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HYDRAULIC MINING IN CALIFORNIA.

HYDRAULIC mining is the modern method of working deep auriferous gravel deposits in California. It is regarded as a California industry,* deriving its origin and growth from the peculiarities of the auriferous placer-formations in the State. Strictly speaking, however, it is simply the perfect development of the earlier form of placer-mining, as illustrated in the cradle or rocker. The rocker is the rudest and simplest of all machines employed for the separation of gold from the gravel through which it is distributed; but it embodies in a small way, nevertheless, all the essential features of the more elaborate machinery used in other forms of placer-mining, the hydraulic method included. The cradle is an oblong box about four feet in length, mounted on a pair of transverse rockers, and furnished with a set of graded sieves laid in tiers, "riffles," amalgamated plates, and blankets for the separation and arrest of the gold in its descent from the hopper into which the auriferous gravel is placed, to the outlet at the lower end. These devices are all present in hydraulic mining, but they are so enlarged as to be almost unrecognizable. Cradling represents a minimum service of water in gold placer-mining, joined to a maximum service of manual labor; the hydraulic method represents the maximum service of water united with the minimum of human exertion. For all that, the cradle is still in use on river bars and other places where an absence of grade makes any other form of washing auriferous gravel impossible. Such diggings, and the cradle with them, have passed almost entirely into the hands of the Chinese.

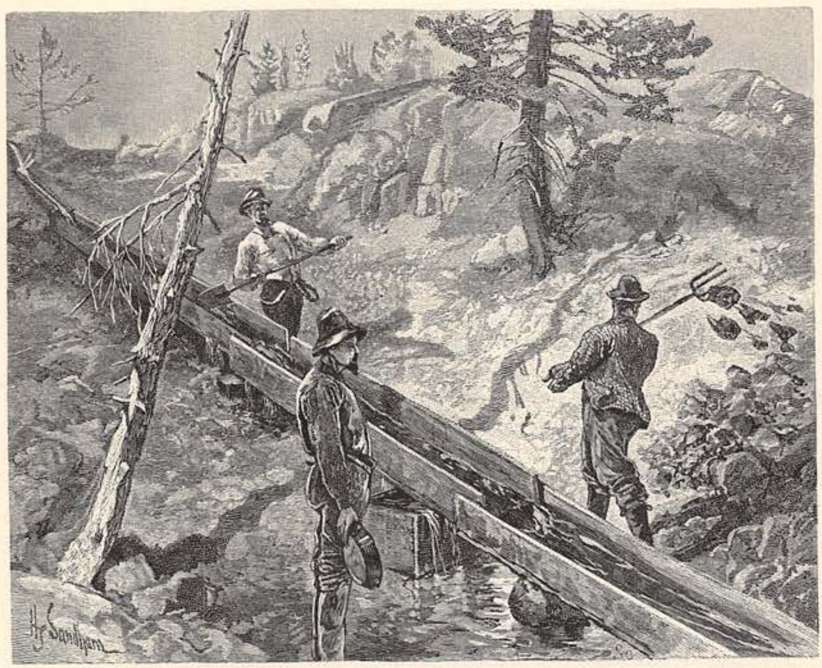
The advancement of placer-mining from the puny cradle to the powerful "monitor" which is now used in hydraulic mines to tear down and wash off the high banks of gold-bearing gravel, was accomplished by easy grades. The various stages of development are represented in the "long tom," "sluicing," and "ground-sluicing." The "long tom" was a box, shaped very much like an open coffin with the foot knocked off, the bottom of which was lined with riffles running parallel with the sides. Into this box the gold-bearing earth was dumped, and a stream of water was turned on at the head, while the "pay dirt" was well stirred with a sluice-fork. The stream of water served a double purpose: it released the gold contained in the dirt, which of its own gravity dropped between the riffles, and it washed off the lighter earth and gravel. The coarser gravel was carefully washed and thrown out with the sluice-fork. The escape of the finer gold at the mouth of the long tom made it necessary to add other long and narrow boxes to the lower end of the long tom, much after the manner of an ordinary flume. Riffles were placed in these boxes also for the purpose of arresting the particles of fine gold as they rolled with the stream. This flume was called the "sluice." The "ground-sluice" consisted of making the bed-rock on which the "pay dirt" rested perform the duty of sluices, the stream of water used for washing away the dirt being constantly trained against the bank. The action of the water was precisely the same as that performed by any stream against its natural banks where they happen to offer resistance to the current. The miner assisted the flowing water by a judicious use of his pick. Where the conditions were favorable, "ground-sluicing" was a great improvement on all other methods, inasmuch as a much larger quantity of "pay

* Pliny (Bohn's translation, Volume VI.) describes a system of hydraulic mines in Spain which resembled, in many respects, the modern method in California.

dirt" was removed with the same amount of water and manual labor.

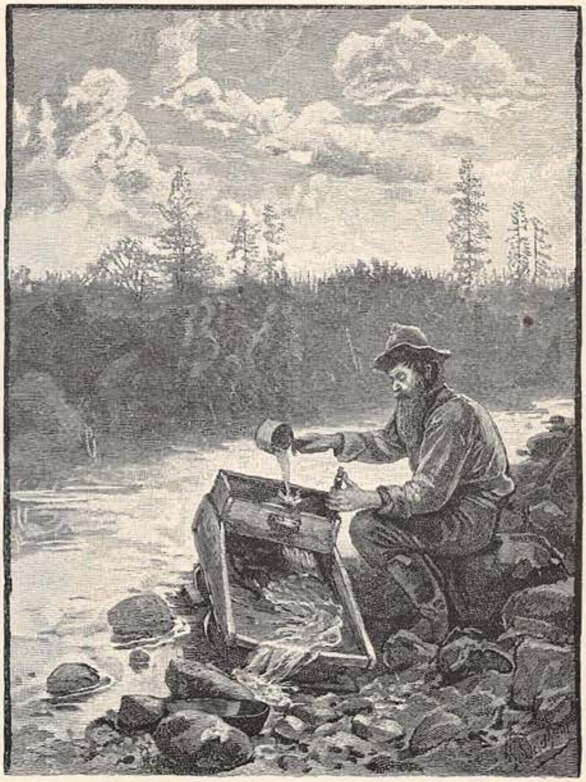
The discovery of gold distributed throughout the deep gravel deposits on the high banks of the cañons of the streams in which gold had before been found, suggested the employment of water under pressure to mine it. This was accomplished by the conveyance of a stream of water, in ditches and flumes, from a convenient source to a point above the gold-bearing gravel-bank to be operated upon. It was then led to the base of the bank in pipes, and discharged against it through a small nozzle. Thus the hydraulic method of placer-mining was brought into use. The best authorities agree in stating that it was introduced about 1856.

In the earlier history of hydraulic mining one hundred miner's inches of water was considered a full head. It is usual to consider a miner's inch as the quantity of water which will pass through an aperture one inch square, under a pressure of about six inches; that is, the stream issues from a box in which the water stands at a constant level of six inches above the upper edge of the aperture. According to different authorities, a miner's inch, flowing steadily for twenty-four hours, is estimated to equal from 2230 to 2274 cubic feet, or 17,000 gallons of water. One hundred miner's inches would thus represent in twenty-four hours 1,700,000 gallons. The hydraulic apparatus consisted of a wooden hopper or cistern, V-shaped, strengthened with cumbersome wooden clamps and suspended on scaffolding in such a position as to receive the discharge from the supply-ditch. To the lower and smaller end of the hopper was attached a hose made of ordinary sail-cloth, and having a diameter of six or eight inches. This hose conveyed the water down the hillside to the workings. The nozzle through which the stream was discharged had an aperture of one or two inches diameter, and was screwed to the end of a tapering copper or brass pipe attached to the hose, resembling very much the pipes used by firemen. The flexibility of the hose enabled the miner to direct the stream to any point on the gravel-bank he desired.



