SYNOPSIS

From John S. Hittell, Esq. Dec. 31, 1880.

OF A

REPORT ON MINING

IN

CALIFORNIA AND NEVADA, U.S.A.

BY

G. THUREAU,

MINING ENGINEER, FELLOW OF THE GEOLOGICAL SOCIETY OF LONDON, HONORARY CORRESPONDENT OF THE CALIFORNIA STATE GEOLOGICAL SOCIETY, LECTURER AT THE BENDIGO SCHOOL OF MINES, LATE DELEGATE TO CALIFORNIA (IN THE YEAR 1877).

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INTRODUCTION.

THE Californian scheme, as it has been termed, originated with the well-known mining capitalist, Geo. Lansell, Esq., of Sandhurst, shortly after his return from a tour through Europe and America. Whilst sojourning in the State of California, Mr. Lansell, who, it is needless to say, possesses a very extensive practical mining knowledge, observed many instances connected with mining and the treatment of auriferous ores, which were there very successfully worked, and which, if introduced here, would, in his opinion, result to the advantage of our miners on Bendigo or elsewhere. Having come to this conclusion, Mr. Lansell, on the 12th November 1876, communicated with the committee of the Bendigo School of Mines in furtherance of that view, and at the same time very generously offered one-third (on certain conditions) of the total expense it would take to send a qualified delegate to America. The committee referred to took immediate steps to raise a sufficient amount by means of subscriptions from the citizens of the Sandhurst district, and applications were requested in the newspapers from persons competent and willing to proceed to the Pacific slopes. Out of nineteen applicants—the necessary funds having meanwhile been subscribed—two were selected, and these two candidates were sent as a final test to the Clunes and Stawell mining districts for the purpose of examining and reporting on the mines there, in the same way as the chosen delegate would have to do in California and Nevada. On the 12th February 1877, the author of this present synopsis of his report was appointed, and on the 5th March following he left Melbourne, *en route* for San Francisco, California.

The delegate was furnished with a *précis* comprising the heads of subjects on which the investigations were to be made and reported upon after his return to Australia; besides, letters of introduction were procured for him from the Chief Secretary (Sir James McCulloch, K.C.M.G.), to their Excellencies the Governors of the States of California and of Nevada, in order to afford the delegate that standing and aid to which he, as the representative of the metropolitan quartz mining district in the colony, should be entitled. A similar communication was handed him for presentation to the (late)

American Consul-General in Melbourne, Thos. Adamson, Esq., jun., who, as a fellow-passenger to California, introduced the delegate to all the leading mining and professional experts in San Francisco, thus paving the way for successfully carrying out his mission, and for which services he desires to record his thanks. Amongst the numerous gentlemen in both the States visited, who received the delegate so very kindly and hospitably, and who aided him so disinterestedly in his laborious task, the proprietor of the *Alta California*, Fredk. MacCrellish, Esq., deserves special mention, for his rendering, besides, timely and unsought-for aid when the delegate was unfortunately left, for a considerable period, in an embarrassed position through non-arrival of remittances.

The return to Victoria was accomplished after an absence of nearly five months, of which time two months were passed on the sea, leaving a very short time for his investigations at the mines of the Pacific slopes and Nevada. The original report was handed to the committee shortly after the return to the colony, and at first it was intended that the committee should publish it at its own expense and under its own authority, but eventually it was deemed more judicious to widen the basis of the scheme, and to ask the Government to undertake this task, as it was likewise felt that, if the authorities were to do so, the miners of the whole colony would be enabled to secure the valuable information obtained at the expense of the subscribers on Bendigo. The Treasurer, the Honorable Graham Berry, M.P. (Premier), agreed to do this in conjunction with the Hon. W. Collard Smith, M.P., Minister of Mines, and thus the manuscript report, together with its numerous diagrams, was then submitted to the Secretary for Mines, Major Couchman, C.E., for examination, and with a view of estimating the cost of its publication, and reproduction of the diagrams accompanying the text. It was found, however, that to do so would necessitate an outlay of about six hundred pounds sterling, and as that amount exceeded the anticipations of the Government, the Honorable the Minister of Mines agreed, in reply to questions put to him by Messrs. Robt. Clark, Jno. MacIntyre, and the Hon. A. Mackay, M's.L.A., during the session of 1878–9, to obtain an amended and condensed report from the delegate, and, by omitting most of the diagrams, sketches, &c., on account of their being too expensive to reproduce, to considerably reduce the cost of the publication. This has been done, and this present synopsis of the original report is therefore published with the sanction and by direction of the Honorable the Minister of Mines; and the delegate trusts that his work in its present form may be favorably received, so that, contingent thereon, the whole of the diagrams, sketches, &c., now laid aside for possible future use, on the score of economy, may be added to a future edition, together with the copious descriptions which will in that event be necessary.

