1908, the Britannia Copper Syndicate and the Britannia Smelting Company were merged under the latter's charter. The new company was known as the Britannia Mining and Smelting Company Limited. It wasn't until 1915 that the Britannia Syndicate was wound up and other companies included - i.e. - the Britannia Land Co. Ltd., Britannia Power Co. Ltd., and Howe Sound Power Co. (South Valley).

In 1910, an exploratory working off the Mammoth Bluff cut a Fairview vein, (Fairview outcrops were known, but inaccessible) and with a fresh impetus, development surged ahead.

There was, of course, extensive prospecting going on over the whole area. Of these, the Empress group developed the only other mine. The company staked, and bought claims till 1915. With few exceptions, they owned or had mineral rights on solid blocks of claims from tide water, on Howe Sound, to east of Indian River - comprising some 25,000 acres, 485 crown granted claims and 17 Beach lots, and 8 timber licenses.

All work except Fairview development stopped; and the only drawback to more tonnage was the aerial tram which was handling only 500 tons per day. In 1912, a new low tunnel was started at 2200 Level. By 1913, plans were made for a Townsite at 2200 Level. The tunnel was completed and shaft (No. 1) and raise (68) were going up. A railway was also planned to handle the new ore, and replace the aerial tram. By the end of 1914, the railway to the top of the incline was finished and the incline part three quarters done. Hoists for the Incline cable car and No. 1 Shaft, were on the property.

At this time, the camp on Jane Creek Flat was the base for mine operations. It was crowded. The mine was developing rapidly, and this small flat was home for several hundred miners. The camp consisted of four bunkhouses, and a large cookhouse, a Jap bunkhouse, warehouse, stable, tram terminal, crusher house, office, compressor and power house, blacksmith shop, candle house, and powder magazine. There were numerous single family dwellings, a small school, tennis court, etc. All the buildings were connected by wooden covered walkways - even the track joining the Jane and Mammoth Bluff mines to the crusher tram terminal were roofed in. This was necessary because of the very heavy snowfalls.

Almost all this material was brought up on the aerial tram. The horse trail from the Beach was pretty rugged, particularly the last mile and a half that climbed 1200 feet. It was this horse trail that the miners and their wives walked, carrying their babies, on the few occasions they travelled to Vancouver. Another deterrent to "trips out" was the fact that the mine worked seven days a week - three shifts a day at this time - and continued to do so, until legislation, the Hours of Work Act, in 1934, necessitated a change.

It was here, at midnight, Sunday March 21, 1915, that a catastrophic slide wiped out about half the camp. With no warning whatsoever, the whole side of the mountain above the camp gave way. In this slide, 56 lost their lives. Most of their bodies were never recovered. 22 were severely injured. The biggest loss of life occurred when the messhouse was crushed. All this occurred in pitch dark when there was four feet of snow on the ground. The camp did not recover from this blow, and was for the most part abandoned.

This disaster only stopped production for three months. In that time, a new tram terminal was built next to the surface railway. The raise system from 2200 Level to 1050 was completed. Bunkhouses and cookhouse erected at the Tunnel Camp alongside the Power House.

This year was probably the most active year ever on the property. Much of the Tunnel camp was built, including the Store, office, and hospital. The dams on Britannia, the bins on the Incline were completed, and the locomotives and cars brought to the surface railway. See map.

The next year, 1916, the club building, an extension to the bunkhouse, a school, 40 more houses, an extension to the compressor plant and a house for the superintendent were built. Other additions to the camp came more slowly, but in the next 14 years, two more bunkhouses were built, a gymnasium, 4 apartment blocks of 16 units, and a staff house erected, and a copper plant built (1927). A swimming pool finished in 1930, completed the building at the Townsite, until a brief period in 1952, when the buildings of the Incline Camp were moved into the lower end of town to increase the housing facilities.

While the Townsite or Tunnel Camp was growing, the Beach Camp was also growing, though at a much slower pace. By 1912, there were a large number of cottages on the "flats", and the big store was put up. The mill was treating 600 tons a day, and produced 14,000,000 pounds of copper. That year the Crofton smelter was closed down because there was not enough feed - the new flotation process had reduced the tonnage. The next year, 1913, the club building was put up, and 30 more cottages built. There was regular, daily, boat service to Vancouver.

1914 saw the erection of the No. 2 mill and new wharf bunkers. Then war was declared, copper market demoralized, and operations were almost halted.

1915, the second 1000 ton unit of No. 2 mill was completed, and the Canadian Government Telegraph office opened, but the slide at the Jane Camp, and an acute shortage of manpower made it a very poor year.

1916, with old and new mills operating, 3000 tons per day were milled, and the general office and warehouse built.

1917, the Customs house was built, and a cloudburst took out the incline railway for almost a month.

1920, due to the recession following the war, the mill was shut down and only development crews kept on. The payroll was cut from 1000 to 250. The railway crew continued to supply the Townsite, and concrete storage bins for development ore were built.

1921, the idle mill was destroyed by fire in March, and seven months later, half the Beach camp was destroyed by a flood. On the night of October 28th, water impounded by the railroad fill at the Townsite, broke down the wall and surged down the creek. There had been very heavy rains - approximately 6 inches - on top of some snow. This great wall of water washed all before it out to sea. 37 were killed, 15 seriously injured, and over 50 houses destroyed.

Next year, 15 new houses were built on higher ground near the railroad connecting with the incline.

By 1923, a new mill was completed, replacing the one destroyed by fire, and a new transportation system for ore, eliminating the incline, was installed.

In 1930, Britannia's peak year, 7100 tons per day were milled with a production of more than 44,000,000 lbs. of copper. To handle the increased production of the mill, larger shops were built, and in 1929 a foundry was added. These shops were capable of making anything used on the property as well as repairing them. For a period balls for the mill were made out of rails by a "slug" plant that turned them out between worms, but this job was later done in the foundry.

Then the depression came. With copper down to 5¢ a pound, the organization was cut to the bone, and employment dropped from 1000 in 1930 to 400 in mid 1933. But during the depression years, additional accommodation was provided. The Beach hotel, which burned down in 1933, was compensated for by additional rooms added to the store building, till a new hotel and dining room could be built. New style bunkhouses, the Ritz and the Savoy were completed, followed later by two others.

By 1938, production was back to 6000 tons per day and 1324 persons were employe

The Second World War did not affect the copper market as did the First one, but the attraction of the armed forces, and higher paid industries - especially shipbuilding, caused the labour force to shrink steadily. One year 1152 men quit, and Britannia was hiring just about anything that walked. In mid 1946, with only 400 men on the payroll, Britannia's only labour strike occurred, lasting from July 1st to October 21st.

A swimming pool was built at the Beach, and by 1949, the road had been completed into the Beach from Squamish. Gradually roads were built around the Beach and the Surface crew started using trucks. A road was built to handle backfill to the No. 8 Mine, and the first mile to the Townsite was then completed.

In 1950, a group of 16 "Honeymoon" apartments were built across from the school, and a new Community Church was constructed. The 4100 yard area was built up with a large "dry" (men's change room), framing shed, car and locomotive barn, powder magazine, etc.

With the increased use of lumber (timber) in No. 8 Mine, and the rapidly increasing cost of timber, it was decided in 1950 to use company timber, which was very abundant along the old mine wagon road, and a site was chosen about 1 mile above the 4100 yard for a mill. In order to eliminate the cost of operating the surface and incline railways, which was increasing with the cost of labour, the road to the Townsite was started in 1951, and completed in Easter 1952.

The foregoing outlines the growth and development of the two main camps, but there were numerous other camps that were built and operated as the need arose, and then abandoned.

