HYDRAULIC MINING

IN

CALIFORNIA.

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ERRATA.

Page 3. ¶ 2, line 3, *for* boundary, *read* eastern boundary.
" 6. Foot note † line 3, *for* Garagua, *read* Jaragua.
" 7. Line 16, *for* clear, *read* cheap.
" 11. Foot note *, *before* p. 488 *insert* Vol. I.
" 17. Foot note *, *for* breaks, *read* breasts.
" 22. Line 18, *for* 4x6, *read* 4x4.
" 25. Foot note †, *for* 2.230, *read* 2,230.
" 30. Line 6 from bottom, *for* 59, *read* 59½.
" 31. Column 6 of Table opposite No. 3, *should read* 2nd, Upper box, each side, blocks. blocks. 3rd, riffles. †
" 71. Column of "Remarks," the 1st & 2d remarks should each be moved down one line.
Page 74. Line 3 from bottom, *for* 2.159, *read* 2,159
Table IV. Column 25, *for* $0.104, *read* $0.0104
" V. Column 17, third item, *for* 1,329.27, *read* 1,339.27
" VI. Last Column, fourth item *for* 6,153.02, *read* 6,153.62
" VII. Last Column, first item, *for* $2,033.50, *read* $2,033.56
" X. Column 2, *for* 5,663.80, *read* 5,663.89
" *for* 4,201.89, *read* 4,201.95
" *for* 53,088.82, *read* 53,088.83
" 4, *for* $0.0203, *read* $0.0283
Page 76, first line below Table X, *omit* $ before 10.401.28

seven thousand feet, with occasional peaks ten and twelve thousand feet high, are cut by numerous deep and precipitous gorges or cañons, through which drains the immense watershed of the Sierra, supplying the main rivers of the State and ultimately emptying into the Pacific Ocean.

* See vol. i, p. 5, Geological Survey of California. J. D. Whitney, State Geologist.

HYDRAULIC MINING IN CALIFORNIA.

BRIEF OUTLINE OF THE GENERAL TOPOGRAPHY OF THE GOLD REGIONS OF CALIFORNIA.

THE topographical features of California, as demonstrated by the explorations of the State Geological Survey, are found to be exceedingly simple. Three equidistant parallel lines can be used in conveying a general idea of the physical geography of Central California.

A straight or "main axial line," whose course would be north 31° west, passing through the culminating peaks of the Sierra for a distance of five hundred miles, can be assumed as the boundary of the State. A second parallel drawn fifty-five miles west of the "main axial line" will skirt the western base of the Sierra Nevada, along the edge of the foot-hills. A third parallel run equidistant from the second will represent "as nearly as possible the western base of the Coast Ranges." These parallel lines divide the State into three belts, namely, the Sierra, the Great Valley of California, and the Coast Ranges.

"This arrangement of the physical features holds good for a length of four hundred miles in the direction of the main axial line, comprising almost the whole of the agricultural and the greater part of the mining districts."*

The section of the country which is of immediate interest to the miner is the western slope of the Sierras. These mountains, rising in a short distance from the Sacramento plains to elevations of over seven thousand feet, with occasional peaks ten and twelve thousand feet high, are cut by numerous deep and precipitous gorges or cañons, through which drains the immense watershed of the Sierra, supplying the main rivers of the State and ultimately emptying into the Pacific Ocean.

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* See vol. i, p. 5, Geological Survey of California. J. D. Whitney, State Geologist.

Between these cañons, ridges or divides are formed, on top of which gold placers are found. These gold-bearing surface deposits extend from Shasta in the north to Kern County in the south, the most extensive deposits occurring in Plumas, Sierra, Placer, and Nevada Counties. The term *shallow placers* is applied to deposits of gravel and earth whose thickness varies from a few inches to five or six feet in depth, to distinguish them from *deep placers* or detrital accumulations found in ancient channels covering large areas, and varying from one hundred to several hundred feet in depth.

THE DISCOVERY OF THE GRAVEL DEPOSITS CONTAINING THE PRECIOUS METAL.

The pioneer miner, after working out the river bars, followed up the stream to find "the source of the gold." Its existence was discovered from slides, denudations, and breaks in the channels, which subsequent explorations proved to be the ancient river system of the State, whose general course is nearly at right angles to the present river system of California.

The indefatigable prospector advancing further into the unexplored mountains again discovered gravel beds at elevations of several thousand feet above the present water-level. The streams flowing through the precipitous cañons of the high Sierra aided materially in the development and discovery of the gold-fields. Their waters were soon appropriated for gold-washing, and thus was inaugurated the system of mining-ditches, which to-day extends over several thousand miles.

The immense gold-bearing drift inclosed between channel walls, or "rim rock," as it is called, was explored by means of tunnels driven in from bordering cañons, tapping the bottom of the deposit, enabling the extraction of the pay stratum, which was subsequently sluiced to extract the gold. This style of mining received the name of "deep placer mining."*

Little by little the "top dirt" of these deposits, composed chiefly of light soil, clay, fine gravel, and streaks of sand, was washed off, and in places considerable gold was thus obtained. Canvas hose was brought into use to convey the water over the banks for wash-

* Deep placer mining is now carried on in those sections of the State where the rich deposits are covered with thick beds of lava, rendering hydraulic mining impracticable.

ing the dirt, and from this originated hydraulic mining. In the progress of the work strata were found composed of boulders, pebbles, quartz, sand, and various rocks cemented together, requiring the use of powder to break them up. The color of this cement was in places white or reddish, and sometimes blue.

Shafts sunk in these strata discovered the presence of gold in great abundance, and a fresh enthusiasm was thus infused into gravel mining, already on the wane, as the river bars were becoming exhausted.

THE GOLD-BEARING DEPOSITS OF CALIFORNIA.

The auriferous deposits of California are chiefly confined to the western slope of the Sierra Nevada Mountains. The principal counties in which placer mining is carried on are Shasta, Trinity, Plumas, Sierra, portions of the east side of Butte and Yuba counties, also Nevada, Placer, El Dorado, Amador, Calaveras, Tuolumne, Mariposa, and Stanislaus Counties. "It is here," says Professor Whitney, "that the belt of metamorphic slates and sandstones, which is peculiarly the gold-bearing formation of the State, is developed to its greatest width, and least concealed from the miners' explorations by the presence of overlying non-metalliferous formations. It is here that the physical conditions have most favored the concentration of the gold in the detrital formation, so that it could be obtained by simple washing, without the necessity of mining for it in the solid rock, and perhaps more readily and more abundantly than any region ever opened to seekers after the precious metal."*

The gold deposits are found in river channels, in basins, and on flats; also as isolated and rolling hills; and occur either as accumulations of gravel alone, resting directly on the surface, or as accumulations of detritus, consisting of gravel, sand, drift, pebbles and boulders of all sizes, covered with lava and other volcanic products. Their geological ages are Post-tertiary and Tertiary. Quantities of fossil wood and numerous remains of land and water animals have been found in the deposits, and are being constantly unearthed as the mines are worked.

The auriferous alluvions mark the lines of ancient rivers, whose action on a grand scale was analogous to that which can be daily seen along the streams which receive the tailings from the hydraulic

* Geological Survey of California, vol. i, p. 214. J. D. Whitney.

claims now being worked. Volcanic eruptions have in places covered these deposits with lava and tufa, hundreds of feet deep. Denudation and erosion, the companions of Time, have subsequently played their parts, and later in turn the product of volcanic activity has been overlain with gold-bearing detritus.

These gravel channels are from a few hundred to several thousand feet wide, and range from the shallow placer to a drift six or seven hundred feet in depth. Their richness in gold varies in general, as well as in particular, in the many parts of the State.

Ferruginous-colored spots, so well marked in "upper or top gravel," are not always as productive in gold here as they are generally found to be in the gold alluvia of the Ural Mountains. A black sand, composed chiefly of glancing grains of magnetic iron, generally accompanies the precious metal, though it does not indicate its presence.

Dr. T. Sterry Hunt, speaking of the erroneous impressions which prevail in reference to the presence of black sand in auriferous alluvions, very appropriately remarks that "similar black sand residues, consisting chiefly of various ores of iron (sometimes oxide of tin and other minerals), may be obtained from the washing of almost all sands and gravels derived from crystalline rocks, and that the occurrence of a black sand, therefore, in no way indicates the presence of gold. When, however, this metal is present in a gravel, it, from its great weight, remains behind with the black sand and dense matters in the residue after washing."*

THE DISTRIBUTION OF GOLD IN GRAVEL DEPOSITS.

It is not unfrequently stated that it is from the washing of the entire banks that the gold is to be expected, it being disseminated throughout the whole deposit. That deposits are or are not auriferous for their entire depth will not be discussed; but that gold is proportionately diffused throughout the detritus, so that it could all be considered as "pay," is denied by experience and facts, as proven in California and other parts of the world.† It is owing to that

* Geological Survey of Canada, Report of the Progress, 1863–66, p. 86.

† Deposits between Tagilsh and Ekaterin, Die Lehre von den Erzlagerstätten, Von Cotta, p. 556. See article on "Gold Deposits," by M. A. Selwin, Geologist of Victoria, Quarterly Journal, Geo. Soc., 1858, p. 583. See "Gold Deposits of Garagua," Annales des Mines, 1817, vol. ii, p. 202. See gold deposits of Santa Rita, Contagallo and Minas Novas, Geology and Physical Geography of Brazil, Hartt, pp. 50, 51, 159, 160. See account of the gold-fields of Yesso, "Mineral Wealth of Japan," Henry S. Munroe, E.M., Transactions American Inst.

circumstance that miners have coined the expression "pay dirt," which means that stratum or those strata which contain the bulk of the precious metal.

In some districts gold is found thirty to fifty feet above the bedrock, in sufficiently paying quantities to wash, and in some shallow* banks gold is quite generally disseminated. Both at San Juan and North Bloomfield the gold is more or less scattered throughout the deep banks, and diggings near Forest Hill, Placer County, twenty to sixty feet above the bedrock, have yielded profits.

The top-gravel of the channel deposit which passes through Columbia Hill, Nevada County, has in several instances been successfully washed. This is especially remarkable on account of the great depth of this deposit, which from the explorations on Badger Hill and Grizzly Hill, is inferred to be six hundred to six hundred and twenty feet deep. With such facilities as would be afforded by a heavy grade, sufficient dump, and clear water, deposits of this character consisting of a fine light quartz wash, containing no boulders or pipe-clay, though they contained an insignificant amount of gold per cubic yard, could be successfully worked by the hydraulic method.

Experience has proved that the quantity of gold found in "top-gravel" is insufficient to warrant any large investment based solely on its value. Under exceptional conditions and circumstances the upper strata have in some cases yielded handsome returns, but on the whole the general results have been anything but fortunate.

It is, thererore, a well-established fact that the pay-dirt is obtained not from the washings of the entire bank, but chiefly from that stratum or those strata† which are in most cases within eight or ten feet of the bedrock.‡ Where this is of slate upturned on its edges, the gold frequently permeates§ it one or two feet. It also

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Mining Engs., vol. v, p 236. See Engineering and Mining Journal, December 2d, 1876.

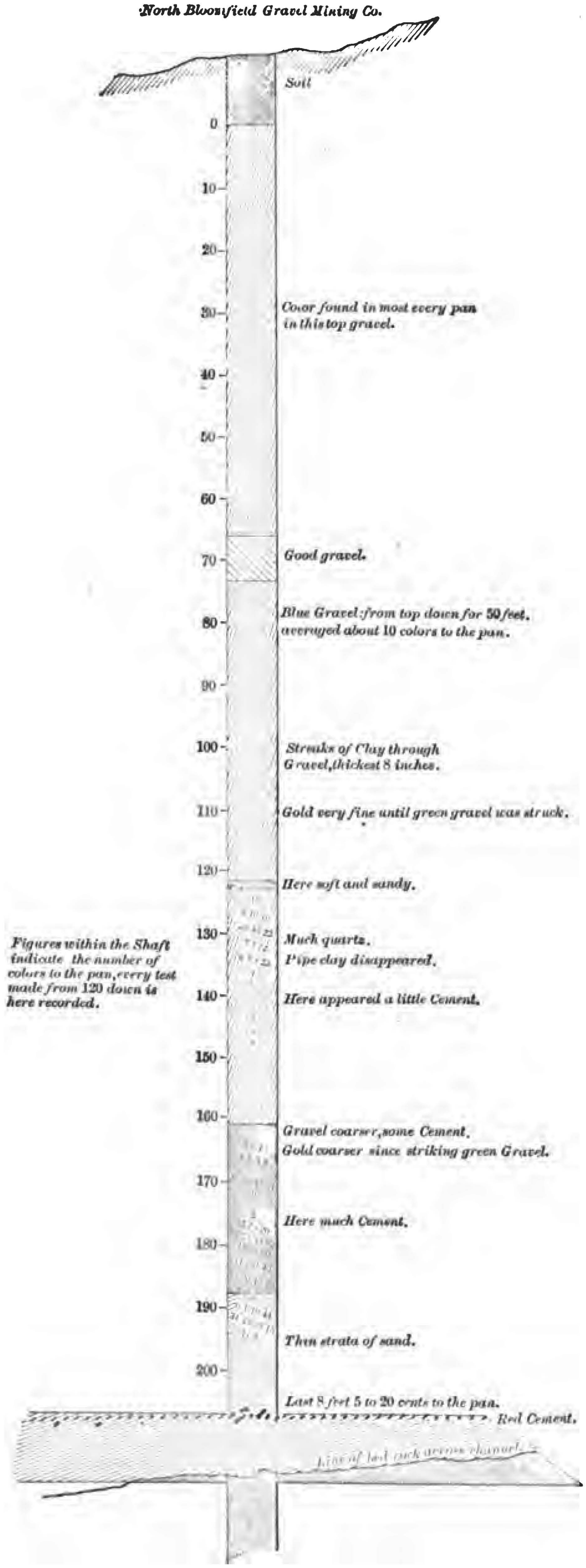
* See description of the auriferous deposits at Morse's and Growler's Creeks, the Gold-fields and Mineral Districts of Victoria, R. Brough Smyth, p. 84.

† On the subject of the relative position of gold in deposits, see report of Mr. Stutchbury, Government Geologist of N. S. W. See Die Lehre von den Erzlagerstätten, Von Cotta, vol. i, p. 101.

‡ See account of the gold deposits at Nation's Gully, New Gully, Never Mind Spur, Beechwood District; also workings at Balaarat, the Gold-fields and Mineral Districts of Victoria, R. Brough Smyth, pp. 81, 82, 87, 131, and 173.

§ See Murchison's description of "Diggings at the Soimanofsk Mines," Siluria, p. 456, vol. i, Russia and Ural Mountains, p. 487; also, see account of the "Gold Deposits in Woods Point District and Windlass Hill," Gold-fields and Mineral Districts of Victoria, by R. Brough Smyth, pp. 86, 106.

SKETCH OF SHAFT NO. 1.
MALAKOFF
North Bloomfield Gravel Mining Co.



occurs in thin streaks of cemented gravel scattered here and there in the alluvial deposits, and not unfrequently a fine lamina gold is found in the grass roots.*

This last-mentioned circumstance is in no way localized, as similar facts have been noted in other countries. Mawe calls attention to the existence of gold in the grass roots on Mt. San Antonio,† in Brazil; and Walsh states that gold was first discovered in the deposits between S. Jose and S. João, Brazil, by Paulistas, who, pulling tufts of grass, "found numerous particles of gold entangled in the roots."‡

The gold alluvia found near and along the banks of the Tuolumne River, Stanislaus County, present some striking examples of the distribution of the precious metal. The pay-dirt in the Chesnau Claim is confined to within six feet of the bedrock, whilst in the Sicard Claim, situated about six hundred feet south of it and across a ravine, with banks from twenty to forty feet high, the gold is more generally disseminated as long as there are no sand strata, but whenever the latter appear the pay is confined to near the bedrock.

Sir Roderick Murchison, describing the gold alluvia of the rich mine of Peshanka, near Bogoslofsh,§ says: "Most of the gold has been extracted near the centre of the detrital mass, whose maximum thickness is about seven feet, and which is clearly divisible, as elsewhere, into two parts, viz., overlying clay and shingle, and auriferous sand beneath."

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* In reference to the occurrence of gold, the following note, taken from the Engineering and Mining Journal, February 10th, 1877, relative to the discovery of pay-gold in the New South Wales coal-measures, will be found interesting. Mr. C. S. Wilkinson, F. R. S., writes from the Geological Survey Office, Gulong, under date of November 25th, to the Mining Department, as follows: "During my examination of the Tallawang Gold-field Reserve, I observed the important fact that the gold found in tertiary alluvial deposits at the old Tallawang and Clough's Gully diggings has been chiefly derived from conglomerates in the coal-measures. These conglomerates are associated with beds of sandstone and shales containing the fossil plant of our coal-measures, the Glossopteris. . . . . This is the first time that gold has been noticed to occur in payable quantity in the coal-measures in the colony, and it is not unworthy of remark that we here possess one of the most ancient 'alluvial' deposits in the world."

† Mawe's Travels, p. 264.

‡ Walsh's Notices of Brazil, 1828, 1829, vol. ii, p. 122. Note.—"The silver mines of Potosi were discovered by a Spaniard, who in ascending the mountain seized a bush to assist him, and this giving way, he found the roots embossed with silver."

§ Russia and Ural Mountains, Murchison, vol. i, p. 482.

At Minas Novas, in the Province of Minas Geraes, Brazil, the "greater part" of the gold is in a deposit called cascalho, which adjoins the decomposed bedrock. The cascalho is a conglomerate, composed of rounded quartz pebbles of various sizes, which have been cemented together with ferric oxide. "To this conglomerate the search for precious metals has been chiefly confined. Over this gravel lies a mass of red drift, varying in thickness from a few inches to fifty feet."*

The stratum of cascalho mined from the bed of the river Jigitonhonha at the Mandanga Diamond Works, consisted of the same materials as that of the other gold districts of Brazil. Large conglomerate masses of rounded pebbles, cemented together by ferric oxide, found on the banks of the stream, occasionally contained gold and diamonds. The gold extracted from the cement gravel at Caparatra, situated higher up the river, was accompanied by a great abundance of "black oxide of iron."†

In the Patricksville Light Claim, Stanislaus County, Cal., the pay stratum is six or seven feet thick and adjoins the bedrock. The gold is concentrated in this gravel deposit as long as there are sand strata in the bank, but with their disappearance it is more diffused throughout the detritus. Whilst working this claim a large hole in the bedrock twenty-five feet deep was bottomed. The hole was filled with gravel, but no pay was obtained. The pay stratum was found to be on a level with and a continuation of the pay stratum of the rest of the claim. On the other hand, at the Chesnau and French Hill Claims, whenever these hollows are found, a large yield of gold is invariably obtained.

The experience of miners in the gold-fields of Victoria has led to the conclusion that "in large auriferous rivers gold is always found on the bars or point, and not in the deep pools or bends."‡ In substantiation of these facts are cited Reid's Creek, Wool Shed, Twist's Fall, or Yackandandah, near Osborne's Flat, and Rowdy Flat; at each of these places large holes were cleaned out, and "only a few colors obtained, whilst shallow flats immediately below them were very rich."

At French Hill, Stanislaus County, where the bedrock was undulating, and in depressions found around a little hill formed by a

* Geology and Physical Geography of Brazil, Hartt, pp. 159-60.

† Mawe's Travels, p. 222-7.

‡ The Gold-fields and Mineral Districts of Victoria, R. Brough Smyth, p. 134.

sudden rise in the bedrock, the gravel paid better than in any other portion of the claim. The gold-fields south of Miask* in the Ural Mountains, present a similar case, all the undulating ground and depressions around conical hills being the most productive in gold. The bulk of the pay-dirt in the cement gravel of Nevada County is within the first thirty feet of the bottom.

INVESTIGATION OF THE COMPARATIVE VALUES OF THE DIFFERENT GRAVEL STRATA AT NORTH BLOOMFIELD.

It was the result obtained by the North Bloomfield Gravel Mining Company from washing three and a quarter million cubic yards of top gravel (1870–74), yielding 2.9 cents per cubic yard, and leaving a profit of only $2232.84, that determined capitalists interested in these claims to investigate the question of the comparative values of the upper and lower gravel deposits.

With their experience of the past and considering the contingencies of proposed explorations, and the attendant costs of an enterprise which had for its ultimate aim the working of the entire auriferous deposit, after mature deliberation it was (as a preliminary step) deemed of paramount necessity to ascertain, as far as practicable, the relative values of the different strata of the gold-bearing alluvia, so that they might judge to what extent the prospects would justify their expenditures. A series of explorations was subsequently carried out under the immediate supervision of their able engineer, Mr. Hamilton Smith, Jr., and the result of his investigation is best given in his own words: "To test the comparative values of ground developed by the shaft-workings and top-gravel, two hundred and forty samples, weighing in all two and one-half tons, were taken at even distances from the sides of the drifts, and the same quantity sampled from different layers of the upper bank. These samples were carefully panned out, and yielded, the blue $1.10 per ton, the white a large number of colors, but an inconsiderable weight of gold. The gold from the blue dirt was from 50 to 100 times heavier than that from the white gravel."† Although the gross yield from this sampling of the upper gravel was slight, it is a noteworthy fact that in each of the 240 pans one or more colors of gold were found.

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* Russia and Ural Mountains, Murchison, p. 488.

† The North Bloomfield Gravel Mining Co., Report by H. Smith, Jr., pp. 17, 18.

COMPARATIVE VALUE OF THE GRAVEL STRATA IN STANISLAUS COUNTY.

At the Light Claim, Patricksville, a comparative test of top and bottom gravel was made. 58,340 cubic yards top gravel* yielded 2 cents per cubic yard. The bottom gravel† (four feet deep) was then washed up, when it was discovered that this ground had been extensively drifted; but notwithstanding this fact, 4966 cubic yards yielded 55 cents per cubic yard. A trial of top dirt was also made at the Light Claim, La Grange. 41,038 cubic yards top dirt‡ yielded 3 cents per cubic yard, and 7242 cubic yards of bottom dirt§ yielded 94 cents per cubic yard.

SAND STRATA.

In the gold-bearing drift of the Sierra Nevada, layers consisting exclusively of wash-sand are generally found to contain very little if any of the precious metal.‖ In gulch mining it sometimes happens that from the position of the bedrock the detrital accumulations assume the form of reclining cones, the apex reposing upon the top of the hill. Where such is the case, the bulk of the gold is concentrated in the lower end of the deposit. These gulches are frequently found to be exceedingly rich.

It is not within the scope of this paper to discuss the origin of auriferous detritus, or in any way to account for the mode of occurrence of gold, but these general facts are merely cited as an explanatory outline of the subject, and to show the reason why a system of sluicing is adopted which bottoms the entire deposit.

THE RECORDS OF GOLD-WASHING.

The early record of gold-washing extends to the days of the Greeks and Romans. History has familiarized us with the wonders of the Pactolus and Tagus, and it is a fact¶ that the diggings north

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* $1200. † $2775.07, ground two-thirds drifted out. ‡ $1500. § $6709.72.

