large quantities of material. As before stated, miners also discovered that as the quantity or volume of water employed was increased, as also the pressure under which it left the delivery pipes, they accomplished better results, and that under favorable circumstances, gravel which contained only a few cents per cubic yard could be made to pay handsomely, and therefore every effort was made to secure these conditions. Out of these efforts has arisen the modern system of hydraulic mining, which I will briefly endeavor to explain.

HYDRAULIC MINING.

Hydraulic mining is accomplished by utilizing the power of water, and the gradient afforded by the fall or difference of level between the auriferous deposits and the dumps into which the debris resulting from the mining operations must be deposited.

The power of the water depending on its volume and the head or pressure under which it can be delivered at the working floor of the hydraulic excavation, it is therefore most essential that the water ditch or canal should be at a high elevation above and as near as possible to the deposit of gravel to be mined. The first condition insures a great hydrostatic pressure, and the second a reduction in the length and cost of the sheet iron or steel conveying pipes.

It has been demonstrated that one thousand miners' inches of water can be discharged under a head or pressure of 300 feet through a six inch nozzle, with a velocity of about 140 feet per second, and in a volume of about 1050 pounds during the same period of time.

Such a volume of water, in the form of a jet uninterruptedly impinging upon a bank of auriferous earth or gravel, having, as it does, about one-tenth of the velocity of a projected cannon ball, must necessarily do great execution, and produces the caving of an ordinary gravel bank without the aid of explosive blasting.

The greater the gradient given to the conveying or mining sluices, the greater will be the duty of the water employed to remove the auriferous material from the excavation to the dumps.

The separated gold is caught between the riffles placed in the mining sluice bottoms, and held there by the use of mercury until it becomes desirable or necessary to recover it therefrom. When the amalgamated gold is cleaned up from the sluices, it is retorted to distil over and recover the mercury and the remaining gold retort, as it is called, is melted into bars and sent to the mints for comage.

Gold-saving appliances, called under currents, are now in general use in California for recovering fine flour gold that could not be recovered in the ordinary riffled sluice.

Figure 5 represents an hydraulic mine in operation.

Figure 6 represents an improved under current.

As it is proposed to remove immense masses or quantities of gravel, only utilizing an infinitesimal portion of the same, it is first necessary to see that there is abundant room to dump below the mine the vast quantities of debris to result from the entire working of the mine, for if this debris was permitted to accumulate near the end of the sluices, it would soon choke and cover the gold-saving appliances. It next becomes necessary to ascertain the quantity of water available, and the head or pressure under which it can be delivered at the mine.

The amount of work that can be accomplished depends greatly on these two contingencies; it is self-evident that to remove a large amount of material composed of sand, gravel, cobbles and rock, a considerable quantity of water is necessary, and if it is not obtainable, the operations of hydraulic mining cannot be carried on successfully. The amount of water used for operating an hydraulic mine varies greatly in different localities, viz: from 200 inches to several thousand inches daily, 500 to 1,500 inches being considered a fair volume to be discharged through one machine or giant, while the work accomplished by the quantity of water used is greater as the pressure under which it is discharged in the mine, and the grade of the sluices for conveying away the gravel increases.

As water used by miners is always measured by the inch, and all calculations of the value of gravel are best estimated by the duty of an inch of water, it becomes necessary to fully understand what an inch of water is, as well as its power to remove gravel under different conditions. The standard of measurement varies slightly in different mining districts, but the usual method of measuring water now in use in California is to discharge the water through a four-inch opening while the water in the measuring box stands four inches above the top of the discharge opening; thus an opening 125 inches long and four inches high will discharge 500 miner's inches, one inch being equal to a discharge of about 2230 cubic feet in 24 hours. As an illustration of the advantage of estimating the value of a bank of gravel by its yield in gold per cubic yard, and the number of yards of gravel removed in 24 hours per inch of water used, where the water was used under different heads and the sluices under different grades, see the annexed table showing the results of the working of a few well managed hydraulic mines in California.