From 1916, on, the Company did extensive surface prospecting. In 1919 ore was found on Victoria claim. This ore was developed during the shutdown of 1920-22. This area was accessible only by trail up Furry Creek - seven miles from tidewater or through the mine via 1600 Level, which was connected to No. 1 shaft in 1918

In the spring of 1921, a crew living in tents, put up a sawmill, cut logs, and built a camp, which was occupied in October. This camp at its peak had 300 men. There was a tram line built to the 1600 portal, which carried the Victoria ore to the mill.

An extensive logging operation developed as the Victoria mine required a great deal of timber. A good part of the surface crew were Japanese who stayed in a separate building and also occupied a bunkhouse at 1600 portal.

In 1924, the Victoria mine was connected to the other mine workings on 2200 level and the tram no longer needed for handling ore. The tram was extended to other portals on that side of the mountain. Victoria was isolated, only accessible through the mine and up the shaft. There were no women at all. Two pool tables, a card room and a bowling alley were the recreational outlets. There was also a good library and books were exchanged with the Tunnel camp library. Radio reception was good, but not popular in the bunkhouse, as there was always someone sleeping. Chinese cooks did a good job. The camp was closed in 1933 and re-opened in 1936 for a few years till it was closed down during the war years for want of crews.

On a flat, near the top of Britannia Mountain in a beautiful location, was the Barbara Camp. Here, in 1916, at 500 foot level, two bunkhouses were built for 80 men. There was also a house for the foreman and his wife. A stable, powder magazine, etc. The camp had a pool table, card rooms, running water in each room, hot water heating, etc. The men here worked the glory holes on top of the mountain. Generally, the camp was greatly reduced during the winter months, because of the snow, and was closed permanently in 1933.

In 1917, bunkhouses were built at Empress, 1000 level, and Beta, 1600 level, portals. These large buildings housed 40 men each. The dry and furnace were on the lower floor, the poolroom, etc., and dining room, and kitchen on the second floor, with the rooms on the third and fourth floors. The Empress was closed in 1933, but reopened in 1939 for a few years. The Beta camp burned to the ground in 1926.

At the head, or top of the Incline, there was a camp first for crews working on the incline, and driving the 2700 tunnel, and later for the crews hauling and crushing the ore. This was started in 1917, with two 8 room houses. Later, 7 houses and another two-storey house were added. It too was closed for a period, 1933-37. In 1938, a new large bunkhouse, and a dry, and a hotel were built. These crews used the Townsite recreational facilities but did have a library and card rooms of their own.

Above and below the Incline were camps on Mineral Creek. There was the Goldsmith or Daisy camp, a group of log cabins at about 1600 level where tunnels (2), and a large amount of trenching was done in 1911. Below was the Seaview Camp at 3100 level and 3250 level, and the raises for the 4100 level were driven by men who lived there. This was occupied 1919-24.

In 1925, a camp was established, approximately a mile up Furry Creek from Victoria - the Fairwest Camp. This housed a crew developing a prospect in the mountain south of the creek. It was abandoned the next year. It was used by the Vancouver Water Board guard until 1940.

And, finally, there was the camp on Seymour Creek at the bank of Vancouver - Saulter's Cabins.

The Townsite, by 1950, had 143 housing untils and beds for 350 in 3 bunkhouses and hotel, and its population was approximately 850. Located high in a mountain valley, where the annual snowfall amounts to as high as 30 feet, and the surrounding mountains prevent the sun from reaching it for two months every year, it was isolated - though just 20 air miles from Vancouver. Its connection to the outside was a narrow gauge railroad, in incline cable cars, and the Union Steamships' Line.

But, there was no dearth of entertainment or employment. There were many local organizations, some short lived, and some lasting as long as there was a town. The Community Club was the father of all the organizations. Everybody was a dues-paying member, and had privileges of club rooms, kitchenette, library, reading room, pool room, gymnasium with a professional instructor, swimming pool, tennis courts.

Traditional annual events were the New Year's Ball, Burn's Night Dance, First Aid Competition, July 1st Celebration, Hallowe'en party, and Christmas Dance. In between times there were innumerable card parties, two movies weekly, frequent dance and many hobby clubs. It was an ideal place for people to develop their own talents and the place had more "characters" per unit than any other camp.

There was little difference in housing - everyone's house was about the same. The rent was low - $1.00 per room, with free water and cheap electricity, and no taxes. There were no old people, or retired couples, no unemployed. Peddlars were carefully checked at the main office, and were few and far between. There were no thieves - no one locked their doors. There was no juvenile delinquency - parents were told to straighten out their children, or get out. The church was unusual, in that Protestant and Catholic occupied the same building; and there was excellent co-operation between them. There was no graveyard.

All night poker games occurred after every pay day. They were deadly serious, stakes were high, and many a complete cheque changed hands. There were always bootleggers.

The Beach community, while not so isolated, developed along very similar lines and most organizations were duplicated in the two camps.

In 1954, things began to change at the Beach, to make way for the road, and P.G.E. railroad. This meant tearing down some houses, and moving others. Some 14 new houses were built to replace the old manager's residence. The following year, 19 other, and similar units, were added. In the fall of 1956, the P.G.E. began regular service through the country, and along the coast of Howe Sound, and for two years, Britannia was the biggest passenger point on the line. With the arrival of the passenger trains, the twice daily service of steamers to Vancouver was stopped, and a real link with the past severed.

In 1956 and in 1957 the Company was having a difficult time to adjust to lower metal prices, and early in 1958, had moved the site of all its operations to the Beach to consolidate its position. However, at the end of February, the directors decided to close it down because of a further drop in copper to 19¢, and by the end of March, 1958, the B.M.&S. Co. was employing only 10 men. During the shutdown, the place was closed up, scrap sold, idle machines sold and the Townsite, or Mount Sheer Camp, about emptied. The Company then divested itself of housing and stores.

August 8, 1958, the Company went into voluntary liquidation and its assets returned to the parent company, the Howe Sound Company.

By the end of 1958, the metal market seemed promising, a new contract was signed with the Union for two years. On re-opening, thanks to the road, it was not necessary to re-open the bunkhouse, the shops were reduced in scale to take advantage of the larger shops in Vancouver, and the foundry was not re-opened.

At first the high grade portions of the ore bodies were mined with the thought of salvaging the operation for a few profitable years, but, as the operation developed, it became apparent that the possibility of finding further ore had not been exhausted.

In 1962 negotiations were started with The Anaconda Company (Canada) Ltd., and in January, 1963, all the properties and assets of the Howe Sound Company at Britannia Beach were sold to Anaconda.

Anaconda acquired the property for use as a base for Canadian operations, but also with the belief that more ore could be found in the Britannia Mine. Anaconda has and is carrying out intensive detailed explorations, both underground and on the surface, with the objective of locating more ore.

Operations were brought to a halt, and exploration curtailed, as the result of a strike which commenced on August 11, 1964. The strike continued for almost seven months, agreement being reached, with the assistance of the Minister of Mines, the Honorable Donald Brothers, on March 2, 1965.

During the strike, the equipment had been removed from the mine, and the lower levels allowed to flood. After settlement, the equipment was re-installed, the mine pumped out, and mining was resumed at a curtailed rate of production. The mill was started up the first of June, and has been operating since then, at one-half to two-thirds the rate in effect before the strike.

Revised by W. B. M.

December 5, 1966

ORE EXTRACTION METHODS AT BRITANNIA

Ore bodies at Britannia are of two main types:

Veins: Depositions of ore-bearing material in fissures or cracks in the earth's crust. These depositions are generally five to ten feet in width and are steeply dipping.

Panels: Zones of mineralization containing numerous small veins which could not be mined economically by themselves, but when taken as an aggregate with the included host rock, constitute low grade minable ore.

In each of these types we must use a specialized mining procedure to extract the ore economically and efficiently.

Horizontal Shrinkage:

Best suited to mine the vein-type ore bodies. Working horizons or levels are established at regular 150' intervals, and the vein outlined by drifting on each succeeding level. The ore is now divided into blocks for mining purposes - rather as a piece of land is subdivided for development purposes. These blocks extend from one level to the next and can be from 100' to 200' in length.

