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THE KAISER RESOURCES PROJECT

LOCATION, ACCESS AND CLIMATE

The Kaiser Resources project is located at Sparwood in the Crows Nest Pass area in the southeastern portion of British Columbia in what is known as the Kootenay coal formation.

Access to the property is by way of the Southern Trans-Canada Highway which is also British Columbia Route 3, 21 miles north of Fernie, B.C., or by way of Highway Route 3 from Alberta. Calgary is approximately 200 miles distant from Sparwood (Figure No. 1).

Although temperatures may reach as low as minus 40 Celsius degrees the climate is generally moderate. Winter temperatures are in the 5 to minus 20 Celsius degree range. An occasional "chinook", or warm-bearing winds, will bring rain and warmer temperatures to the area. There is abundant snowfall between November and April, reaching as much as 24 feet. Summer temperatures reach a high of 32 degrees Celsius.

HISTORY AND OWNERSHIP

Coal was first discovered in the area, over a century ago, in 1873 by William Fernie. The Crows Nest Pass Coal Co. was formed in 1897, taking its name from the Crows Nest Ridge on the border between British Columbia and Alberta, to mine coal in the Coal Creek-Morrissey district near Fernie. Several years later they began coal operations in the Michel Creek Valley, several miles southeast of Sparwood.

Most of the coal mined was used as locomotive fuel by the Canadian Pacific and Great Northern Railroads. However, with dieselization of the railroads, the markets for southeastern B.C. coal were greatly reduced forcing closure of many of the mines in the area. Crows Nest Industries closed its Coal Creek operation in 1958 but continued to operate the Michel Mines.

In 1966 the Crows Nest Pass Coal., changed its name to Crows Nest Industries (CNI). Up to 1970 when Kaiser Resources assumed control, the Michel Mines produced about one million tons of coking coal annually.

Over the years CNI acquired considerable coal lands extending 28 miles north of Sparwood to a point about 30 miles south of the town.

In 1966 CNI approached Kaiser Steel with a lease offer if suitable markets could be developed. However, development of that market was faced with obstacles.

The Japanese were reluctant to enter into any long term contracts where the export prices were supported by government subsidies. The high freight rates between Sparwood and Vancouver and the inability of that port to handle the 100,000 ton carriers were critical issues. Consultation with the various parties resulted in the following developments:

1) The Canadian National Harbours Board dredged and created a 3 mile long causeway and a 50 acre island at Roberts Bank, south of Vancouver, to form a new shipping terminal.

2) Kaiser constructed loading and shipping facilities on the island under the name of Westshore Terminals Ltd.

3) CPR agreed to use unit trains to deliver the coal to Westshore Terminals at reduced rates.

4) Kaiser acquired, by lease, 108,000 acres of coal lands from CNI.

5) A 15 year contract was finalized with Mitsubishi.

GEOLOGY

The coal-bearing measures, of Lower Cretaceous age, are part of the Kootenay formation. The formation varies in thickness from about 300 feet at the northern end to about 2,000 feet at the southern end. This coal basin contains from 8 to 15 seams varying in natural thickness from 5 to 50 feet.

The seams are numbered from the bottom up, starting with the Balmer or No. 10 seam. There are four seams above the No. 1 designated in ascending order as A,B,C and D.

In the present strip mining area, Figure 1, on Balmer Ridge the No. 10 seam averages 50 feet thick, but is locally much thicker as a result of folding and faulting and is the only seam left. All others having been lost through erosion although some traces of No. 8 and 9 remain.

Balmer No. 10 dips up to 30 degrees to the southwest from Harmer Ridge, passing under the Michel Creek valley, then rising on the south side of that valley. The higher seams outcrop on both valley sides.

The rock between the seams consists mainly of laminated shales and lesser sandstone.

Exploration has proven strippable reserves of over 100 million long tons of Balmer No. 10 seam coal on Harmer Ridge. Underground reserves exceed strip reserves.

The volatile matter in the coal seams decreases with depth ranging from high to low volatile. Balmer No. 10 averages 21 to 22 percent volatile, 0.4 percent sulphur, 16 to 18 percent ash and a free swelling index of 4.5 to 7.0.

All of the seams are of coking quality except near the surface where oxidation destroys the coking characteristics. Oxidation may occur down to 40 feet below surface; this oxidized or thermal coal is stockpiled and sold under separate contracts.

HARMER RIDGE MINING OPERATION

After many studies of active strip mining operations on seams pitching up to 30 degrees or so, Kaiser settled on a combination of shovel/truck and dragline removal of overburden. The size of the operation demanded large equipment which led to the development and use of the 60-yard dragline, the 25-yard shovels and 200-ton trucks.

In order to achieve a balance in production between coal and overburden, and to meet blending requirements, multiple pit mining is carried out. At present four areas are in production, Harmer I, Harmer 2, Adit 29 and Adit 40 as shown in Figure No. 2. The overall stripping ratio is 6 to 1.

OVERBURDEN REMOVAL

Because of the steeply pitching coal seams the dragline could not be used to its fullest capability and so a decision was made to sell it. All overburden is now removed by shovel and trucks. The list of equipment is given in Table 1. The rock is loaded into either Unit Rig M-200 (200-ton) or Unit Rig M-100 (100-ton) trucks for the short run to the disposal areas. Initially the M-100 trucks were equipped with 100 c bic yard struck capacity coal boxes for service on coal haulage only. Subsequent purchased M-100 trucks are equipped with a combination rock-coal box. The Marion 183-M diesel/electric shovel is used to do the initial stripping when electric cables have not been installed.

The M-200 trucks are about 43 feet long, 24 feet wide, have a loading height of 17½ feet and ride on 10 foot diameter 40.00 x 57 tires costing about $12,000 each. They use a General Motors EMD 1650-hp locomotive diesel engine directly coupled to an alternator. The ac power developed is rectified to dc for driving the electric wheels. Rear wheel motors are used as generators for dynamic retarding.

The M-100 units are 22 feet long, 14 feet wide, have a loading height of 16 feet and ride on 8½ foot, 27.00 x 49 tires costing over $3,000 each. These trucks are equipped with either General Motors 1000-hp or Cummins 800-hp diesel engines. Electric drive and rear wheel dynamic braking are standard practice. See Table No. 1 for the equipment list and specifications.

Strip mining operations are on a 3-shift per day, 7-days per week schedule, with the exception of loading and firing blastholes which is carried out on day shift only.

Overburden removal is scheduled at 115,000 cubic yards per day. Using a multiplier of 2.2 for rock in place the daily tonnage is 253,000 short tons. The yearly schedule is 40 million cubic yards or 88 million short tons (Table No. II).