As regards the classification of the subjects treated in the present publication, the delegate found it necessary, under the altered circumstances of the case, to depart from his original instructions, as the latter were drawn up somewhat ambiguously, and therefore the following course, as more practical, has been adopted, viz. :—To first describe the geological and mineralogical features of the country, with their metalliferous deposits and lodes; then to investigate and take note of the operations in the latter from their displacement by the miners, by means of various operations and appliances, through their subsequent manipulations to the final resultants of commercially valuable metals and other products, as well as the rejected wastes at the conclusion of the whole process.

In describing the various matters connected with mining in America, and submitting my views for adoption here, it is not intended to convey an impression unfavorable to what we may have become accustomed to from actual practice, but rather to give the *thinking* portion of our mining community an opportunity to read, compare, and form their own judgment as to which of the two systems—viz., the Victorian or the Californian—is preferable, and what should be adopted of either, or what should be rejected.

"THE DELEGATE."

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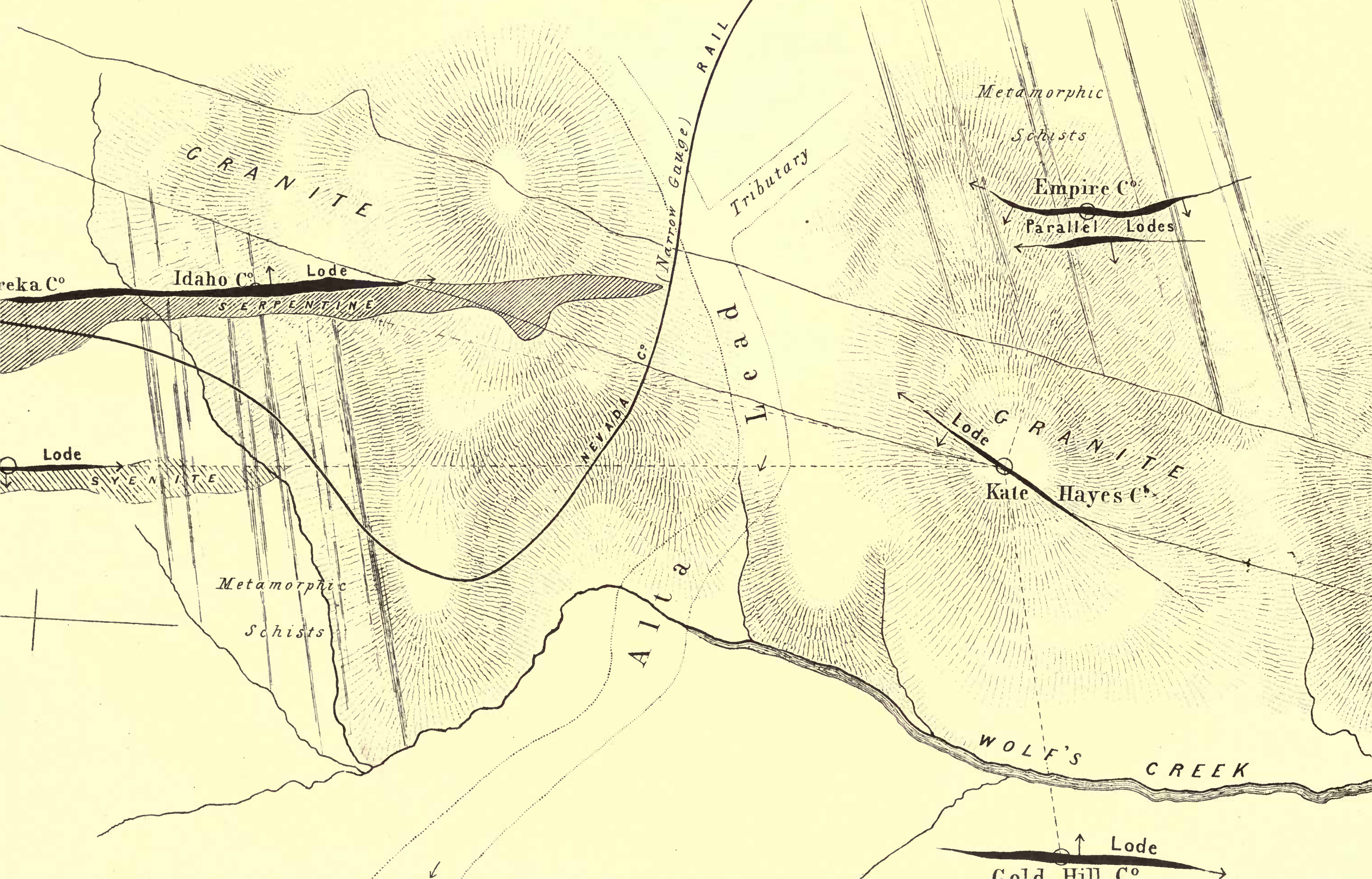


Part I.