By reference to the table, it will be seen that the mine yielding the least amount of gold per cubic yard gives the largest returns to its owners, for the reason, as the table shows, that the water was delivered at the mine under the greatest head, and the sluices for running away the gravel have the heaviest grade. It is evident that the value of the gravel per cubic yard is not a good standard, and for this reason the power of a definite quantity of water and a heavy grade in the sluices have been substituted to accomplish the desired result.

If grade for sluices, dump for debris, and a sufficient quantity of water are available, it is then worth while to ascertain whether the gravel will pay to wash, and under this head it will be easy to show, by reference to many operations on a large scale, that the cost of mining and washing a cubic yard of gravel may be brought to exceedingly low figures, but it is almost impossible to say what it should contain to be remunerative, as so many elements and conditions enter into the calculations.

The price of water sold to miners in California for hydraulic mining varies from ten to twenty cents per inch per twenty-four hours, and this item must always influence the result, as it is the main one, but at the same time the actual cost of water to the ditch owner is not more than from two to five cents per inch, so that the ditch owners can afford to work gravel on their own account that would not yield more than one or two cents per cubic yard, considering other conditions, such as grade for sluices and dump for debris being reasonably favorable.

It is hoped that this brief sketch, which deals only with the principles employed and not with their individual application, will give an intelligent idea of hydraulic mining, which promises to become an important industry in British Columbia.

Had I the time, Gentlemen, I would willingly enter more into details of working and equipment of deep gravel drift and hydraulic mines.

I thank you for your patience and attention, and hope to have the pleasure of meeting your Association at some future time.

Notes on Hydraulic Mining in British Columbia.

By Dr. G. M. Dawson, C.M.G., Director, Geological Survey of Canada.

[During the past summer Dr. Dawson visited the more important new works of this kind in British Columbia, of which a description was given, as well as some discussion of the geological conditions and age of the auriferous gravels, in an address to the members of the association of which the following is a synopsis.]

Although hydraulic mining has long been practised on a small scale, particularly in the vicinity of the old gold mining camps in the Cariboo district, it is within the past two years only that really extensive operations of this kind have been initiated. Of these the most important are the Cariboo Hydraulic Company, operating on the south fork of Quesnel river, the Horsefly Hydraulic Company, on the river of the same name, and the Van Winkle Hydraulic Company, near Lytton, in the Fraser valley.

The two first mentioned companies are under the management of Mr. J. B. Hobson, to whose practical knowledge and advice based upon long experience in California the renewed interest in mining in the Cariboo district is largely due. Both of these companies will be in full operation next spring, and it is anticipated that they will be closely followed by many other enterprises of the same kind. All these should be undertaken, however, only after thorough prospecting, for although the Cariboo district abounds in streams and lakes at many different levels, the initial expenditure in obtaining a sufficient supply of water with the requisite head is generally very considerable. In order to give an idea of the character of the operations now in progress, the following particulars relating to the Cariboo and Horsefly companies may be cited.

The property of the Cariboo Hydraulic Mining Company is situated on the south side of the south fork of Quesnel river, about three miles above the village of Quesnel Forks. It comprises several claims, and is believed to cover about 8,500 feet of an old high channel of the river, separated from the modern deep and canon-like river gorge for a considerable part of its length by an exposed rocky ridge, known as French Bar Bluff. Near the lower end of the property, on Dancing Bill Gulch, successful hydraulic mining on a small scale and with imperfect appliances has been carried on for a number of years by a Chinese company. At a distance of about 3,000 feet further east, on Black Jack Gulch, a good deal of work had been done by the South Fork Company, but without effectively reaching the richer gravels, which are below the level of the rim rock where this has been cut through. Short ditches have been made by both these earlier companies, and the exposures in their hydraulic pits afford most of the information obtainable as to the character of the deposits.

A ditch with a total length of seventeen miles and a capacity of 3,000 miner's inches has now been laid out by the present company and will be completed in the spring. This is to derive most of its water from Polley's Lakes, situated in the hills to the south-eastward. It is also I believe ultimately proposed to bring an equal volume of water from Moorhead Lake by means of a second ditch, which will be thirteen miles in length.