Our ore block can be compared to a ham sandwich stood on end - the bread being rock and the ore being ham. The job is to get all the ham out of the sandwich without disturbing the bread.

As we invariably work along with gravity, mining is commenced at the bottom of a block and continues upwards as horizontal cuts or benches are taken. As this ore is drilled and blasted it falls to the floor of the stope, where the excess is drawn off through chutes. The floor of the stope - which is the top of the column of broken ore, is maintained at a convenient distance from the back or unbroken ore by regulating this excess. Manways or vertical openings from the floor of the stope to the level below are maintained for access, ventilation and servicing.

The cycle of mining becomes as follows: set up rock drills on the floor of the stope, drill off a bench, load and blast. As broken ore takes up more space than when unbroken, the excess or "swell" must be drawn off to maintain proper working room. Manway openings are raised well above the floor of the stope, and the cycle is repeated. When mining is completed the solid block has become a block of broken ore. This can now be drawn off as required to make up the flow of ore to the Mill.

Advantages are low cost of mining and high productivity which can be offset by dilution from wall rock and incomplete recovery of the broken ore due to caving.

Fifteen percent of present production comes from shrinkage stopes.

Square Set Method of Mining:

A limited amount of square set mining is done at Britannia Mines, with only about five percent of current total production being extracted by this method. The square set method is utilized to mine wide lenses and veins of well mineralized ground of sufficient grade to justify employment of this expensive mining method.

The square setting has been applied to all classes of ground, but is chiefly used where the deposit has weak walls which would slab off and cause excessive dilution to preclude shrinkage methods, and where the main weight on the timber structure comes from the back, or roof, of the deposit. Ordinarily a raise is driven through the ore body, usually in the footwall of the deposit. The raise provides access for men and materials to the stope and provides a means of ventilation. The stope faces are advanced from the raise by a series of excavations which ordinarily will accommodate one set of timber. The ore face is broken by drilling flat or slightly inclined holes, loading and blasting them such that the face is advanced in a horizontal direction. The excavation caused by a blast is usually timbered before other blasting is done.

A standard square set consists of rectangular-framed posts on each corner. Two caps and two girts are installed across the tops of the posts, with the caps across the structure and the girts parallel to the structure, thus forming an enclosed timbered cubicle (see accompanying Sketch). Floors are made by laying planks from girt to girt or cap to cap. The lowest floor is called the sill floor; the highest working floor is known as the mining floor. Generally one floor of ground is mined out before mining is started on another floor. The blasted ore falls by gravity, or is assisted by slides, or is scraped into chutes or mill-holes which are frequently drawn at the level below the stope to extract the ore. Mined out floors are filled with waste rock introduced to the stope from the level above and passed through the original raise chute.

The principal advantages of square setting are that it permits flexibility; stopes can be expanded or contracted at will, irregular stringers followed into the walls, dykes or waste inclusions left unmined, and prospecting drifts started from any floor. Virtually all the ore can be mined on a selective basis and recovered. Principal disadvantage is the high cost due to the use of much framed timber, and to a lesser extent, danger from fire.

Longhole Stoping:

This type of mining is used on the lower grade, larger ore deposits and its main advantage is lower cost mining. Its disadvantages are less selectivity and flexibility of mining procedure, more dilution from wall waste rock, and subsidence or caving of areas of the mine over the mined out area.

The general procedure used in longhole stoping is to first develop openings in the ore zone from which holes, varying in depth from 20' to 60', are drilled and blasted. These blasts break the ore into previously made voids called slots or undercuts. The broken ore is moved either by gravity or a combination of gravity and scraping to ore passes and ore cars.

Two methods of longhole stoping are presently employed:

(a) Horizontal ring drilling;
(b) Vertical ring drilling.

Design of stopes varies and is directly relative to size and position of each ore block.

Preparatory Development: The following development is required prior to stope excavation: A scram drift or bulldoze drift is driven on the footwall side of the ore block. Drifts may be driven on existing levels or between levels. Ore pass connections are established from the level below. On completion of the above, several wing raises are driven from the scram drift on 25' to 33' centres. The undercut drill drift is formed by connecting the tops of wing raises. From this point on, stope development differs, depending on which type of mining will be used.

(a) Horizontal Ring Drilling: One or several drill raises are driven through the ore block. These are in fact extensions of wing raises to facilitate raise muck disposal. The initial opening is created by shrinking a narrow block of ground between the two branches of a wing raise up to undercut drift back elevation. Intervening ground is drilled off with vertical fans from the undercut drill drift and blasted into the slot opening. Blasting of the horizontal rings, which are drilled from the drill raises, takes place into the undercut.

(b) Vertical Ring Drilling: This method requires more pre-production development than horizontal ring drilling. One branch of wing raise, generally in the widest part of the stope, is driven to connect with the level above. Slot crosscuts are driven at predetermined intervals from this slot raise. Slot crosscuts are 12' wide and run normal to the strike of ore. Slots are removed to this width (between slot crosscuts) with series of parallel holes on 3 1/2-foot centres.

Fringe drifts, 7' x 7' in cross-section are driven on footwall and hangingwall contacts. Vertical rings are drilled from these drifts and rings are blasted into slot opening.

Drilling: In both types of stopes drilling is done with extension rod machines, drilling 2" diameter holes on a full ring pattern. Rings are generally spaced 3 1/2 feet apart and burden at toes varies from 5 feet to 8 feet. Mine averages approximately 1 1/2 tons per foot drilled. The low ton per foot drilled ratio is necessitated by lack of underground crushing facilities.

Loading and blasting: Longhole crews, comprised of a leadhand and two helpers are responsible for all loading, blasting and related work such as cleaning and checking depth of holes, moving powder into loading area, etc. Capping pattern and loading instructions are compiled in a Blasting Letter. The letter also contains information on electrical hook-up, the resistance rating and other relative information.