CALIFORNIA.

Section I.—Geological Features.

In confining myself in this paper to the really metal-producing districts visited in the State of California, I may, however, in passing state that that country is traversed nearly north and south by the Sierra Nevada Mountains, which obtain an altitude of over 8,000 feet above sea-level. The western slopes comprise California, whilst to the east the State of Nevada is located. The base of the Californian side is formed of Tertiary drifts or gravels, which partly constitute further inland the "Foot-Hills," or one of the terraces rising above the fertile lands along the Sacramento and other rivers. Above these foot-hills, the country becomes rapidly more and more mountainous, and thus the gold-bearing regions occur at an elevation varying from 2,000 to 4,000 feet above the Bay of San Francisco, forming an almost uninterrupted metalliferous belt, not only within California proper, but likewise in portions of Arizona in the south, and Oregon territories in the north, extending many hundreds of miles in those directions.

Having explored, as far as my time would permit, the following counties in the State—viz., Nevada, Sierra, Calaveras, Tuolumne, and Mariposa—it will be seen that these areas cover a large extent of country, which, however, do not include all the other mining regions equally worthy of notice, but which I was prevented from visiting during the three months only at my disposal in America. In all the counties visited, however, nearly the same geological features were observed, with but few unimportant departures from the general character and position of the country rocks and the quartziferous gold-bearing lodes those rocks enclosed. And, as the well-established quartz mining district near Grass Valley City, Nevada County, attracted my first attention on account of its leading position amongst the others, a concise description of the place will, I submit, suffice for all present practical purposes, and at the same time elucidate the condition, geologically considered, of other and similar mines as well (Plate No. I.).

The Kate Hayes mine, south-west of the City of Grass Valley, is situated upon an eminence, which permits of an extensive view up to the snow-clad Sierra Nevada in the far distance, and, in the more immediate neighborhood, of all the mines worked or in the course of exploitation ; besides, the first-mentioned mine occupies a position on that central belt of coarse feldspathic granite bearing N. 20° E., which divides the sedimentary and metamorphic rocks as well as the serpentines and syenites, which latter occur here as the enclosing or "wall rocks" of nearly all the quartz lodes, with this difference, that the strike of the first-named is nearly due east by west with frequent alterations, thus differing materially from our regular Silurian strata at Bendigo and elsewhere. The arrows in black shown on the chart at the lodes named and delineated, denote both their dip and underlay, which, it will be seen, not only varies considerably, but demonstrates besides a total want of regularity and continuity in the line of strike such as we are accustomed to in Victoria, and which circumstance, in California, is doubtless be remarked that these ledges are found in extensive belts of granite, which run west and east, and as the lodes strike north by a little south, besides exhibiting other characteristics, it may be safely inferred that they are true *fissure veins*, according to Californian theories, and therefore permanent. This view is strongly supported by the fact that numerous blocks, or "makes," as described above, formed against the "main back," were worked by this proprietary, and that, at their bottom level (800 feet), another block had just been cut into, resembling all those at the higher levels; this new discovery proved, after proper tests had been made of the ore, exceptionally rich in gold-bearing pyrites. There are quite a number of mines here also located in the granite country, but, as their general character resembles that which has been said of the New Providence mine, I consider all present purposes of this paper have been served, and consequently I proceed to the description of mines differing from any hitherto referred to.

The Pittsburg is situated a short distance east of the granitic belt, in which the New Providence and other mines are located, and about three miles south of that mine; this lode, however, occurs in a kind of coarse sandstone, which is farther on metamorphosed into greenstone syenites, traversed by strong dykes of diorite, highly crystalline and easily distinguished at the surface. I regret not having been able to investigate these interesting features more closely, owing to the short time at my disposal, especially as this formation would ultimately join a belt of lodes in the south, occurring, however, in chloritic schists and serpentines; the time at my disposal would be utilized by the more practical matters, of which the elaborate treatment of the quartz after crushing would engross all my attention. This Pittsburg lode ranges from 15 inches to 3 feet in width, and the ore averages from 20 to 50 dollars per ton, inclusive of the 5 per cent. of sulphurets it is charged with. The latter, after careful concentration and chlorination, have, however, given as high as 110 dollars per ton (American ton, 2,000 lbs.). In this mine the same rule has been found to prevail as mentioned in regard to the behaviour of the blocks of ore on a western or eastern underlay, thus affording a field for geological deductions as to the dynamic and kindred forces in action previous to, during, and since the formation of these and similar metalliferous deposits. As regards the frequently discussed and mooted existence of "*barren zones*," or country at one time very prolific in rich ores becoming quite devoid of such ores, I may state that I have arrived at the conclusion that these are only temporary occurrences if compared with what I saw in California. After careful examination, I offer the following conclusions for consideration, as tending to dispel doubts, and, instead, to encourage "deep quartz mining" with more confidence of success and for permanent results than many regard the stability of our lodes in Victoria :—

1st. I observed no "saddle" or anticlinal reefs or ledges in California.