OVERBURDEN BLASTING

Blastholes are drilled by six Bucyrus-Erie 60-R units (B-E 60-R) and one Bucyrus-Erie 45-R diesel/electric drill (B-E 45-R D/E) using 12¼ inch and 9 7/8 inch Hughes Tool Co. HH-4 steel tooth bits respectively. Initially, the benches were 60 feet high with 10 feet of subgrade drilling but have been changed to 50 feet in height and 10 feet of subgrade. See Table No. III for further particulars.

TABLE NO. I

MINE PRODUCTION EQUIPMENT

Function	Type of Unit	No. Units	Size or Model	Daily Schedule Capacity	Approximate Cost	Manufacturer
Blasthole Drilling	B-E 60-R	6	12¼ inch	615 feet	$ 400,000	Bucyrus-Erie Co.
	B-E 45-R D/E	1	9-7/8 inch	640 feet	300,000	
Rock Loading	P & H 2800	4	25 cu.yd.	17,000 cu.yd.	1,600,000	Harnischfeger Corporation
	P & H 2100	2	15 cu.yd.	11,400 cu.yd.	700,000	
	P & H 2100 BL	1	15 cu.yd.	11,400 cu.yd.	700,000	
	Marion 181M	1	10 cu.yd.	6,100 cu.yd.	660,000	Marion Power Shovel Co.
	Marion 183M D/E	1	8 cu.yd.	3,000 cu.yd.	610,000	
Coal Loading	Dart 600	3	20 cu.yd.	4,700 cu.yd.	250,000	Dart Truck Co.
	Letro 700	1	22 cu.yd.	4,700 cu.yd.	250,000	R.G. LeTourneau Inc.
Rock Haulage	Lectra Haul M-200	20	200-ton 40.00x57 tires		540,000	Unit Rig & Equipment Co.
Rock & Coal Haulage	Lectra Haul M-100	28	100-ton 27.00x49 tires		270,000	Unit Rig & Equipment Co.
Dump Maintenance & Shovel Cleanup	Crawler Tractors	14	D-9		120,000	Caterpillar Tractor Co.
		4	D-8			
	Rubber-Tired	4				
Road Maintenance	Crawler Tractors	1	D-7			Caterpillar
		1	D-4			
	Rubber-Tired Tractors	2	824B		90,000	Caterpillar
	Graders	7	Model 16		100,000	Caterpillar

TABLE NO. I (continued...)

MINE PRODUCTION EQUIPMENT

Funcation	Type of Unit	No. Units	Size or Model	Daily Schedule Capacity	Approximate Cost	Manufacturer
Road Maintenance	Scrapers	2	30 cu.yd.		$ 125,000	Caterpillar
	Snowblower	1				Sicard
	Trucks	4	35-ton			Caterpillar
	Water Trucks	3				Caterpillar
Maintenance	Cranes	2	60-ton		133,000	Harnischfeger
	Cranes	2	20-ton			Pettibone
	Fork Lift	1	15-ton			Clarke Equipment Co.
	Tire Truck					
	Fuel Tankers	2	3.500 gallon			
	Welders	8	Lincoln			
	Air Compressors		175 cfm			Ingersoll Rand

TABLE No. II

PRODUCTION - 1973

Surface Mining	
Rock Stripping	39,353,000 bank cubic yards
Metallurgical Coal	5,631,000 short tons
Steam Coal	307,000 short tons
Underground Mining	
Metallurgical Coal	
Hydraulic Mine	914,000 short tons
Balmer North Mine	356,000 short tons
Elkview Preparation Plant	
Output clean coal	5,057,000 short tons
Rated capacity (input)	1,400 tons per hour
By-product Ovens	
Coke and coke breeze output	186,000 short tons
Tar	705,000 gallons

An early experimental excavation at Kaiser's Elkview operations shows typically sloping nature of the deposit.

TABLE No. III

DESIGN PARAMETERS

Blasting Pattern	
60-Rs	32 x 32 feet
45-R	28 x 28 feet
Powder Factor	1 lb./cubic yard
Bench Height	50 feet
Sub-grade Drilling	10 feet
Working Face Slope	70 degrees
Overall Pit Slope	35-50 degrees
Safety Rock Berm	25 feet every bench
Roadway Widths	
M-100's	70 feet
M-200's	90-100 feet
Roadway Gradients	
M-100's	maximum 8 percent
M-200's	maximum 5 percent

The holes are loaded with ammonium nitrate and 6 percent fuel oil (ANFO) in the top and aluminized slurry in the bottom in a 4 to 1 ratio. Wet holes are pumped dry and a polyethelene liner used. Aluminized ANFO is being tried as a replacement for the slurry. The holes are charged under contract by Dupont of Canada which maintains on-property storage and mixing facilities and delivers the explosives to the pit in bulk explosive trucks.

Each hole is provided with two bottom HDP 1-lb primers, two more halfway up, on two downlines of primacord detonating fuse, then is collar-stemmed with drill cuttings for the last 22 feet of hole. Up to 200 holes are shot at one time using 15 MS delays. Up to 200,000 lb. of explosives are loaded each day averaging 1,800 lb. per hole. Blasting averages 1 lb of explosive per cubic yard of rock. It is not necessary to blast the coal.

COAL LOADING

In any of the pits where coal is uncovered it is loaded into M-100 truck by large front-end loaders. Normally the shovels are kept busy loading rock but may, on occasion, load coal in the event that no front-end loaders are available.

The trucks discharge their loads, after hauls ranging up to four miles in length, at the breaker station. There the coal is broken to minus 4 inch and transported by a belt conveyor via tunnel and overland structure to the raw coal silos at the Elkview preparation plant.

The volatile content varies from 20 percent at the north end of the mine to 24 percent at the southern limit. The yield varies from 72 percent in the north to 82 percent in the south. The plant schedule calls for an average of 485,000 short tons of raw metallurgical coal per month of 5.8 million annually.

There are presently two stockpiles at the breaker station. One pile of 150,000 tons is metallurgical coal that serves as a buffer supply to even out coal delivery to the breaker station. The other, 300,000 - 500,000 ton oxidized non-metallurgical coal pile is excellent quality thermal fuel and is being marketed under various contracts.

POWER SUPPLY

Electric power is purchased at 69 kv from the British Columbia Hydro and Power Authority, then carried on overland pole lines to four portable substations where it is reduced to 6.9 kv for equipment use.

Trailing cables to electric shovels and drills are of No. 4 8 kv size in 1,000 foot lengths with connections made by PLM couplers.

MAINTENANCE

The maintenance program, because of the isolated nature of the project must be self-sufficient. The Maintenance Complex is located centrally among the operating pits as shown in Figure No. 2.