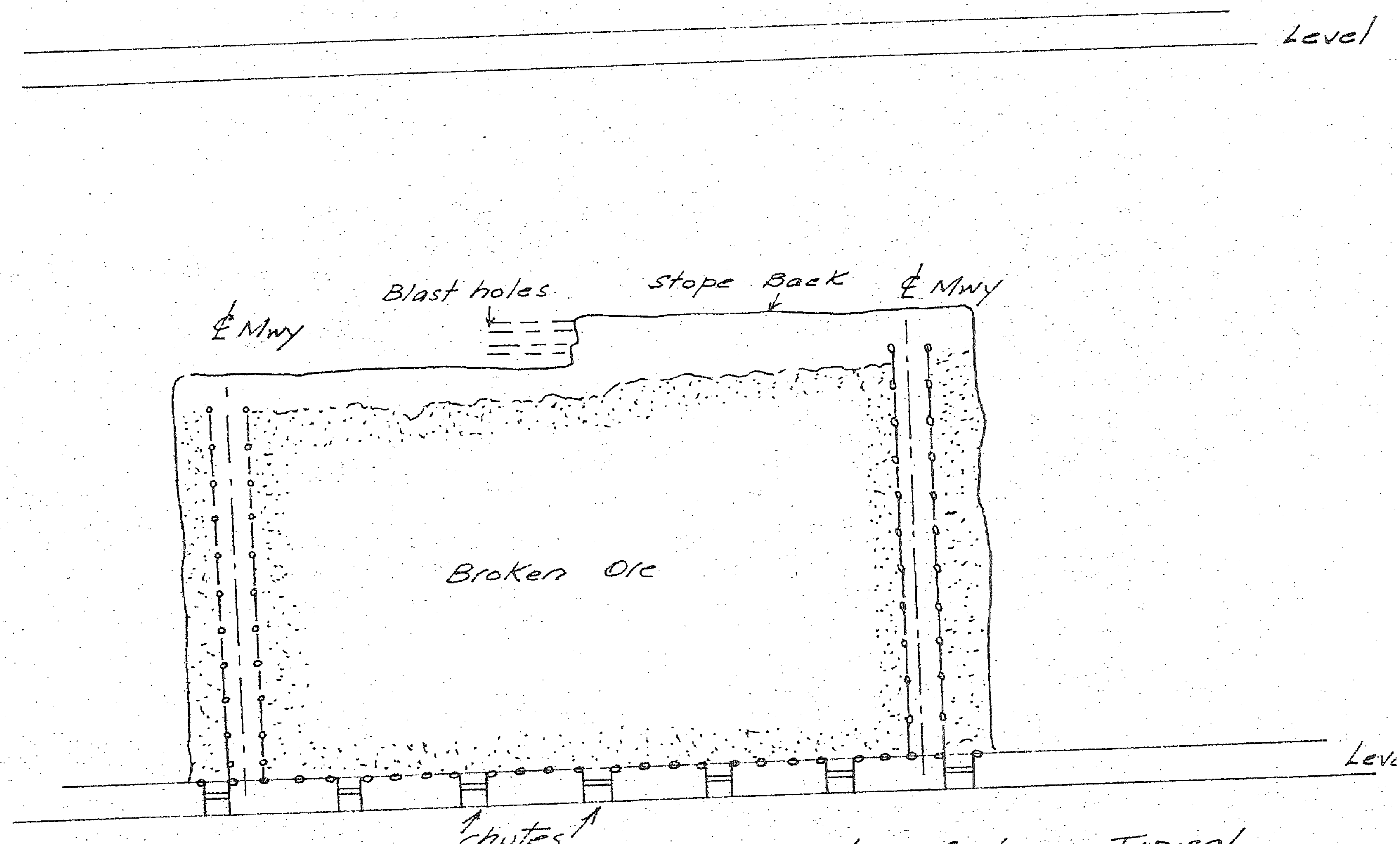
Holes are loaded with 75% Forcite dynamite in continuous columns; 0.60 pounds of dynamite is required for each ton blasted.

In dry headings, prilled ammonium nitrate explosive is used also.

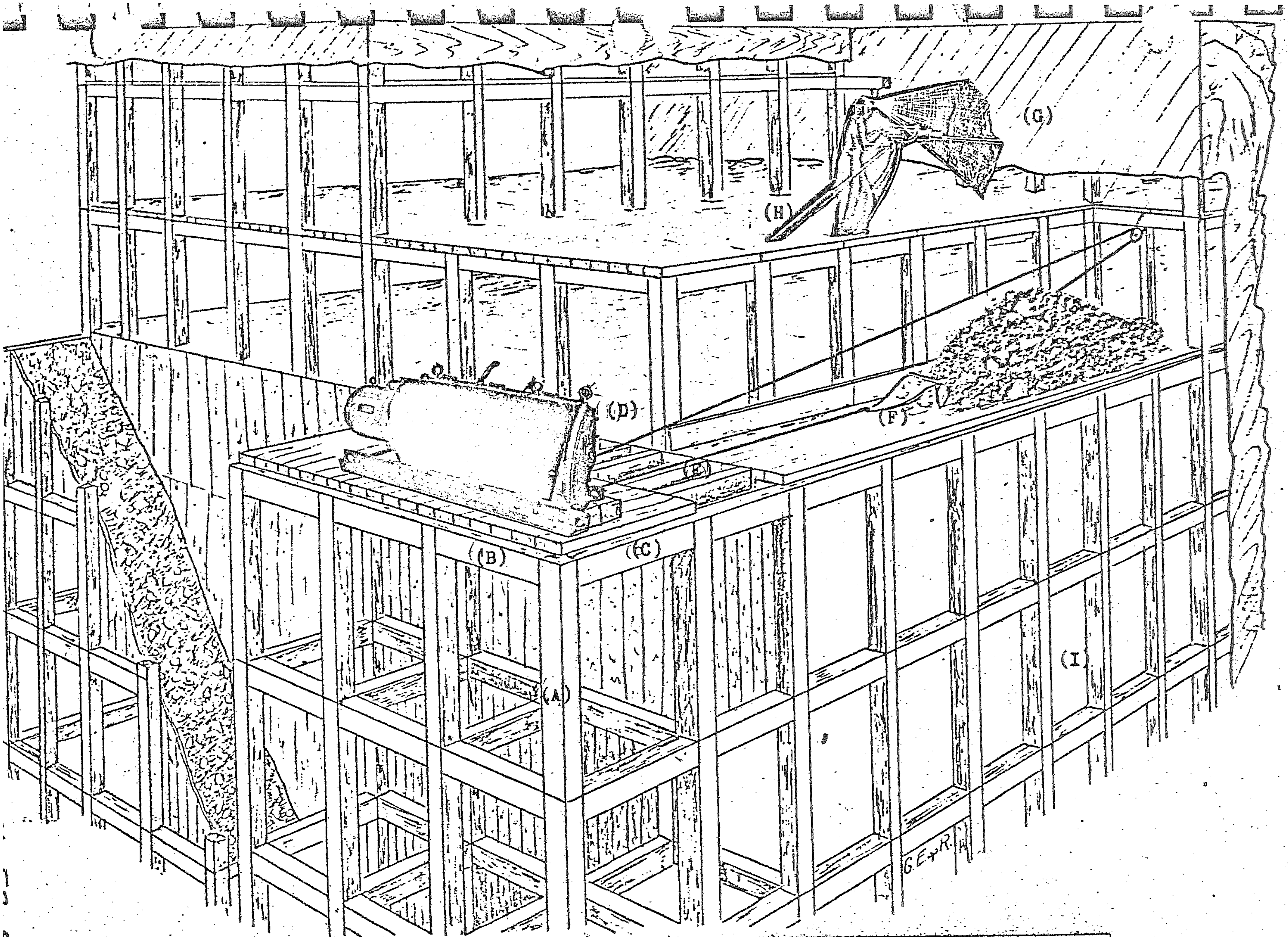
Mucking: The broken ore is now handled in scram drifts with 60" scrapers and 50 H.P. slushers. In bulldoze chambers muck is by-passed directly into ore pass. Grizzly bars are placed over the ore pass opening to size rock to -14". Oversized boulders are sand-blasted.

LP
BG /je
JG
JJK

December 5, 1966.