‖ From Whiskey Run to Coquille River, Oregon, the beach sands, formerly very rich, have been extensively worked for 3 or 4 miles along the seacoast. The productive stratum was a layer of black sand 1 to 2 feet thick, buried from 2 to 5 feet below lighter sands. The gold occurs in minute particles. This sand likewise contained some platinum and iridosmine.—Ext. Trans. California Acad. Sciences, W. A. Goodyear, of the State Geo. Survey.

¶ Strabo, book iv., chap. vi, 12. Footnote Siluria, p. 449.

of Aquitania produced in two months such a large amount of gold that its price fell 33 per cent. throughout the whole of Italy.

Gradually, one after the other, the well-known deposits of the Old World have been exhausted. The alluvia in Siberia, however, kept alive the interest in gold-washing, and the subsequent discoveries in California and Australia infused a new life into this kind of mining. Since that time gold-washing has been carried on in different parts of the world on a most extensive scale, but the application of water under great pressure to "gold placer mining" is an outgrowth of the present century. Its use is chiefly confined to the Pacific Coast, and consequently the contributions to mining literature relative to its application have not been numerous.

HYDRAULIC MINING.

It was left to the untiring ingenuity of the California miner in his battles for fortune to devise the economical method of hydraulic mining, by which mountains of auriferous gravel are removed through the agency of a continuous stream of water, extracting the precious metals stored away by nature, and adding millions of hidden wealth to the treasures of the world.

Independent of the financial importance of this most modern method of mining, its effects, from the gigantic scale with which it is now carried on, upon the system of drainage of the country as well as the navigation of rivers, will sooner or later bring it in direct conflict with agricultural and commercial interests.

Apart from the construction of ditches and tunnels necessary for the hydraulic washing of the gold-bearing drift, engineers, as a rule, have had but little to do with the subsequent working of this class of mines. The primitive placer mining of 1853 to 1865 has passed into history. Forty-inch wrought-iron pipes have been substituted for canvas hose and stove-pipes, and with the replacing of one-inch streams by a mass of water discharged through nine-inch nozzles, under four hundred feet pressure, the last remnant of the Argonauts'* method disappeared, and hydraulic mining, with one gigantic stride, has become an operation of such magnitude as to require the aid of science.

* The name is generally applied to those pioneers who arrived here in 1849–50.

THE DEFINITION OF HYDRAULIC MINING.

Hydraulic mining may be defined as the art of extracting gold from gold-bearing detritus, *i. e.*, surface deposits, placers, or washings, by means of water under great pressure discharged through pipes against the auriferous material. In working gold deposits by this method, it is essential to success that there should be, first, economical management; second, ample facilities for grade and dump; third, a sufficient head and an abundant supply of cheap water. As regards the "economical management," the same can be considered a *sine qua non* for success in all enterprises, but it is especially requisite here, as the value of this kind of mining is based on the great facility with which profitable results can be obtained at trifling costs from washing vast areas of ground which contain relatively per cubic yard insignificant amounts of precious metal, but in the aggregate, when expeditiously and skilfully worked, give large remunerative returns.

THE DUMP.

Without the dump, hydraulic mining is an impossibility. On this point too much stress cannot be placed. Where thousands of cubic yards of alluvions are being daily washed from their original positions into cañons, valleys, streams, or rivers, it is not the accumulations of a few months which must be considered, but places must be provided at lower elevations, where the immense hills of gravel, when "hydraulicked,"* can be redeposited; and in general a very much larger superficial area for this is requisite than was originally occupied by the material removed.

It sometimes happens in claims near or adjoining one another, working with the same dump on a light grade, that the bedrock in one is lower than that of the other. Where this occurs, the claim with the highest bedrock should be the last run off, so as not to interfere with the dump of the lower claim. An illustration of this condition of affairs is afforded by the Patricksville Hydraulic Claims, in Stanislaus County, where three claims, one tailing over the other, are annually worked. During the last two years the lowest claim, called the Chesnau, has been closed in the fall, its dump giving out, whilst the upper ones continued work. With the return of spring freshets, the cañon has been cleared of the débris,

* The words "hydraulicked" and "hydraulicking" are the coinage of the California placer miner, and custom has here sanctioned their use.

and washing has been regularly resumed in the Chesnau, continuing as long as the dump lasted. The upper claim is closed whilst the Chesnau is working, to avoid the too rapid filling up of the creek. If the two higher claims were worked at the same time, the Chesnau would soon be closed for an indefinite period.

TAILING INTO STREAMS.

It is supposed by many that the want of dump is remedied by discharging into a current or mountain rapid. This undoubtedly would be so were the gold placers on the borders of large, rapid, and well-confined streams; but in the mountains where the gold-bearing deposits are found, the rivers are narrow, shallow, only running water in quantity during the winter and early spring.

Some of the annoyances and difficulties arising from tailing into a stream can be seen on the Tuolumne River below La Grange. The river for seventeen miles above the town has a fall approximating eighteen feet to the mile. It is a large mountain stream (fed by the snows and rains of the Sierra Nevada), well confined by abrupt banks.* At La Grange† its width is five hundred and twenty-five feet. Three hundred yards below the town, opposite the Light Claim, it widens to seven hundred and fifty feet.‡ Down the stream from this point the hills for the succeeding three or four miles recede, but subsequently form prominent banks of the river. During high water in the winter opposite the Light Claim, at its greatest width, its average depth was ten feet,§ the centre of the channel being fourteen feet deep. When the La Grange Hydraulic Mining Company commenced work, in 1872, the bottom of the channel was a few feet deeper.

The Light Claim was worked in 1873, and by June 23d, 1874, 720,086 cubic yards of gravel had been discharged into the stream near the claim, and during the same period 975,064 cubic yards were dumped into the river from the Kelly and French Hill properties. The results at the expiration of twenty-one months were, that the channel opposite the Light Claim was filled up, the sluices were run out of grade, the river bed was shoaled on all sides, the water of a

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* The river opposite the old French Hill dump is five hundred feet wide.

† At the Ferry. The grade of the river from here to its mouth is only a few feet to the mile.

‡ Extreme width during high water. Width at lower sluice, 700 feet.

§ Deeper in narrow places.

former rapid stream straggled over the accumulated débris with a barely perceptible motion, and it is hardly necessary to add that the claim was closed.

The spring freshets of 1875–76 were unusually severe, clearing the river at the claim for its entire width, and leaving a dump of over eleven feet along its west bank. This spring* (1876) work was resumed, and since then 48,280 cubic yards have been moved in the "Light," and 212,346 cubic yards from French Hill, which is a quarter of a mile up stream. At present† the river is filled up nearly its entire width to the height of the sluices, and the water is confined to a strip thirty feet wide, discharging one foot deep over a bar.

Where a small amount of tailings is discharged into narrow and steep cañons, winter rains and spring freshets suffice to clean them out, but where the quantity is large, in spite of the water the ravines gradually fill up, and hydraulic mining in those localities ultimately ceases. It occasionally happens that the want of dump room is obviated by a tunnel, and by means of it the tailings are conveyed into large and precipitous ravines, consigning them to the action of time and water for their further removal.

PRELIMINARY WORK.

As a prerequisite to success in the selection of a tunnel site, considerable preliminary work is demanded. It necessitates the study of the deposit, the ascertaining of the position of the channel, the depth of the bedrock, covered generally with hundreds of feet of detritus, and the calculation of the costs of the work, with estimates of the yield of the ground, all of which afford a fine field for the engineer.

Hence, it is a prime necessity for the hydraulic miner to obtain accurate information on these points. The explorations of the North Bloomfield Company furnish a remarkable instance of the extent to which such preliminary work has been successfully carried out.

To determine the value of their claims and the feasibility of working them by the hydraulic process, four prospect shafts were sunk to ascertain the position of the channel and the depth to the bedrock. Of these shafts No. 1 alone struck the main channel, developing 135 feet of blue gravel,‡ and finding bedrock at a depth of 207 feet.

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* April 10th, work was resumed on top dirt.

† Dry season, months of August, September, and October.

‡ This 135 feet of gravel yielded 46 cents per cubic yard.

Drifts were driven from the bottom of this shaft a distance of 1200 feet on the course of the channel, and its width was approximated at 500 feet. The aggregate length of the channel explorations was over 2000 feet. The gross cost of the entire prospecting work was $63,956.20.*

Having ascertained the value of the gravel, the depth and position of the bed-rock and channel being determined, the company decided to open their mines, and a working tunnel was then located.

The profitable removal of the gold-bearing detritus by the hydraulic method requires that the greatest facilities should be afforded for the rapid transport of the material. Where a dump can be obtained and it is practicable, open cuts are run sufficiently deep in the bed-rock to bottom the channel. In those cases where open cuts are not serviceable, a tunnel is requisite.

TUNNELS AND THEIR LOCATION.

The object of tunnels in gravel mining is to afford suitable means for the hydraulic washing of the auriferous deposits, and from their general relative positions they are fitted with sluices† to catch the gold from the washings. The size of the tunnel is dependent on the requirements, viz., with a six-foot flume it should not be less than 8 by 8 feet; with a four-foot flume, 5 by 7 feet.

In locating drainage-tunnels, or in opening hydraulic claims which do not require tunnels, that place is to be selected from which the sluices, running on the straightest practicable line with a given grade, can bottom the major part of the "pay deposit" at the smallest possible expense.

Due regard should be had for the dump in the establishment of this line, and allowances made for contingencies arising from changes, such as depressions and holes in the bed-rock. It is advisable, besides allowing for grade and dump, to run the tunnel or cut from a point sufficiently deep to strike from fifty to seventy-five feet below the top of the bed-rock, at the point where connection is to be made with the surface.

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* From the several drifts and breaks 21,614 tons of gravel were extracted, yielding $32,600, or $1.50 per ton. In one of the drifts the gravel paid 75 cents per ton, at a height of from 15 to 20 feet above the bed-rock. The actual yield from all the drifts was about $2.75 per cubic yard, and as determined by sampling, $2.01 per cubic yard. For particulars, see report of H. Smith, Jr., C. E. to the N. B. G. M. Co., 1871, p. 17.

† In the lower end of the N. B. tunnel no box-sluices are used.

This additional depth* is a matter of judgment, and in determining it one should be governed by the character of the bed-rock, extent of ground to be worked, and the position of the shaft. It is always an easy matter to ease up the grade, but if the main line of drainage is once fixed, and proves to be too high, it is a source of endless expense, and is frequently fatal to the enterprise.

At the Pioneer Mine, Grass Flat, Plumas County, the original owners in opening their claim ran a tunnel 4000 feet long. When midway in the channel the tunnel was found to be twenty-two feet above the bed-rock. The sum of sixty thousand dollars expended in this work was a total loss.

Generally the difficulty in locating tunnels is to find suitable places which do not involve heavy expenditures. Some idea of the extent of these preliminary operations may be obtained from the following memoranda concerning several tunnels on the ridge (Nevada County) driven within a few years past :†

Name of Mine or Tunnel.	Locality.	Length of Tunnel.	Average Grade of Tunnel.		Reported Cost.
			Inches per Sluice-box.	Feet per 100.	
			In. Ft.		
Boston, ...	Wolsey's Flat, .	1600	10½ to 12	7¼	$40,000
North Bloomfield, ...	Humbug Cañon,	8000	6½ " 12	4½	500,000 ‡
Farrell, ...	Columbia Hill, .	2200	6 " 14	3½	Not complete.
English Mine, ...	Badger Hill, . .	1400	12 " 14	7	
American, ...	Below San Juan,	3900	10⅓ " 14	6¼	$140,000 §
Manzanita, ...	Sweetland, . . .	1740	7 " 14	4⅙	62,000
Sweetland Creek, ...	Sweetland, . . .	2200	8 " 14	4⅔	90,000 §
Bed-rock, ...	Below Sweetland,	2600	9 " 14	5¼	
French Corral, ...	French Corral, .	3500	8 " 14	4⅔	165,000

To these may be added the principal tunnels driven in the mining district of Smartsville.

* Where the bed-rock disintegrates on exposure to the air, *i. e.*, soft bed-rock, it is advisable to allow for considerable depth when practicable.

† Ext. Report on the Water and Gravel Mining Properties of the Eureka Lake and Yuba Canal Company. By James D. Hague, M. E.

‡ With 8 auxiliary shafts, increasing the cost, but diminishing the time required.

§ Not from official reports.

Name of Tunnel.	Locality.	Length of tunnel.	Average grade of tunnel.	
			Inches per sluice-box.	Feet per 100.
		Feet.	In. Ft.	
Babb, . . .	Timbuctoo.	1200	5½ to 12	3.80
Pactolus, . .	" "	1700	6 to 12	4.16
Rose's Bar, .	" "	1600	6 to 12	4.16
Blue Gravel, .	Succor Flat.	1100	6½ to 12	4.50
Pittsburg, . .	" "	900	6 to 12	4.16
Blue Point, .	" "	2250	6 to 12	4.16
Enterprise, .	" "	1200	6 to 12	4.16
Deer Creek, .	Mooney's Flat.	2200	5 to 12	3 40

THE EXTENSION OF THE TUNNEL AND THE CONNECTION OF ITS HEADING WITH THE SURFACE.

When a tunnel is used to open a claim it should be driven well into the channel before any connection is made with the surface. The shaft which connects with the heading should be vertical.* Its size is to be determined by the requirements of the work, 4 x 4 feet or 5 x 9 feet in the clear, according to circumstances. Whilst raising from the tunnel due precaution should be taken against accidents arising from the rush of water, sand, and gravel, which is liable to occur when the bottom of a deposit is tapped.

Where a shaft 5′ x 9′ in size is sunk it should be divided into two compartments, one of which will serve as a man-way, and in the event of obstructions arising in the other compartment, this one can be used in removing them. There is some difference of opinion as to the use of vertical shafts; also as to the expediency of making direct connection between the shaft and tunnel. Respecting the former, it may be observed that a vertical shaft, when properly timbered, is the most desirable and economical to use for opening hydraulic claims. With drops 200 feet no difficulty in working has been experienced. As regards the direct connection of the shaft with the tunnel, where the work is well constructed no trouble or set-back will be encountered in adopting this method of mining. Where a tunnel has to be extended beyond the shaft, it is sometimes convenient to sink the shaft off to one side of the tunnel, connecting it by means of a short drift. In general, where an extension of the tunnel has become necessary, the shaft has been reduced to a drop-off of

* Occasionally inclines are used.

fifty or sixty feet, or bed-rock cuts have lowered it to a level, and consequently the tunnel as extended will diverge from the course of the main tunnel. This is especially the case when the main tunnel enters the channel, as is most usual, at an angle to its general direction.

THE TIMBERING OF THE SHAFT, ETC.

To avoid any accident or trouble, such as might be occasioned by caving of the shaft, it should be strongly timbered, closely lagged, and lined on the inside with two-inch lumber to within, say, eight feet of the surface. This top being the first washed off, is used for fall. When in soft rock, the shaft should be timbered close with timbers of the requisite size. These timbers are then lined on all four sides with blocks of wood from four to six inches in thickness set on the end of the grain.

The bottom of the shaft can be protected against wear by using pieces of heavy logs or sticks of twelve inches square timber, stood on end, securely bound together, or it can be paved with heavy stones, but in many cases the bare bed-rock only is used. The last fifty to seventy-five feet of the tunnel which connects with the shaft should be heightened from eight to twelve feet, and at their junction the ground should be securely timbered and protected.

With long tunnels it is advisable to sink a second shaft at a convenient distance from the heading. As a precautionary measure a man is sometimes placed in the tunnel to watch the runnings, and in such cases a second shaft is indispensable. Should an accident occur at the main shaft by its caving or closing up, the second shaft would also afford the necessary facilities for reopening the work.

FIRST WASHINGS THROUGH THE SHAFT.

When a claim is opened by means of a shaft, the first washings through it should be done with care, and the surface, within as great a radius as can be conveniently washed and drawn, should be cleared on all sides, before any descent is made by taking off the top timbers. Attempts to push this preliminary work have frequently caused an overcrowding of the shaft, resulting in its filling up or getting choked by caving. It is, therefore, essential that the gravel should be run so as to avoid the rush of material from caves; and to prevent the accumulation of rocks in the bottom of the shaft an excess of water should always be used.

THE GRADE.

The facility with which gravel can be moved by water depends mainly on the inclination which can be given to the sluices. The question of grade is, therefore, one of vital importance, and to carefully investigate and determine this question great care and skill are often required. When the topography of the country admits of unlimited fall, the grade or incline upon which the sluices are set should be regulated by the character of the gravel to be moved. Where the wash is coarse and cemented, requiring blasting, or where there is much pipe-clay, a heavy grade is requisite. Strongly cemented gravel requires falls or drops to break it up. To prevent the loss of gold, grizzlies* and undercurrents are used to relieve the sluices of the finer material containing gold already detached and being carried forward by a strong stream and heavy grade.

Experience so far has led to the adoption, in most localities, of what is called a six inch grade, meaning six inches to the box twelve feet long, or say 4 per cent. grade. In some places, where large quantities of pipe-clay are washed off, nine and twelve inch† grade to the box is used (6 to 8 per cent.), in others, on account of natural obstacles encountered, a 1½ per cent. grade, or 2½ to 3 inches per box of sixteen feet, is used.

Light gravel can be moved on an easier grade and with less water than heavy gravel, nevertheless when a 4 per cent. grade can be obtained it is desirable, as it lessens the labor of handling rocks. Moreover, as light gravel is generally poor in gold, this deficiency can only be made up by washing large quantities of it. On the other hand, coarse gravel demands from 4 to 7 per cent. grades, and a proportionate increase of water.

In washing heavy gravel, the water in the sluices should be deep

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* "Grizzly:" where a drop-off can be made in a line of sluices, steel bars or pieces of railroad iron laid parallel, with spaces between them, are placed on the bottom across and in the end of the sluice, so as to discharge the boulders over an embankment, whilst allowing the finer material to pass between the bars and drop into the undercurrents. The grating formed by the bars is called a grizzly. "Undercurrents" are sluices, 15 to 20 feet wide and 40 to 50 feet long, set on a very slight grade (nearly flat), provided with riffles to catch the gold and amalgam. They are placed to one side, below the main sluice. See chapter by Charles Waldeyer, Raymond's Report, 1873, 415, 416.

† In Placer County, at some of the mines, the sluices have a grade from 15 to 24 inches per 12-foot box. NOTE.—Oro Consolidated, sluices, 2½ feet wide and 20 inches deep, grade 5 inches to 12 feet (or 10.41 per cent.), are calculated to run 700 miner's inches of water.

enough (10 to 12 inches) to cover the largest boulders ordinarily sent down, whilst light gravel requires the water to run in sufficient force to carry the rocks washed through the sluice, and yet be in only sufficient volume to prevent the packing of black and heavy sand. If too much water is used, by superincumbent pressure the sand drops and packs the riffles. The best results are obtained with shallow streams on light grades.

SETTING SLUICES AND THEIR CONSTRUCTION.

In setting sluices, a straight line should be adopted, and where curves occur, the outer side of the box is slightly raised, in order to cause a more general distribution of the materials over the riffles.

Sluices are made of 1½ inch plank, tongued and grooved, carefully fitted together so as to prevent any leakage, resting on sills 4 x 6 inches. The length of the sill depends chiefly on the width of the sluice; thus, a 4 foot sluice would require a sill seven feet long. To securely tighten the bottoms of the sluices, the planks should be grooved and then joined together by driving in a soft pine tongue.

The posts are 4 x 6 inch scantling, forming with the sills a frame, which is placed every four feet to receive the sluice. The posts are dovetailed into the sills, and are likewise strengthened with side braces connecting the ends of the sills and the posts together. The size of the sluice* is regulated by the grade, character of the gravel, and quantity of water to be used. A sluice six feet wide and thirty-six inches deep, on a 4 or 5 per cent. grade, will suffice for running 3000 to 3500 miner's inches† of water. One four feet wide, thirty inches deep, on a four inch grade to sixteen foot boxes, will suffice for 1200 to 1500 inches of water, and on a 4 per cent. grade it is large enough for 2000 inches. A sluice three feet wide and thirty inches deep, with a 1½ per cent. grade, is ample for 800 to 1000 inches.

The requisite length of the sluice is determined by the character of the gravel washed, volume of water used, the grade, and the size of the sluices, the principle being to construct the line sufficiently long to insure the most complete disintegration of the material, thus affording ample surface for the grinding of the cement, and offering under such conditions the best facilities for the gold to settle in the riffles.

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* Double sluices are frequently used in large claims to advantage for continuous washings.

† Miner's inch, see further on in this article.

RIFFLES.

Square blocks of suitable length and breadth, 8 to 12 inches deep, called riffles,* arranged with spaces of 1 to 1½ inches between each cross row, are used to line the bottom of the sluices. They are held in position by small boards, 1½ x 6 inches, fastened crosswise on the bottom between the rows by means of headless nails, and made secure by a cleat, 1½ x 3 inches, nailed longitudinally on top of the blocks on both sides of the sluice. This method of setting riffles is falling somewhat into disuse. Block riffles are now frequently set and held firmly in position by means of soft pine wedges driven between the blocks and the sides of the sluice. When wedges are used it is necessary that the sides of the blocks should be square where they adjoin one another. A side lining is required in all sluices. In cement claims, blocks 4 inches thick, 18″ x 24″ in size, are used for side lining.

In many localities round stones instead of blocks are used for riffles, and where heavy cement† is washed these are considered preferable on account of their cheapness. At Smartsville they have been found to serve fully as well as the blocks, and are claimed to be cheaper. It must, however, be stated that they are more costly to handle, as longer time is required to clean up and repave the sluices when they are used. In some sections of the State longitudinal riffles are preferred, *i. e.*, riffles made of scantling placed lengthwise in the sluice. It is frequently the case that the several kinds of riffles are used in long sluices. Where the banks contain many large boulders, as at the Paragon Mine, a different style of riffle has been introduced. These riffles are made of 6 inch scantling, 1½ inches wide, 8 feet long, separated by blocks 1½ inches wide, and an iron bar, 1½ inches wide, 1 inch deep, and 8 feet long, is fastened on top of each scantling. The grade of these sluices is 18 inches per 12 foot box, and the width of sluice is 44 inches.

A system of riffles consisting of a row of blocks alternating with an equal section of rocks has been found to work successfully. This arrangement of the sluices materially reduces the wear and tear of

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* The primitive riffles used by the South American gold-washers, consisted of steps cut in the bare bed-rock. Blankets and grass sods were also used to catch the gold. See detailed description of the gold-washings of Jaragua, Mawe's Travels, pp. 77–8.

† The term cement is applied to a conglomerate which is chiefly cemented together by ferric oxide.

the blocks, and has given excellent results. The block and rock riffles are not desirable for those sluices which have frequently to be cleaned up.

So far, experience shows square block riffles to be the best for saving gold. The objection to their use is the cost of wear and tear. Rocks are the most economical substitute, but sluices set with them require steeper grades and more water than those arranged with blocks. As a matter of convenience and economy, block riffles should be used in the head sluices of those claims where the gravel is rich, or where a large amount of gold is monthly produced and cleaned up.

CHARGING THE SLUICES.