2nd. That in California isolated lodes were more frequent than they are here in Victoria.

3rd. That in a few instances a "line of reef," in the Bendigonian acceptation of the term, was found to exist, but that these lodes were in themselves very irregular, and that the barren country intervening betwixt the blocks or makes of ore would amount to as much as the actual quantity of gold-bearing quartz.

4th. That in California the occurrence of payable ledges was subject to more irregularity than, generally speaking, in Victoria.

5th. That, owing to the nature of the mountainous mining regions, a much greater number of gold-bearing lodes were exposed at the surface in California than in this country, though this circumstance would be, to some extent, counterbalanced by the greater regularity, continuity in the lines of strike, and easier-working country observed with our Victorian quartz reefs.

6th. That the Californians, in order to overcome all difficulties, and also the equally great question of treating their crushed quartz, which contains certain ingredients detrimental to perfect gold extraction, have adopted and are continually perfecting a very superior method for treatment of such quartz, which latter, I submit, serves the purposes intended admirably.

The ledges located and worked in the more southern counties of California—viz., Calaveras (part only visited), Tuolumne, and Mariposa—proved on investigation to be similar to those already described; but as in all these mining regions the term "*mother lode of California*" is much used, it may be as well for me to explain that phrase, as it means simply a characteristic succession of strongly developed outcrops of auriferous quartz, of more or less value, frequently rising above the surface in ponderous masses to a height approaching 60 or 80 feet, and invariably almost stained green from carbonates of copper. And as these masses of quartz are of considerable thickness, and, besides, surmount the more prominent mountain peaks, their appearance for many miles has found what may be considered a very appropriate appellation. We, in Victoria, would be justified, I think, on nearly as good grounds, if we were to term the continuation of the Bendigo lodes throughout the Castlemaine, Taradale, Daylesford, and Blackwood districts the "mother lode of Victoria."

The country rocks in the Californian gold districts differ unmistakably from those found in contiguity with our Victorian reefs. Near Grass Valley they are mostly highly metamorphosed schists or sandstones, passing into diorite or greenstone syenite, all of which are charged with pyrites of iron; and in other districts the country rocks belong to the chlorite, talc, and hornblende groups of schists. The marked difference thus exhibited does not, however, in any one case extend to the gold-bearing lodes, which, as already stated, resemble very closely indeed those worked in Victoria. Many times, underground, I could not see any difference between our reefs on Bendigo, Clunes, and Stawell, though I well knew I was examining Californian ledges all the time. The only place where I observed true Silurian slates and sandstones, with faint traces of "graptolites" and allied petrifactions in the wall rocks, was at Tuttletown, Calaveras County. In these slates, &c., a very similar formation to that worked at Snob's Hill, Eaglehawk, was visible; but, instead of the heavy gold generally found in the spurs worked near Eaglehawk, this Californian quartz contained that very peculiar kind of "leaf gold" which fills the crystallized cavities of their quartz, and is of course very light, and therefore difficult to collect. (Marks and Durrow mines.)

In the Mariposa County, adjoining, near Coulterville City, the Mercèd River has, during the process of its erosion, disclosed many valuable quartz lodes where that river intersects the "mother lode" with its numerous parallel ledges. Amongst these, the following deserve notice, viz.:—Pine Tree, Anderson, Crown Peak, Adelaide, Midas, Ralston, and others. All these have, time after time, given excellent returns to considerable depths from the surface, and, right here, the continuity of lodes to a great depth has been proved in a very convincing sort of a way. As this is a very mountainous region, the valleys are frequently from 1,000 to 2,000 feet deep, and from the summits of the mountains down to their base these reefs are exposed to view, maintaining the same width and extent of each "pay-chimney" or "chute," or the blocks in which they may be enclosed, with the aggregation of richer, poorer, or worthless quartz, the same as in Victoria. Comparing the yields, as taken from many official records, a similar fluctuation is observed as with us, and, as this may be of some interest, I append a short statement obtained from the books of the frequently mentioned Idaho mine, Grass Valley City, showing the yield of various levels, viz.:—