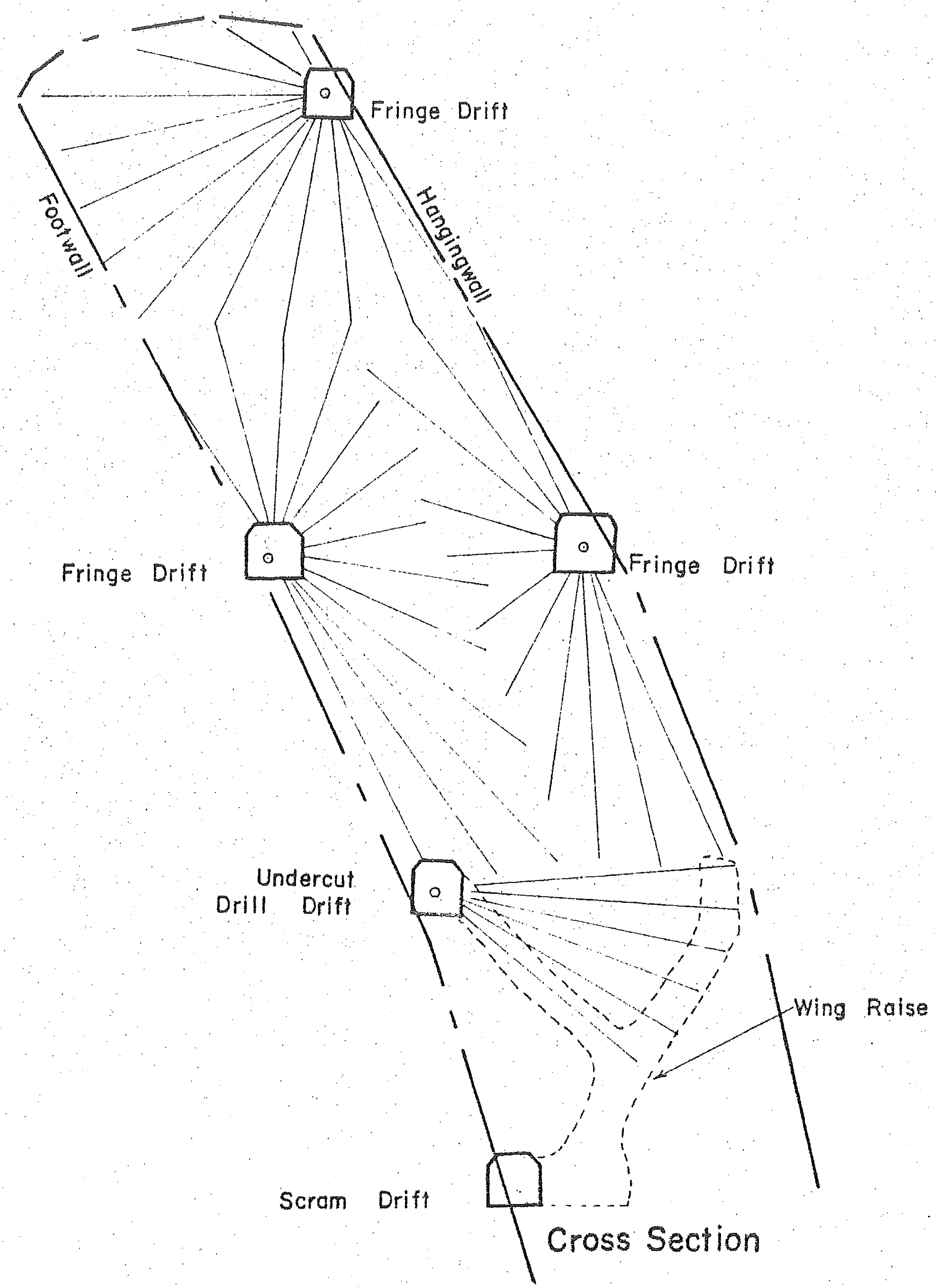


Long Section – Typical
Shrinkage Stope.
1" = 30' approx.



TYPICAL SQUARE SET LAYOUT:

(A) FRAMED POST (C) FRAMED GIRT (E) CHUTE (H) MINING FLOOR



Typical Vertical Ring Stope.

THE BRITANNIA MILL

The Britannia mill is over forty years old, and in many respects differs from a modern mill, particularly as regards physical layout and types of equipment. Nevertheless, the mill produces metallurgical results which would be a credit to any mill in the world.

We will attempt in these notes both to describe the earliest features of the Britannia mill, and the changes which you might see if you were visiting a mill of the latest design.

I Physical Layout

The mill occupies a steep hillside site as was characteristic of the mills of the twenties. At that time, truly satisfactory sand pumps had not been developed, and every effort was made to utilize gravity flow to the maximum extent possible. The advantages inherent in such a design were the savings in power and pump maintenance costs provided by gravity flow, particularly with the coarser products handled in the gravity separation methods then in use.

The disadvantages which make steeply-sloping mills a rarity today are the excessive cost of building design and construction, and the inefficient use of both labour and supervision which result from an excessive number of operating levels. Even the best of operators and supervisors can find convincing reasons why one more trip up several flights of stairs to check a bearing temperature or a reagent feed rate isn't really necessary.

II Crushing

Until 1958, primary crushing was performed underground. At that time, increasing distances underground made centralized crushing in the mine prohibitive in cost. The present primary crusher, a 24" x 36" Buchanan jaw crusher was installed at that time. The discharge from the jaw crusher goes to Symons Short Head Cone Crushers and then to fine ore bins.

A modern design would utilize essentially the same equipment, i.e. a jaw or gyratory crusher as a primary, and cone crushers as secondaries, but the crushing plant would be housed in a separate building for purposes of dust and noise control, and a primary crusher would precede all storage.

III Grinding

Grinding is accomplished in two stages, (1) in rod mills in open circuits, followed by (2) ball mills in closed circuit. Open circuit means the ore has a single pass through the mill. Closed circuit means a sizing and sorting device is provided to return oversize products to the mill for another grinding step.

The rod mills are 8' x 12' Dominion mills, using alloy steel liners. Each mill has a capacity of about 75 - 80 tons per hour. The rods are 3½" diameter. Rod consumption on normal Britannia ore is about one pound per ton of ore.

The ball mills were originally built as Danish Pebble Mills, i.e., they were intended to operate using very hard flint pebbles from Denmark as grinding media. The mills now use steel balls, and consequently are very much underpowered. The mills operate in closed circuit with classifiers. We have two types of classifiers (1) Dorr Rake Classifiers and (2) Esperanza type classifiers designed and built at Britannia and called Munro classifiers after a former mill superintendent here. The classifiers rake coarse or oversize sands back to the mills for additional grinding while the fine sands and slimes overflow a weir and are sent to flotation.

The ball mills use a combination cement and steel slug liner developed here and known as a Britannia liner. The mill charge is either 2" Nihard slugs or 2" forged steel balls.

IV Flotation

The ground ore from the ball mills (actually the classifier overflow) next goes to flotation. Flotation is a process where finely ground ore and water are mixed with various chemicals and oils and agitated vigorously. A froth is produced which carries certain mineral particles to the top of the cell or tank containing the pulp. The process works because the chemical constituents of the pulp can be varied so certain minerals become wetted and sink, while other minerals become attached to the air bubbles in the froth and are floated out of the cell. The process is <u>not</u> dependant on the specific gravity of the various minerals. In most separations, heavy sulphides are floated while lighter silicates sink.

The various reagents or chemicals we use in flotation can be divided into four classes. These are classified as 1) Modifiers, 2) Frothers, 3) Activators, 4) Depressants and 5) Collectors. Their usages are as follows:

1) Modifiers generally are acids or bases which are added to change the pH of the pulp. pH in case you are not familiar with the term is an electrical method for determining the acidity of a pulp or solution. A low pH number indicates acidity, a value of 7 is neutral, and a value above 7 indicates a basic solution.

2) Frothers, as the term implies, are reagents used to produce froth. They are usually oils, alcohols, or soaps.

IV Flotation (Continued)

3) Activators are chemicals used to produce a mineral surface amenable to flotation. For example we use copper sulphate to produce very thin copper mineral surfaces on the zinc mineral sphalerite.

4) Depressants are chemicals used to produce a mineral surface not amenable to flotation. Here we use zinc sulphate when we want to depress the sphalerite at a later stage.

5) Collectors are chemicals which produce air coated mineral particles which will float. A chemical family known as the "Xanthates" are a very important group of collectors for sulphide flotation.

Flotation chemicals are used in very small quantities, on the order of tenths or even hundredths of a pound per ton of ore. Proper reagent addition is critical for successful flotation, and over-addition may be as harmfull as adding too little.

Britannia practise is to make a "bulk" flotation of all the sulphides followed by "differential" flotation of first, the copper minerals, next the zinc, and finally the pyrite. These separations are accomplished in flotation machines, of which there are two main types, pneumatic and mechanical. Pneumatic machines use compressed air to produce pulp agitation, while mechanical machines use a mechanically driven agitator of some type. There are also combination machines using both types of agitation.

Britannia uses pneumatic machines, a type known as the Forrester for differential flotation, and a deep cell variation developed here and known as the Britannia cell for bulk flotation.