When work commences, the sluices are run half a day in order to pack them. A few moments before the quicksilver is added, the water is run clear, and they are then charged. More quicksilver is added during the second and third days, the quantity being increased until the riffles hold the mercury at the surface. During the washings, the sluices are repeatedly examined and recharged. The amount subsequently added is regulated by the quicksilver exposed to view; the total quantity required is more or less dependent on the length of the run.

When charging the riffles all splashing of the quicksilver should be avoided. When it is sprinkled into the sluice (a practice to be condemned), it divides itself into minute particles, the bulk of which is easily carried off by the swift stream, while portions of it will even float in the clear water. The buoyancy of these small particles is very considerable.

Float quicksilver, containing gold particles,* has been taken from off the surface of the water 20 miles from where the amalgam entered the stream. An instance of floating amalgam was observed on the north fork of the Yuba River. At a point four miles below where tailings were dumped, a flume (conveying water to a pump) was set 10 feet above the bottom of the stream drawing direct without any dam. An examination of the flume subsequent to its removal revealed the presence of about 1 oz. gold amalgam, collected at the junction of the boxes.†

* The gold particles were microscopic.

† This occurred in 1864. The flume was owned by Mr. Banks of San Juan, Nevada County.

LOSS OF QUICKSILVER.

In hydraulic mining a loss of quicksilver cannot be avoided, the amount lost depending on the character of the gravel washed, the quantity of water used, the grade, length, and condition of the sluices, and on the number of days run. The use of a long line of sluices, kept in good order, and the employment of undercurrents, tend to diminish it.

The aggregate amount of quicksilver lost at the La Grange Hydraulic Company's mines during a period of two and one-half years in running six claims 1520 days* (24 hours), washing and moving 2,275,967 cubic yards of gravel, and using 1,533,728 inches of water (2159 cubic feet each), amounted to 553.75 lbs. quicksilver. The North Bloomfield claims, for the year ending November 3d, 1875, used 464,600 miner's inches of water,† and 9649 lbs. of quicksilver were employed in the sluices. The loss of quicksilver at the respective claims was as follows:

Name of claim.	Miner's inches used.	Length of sluice.	Loss of quicksilver.	Per cent.
		Feet.	Lbs.	
No. 8, ...	386,972	1800	900	11
Woodward, ...	51,550	600	217	25
Eisenbeck, ...	26,000	400	125	25

The losses at the Woodward and Eisenbeck claims are attributed to old and poor sluices and steep grade. For the year ending October 31st, 1876, the loss of quicksilver at the above-mentioned claims was as follows:

Name of claim.	Miner's inches used.	Length of sluice.	Loss of quicksilver	Per cent.
		Feet.	Lbs.	
No. 8, ...	700,000	1800	2251	
Woodward, ...	30,000	600	123	
Eisenbeck, ...	56,200	400	182	

THE LOSS OF GOLD.

The loss of quicksilver would seem to involve a loss of gold, but

* The aggregate number of days' work of all the claims.

† Each of these inches discharged 2.230 cubic feet of water per 24 hours.

it is practically impossible to determine to what extent this is the case. There are many conflicting opinions as to the amount of fine floured and "rust" gold lost in hydraulic mining, but in properly constructed sluices the already known appliances, when used, save all that can at present be economically and profitably caught.

In substantiation of this can be cited the work done at Gardner's Point during the last four years. The number of inches of water used at this claim during this period is not known. The number of cubic yards of gravel moved has been approximated from the best obtainable data and an inspection of the property. From 1872–74 inclusive, about 148,000 cubic yards of dirt were moved. In 1875 the claim was only run fourteen days full time. This year (1876) 40,000 cubic yards of gravel and 260,000 cubic yards of lava ashes were washed off. The gross yield from 1872–76 was $140,000. The number of cubic yards of gravel moved during the corresponding time is sufficiently large to warrant the conclusion that the present known appliances for catching gold are adequately effective.

THE RESULT OF WORKING TAILINGS AT GARDNER'S POINT.

The tailings from all these washings were caught and confined in a ravine situated a short distance below the claim. The length of the sluice through which the gravel passed was 1373 feet, with three undercurrents. This year the ravine, supposed by many to be exceedingly rich, was cleaned up on joint account by Chinese, under special engagement with the owners, and its gross yield was $1168, not 1 per cent. of the total receipts from the washings.

ON THE DISTRIBUTION OF GOLD THROUGHOUT THE SLUICES.

In cleaning up sluices, the largest proportion, approximating 80 per cent. of the gold caught, is found in the first 200 feet of the head of the sluices.* The gross yield of the Gardner's Point claims for the season of 1874 was $68,000 for 100 days' run. Of this amount $54,000 was obtained in the first 150 feet of the sluices, and $3000 taken from the undercurrents. The remainder was found

* Mr. P. Wright, Assistant Engineer for Water Supply, Beechwood District, giving his experience on this subject, says: "With a sluice 12 inches wide on an incline of 1 foot to 48 feet, using 600 gallons per minute, I have found 95 per cent. of the gold within three feet of where the gravel was filled into the sluice—where the gold was lying upon a smooth board, and yet a powerful current failed to move it."—*The Gold Fields and Mineral Districts of Victoria*, R. Brough Smyth, p. 133.

lower down along the sluices. The first undercurrent was 790 feet distant from head of the sluice, and yielded 50 per cent. of the total yield of the undercurrents. The second undercurrent was 78 feet distant from the first, with a drop of 40 feet between them, and it contained 33 per cent. of the gross undercurrent yield. The third undercurrent was 91 feet distant from the second undercurrent, with a drop of 50 feet between them. Its yield was nearly $500.*

It sometimes happens that a hundred or hundred and fifty feet at the head of a sluice are covered with gravel during the greater part of a run. In such cases, the gold is found so much further down the sluice. In the North Bloomfield tunnel, the upper 300 feet of the sluice is generally filled with gravel, from 1 to 5 feet deep, and still this portion yields much more amalgam per linear foot than the next 300 feet of sluice below.

From the report of this company for the year ending October 31st, 1876, the following data and facts are worthy of note, as showing the position of the gold as cleaned up in the sluices at No. 8 claim, where some 700,000 inches of water were run, washing 2,919,000 cubic yards of gravel:

Sump, . . .	$1,510 00	.80	per cent. of gross yield.
Flume (1800 feet),	176,900 73	92.00	" " "
Tunnel below flume,	7,290 00	3.75	" " "
Tail sluice (300 feet),	1,800 00	.95	" " "
Undercurrents, .	5,235 00	2.50	" " "
	$192,735 73	100.00	

THE DISTRIBUTION OF GOLD IN TAIL SLUICES.

The North Bloomfield tunnel (8000 feet in length) has 1800 feet of sluices, paved with blocks, at its upper end, but in the succeeding 6200 feet no sluices are used, the tailings being allowed to run on the bare bed-rock (a tough slate).

From the rock cut at the mouth of the tunnel a sluice paved with rocks receives the tailings. From here on they are carried through sluices and cuts, distributing them over undercurrents set on different grades, paved in some instances with rocks and blocks, and occasionally arranged with longitudinal riffles covered with strap iron. The grizzlies used are made of wrought iron one by four inches in size, set on edge.

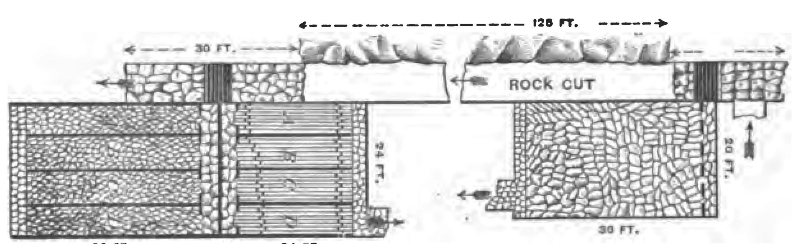
* The figures showing the yield of the undercurrents were calculated from the amalgam.

The discharge from the several undercurrents is taken up by the main sluice, and subsequently redischarged over the succeeding undercurrents, till the lowest sluice and undercurrent finally discharge the tailings into the cañon. From December 1st, 1876, to June 1st, 1877, three hundred and fifty thousand (350,000) twenty-four hour miner's inches of water (2230 cubic feet each) conveying the tailings passed through the tunnel, and were discharged through the tail sluice and undercurrents.

The annexed sketch shows the general arrangement of the tail sluices and undercurrents, which latter were subdivided into compartments as shown.

The distribution of the gold along the line of sluices and in the several undercurrents was as follows:*

ARRANGEMENT OF TAIL



No. 6.—Rock riffles. Grade 17 in. per 12 ft. No. 5.—Rail riffles. Grade 12 in. per 12 ft. No. 4.—Rock riffles. Grade 12 in. per 12 ft.

TAIL SLUICE, ETC., FROM DECEMBER 1ST, 1876, TO JUNE 1ST, 1877.

Miner's inches of water, 24 hours each,	350,000
150 feet at head down to No. 1 undercurrent, yield,	$3150 00
" remainder of sluice,	350 00
Total,	$3500 00†

No. 1 Undercurrent.—Size, 24 by 36 feet; grade, 13 inches to 12 feet; chute, 2 feet wide at opening, contracted to 10 inches; iron rail riffles.

* I am indebted to Mr. H. C. Perkins, Superintendent N. B. G. M. Co., for the data given. The results show the total yield of the many places, the number of "clean ups" made being noted in each case.

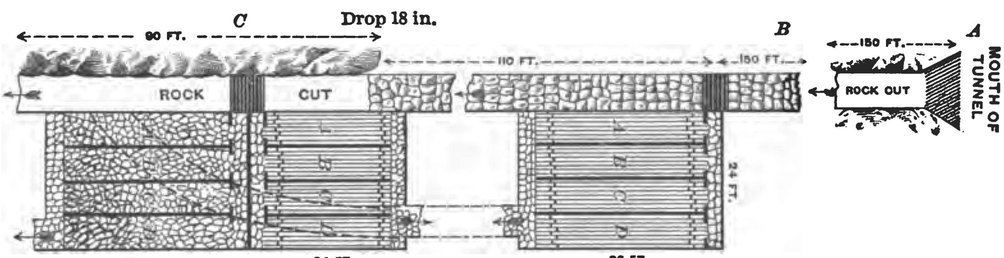
† 700,000 miner's inches water were used in 1875–6; the yield was $1800.

A	yielded	108½	oz.	amalgam.	3 clean ups.
B	"	83¾	"	"	
C	"	46½	"	"	
D	"	81¼	"	"	
Chute	"	46¼	"	"	
		316¼	oz.	. . .	$1920

No. 2 Undercurrent.—Size, 24 by 24 feet; grade, 12 inches to 12 feet; chute, upper end 2½ feet, lower end 2 feet; iron rail riffles.

A	yielded	48¾	oz.	amalgam.	2 clean ups.
B	"	36¼	"	"	
C	"	20¾	"	"	
D	"	23½	"	"	
Chute	"	14	"	"	
		143¼	oz.	. . .	$874

Sluices and Undercurrents.



No. 3.—Rock riffles. Grade 15 in. per 12 ft.
No. 2.—Iron rail riffles. Grade 12 in. per 12 ft.
No. 1.—Iron rail riffles. Grade 13 in. per 12 ft.

No. 3 Undercurrent.—Size, 24 by 36 feet; grade, 15 inches to 12 feet; chute, 2½ feet upper end, 2 feet lower end; rock riffles.

A	yielded	50½	oz.	amalgam.	2 clean ups.
B	"	35¼	"	"	
C	"	18½	"	"	
D	"	16	"	"	
Chute	"	8½	"	"	
		128¾	oz.	. . .	$883

No. 4 Undercurrent.—Size 20 by 36 feet; grade, 12 inches to 12 feet; rock riffles.

71¾ oz. amalgam, ... $430

No. 5 Undercurrent (constructed in March).—150,000 miner's inches of water; size, 24 by 24 feet; grade, 12 inches to 12 feet; chute, 2½ feet upper end, contracted to 2 feet lower end. Riffles, 1½ by 4 inches lumber, covered with strap iron, rails 1 inch apart.

A	yielded	5 oz.	amalgam.	} 1 clean up.	
B	"	8½ "	"		
C	"	5 "	"		
D	"	6½ "	"		
		25 oz.	. . .		$150

No. 6 Undercurrent.—Size, 24 by 36 feet; grade, 17 inches to 12 feet of rock riffles; chute, 2½ feet upper end, 2 feet lower end. 150,000 miner's inches of water.

A	yielded	8 oz.	amalgam.	} 1 clean up.	
B	"	5 "	"		
C	"	3¼ "	"		
D	"	3 "	"		
		19¼ oz.	. . .		$115

The total yield of the undercurrents and tail sluices for the period mentioned was $7872, whilst the total yield of the claims was $145,000.

The amalgam from the main sluice is worth from $7.50 to $8.50 per ounce troy, whereas that of the undercurrents varies from $6 to $6.20 per ounce troy.

The result of the undercurrents and tail sluice "clean ups," for the year 1876–7, was as follows:

	Yield.		
Cut A to B	334	ounces	amalgam.
Tail sluice, B to C . .	1380½	"	"
Undercurrent, No. 1, .	648¾	"	"
" No. 2, .	280¾	"	"
" No. 3, .	253¾	"	"
" No. 4, .	143¾	"	"
" No. 5, } 6 mos.	69	"	"
" No. 6, } 6 mos.	59	"	"
Total in cañon, . . .	3170	ounces	amalgam.

This amount (3170 ounces) equals in value about seven per cent. of the total yield of the mine for this last fiscal year, during which period 595,500 miner's inches of water have been used extracting $291,116 $\frac{90}{100}$ gold.*

* The cost of melting and refining has been deducted from the amount given.

Comparing these final results with those of the previous year, 1875–6, the precious metal is found distributed throughout the sluices and undercurrents in the same relative proportion.

This fact is worthy of note since last year the bulk of the material moved was "top gravel," whilst this season a much larger proportion of cement gravel has been run through the sluices.

In the heavy cement at French Corral and Manzanita a high percentage of the gross yield of the mines is found in the undercurrents.

Hydraulic mining in the so-called "cement claims" is carried on under great difficulties. An exhibit of the workings of the sluices of a representative cement claim (French Corral) is here given, and the contrast thus afforded with the workings of sluices in the generality of cases is most striking and especially interesting.

The washings from the French Corral Mine, after passing through the new tunnel, are distributed successively over nine undercurrents before they are finally discharged. The sizes and arrangement of these undercurrents are given in the accompanying table.

French Corral Mine, Undercurrents, etc.

Undercurrents.						Secondaries.			Chutes.	
From mouth of tunnel down.	No. of boxes.	Length over all.	Width of two compt's in cuts.	Grade, whole amount.*	Bottom lined with.	Length.	Width.	Grade.	Length.	Width.
		Feet.	Feet.	Ft.In.	4″ blocks.	Feet.	Feet.	Ft.In.	Feet.	Feet.
No. 1	3	42	20	3.9	6″x12″x4″				Main sluice.	5
" 2	3	42	20	3.9	W. side. Blocks. do. E. side. 1 bx blocks. 2 bx riffles.	21	12	1.10½	42	6
" 3	3	42	20	3.9	Upper box, each side.† 2d blocks. 3d riffles.				28	6
" 4	3	42	20	3.9	Same as No. 3.				28	6
" 5	3	42	20	3.9	" "				42	6
" 6	3	42	20	3.9	" "				28	6
" 7	3	42	20	3.9	" "	21	12	1.10½	42	6
" 8	3	42	20	3 9	" "				28	6
" 9	3	42	20	3.9	" "	28	12	2.6	28	6

From January 14th, 1877, to October 3d, 1877, there were 163,263 miner's inches of water discharged over these undercurrents,

* Grade fifteen inches to fourteen feet.

† Riffles, made in frames seven feet long, twenty inches wide, from slats 1¾″ x 4″, ¾″ apart. The bottoms of the undercurrents were lined with slat riffles, until clean up of July 21st.

and the corresponding yield of the washings was $\$201,284\frac{36}{100}$ gold, seventeen and one-half (17½) per cent. of said amount being found in the undercurrent distributed in the following proportions:

Yield of the Undercurrents, etc., at the French Corral Mine.

AMALGAM YIELD IN LBS. AVOIRDUPOIS.															Per ct. of total gross yield of the mine.
	UNDERCURRENTS.									SECONDARIES.			Pickings from chutes and aprons.	Total yield.	
Nos.	1	2	3	4	5	6	7	8	9	1	2	3			
Lbs.	96	67½	56¾	42	31	24½	23¼	17	12¾	5½	1¾	1	9½	388½	17.5

As further illustrative of the distribution of gold in the sluices of hydraulic claims, a classified statement is here added, showing the workings of the sluices at the Manzanita Mine in Nevada County, California.

The Milton Mining and Water Company.

Statement showing the relative yield of the sluices at the Company's Manzanita Mine from December 20th, 1876, to October 3d, 1877.

Date of clean up.	Total amount of water used in run 24 hours, miner's inches.	AMALGAM YIELD IN LBS. AVOIRDUPOIS.										Total.	Bullion Yield.
		Cut.	Tun'l.	LONG SLUICE BY SECTION.						Und'reur'nts			
				1	2	3	4	5	6				
January 4, . .	8,626	18	48	16						8		90	$7,734.87
March 17, . .	25,937	37	103							30		170	15,970.53
April 23, . .	21,491	51	89½					49		30½		220	20,238.51
June 8, . . .	29,187	46	78				83½			34¼		241¾	21,562.47
July 13, . . .	15,868	64	53½	32						8½		157½	15,401.70
August 9, . .	17,000	33¼	66			37¼				17½		154	15,970.53
September 29,	23,400	104	124	15	109		28	38	64	44		526	*46,307.19
From top mine worked in March and May	16,985											40¾	3,222.41
Total, . . .	158,494	353¼	561½	63	109	37¼	111½	87	64	172¾		1600	$146,408.21

* Bar of October 26th, valued at $5800.

The arrangement of the sluices at the Manzanita Mine is as follows:

1st.	East cut contained, average, ...	40	boxes.*
	West, " "	28	"
2d.	Tunnel, " "	120	"
3d.	Long sluice, "	300	"
4th.	Undercurrents, {8 to commence, 10 at end.} average, .	50	"
	Total, ...	538	"

The long sluice is divided into six sections, each section containing the following number of boxes:

1st	section,	29	boxes,	to second angle below tunnel.
2d	"	56	"	Pease Ravine.
3d	"	28	"	Buckeye Point.
4th	"	67	"	Armstrong Ravine.
5th	"	62	"	Quinn's.
6th	"	63	"	Lower.

The sluices in the cut are four feet in width, while those in the tunnel and the long sluice are five feet wide, all of them having a side lining of blocks three inches thick. The riffles used in the cut sluices are hand-sawed blocks 13½″ x 13⅛″ x 10 inches, and those in tunnel sluices are hand-sawed blocks 13½″ x 13½″ x 10 inches, and 17½″ x 17½″ x 10 inches, about half of each. In the long sluice quarried granite rocks sixteen inches thick (now eighteen inches thick) are substituted for block riffles.

The grade along the line of the cut and tunnel is seven inches to fourteen feet, whilst that of the long sluice averages nine inches to fourteen feet.

The undercurrents (ten in number) are similar to those used at the French Corral Mine. They are 42 feet long (the apron over which the water is spread forms a part), 20 feet wide, set on grades ranging from 13½ inches to 16 inches per box, and are paved with blocks 6 in. x 17 in. x 4 in. in size.†

THE SAVING OF GOLD—FINE GOLD.

The most efficient means of saving gold from cement gravel are by a liberal use of the best shattering powder, breaking the cement before it is washed into the sluices, and by the introduction of

* Each box fourteen feet in length.

† The statements of yield of the French Corral and Manzanita Mines are condensed from the official returns of the Milton Mining and Water Company.

several "drops," when possible, along their line. Frequent drops and short lines of sluices give better results than one long continuous line of sluices. Gravel moving in sluices is subjected to a grinding and scouring process, which alone is not sufficient to disintegrate the cement gravel except at considerable cost.

As regards the saving of fine gold, it may be stated that the lessening of grades and the use of undercurrents tend to diminish the losses. Extensive lines of sluices and undercurrents are expensive to build and keep in repair. Like the last concentrator, so the last undercurrent will always catch some metal. So long as the knowledge of the quantity of gold in gravel banks remains as imperfect as it is at present, the simple and well-known appliances now in use are the most convenient and economical, and the excuse so often given for small yields, namely, loss of microscopic gold and bad sluices, can be set down by the capitalist as one of the preliminary indications of a bad investment.

MEASUREMENT OF WATER.

The miner's inch is an arbitrary measurement of water, established in early days by the miners in the different camps, in accordance with the laws they adopted. The miner's inch, as accepted in some districts, is an amount of water discharged from an opening one inch square through a two-inch plank, with a pressure of six inches above the opening.

The Smartsville inch is calculated from a discharge through a four-inch orifice, with a seven-inch board-top; that is to say, the pressure is seven inches above the opening, or nine inches from its centre. The bottom of the aperture is on a level with the bottom of the box, and the board which regulates the pressure is a plank 1 inch thick and 7 inches deep. Thus an opening 250 inches long and 4 inches wide, with a pressure of 7 inches above the top of the orifice, will discharge 1000 Smartsville miner's inches. Each square inch of the opening will discharge 1.76* cubic feet per minute, which approximates the discharge per inch of a two-inch orifice through a three-inch plank, with a pressure of 9 inches from the centre of the opening, the said discharge being 1.78 cubic feet per minute. The Smartsville miner's inch will discharge 2534.40 cubic feet in 24 hours, though in that district the inch is only reckoned for 11 hours.

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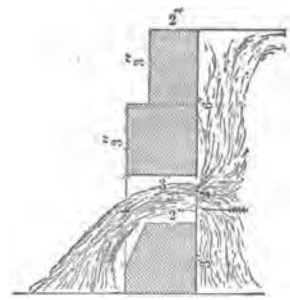
* Determined by Mr. Thurston.

The miner's inch of the Park Canal and Mining Company, in El Dorado County, discharges 1.39* cubic feet of water per minute. The inch of the South Yuba Canal Company is computed from a discharge through a two-inch aperture, over a one and a half inch plank, with a pressure of 6 inches from the centre of orifice.



At the North Bloomfield, Milton, and La Grange Mines, the inch has been calculated from a discharge through an opening 50 inches long and 2 inches wide, through a three-inch plank, with the water 7 inches above the centre of the opening.

To determine the value of this miner's inch, a series of experiments were made at Columbia Hill, lat. 39° N., elevation 2900 feet above sea-level. The module used was a rectangular slit 50 inches long and 2 inches wide, pressure 7 inches above the centre of the opening. The discharge was over a three-inch plank, the last inch chamfered, as shown in the sketch. The size of the opening was taken with a measure (micrometer attached) which had been compared with and adjusted to a standard United States yard. Time was read to one-fifth of a second. The level of the water (drawn from a large reservoir) was determined with Boyden's hooks, micrometer adjustment. The following results were obtained:

1 miner's inch will discharge in	1 second . .	.02624	cubic feet.
" " "	1 minute .	1.5744	"
" " "	1 hour . .	94.4640	"
" " "	24 hours . .	2267.1360	"

Ratio of actual to theoretical discharge, 61.6 per cent. These figures are within the limit of 1-500 possible error.†

A series of experiments made last summer at La Grange, to determine the effective value of the above-described inch, gave the following results:

1 miner's inch discharged in	1 second . .	.02499	cubic feet.
" " "	1 minute .	1.4994	"
" " "	1 hour . .	89.9640	"
" " "	24 hours . .	2159.1460	"

Ratio of effective to theoretical discharge, 59.05 per cent. ‡

* Estimated by J. J. Crawford, M. E.