At and above the 300-foot level, which was worked by the Eureka Company, the average yield was returned at 100 dollars, *i.e.*, about 5 oz. of gold per ton. The 400 and 500-foot levels were poor for the whole extent worked, whilst the 600, 700, and 800-foot levels produced quartz that fluctuated from 25 to 35 dollars per ton. The 900-foot level averaged about 35 dollars: and the 1,000-foot, according to late advices, state that a higher average is being obtained from this company's deepest level. The Alaska mine, in the same locality, had also very rich ore in the deep ground; the Pittsburg and New Providence, Nevada County; the Rising Sun, Colfax; the Golden Gate, Sonora City, Tuolumne County; the Banderitos, Skendlin, Marble Vein, Haslon, Derrick, and others, near Coulterville, Mariposa County, all exhibited this same satisfactory feature in their bottom levels.

On the whole, I may state that, in most of the Californian mines I have inspected, the quartz looked and yielded as well, and in many cases better, in the deep ground than it had done nearer the surface. I took particular care and trouble to assure myself of this fact, by reference to the official reports and accounts kept by the mine superintendents and secretaries, and I submit that this information should be of value to us in our deeper mining operations.

AURIFEROUS SLATES.

These remarkable formations have given rise to extensive operations near Coulterville and other places. The Ferguson Company, near the former city, was successfully engaged on a vein or stratum nearly vertical in position; and this talcose, friable slate was impregnated with thin, flat, and very fine flakes of gold for a varying thickness of the vein of from 12 inches to 6 feet. Owing to the frangible nature of this slate, and on account of the light character of the gold in it, which, after crushing, formed a "pulp" of very little specific gravity, the utmost care had to be exercised both in the concentration and amalgamation of these atomic grains of gold. I would not have referred to this remarkable occurrence, or have described lower down the process adopted for treatment, were it not that frequently our Bendigo lodes diminished first in size, and then passed gradually into a soft, deep-black slate (flucan), also impregnated with very fine gold, which we cannot very successfully collect with our appliances; so that, by adopting the Californian method, we might add to our yields of gold from similar formations.

DILUVIAL GOLD-BEARING GRAVELS AND DEEP LEADS.

These important deposits are very appropriately termed "ancient rivers" in California, and the extent of their extensive watersheds must have been, at that remote period, very considerable, to judge from the various points, many miles apart, where they have been subjected to mining operations on almost a gigantic scale. And it may also be observed that in but two instances the working of deep leads beneath the basaltic or trappean coverings had been taken in hand, although "bald hills," capped with porous and dense basalt, and underlaid with Tertiary drifts of as pronounced a type as at the Loddon, Ballarat, Charlotte Plains, Creswick, &c., were frequently passed over during my peregrinations. The ancient rivers of California somewhat resemble our deep leads, with this difference, that, in most cases, the modern water-courses have cut their way into the bed-rock *below* the older river beds, and which latter are filled with the detritus of rocks evidently brought along by either fluvial or glacial action. In this manner these valuable deposits assume frequently, through the intersection of the present drainage system of the country, the aspect of our *made* hills, whereas, in reality, they are but the severed parts of a network of ancient water channels now altogether obliterated and filled with Pliocene gravels or drifts. In many cases the present rivers run more than 100 feet below the old beds, thereby facilitating to a considerable extent the economic working of these auriferous gravels. These ancient drifts are generally of two kinds, viz., that which rests immediately on the bed-rock presents that dark-blue color so frequently found in our own districts, and which is mainly due to the presence of iron pyrites; immediately above this older gravel a seam of tough pipeclay occurs, of a whitish color, which is in turn overlaid by a stratum of loose reddish-white colored gravel and sand, not nearly so coarse or containing such immense boulders as in the "blue gravel" below. As stated before, cappings of more recent flows of lava and volcanic muds occur, but they are not much taken notice of, on account of the difficulties experienced in their removal by the miners, who so systematically wash the whole of these deposits upwards of 380 feet in height by means of powerful jets of water from nozzles and pipes. As regards the extent of one particular channel, or ancient river, I may state that the "lead" in question has been traced from beyond Forrest City, Sierra County, through North Bloomfield, San Juan, Nevada City, down to the Sacramento River, a distance of nearly 60 miles in a *direct* line. Considerable interest attaches to the number of fossilized trees in these gravels, of which some have become beautifully opalized in texture and appearance, preserving their origin as oak, manzanite, and cedar by means of the year rings, knots, and fibrous grain. The lower or blue gravels contain large blocks of rock of the older volcanic formations, very little water-worn, besides large fragments of bones belonging to the mammalia group; the gravels above the pipeclay are composed exclusively of completely rounded quartz boulders and gravels. The blue gravel is richest in gold in most of these ancient rivers, but at the Table Mountains, near Sonora, very rich deposits of fine gold were worked in a deep-red colored kind of sandy clay, which is difficult to wash, on account of its great cohesiveness, and which resembles the red clays found in the tributaries of deep leads near Taradale, Daylesford, Creswick, and Clunes. There remains but to be mentioned that implements, evidently shaped by human hands, were found in these gravels at Buckeye Hill, Sweetland, some 60 feet beneath the surface, and that I found that the deep lead at Forrest City measured from the surface to the bottom of the gutter not less than 1,100 feet in depth, and, owing to the present water channels draining the country, quite dry.