The flotation concentrates are gathered in large tanks knowns as thickeners where they are allowed to settle. Water overflows the top of the tank, while concentrates are drawn from the bottom of the tank, filtered, and sent to storage to await shipment.

V The Re-grind Section

In our bulk flotation we use copper sulphate to produce a copper mineral surface in the zinc minerals and permit them to float. In order to depress the zinc at a later stage, we must remove this copper surface. It is also desirable to reduce the amount of soluble salts in the water before making the differential separation. We accomplish this by thickening, filtering, and regrinding the bulk concentrate. The re-grind attritions the surface of the zinc minerals to produce fresh zinc sulphide faces which will not be collected by xanthates.

WRS/je
September/65

COPPER PRECIPITATION AT BRITANNIA

The method of obtaining copper by precipitating it from copper bearing waters using iron as a precipitant is one of the oldest methods known. It was carefully reported by metallurgists in the 16th century. This method has been in use at Britannia since 1924 when a plant was erected on the 1000 Level Jane Flats. This plant was improved and several other small plants, both on surface and in the mine, were operated until 1928. In 1927 a tank type plant was built at Mt. Sheer, going into operation in January 1928. The other plants were closed and the high grade waters were separated and flumed into this new plant. The plant used scrap cans as a source of iron for precipitating media. It operated until early this year and is now being salvaged. A plant was built at the Beach level in 1955 to treat the low grade waters from 4100 Tunnel. This plant is a concrete launder type and like the Mt. Sheer plant uses scrap tin cans as precipitating media. Last year a section of the plant used heavy steel scrap to supplement the cans. In 1965 a new launder type plant was built at Mt. Sheer to handle all the water coming out of the mine at 2200 Level, or almost ten times the volume of the older plant it replaced (most of this water had been going to waste).

Mining at Britannia Mountain has disturbed the surface and the water and snow falling on this area find its way into the mine rather than draining into the valley bottoms. Thus all the precipitation from an area of approximately 340 acres at elevation above 3250 feet above sea level is taken into the mine to come out at either 2200 or 4100 levels. The average annual precipitation is 108 inches. Due to the high average elevation the melt is held back and the heavy run-off is spread over the months of June and July. This water comes into contact with mineralized rock and due to chemical and bacterial action between the copper and iron bearing sulphides it leavesthe mine carrying copper sulphate, ferrous sulphate, ferric sulphate, sulphuric acid and numerous aluminum salts plus varying amounts of suspended matter. It is interesting to note here that the copper content of the water increased with the increase of flow which is the reverse to what one would normally expect. The reason is that the excessive flow of water reaches places that have had a rest and during this interval oxidation and bacteria have had a chance to work. The water issued from the mine at 200 Level is clear as there is no mining operation to disturb it. At the Beach the water from 4100 Tunnel up to a total of 2,500 gallons/minute goes to a large settling pond to remove contained sediment before going to the plant for treatment. As soon as the acidic copper water strikes the clean iron it starts to attack it and soon pure copper is visible on the iron. Gradually the copper completely replaces the iron with a soft porous plating of copper. In the launder type plants the copper is recovered by turning the tin over with a tractor and washing the loosened copper into a settling pond where it is later removed with a front end loader. The following reactions are basic:

$$Fe_2(SO_4)_3 \text{ plus } Fe \longrightarrow 3FeSO_4$$

$$CuSO_4 \text{ plus } Fe \longrightarrow FeSO_4 \text{ plus } Cu$$

As the ferrous sulphate is soluble it is washed away with the tailings and as the copper is insoluble it settles out as a precipitate. This reaction is favourable under acidic conditions; i.e. with a pH of better than 3.5 and a grade of 1 gram/litre. The reaction is more difficult to achieve with more dilute solutions and more iron is required to effect this end. At one gram per litre copper (10 pounds per 1,000 imperial gallons) only 0.9 pounds of iron is required to recover one pound of copper. However, in practice at the Mt. Sheer plant with an average head of 0.125 grams/litre copper and an average recovery of 85% almost 2¼ pounds of iron are used to recover a pound of copper. (Note the first equation above showing iron loss due to ferric sulphate). At the Beach plant with an average head of 0.05 grams/litre copper almost 3½ pounds of iron are required to recover a pound of copper and only a 55% recovery is realized. (A higher recovery would greatly increase the iron cost.)

Some plant statistics –		Mt. Sheer	Beach
Flow	imperial gallons/minute	400 – 2500	400 – 2500
Heads	grams/litre copper	0.100 – 0.175	0.030 – 0.105
Recovery	percent	50 – 90	30 – 75
Recovery	pounds of copper	Approx. 385,000	Approx. 78,000
Scrap tin used – tons		425	120

ATS/ww

December 3, 1966

JANE BASIN PROJECT

In 1964, The Anaconda Company initiated a programme to rehabilitate, sample, and study the older mine workings (2200 Level and above) with a two-fold purpose in mind:

1. Increase the volume and copper content of mine ditch water flowing to the precipitating plants. This would be accomplished by diverting present natural flows of water into dry stopes on the upper levels and also by bringing additional water into the upper levels by pipe lines from outside sources. In conjunction with this, water surveys and samples were to be taken on the various levels to trace water courses and determine any increases in copper content as it percolated down through the old workings.

2. Determine the feasibility of re-mining, by open pit, the old workings and recover any copper left by previous underground mining methods. This would require extensive sampling and sample drilling.

A main access road was built in the summers of 1964 and 1965 from the Old Townsite to the area known as the Jane Basin or 1050 Level. The portal of the 1050 Level was uncovered and many of the old workings rehabilitated. In the summer of 1966, all of the glory holes or areas of surface subsidence were made accessible by roads and rotary and diamond drilling started. In addition, a sampling plant was installed in the Jane Basin so that bulk sampling of the surface rock could be accomplished.

LP/je
12-5-66

GEOLOGICAL RESEARCH LABORATORY

This lab was set up last year as part of The Anaconda Company's recently expanded program of research. Though two new geological laboratories have been constructed by the Company in the last few years and several others are in the planning stages, for many years basic geological studies have been in progress at the original Butte Mine. The purpose of these studies has always been to find out everything possible about the conditions under which ore bodies form, with the idea that the understanding of known ore bodies will help in finding new ore bodies.

The main purpose of this laboratory is to study the Britannia Mine. Because the Britannia Mine is similar in many ways to a number of mines in eastern Canada and British Columbia, what we find out about the ore here will be applicable not only to finding new ore bodies at Britannia, but will also be useful in exploration throughout Canada and the rest of the world.

Most ore bodies and the rocks associated with them originate deep in the crust of the earth. Since it is impossible to watch an ore body forming, we have to try to figure out by studying the minerals which make up rocks and the textures of rocks, what actually caused ore to form. The advances of our technological age have provided the modern geologist with many new tools not available even a few years ago. However, many of the techniques used in the laboratory have been in use for over a hundred years.

The most basic tool for studying rocks and minerals is the microscope. To study rocks with the microscope, paper-thin slices of rocks which are transparent to light have to be prepared. Another very useful tool is the X-ray machine. With our X-ray machine it is possible to identify minerals and determine their atomic structure, and also to analyze any rock or mineral to find out its chemical composition. Recently we have been doing a large number of analyses of rocks from near ore bodies to find out if these are any different from rocks not near ore bodies -- if there were detectible differences, then this would be very useful in looking for new ore bodies.

To test various ideas on the origin of ore we have an experimental laboratory where we can reproduce on a small scale pressure and temperature conditions deep in the crust of the earth where ore bodies form. Other facilities in the laboratory include devices for separating minerals by their magnetic properties, or by their heaviness; a chemical laboratory where synthetic minerals can be prepared, or the melting temperature of rocks determined; a photographic dark room for developing and printing films to illustrate reports presenting the lab findings; and offices and a drafting room where maps and reports are prepared.