TABLE No. IV

MATERIAL CONSUMED

HARMER RIDGE

Blasting		
Slurry	10,212,000	pounds
Anfo	21,677,000	pounds
Primers	104,000	
Detonating Cord	4,169,000	feet
Diesel Fuel and Kerosene	4,586,000	gallons
Electric Power	117,988,000	Kwh
Natural Gas	1,333	Mcf
Propane	206,000	gallons
Gasoline	454,000	gallons

Aerial view of the Kaiser operation which shows the minesite, and Baldy Mountain, through which coal is transported to treatment plant.

The complex consists of a large maintenance and warehouse along with a separate contract repair shop for caterpillar equipment and front-end loaders. The maintenance section of the repair shop is divided into the following bays: welding-2; tractor repair-2; lubrication-1; trucks and loaders-5; wash rack-1. In addition there is an electrical repair ship and a component rebuilding shop for trucks and loaders.

Field service is provided by the equipment listed in Table 1 which includes two lubrication units supplying lubricants, greases, oils and antifreeze, a shovel repair truck with hydraulic crane and an electrical repair unit with a chair lift.

The maintenance complex operates on a 3 shift per day, 7 days per week schedule.

When Kaiser Resources acquired coal reserves from Crows Nest Industries in 1970 it also acquired the active mining operations of that company. These consisted of several underground mines and several surface mines, none of which were of major size.

Underground operations by CNI had been plagued by difficult mining conditions -a rolling structure, steep pitches and heavy gas emissions. Kaiser was faced with the problem of how to mine the deep 50-ft pitching Balmer No. 10 seam, which in the Michel Creek valley area has more extensive reserves than those defined as strippable on Harmer Ridge, and do the job safely and economically.

There are presently two active underground mines. These are the Balmer North Mine, located on the north side of the valley at the eastern end of the town of Natal, and the experimental hydraulic system mine, located on the south side of the valley at the western end of Natal. Their locations are shown in Figure No. 2.

BALMER NORTH MINE

This mine uses mechanical mining and transportation equipment on a 3 shift per day, 5 day per week schedule to produce from 1,500 to 2,000 tons per day on development work and up to 4,000 tons per day in panel operations.

The mine was opened by driving two portal entries horizontally in a northerly direction at a point slightly above valley level to intersect the seam.

Development entries were then driven in a westerly direction along the strike of the seam 16 to 18 feet wide on 80 foot centres, with crosscuts driven on the same width on centers of 100 feet or less depending on ventilation needs.

The entries are driven as single lifts 10 feet high along the top rock or hanging wall. That rock, of sandy shales considered relatively stable, is supported by 7 foot bolts, plates and expansion shells installed by stoper and pneumatic wrench application on 5 foot centers. Occasionally capboards are used in addition to the plates to support fragile roof material.

TABLE No. V

MAJOR EQUIPMENT

BALMER NORTH MINE

Equipment	No. Units	Manufacturer
Continuous Miners		
6CM3	1	Joy Manufacturing Co.
CM48H	1	Lee-Norse Co.
Shuttle Cars		
10SC, 7½ ton	2	Joy Manufacturing Co.
Loader	1	Wabco Mining Equip. Division
Battery Supply Tractors		
Model P1144E	1	Kersey Manufacturing Co.
BUT Utility Truck	1	Acme Machinery Co.
36 inch Belt Conveyor (rope sideframe)	1	Miscellaneous Suppliers
Frontend Loaders		
Cat. 992, 10 yd.	2	Caterpillar Tractor Co.
Cat. 988, 6 yd.	1	Caterpillar Tractor Co.
Aerodyne Mine Fan		Jeffrey Mining Machinery Co.
HYDRAULIC MINE		
Hydraulic Monitor	1	
Continuous Miners	3	Joy Manufacturing Co.
	1	Lee-Norse Co.
Shuttle Cars	2	Joy Manufacturing Co.

Panels, developed from the development entries, are normally about 1,800 feet in length along the strike and 600 feet wide in the direction of pitch but may be smaller in size where mining conditions place a limit on the area to be mined.

The initial panel operation consists of driving a place up the pitch adjacent to the hanging wall 18 feet wide and 10 feet high. The coal is mined by either a Joy 6CM3 or 6CM4 or a Lee-Norse CM48H continuous miner. These discharge to Joy 10SC 7½-ton shuttle cars that deliver their loads to a 36 inch blt conveyor system that stockpiles the coal at the mine portal area. One miner is serviced by a WABCO loader which picks up coal discharged at the rear and loads it into shuttle cars (Table No. V).

Present development of the mine in a relatively low pitch area near the bottom of the Balmer seam syncline permits the use of mobile mining and haulage equipment with a minimum of difficulty. As the mining area moves up hill and steeper pitches up to 30 degrees are encountered, angling the places across the pitch to obtain reasonable grades will be necessary.

After the initial panel lift has been driven to its planned limit, the place is widened to about 25 feet. The next 10-foot high lift driven up the pitch underneath the first lift in the same place is narrower, about 20 feet wide, and successive underneath lifts are correspondingly narrower than previous lifts. This results in development of coal ribs that angle outward and thus have greater stability.

The number of lifts that can be taken in any one place depends on the roof conditions. Three lifts are considered average, four is excellent, and five or the full seam depth are rarely obtained. If roof conditions deteriorate during development of any of the lifts, the place is abandoned since efforts to correct roof conditions at heights of 20 to 40 feet are not justified.

Places in panels are developed on centers ranging from 60 to 100 feet depending on roof conditions in the last place mined.

Ventilation is provided by an Aerodyne fan at the top of a 16 foot diameter air shaft located near the inby end of the portal entries that moves 300,000 cfm of air through the mine workings. The two portal entries and several 6 foot diameter shafts located strategically with respect to the active workings serve as intakes.

Rock dust is applied by a locally developed unit that utilizes compressed air supplied from the power house sited near the Michel preparation plant. Supply lines in the mine are either 3 or 4 inch diameter in the entries, 2 inch diameter in the face areas.

Stockpiled coal is loaded by either a Cat 992 or 988 front-end loader into contract trucks for delivery after a 3½ mile haul to the truck raw coal surge bin at the Elkview preparation plant.

HYDRAULIC MINE

Introduction

The experimental work in hydraulic mining of coal was established in co-operation with the Japanese Mitsui Mining company to obtain their expertise. The experimental work was continued by Kaiser personnel.

The initial developments in the pitching Balmer seam were made near the outcrop several hundred feet above the valley floor so as to obtain sufficient elevation for the hydraulic flow of mined material to dewatering equipment at valley level. Those developments consisted of entries for access to the workings and ventilation, and sublevels for coal extraction.