At the lower, or "China Pit," the bed rock of the old channel where cut by the present river bank is believed to be approximately 134 feet above the river. The head of the train of sluices near the working face is 200 feet above the same datum, while the sand box at the top of the bank is at a height of 489 feet; giving a head of water equal to about 289 feet, with ample fall for the dump, which is made direct into the river. Two monitors of five and five and a-half inches diameter of nozzle respectively, are established in this pit. Mr. Hobson estimates that the old Chinese company removed in all about 150,000 cubic yards of the bank, from which, it has been ascertained, $135,000 of gold was obtained, without the employment of mercury, or at the rate of about 90 cents per cubic yard. The scanty water supply available in advance of the completion of the main ditch enabled a run of only forty-seven hours to be made in the early summer. The mean volume of water employed was 2,000 inches, and the yield was 302 ounces.

The floor of the pit of the Old South Fork Company is about 200 feet above the present river, and the bed rock run has been found in test pits at a depth of about 30 feet below this floor, while above it on one side of the gully, is a nearly vertical face of clay and gravels about 200 feet in height. The head of water from the sand box to the present bottom of the pit is about 246 feet; but as already stated the rim rock has not yet been cut through to the full depth of the old channel. It is proposed to begin active work here in the spring.

The Horsefly Hydraulic Company's claims are situated on the Horsefly river at a distance of about six miles south of Quesnel Lake. The river was notably rich in this particular part of its length, the bars had all been worked over by Chinamen some years ago. The source of this gold was found by Mr. McCallum to be the old gravel deposit now being worked by the Company.

By the hydraulic system now successfully completed, water is brought from Mussel creek, a southern feeder of the Horsefly by a ditch and pipe line aggregating over eleven miles and a half in length. The ditch is about ten miles long, with a capacity of 2,000 miner's inches. The pipe line is steel, 30 inches in diameter, in two lengths aggregating 8,300 feet. There is also about 600 feet of flume. From the sand box the water is led to the pit by two lines of 22 inch pipe, each of which is intended eventually to supply the monitors. Water is delivered from the main ditch with a head of 168 feet and from the pooling reservoir with a head of 106 feet. The bed rock, constituting the floor of the pit, is about 90 feet above the level of the river and the working face (60 feet in height at its highest part) at the time of my visit, was about 560 feet back from the river bank. The dump is formed in the river itself, which is a moderately rapid stream, capable, (particularly in high water) of removing a large quantity of debris.

Respecting the actual average gold content of the gravels as worked, much has doubtless been ascertained since my visit, some $13,000 being reported as the result of the last clean up. The preliminary run made by the Company was estimated to have dealt with 21,333 cubic yards of gravel. It produced gold to the value of $5,000, or at the rate of about 25 cents per cubic yard, but about a third of the area then worked had already been drifted on bedrock by the original discoverer, rendering it probable, in Mr. Hobson's opinion, that the unworked ground would average about 40 cents. A small percentage of platinum occurs with the gold at this place.

The ground being worked by the Van Winkle Company is situated on the west side of the Fraser river about two miles above Lytton. It consists of a series of terraces rising in steps from the river toward the bases of the mountains. The first of these is about 100 feet above the river, the second some 60 feet higher, while others occur at various still greater heights. The first has taken the form of a great isosceles triangle, of which the apex touches the river, the base being about 1,200 feet distant. The yield in gold has not yet been found to be so good as the rich character of the old flat worked over here many years ago appeared to indicate it would be, but the prospecting carried on in advance of the work shows richer ground.

The water employed is brought along the upper terraces by ditch from a branch of Stein Creek and then down to the work by an 18-inch pipe-line 1,500 feet long. The working head is about 350 feet and about 1,600 inches of water is employed.

The auriferous gravels at Horse-Fly are probably of Pliocene Tertiary age and are overlain by boulder-clay, referable to the glacial period. Those in the Cariboo