Section II.—Mining Operations.

SINKING SHAFTS.

The methods for sinking shafts in connection with lodes and the vertical shafts examined call for no special remark, but, in cases where the underlay of lode is followed like the Idaho Company, the main shaft of which measures 20 feet long by 6 feet wide in the clear of timber, and is divided into four compartments, a considerable saving of time and expense was obtained by, firstly, using one of the compartments exclusively for the "sinkers," and providing a "tub" specially for their use in removing the *débris* to the surface by means of a separate drum at the winding engine; secondly, it was found to be more expeditious and cheaper on the whole to sink a smaller shaft in advance, say 100 feet deep, then open out to the full size and put in the permanent timber from the bottom, widen out to full size of main shaft whilst rising above the bottom sets until the above-mentioned space was secured in the ordinary way. That this operation was effected in a superior manner, I found after numerous inspections, and that the sinking was of a satisfactory speed from the fact that this company sank that large shaft, measuring 23 feet long by 9 feet wide, "outside of timber," to a depth of 1,000 feet, in five years and eight months. When it is borne in mind that the hard schist at the hanging wall and the continuously swelling serpentine at the foot wall necessitated continual repair, and a complete system of "false sets" to keep up the sides, the actual time consumed would appear reasonable as well as the expense per foot, viz., 100 dollars, inclusive of all material, labor, engine work, fuel, and interest.

The American boards of directors or trustees controlling mines go very systematically to work, and they require their mine superintendents to furnish the board with complete written estimates of every kind of permanent work, so that they may possess always a knowledge of what amount of expense within a given time is required to carry on the operations necessary, whereby a continuous opening of the ground is effected. In this connection it should also be stated that in place of written reports of what has been done during the past month—all retorting and payments are made monthly to save time—a comprehensive set of tables are printed, which are filled up under various heads by the superintendent, chief engineer, amalgamator, assayer, surface manager, and foreman of shifts, as the case might be, filed for reference and comparison, and are always ready for use in future.

Returning to the shaft named: the squared frames of spruce pine, 15 inches thick and joggled, are placed every 4 feet, thus making the "studdles" 2 feet 9 inches in length each; and in this case, owing to the angle of underlay it has been found requisite to stay diagonally their shaft timber both above and below the various "stations" or plats. Iron rails, from 30 lbs. to 40 lbs. per yard, are laid on and secured to the foot-wall frames, and they form two or three lines of tramway to the bottom, the cages with trucks travelling upon same by means of flange wheels provided for each cage. In this case the cages have been furnished with a movable bottom working on a strong hinge, which adjusts itself to any angle of underlay or to the level bottom of each plat. Cast-iron rollers are fixed between the rails in order to save the trailing rope from chafing, and the working of underlay shafts appears in some cases to be advantageous, because they avoid expensive crosscuts for the lode, as with vertical shafts; but for other reasons the latter are preferred, inasmuch of the danger in the angles of underlay, which cause the cages to jump the rails and cause accidents and delay.

DRIVING OF LEVELS AND CROSSCUTS

does not differ from our methods, except that, in some cases, "headers," or smaller drives, are pushed on ahead the permanent level, and that percussive drills are used in all these operations with good effect.

PUMPS.

The Californian columns are nearly fac-similes of ours, although constructed somewhat differently from the latter, without, however, interfering with the principle of plungers and drawlifts. The only important feature requiring attention is, that they are all made of stout boiler-iron plates, cut to size and riveted together so as to form "break joints." Of course the "workings" and the flanges riveted to the pipes are made of cast iron, and they are pierced for the bolts at the joints where necessary. The boiler plates are rolled and riveted together in three lengths, of such diameter of lift as required, and all the longitudinal and cross joints are riveted in zig-zag fashion. The lifts are made in 12 to 16 feet lengths; they are much lighter than cast-iron lifts of the same size, and therefore need not such heavy bearers and yokes in the shafts. The experience had with these pipes for many years proves that they are much less liable to burst under heavy pressure. They are, on the average, tested up to 300 or 360 lbs. per square inch pressure, and are also much freer from flaws, and they last a deal longer, even in such mines where the mineral water destroys extra thick cast-iron pipes in a very short time. As a further preventative against mineral water, and especially hot to boiling mine water, these lifts are covered with a series of coats of coal tar, pitch, and asphaltum from time to time, which are a satisfactory means to preserve them from injury.