The coal is dislodged at the faces of the sublevels by water jets under a pressure of 2,000 psi and sluiced in flumes to the surface and down to hillside to a screening plant. The fine size material through the screen is carried by the water to a thickener for recovery and combining with the coarser material as raw coal to be trucked to the Elkview preparation plant. The clarified thickener overflow is recycled to the hydraulic mining system.

One of the basic problems of mining thick and steeply pitching seams by blasting is that recovery of the blasted coal and over-all recovery of a reasonable percentage of the reserves is difficult. By utilizing the water, which was used to break the coal, as the loading and conveying media, the broken coal can be easily brought out of the face and onto a loading and sizing machine called a feederbreaker. The only requirements to accomplish this part of the cycle are sufficient water and an adequate grade. With the coal sized and mixed with water it is a logical step to make a simple ditch, line it with a material which will enable the mixture to flow smoothly and ensure that there is a roadway out of the mine with the required gradient to enable it to flow.

Results of the experimental work were promising. Successful application assures recovery of the coal from not only the Balmer No. 10 but also the other minable pitching seams in the Michel Creek valley area with a minimum of mechanical mining equipment.

Principal Requirements

The principal requirements for this method of mining to be operable are:

(1) The dip of the seam must be no less than 7 degrees;

(2) An adequate supply of water must be available;

(3) The roof and floor of the coal seam should be reasonably strong to minimize dilution and prevent problems with floor heave;

(4) The coal should be relatively soft, contain few hard bands and/or be friable;

(5) The seam must be reasonably thick, the thicker the better.

Hydraulic Monitoring

The monitor face area is situated at the upper end of a sub-level which is driven in the lower section of the seam at a gradient of 7 degrees and is equipped with very simple machines relative to other mining systems; these consist of a monitor, its pipelines and a specially designed feederbreaker.

The monitor, which is a hydraulically activated water nozzle, is designed to direct the water in any direction within a 180 degree horizontal and 90 degree vertical arc. Its mechanism is simple, robust and subsequently quite reliable. The power to operate it is provided by taking a small quantity of high-pressure water from the main high-pressure water line, reducing its pressure and using this as the hydraulic activating media. This simplifies the face equipment, as no power pack,.etc. is required.

Face manpower consists of two men, one operates the monitor, the other starts and stops the feederbreaker, moves the off 5 foot lagging plank from the feederbreaker or spells the operator. As mentioned earlier, the operator and second operator operate from a position some 35 to 100 feet from the working face.

To cut the coal, the water is directed on an angle of 90 degrees to the line of the sub-level, directly at the coal pillar and moved slowly up and down, slicing deeply in areas of fissures or soft bands of coal.

After a reasonably deep slot has been made, the water is directed a few degrees farther toward the goaf and the slot widened. This procedure of widening and deepening continues until all the coal is removed. However, the coal builds up on the floor during each cutting operation and a few minutes' sweeping the water jet around on the floor helps to load the cut coal onto the feederbreaker, where it is sized and loaded into the flume line for transportation out of the mine

Owing to the flexibility of the monitor's movements, cutting, breaking large lumps or simply washing the coal from the face can be done quite easily. Keeping in mind that the water when it hits the coal is similar to the blow from a 1-ton hammer, it is quite easy to see how effectively the coal is reduced to a reasonable size for washing to the feederbreaker.

To ensure that the product is kept as free from dilution as possible, a closed cutting method is used which enables most of the coal to be removed before the roof caves or the rock from the previous cycle slides into the monitoring area. Closed cutting is simply cutting and loading the coal, in a particular retreating increment, starting from a point nearest the monitor and farthest from the "goaf" and gradually extending toward the "goaf" until all the coal is removed. As the monitor will cut at least 60 feet into the solid coal, retreat increments of 40 to 60 feet are the rule, and sub-levels are kept slightly more than 60 feet apart.

By using this method, reserves recovery in the panel is averaging 60 to 70 percent of th total coal in the panel, which is several times greater than previous methods have achieved in the area.

Advantages of Hydraulic Mining

1. Safety (a) As there is no electricity or moving parts in the actual coal cutting area, the possibility of having sparking occur is eliminated. This of course is a distinct advantage to an area that has been constantly troubled with the possibility of methane and/or coal dust explostions.

(b) As the cutting unit itself is water, no dry coal dust is produced. When considering the problems facing underground coal mine operators today in the field of airborne dust control, this aspect is extremely interesting and in itself could determine the economics of building or not building a mine.

(c) Accident frequencies in the face area of coal mines are still quite high, even though considerable effort has been put into decreasing the frequency. The operators of the monitor and feederbreaker are situated some 35 feet behind the monitor in a small control cab and, depending upon the particular part of the operating cycle, are between 35 and 100 feet from the actual coal cutting operation. This remoteness from the mining face ensures that if a roof cave did occur at the face, the operators would be in a safe place and not endangered by it.

2. Productivity When operating in conditions amenable to the hydraulic system, productivity, on a tons-per-man-shift basis, is extremely good when compared with other mining systems working in the same or similar conditions.

3. Ventilation Hydraulic mining has what is perhaps the most effective of all ventilation systems. Fresh air is brought into the sub-level and passes the operators before being contaminated by moisture as it passes over the mining equipment. After passing over the face equipment it is returned to the main return roadway through the "gob" area. This ensures that the operators are never supplied with air that is contaminated by a production process. Actual airborne dust samples taken by an instrument attached to the operators have indicated average dust counts of less than 1.00 mg/m3.

4. Seam Conditions Steeply pitching seams, undulating seams and very thick seams are all reasonably easily accommodated by this system. Unlike belt conveyors, flumes, with their water and coal mixture, do not require straight roadways. This enables development machines to follow the seam at a set gradient with very little pre-mining information and, except for obvious problems associated with encountering major faults, most other variations can be accommodated.

5. Recovery of Reserves In thick seams, loss of a large percentage of the reserve is quite normal because by using water to cut and load the coal there is no need for any one, or any machine, to go into unsupported or poorly supported ground, which makes it possible to extract the coal from a block until all the coal is taken or until the roof caves. As the water jet is the only thing exposed to the falling roof there is no possibility of damage to personnel or equipment.

6. Low Material and Equipment Cost The costs of setting up a hydraulic mine are considerably less than those involved in most other systems. The basic reasons for this are:

(a) the output for a monitor face unit is extremely high, so that multiple coal-producing units are unnecessary for the production of large tonnages;

(b) the underground equipment is extremely simple and robust, with very few moving parts, and so is not expensive to purchase, install or maintain;

(c) the surface equipment, except for the high-pressure pump, is standard, and is not in any way sophisticated, and the dewatering can be done in the normal coal cleaning process;

(d) electrical costs to operate a monitor are low, and as less than 3,000 horse power is required to operate a unit producing such large quantities of coal, the costs per ton are reasonable.