† Experiments were made in 1874 by H. Smith, Jr.

‡ These results are the average of a series of experiments made by the writer.

DITCHES.

Before describing the *modus operandi* of hydraulic washing, a few remarks on the water-supply system of the gold mining regions will not be inappropriate. Thousands of miles of ditches have been built throughout the State for the purpose of conveying water to the mines, and in some instances are now being used likewise for irrigation.

The use of steep grades for running water, the construction of high flumes, and the successful introduction and use of wrought iron pipes, are all due to hydraulic mining.

In locating mining ditches, the following rules or principles should be observed:

1. The securing of an abundant and permanent supply of water, particularly during the summer months.

2. That the source of supply be at a sufficient elevation to cover the greatest range of mining ground at the smallest expense, hydrostatic pressure being always desirable.

3. The snow line, when possible, should be avoided, and the line should be located so as to have a southern exposure, particularly in the snow regions.

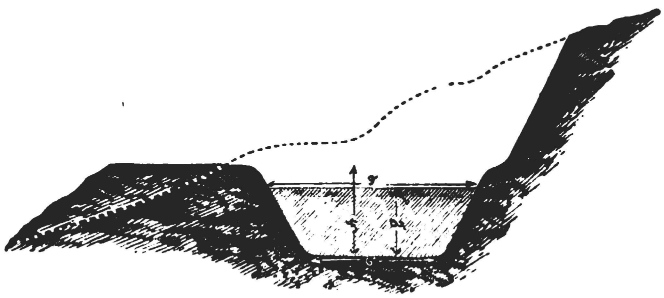
4. All watercourses on the line of the ditch should be secured. Their supply partially counteracts the losses by evaporation, leakage, and absorption, and frequently furnishes an additional quantum of water during several months of the year.

5. Waste-gates, at proper intervals, should be arranged so as to discharge the water, when necessary, without risk of damage to the ditch.

6. Ditches, when practicable and the cost not excessive, should always be preferred to flumes.

Among the principal ditches constructed in the State are the North Bloomfield, the Milton, the Eureka Lake, San Juan, the South Yuba Canal, Excelsior or China Ditch, Bouyer and Union, El Dorado, Cherokee and Spring Valley, Hendricks, and La Grange.

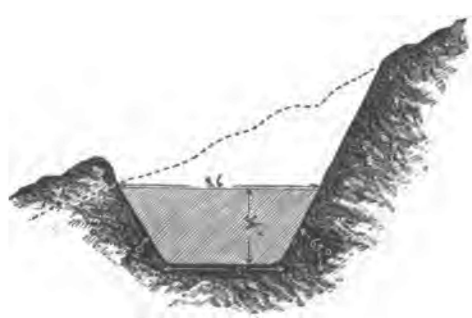
The North Bloomfield main ditch, including distributers, is 55 miles long. Its size is 8.65 feet on top, 5 feet at bottom, and 3½ feet deep. The ditch and distributers cost $422,106.22. Its grade is from 12 to 16 feet per mile, discharging 3200 miner's inches. The Milton Company's ditches are 100 miles long, and their average grade is from 12 to 25 feet to the mile. The size of the main ditch is 4 feet on bottom, 6 feet on top, and 3½ feet deep, discharging 3000 miner's inches. Cost, $259,020.14. The Eureka Lake Ditch is 18 miles long, and has a capacity of 2500 miner's inches. Its cost, including water rights and flumes, was $430,250. The San Juan



La Grange Ditch.

ditch and branches extend some 45 miles in length. The main ditch is 32 miles long, and its capacity is 1300 miner's inches. Their cost was $293,092. These two last-mentioned ditches belong to the Eureka Lake and Yuba Canal Company.

The main ditch of the South Yuba Canal Company (from the head to Bear River is 1½ miles long) is 6 feet wide on top and 5 feet deep, with a grade of 13 feet per mile. Its present capacity is said to be 7000 miner's inches of water. From Bear Valley (the junc-



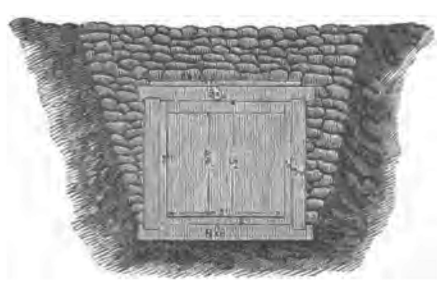
North Bloomfield Main Ditch.

tion of the main and Dutch Flat ditches), the size of the canal for the succeeding 31½ miles, is 6 feet wide on top, 4½ feet deep, with a grade of 8 feet to the mile. The Dutch Flat Ditch is 13 miles long. Its size is 6½ feet on top, 4 feet deep, and has a grade of 13⅓ feet per mile. The capacity of this ditch is 3150 miner's inches of water. The Chalk Bluff Ditch is 6 feet wide on top, and 5 feet deep, with a grade of 16 feet per mile, and has a capacity of 4100 miner's inches. The several ditches, etc., owned by the South Yuba Canal Company, have an aggregate length of 123 miles. The Excelsior or China Ditch, at Smartsville, is 33 miles long. Size, 5 feet bottom, 8 feet on top, and carries 4 feet of water. The grade is 9 feet to the mile, and the ditch discharges 1700 Smartsville miner's inches. The Bouyer and Union Ditches are each about 15 miles long. Size, 4 feet on bottom, 8 feet on top, carrying 3½ feet of water. Their grades are 13 feet to the mile, discharging each 1200 Smartsville miner's inches. There are several minor ditches which deliver water in and around Smartsville. The total capacity of all the ditches is 5000 Smartsville miner's inches, and the whole investment in this class of property, in this locality, approximates $1,200,000.

The Spring Valley and Cherokee Ditch is 52 miles long, and has 3½ miles of iron pipe, 30 inches in diameter. The size of the ditch averages 5 feet wide, 3½ feet deep, discharging about 2000 inches of water.

The Hendricks Ditch,* in Butte County, is 46½ miles long; grade of the upper line of ditch, 12.8 feet per mile; grade of the lower line, 6.4 feet per mile; dimensions, 5 feet wide, 2 feet deep. Total cost, including Glen Beatson Ditch and Oregon Gulch Ditch, $136,150.

The La Grange Ditch,† including Patricksville branch, is over 20 miles in length. Size, 9 feet on top, 6 feet bottom, 4 feet deep.



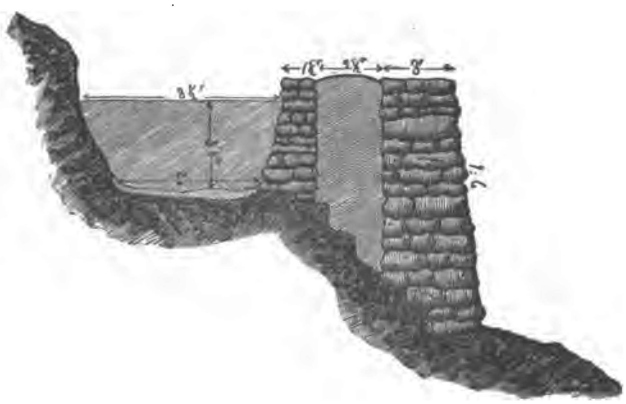
La Grange Flume. Crossing at Indian Bar.

Grade from 7 to 8 feet to the mile. The greater part of the ditch is cut in granite, and in places there are solid walls 50 to 70 feet

* See Raymond's Report, 1873, pp. 73, 74.

† The original ditch, about 19 miles long, is said to have cost $375,000. Since its completion, the Patricksville Ditch and reservoir have been built at a cost of $75,000.

high, built of stone. It discharges 2700 miner's inches of water, and its cost to date is about $450,000.



Section of Wall Ditch on Line of La Grange Mining Company's Ditch.

GENERAL OBSERVATIONS.

Ditches in California with carrying capacities as large as eighty cubic feet per second have been built, and are now in successful operation, with grades of from sixteen to twenty feet per mile. In a mountainous country, where steep grades can be generally obtained by a slight increase in the length of the canal, and where the cost of excavation is large, a great saving can be effected by using the smallest-sized canals and aqueducts practicable to carry the given quantity of water, or, in other words, by running water rapidly through a small channel rather than slowly through a large one. It is found to be safer and more economical, on account of the deep snows and terrific storms which rage in the mountains during the winter, to run and maintain in repair narrow and deep ditches on heavy grades than broad ones with light grades. The experience of the ditch-builders in this State has been highly favorable to these steep grades, but little trouble being caused by the washing of the banks due to high velocities.* In the valleys with ashy soil such grades, of course, would not be practicable.

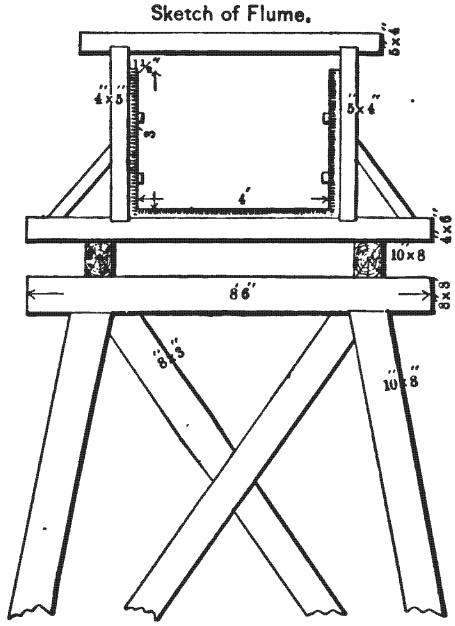
* These narrow ditches with steep grades do not discharge within 25 to 30 per cent. of the amount of water given by the formulæ for "the discharge of water in canals."

FLUMES, AND THEIR CONSTRUCTION.

In crossing ravines, flumes or wrought iron pipes are used. Many miners object to flumes on account of their continual cost and danger of destruction by fire. Where practicable they are set on heavier grades than ditches, 30 to 35 feet per mile, and are consequently of proportionately smaller area than the ditches. In their construction a straight line is the most desirable. Curves, where required, should be carefully set, so that the flume may discharge its maximum quantity. Many ditches in California have miles of fluming. The annexed sketch will show the ordinary style of construction.

The planking ordinarily used is of heart sugar-pine, 1½ to 2 inches thick, and 12 to 18 inches wide. Where the boards join, pine battens, 3 inches wide by 1½ thick, cover the seam. Sills, posts, and caps support and strengthen the flume every four feet. The

Sketch of Flume.

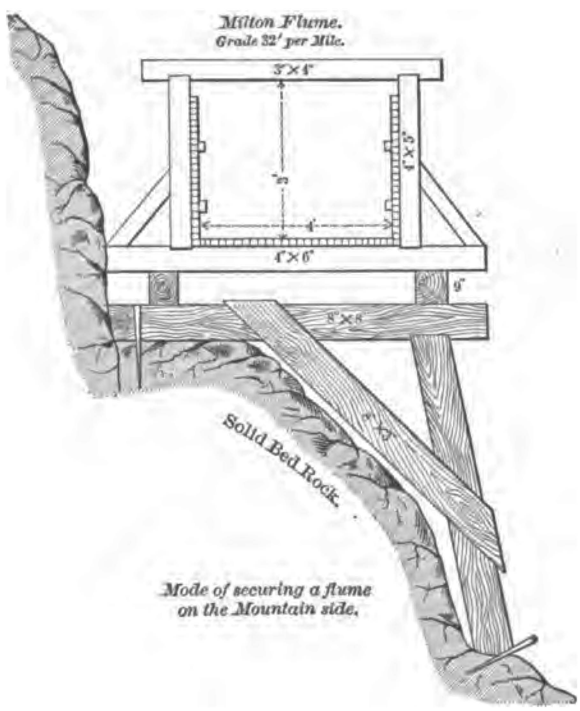


posts are mortised into the caps and sills. The sills extend about twenty inches beyond the posts, and to them side braces* are nailed to strengthen the structure. This extension of the sill timbers

* Side braces and the extra extension of the sill are, in many cases, only an unnecessary expenditure of money.

affords a place for the accumulation of snow and ice, and in the mountains such accumulations frequently break them off, and occasionally destroy a flume.

To avoid damage from slides, snow and wind storms, the flumes are set in as close as possible to the bank, and rest wholly or partially on a solid bed, according as the general topography and costs will admit. Stringers running the entire length of the flume are



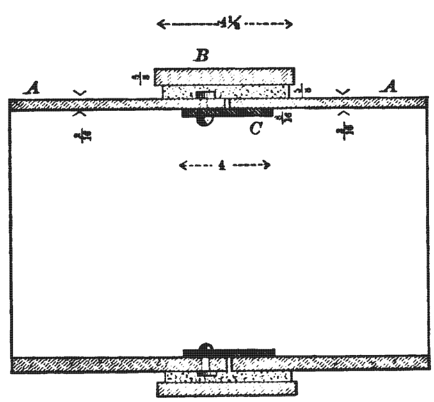
The details of the cost and construction of this flume are to be found in *Raymond's Report*, 1875.

placed beneath the sills just outside of the posts. They are not absolutely necessary, but in point of economy are most valuable, as they preserve the timbers. As occasion may demand, the flume is trestled, the main supports being placed every eight feet. The scantling and struts are used in accordance with the requirements of the work.

WROUGHT IRON PIPES.

The use of sheet iron pipes for conveying water in large quantities originated with the hydraulic miner. Their insignificant weight, coupled with their great strength (tensile), admirably adapted them to the service for which they have been employed.

The general sizes of the pipes used in the mines are 40, 30, 22, 15, and 11 inches in diameter, of riveted light sheet iron, No. 16, 14, or 12 iron, Birmingham gauge, made in lengths of about 20 feet, and put together in stovepipe fashion, neither rivets nor wire being used to hold the joints in place. These pipes are light and can be readily and cheaply moved; this in hydraulic mining is of great importance, as it is often requisite to change the position of the lines of pipe. Pipe put together in this rough manner will remain tight when subjected to even as great a pressure as 200 lbs. to the square inch. Where the pressure requires it, lead joints are used. (See sketch.) *A* represents the pipe; *B* an iron sleeve, between which and the pipe the lead, represented by dotted lines, is poured; *C* is a flange bolted to one length of the pipe on the inside, for the other pipe to fit over, as shown.



Lead Joint for Pipe.

Though roughly constructed and of very light iron, this kind of pipe (connected more like stovepipe than water-pipe), is found in practice to be most serviceable, and from its form, floating particles of matter readily render it water-tight. Such a pipe, 12 inches in diameter, made of No. 18 iron, is riveted in the longitudinal seams every inch to inch and a quarter; whilst in the round seams the rivets, which are only $\frac{1}{8}$ of an inch in diameter, may be as much as 3″ apart, showing daylight between the iron; but after the water has run through the pipe a short time nearly all leaks stop. If necessary, however, two or three bags of sawdust put in the inlets, and a few shovelfuls of earth, will usually make everything tight.

This class of pipe is now being replaced by one of better make, in which the round seams are made with rivets $\frac{3}{4}$ of an inch apart, and the longitudinal seams are double riveted, with rivets 1 inch apart in the row, and with about $\frac{1}{2}$ inch apart from one row to the other. If riveted with care, such pipes, after being dipped in an asphaltum bath, are excellent, and will last for many years.

For this asphaltum bath the following preparation can be used:

Crude asphaltum, ...	28 per cent.
Coal tar (free from oily substances), . .	72 "

Or,

Refined asphaltum, ...	16½ per cent.
Coal tar (free from oily substances), . .	83½ "

When the mass has been boiled to a proper consistency, and by test the coating is found to be brittle, it at once indicates that the mixture has been boiled too hot, or that there was too much oil in the tar or asphaltum.

THE THICKNESS OF THE IRON, RIVETS, ETC.

The thickness of the iron is usually proportionate to the head of water and the diameter of the pipe. Pipes made of the different sizes iron here mentioned will stand the following strain per sectional inch.

No. of Iron.	Made to stand strain per sectional inch, lbs. Avd'p.
12, ...	7000 to 9000
12 to 9, ...	9000 " 12,000
9 " $\frac{3}{16}$ inch, ...	12,000 " 14,000
$\frac{1}{4}$ inch to $\frac{3}{8}$ inch, . . .	17,000 " 18,000

The head of the water in pounds avoirdupois, multiplied by the diameter of the pipe in inches and divided by the above coefficients, gives twice the thickness of the iron to be used. Allowance must be made for the security required, that is, if the breakage of the pipe will cause much damage it is advisable to lower the margin for greater safety.

The diameter of the rivets usually used are:

No. 18.	No. 16.	Nos. 14, 12, 11.	Nos. 10, 8, 7.	No. $\frac{1}{4}$.	No. $\frac{5}{16}$.	No. $\frac{3}{8}$.
$\frac{5}{32}$ in.	$\frac{6}{32}$ in.	$\frac{5}{16}$ in.	$\frac{3}{8}$ in.	$\frac{1}{2}$ in.	$\frac{5}{8}$ in.	$\frac{3}{4}$ in.

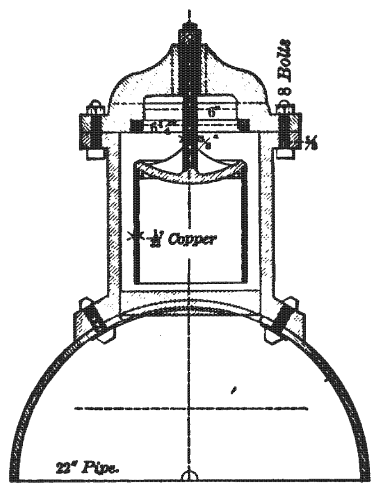
They are usually spaced to make the pipe tight, that is, closer than is necessary for the strength of the seam; but this in turn is governed by the pressure on the pipes.

Table showing usual distance of rivets for corresponding thickness of iron. Items relating to a 22 inch wrought iron pipe.

Thickness of the iron used.	Diameter of the rivets.	Length of the rivets.	Pitch of the circle seams	Number of rivets in each circle seam.	Pitch of the rivets in the longitudinal seam or double row.	Width between the centres of the rivets in the double row.
No. 12	$\frac{3}{16}$ in.	$\frac{3}{4}$ in.	1 in.	69	$1\frac{3}{8}$ in.	$\frac{5}{8}$ in.
" 11	$\frac{5}{16}$ in.	$\frac{5}{8}$ in.	1 in.	69	$1\frac{3}{8}$ in.	$\frac{5}{8}$ in.
" 9	$\frac{3}{8}$ in.	$1\frac{3}{8}$ in.	$1\frac{3}{16}$ in.	59	$1\frac{7}{16}$ in. full.	$\frac{5}{8}$ in.
$\frac{3}{16}$ in.	$\frac{1}{2}$ in.	$1\frac{1}{4}$ in.	$1\frac{7}{16}$ in.	39	$1\frac{11}{16}$ in. full.	$1\frac{1}{16}$ in.
$\frac{1}{4}$ in.	$\frac{1}{2}$ in.	$1\frac{1}{2}$ in.	$1\frac{7}{16}$ in.	39	$1\frac{11}{16}$ in. full.	$1\frac{1}{16}$ in.

When the pipe is made and put in position, air-valves are provided, to allow the escape of air from the pipe whilst filling, and especially to prevent any collapse should a break occur. These valves are of many forms, the most usual being a piece of leather, loaded and forming a valve opening to the inside of the pipe, and when shut covering a plain hole of from 1″ to 4″ on the top side of the valve. When required, a better class of valve is used, which sinks and opens when the water leaves it, and floats and shuts when the water rises up to it. (See sketch.) An important point is the admission of the water to the pipe in such a way as to prevent air from being sucked into and travelling along the pipe, which will happen and in large quantities unless the water is regulated. The best plan is to put a gate in the pipe, a little below the level where the water enters it, and regulate the flow by the gate, and by this means a steady pressure without violent oscillation can be obtained. Usually, however, the water enters through a funnel-shaped pipe, which allows the air to escape as it enters, and with a little care can be made to answer every purpose. In some instances an air or stand-pipe is put in at a distance from the inlet. This catches the air as it travels along the top of the pipe and allows it to escape.

The following figures,* given in tabular form, show the details of the construction of wrought iron pipe, 18 inches in diameter, 5800 feet long, manufactured by the Risdon Iron and Locomotive Works, San Francisco, for the Spring Valley Water Company, which supplies the City of Francisco with water. The information here afforded



Air Valve for 22" Water Pipe.

mechanical engineers is sufficiently explicit for the construction of wrought iron pipes. This pipe has a tensile strain of about 5000 or 6000 lbs. per sectional inch, and has been made with this low co-efficient in order to withstand the pulsation caused by a single-acting plunger pump, making as high as 36 single (4 feet in length) strokes per minute.

These oscillations are found in practice to run from 5 to 9 lbs. per stroke when the air-vessel is properly charged, otherwise by carelessness it may exceed 50 lbs. per stroke.

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* The data have been obtained from Joseph Moore, M. E., Superintendent of the R. I. and L. Works, under whose immediate direction the pipe was constructed.

Table showing Details of Construction of Wrought Iron Pipe for the Spring Valley Water Company, San Francisco, Cal.

Thickness of the bands.	Width of the bands.	Thickness of the sleeves.	Width of the sleeves.	Width of the sheets used in the pipes.	Thickness of the iron used in the pipes.	Diameter of rivets used.	Pitch of the circle seams in the outside courses.	Pitch of the circle seams in the inside courses.	Amount of two laps.	Space between double row.	Length to the joining holes in the outside courses.	Length to the joining holes in the inside courses.	Whole length of the outside courses.	Whole length of the inside courses.	Spaces in the circle seams.	Pitch of the double row.	Spaces in the double row.	Amount of the two outside spaces of the double row.	Amount of two laps for the double row.
In.	In.	No.	In.	In.	In.	In.	In.	In.	In.	In.	In.	In.	In.	In.	In.	In.	In.	In.	In.
5-16	4½	11	5½	42	¼	½	1.45229	1.4106233	2	1.10	56.63931	55.01431	59.739	58.114	39	1.7223	22	2.1094	2
¼	4½	11	5½	42	3-16	½	1.45229	1.4207515	2	1.10	56.63931	55.40931	59.73931	58.50931	39	1.7228	22	2.1094	2
¼	4½	11	5½	44	3-16	½	1.45229	1.4207515	2	1.10	56.63931	55.40931	59.73931	58.50931	39	1.7228	23	2.3871	2
					Nos.														
¼	4½	11	5½	42	9	⅝	1.197	1.7915	1.625	.625	57.456	56.5999	59.706	58.8492	48	1.468	26	2.207	1.625
¼	4½	9	5½	40	11	5-16	.9934692	.9816157517	1.5	.625	57.6212136	56.9337136	59.746	59.0575	58	1.468	25	2.05	1.25
¼	4½	9	5½	42	11	5-16	.9934692	.9816157517	1.5	.625	57.6212136	56.9337136	59.746	59.0575	58	1.468	26	2.332	1.5
¼	4½	9	5½	40	12	5-16	.9934692	.9837709	1.25	.625	57.6212136	57.0587136	59.496	58.9333	58	1.468	25	2.05	1.25
¼	4½	9	5½	38	12	5-16	.9934692	.9837709	1.25	.625	57.6212136	57.0587136	59.496	58.9333	58	1.468	24	1.518	1.25

At Cherokee there is an inverted siphon of wrought iron. The pipe has an approximate inner diameter of 30 inches, discharging 52 cubic feet of water per second. It has been in continuous use for five years, and is now in first-class order. The iron used was ordinary English plate of fair quality. The greatest pressure it sustains is 887 feet, and the thickness of the iron at that point is three-eighths of an inch.