CJH/je

June /66

November 15, 1957.

BRITANNIA'S POWER DEVELOPMENTS

Cliff Watson - Electrical Foreman.

Britannia's original hydro plant was installed at Britannia Beach in 1905 in the vicinity of the present freight wharf. The foundation of the power house was 10 feet above high tide level so as to provide a maximum effective head for the water that was carried down from the Tunnel Dam by means of 18" diameter wood stave pipe and 12" and 10" diameter steel pipe. The electrical development consisted of two 200 KW Generators, each direct connected to a 330 HP Pelton Water Wheel. Also in the power house was installed one 400 HP Pelton Water Wheel connected by a rope drive to a 2,500 cu. ft. Ingersoll-Rand air compressor. This provided a total of approximately 1,000 HP of energy from the power house equipment. Tunnel Dam was built at approximately 1990 ft. elevation to divert Britannia Creek water into the pipe line.

The Tunnel Power House was built at approximately the 2100 ft. elevation and water was obtained from Marmot Creek to provide for the generation of 440 HP of electrical energy and 360 HP of mechanical energy for driving air compressors, all totalling 800 HP.

Water was also provided from Mineral Creek dam at 800 ft. elevation to develop 400 HP for driving machines in the Mill. Total 2,200 HP.

In 1912 a Steam Turbo-Generator (rated at 700 HP) was added to the Beach Power House, thus making hydro and electrical power available to a total of 2,900HP.

In 1913 a power house was built at an elevation of 165 feet and a 200 KW Generator was installed with electrical characteristics to match the other two generators. The purpose of this move was to make tail race water available for mill wash water.

In 1915 it was decided that the 200 ton mill was inadequate for Britannia's requirements and that a 2,000 ton mill should be built. This meant that additional power would have to be made available.

To accomplish this a 2,000 KW turbo-steam generator was added to the steam plant and new systems of dams and pipe lines were installed to provide water power for the development of electrical and mechanical energy. Both the Beach and Tunnel Power Houses were enlarged to accommodate the additional equipment required with the result that they were made approximately as they are today.

The hydro and electrical equipment in the Tunnel Power House consists of:

Two 550 HP Pelton water wheels, each direct connected to a 3,600 cu. ft. capacity Ingersoll-Rand air compressor. These wheels are operated on water from Park Lane dam at 650 lbs. pressure.

Two 300 HP Pelton water wheels, each direct connected to a 200 KW 6,600 volt motor. These are the two original generators from the Beach Plant which were installed in 1905 and are now used as motors to drive two Ingersoll-Rand air compressors by belt drive, the water wheels being used only for starting purposes.

One 100 HP motor belt connected to a 650 cu.ft. capacity air compressor.

Also for developing compressed air, in 1928, a 500 HP motor direct connected to a 3,200 cu. ft. Ingersoll-Rand compressor was installed.

For developing 500 Volt D.C. for railway purposes there is one 1,250 HP Pelton Water Wheel connected to an M.G. Set, the A.C. end of which can be run either as a motor or as a generator. The D.C. generator can be run by the A.C. motor or the water wheel, the wheel having sufficient capacity to carry both the A.C. and D.C. loads. The capacity of this set is 500 KW A.C. and 300 KW, D.C.

There is also a duplicate M. G. set to the above operated by the 500 KW 6,600 volt synchronous motor only.

In 1932 the original switchboard in this power house was replaced and modern metal-clad gum filled type switchgear with removable type Oil Circuit Breakers and a steel control Panel was installed. Power for the operation of these circuit breakers is from a 60 cell storage battery which also furnishes emergency lighting for the power house in case of a power failure.

Hydro and Electrical Equipment in Beach Power House

There are three A.C. generators, each being Canadian Westinghouse Co. machines rated at 2,500 KVA, 3 phase, 60 cycles, 6,600 volts at 720 R.P.M. These are driven by Pelton Water Wheels.

No. 1 generator has a shaft extension at each end on which are overhung two Pelton water wheels with two needle nozzles each making a combined capacity of 3,750 HP. The wheels are governed by deflector nozzles operated by a Pelton governor. This machine is operated on water from South Valley dam with a pressure of approximately 300 lbs.

No. 2 generator has a Pelton water wheel on one end only and one hand-operated needle nozzle and a deflector nozzle operated by a Pelton governor. This wheel is rated at 3,750 HP and is operated by water from Tunnel dam at a pressure of approximately 800 lbs.

No. 3 generator has a combination system of water wheels all connected on one end of the generator. One wheel is the same as that of No. 2 generator and the other two wheels are the same as on No. 1 generator, making it possible to operate this machine on either Tunnel Dam or South Valley Dam water.

The exciters for Nos. 1 and 3 generators are M.G. sets and No. 2 generator has its exciter belt connected to the generator shaft, thus providing a means of exciting the generator following a complete shutdown of the plant.

For generating 250 volt D.C. power for the Beach Railway and cranes and magnets there is one 150 KW generator direct connected to a 300 HP Pelton water wheel driven by South Valley water. A stand-by for this service is a 150 KW M.G. Set.

For generating 550 volt D.C. power for the 4100 haulage there is one 200 KW M.G. Set with a 330 HP Pelton water wheel which is now used for starting duty only.

Compressed air is developed in this Power House by two compressors. No. 1 is driven by a direct connected 600 HP synchronous motor and No. 3 by a 200 HP motor.

The main switchboard consists of 14 marble panels controlling the three A.C. generators, D.C. generators, synchronous motors and eight outgoing H.V. circuits and the B.C.E. power. A second board of two panels contains recording instruments and protective relays for the B.C.E. power. All H.V. circuit breakers are remotely operated type with the operating power being supplied by station storage batteries. Here again the storage batteries provide emergency lighting for the operators.

In 1921 the Mill burnt down with the result that a third mill was erected in 1922. At this time the B.C.E. Co. constructed a 34,000 volt transmission line from North Vancouver to Britannia. This power is transformed by three 2,000 KVA transformers to 6,600 volts and connected to the main H.V. bus bars in the Beach Power House through a 600 amp. oil circuit breaker. Britannia's generators are synchronized with the B.C.E. power and are operated on a base load depending on the volume of water available. Thus the B.C.E. system supplies any additional load required and controls the frequency of our system.

Following the installation of the B.C.E. service in 1923 the 2,500 KW turbo-steam generating plant was dismantled and sold.

It may be of interest to consider the sources of water available for Britannia's hydro equipment. Due to the nature of the terrain above the power houses there is no natural location for any large storage of water so the bulk of the power generated from this source depends largely upon the run-off in the several watersheds. However, some dams were built to provide a certain storage capacity for the essential water requirements during the months when there is little or no run-off.

Above the Tunnel Power House there are three storage reservoirs. At 4,775 ft. elevation is situated Mountain Lake which has a capacity for 17,000,000 cu. ft. (417 acre feet) of water. Approximately 700 ft. lower at the 4080 ft. level Utopia dam was constructed to provide a capacity for 35,000,000 cu. ft. (700 acre feet). Following down the natural creek bed to the 3547 ft. elevation Park Lane dam was erected providing 20,000,000 cu. ft. storage. With these three reservoirs we have a possible 72,000,000 cu.ft. of water available when they are full. It is interesting to note that this full capacity is only available for a month or two during the early summer.

Looking at the map you will see that any water released from Mountain Lake will flow down the creek to Park Lane dam. This water can be drained at a rate of 2 1/2 M. cu. ft. per day, that is it could be transferred to Park Lane dam in 7 days.

Likewise water released from Utopia will flow down to the Park Lane dam. This flow is regulated by control gates in the discharge pipes and is transferred as required.