Disadvantages

(1) In seams interbedded with rock and/or dirt partings, or where the roof or floor is weak, selective mining of the coal is difficult. If the hardness of the rock or dirt is not too much more than the harder sections of the coal, the operator would be unable to define which material he was mining, and therefore some dilution has to be accepted.

(2) The product, even after dewatering, contains a greater percentage of moisture than coal produced by most other underground mining methods. This may require that the coal be dried unless it is to be beneficiated by wet means.

(3) As a gradient sufficiently steep to allow the coalwater mixture to flow is an integral part of the system, level or almost level seams could be very difficult to mine.

(4) Unless development costs can be kept to a level where they are of very little burden to the over-all mine, thin seams could be uneconomical to mine.

ELKVIEW PREPARATION PLANT

The Elkview preparation plant was designed to use heavy media vessels and cyclones and hydro-cyclones in processing raw coal with an expected 30 percent minus 28 mesh material. Degradation during process compelled plant modifications to handle the heavier than expected fine coal load.

In planning the Elkview preparation plant consideration was given to the recognized friability of the Balmer No. 10 seam coal to be processed. The plant was designed for a 4 x 3/8 coarse coal section of 350 tons per hour and a 3/8 x 0 fine coal section of 1,050 tons per hour. Plant feed was expected to have from 28 to 30 percent minus 28 mesh material, and operation data indicates that this was an accurate estimate.

Early test data on the coal indicated that the ash of the 35m x 0 raw coal was such that a portion of it would not have to be cleaned so Kaiser decided to use dedusters on the raw coal feed.

Once processing was started, the raw coal ash was found to be higher than previously indicated, and it was not pratical to put a part of the 35m x 0 raw feed in the clean coal. This has necessitated the addition of fine coal equipment to handle the 225 tons per hour of raw coal that was being dedusted and bypassing the cleaning circuits.

1. Raw Coal Feed Strip mined coal delivered to a 300 ton surge bin at the breaker station in the pit area is discharged by two Link-Belt 8 x 5 feet reciprocating feeders to two Allis-Chalmers Ripl-Flo 6 x 16 screens where separation is made at 4 inch. The oversize is reduced to minus 4 inch in a McNally Pittsburg 12 x 27 rotary breaker and combined with the 4 x 0 fraction on a 54 inch, 63 foot transfer belt. The rock removed by the breaker is belt conveyed to the breaker yard for disposal in the pits.

The transfer belt equipped with an Engineered Equip. tramp iron detector, feeds the 4 x 0 material to a 48 inch cable reinforced belt 8,225 feet long that passes through a 4,800 foot, 16 x 12 foot tunnel driven through Baldy Mountain and through a 9 foot tubular steel overland gallery to four 2,000 ton raw coal silos near the preparation plant.

The belt drops from an elevation of 5,675 feet at the breaker station to 4,321 feet at the silos, an average dip of about 10 degrees. The belt is driven by a 2,000 horse power regenerative drive system and 9 inch backup brakes for emergency conditions.

Since the tunnel cuts through a coal seam, regulations require the installation of an automatic methane detector (MSA) at the upper end. Water that collects in a sump at the lower end of the tunnel is pumped to a strip mine maintenance complex for use by personnel. A 3 million Btu/hour propane heater counteracts ice buildup in the lower end of the tunnel during cold weather.

Raw coal from the Balmer North and hydraulic mines is delivered by contract trucks to a 150-ton surge bin on the hillside near the raw coal silos.

The coal is fed from the bin by a Paramount 72 inch x 16 foot combination grizzly and electro-mechanical feeder to a Pennsylvania 30 x 60 inch crusher. The grizzly plus 4 inch oversize is reduced to minus 4 inch and combined with the 4 x 0 fraction on a 36 inch belt as feed to the raw coal silos.

Strip mine coal is discharged to all four silos, with automatic switchings of flop gates as coal builds up in any silo. The deep mined raw coal is discharged to only two of the silos.

Plant feed from the silos at 4 x 0 is provided by four Paramount 84 inch x 16 foot variable feeders rated at 1,000 tons per hour which discharge to the 36 inch plant feed belt.

Two Ramsey plant feed belt scales, one on the raw coal belt from the strip mine to the raw coal silos and one on the plant feed belt provide raw coal tonnages. An Eriez 36 inch magnet at the plant feed belt head removes tramp iron. A Denver sampling system that cuts across the coal stream from the plant feed belt provides for raw coal analysis.

Flex-Kleen dust collectors have been installed at the truck coal bin crusher, the belt discharges of raw coal to the raw coal silos and the plant feed belt discharge. These collectors automatically discharge the collected dust from the collecting bags to the coal flow periodically.

2. Coarse Coal Processing The 4 x 0 raw coal feed is screened on two 8 x 20 Ripl-Flo units for separation at 3/8 inch.

The 4 x 3/8 fraction is discharged to two Allis-Chalmers 8 x 16 Low Head prewet and classifying screens where separation is made at 1/4 inch. The 4 x 1/4 fraction is fed to two "primary" heavy media Barvoy vessels for processing at 1.40 specific gravity.

Initially a "secondary" Barvoy vessel was used to process the reject of the primary vessels. Now that secondary vessel is serving as a spare primary vessel, and the reject is dewatered on a 5 x 16 Low Head screen, with discharge of the reject via a refuse belt to the plant refuse bin for disposal.

Clean coal from the Barvoy vessels is dewatered on two 8 x 16 Low Head screens with separation at 1¼ inch. The 4 x 1¼ fraction is reduced to minus ½ inch by a Gundlach two-stage crusher, then combined with the 1¼ x 0 fraction and discharged to the "dust" belt for delivery to the metallurgical coal mixing unit.

Clean coarse coal, fine coal and dust are blended in the paddle mixer prior to discharge to the met coal belt and the four 15,000 ton clean coal silos.

Ramsey belt scales on the dust and met coal belts provide tonnage values. A Denver sampling system that cust across the mixer discharge provides for met coal analysis.

3. Deduster Circuit The 3/8 x 0 fraction of the raw coal screens is discharged to two Combustion Engineering "dedusters" where fan induced draft removes a portion of the 0.4mm x 0 dust (minus 35 mesh). Considered as clean coal, the dust can be discharged to the dust belt for mixing with other met coal sizes.

An alternate procedure is to add the dust to the fine coal processing circuit, using dust regulating feeder screws to supply measured amounts of feed.