The plan* on the next page taken from the original survey on file in the office of the company, shows the line of the pipe, and different sizes of iron used in construction of the siphon. The maximum strains on the several sizes of iron used are given in the following table:

SIZE OF IRON.		GREATEST PRESSURE.		Maximum tensile strain on iron per square inch, in pounds.
No. of gauge. B. G.	Thickness in decimals of an inch.	Feet.	Pounds.	
14	.083	170	74	13,374
12	.109	288	125	17,202
11	.012	293	127	15,875
10	.134	355	154	17,240
$\frac{3}{16}$	.187	435	188	15,080
$\frac{1}{4}$	.250	594	257	15,420
$\frac{5}{16}$	.312	842	365	17,549
$\frac{3}{8}$	.375	887	384	15,360

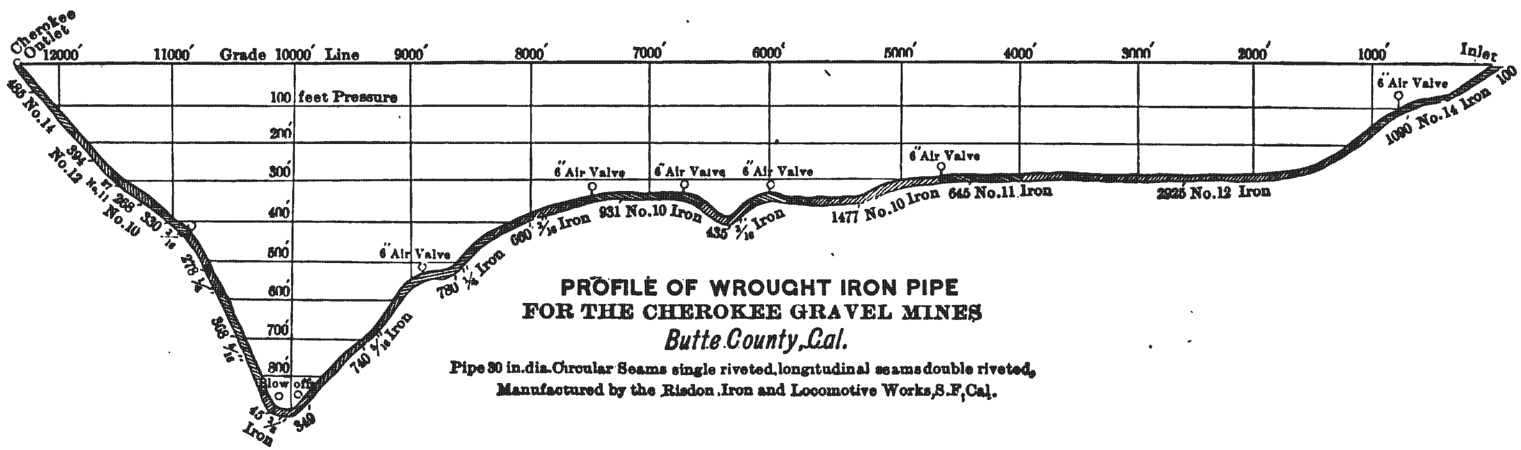
The Virginia City Water Company, Nevada, has constructed a similar wrought iron siphon, 11½ inches in diameter. The maximum pressure in its greatest depression is 1720 feet, equal to 750 lbs. per square inch. The thickness of the iron at the lowest point of depression is No. 0. The pipe was hot-riveted, ⅝-inch rivets, double row on straight seam and single row on round seam. This pipe, when tested, is said to have stood a pressure of 1400 lbs. per square inch.†

THE SUPPLY OR FEED-PIPES.

The water is conveyed to the claims in iron pipes from the pressure-box, and by means of iron distributers on the lower end of the feed-pipe it is distributed to the discharge-pipe as required.

* The Mining and Scientific Press of January 7th, 1871, contains a detailed account of the construction of this pipe, and also gives a diagram of the line.

† The Virginia City Water Company has constructed a second siphon, made of lap-welded pipe, 10 inches inner diameter, ¼-inch iron, and placed it alongside of the siphon already built.



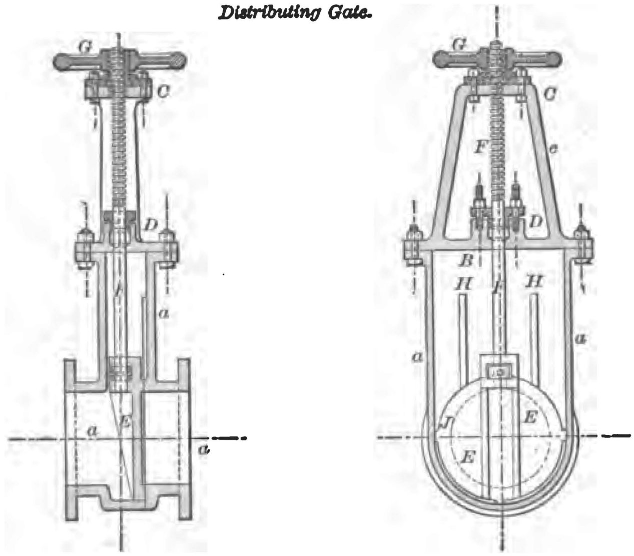
PROFILE OF WROUGHT IRON PIPE
FOR THE CHEROKEE GRAVEL MINES
Butte County, Cal.

Pipe 30 in. dia. Circular Seams single riveted, longitudinal seams double riveted,
Manufactured by the Risdon Iron and Locomotive Works, S.F. Cal.

The pressure-box should be strongly built, and the water supplied in sufficient volume to keep the top of the pipe covered several feet. A grating on the end of the flume which connects with the box prevents the entrance of foreign material, such as sticks, leaves, etc. The pipe is of uniform diameter down to the distributer, except where it enters the pressure-box. Here it swells to a funnel shape, connecting at its greatest diameter with the box. The size of the feed-pipe is determined by the head and quantity of water to be used. The thickness of the iron of which it is constructed varies with the diameter of the pipe and according to the hydrostatic pressure.

As it is not desirable to alter the position of the main feed-pipe often when in place, it should descend in the most conveniently direct line into the diggings, avoiding as far as practical all angles, rises, and depressions. Air-valves with floats, or such valves as will open and close automatically, should be arranged at proper points, to allow the escape of air when filling the pipe, and also to prevent any collapse from atmospheric pressure should a vacuum occur.

Distributing Gate.



Where the pipe passes over steep banks into the claim, it is carried on an incline trestle, and braced, care being taken to prevent any movement or sliding of the column. When necessary, the pipe is secured with framework and weighted with stones. At the bottom of this incline, where it reaches the bed-rock or level of the workings, it is securely braced and weighted.

A distributing-box (made of cast iron into which the supply-pipe is led, and from which one or more branches can be taken as wanted by means of valves) is generally placed at this point. In some claims double distributing gates are used, in others the main pipe is here forked by means of a breeching having two branches, and a distributer placed on each branch. The branch pipes (generally 11 and 15 inches in diameter) connect directly with the discharge nozzles.

The annexed sketch shows the form of a single "distributer" used in hydraulic mines. This style of distributer is also used as a discharge gate for reservoirs.

In filling the feed-pipe the water should be turned on gradually, all sudden straining of the column being thus avoided. Any leakages in the slip-joints can be readily stopped with a few bags of sawdust, and by wedging them with thin pieces of soft pine.

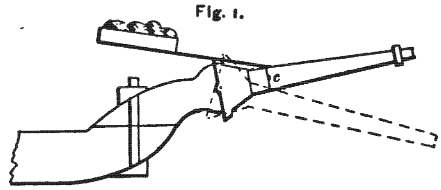
THE DISCHARGE-PIPES.

The discharge-pipe most generally used is called the "Little Giant."* It is portable and easily handled, having a knuckle-joint and lateral movement. The "Giants" have stream concentrators, and the nozzles used are from 4 to 9 inches in diameter, 5½ to 7-inch nozzles being those most generally in use. The number of "Giants" employed in a claim depends on its size and quantity of available water. There are generally two or three used in a claim.

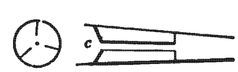
The annexed sketch (Fig. 1) shows the general form of the Little

The Little Giant. (Hoskin's patent.)

Fig. 1.



Section along line c, showing the rifles.

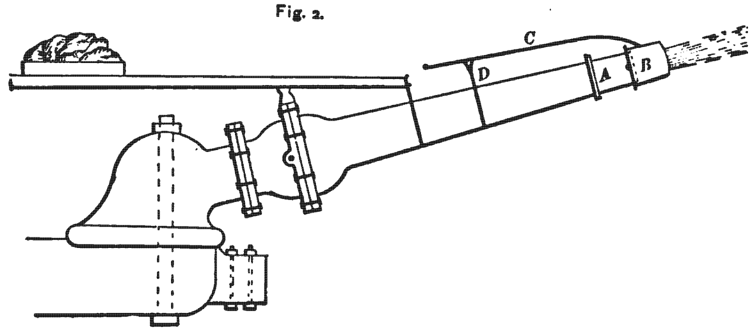


* Other nozzles in use are the "Dictator," of Mr. Hoskins, who also invented the "Little Giant," Craig's "Globe Monitor," and the "Hydraulic Chief," an invention of Mr. F. Fisher.

Giant. Fig. 2 represents a monitor hydraulic machine with a "deflecting nozzle," the invention of Mr. Henry C. Perkins, superintendent of the North Bloomfield Gravel Mining Company.

By means of the "deflecting nozzle" the Giant can be turned to any point, and the stream issuing from the pipe can be directed with the greatest facility. Its workings will be easily understood from the following explanation:

Fig. 2.



A, Cast iron nozzle.

B, Deflecting nozzle of wrought sheet iron, attached to A by a joint similar to a compass gimbal.

C is a lever to govern the movement of B.

D is a rest for lever, B.

The operation is as follows: When the lever, C, is in the rest, D, the deflecting nozzle, B, allows the stream of water from nozzle, A, to pass through without obstruction. To move the pipe the lever is taken from the rest and thrust in the direction it is desired to throw the stream. Any movement of the lever, C, either to the right or left, or up or down, throws the end of the nozzle, B, into the stream of water, and the force of the water striking it changes the course of the discharge, the entire machine moving in accordance with each change of the deflector. The joint attaching B to A being a universal joint, the nozzle can be turned in any direction.

STORAGE RESERVOIRS.

When water is not taken from running streams, the mines are dependent for their supply on the winter rains and snows. Large reservoirs are built to catch the water from the rains and melting snows, and store it in the spring and summer months for use during the dry season.

The North Bloomfield Company has established a complete system of reservoirs for the storage of water. The Bowman reservoir, and the small reservoirs about it, will hold, when the main dam is completed to a height of 96 feet 3 inches, about 1,000,000,000 cubic feet of water. The cost of the reservoirs and dam to date is $214,392.06.

The Rudyard reservoir, of the Milton Company, contains 535,-000,000 cubic feet of water, or 3,980,000,000 gallons. The reservoir is formed by 3 dams, the highest being 100 feet vertical, and its cost $150,000. The storage reservoirs of the Eureka Lake and Yuba Canal Company, consisting of the French, Weaver Lake, and Fancherie reservoirs, have an estimated aggregate* capacity of 819,800,000 cubic feet of water. Independent of these reservoirs, all mines at a convenient distance from their works have what are called distributing reservoirs. From these places water is easily distributed to the claims, or they are used to retain the surplus coming from the main ditch when the claims are shut down.

DAMS.

In California, the rainfall from the 1st of May to the middle of October is inconsiderable, and hence, in order to secure a permanent supply of water for the hydraulic mines, it has been in many cases necessary to form large reservoirs, in which water is impounded during the rainy season, or while the mountain snows are melting, which is used to supply the mines during the dry months.

Large dams of earth, timber, or stone have been constructed to form these storage reservoirs. Amongst the most considerable dams in the State are: The Bowman dam, height 100 feet; catchment, 28.94 square miles; three dams owned by the Milton Mining and Water Company, forming the English reservoir; the largest of these dams having a height of 131 feet from the deepest portion of its foundation to its summit; this reservoir impounds 618,000,000 cubic feet of water, has a high-water area of about 395 acres, and is fed from a catchment basin 12.1 square miles; the cost of three dams has been about $150,000; the Fordyce dam of the South Yuba Canal Company, height 60 feet, costing about $160,000; catchment basin, about 40 square miles; the Eureka Lake dam of the Eureka Lake and Yuba Canal Company, height 68 feet, storage capacity 630,000,000 cubic feet, high-water area 328 acres; catchment basin, 5.1 square miles.

All the foregoing dams are built of dry rubblestone, and faced with a water-tight lining of plank. The Tuolumne County Water Company has several large dams built of timber-cribs. The largest dam built by this company is across the south fork of the Stanislaus River.

* French reservoir, 661,000,000 cubic feet capacity; Weaver Lake reservoir, 100,000,000 cubic feet capacity; Fancherie reservoir, 58,800,000 cubic feet capacity. See Report of J. D. Hague, M. E., pp. 15, 16, 17.

It* is over 60 feet in height, and 300 feet wide on top (across the stream), forming a reservoir with 300 acres high-water area. The catchment is of large size, and great freshets pass over the dam. The dam is at an elevation of about 8000 feet above the sea-level.

It is built of cribs of round tamarack logs, from 2 to 3 feet in diameter, and with no stone-filling. The cribs are about 8 feet square from log to log (say 10 feet centre to centre), and the timbers pinned together by wooden treenails. The dam rests for its entire base on solid granite bed-rock. The angle of face with horizon is 50°.

The face is formed of flattened 8-inch timbers, pinned with wooden treenails to the crib, and calked with cedar-bark. The flood-water passes over the crest of the dam for its entire length.

The water is drawn off by several gates, one above the other, placed on the inclined water-face. When a gate is opened, the water flows directly into the interstices of the crib.

The dam was built in 1856, and has needed no repairs. Large derricks lifted the logs into place. The total cost of the dam did not exceed $40,000.

Pine dams, owned by the same company, constructed on the same plan, have decayed, while cedar cribs are still in perfect order.

The Spring Valley Company's Concow reservoir is formed by two earthen dams, each about 55 feet in height; one of these dams, which is used as a waste, has its lower side built of heavy brush, imbedded in the earth.

The catchment basins of most of these reservoirs embrace bare mountain slopes and valleys, and in ordinary seasons from 60 to 80 per cent. of the rain and snowfall flows into the reservoirs.

The Bowman dam, owing to its position, has been constructed by the North Bloomfield Company with due reference to the possibilities of breaks occurring in the several other reservoirs east of it, and it is intended, in any emergency, to hold the drainage not only of its own watershed, but also in case of accident to withstand any rush of water from the reservoirs beyond it. It is the largest dam on the coast. The following detailed account of it was written for this paper by Mr. Hamilton Smith, Jr., C. E., who planned and constructed the dam:

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* These details were received from Mr. Dobie, who for many years had charge of the reservoirs and ditches of the Tuolumne County Water Company.

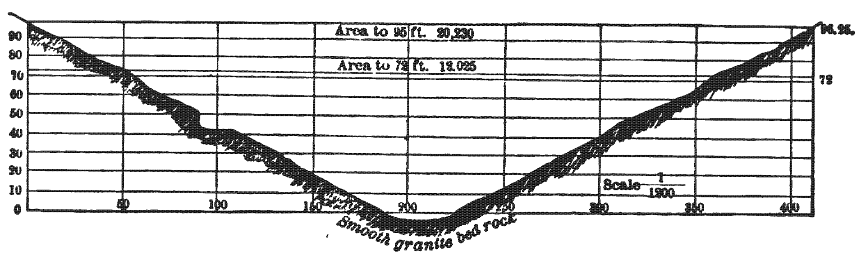
THE BOWMAN RESERVOIR AND DAMS.

This reservoir was designed for the supply of water during the dry season of the year for the Bloomfield Hydraulic Gravel Mine, owned and operated by the North Bloomfield Mining Company.

It is located in a mountain valley, on the head-waters of one of the branches of the Yuba River, in Nevada County, California, at an elevation of 5400 feet above sea-level.

THE BOWMAN DAMS.

1
Section across Cañon
through main dam.



It is fed from a gross catchment basin of 28.94 square miles. There are a number of other reservoirs owned by the Bloomfield and Eureka Lake companies on the same stream above the Bowman reservoir; the upper one of these is of large size, holding 630,000,000 cubic feet of water. In ordinary seasons these upper reservoirs retain all the water flowing into them; hence the catchment basin of the Bowman is only about 22 square miles, except in years of large rainfall. The mean annual rain and snowfall at the Bowman dam has been 77.91 inches for the past five years, of which about 75 per cent. flows into the reservoir. Two dams are needed to impound the water. The main one, placed across the narrow gorge forming the outlet of the valley, has a maximum height of 100 feet (96¼ feet above datum base-line), and an extreme length on top of 425 feet. The smaller dam, placed across a gap near the mouth of the valley, has a maximum height of 54 feet, and an extreme length on top of 210 feet. It is fitted with wasteways, and over it will be discharged all the surplus water from the reservoir.

Ordinary high-water mark will be fixed at a point 4 feet below the summit of the main dam, being coincident with the crest of the waste dam. At this height there will be impounded 845,000,000 cubic feet of water, with a surface area of 502 acres. By placing temporary flush-boards on the top of the waste dam, the water can be brought up to the 95-feet line (above datum base), increasing the quantity of water stored to 920,000,000 cubic feet.

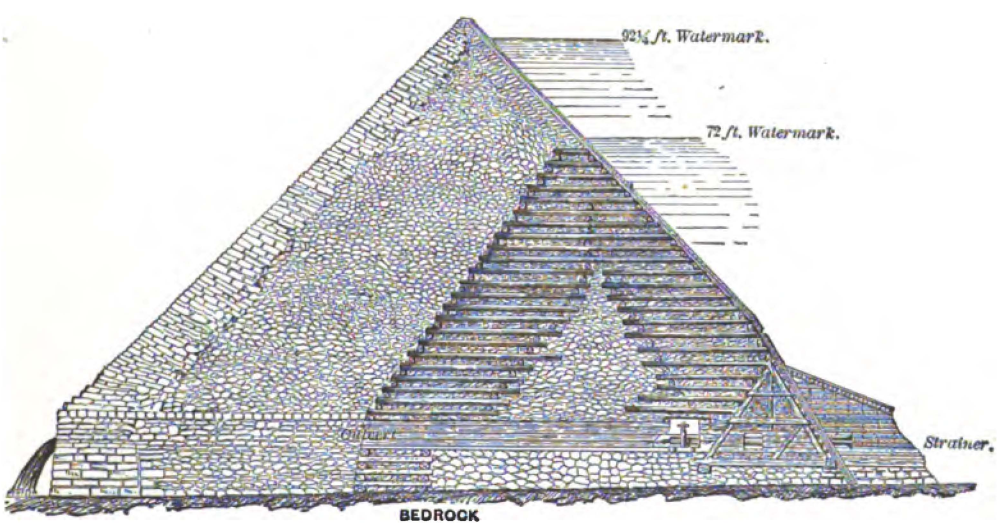
The cañon or stream feeding the reservoir has a maximum flow during great freshets of from 5000 to 7000 cubic feet of water per second. The existence of other reservoirs higher up the stream adds to the danger from great floods, and therefore the Bowman dams have been designed to withstand not only the freshets in the cañon, but also any additional influx of water caused by breaking of upper dams.

DESCRIPTION OF THE MAIN DAM.

Sketch 1 shows a profile across the cañon, being a longitudinal section through the dam. Sketch 2 gives a cross section of the dam at its extreme height.

Section through main dam
at deepest point.

Scale $\frac{1}{480}$



It rests on solid granite bed-rock, which is sufficiently free from seams to prevent any considerable leakage through crevices in the rock.

The dam was built in the year 1872 to the height of 72 feet, as shown by sketches, being a timber crib formed of cedar and tamarack unhewn logs, firmly notched and bolted together, and solidly filled with loose stone of small size. A skin of pine planking spiked to the water face formed its water-tight lining. During the years 1875 and 1876 the dam was increased to the height of 96½ feet above datum line (100 feet extreme height)* by filling in a stone embankment on the lower side of the old structure, faced with heavy walls of dry rubblestone of large size. The down-stream face-wall is 15 to 18 feet thick at the bottom, diminishing to 6 or 8 feet at the top. Most of the face-stone in this wall are of good size, weighing from ¾ to 4½ tons, and there are many stones of equal weight in the backing. The lower portion of the wall is 17½ feet high, with a batter of 15 per cent. It is built of heavy stone with ranged horizontal beds, and with the face-stone tied to the backing with long iron clamps.

The upper portion of the wall is built with a slope of 45°, and the face-stone are bedded on an angle of 22½°, thus dividing the angle between a horizontal bed and a bed at right angles to the face. No attempt at range work was made in this upper portion of the wall. Above the 68-feet line ribs of flattened cedar 8 inches thick are built into the up-stream face-wall, and are tied to it by iron rods ¾ inch diameter and 5 feet long. To these ribs a planked skin is firmly spiked. This planking is of heart sugar-pine, 3 inches thick and 8 inches wide, with planed edges fitted with an outgage similar to ship planking. The plank was put on nearly thoroughly seasoned, and swells sufficiently to make the face practically water-tight, without either battens over the joints or calking. The opening at the joints made by the outgage suck in small particles of vegetable matter, which take the place of calking to a great extent. At the bottom the planking is fitted closely to firm bed-rock and calked with pine wedges. There will be three thicknesses of plank (9 inches in all) placed on the lower 25 feet, two thicknesses (6 inches) on the next 35 feet, and one thickness on the upper 36 feet. From past experience, it is believed that this planking will remain sufficiently sound for twenty years at least, and then it can readily be replaced.

* The main dam was not quite finished in 1876, it being deemed advisable to allow a large stream of water, 50 to 75 cubic feet per second, to flow over the present summit of the stone at 85 feet above datum, and to percolate through the stone embankment, in which some sand and fine stone are mixed. This will finally settle the structure, and then the top courses for the crest will be put in place.