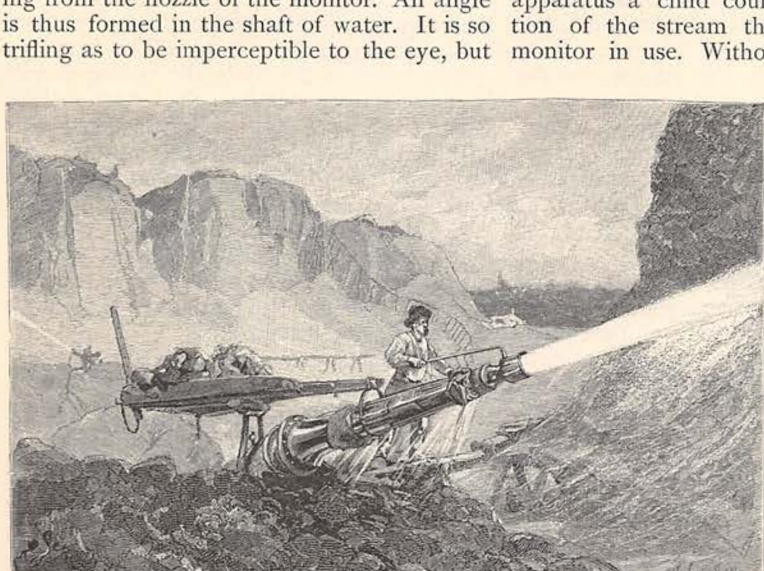
THE SLUICE.

The evolution of hydraulic pipes from sail-cloth, through leather and rubber, to iron, was easy. But the transition of the discharge-pipe to the "monitor" of the present day did not occur for years afterward. Since the employment of iron, the pipes have been gradually enlarged and strengthened, and the volume of water and the pressure have been increased, until now pipes from fifteen to thirty inches in diameter, like the water-mains of a great city, may be seen winding through a hydraulic mine. These pipes terminate in monitors, each discharging a gleaming shaft of water so powerful as to toss about rocks, tons in weight, as if they were mere pebbles. The volume of water supplied to a monitor has increased to one thousand and even fifteen hundred miner's inches, and the pressure ranges from two hundred and fifty to four hundred feet. One thousand miner's inches thus discharged through the nozzle of a monitor is estimated to represent a natural flow of fifteen hundred and seventy cubic feet per minute.



THE CRADLE.

The hydraulic monitor was first used, according to good authority, in 1865. But it was not until a much later date—in 1869 or 1870—that it came into anything like general use. It resembles nothing so much as it does a piece of military or naval ordnance. It is united to the supply-pipe at the breech with a water-tight socket-joint, which is a good substitute for flexibility, as it enables the miner to direct the nozzle in any direction. It is nicely ballasted with a carriage extending backward from the breech and loaded with rocks. It is operated by a very simple and effective arrangement, called a "deflector," and consisting of a sleeve of sheet-iron working on an elbow-joint over the nozzle. To this sleeve is riveted an iron handle four or five feet long, by means of which the "deflector" may be moved so that the lip shall impinge on the column of water emerging from the nozzle of the monitor. An angle is thus formed in the shaft of water. It is so trifling as to be imperceptible to the eye, but it is enough to affect the monitor, which slowly moves in the opposite direction, so as to relieve the friction and straighten the line of discharge. With the aid of this simple apparatus a child could change the direction of the stream thrown by the largest monitor in use. Without the "deflector" it would be a difficult and hazardous undertaking for a half-dozen strong men to attempt the operation.



THE MONITOR.

The deep placers of California extend through seventeen counties lying on the west flank of the Sierra Nevada, and are traceable for three hundred or four hundred miles. Their continuity within well-defined channels, having a grade varying from twenty to three hundred feet per mile, has given rise to the conviction that they constitute the débris of an ancient system of rivers. This auriferous débris consists largely of eroded slate and quartz. The deposit varies in thickness from one hundred to one thousand feet. In many places it is overlaid with a stratum of lava which was undoubtedly emitted by Mt. Shasta and other now extinct volcanoes in its neighborhood, during a period of great volcanic activity which succeeded the geological period when the auriferous gravel deposit was formed. Evidences of this great lava flow are to be found all over Northern California and Oregon. In some of the counties in which the gold-bearing placers exist, the stratum of lava overlying them is so thick that the only way in which they can be worked is by the drift or vein process of mining. Hydraulic mining is confined chiefly to the counties of Nevada, El Dorado, Placer, Yuba, and Butte, where large portions of the lava-sheet is so thin that it offers little or no obstacle to the process. There are also some large hydraulic mines in Plumas, Calaveras, and Stanislaus counties. It is not necessary to discuss the question of the agency which formed the deep gravel deposits,—whether it was ice or water. They may belong to that glacial epoch which John Muir, the California geologist, has so graphically described as having sculptured the Sierra and grooved the Yosemites out of the solid granite.* They probably belong to an epoch when ice and water were more active than now, for there are some things about them which cannot very well be ascribed to either one of these two agents. But, whatever agent formed them, the course of these dead rivers was different from that of the present streams. Deep cañons through which the streams of the present day flow intersect the ancient river-beds in many places. Gaps have, consequently, being formed in the ancient river-channels. The material washed out of these gaps, being reduced and concentrated by the modern streams, formed the source of the gold obtained by "the Argonauts of '49." They also exposed those portions of the channels of the ancient rivers which had not been disturbed since the time of their interment. Nor does the grade of the ancient channels correspond with that of the present streams. Near Marysville, the ancient channel dips into the plain below sea-level; forty miles off—at North Columbia—it stands about one thousand feet above the bed of the Forks of the Yuba, and it ultimately attains an altitude of two thousand feet above the modern channel. An artesian well sunk at Stockton, San Joaquin County, penetrated the same gravel formation at a depth of one thousand feet below the surface. From workings extending over a distance varying from

DISTRIBUTING-RESERVOIR—TURNING ON THE WATER.

one-half mile to four miles in continuous length along these ancient channels, it has been found that they yield from one thousand dollars to two thousand five hundred dollars per lineal foot. Wherever these ancient river-beds are situated on a plain high enough for the purpose, and are comparatively free from lava, there hydraulic mining will be found.

The heart of the hydraulic mining district is in what is popularly called "The Yuba Ridge." "The Ridge" is an elevated spur of the Sierra Nevada thrust into the Sacramento basin through Nevada and Yuba counties. It lies chiefly within the boundaries of Nevada County. Incidentally it may be noted that "The Ridge" is a section of special interest, for it was along its summit that the overland emigration of Argonauts entered the Sacramento Valley. The old emigrant trail enters the State and "The Ridge" at Emigrant Gap,—a locality on the line of the Central Pacific railroad familiar to those who have traveled overland to or from California, and near the head-waters of the South Yuba and Bear rivers. The old trail may be traced along the summit of "The Ridge" at the present time. Even the trees around which the overland emigrants slipped their ropes in letting their loaded wagons down the steep grades are still standing. The main

* See "The Glacier Meadows of the Sierra," in this magazine for February, 1879.