AIR COMPRESSORS.

These machines, as an auxiliary to mining, are in use with all the larger companies, and have been found both economical and advantageous as against manual and expensive labor. Inasmuch as these machines and the percussive power drills are likely to find much favor with our miners, I shall briefly describe them, and offer general directions for their practical use. Air compressors consist generally of two principal parts, viz., the motive-power as represented by a steam engine, and the cylinder in which the air about to be compressed is manipulated. If the steam engine is directly geared to the compressor, the direct action of the former will save power, and therefore the effects are more serviceable. The compressor is also a cylinder with piston complete, like the steam cylinder, and they work generally end for end or sideways. The compressor is set in motion by the crank shaft worked from the end of the piston-rod of the steam engine, and as these cranks, or rather solid discs, are working the air piston as well, the air, sucked into the air cylinder by means of some kind of tumbler valves, is compressed with every return stroke as the valves shut after admitting the air sought to be compressed. The object and the aim of all inventors has been to construct air compressors that will give a high pressure of air, and at the same time obviate the difficulty occasioned by the heat engendered during the process of its compression. The results are not always satisfactory, owing to the difficulty of confining the compressed air at the end of every stroke by the piston, and to avoid its forming a cushion before it leaves the air cylinder for practical use. To produce, therefore, a pressure of air of over 100 lbs. per square inch pressure in the receiver or reservoir necessitates a corresponding expense of steam-power.

TABLE showing Horse-power required to Work a given number of Power Drills.

Steam Cylinder.		Air Cylinder.		Stroke per Minute.	Cubic Feet of Compressed Air per Minute.	Will drive 3⅛-inch diameter Rock Drills.	Horse-power required.
Diameter.	Length of Stroke.	Diameter.	Length of Stroke.				
inches.	inches.	inches.	inches.	No.		drills.	
10	12	12	12	60 to 75	100 to 110	4	15
20	30	24	30	30 to 50	650 to 750	15 to 16	50

* Power drills are rock-boring machines on the percussive principle.

A check valve placed at the delivery pipe regulates the emission of the compressed air into a receiver constructed of boiler-iron, and a "main" thence serves for the reticulation of the principal underground workings, where service pipes eventually connect with the rock-boring, winding, ventilating, and pumping machines so frequently worked in California and Nevada. The distance travelled by the air so compressed does not appear to diminish the pressure very much, for I found in Grass Valley that the pressure registered at the surface receiver had barely decreased ¼ lb. at the second receiver placed in the 800-foot level, or a total distance of 1,800 feet from the compressor; and at the Sutro tunnel, Nevada, one per cent. of pressure was only lost in a distance of over 13,000 feet, through leakage and friction in the air pipes. The compression of air causes the evolution of heat, and when in that state it loses its valuable expansive power as a motor. The engines, or compressors, also become disordered on account of this heat expanding the ends of the air cylinders, leaving the central portions cool, thereby depriving the piston of its necessary perfect fit, whereby the air streams through the crevices around the piston, thus disabling the check valves as well as injuring the packing, and becoming quite useless as a motive-power. Some compressors have therefore their pistons working in water; their suction valves are likewise made of brass, to better withstand the heat, but those are only temporary preventatives; and the idea of the National Company to cast their air cylinders with double walls and forming a spiral jacket at the outside of these cylinders, surrounding the inner one, by means of which an open passage is supplied with regular flow of cold water, has been very effective in keeping both the cylinder and the piston cool, and in a fit state for heavy work, and likewise in preventing the injurious mixing of air with water so heated. The mains are simply gas pipes, the same as the service pipes; but for a length of from 30 to 40 feet next to the machines to be worked by compressed air five-ply canvas vulcanized rubber hoses wrapped with marlin are used, in order to save them from injury during blasting or other rough usage.

It may be stated here that the American miners look upon manual labor with the greatest possible aversion, and, as they are a very inventive people, machines of various kinds are made to take the place of the laborer, whose functions are much relieved thereby, and a greater number are found employment for.

PERCUSSIVE ROCK-BORING MACHINERY.

In view of the great expense and, comparatively speaking, the slow progress made with mining operations if carried on by means of manual labor, the Californians possess a number of machines which take the place of boring of holes, for blasting, by hand. Amongst these the Victor hand drill was seen at work, the special advantages claimed for it being a greater rapidity in boring; but as this drill, which was raised in the same manner as the shank of a stamp-head, and turned likewise by the lifters, depended in a very considerable measure upon a couple of powerful steel springs to aid the force and weight of the blow, it was seen that the strongest effects were achieved if the drill bored vertical or nearly so. At the same time it required two men constantly at the two handles fixed at each side on small fly-wheels, who would have hard work to attend to the boring for three or four hours at a stretch. Any holes bored at and more or less above the horizontal compared unfavorably with ordinary miners' work, though for quarry and open cutting work it would appear suitable.