4. Fine Coal Processing The ¼ x 0 fraction from the Low Head prewet/ classifying raw coal screens is fed to a pulping head water tank, then combined with the 3/8 x 0m fraction from the dedusters as 3/8 x 0 feed to the fine coal processing circuit.

That feed is screened on 10 R&S 6 foot sieve bends, with the overpass screened on 7 x 14 Low Head desliming screens equipped with ½mm Bixby-Zimmer decks. The underpass of the sieve bends joins the underpass of the desliming screens as 28m x 0 feed to the fine coal processing circuit.

The 3/8 x 28m fraction of the desliming screens is mixed with heavy medium from pulping tanks, then fed to 12 R&S 24 inch primary H.M. cyclones for processing. The overflow of the cyclones is dewatered on 12 Low Head 8 x 16 screens preceded by 12 R&S 6 foot sieve bends. The underflow of the screens is recycled to the H.M. pulping tanks.

The overpass of the dewatering screens is fed to CMI VC-48 centrifuges, then discharged via belt to a Link-Belt Fluid-Flo dryer rated at 73 tons per hour evaporative capacity. The product, thermally dried to 4 percent moisture, is blended with the other clean coal sizes in the metallurgical coal mixer. Underflow of the cyclones used to collect dust from the dryer stack gases is combined with the dried coal feed to the mixer.

The underflow rejects of the primary H.M. cyclones are screened on 4 R&S two-stage 5 foot sieve bends, with the overflow of the first stage passing to the second stage, and the underflow of both stages being recycled to the H.M. pulping tanks.

The overflow of the second stage sieve bends is collected in a heavy media pulping tank, then pumped to 5 R&S 24 inch secondary H.M. cyclones for processing.

The overflow of the secondary cyclones containing clean coal is dewatered on 3 Low Head 7 x 16 screens preceded by 3 R&S 5 foot sieve bends, then discharged to the plant refuse belt. The underflow of the screens is recycled to the heavy media pulping tank for the secondary cyclones.

Feed to the fine coal circuit is also provided by the 28m x 0 underpass of the fine coal (3/8 x 0) desliming screens and the 35m x 0 fraction of the dedusters. The blended fines are fed to two primary hydro-cyclone (H.C.) feed sumps, then pumped to 30 R&S 14 inch primary hydrocyclones.

Underflow of those primary hydro-cyclones is discharged to a secondary H.C. feed sump, then pumped to 6 secondary H.C. 14 inch units. The reject underflow of the secondary units is sluiced to a refuse lagoon. The overflow is recycled to the primary H.C. feed sumps.

Overflow of the primary H.C. units is collected in two fine coal classifying sumps, then pumped to 10 R&S 24 inch classifying cyclones for separation at 100 mesh. The clean coal underflow coal is discharged to 3 Peterson 12 foot, 6 inch, 12 disc filters and the filter cake is combined with other sizes as feed to the thermal dryer.

The overflow of the classifying cyclones is sluiced to a Wemco flotation setup with 3 banks of 5 cells each. The frothed coal is combined with the feed to the Peterson filters.

5. Refuse Disposal Solid refuse, 4 x 28m, discharged to the plant refuse bin is hauled to a disposal area on the hillside north of the plant by a Cat 657 scraper loader, 32/44 yard capacity. The refuse is spread in thin layers on benches, dozed out of the hillside starting at the Elk River valley bottom with successive dozing material used to cover the next lower bench refuse. The covered benches are planted as part of the company's reclamation project.

Fine refuse including the underflow from the secondary hydrocyclones, tailings from the flotation cells and slurry from the thermal dryer cyclone scrubbers is collected in a Dorr-Oliver-Long 175 foot static thickener. Clarified overflow water is recycled in plant circuits.

Thickened 28m x 0 underflow of the thickener is sluiced to a pumphouse in the lagoon area inside the railroad track loop immediately west of the plant, then pumped by an Allen-Sherman-Hoff rubber-lined 700 gallons per minute pump to an active lagoon.

6. Magnetice Circuit Heavy medium recovered from the dewatering screens in the primary H.M. vessels circuit is sluiced to a sump, then pumped to two 24 inch classifying cyclones. The cyclone underflow is discharged to a 30 inch by 6 foot double drum Eriez magnetic separator for recovery of the magnetite which is fed to a 28 foot thickener.

A similar recovery setup is used for the heavy media cyclone circuits. The greater volume of heavy medium used requires 8 of the 24 inch classifying cyclones, four 30 inch by 8 feet double drum Eriez magnetic separators and two 36 foot thickeners. Provisions have been made to pump heavy medium to the H.M. vessel circuit thickener when necessary.

7. Makeup Water Although the Elkview plant operates on a closed water circuit basis, losses on refuse and through evaporation required the addition of makeup water in the amount of 1,500 gallons per minute.

This is provided by a pumping station on the Elk River, with two 1,000 gallons per minute Peerless pumps discharging to a surge pond in the refuse lagoon area. Two additional Peerless pumps of equal capacity, in a second pump house adjacent to the surge pond, lift the water to the preparation plant.

8. Coal Loadout The original plan for transporting coal from the Elkview plant to Roberts Bank for loading of Japanese freighters called for six Canadian Pacific Railroad trains, each with 100 solid bottom cars holding 105 tons, to operate on a 72 hour cycle, with two trains loading each day. In practice there have been some modifications, and the plant must be prepared to load trains at any hour of the day.

The four clean coal silos have a total capacity of 60,000 tons. Withdrawal of two full unit train loads per day would draw off only about 21,000 tons so the silos have ample surge capacity.

The empty train is pulled around the track loop and through the loading tunnel under the silos at about ½ mile per hour or 50 feet per minute. The engines are equipped with automatic speed controls that maintain the precise loading speed throughout the entire loading period.