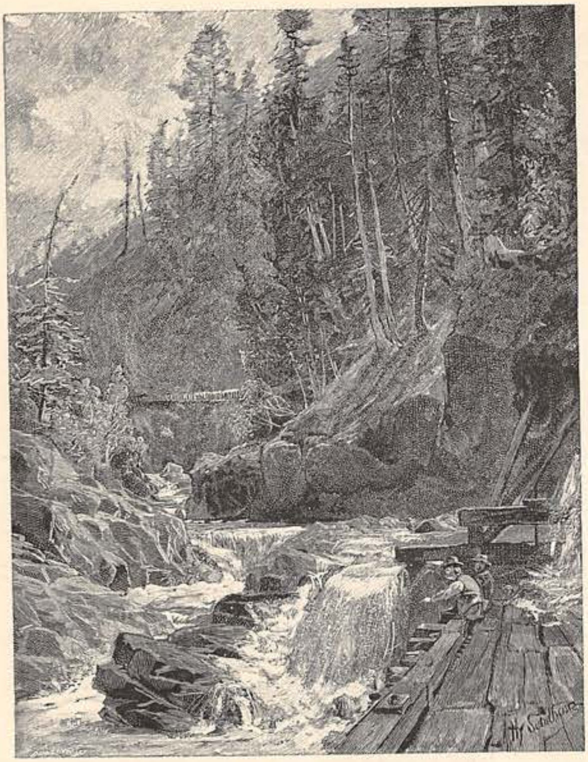
arteries of the ancient river system coursed along "The Ridge." At present the three branches of Yuba River, known respectively as North Fork, Middle Fork, and South Fork, drain "The Ridge." In whatever direction the eye is turned, when on "The Ridge," evidences of the presence of the hydraulic miner are presented, either in the form of a desolate waste of tailings, mammoth excavations in the flanks of the pine-clad and round-topped hills, or in the lines of ditches and flumes winding along the summit of the range or clinging from the precipitous sides of the cañons and conveying water from far-off mountain-reservoirs to the mines.

A hydraulic mine is simply an open cut of huge dimensions excavated in the deep gravel deposits. Sometimes this is accomplished without difficulty from the side of the cañon forming the bed of the modern stream, or through the agency of a conveniently situated ravine. But, in many cases, the rim-rock of the ancient river-bed intervenes between the auriferous deposit and the cañon which the hydraulic miner desires to use as a "dump" or depository for the "tailings" or débris of his sluices. To reach the deepest place in the dead river-channel, long tunnels are frequently necessary. The North Bloomfield Mining Company, for instance, in one part of the claim, had to bore a tunnel eight thousand feet in length before the bottom of the auriferous gravel deposit was drained, and a branch tunnel nine hundred feet farther before another part of the company's ground was so drained that it could be effectively worked by the hydraulic process. The original tunnel and its three air-shafts cost the company two million dollars; the branch tunnel was proportionately costly. All the water used in the mine, and all the material removed, passes through this tunnel into the cañon of the South Fork of the Yuba. Such a hydraulic mine looks like an enormous basin hollowed out of the mountain side. Many of the principal hydraulic mines on "The Yuba Ridge" are of this order.

The character of the gravel formation is shown to great advantage in a hydraulic mine. The upper stratum, for a depth of one hundred feet or so, is loose and friable, and of a rusty color, which is caused, no doubt, by the oxidation of iron pyrites, of which the lower stratification is full. The process of oxidation is no doubt facilitated by the percolation of surface-water through the gravel. The lower stratum of gravel is denser, well cemented, coarser, and of a bluish color. Owing to this latter feature, it is called by miners "blue gravel," and, because of the greater proportion of gold found in it, the term "pay dirt" is also applied to it. Occasionally a stratum of pipe-clay will intrude between the upper and lower strata of gravel, and a layer of gravel varying in thickness almost invariably overlies everything. The gravel deposit is rich in vegetable fossils and curious petrifactions. Trunks of sugar-pine, manzanita, and other forest-trees and shrubbery, converted into solid stone, are abundant. Fossil leaves and ferns are plentiful in the pipe-clay, and the foot-prints of birds are numerous in the same formation. Here, then, are evidences of vegetable growth during the formation of these deep placers, which is identical with, and quite as rank as, that which now exists. Who shall interpret the testimony of the deep placers of California? The great openings formed in them by the hydraulic miner furnish the enterprising and intelligent geologist a rare opportunity, which, thus far, has been almost entirely neglected. The only attempt worthy of mention is that of Professor J. D. Whitney's monograph of the deep placers of California, published at Cambridge, Mass. One thing is, however, certain: It was after the great lava flow which overran the State of Oregon and Northern California that the present water-courses were carved out, not only carrying off, in the course of erosion, the lava-cap and gravel deposits, but also grinding down the country rock, in some places, two thousand feet deeper than the beds of the dead rivers.

CLEARING UP A TUNNEL.

The mode of working a hydraulic mine is very simple. From the distributing-reservoir

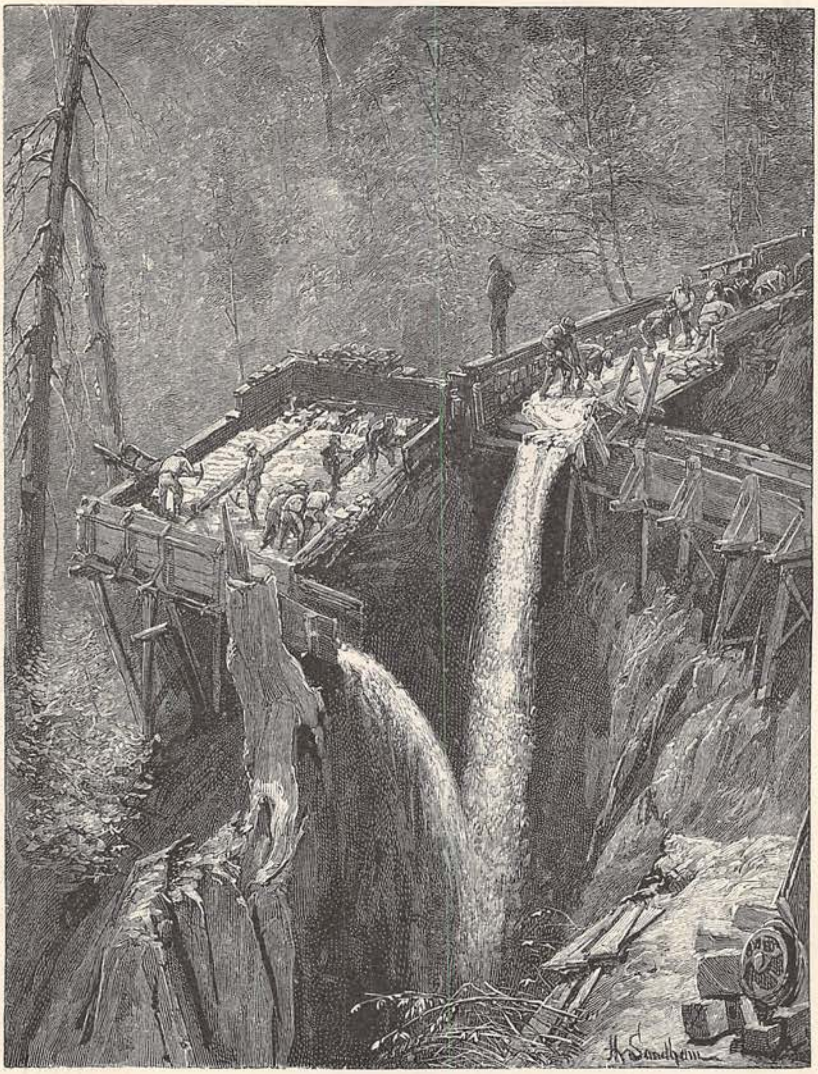


HEAD OF FLUME.

to supply blocks for riffling. In the spaces between the bowlder and block pavements the gold finds a lodgment.