From the Park Lane dam a pipe line carries the water to the Tunnel Power House. This pipe line is 2 1/10 miles long and consists of 3,225 ft. of wood stave pipe and 7,900 ft. of steel pipe. The water through this line reaches the Tunnel Power House at 650 P.S.I. pressure.

After passing the water wheels in the Tunnel Power House this water flows into the Tunnel dam, situated just below the Power House, with a storage capacity of approximately 1,000,000 cu. ft. Water flowing in the Britannia Creek watershed above Tunnel dam which is not retained in the upper dams flows down the creek to Tunnel Dam.

From this dam the water is carried to the Beach Power House through 7,700 ft. of continuous wood stave pipe and 6,900 ft. of steel pipe, a total length of 2 3/4 miles. The wood section of the line is from 36" to 28" diameter. The pressure at the Beach Power House is approximately 800 lbs. P.S.I.

The other source of water supply is from both the North and South Forks of Furry Creek. The diversion dam in Furry Creek is known as South Valley dam, and is situated in the north branch at 925 ft. elevation, with a storage capacity of about 1/2 million cu. ft. In the south fork is a small diversion dam with practically no storage from which the water is diverted through a tunnel to the north fork where it empties just above South Valley dam.

The water, on leaving the dam, is carried to the Beach Power House through pressure tunnels and pipe line. This has an overall length of approximately 4 miles and delivers water at 300 lbs. P.S.I. pressure. The continuous wood stave pipe at the dam end is 5 ft. I.S. diameter and tapers down to 32" I.S. dia. where it connects to 640 ft. of 28" dia. steel pipe which brings the water into the Power House.

Power Available from Storage

In the Tunnel Power House it is possible to use 600,000 cu. ft. of water per day in driving the two air compressors and 400,000 cu. ft. per day through No. 2 M.G. Set. This is a total of 1,000,000 cu. ft. per day and as there is a total storage possible of 72,000,000 cu. ft. it is apparent that the water could be used up to 72 operating days. This, however, would only provide 50% of the energy required at the Tunnel Power House for Mine operation itself.

Now to supply this same amount of water on through Tunnel dam to the Beach Power House the total energy developed would provide 20% of our full load requirements. It is apparent that this amount of water would be useless for endeavouring to operate the plant efficiently.

However, if Mt. Lake and Utopia dam gates were opened so as to spill the water in sufficient quantity to provide a full Britannia Creek load at both power houses the storage would provide for approximately 2/3 of our total electrical requirements for 20 days.

This will indicate how essential it is that the water be conserved and how much we depend upon continual precipitation to provide a good run-off from the watersheds.

Now to consider the water from the South Valley area. I intimated that S.V. dam is only a diversion dam as its storage would last about 2 1/2 to 3 hours, at the maximum rate of use and then only provide nearly 1/3 of the full load requirements. Fortunately the Furry Creek watershed comprises 22 sq. miles so provides a good run-off for a good part of the year. It is interesting to note that occasionally at the end of the summer when we have all enjoyed basking in sunshine for a month or more the run-off from this watershed drops to nil and in order to maintain the services it provides apart from electrical generation, water has to be by-passed into the S.V. system from the Tunnel dam line. Fortunately this does not happen very often.

From what I have told you those of you who operate departments using blocks of power, such as sections in the Mill and the Foundry, will realize why we ask your co-operation in notifying the Beach Power House operator when you make any appreciable change in your power requirements whether by starting up or shutting down. This enables the operator to use or conserve the water that is available and control the demand from the B.C.E. system. It will also be apparent why we have to shut down when the B.C.E. power is off during periods when the run-off water is low.

While referring to the run off in our water sheds it may be interesting to consider our precipitation which is so necessary. Recordings are made at both power houses for the Dominion Meteorological Department and these reports provide us with the following results:

The past ten year average annual precipitation at the Tunnel Power House was 105", during these years the minimum was 85" and maximum 130"; at the Beach Power House corresponding figures were 79" avg. and 66" minimum and 92" maximum. During these 10 years the monthly minimum was .62" and maximum 20.19" at the Beach, Mt. Sheer would be slightly higher.

Britannia's Annual Power Requirements

In regard to power consumption it is interesting to note that, averaging the past ten years, Britannia's annual consumption was 44,000,000 KWH, the highest year being 47,000,000 KWH. During this period Britannia generated an average of 30 1/2 M. KWH, with an annual max. of 35 1/2 M. KWH. Purchase power averaged 13,400,000 KWH with an annual maximum of 18 1/2 M. KWH.

In other words, Britannia generated 70% (Max. 78%) of her requirements and purchased 30% (max. 40%).

Britannia's generated power was 8.9% in Tunnel Power House and in the Beach Power House 33.9% from Tunnel dam and 27% from South Valley.

Our monthly energy generated has varied from 4,000,000 KWH to 400,000 KWH. This minimum figure of course being produced by water drawn from Britannia Creek reservoirs.

Our connected load is some 14,000 HP and the maximum demand is approximately 10,000 HP. This is distributed 56% (5,600 HP) in the Mill, 24% (2,400 HP) for mining and 20% (2,000 HP) on the surface.

The power is distributed from both power houses at 6,900 volts and stepped down through transformers to 115/230 volts for lighting, 220 and 440 volts for power loads and for No. 8 hoist only 2,200 volts.

Cliff Watson

November 15, 1957

Cap. 17,000,000 cu.ft.
Drains at 2,500,000 cu
Water shed .07 sq.mi.
Limited use. Requires
2 years to fill.

Ophelia Dam
El. 4080'
Cap. 35,000,000 cu.ft.
Gate open 4" drains at 400,000 cu.ft./day
Water shed .455 sq.mi.

Park Lane Dam
El. 3457'
Cap. 20,000,000 cu.ft.
Watershed 1.08 sq.mi.

3,225' wood stave pipe
7,999' steel pipe

1 KW requires 25 cu.ft.

Tunnel Power House
El. 2100' Park Lane water at 740 PSI
Capacities:

#1 compressor	700	cu.ft./min.	100 HP 440 Volt
#2 "	1250	"	250 KW 6900 Volt
#3 "	3350	"	490 HP Pelton 300,00[illegible] cu.ft.
#4 "	3350	"	" " "
#5 "	1400	"	250 KW 6900 Volt
#6 "	3200	"	500 HP 6900 Volt
#1 M.G. Set	575 V.DC		500 HP 6900 Volt
#2 M.G. Set	575 V.DC		500 HP 6900 Volt and
	500 KW		1250 HP Pelton/400,00[illegible] cu.ft.

Britannia Creek

Tunnel Dam
El. 1990'
Cap. 1,000,000 cu.ft.
Watershed 3.71 sq.miles

7,700' Wood stave pipe
6,900' steel pipe

1 KW requires 25 cu.ft.

820 PSI

Marion-Phylis Dam
El. 1510
Cap. 16,000,000 cu.ft.
Watershed 2.55 sq.mi.

South Valley Dam
El. 925'
Cap. 500,000 cu.ft.
Watershed 19.5 sq.mi.

4 miles pipe line

1 KW requires 100 cu.ft.
345 PSI

Beach Power House

continued on page 2

Beach Power House

El. 155'

Capacities:

#1 generator	on South Valley	2500KW	Pelton drive.		6,000,000	cu.ft./day
#2 "	on Tunnel Dam	2500KW	"	"	1,000,000	"
#3 "	on South Valley	1250KW	"	"	3,000,000	"
	on Tunnel Dam	1250KW	"	"	750,000	"
#4 "	on South Valley	150 KW	"	"	720,000	"
#5 "	150 HP	150 KW AC drive				
#6 "	200 HP	200 KW AC drive/water start				
#1 Compressor	600 HP 3000 cu.ft.air per min.					
#3 "	250 HP 1500 " " " "					

Mill wash water

Britannia Creek

British Columbia Electric

El. 350'

Cap. 3-2000 KVA

34,000/6900 Volts