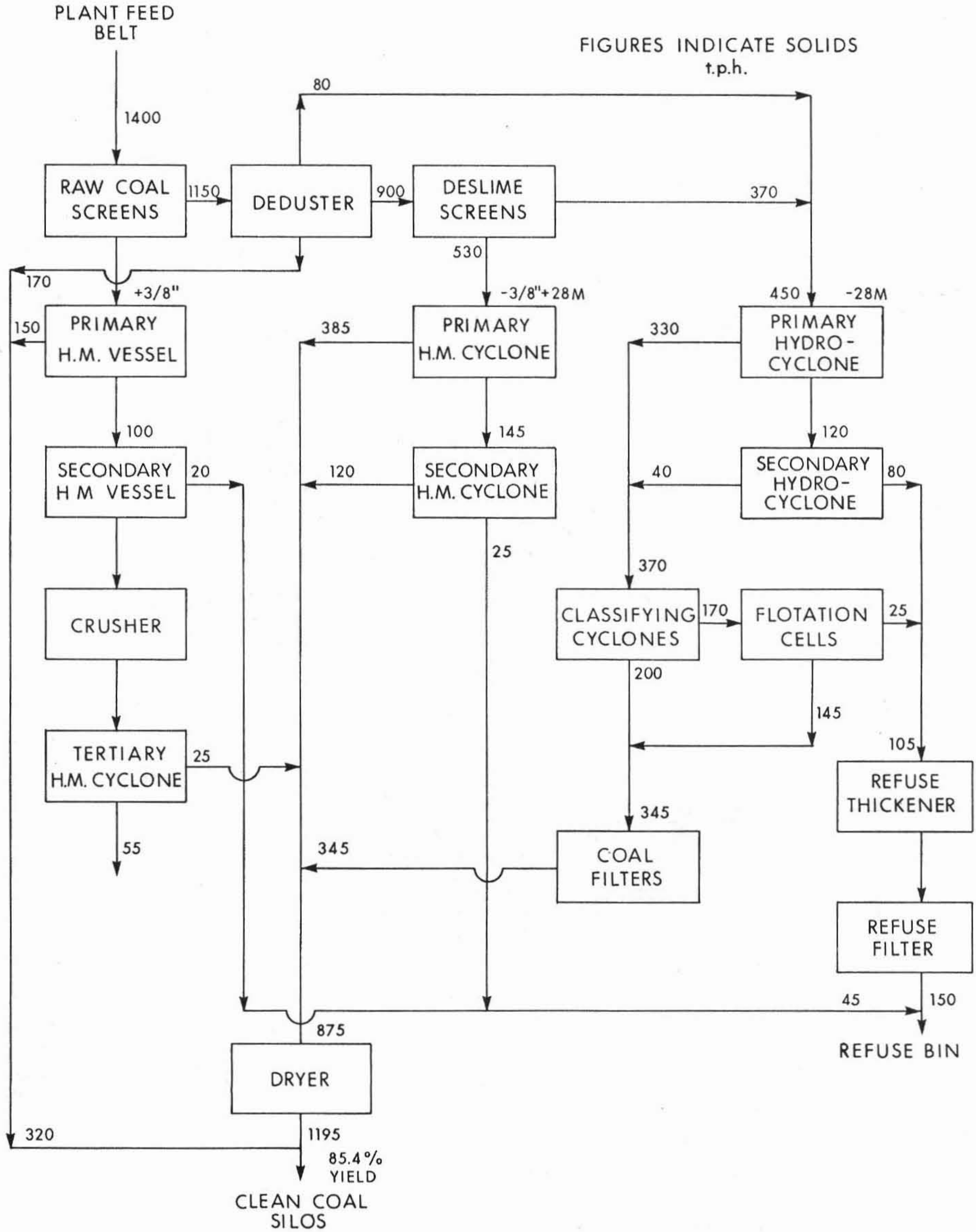

FIGURE 3 – ORIGINAL FLOWSHEET

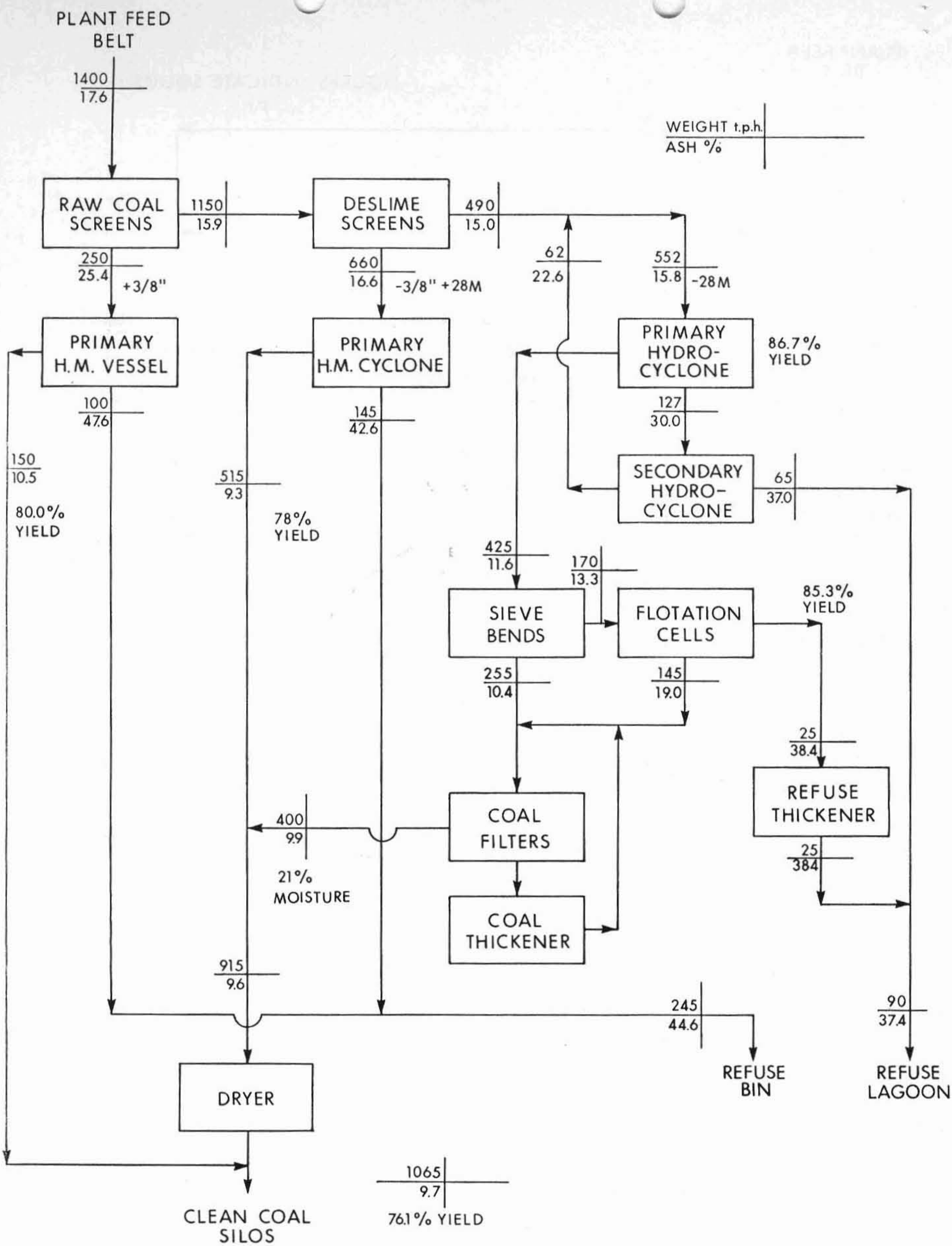

FIGURE 4 — REVISED FLOWSHEET

Normal loading practice is to load the bottom half of a car from one of the two first silos (3 & 4), then finish loading the car from one of the last two silos (1 & 2). The cars can be flood loaded at rates up to 6,000 tons per hour. The Kaiser operator in the loading control room can communicate with the engineer by shortwave radio in the event any adjustment in train movement is found to be necessary.