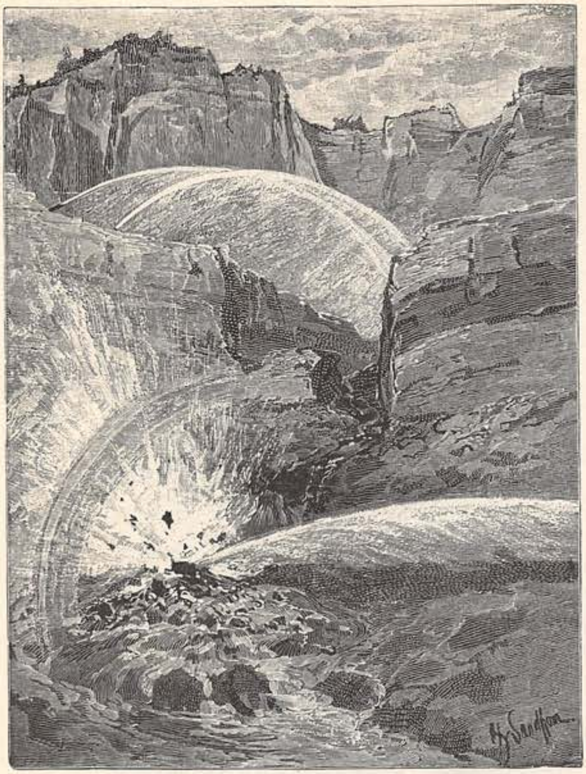
The under-currents are a very useful and ingenious device to utilize the immense fall between the mouth of the tunnel and the bottom of the cañon into which the tailings are dumped. Without them miles of sluices would have to be constructed and maintained at great expense, and the separation of the gold from the gravel would even then scarcely be as thorough. The under-currents are a system of zigzag sluices placed underneath one another, at distances of forty or fifty feet apart. The under-current may be briefly described as follows: The sluice emerging from the tunnel is run out on scaffolding a few feet over the steep side of the cañon. At the end of the sluice, and forming a part of the bottom thereof, is a large and strong iron grating, called the "grizzly," over which the greater part of the water and the coarser débris are projected by their own momentum, falling a sheer distance of forty or fifty feet, where they are taken up and carried forward by another similar set of sluices, to be again discharged in the same way. Through the grating, or grizzly, at the end of each of these sluices, the gold which has traveled thus far, the finer gravel, and a small volume of water drop on to a broad table placed underneath and riffled with blocks. Over this broad table the light material and gold are carried at a greatly reduced speed. The gold drops of its own gravity into the spaces between the blocks, which have been charged with quicksilver, while the water passes off and joins the main stream at the foot of the falls, carrying with it the fine débris. Six or seven of these under-currents suffice to separate the gold thoroughly from the gravel, and the lower under-current in the chain barely pays the cost of maintaining it. One man is constantly employed watching the under-currents and keeping the dump clear at the foot. A jam, which sometimes occurs through the stoppage of tree-stumps or large bowlders, turns the stream, freighted with its precious burden, on a wayward course. The watchman must, consequently, be vigilant, active, brave, and energetic. He is usually a broad-shouldered giant, with a quick eye, sinews of steel, and plenty of nerve. He is armed with a rifle, to shoot down any thief that may attempt to rob the sluices. The sluice-

—a large artificial lake in the vicinity of the mine, but situated at a much higher elevation —the water is conveyed in ditches and large iron pipes, fifteen, twenty-two, or thirty inches, in diameter, to the monitors. The gravel removed by the stream is led through the ground-sluices into the deep open cuts that have been excavated with powder and pick in the solid bed-rock. These open cuts are from fifteen to forty feet (and sometimes even more) in depth, and from four to six feet in width. They discharge into the tunnel excavated through the rim-rock, and the débris is then delivered to a system of sluices and "under-currents," by which it is expelled at "the dump." Great care is taken to prevent the escape of the gold with the outpouring flood and débris. The tunnels and open cuts are paved with heavy bowlders or heavy blocks of wood, which pavement has to be frequently renewed, owing to the enormous attrition to which it is subjected. The sluices and under-currents are paved with wooden blocks a foot thick and eighteen or twenty inches in diameter, the end of the fiber of which is presented to the action of the flowing water and débris. Every few weeks these blocks are so far worn that new ones have to be substituted. The forest-timber growing on the surface of a hydraulic mine is, consequently, rapidly destroyed robber usually is a Chinaman. His latest method of sluice-robbing is to supply himself with a silver knife, and when an opportunity is presented by the watchman turning his back for a few minutes, to thrust the blade of the knife between the riffles of the under-current. Quicksilver having an affinity for silver, the blade comes up covered with auriferous amalgam. A sentry-box on the brow of the hill is the watchman's tower. From it he commands an unobstructed view of every foot of the under-currents, and of the tail-dump down to the river below. Woe betide the sluice-robber he may detect pursuing the nefarious calling!



CLEARING UP UNDER-CURRENTS.

Each monitor in a hydraulic mine is worked by one man. He has been selected for his superior skill in the management of the machine, and the excellence of his judgment in the use of water. He is known as the "pipeman," and is, next to the foreman or superintendent, the most important man in the mine. A competent pipeman will work off twice as much gravel as an ordinary miner can do with the same machine in a given time. In the pipeman's hands the monitor is always engaged in the most effective work, and the sluices are kept full to the brim with moving material. Immense blasts of powder have previously loosened the bank so that it dissolves with great rapidity under the influence of the streams of



MONITORS AT WORK ON TERRACES.

run from thirty-five thousand to fifty thousand dollars per annum. On the top of the embankment, and commanding a good view of the face of the workings, watchmen are stationed in large wooden boxes, to signal the workmen below that there is danger from sliding banks. The distributing reservoirs and the mine are connected by telephone, and a telephone or telegraph line also connects the distributing reservoir with the head of the supply-ditch and main reservoir, forty or fifty, or even one hundred miles away.

Hydraulic mining has given birth to an extensive system of artificial reservoirs in the Sierra for the storage of water, and to the construction of artificial water-courses to convey the water thus stored to the scene of mining operations. Were it not for these reservoirs, the hydraulic miner would be able to work only a small-portion of the year. The natural streams fail in the early part of July, and they continue low until the melting of the snow in the following spring. With the artificial reservoirs built by the hydraulic miner in the high Sierra, he is able to continue his work almost the year round, except when frost seals up his ditches. The visitor finds difficulty in believing that the white shaft of water which he sees emerge from the muzzle of the monitor at work has been carried along precipitous cliffs, over deep gorges, and along the flanks of Sierra spurs, a distance of fifty or more miles, and that the source is an artificial lake created by the miner's means and industry in some high Sierra valley, possibly at an elevation of six or eight thousand feet above sea-level. The canals carrying the water have a grade of from four to twenty feet per mile, and carry a volume of two thousand to four thousand miner's inches.