A culvert extends through the dam, as shown by sketch 2, through which the water is drawn from the reservoir. This culvert is built with heavy dry rubble foundation and walls, and is covered with granite slabs, 16 to 18 inches thick and 6½ feet long. Three wrought iron pipes of No. 12 iron, each 18 inches in diameter, pass through the water face of the dam, as shown by sketch 2. Their upper mouths are protected by a strainer formed of two-inch plank, anchored to the bed-rock. A separate valve or gate is placed at the lower end of each pipe; the water passing through the gates, aggregating a flow of 280 cubic feet per second when the three are open, discharges into a covered timber sluice 7½ feet wide, 1¾ feet high, passing to the lower edge of the dam, and discharges on the solid bed-rock of the creek bed. The gates are approached by a man-way above the sluice. The crest of the dam will be formed by a coping of hewn heart cedar timbers, 18 inches wide on top, and anchored securely by iron bolts to the stone wall below.

It is not probable that any water will ever pass over the crest of the main dam; but should a break occur at the large reservoir higher up the stream, when the waste-gates at the waste-dam are closed, the difference in level between the crests of the main and the waste dams might be insufficient to allow the resulting flood to pass over the waste-dam. Additional care was, therefore, taken in building the down-stream face-wall of the main dam, so that it can in any such possible emergency resist without injury a large stream of water passing over the crest. Should this happen, a large quantity of water would enter the structure, owing to the inclined beds of the face-stone and the flat slope of the wall, which would seek its discharge through the interstices purposely left in the nearly vertical portion of the lower wall. To prevent the consequent hydrostatic pressure, which would accumulate at the base of the dam to perhaps twenty pounds to the square inch, from forcing out the lower face of the wall, it was carefully built and tied with iron rods, as before described.

There are 55,000 cubic yards of material in the structure, weighing about 85,000 tons; the hydrostatic pressure, with the water-line 95 feet above datum against a vertical plane of that height across the cañon at the dam site, will be 21,745 tons. The dam is built v-shaped, with the vertex of the angle of 165° pointing up stream. This mode of construction adds somewhat to the stability of the structure.

The cost of the dam, when completed,* will be $132,000. The rather peculiar construction of this dam was due to the following causes: The stone cliffs in the vicinity of the dam are composed of an exceedingly hard granite with great numbers of short cross seams, making it most costly to quarry dimension stone of considerable size. The stone has rarely a good cleavage, and the cost of dressing it down to regular beds is hence great.

No limestone is to be found near by, and any lime used must needs have been transported to the work from a long distance. The cost of transport would have been so great as to render the use of lime impracticable.

On the side of the mountain, at the distance of about one mile from the dam, there was a large pile of loose stone, the result of centuries of disintegration of the cliffs above. This stone was too irregular in shape to be used in wall-building, but of good quality for an embankment. It was much cheaper to build a tramway to this stone already quarried by nature, load it on cars, and haul it to the work than to quarry a smaller quantity from the cliffs nearer the dam.

Hence, the supply of material being abundant, the flat slopes of 45° for the wall were adopted, which allowed with safety very much lighter face-walls to be used than would have been the case had they been more nearly vertical.

The stone for the walls as built was quarried from solid rock, and cost in place per cubic yard three or four times more than the loose stone brought from the mountain side. When in the future the timber logs forming the cribs in the original 72-feet dam decay, there will be some slight subsidence of superincumbent stone. The depth of the stone is so considerable, and the slopes of the walls so flat, that it is believed this subsidence will not be noticeable.

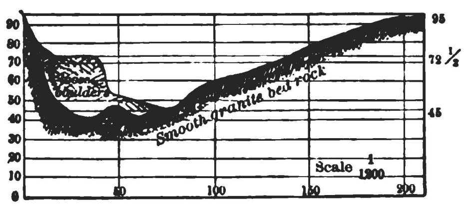
DESCRIPTION OF THE WASTE-DAM.

Sketches 3 and 4 show longitudinal and cross sections of the dam. It is a crib of round cedar timbers, varying from 12 to 30 inches in diameter, notched down to heart wood at the joints, and firmly bolted with three-quarter and one-inch long drift bolts, with the foundation logs fastened to the bed-rock with 1½ inch

* Up to December 31st, 1876, $126,000 had been expended on its construction, and the remaining $6000 necessary to complete the work will be expended during the year 1877.

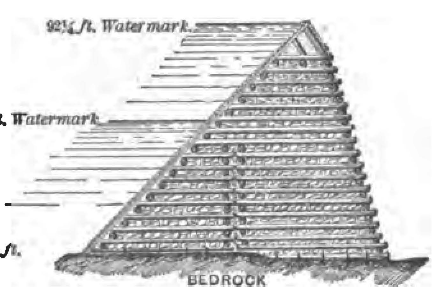
iron dowels. The crib or rather the successive cribs are solidly filled with granite stones of various sizes, from several tons down to a few pounds. No sand or fine stone was used in this filling. A plank facing of three-inch heart sugar pine is spiked on the water face,

3
Section across Ravine
through waste dam.



making a water-tight lining similar to that on the main dam. The crest of the dam is 92½ feet above datum line, being, as stated before, 4 feet lower than the summit of the main dam. In it are cut 28

4
Section through waste dam.
Scale $\frac{1}{480}$



waste-ways, each 4 feet in width, and having a depth of 7 feet below the crest. These wastes are closed, when all danger from freshets is passed, with boards 2 inches thick, 8 inches wide, 4½ feet long, placed horizontally, and sliding to their places one above the other on the inclined slope of the water face. This style of gate, although the simplest form known, has been found by long experience to be the very best.

The weight of the dam is about 6500 tons, and the hydrostatic pressure, with the water-line at 95 feet above datum against a vertical plane of that height across its upper face, will be 2571 tons.

It is believed that the structure is sufficiently stable to allow with safety a flood of 16,000 cubic feet of water per second to pass through the wastes and over its crest.

The water passing over the dam will fall on bare granite bed-rock, and thence down a steep gorge. From past experience in the use of cedar timber, it is safe to assume that the life of this structure will be from twenty-five to thirty years, and possibly longer. Its cost has been $15,000.

HYDRAULIC WASHING.

The tunnel or opening for the sluices having been completed, the sluices placed in position, lined, and riffles set, water is turned on in the pipes, and work commences. The first work is started near the head of the sluice, and the mine opened from that point. As the banks are washed away, the bed-rock cuts are driven towards the face of the work, and the sluices are advanced as required.

To cave the bank, one pipe is kept playing on the lower part of it, at an obtuse angle, cutting out the gravel, and a second stream of water is directed from another pipe on the opposite side, forming a cross-fire, which materially aids the undermining. Any surplus of water not used in the pipes is allowed to run over the banks. In well-regulated works all the water should be used through pipes, and none allowed to waste into the claim. When the dirt caves readily, one pipe should be employed to do the cutting, and the second pipe should be manipulated clearing away the débris.

In working a claim, the face of the bank should be kept square. Advantage should be taken of the corners when left, and under all circumstances working into what is called a horseshoe form should be avoided. If the banks are kept square, the work can be accomplished in less time, at less expense, and with fewer accidents. On the other hand, where a cut is pushed rapidly ahead, and the work is not squared, the men at the pipes soon stand encircled by high banks, washing can no longer be prosecuted to advantage, and the lives of the miners are imperilled. The majority of accidents arising from caves have been caused by this style of work.

HIGH BANKS.

Where the banks are very high, to mine to advantage it is advisable to wash the deposit in two benches. Banks over 150 feet in height are dangerous to work as a single bench. At North Bloomfield and at Smartsville, they are working single benches 250 feet high. When a cave is coming, to avoid the sliding of the great detrital accumulations, the water should be turned away from the falling masses, and the dirt will not run any distance; but if it is allowed to remain on the bank, a great rush of water and débris ensues, and the men at the pipe have frequently to run for their lives. Such occurrences, arising either from carelessness or accident, cause a loss of time, and frequently entail damage to the pipe and machines.

Caves, when practicable, are generally made towards evening, and the night-shift runs them off. Locomotive reflectors or fires of pitchwood are used to illuminate the banks during the night. The electric light may ultimately be found the most desirable.

CONTINUOUS WORK—GROUND SLUICES.

In well-conducted claims the washing should be continuous, and no water allowed to run to waste. It is, therefore, requisite to have several faces or openings, so that the water can be used from time to time on them, whilst the cuts are being advanced and the sluices lengthened. These cuts, or "ground sluices," as they are called, are mere trenches made in the bed-rock towards the face of the bank, washed for the purpose of collecting the water and material, and conveying them to the sluices. As a protection against theft, the sluices of claims worked intermittingly are run full of gravel before turning off the water.

The length of runs in gravel claims is dependent on circumstances. Some claims clean up every twenty days or month, others run two or three months, whilst some only clean up every season, after the water supply has ceased. In point of economy, the fewer clean-ups the better.

BLASTING.

Where the ground is very hard, recourse is had to blasting. For this purpose a small powder-drift is run in on the bottom from the face of the bank a given distance, proportionate to the ground to be blasted. From the end of the straight drift a cross drift forming a T is driven. For example, in hard cement like at Smartsville, with an 80-feet bank, in a case where the ground is ordinarily bound, a drift is run in at the bottom of the bank, say 85 feet long. At the end of it cross-drifts are run out 45 feet in length; 40 feet from the face of the bank two similar cross-drifts are also driven. From the ends and centre of each cross-drift two small "lifters," as they are called, are driven at right angles, extending respectively half way between the cross-drifts and the face of the bank. These places are then filled with powder, hard cement ground requiring from 450 to 500 kegs.

The heads of several of the kegs being removed, the main drift is tamped, and the powder is exploded by means of an electric battery or fuse.

In large blasts several cross-drifts may be required, and in such cases it is customary to fire the powder simultaneously in several different places by electricity. The quantity of powder used is determined by the position, character, and height of the bank, a sufficient quantity only being taken to shatter it.

In some places, with lighter material, two or three hundred kegs of powder will easily do the work that five or six hundred barely accomplishes in heavy cement. At Blue Point, a blast of 2000 kegs was exploded; at the Enterprise Mine, 250-feet banks, a blast of 1700 kegs was fired. The powder is of the ordinary blasting quality. For destroying large pieces of lava, pipe-clay, boulders, trunks and stumps of trees, giant powder cartridges are found very efficient.

It is customary in certain districts to wash off the top or lighter gravel, and subsequently blast the bottom cement. For this purpose shafts, fifteen to twenty feet deep, as may be demanded, are sunk, and a smaller chamber is excavated in the bottom of them. The chamber is charged with five or six kegs of powder, tamped, and then exploded by electricity. Undoubtedly there is a great waste of powder in bank blasting, and the subject is worthy of investigation with a view to future improvement in this particular.

In blasting, it is desirable to thoroughly shatter the material, *i. e.*, to separate rock and cement, so as to facilitate its washing, thus insuring the earliest separation of the gold, by enabling the bulk of the precious metal to come in immediate contact with the quicksilver in the head of the sluices, and affording every opportunity for the most complete scouring and securing of the eroded gold particles.

The following method of bank blasting has been found to give excellent results with banks from 50 feet to 125 feet high, such as are generally encountered in hydraulic mining, and likewise in cement gravel of ordinary tenacity. In the absence of more definite knowledge on the subject, its adoption can be recommended.

The main drift should be run in a distance two-thirds the height of the bank to be blasted. The cross-drifts from the end of the main drift should be driven parallel with the face of the bank, and their lengths determined by the extent of the ground which is to be blasted. A single **T** is all that is necessary. The amount of powder* required for charging the drift is from one-half to two-thirds of a keg of powder, minimum quantity, per 1000 cubic feet of ground covered by the drifts—*i. e.*, height of bank × length of cross-drifts × length of main drift = cubic contents. The quantity of powder used must depend on and vary with the position† of the bank and the character of the gravel.

Late experiments made with the Judson powder, applied as above directed, have given good results, and, though not definitely determined, the indications at present are that the use of this new explosive will be a great saving in the cost of bank blasting.

The shattering effects of powder, used in the manner and proportion already described, have been roughly estimated from the appearance of the ground subsequently washed at from 225 to 230 cubic feet of ground shattered per pound of powder exploded.‡

Apropos of tamping, one of the attendant costs of bank blasting, it may be well to remark that, as yet, with the present explosives employed, all experience in bank blasting proves that, with *a strong tamping*, the best results are obtained. With 150, 250, and 350-feet banks a different method of blasting is adopted. The main drift in such cases is driven in from the face of the bank 45 to 50 feet in length. The cross-drifts are run parallel with the face of the bank, and their length determined by the ground to be moved.

In charging these drifts the amount of powder used should be sufficient to blow out the bottom ground (the line of least resistance), the bank then falling by its own weight. The firing§ of all blasts is best done by electricity, and where dynamite exploders with platinum wires are used the "compound circuit" is most desirable.

The powder in boxes or kegs is piled up in rows in the drift; two wires, *A A* and *D D*, extend along the middle row, the tops of

* Ordinary black blasting powder, 25 lbs. per keg.

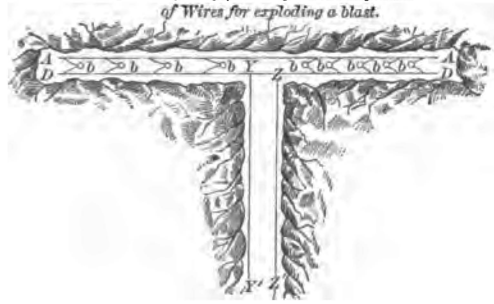
† The quantity of powder is increased when the banks are strongly bound, or when the gravel is exceedingly tough.

‡ Experiments made with blasts of 250 to 400 kegs powder.

§ A paper, titled On the Simultaneous Ignition of Thousands of Mines, by Julius H. Striedinger, read before the American Society of Civil Engineers, and published in its Transactions for June, 1877; also in London Engineering, August 17th and September 21st, 1877, contains much valuable information on the subject of simultaneous ignition of mines.

the boxes on which the wires rest being removed. The exploders, *b b b*, are inserted in giant powder cartridges, and placed on top of the paper covering the powder. (The Judson powder comes covered

Sketch of Drift showing the arrangement of Wires for exploding a blast.



with strong paper to exclude moisture.) The wires, *A A* and *D D*, are then connected with the wires, *Y Y'* and *Z Z'* (as shown in sketch), which extend to the battery.

DERRICKS.

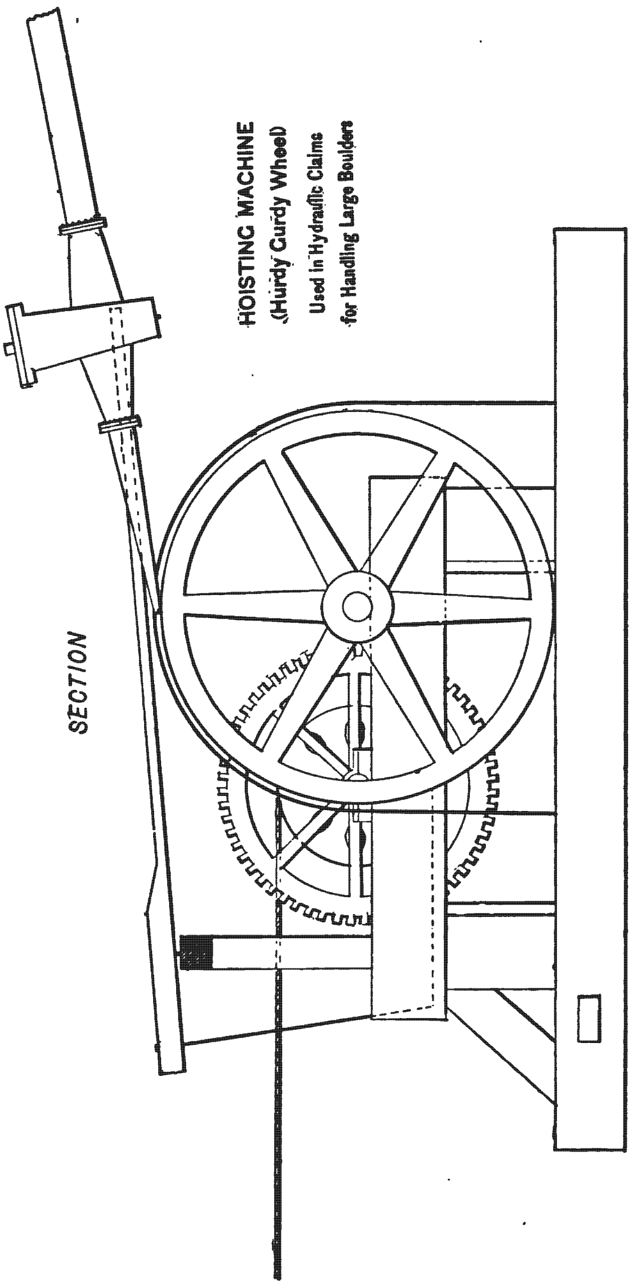
In working hydraulic claims, boulders are frequently encountered which cannot be moved by hand. To facilitate their removal a strong derrick is used. The bed-rock derrick now in use has a mast 100 feet high, and a boom 92 feet long. The whole is set in a cast iron box placed on sills. It is held in position by six guys of galvanized iron wire rope, 1⅛ inches in diameter. A whip-block, with ⅝ inch diameter steel rope, is used for the hoisting tackle. A 12-feet diameter hurdy-gurdy wheel is attached, and, using 30 inches of water, it lifts stones weighing 11 tons. The guys are held by double capstans.

The derrick is not taken down when moved. It can be readily moved one hundred feet in ten hours.

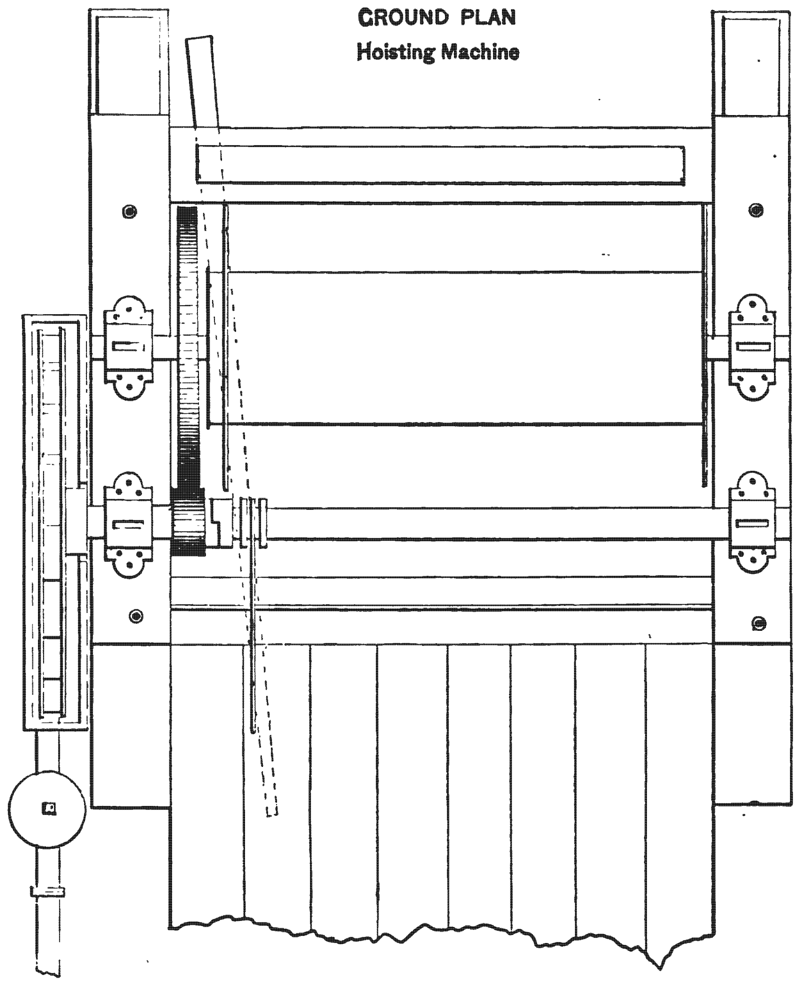
EXPERIMENT WITH THE HURDY-GURDY WHEEL,* AT NORTH BLOOMFIELD.

As the hurdy-gurdy wheel is the outgrowth of hydraulic mining, the following table showing its efficiency may be interesting.

* These experiments were made at the N. B. G. M. Co.'s Works, by H. Smith, Jr., C. E., and as they are the only experiments of the kind made with the hurdy-gurdy wheel, they are here given.


HOISTING MACHINE
(Hurdy Gurdy Wheel)
Used in Hydraulic Claims
for Handling Large Boulders
SECTION

The wheel was 18 feet in diameter on outside, and 17 feet 4 inches in diameter to inner line of buckets (17 feet 8 inches in diameter at centre line of buckets). The buckets were 4 inches deep, with flanges on each side.



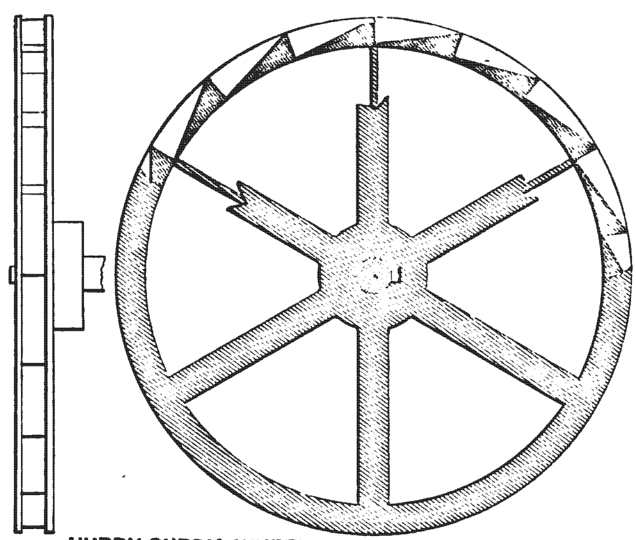
The work done was measured by a Prony dynamometer, carefully made.

The head given shows the *real* head in feet at the point of discharge; that is, the head due to a discharge from a pipe of infinite size.