An Ametron single axle track scale by Streeter-Amet was installed just outside the track loop to obtain train load weights. The computerized weigh system, coupled with an automatic car identification system that reads the standard A.C.I. label on the side of each car, tabulates the car number, tare weight, gross weight and net weight of the coal, with totals for each weight class for the entire train.

The weight system which was installed by CPR has a backup teletype printer that records the information for later use if necessary. The information is also transmitted to Nelson, about 250 miles west of Sparwood, for CP Railroad use.

Kaiser installed their own track scale just out by the silos to assist the loading operation through assurance that the cars are not being overloaded.

9. Plant Modification Extensive plant modifications were made mid-summer of 1971 with a view toward handling the greater than expected fine coal circuit load and securing better control of the clean coal quality. The modification work included the following:

(a) Removal of the deduster circuit.

(b) Increasing the 3/8 x 0 desliming screens from 10 to 12.

(c) Conversion of the secondary H.M. vessel to a spare primary vessel.

(d) Increasing the primary hydro-cyclones from 30 to 50.

(e) Increasing the secondary hydro-cyclones from 6 to 12.

(f) Removing the fine coal classifying cyclones and replacing them with rapped sieve bends. These are R&S sieve bends equipped with pneumatic rappers.

(g) Separating the refuse magnetite rinsings from the clean coal magnetite rinsings and providing separate magnetic separation for them.

(h) Tailings of the refuse magnetic separators is sent to the fine coal cleaning circuit.

(i) Tailings of the clean coal magnetic separators are added to the feed to the clean coal filters.

(j) A conditioner was installed ahead of one bank of flotation cells for test purposes.

(k) Construction of a second 175 foot diameter static thickener for additional water clarification.

(l) Installation of a fourth bank of flotation cells.

(m) Modifying old refuse vacuum filter as a clean coal filter.

(n) Installation of dust collection systems on top of raw and clean coal silos.

(o) Installation of spare in-line pumps.

See Figures No. 3 and No. 4.

RECLAMATION

The initial step in development of the reclamation program was the hiring of a reclamation biologist. His education and training place him in a good position to develop and carry out effective land reclamation in an area that poses a number of problems, some of which have not been experienced previously.

Since the surface mining operations on Harmer Ridge are relatively new, reclamation of those mined land areas has only started. Plans are being developed along with the necessary test planting, so that the mining areas can be reclaimed as soon as they become available.

In the meantime reclamation work has been carried out in the Michel Creek valley area.

Two adjacent towns, Michel and Natal, several miles southeast of Sparwood, have been the population centers for coal miners who have worked the coal seams in the adjacent hills since the turn of the century.

Prior to the start of Kaiser operations both towns had experienced a lengthly period of economic depression. Many of the homes and other buildings had been abandoned and boarded up.

Located astride Trans-Canadian Highway No. 3, 10 miles northwest of Crows Nest Pass on the boundary between Alberta and British Columbia, they presented an unpleasant introduction to Tourists of beautiful, scenic British Columbia.

Prodded by the Canadian government, the Provincial government took a vote among the inhabitants on complete removal of the towns, with residents given assistance in moving to the new and expanding town of Sparwood or elsewhere.

The option was approved and by mid-summer of 1971 many had moved and a large portion of Natal had been dozed into a workable reclamation area. Work is continuing on this project.

Planting work has already begun. In May 1971, 15 acres were planted with various ornamental trees including Douglas fir, blue spruce and paper birch on a landscape plan that will include other trees and grass. It will take about four more years to complete the program in the Michel Creek Valley.

Experimental work has also been initiated on the reclaiming of old strip-mined areas in the hills that rise on both sides of Michel Creek valley. An old spoil-bank that became water-logged and slid into the valley, covering the main road, has been sown with grass seeds applied by aerial hydroseeding.

The types of trees and shrubs that can best be used on the mined land areas presently being developed on Harmer Ridge will be determined by experimentation on old strip-mined areas adjacent to the valley.

Successful application of trees and shrubs must give consideration to such factors as altitude, climate, rainfall and temperature conditions.

For example, altitudes where reclamation work will be carried out will range from 4,000 to 7,000 feet. It has been learned already that certain pine species will withstand heat better than others.

It has been noted also that black cottonwood, two species of wild rose, and silver buffalo berry have grown voluntarily on old strip spoil banks.

The aim in planting strip mined land with trees and shrubs is to reduce erosion, provide timber for future logging and also provide food for native wild animals and birds. Trees and shrubs are being developed from seeds and cuttings in a nursery and greenhouse on the banks of Elk River.

Present activities in the nursery are concentrated on raising species of trees for sheltered valley bottom planting. The seedlings are planted in beds and allowed to grow to a height of 12 to 14 inches which takes about two years. Then they are lifted in a dormant condition without earth on the roots and planted in the early spring season.

For higher altitudes and old strip spoil banks it may be necessar to plant the seedlings in peatpots for growing, also for raising trees and shrubs from seeds.

The greenhouse is used primarily for propagating shrubs from cuttings. At an appropriate time these cuttings are removed to a small adjacent nursery, normally about February, so that they can have the advantage of cold weather growth in the nursery before they are transplanted.

A new "bullet" planting method for shrub cuttings is being tried out. The cuttings are planted in bullet-shaped holders which facilitate insertion into the ground easily and rapidly by means of a special tool.

The Kaiser Resources reclamation program for the Sparwood area is still in its initial stages. Some results are apparent in the Michel Creek valley although completion of that phase will not be realized before 1975 or 1976. By that time the initial work on the Harmer Ridge mined land will have been started. Completion of that reclamation phase is a long way off, at least 15 years according to present plans for surface mining activity.

LABOUR FORCE

Surface Mine and Coke Ovens work 3 shifts per day, 7 days per week. Underground mines work 3 shifts per day, 5 days per week.

	Hourly	Salaried	Total
Surface Mine - operation	455	49	504
Surface Mine - maintenance	377	53	430
Underground Mines	210	38	248
Elkview Preparation Plant	147	22	169
Coke Ovens and Michel Surface	174	10	184
Administration		166	166
TOTAL	1,363	338	1,701

Mountain-top coal mining of Kaiser Resources, near Natal

George Hunter photo