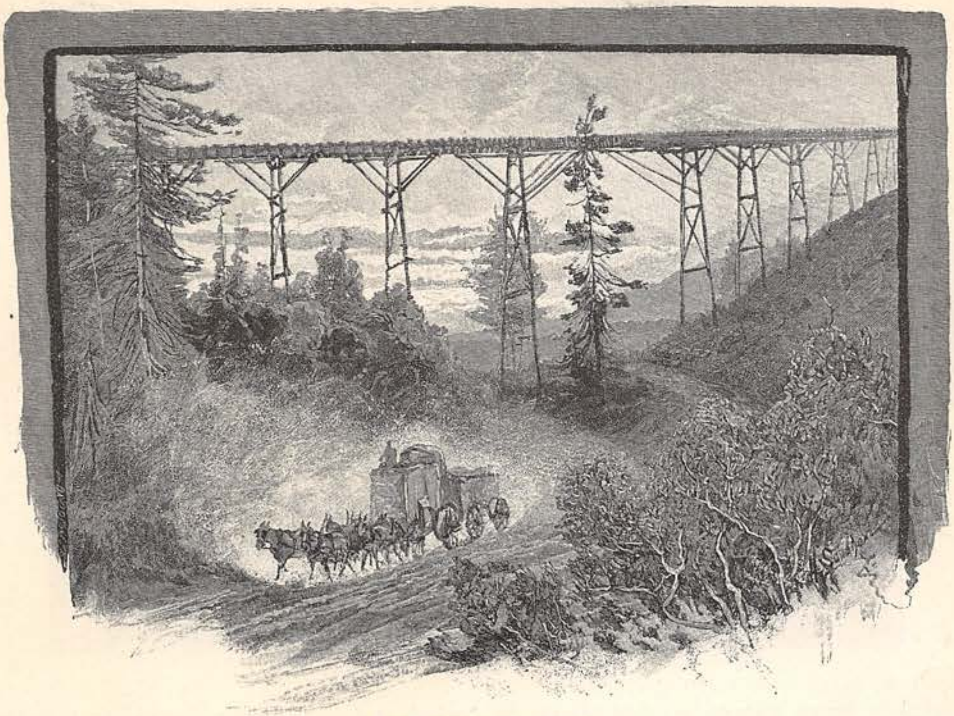
The hydraulic mining-ditches are wonderful specimens of engineering skill. In many places it is impossible to find room along the precipitous sides of the great cañons, for miles, to excavate a canal or rest a flume. In such places the flumes are literally hung to the cliffs. The Miocene Mine has a flume carrying three thousand miner's inches of water, suspended by iron slings and brackets from the face of the perpendicular cliff. The Blue Tent Mining Company's ditch, which carries just as great a volume of water, runs a distance of six miles along the face of a cliff over which the surveyors had to be sus-

of water thrown upon it by the monitors. In the preparation of these blasts a narrow and low drift or passage-way, one hundred feet in length, is run into the bank along the bed-rock at its base. At the inner end of this drift a cross-drift of equal length is excavated. When ready to receive the charge of powder, these underground workings are in the form of the letter T, with chambers at the extremities of the cross-drifts. Kegs of black powder, are then packed in by the ton,—as much as thirty-five tons forming one charge. Telegraph wires connect the mine with an electric battery stationed at a safe distance. After the outer drift has been securely closed up, the mine is sprung, and a bank, containing half a million tons or more of gravel, is lifted and loosened as if by a mighty convulsion of nature. Masses of rock too large to pass through the sluices and under-currents (and the blue gravel is full of them) are also broken up by charges of powder. Sometimes masses of cemented gravel, not affected by the main blast, have to be broken up in a similar manner. Drift-miners are, consequently, constantly at work in a hydraulic mine, and powder forms a considerable item in the current expenses. The powder bills of some hydraulic mining companies

MONITOR AT WORK ON BED-ROCK.

pended by ropes a thousand feet above the bottom of the gorge, to establish the line of the flume. In other places deep gorges are crossed by means of inverted syphons. The Spring Valley Company's Cherokee ditch crosses the cañon of one of the branches of the Feather River in this way. The pipe sustains a columnar pressure equal to eight hundred feet in perpendicular height, and twelve thousand feet of thirty-inch iron pipe, three-eighths of an inch in thickness, is used in making the crossing. This is an engineering feat without its parallel in the world. Before it was undertaken, the most eminent English and French engineers pronounced it impracticable, considering the cost of construction. It is estimated that there are six thousand miles of mining-ditches in the State, which have cost a total of $15,000,000. Some of them have been built at an expense of $25,000 per mile. The canals of the South Yuba Canal Company are one hundred and fifty miles in length, and cost over $1,700,000. Twenty-four and one-half miles of the El Dorado and Deep Gravel Mining Company's ditch cost nearly $700,000. Mining-ditches cost, to keep in order, from three to three and one-half cents per inch of water. The expense is due to land and snow slides, falling trees, lodgment of snow, frost, and the employment of watchmen and gate-tenders. The hydraulic miner has to maintain a ceaseless contest with the elements,—frost and flood, ice, snow, wind, and rain. It is estimated that at least $100,000,000 is represented in the capital stock of hydraulic mining property in Cali-

AN AVALANCHE OF SNOW DESTROYING A FLUME.



FLUME CROSSING A VALLEY.

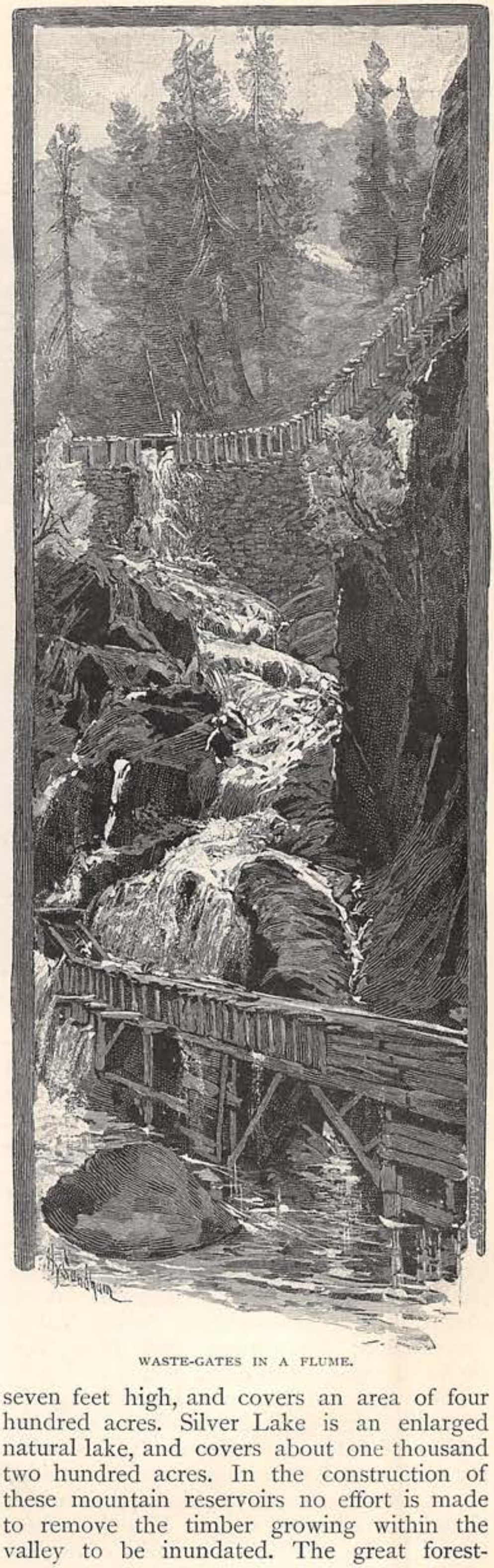
fornia, a large portion of which has been expended in the construction of tunnels, ditches, flumes, and reservoirs. The hydraulic miner's ditches and flumes are, of course,

FLUMES PASSING AROUND CAPE HORN.

employed in diverting the streams from their natural channels. In older countries, where law and custom establish what is known as riparian rights, such a diversion would be impossible. The location and other peculiarities pertaining to the working of the deep gravel deposits of California made it necessary so to divert the streams. What was at first the custom, was subsequently recognized by the law, special acts of the legislature being passed granting the hydraulic mining companies water-privileges unknown in other countries.