Description of nozzle.	Diameter of nozzle in feet.	Head in feet at nozzle.	Discharge of water per second in cubic feet.	Velocity of water due to gravity.	Actual velocity of water at smallest diameter of nozzle.	Speed of wheel at centre of buckets when running light.	Highest horse-power developed.	Ratio of work done to theoretical power of water.	Speed of wheel at centre of buckets when giving most work.	Number of nozzles. See sketches.
Nozzle tapered,	.0531	322.3	.323	144.0	145.8	82.8	3.8	.318	48.8	1
Ring, ...	.0597	316.3	.240	142.6	85.7	76.4	2.7	.312	44.8	2
Nozzle tapered,	.0850	312.1	.759	141.7	133.7	93.6	11.7	.437	57.1	3
Ring, ...	.0847	312.6	.511	141.8	90.7	. . .	7.5	.414	54.7	4
		312.2	.509	141.7	90.3	90.4	. . .	. . .	. . .	4
Nozzle, ...	.0850	314.4	.774	142.2	136.4	. . .	11.8	.427	57.3	3
Nozzle tapered, uucut, . . .	.0868	316.1	.813	142.6	137.4	. . .	11.3	.387	59.8	5A
Nozzle, ...	.1017	317.9	1.111	143.0	136.8	. . .	15.9	.396	66.1	7
		315.6	1.110	142.5	136.7	95.2	. . .	. . .	. . .	7
Nozzle cut off, .	.0868	332.6	.831	146.2	140.4	. . .	13.0	.413	58.2	5B
		335.9	.833	147.0	140.8	98.5	. . .	. . .	. . .	5B

An experiment at the Empire Mill, French Corral, was made under the following circumstances, giving the annexed results:

Ten stamps, weight of each 693¼ lbs. Drop, .768 feet. Speed of stamps, 62.2 drops per minute. Work done by 91.68 cubic feet of



HURDY CURDY WHEEL

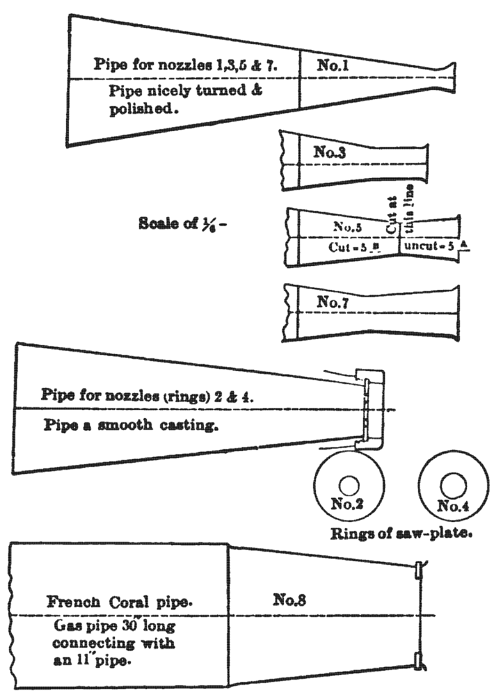
Scale

0 1' 2' 3'

water per minute. Head, 130.1 feet. Size of wheel, 13⅛ feet outer diameter. Diameter of wheel, 12.58 feet to centres of buckets. Size of buckets, 4 inches wide and 6 inches deep, set 10 inches apart. Water conducted to wheel through an 11-inch pipe 866 feet long. The wheel was direct on the cam-shaft; single cams used. The mill crushed sixty tons of gravel in twenty-four hours; ¼ inch screens used.

Description of nozzle.	Diameter of nozzle in feet.	Head in feet at nozzle.	Discharge of water per second in cubic feet.	Velocity of water due to gravity.	Actual velocity of water at smallest diameter of nozzle.	Speed of wheel at centre of buckets when running light.	Highest horse-power developed.	Ratio of work done to theoretical power of water.	Speed of wheel at centre of buckets when giving most work.	Number of nozzle. See sketch.
Ring, ...	.1823	130.1	1.528	91 4	58.5	. . . .	10.0	.445	41.0	8

The head at French Corral was the height of the water in pen stock above the nozzle, no allowance being made, as was the case in



the Bloomfield experiments, for loss of head by friction in pipes and some leakage.

STATISTICS OF YIELD OF GRAVEL-FIELD.

Statistics showing the quantity of material washed, and the corresponding yield in gold, are rare, difficult to obtain, and for the most part unreliable. This is due principally to the fact that, in the early days of placer mining in California, the question to be solved by the miner was not what the gravel would yield per cubic yard, and what it would cost to move it, but rather how many ounces of gold dust he could "pan out" or "rock out" between sunrise and sunset. All that he required was that the daily yield in *dust* should exceed the cost of living, etc. When it fell below this, he moved his camp to other grounds.

The wonderful productiveness of the river bars and shallow placers, attested by the early gold bullion and dust shipments from this State, created an extravagance usual to all new and rich mining countries, the baneful effects of which are still visible. Gold in such profusion is no longer found so conveniently scattered. The introduction of hydraulic mining requiring the assistance of capital has inaugurated a new era in gravel-washing. Hence all data of the yield and costs of working gold-bearing surface deposits become valuable, and accordingly the following tables have been added:

Table I. Showing the Yield of Gravel per Cubic Yard at Various Hydraulic Claims.

Name of claim.	Location.	No. cubic yards washed.	Gross yield.	Yield per cubic yard.	Height of banks in feet.	Authority.	Remarks.
American Co.,	Sevastopol, Nev. Co.	5,171,834	$1,241,240.30	$0.24	120	H. Smith, Jr.	
Blue Tent,	Nevada Co.	5,138,150	780,000.00	15	....	Ray. Rep., 1874	Estimated by several engineers, Ray. Rep., 1874, p. 19.
Eastground, Dry Creek,	Shasta Co.	50,000	9,000.00	18	....	" "	
Westside, Dry Creek,	" "	2,000	741.26	37	....	" "	
Piety Hill,	" "	1,333	22,000.00	16.50	20	W. K. Conger	Raymond's Report, 1874.
Dry Creek,	" "	200 lin. ft. chn'l.	170,000.00	....	....	Cooper	" " "
Whitesides Mine,	El Dorado Co.	9,722	100,000.00	10.28	70	Ray. Rep., 1875	Calculated from data, p. 84.
Spanish Mine,	" "	1,422	13,600.00	9.56	4	" "	" " "
Nagler Claim,	" "	20,000	100,000.00	5.00	30	" "	" " "
*Indiana Hill,**	Placer Co.	14,738	75,422.47	5.29	....	" "	Gravel worked in a mill. Cubic yards estimated from coarse dirt in cars, p. 100.
Bald Mountain Co.,	Sierra Co.	115,950	328,352.38	2.83	....	" "	Deep placer mining; gravel extracted and then sluiced. Cubic yards estimated from coarse dirt.
Bald Mountain Co.,	" "	50,040	296,737.28	5.93	....	H. W. Wallace	From June 24th, 1875, to June 24th, 1876, 100,080 car-loads of gravel mined, stripping 300,240 superficial feet of bed-rock. Each car contained 1 cubic yard of loose gravel = ½ cubic yard of gravel in place.
Bald Mountain Co.,	" "	49,022	235,797.87	4.79	....	" "	Year ending June 24th, 1877, 98,044 car-loads extracted, stripping 343,768 superficial feet of bed-rock.
Bennet's Claim,	Calaveras Co.	963	1,320.00	1.37	13	J. Rathgeb	Calculated from data in Raymond's Rep., 1872.
Johnston Claim,	" "	2,268	1,560.00	68.5	12½	"	" " " "
Hedwick's Claim,	" "	2,963	1,450.00	48.5	20	"	" " " "
Kansas Co.,	Fr. Corral, Nev. Co.	67,500	223,000.00	3.30	27	H. Smith, Jr.	Cement claim.
Empire Claim,	" " "	29,166	200,000.00	6.85	18	" "	The richest gravel selected and milled.
Nebraska Co.,	" " "	(tons) 600	9,000.00	15.00 per ton.	....	" "	
Blue Point,	Smartsville, Yuba Co.	93,944	115,728 17	1.23	57	" "	
No. 8 Claim, 1874-5,	N. Bloomfield, Nev. Co.	1,858,000	74,271.77	03.9 }	180	Henry C. Perkins.	
No. 8 Claim, 1875-6,	" " " "	2,919,700	192,735.73	06.6 }	260	" "	
French Hill,	Stanislaus Co.	16,368	9,782.98	61	18	R. Abbey	
Light Claim,	" "	73,566	8,468.35	11.4	57	"	
Sicard Claim,	" "	155,347	20,197.07	13	38	Joseph Messerer	Top gravel.
New Kelly Claim,	" "	161,032	8,852.31	05½	....	J. L. Jernegan, Jr.	Upper bench gravel.
New Kelly Claim,	" "	252,614	35,012.33	13.8	....	" "	This ground was washed in 176 days and five hours, ending August 3d, 1877. The yield includes the top and bottom gravel.

Gold Run,....................	Placer Co..................	43,000,000	2,074,356.00	04.8	....	Wm. H. Pettee......	This deposit contains many large boulders.
Paragon Mine,............	" "	124,000	92,000.00	74.2	70	Jos. McGillivray...	
Paragon Mine,.............	" "	22,275	17,387.78	78	71	" "	
Dardanelles & Oro,........	Forest Hill, Plac. Co...	3,630,000	476,000.00	13.1	150	" "	Rep. Eureka Lake & Yuba Canal Co. Clms., p. 37.
McCarty's Diggings,.......	Columbia Hill, Nev. Co.	3,000,000	345.663.10	04.3	... .	J. D. Hague..........	
Smartsville Mine,.........	Sucker Flat, Yuba Co.	2,042,880	400.000.00	19.5	112	Amos Bowman......	See Report on the Smartsville Blue Gravel and Excelsior Canal Co., pp. 32-35.
Union Gravel Mine,......	Empire Hill...............	792,000	120,000.00	15	90	" "	
Pactolus Gravel Mine,...	Yuba Co....................	1,468,800	295,000.00	20.8	85	" "	
Blue Gravel Mine,.........	Temperance Hill.......	2,449,120	1,550,000.00	63	83	" "	
Pittsburg,....................	....	565,760	237,000.00	41	59	" "	
Pactolus,.....................	Yuba Co....................	60,000	26,600.00	44	50	Wm. Ashburner & J. D. Hague.......	
Crawford's Claim,........	El Dorado Co.............	77,880	35,046.00	45	85	J. J. Crawford.......	1186 ft tunnel in gravel; 10 to 20 ft. above bed-rock.
Pioneer Tunnel,...........	Sierra Co..................	883.37	1,400.53	1.59	....	Charles Hendel.....	
Green Flat,..................	Plumas Co.................	22,000	15,000.00	67.5	15	Aug. J. Bowie, Jr.	
Fale's Hill,..................	" "	25,000	4,794.49	19	75	" "	
McDoran Claim,...........	" "	5,555	300.00	05.4	20	" "	
Bean's Hill,..................	" "	314	220.00	70	5	" "	Shallow spots.
Jack's Hill,..................	" "	740	37.37	05	8	" "	
Gardner's Point,...........	" "	148,148	118,000.00	79	80	" "	Estimated from best obtainable data.
Light Claim, La Grange,	Stanislaus Co............	746,640	64,714.27	08.6	48	" "	Banks contained several thick strata of sand.
Kelly Claim,................	" "	701,685	15,770.34	02.2	100	" "	Pay stratum adjoining bed-rock previously drifted.
French Hill Claim,........	" "	1,020,347	188,433.11	15.5	30	" "	Originally rich; portion drifted in early days.
Kelly Claim,................	" "	83,660	3,406.33	04	85	" "	Results obtained from cleaning out a deep hole.
Chesnau Claim,............	Patricksville, Stanisl's [Co.	27,250	11,009.00	40.4	18	" "	Shallow ground.
Chesnau Claim,............	" " "	338,880	62,980.37	18.6	60	" "	Virgin ground.
New Light Claim,.........	" " "	667,347	45,511.81	06.8	35	" "	Drifted in placer.
Johnson Claim,............	" " "	196,632	9,148.27	04.6	30	" "	Virgin ground.
New Claim,..................	" " "	17,796	773 72	04.3	42	" "	Virgin ground.
Trans Baikal Mines,......	Siberia........	4,143,280	8,814,216.90	2.12	....	R. Pumpelly.........	Sluice washings, App. 5, "Across America & Asia."
Riviere du Loup,...........	Canada......................	3,226	4,323.00	1.34	....	Sir W. E. Logan....	"Geological Survey of Canada," '63, vol. 1, p. 741.
Musa Gold-field,.............	Oshima Prov., Japan..	2,800,000	21,000.00	00.75	....	Henry S. Munroe..	Trans. Am. Inst. of Min. Engineers, vol. 5, p. 289, also, *Eng. & Min. Journal*, vol. 22, pp. 425, 426.
				Cu. yd. in gms.			
Gold diggings of Miassk, 1827-41,.........	Siberia......	2,097,592	....	3.14	....	N. Sewastjanon.....	These results have been calculated from tables published in the Berg- und Hüttenmännische Zeitung. January 19th, 1877. Official report of the Director at Miassk.
Gold diggings of Miassk, 1841-51,......	"	2,829,769	....	2.85	....	" "	
Gold diggings of Miassk, 1851-61,......	"	3,861,956	....	2.00	....	" "	
Gold diggings of Miassk, 1861-75,...	"	3,716,250	....	2.46	....	" "	

* Italics denote mines not worked by the hydraulic method.

Table II. The Gold-fields of Japan, showing the Yield of Gravel per Cubic Yard.

Name of claim.	Location.	No. of cubic meters washed.	Value of 1 cubic meter in cents.	Yield per cubic yard.	Height of banks in feet.	Authority.	Remarks.
Moshibetsu....................	Kudo Gold-field, Shiribeshi Province, Japan...............	2	$0 00.42	$0 00.30	5	Henry S. Munroe.	See "Gold-fields of Yesso," p. 35.
Usubetsu.......................	Kudo Gold-field, Shiribeshi Province, Japan...............	2	0.07	0.05	3	" "	" " "
Otobe.	Esashi Gold-field, Oshima Province, Japan...............	0.25	0.71	0.09		" "	" " p. 42, 43.
Jimikishi.......................	....	1	10.46	1.31	8	" "	" " "
"	....	2	1.58	0.20	3.8	" "	" " "
Gokatte..........	....	0.50	0.07	0.01	5	" "	" " "
Todo.........	....	1	0.42	0.05	4	" "	" " "
Mena...........	....	1	0.29	0.04	5	" "	" " "
Sangiurono................. ..	Musa Gold-f'ld, Oshima Prov. [Japan.	7	1.89	1.44	10	....	" " p. 64.
"	" "	2.50	1.31	1.00	6	....	" " "
Shikubeno.......................	" "	3	1 00	0.75	10 to 12	....	" " "
Unoshiri.........................	" "	8	0.60	0.46	13	....	" " "
"	" "	4	0.56	0.43		....	" " "
Minagoya.......................	" "	7	0.50	0.38		....	
Toshibetsu Gold-field:					Dpth. gravel tested.		
Upper Toshi.................	Iburi Province, Japan.........	1.25	8.11	6.13	4 to 6	Henry S. Munroe.	"These results were obtained by washing measured quantities of gravel in different parts of this field. In measuring, no allowance has been made for the increased bulk due to the loosening of the gravel and to vacant spaces necessarily left between the stones in filling the measuring box." See Report of Henry S. Munroe, M. E., "Gold-fields of Yesso," pp. 23, 24.
Akabuchi.......................	" "	3.00	6.81	5.16	....	" "	
Kuusube.........................	" "	3.00	4.66	3.53	7	" "	
Highest Terrace............	" "	....	3.00	2.25	35 to 37	" "	
Okajisawa......................	" "	3.00	4.06	3.07	18	" "	
Ponkajisawa...................	" "	1.00	1.84	1.40	....	" "	
Chingkombe..................	" "	1.00	0.20	0.15	....	" "	
Nisheumbetsu................	" "	1.00	0.01	0.01	5	" "	
Average..			5.00	3.77			

Table III. Yield of the Russian Gold-fields for the year 1874.*

Name of Works.	No. places where washing is carried on.	No. cubic yards of gravel washed.	Total yield of gold. Troy pounds.	Yield of gravel per cubic yard washed. Troy grs.
GOVERNMENT WORKS:				
Beresowsk	16	293,198	1,004.88	19.7
Bogolslowsk	28	111,548	646.48	33.5
Miassk	15	384,312	2,260.98	33.8
Nertschinsk	....	564,944	6,592.23	67.2
PRIVATE WORKS, EST'N SIBERIA:				
District Jenisei:				
Northern Division	104	1,190,022	7,158.26	34.8
Southern Division	110	1,198,116	7,521.39	36.1
Atschinsk	19	168,868	727.70	24.8
Minusinsk	30	318,046	1,423.91	25.8
Kansk and Nischneudinsk	20	115,071	727.84	36.4
Oleksminsk	34	687,332	26,768.18	224.3
Werchneudinsk	13	59,070	264.59	25.8
Barguainsk	22	155,083	1,702.65	63.2
Nertschinsk	213	852,205	7,493.10	50.6
Wercholensk	1	6,191	17.19	16.01
District of Amur	4	328,707	6,508.40	114.1
WESTERN SIBERIA:				
Marlinsk	78	529,907	2,073.25	22.5
Altai	34	731,774	3,507.31	27.6
Semipalatinski District	19	210,568	407.97	11.2
Akmolenski District	1	137	14	5.9
URAL:				
Government Orenburg	243	791,109	4,575.57	33.3
Government Perm	124	480,194	2,543.17	30.5
Other works in Ural	81	743,525	3,349.78	25.9

RELATIVE YIELD OF HYDRAULIC CLAIMS.

In many districts the yield of the gravel is not figured per cubic yard, but per inch of water used, this being a more convenient and shorter mode of calculation. A record of the quantity of water used is always kept.

The yield per miner's inch is figured under peculiar local con-

* These tables have been calculated from the official statements published in the Berg- und Hüttenmännische Zeitung of April 20th, 1877. The gold pounds have been figured from the Russian doli, which, according to the mint standard, is 750 fine. The number of yards washed has been estimated from the Russian pud. 100 puds have been assumed to equal 1.058 cubic yard. See Berg- und Hüttenmännische Zeitung, January 19th, 1877. On this basis the cubic yard gravel weighs 3397 pounds avoirdupois. The cement gravel of Nevada County Cal., will approximate 3600 pounds avoirdupois per cubic yard.

ditions and circumstances, which, apart from its own variations, are multifarious in every district; therefore, any comparative estimates of the value of gravel deposits, based on such calculated returns or comparisons of work done per inch of water used in the several mining camps, are exceedingly difficult to make, and in most cases unsatisfactory when obtained. The quantity of dirt moved by any given head of water properly applied is dependent on the height of the banks, character of the gravel, and on the grade and arrangement of the sluices. The value of the ground per cubic yard varies in the different parts of the country, changes even occurring in a claim, the discovery of which is only made after an extensive run and clean up.

To better familiarize the reader with the subject of gravel mining, and enable him to form an idea of the amount of water used per cubic yard of dirt moved, the corresponding yield, and attendant costs, an exhibit of a claim running on an approximate minimum basis, viz., light pressures and smallest practicable grades, has been selected. For this purpose the claims of the La Grange Hydraulic Mining Company have been chosen, as the yield per cubic yard and the grades there used can be considered as nearly the lightest with which a hydraulic claim can yield any remunerative returns.

The annexed tabular statements show, in the most convenient form, the data alluded to.* The tables have been carefully arranged, and the results were obtained at cost of great labor, several examinations and surveys of the ground. The data of the yield and disbursements are accurate. The apportionment of the material account has in some places been calculated *pro rata* per cubic yard from general material account. The measurements of the ground washed were made at each clean-up, and subsequently the entire ground was resurveyed, and the work checked. (See Tables IV, V, VI, VII, and VIII.)

A résumé of the entire work done by this company from June 1st, 1874, to September 30th, 1876, showing gross receipts and total disbursements, including the rebuilding of the dam at the head of the ditch, the construction of roads, ditches, etc., but excluding the purchase of some mining ground, gives the following result:

1,533,728 inches (2.159 cubic feet each) washed
2,275,967 cubic yards of gravel, which yielded
$231,893 = 12,026.84 troy ounces.

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* In obtaining the data for these tables, I am greatly indebted to the valuable assistance of Mr. Joseph Messerer, superintendent of the La Grange Ditch and Hydraulic Mining Company.

TABLE

THE FRENCH

Tabular Statement Showing Amount of Water Used and Cubic Yards

May 30, 1874, to C

Year.	Run Commenced.	Months.	End of Run.	Washings. Days.	Washings. Hours.	Amount of Water used in 24 hours M. I.	Grade of Sluices.	Height of Banks.	Water Pressure.	Cubic Yards Gravel Washed.	Cu. Yds. Gravel Moved per in. of water	Av'g Yield. Per inch Water.	Av'g Yield. Per Cubic Yard.	Average Cost. Water per Yard Gravel Moved.	Average Cost. Material, Etc., per Cubic Yd.	Total Cost. Melting and Refining.	Total Cost. Labor.	Total Cost. Blocks & Lumber.	Total Cost. Water.
1874	30	May....					4 in. to 16 ft.; sometimes less. Sluices 4 ft. wide 30 in. side.	10 to 48 feet. Average 30 feet.	50 to 70 feet; Number of pipes, 3; nozzles, 4, 5, and 6 inch.										
		June...																	
		July ...	6	43	21	52,675				32,822	0.62	$0.25	$0.40			$16.68	$2,699.50		$589.96
	15	Aug....																	
		Sept....																	
	3	Oct......	1	38	21	46,675				52,316	1.01	.13	.12			31.36	1,880.06		522.76
	27	Nov	26	44	23	53,975				57,600	1.06	.13	.12			7.32	2,293.43		604.52
		Dec																	
1875		Jan....																	
	23	Feb.....	21	60	9	72,565						.16				44.02	3,427.67		812.72
		March																	
		April...																	
	29	May....	28	60	5	72,275						.14				35.71	4,486.14		809.48
		June...																	
	15	July ...	14	22	12	27,000						.10				10.33	1,785.26		302.40
		Aug....												$.0104	$0.0526			$2900.00	
	9	Sept....	8	41	12	49,800						.15				24.69	2,209.71		557.76
	14	Oct......	13	12	3	14,150				490,230	1.14	.12	.12			10.20	1,309.53		158.48
		Nov....																	
	3	Dec	2	22	2	26,500						.16				19.47	1,292.54		296.80
1876		Jan	31	45	17	54,850						.11				32.89	2,063.99		614.32
	1	Feb.....																	
		March																	
	25	April...	24	73	15	87,750						.11				50.00	2,863.74		982.80
		May....																	
	8	June...	7	20	13	24,680						.13				13.70	1,099.91		276.41
		July ...																	
		Aug																	
		Sept....																	
		Oct......	12	34	21	41,850				44,000	1.05	.10	.09			16.59	1,164.58		468.72
				521	7	624,745				676,968	1.08	$0.14	$0.13	$0.0104	$0.0526	$312 96	$28,576 06	$2,900.00	$6,997 13

Note.—A recent survey by Mr. J. L. Jernegan, M. E., of the ground washed on this claim since the date of above work

IV.

HILL CLAIM.

of Gravel Moved; Cost and Receipts of Hydraulic Washing from
ctober 12, 1876.