After heavy snow-storms, the flumes are choked and often destroyed by the snow-slides. The miners and ditch-tenders are sent along the flumes to keep the snow moving along with the water; but this is necessarily a work of considerable danger, as the snow gathers in enormous quantities upon the mountain sides, causing avalanches that sweep all before them, often destroying in an instant hundreds of feet of the flume. In case of an accident of this kind, the first waste-gate above the break is opened, and the water is allowed to run off till the gate at the head of the flume can be shut. Owing to the watchfulness of the flume-tenders, fatal accidents seldom occur, but uncomfortably narrow escapes are very common. The ditch-tenders are stationed every five or six miles along the flume, and are always on duty. They have a large float in the ditch, to which a rope is attached. The rope passes through a pulley and into the small station-house, where it supports a shelf, upon which are placed all the tinware and iron pots. In case of a break in the night, the float drops, and so does all the tinware, awakening the attendant, who runs out, opens the waste-gate, and then proceeds along the ditch to the next station or the place of accident.

The construction of a hydraulic mine reservoir is no mean undertaking. It involves a vast amount of labor and expense. Suitable valleys are selected for the purpose, near the summit of the Sierra, and almost within the line of perpetual snow. Such valleys are abundant. Huge dams of solid masonry are built across the gorges at the mouths of the valleys selected. The melting snows on the surrounding water-shed supply such a reservoir with water. Water which would otherwise escape into the beds of the natural streams, and be carried off with the spring floods materially increasing them, is thus stored until the natural streams have dried up, or run down so low that they are no longer of any service to the hydraulic miner. The Fordyce reservoir is the largest artificial lake in the Sierra. The dam is ninety feet at the base, which lies on the solid granite; it is seventy feet high and is six feet thick at the top. The inner slope has a rise of one in one, and the outer slope has a rise of five in one. Both slopes are made of dressed granite blocks carefully laid. On the inner slope stringers twelve inches by twelve inches are laid close together, and then covered with three-inch planking. The whole structure is bolted firmly together, and to the rock on which its foundation stands. Every precaution which the best hydraulic engineering skill can suggest is thus employed to make these mining-reservoirs permanently secure. Each dam is equipped with suitable weirs for the escape of overflow, with sluice-gates, etc. The Bowman or Big Cañon reservoir is, next to the Fordyce, the largest of these artificial mining lakes. It covers a mountain valley five thousand four hundred and fifty feet above sea-level, of an area of five hundred and thirty acres, formerly owned by a man named Bowman. Mr. Bowman was also the keeper of an overland stage station situated in the center of the valley. At present a few feet of the tall flag-staff of this stage station sticks out of the water. This reservoir was formed by the construction of just such a dam as has been described, only it is ninety-six feet high. English Reservoir, belonging to the Milton Company, has a dam eighty-

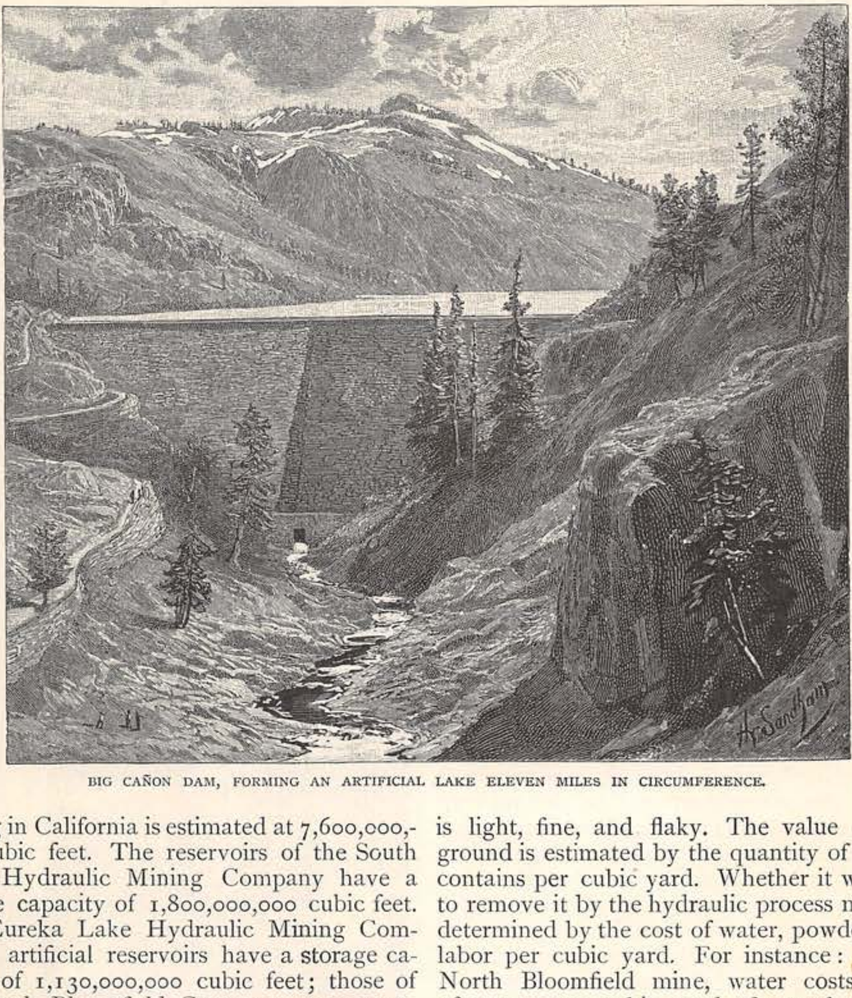


WASTE-GATES IN A FLUME.

seven feet high, and covers an area of four hundred acres. Silver Lake is an enlarged natural lake, and covers about one thousand two hundred acres. In the construction of these mountain reservoirs no effort is made to remove the timber growing within the valley to be inundated. The great forest-trees are left standing, and when the waters rise well up to their upper branches they soon wither and die. It is a curious sight to see this dead timber rising out of the clear water.

The storage capacity of artificial reservoirs constructed by those engaged in hydraulic mining in California is estimated at 7,600,000,000 cubic feet. The reservoirs of the South Yuba Hydraulic Mining Company have a storage capacity of 1,800,000,000 cubic feet. The Eureka Lake Hydraulic Mining Company's artificial reservoirs have a storage capacity of 1,130,000,000 cubic feet; those of the North Bloomfield Company, 1,050,000,000; the El Dorado and Deep Gravel Mining Company, 1,070,000,000; the Milton Company, 650,000,000; the California Water Company, 600,000,000; the Spring Valley, 300,000,000; the Omega and Blue Tent (united), 300,000,000 cubic feet.

The value and success of the working of a hydraulic mine depends principally upon the volume of water at command. It is astonishing what a small percentage of gold contained in a gravel-bank will yield a profit where abundance of water can be brought to bear upon it. The greater the quantity of auriferous earth that can be washed off within a given time, the smaller is the percentage of gold necessary to make it pay. As a rule, the gold is distributed through the deep gravel deposit. The coarser and larger quantity of gold is found on or near the bed-rock in the blue stratum. The gold found in the top dirt is light, fine, and flaky. The value of the ground is estimated by the quantity of gold it contains per cubic yard. Whether it will pay to remove it by the hydraulic process must be determined by the cost of water, powder, and labor per cubic yard. For instance: In the North Bloomfield mine, water costs .0755 of a cent per cubic yard of gravel moved, and labor two and one-fourth cents, making a total expense of three cents to remove each cubic yard of gravel. Consequently, it will pay to wash off all gravel containing upward of three cents' worth of gold per cubic yard. An average of the yield of six prominent hydraulic mines during two seasons' work shows only seven and one-fourth cents per cubic yard. But, when it is understood that a twenty-four-hours miner's inch of water—that is, a stream of one miner's inch discharged uninterruptedly during the twenty-four hours by the monitor—is estimated to remove from



BIG CAÑON DAM, FORMING AN ARTIFICIAL LAKE ELEVEN MILES IN CIRCUMFERENCE.

two to four and one-half cubic yards of auriferous gravel, according to locality, and that the monitors may be discharging an aggregate volume of 6,000 miner's inches,—equal to 102,000,000 gallons in twenty-four hours, a larger volume than is needed to supply the wants of the city of London,—the significance of this small average yield per cubic yard will be fully appreciated. For instance, on Auburn Ravine and Rossville Creek, where the volume of water is not large and the gravel deposits are shallow, the minimum service of two cubic yards per miner's inch is obtained; on Bear River, the average is three cubic yards, and, on the American River, four and one-half cubic yards. Computing by the water used, Blue Tent mine yielded from sixty to eighty-seven cents per inch.

Illustrating the wonderful power and execution of water employed against the deep gravel deposits through the hydraulic monitors, it is only necessary to refer to what was actually accomplished in the Miocene mine, near Oroville. In a period of forty days, the monitors in this mine projecting streams aggregating 3,000 miner's inches, removed 300,000 cubic yards of earth, which yielded one thousand dollars per day, or thirteen and one-third cents per cubic yard. The quantity of gravel washed off in a season in a hydraulic mine is measured by acres, and by so many millions of cubic yards. State Engineer William Hammond Hall estimates that, on streams draining into the Sacramento basin, 15,122,000 twenty-four-hours miner's inches of water is used in hydraulic mining, and that 53,404,000 cubic yards of material is washed off by it into the cañons, 22,326,500 cubic yards being dumped into the Yuba and its tributaries—namely, the streams draining "The Ridge." Thus, the degradation of the placer-formations of the mountains, which would take nature ages to accomplish by ordinary agents, is being consummated with great rapidity by the hydraulic miner in his pursuit for the precious metal.

The number of men employed in a hydraulic mine using, say, one thousand miner's inches of water, is from twenty-five to thirty. Chinese laborers are employed in the least important work, in drudgery which it would be difficult to get competent white labor to perform. It is estimated that at least twenty thousand men are employed in hydraulic mining. The last census shows a population of 127,858 in the counties where mining is the chief industry. Some of the most beautiful and most flourishing mining towns are situated in the hydraulic mining districts. Nevada, San Juan, and Smartsville are towns of considerable population, and rely mostly, or exclusively, for their existence, on hydraulic mining. Of course, most of the buildings in these mining towns are not of a permanent character. In some of them mining operations have compelled a removal of an entire town to a new site. But the hydraulic miner, nevertheless, makes his habitation as comfortable and beautiful as his time and his means will permit. It is no uncommon thing to find the miner's cottage embowered in roses and surrounded by a productive orchard bearing choice fruits.

Most of the hydraulic mines are owned by persons resident in the State. The gold product of California, from the discovery of the precious metal by James W. Marshall, in the tail-race of Sutter's Mill, January 19, 1848, to June 30, 1881, amounted to $1,170,000,000. Of this sum $900,000,000 is estimated to have been extracted from the auriferous placers. The remainder represents the yield of gold-quartz mines, of which the State contains many. The yearly product of gold in California is from $15,000,000 to $20,000,000. From the date of discovery to 1861 inclusive, the gold product of California aggregated $700,000,000, derived chiefly from the modern river-beds and shallow placers. A large proportion of the remaining $200,000,000 has been obtained in the deep gravel deposits, by the hydraulic method. Strange as it may appear, an industry which has contributed so largely to the wealth of the world, and has been the means of the settlement and development of California, has reached a period in its history when it is claimed by a large portion of the community to be a greater evil than blessing, and the question of suppressing the hydraulic method of gold-mining has been the subject of earnest discussion in and out of the halls of legislation. The law has been invoked to suppress or control it. Even the State, through its Attorney-General, has commenced a suit to suppress it. The trouble grows out of the immense amount of débris which the hydraulic miners are discharging constantly into the water-courses of the State. That trouble would finally arise from the great volume of hydraulic mining débris has been apparent for years. The hydraulic miners themselves early saw the impending trouble. Several years ago, when a suit was commenced by a Bear River farmer, named Keyes, against a hydraulic mining company, they prepared to defend their vested rights by organizing what is known as the Hydraulic Miners' Association. Every company in and out of the association fortified its position by securing all needful water-privileges under the State laws, and a United States patent to the land. The diversion of water from its natural courses was included in these privileges. In most cases patents have been issued to these hydraulic mining companies, the miners paying the Government for hydraulic deposits double

A MINER'S HOME.

the price of agricultural land. So long as the agricultural products of the State did not exceed home needs, and the damage caused by the down-pouring of mining débris was confined to the filling up of the foot-hill cañon and the destruction of an occasional orchard or small farm adjacent to the mining districts, it received only a passing notice. It was not until the great tributaries of the Upper Sacramento River began to fill with débris so that their beds were unable, during the flood season, to carry the waters which poured down from the Sierra, that the valley men became alarmed. About the same time complaints of the shoaling of the navigable waters of the Sacramento River became common. It led to a unanimous cry from the men of the valley against the men of the mountains. The inundation of the Sacramento Valley, in the spring of 1878, brought matters to a crisis. A Farmers' Association was organized for the purpose of self-protection against the hydraulic miners and as a counter institution to the Hydraulic Miners' Association. The city of Marysville, situated at the confluence of the Feather and Yuba rivers (and which, notwithstanding a costly system of levees, was threatened with inundations, owing to the filling of the beds of the stream) also rose against the miners, and resort was had to the courts. It is a somewhat singular fact, in this bitter controversy between miners and farmers, that circumstances should have compelled Marysville to side against the very industry which created it.

A survey of the Sacramento Valley, made by the State Engineer in 1878–79, showed that there are 1,742 square miles in it subject to overflow. This territory comprises some of the best wheat-land in the State. A large portion of the million tons and upward of wheat which the State exports each year is grown within this region. Some of the most important towns and cities in the interior of the State are located within the inundatable district, among them Sacramento, the capital. Levees are required to protect these towns from the rising waters, and levees have also been built on a costly and extensive scale, to protect the inundatable land which is under cultivation. But, on various occasions, the floods have overtopped them.