Material.	Grand Total.	Relative Cost Per Cubic Yard. Labor.	Blocks & Lumber.	Material.	Water.	Melting and Refining.	Total Cost.	Bullion Yield. Amalgam. Pounds Avd'ps.	Weight Before Melting. P'nds Avoirdupois.	Fineness Gold.	Fineness Silver.	Value of Gold.	Value of Silver.	Total Amount of Bullion Produced.
...	...	...	...	...	...	...	...	...	...	...	...	...	...	...
...	...	...	...	...	...	...	...	...	...	...	...	...	...	...
...	$3,306.14	$0.082	...	...	$0.017	...	$0.109	121.00	48.00	.921	...	$13,304.29	$39.29	$13,343.58
...	...	...	...	...	...	...	...	...	...	...	...	...	...	...
...	...	...	...	...	...	...	...	...	...	...	...	...	...	...
...	2,434.18	.035	...	...	.009	...	.054	58.00	23.00	.936	.055	6,411.13	15.49	6,426.62
...	2,905.27	.039	...	...	.010	...	.059	70.00	25.75	.934	.051	7,220.39	19.99	7,240.38
...	...	...	...	...	...	...	...	...	...	...	...	...	...	...
...	...	...	...	...	...	...	...	...	...	...	...	...	...	...
...	4,284.41	...	...	...	...	...	...	117.25	43.31	.938	.054	12,050.93	29.07	12,080.00
...	...	...	...	...	...	...	...	...	...	...	...	...	...	...
$3757.29	3,757.29	...	...	...	...	...	...	...	...	...	...	...	...	...
...	5,331.33	...	...	...	...	...	...	103.50	37.25	.921	.056	10,366.59	30.49	10,397.08
...	...	...	...	...	...	...	...	...	...	...	...	...	...	...
...	2,097.99	...	...	...	...	...	...	30.00	10.50	.928	.055	2,891.58	8.10	2,899.68
...	2,900.00	...	$0.0042	$0.0057	...	$0.0004	...	...	...	...	...	...	...	...
...	2,792.16	...	...	...	...	...	...	73.75	26.68	.951	.047	7,545.31	15.80	7,561.11
...	1,478.21	.041	...	...	.008	...	.059	17.31	6.44	.941	.052	1,818.34	5.05	1,823.39
...	...	...	...	...	...	...	...	...	...	...	...	...	...	...
...	1,608.81	...	...	...	...	...	...	46.00	15.44	.919	.057	4,462.84	20.49	4,483.33
...	2,711.20	...	...	...	...	...	...	63.12	22.68	.940	.050	6,121.73	15.00	6,136.73
...	...	...	...	...	...	...	...	...	...	...	...	...	...	...
...	...	...	...	...	...	...	...	...	...	...	...	...	...	...
...	3,896.54	...	...	...	...	...	...	105.25	36.44	.936	.052	10,151.95	27.00	10,178.95
...	...	...	...	...	...	...	...	...	...	...	...	...	...	...
$112.39	1,502.41	...	...	...	...	...	...	31.75	12.09	.936	.054	3,325.67	8.91	3,334.58
...	...	...	...	...	...	...	...	...	...	...	...	...	...	...
...	...	...	...	...	...	...	...	...	...	...	...	...	...	...
...	...	...	...	...	...	...	...	...	...	...	...	...	...	...
...	1,649.89	.026	...	...	.01	...	.046	42.00	15.25	.926	.059	4,269.76	11 00	4,280.76
$3,869.68	$42,655.83	$0.042	$0.0042	$0.0057	$0 104	$0.0004	$0.063	878.93	322.83			$89 940.51	$245.68	$90,186.19

showed that 252.614 cubic yards moved, yielded 13.8 cents per cubic yard.

TAI

THE LIGHT CLAI

Tabular Statement Showing Amount of Water Used and Cubic Ya
February 12, 1875,

Year.	Run Commenced.	Months.	End of Run.	Washings. Days.	Washings. Hours.	Amount of Water used in 24 hours M. I.	Grade of Sluices.	Height of Banks.	Water Pressure.	Cubic Yards Gravel Washed.	Cu. Yds. Gravel Moved per in. of water.	Av'g Yield. Per Inch Water.	Av'g Yield. Per Cubic Yard.	Average Cost. Water per Yard Gravel Moved.	Average Cost. Material, Etc., per Cubic Yd.	Total Cost. Melting and Refining.	Total Cost. Labor.	Total Cost. Blocks & Lumber.	
1875	12	Feb.....	...	....		....	4 in. to 16 ft. Sluices 4 ft. wide 30 in. side.	24 to 60 feet. 27 to 60 feet.	60 feet; 3 pipes, nozzles 6 and 7 inch.	....	......	....	....	....	....	....	....	....	
		March.	...	....		....				....	......	....	....	....	....	....	....	....	
	23	April...	22	46	21	42,198				....	......	$0.12	....	....	....	$18.26	$1,928.74	....	
		May....	...	....		....				....	......	....	....	....	....	....	....	....	
	4	June...	3	30	4	27,152				....	......	.10	....	....	....	7.08	1,187.32	....	
	16	July ...	15	32	12	29,250				453,038	2.36	.10	....	....	....	10.33	1,329.27	....	
		Aug....	...	....		....				....	......	....	$0.05	....	....	....	....	....	
	11	Sept....	10	49	18	44,784				....	......	.13	....	....	....	24.69	1,761.69	....	
	15	Oct......	14	24	14	22,132				....	......	.17	....	....	....	10.20	987.52	....	
		Nov....	...	....		....				....	......	....	....	....	....	....	....	....	
	2	Dec......	1	29	3	26,214				....	......	.10	....	$0.0062	$0.0318	17.10	1,233.96	$5800.00	
1876		Jan	...	....		....				....	......	....	....	....	....	....	....	....	
	7	Feb.....	6	44	4	49,688				84,220	1.69	.14	.08	....	....	32.88	1,925.36	....	
		March.	...	....		....				....	......	....	....	....	....	....	....	....	
	26	April...	25	70	8	79,126				82,680	1.04	.12	.12	....	....	50.00	2,459.86	....	
		May....	...	....		....				....	......	....	....	....	....	....	....	....	
		June...	...	....		....				....	......	....	....	....	....	....	....	....	
		July ...	...	....		....				....	......	....	....	....	....	....	....	....	
		Aug. ..	...	....		....				....	......	....	....	....	....	....	....	....	
		Sept....	26	48	13	54,611				63,306	1.15	.07	.06	....	....	16.63	1,917.76	....	
				373	4	375,155				683,244	1.82	$0.12	$0 066	$0.0062	$0.0318	$187.17	$14,741.48	$5,800.00	$4

LE V.

M, PATRICKSVILLE.

·rds of Gravel Moved; Cost and Receipts of Hydraulic Washing from
o September 26, 1876.

			Relative Cost Per Cubic Yard.						Bullion Yield.						
Water.	Material.	Grand Total.	Labor.	Blocks & Lumber.	Material.	Water.	Melting and Refining.	Total Cost.	Amalgam. Pounds Avd'ps.	Weight Before Melting, P'nds Avoirdupois.	Fineness: Gold.	Fineness: Silver.	Value of Gold.	Value of Silver.	Total Amount of Bullion Produced.
......	......	......	......	......	......	......	......	......	......	......	......	......	......	......	......
......	......	......	......	......	......	......	......	......	......	......	......	......	......	......	......
472.62	......	$2,419.62	......	......	......	......	......	......	51.00	18.15	.935	.052	$5,115.15	$11.13	$5,126.28
......	......	......	......	......	......	......	......	......	......	......	......	......	......	......	......
304.10	......	1,498.50	......	......	......	......	......	......	27.25	10.60	.950	......	2,926.47	6.65	2,933.12
327.60	......	1,678.70	$0.018	$0.008	$0.0017	$0.004	......	$0.035	32.00	11.20	.928	.055	3,084.63	8.26	3,092.89
......	......	956.08	......	......	......	......	......	......	......	......	......	......	......	......	......
501.58	$956.08	2,287.96	......	......	......	......	......	......	59 00	21.35	.951	.047	6,035.55	15.00	6,050.55
247.88	......	1,245.60	......	......	......	......	......	......	35.81	13.33	.941	.052	3,765.64	8.55	3,774.19
......	......	......	......	......	......	......	......	......	......	......	......	......	......	......	......
293.60	......	1,544.66	......	......	......	......	$0.0003	......	31.00	10.41	.942	.054	2,760.89	10.05	2,770.94
......	......	5,800.00	......	......	......	......	......	......	......	......	......	......	......	......	......
556.50	......	2,514.74	.022	.0084	.0017	.006	......	.038	72.53	26.06	.940	.050	7,426.10	18.81	7,444.91
......	......	......	......	......	......	......	......	......	......	......	......	......	......	......	......
386.21	......	3,396.07	.029	.0084	.0005	.01	......	.048	106.25	36.79	.936	.052	10,249.70	27.00	10,276.70
......	......	......	......	......	......	......	......	......	......	......	......	......	......	......	......
......	76.36	76.36	......	......	......	......	......	......	......	......	......	......	......	......	......
......	......	......	......	......	......	......	......	......	......	......	......	......	......	......	......
......	......	......	......	......	......	......	......	......	......	......	......	......	......	......	......
511.64	......	2,546.03	.030	.0084	.0005	.009	......	.048	39.50	15.00	.880	.064	3,963.41	11.66	3,975.07
201.73	$1.032.44	$25,962.82	$0.022	$0.008	$0.0015	$0.006	$0.0003	$0.038	454.34	162.89			$42,566.65	$107.06	$45,444.65

TABL

THE CHESN

Tabular Statement Showing Amount of Water Used and Cubic Yard

June 1, 1874, to

Year.	Run Commenced.	Months.	End of Run.	Washing. Days.	Washing. Hours.	Amount of Water used in 24 hours M. I.	Grade of Sluices.	Height of Banks.	Water Pressure.	Cubic Yards Gravel Washed.	Cu. Yds. Gravel Moved per in. of water.	Av'g Yield. Per Inch Water.	Av'g Yield. Per Cubic Yard.	Average Cost. Water per Yard Gravel Moved.	Average Cost. Material, Etc., per Cubic Yd.	Total Cost. Melting and Refining.	Total Cost. Labor.	Total Cost. Blocks & Lumber.	Total Cost. Water.
1874	1	June...	...				3 in. to 16 ft.	12 to 62 feet.	50 to 80 ft. 2 pipes, nozzles 6 and 7 in.										
	4	July ...	3	14	11	8,675				24,395	2.81	$0.45	$0.16			$22.23	$711.36		$97.[illegible]
	17	Aug....	15	31	23	19,175				30,346	1.58	.23	.14			5.64	1,111.25		214.[illegible]
		Sept....	28	34	21	21,345				30,118	1.41	.25	.18			31.36	1,050.87		239.[illegible]
	2	Oct......	...																
	24	Nov....	23	43	2	25,850				55,413	2.14	.23	.11			7.32	1,342.87		289.[illegible]
		Dec.....	...																
1875		Jan	...																
		Feb.....	19	72	16	43,920				50,800	1.15	.33	.28	$0.0082	$0.0497	44.02	2,419.87	$1217.97	491.[illegible]
			...	Claim		Closed													
		March.	...				4 in. to 16 ft.												
		April...	...																
1876	1	May....	...																
	6	June...	5	20	17	23,425				71,810		.14	13			13.70	1,178.30		262.[illegible]
		July ...	...								1.18								
	6	Aug....	5	36	14	37,230						.17				27.64	1,881.52		416.[illegible]
		Sept	...																
		Oct......	3	24	22	27,390				22,050	0.80	.11	.14			16.60	746.93		306.[illegible]
				279	6	207,010				284,932	1.37	$0.23	$0.16	$0.0082	$0 0497	$168 51	$10,442 97	$1,217.97	$2,318.[illegible]

E VI.

IAU CLAIM.

s of Gravel Moved; Cost and Receipts of Hydraulic Washing from October 3, 1876.

			Relative Cost per Cubic Yard.						Bullion Yield.						
	Material.	Grand Total.	Labor.	Blocks & Lumber.	Material.	Water.	Melting and Refining.	Total Cost.	Amalgam. Pounds Avd'ps.	Weight Before Melting, P'nds Avoirdupois.	Fineness Gold.	Fineness Silver.	Value of Gold.	Value of Silver.	Total Amount of Bullion Produced.
16		$830.75	$0.028			$0.004		$0.043	35.00	14.00	.943	.047	$3,958.31	$9.03	$3,967.34
76		1 331.65	.036			.008		.025	41.00	15.75	.944		4,506.97	6.11	4,513.08
06		1,321.29	.034			.007		.052	52.25	19.73	.936	.055	5,497.39	15.49	5,512.88
52	$1471.19	1,639.71	.024		$0.0076	.005		.040	63.75	21.88	.934	.051	6,134.53	19.09	6,153.02
		1,471.19													
01		2,955.80	.047	$0.0042		.009	$0.0005	.067	142.00	52.45	.945	.051	14,585.74	43.65	14,629.39
		1,217.97													
36		1,454.36							31.25	11.90	936	.054	3,273.29	8.88	3,282.17
			.042		.0031	009		.055							
07	304.56	2,326.13							63.0	24.50	.895	.068	6,544.73	20.58	6,565.31
		304.56													
7		1,070.30	.033			.013		.050	31 00	11.25	929	.059	3,147.36	10.58	3,157.94
1	$1 775 75	$15,923.71	$0.036	$0.0042	$0.0062	$0.0 8	$0.0005	$0.055	459 25	171.46			$47,648.32	$133 41	$47,781 73

TABL

THE JOHNS

Tabular Statement Showing Amount of Water Used and Cubic Yard

March 1, 1875, to

Year.	Run Commenced.	Months.	End of Run.	Washings. Days.	Washings. Hours.	Amount of Water used in 24 hours M. I.	Grade of Sluices.	Height of Banks.	Water Pressure.	Cubic Yards Gravel Washed.	Cu. Yds. Gravel Moved per in. of water.	Av'g Yield. Per Inch Water.	Av'g Yield. Per Cubic Yard.	Average Cost. Water per Yard Gravel Moved.	Average Cost. Material, Etc., per Cubic Yd.	Total Cost. Melting and Refining.	Total Cost. Labor.	Total Cost. Blocks & Lumber.	Total Cost. Water.
1875	1	March.																	
	22	April...	21	22	13	18,040						$0.11				$18.26	$1,715.25		$202.05
		May....																	
	3	June...	2	27	5	21,770						.06				7.08	558.24		243.82
	17	July ...	16	33	6	26,604						.07				10.33	667.83		297.97
		Aug....					3½ in. to 16 ft.	20 to 40 feet.	80 feet.	196,632	1.76		$0.04	$0.0063	$0.0286			$582.03	
	10	Sept....	9	24	12	19,600						.07				24.69	494.39		219.52
	10	Oct......	9	11	12	9,200						.06				10.20	250.87		103.04
		Nov....																	
		Dec.....	16	20	2	16,064						.09				9.95	356.50		179.91
				139	2	111,278				196,632	1.76	$0.08	$0.04	$0.0063	$0.0286	$80.51	$4,043.08	$582.03	$1,246.31

TABLE III.

THE SICAR

Tabular Statement Showing Amount of Water Used and Cubic Yard

May 28, 1874, to

Year.	Run Commenced.	Months.	End of Run.	Washings. Days.	Washings. Hours.	Amount of Water used in 24 hours M. I.	Grade of Sluices.	Height of Banks.	Water Pressure.	Cubic Yards Gravel Washed.	Cu. Yds. Gravel Moved per in. of water.	Av'g Yield. Per Inch Water.	Av'g Yield. Per Cubic Yard.	Average Cost. Water per Yard Gravel Moved.	Average Cost. Material, Etc., per Cubic Yd.	Total Cost. Melting and Refining.	Total Cost. Labor.	Total Cost. Blocks & Lumber.	Total Cost. Water.
1874	28	May....																	
		June...																	
	14	July...	3	17	18	17,208				51,667	3.00	$0.41	$0.13			$22.23	$429.12		$192.73
	13	Aug....	12	16	16											4.75	613.25		
		Sept....	24	15	17	7,854				11,515	1.46	.43	.29			31.36	658.75		87.97
	5	Oct......					3½ in. to 16 ft.	20 to 40 feet.	90 feet.					$0.0039	$0.0360			$950.00	
	20	Nov....	18	19	22	9,958				28,640	2.87	.41	.14			7.32	973.62		111.53
		Dec....																	
1875		Jan.....	21	37	10	18,708				63,625	3.39	.29	.08			44.04	1,265.74		209.53
				107	11	53,728				155,347	2.89	$0.37	$0.13	$0.0039	$0.0360	$109.70	$3,940.48	$950.00	$601.75

E VII.

3ON CLAIM.

's of Gravel Moved; Cost and Receipts of Hydraulic Washing from December 16, 1875.

		Relative Cost Per Cubic Yard.						Bullion Yield.						
Material.	Grand Total.	Labor.	Blocks & Lumber.	Material.	Water.	Melting and Refining.	Total Cost.	Amalgam. Pounds Avd'ps.	Weight Before Melting, Pn'ds Avoirdupois.	Fineness Gold.	Fineness Silver.	Value of Gold.	Value of Silver.	Total Amount of Bullion Produced.
....	$1,935.56	....	....	....	....	....	....	20.25	7.20	.935	.052	$2,026.26	$7.30	$2,033.50
....	....	....	....	....	....	....	....	....	....	.....	.....	....	....	....
....	809.14	....	....	....	....	....	....	13.50	5.25	.950	.....	1,447.97	4.75	1,452.72
....	976.13	....	....	....	....	....	....	22.00	7.60	.928	.055	2,092.27	6.54	2,098.71
$1514 06	2,096.09	$0.020	$0.0029	$0.0076	$0.006	$0.0004	$0.037	....	....	.....	.....	....	....	....
....	738.60	....	....	....	....	....	....	13.75	4.97	.951	.047	1,404.14	4.35	1,408.49
....	364.11	....	....	....	....	....	....	5.31	1.98	.941	.052	557.66	2.95	560.61
....	....	....	....	....	....	....	....	....	....	.....	.....	....	....	....
....	546.36	....	....	....	....	....	....	16.00	5.20	.935	.050	1,568.87	5.21	1,594.08
$1.514.06	$7,465.99	$0.020	$0.0029	$0.0076	$0.006	$0.0004	$0.037	90.81	32.20			$9,117.17	$31.10	$9,148.27

E VIII.

RD CLAIM.

ds of Gravel Moved; Cost and Receipts of Hydraulic Washing from January 21, 1875.

		Relative Cost Per Cubic Yard.						Bullion Yield.						
Material.	Grand Total.	Labor.	Blocks & Lumber.	Material.	Water.	Melting and Refining.	Total Cost.	Amalgam. Pounds Avd'ps.	Weight Before Melting, Pn'ds Avoirdupois.	Fineness Gold.	Fineness Silver.	Value of Gold.	Value of Silver.	Total Amount of Bullion Produced.
....	....	....	....	....	....	....	....	....	....	.....	.....	....	....	....
....	....	....	....	....	....	....	....	....	....	.....	.....	....	....	....
....	$1,262 08	$0.020	....	....	$0.003	....	$0.033	32.00	11.75	.943	.047	$3,320.74	$9.00	$3,329.74
....	778.07		....	....		....		36.00	13.50	.940	.....	....	....	3,801.11
....	1,553.47	.057	....	....	.007	....	.074	32.50	12.27	.936	.055	3,413.20	15.51	3,428.71
$603.47	....	....	$0.0061	$0.0038	....	$0.0007	....	....	....	.....	.....	....	....	....
....	1,092.47	.033	....	....	.003	....	.046	43.25	14.85	.934	.051	4,158.40	18.96	4,177.36
....	....	....	....	....	....	....	....	....	....	.....	.....	....	....	....
....	1,519.31	.019	....	....	.003	....	.032	53.00	19.57	.941	.050	5,445.60	14.55	5,460.15
$603.47	$6,205.40	$0.025	$0.0061	$0.0038	$0.004	$0.0007	$0.039	196.75	71.94			$16,337.94	$58.02	$20,197.07

DISBURSEMENTS.

Water,	$17,807 62	Contingent,	$8,125 80
Labor,	82,845 70	Taxes,	1,130 41
Material,*	21,788 85		
Officials,	11,244 94		$186,942 82

Average value of the oz. metal, gold and silver,	$19 29
Total cost per oz. metal produced,	11 38
Distributed as follows:	

Water, per ounce,	$1 43	Contingent,	$0 26
Labor,	6 85	Taxes,	09
Material,	1 81		
Official,	94		$11 38

Total cost of hydraulic washing per cubic yard is,	$0 06
Distributed as follows:	

Water,	$0 008	Official and contingent,	$0 006
Labor,	036		
Material,	010		$0 060

Average yield per cubic yard,	$0 1019
Average amount of gravel washed per inch water, cubic yards,	1.48

The following tabular statement shows the workings of a mine on four per cent. grades, high banks, and with great hydrostatic pressure. The advantages of heavy grades and pressure, over the minimum La Grange grades, are clearly shown by the quantity of material moved, and a comparison of the work and costs will be of interest to those engaged in hydraulic mining. (See Tables IX and X.)

Table IX. No. 8 *Claim, North Bloomfield Gravel Mining Company.*†

Year.	Length of run. Days.	Washings commenced.	Washings ended.	Amount of water used. Mining inches.	Grade of sluices.	Depth of banks.	Cub. yards gravel washed.	Gross yield.‡	Total costs.§	Cub. yards gravel washed per inch of water.	Relative yield. In cents.		Relative cost. In cents.	
											Per inch water.	Per cubic yard.	Water per cub. yard.	Labor, etc., per cubic yard.
1874–5	295	Jan. 1	Oct. 14	386,972	6½ in. to 12 ft.	180 ft.	1,858,000	$74,271.77	$53,088.83	4.80	19.1	4.0	.77	2.07
1875–6	342	Nov. 13	Oct. 18	700,000	"	260 ft.	2,919,700	192,735.73	94,823.75	4.17	27.5	6.6	.74	2.45

* Material account excludes $8807.81 on hand.
† For details see Reports of the North Bloomfield Gravel Mining Company for years 1874–6.
‡ Less cost of melting and refining.
§ Exclusive of costs of melting and refining.

Table X. Statement of Disbursements and Relative Costs per Cubic Yard.

	1874-5	1875-6	1874-5	1875-6
Labor account	$22,790.89	$40,975.85	$0 0122	$0 0140
Blocks and lumber	3,007.26	5,212.62	....	....
Explosives	2,944.94	10,279,73	0 0032	0 0053
Material account	5,663.80	9,249.96	0 0030	0 0031
General expense account	4,201.89	7,364.12	0 0022	0 0025
Water	14,480.40	21,740.97	0 0077	0 0074
	$53,088.82	$94,823.25	$0 0208	$0 0323

1875-6—Gold bullion, ounces,	$10,401.28
Value per ounce, gold and silver,	18 53
Total cost per ounce,	9 08

Distributed as follows:

Labor,	$3 93	General expense,	$0 70
Blocks and lumber,	50	Water,	2 09
Explosives,	98		
Material,	88		$9 08

CONCLUSION.

The question of the yield and costs of working hydraulic claims is one of great interest to the engineer. In estimating the production of gravel mines, the calculation of a given number of cents per cubic yard refers to the entire quantity of gravel moved or to be moved, since it is impracticable to wash out the gold-bearing strata without moving the entire superincumbent mass. The yield is, therefore, apportioned to the total quantity of ground washed.

Having prospected a claim, and ascertained the approximate value of the gravel per cubic yard, grade and quantity of available water being known, its yield can be estimated for a reasonable period.

In discussing the question of working unexplored localities, and even those already developed, it is to be observed that there are no known means which enable one to predetermine accurate economical results.

Therefore, in estimating the yield of gravel properties, even under the best of circumstances, the most careful opinion drawn from immediate facts is, owing to the nature of deposits, necessarily qualified.