There is some difference of opinion concerning the area of land damaged or buried, and the value of the property destroyed. A committee on "medical topography, meteorology, endemics and epidemics" of the State Medical Society of California, has made the subject a matter of special study and investigation. The chairman of that committee, Dr. M. M. Chipman, of San Francisco, visited the district invaded by the miners' "slickens," and in his report to the society he says: "slickens" has destroyed "40,050 acres of the richest and most valuable fruit and garden land in the State * * * and 270,991 acres of other valuable lands have sustained great damage and depreciation of value." He estimates the value of the aggregate loss at $15,944,739. The State Engineer, on the other hand, has placed the damage from mining débris much below Dr. Chipman's figures. He estimates the total area damaged at 43,546 acres, and the total depreciation in value at $2,597,635.

Great floods are among the periodical natural phenomena of California rivers. The filling-up of the beds of the streams with débris increases their tendency to overflow. The denudation of forest-land in the mountains has also increased the rapidity of their drainage. The sources of this débris are numerous. Agriculture, the construction of roads, the cutting of timber, the disturbance of the surface-soil by live stock, and the degradation by the elements of the volcanic conglomerate which figures largely in the geological formation at the head-waters of some of the principal northern streams, form some of the sources of this débris. But the chief source is mining, and more particularly hydraulic mining. Quartz and drift mining are not unimportant elements in it. At least ten thousand tons of pulverized matter finds its way each day into the beds of the streams from this source. It is the lighter soils of the hydraulic mines and the pulverized matter from the quartz-mills of the mining region which constitute "slickens."

The specific gravity of slickens, as determined by M. Hanks, is 2½. After the floods subside, the slimy sediment which has been deposited drains off and hardens, resolving itself into a creamy-colored substance, yielding no vegetation, where lying in large quantities, except willows; a flake of dry slickens looks very much like brick-dust, such as is used by every housewife for burnishing cutlery, etc. The bottom-lands of the Feather, Yuba, Bear, and American rivers have received an enormous deposit of slickens and coarser débris, which is in many places several feet in thickness. A scene of desolation is thus presented to the eye. Slickens has invaded every nook and corner. It blinds one to look at it. It fills the air and stifles the nostrils in moving through it. It has converted clear and high-banked streams of former days into sluggish, turbid, and erratic water-courses, flowing on elevated beds between artificial banks. Land formerly luxuriant with growing crops is barren as Sahara. The first remedy suggested was the enlargement of the drainage capacity of the Sacramento River, by the construction of a canal from a point north of Sacramento to the head of Suisun Bay. It was expected that the city of Sacramento and the river islands would be saved from inundation by this means. As a matter of fact, the river islands have been under water since 1879, despite an improved system of levees. The canal project was abandoned partly on account of the estimated expense, but more particularly because its failure was almost certain, as the scouring action of the river would be reduced in proportion to the volume of its water diverted into the canal. The next proposition was to impound the débris in the river-cañons, and thus prevent its flow into the valley. Some of the ablest engineers in the country have declared the feasibility of such an undertaking. The plan contemplates the construction of dams of rip-rap at suitable localities (of which there are plenty in the cañons), which shall arrest the downward progress of the heavy débris. For the impounding or storage of débris in the cañons of the Yuba and its tributaries, it was estimated that dams of a capacity of 530,000,000 cubic yards could be constructed at a cost of $2,453,779. These storage-dams, it is argued by the State Engineer, in a report which he made to the Legislature, would retain the heavier débris of thirty-two years' hydraulic mining on the same ratio as he represents it is now being carried on,—namely, the removal of 22,326,500 cubic yards of gravel per annum,—which would represent the removal of a grand total of 755,000,000 cubic yards. To provide similar impounding dams for the Feather, Bear, and American rivers, State Engineer Hall estimated that the total expense would amount to $7,000,000. Whether these figures are delusive or not, they had the charming feature about them of leading a great many people to believe that agricultural land worth many times the total cost of these dams might be saved through their construction, and that hydraulic mining, which yields annually double the amount, need not be stopped. But the Legislature hesitated to authorize the undertaking. At this juncture, Captain Eads, of Mississippi jetty fame, was called in as a consulting engineer, and it was afterward determined to construct a brush dam at the mouth of the Yuba, and another of the same material at the mouth of Bear River. These dams were built on the same plan as the jetties built by Captain Eads, to deepen the South Pass of the Mississippi. The Yuba dam was 8,700 feet in length. The Bear dam was somewhat shorter. Half a million dollars of the State's money was spent in the construction of them, and with the first rising of the waters seventeen hundred feet of the Yuba dam was undermined and washed out. Wide gaps were also broken in the Bear River dam.

What the flood spared of Yuba River dam was destroyed by fire during the following summer. A great plain of slickens lies above each of these brush dams, ready for coming floods to sweep into the doomed valleys and towns below.

The failure of the brush dams to fufill their intended mission was followed by a decision declaring against the constitutionality of the tax levied to build and maintain them. This was the signal for a renewal of hostilities. The mines were enjoined, and for many weeks many of them remained closed. The hydraulic mining companies estimate their losses through these distressing legal restraints at over $1,000,000.

It is impossible to tell what will be the outcome of the controversy which has grown out of the peculiarities of the drainage of the Great Valley of California and the disposition of the débris of gold-mining. It involves the right of one person so to manage his property as to damage and destroy that of his neighbor. It involves the right of one or more of the industrial classes to say that an industry which was originated under and has been fostered by the laws of the State and the nation, shall no longer exist. It involves the right of the State to interfere with the operations of an individual or corporation in the prosecution of a calling lawfully carried on under rights and privileges derived from the Federal Government, as well as from the Commonwealth of California, and holding the letters-patent of the United States to the land to do with it just that which is being done; in other words, "States' rights under a new form." It also involves the maintenance of the navigable waters of the State; the support of a large and industrious population in the valleys and in the mountains; questions of drainage, of influence on climate through the denudation of the forest land of the Sierra for mining and other purposes; and it may involve the question of public health, so far as it relates to the valley towns and settlements. It may likewise involve the construction of great and costly works by the nation to impound the moving débris, and to keep open the bays and streams to navigation. The question thus assumes a national aspect. It is brought home to the nation when California's representatives introduce bills in the National Congress to meet the exigencies of the case. In the meantime, some of the hydraulic mining companies in Sierra County have made the best of the situation by building dams across the cañons into which their débris is discharged, to impound it. It is making a virtue of necessity; but it may also be construed as an acknowledgment of the principle that the mines must take care of their own "tailings."

It is not reasonable to presume that hydraulic mining will cease. The great gravel deposits will furnish at least a half-century's vitality to the industry, and they contain, it is estimated from what has been worked already, not less than $6,000,000,000 in gold. It is not likely that an industry which gives a large percentage of the gold product of the world will be suppressed because engineering skill has not yet devised or put in operation means to neutralize or overcome the evils it creates.

Taliesin Evans.

EPHEMERA.

Midges and moths—ay, all you restless things
That dance and tourney in the fields of air,
You—Psyche's postman, trim and debonair,
With eye-like freckles on your bronzéd wings;
You—candle-elves, whose strange emblazonings
With sign of death our ancient gossips scare;
Or, who, when sleeps the humming-bird, repair,
With stealthy beaks to drain the honey springs:—

Your secret's out! I know you for the souls
Of all light loves that ever caused heartache,
Still dancing suit, as some new beauty toles!
Nor can you e'er your flitting ways forsake,
Till the just winds strip off your painted stoles,
And sere leaves follow in your downward wake.

Edith M. Thomas.