Taking into consideration the primary outlay for such "power drills" if driven either by compressed air, water, or steam pressure, the costs of repairing them, and the additional motive-power of any kind required, it is agreed upon that the introduction of such labor-saving machines would in future reduce the working expenses one-half, but undoubtedly admit also of a greater speed being obtained in opening new ground, or in working our quartz lodes, than what we have been accustomed to hitherto. For-as-much those power drills, as driven by means of compressed air, act likewise as very powerful ventilators, through the cold exhaust air they emit or discharge every piston-stroke, driving out all depraved gases in the workings, the miners can perform a larger amount of work there than in hot and unwholesome air; and it may be added that they do about 50 per cent. more work than a similar number of miners would perform as those needed for the working of each of these drills. In the absence of my original diagrams of such drills, I can but give a brief description of such machines, to which a number of rules will, however, be added that may be found useful by those who have not had any opportunity of working them, or who have not seen them at work. These power drills resemble, in their principal parts, engines of a small calibre, having, however, several essential parts added for the due performance of the special work alloted to these borers. There is the ordinary cylinder, from $3\frac{1}{8}$ to 6 inches in diameter, a slide valve, piston, and rod, with the necessary air, water, or steamports, to admit the motive-power used, which latter stands in the following proportion, in accordance with practical experience, viz., air, water, and, lastly, steam. There are besides two outlets, viz., for the exhaust and for the compressed air, which is conveyed by means of strong gas pipes —malleable iron chiefly—to a receiver, which is furnished with a proper pressure gauge, to show the pressure per square inch. There being but one stuffing-box, the piston-rod protrudes through same, having the "drill-bit" proper geared to its outer end by means of an adjustable "chuck," and, on the turning on of motive-power, the piston and drill-bit perform their ordinary work by back and forward strokes, and by means of greater pressure these strokes are propelled with increased force against the rock, the drill-bit at the end of the piston-rod indenting the latter with a power ranging from nothing to a weight of 1,000 lbs. each stroke. In order to give the drill-bit the requisite turn each stroke, to enable it to bore a perfectly cylindrical hole, the piston-rod has been shaped in a both spiral and flat manner, and, as it passes through a movable "hub" or boss of a ratchet wheel, the back stroke turns the ratchet every time to the extent of one tooth, or an average of one-tenth of an inch, similarly as is done by the miner holding and turning the drill for the striker. As the hole gets deeper, either a longer and sharper drill needs to be inserted at the chuck, or, if the end of the cylinder is close to the rock, the motive-power is turned off and the cylinder with drill, &c., is "fed" backwards to the full extent of the screw provided, and boring can again be commenced. The "feeding" forward is of very great importance, and requires very careful attention on the part of the "boss" in charge, because he must feed in accordance with the exact nature of the rock passing through, and any want of care will prevent his getting full duty from the motive-power expended in working these drills. Upon the character of the rocks about to be perforated depends also the velocity given to the blows given per minute by the piston, and they can be delivered to the number of 500 or 1,000 if required.

With all these machines it is a matter of grave importance that their inner parts, which are subjected to extraordinary wear and tear under great pressure, are solid and as few as possible in number ; that the drills should at the same time be portable, and easily fixed for boring at any conceivable angle, the same as a miner is required to do with hand drills. By way of comparison and explanation, I would state that the English Burleigh drill consists of 120 pieces, and it weighs about 230 lbs.; the Ingersoll of the same size weighs 185 lbs.; and the National weighs but 168 lbs., the latter being composed only of but 80 principal and interchangeable parts.

These drills are either mounted on a tripod to suit the bottom of workings, however uneven, when they are held down by heavy weights, to withstand the enormous concussions in drilling underfoot ; in other workings they are geared to a hollow iron "bar," by means of an adjustable and massive clamp, which is furnished with a knuckle, or universal joint, enabling the drill to be fixed in any given direction by means of set screws. This bar is made of strong wrought-iron tubes, which at one end has a strong movable double anchoring bit riveted on, for the purpose of gripping in the "hitches" cut for that purpose in one side of the workings. At the other end, and inside the bar, a square-threaded screw works in a thread of the same description—the screw thread varying from ¼ inch to ⅜ inch in proportion to the size of the drills —and of such a length as will permit the extension of the bar considerably over its ordinary length, by means of a lever that is inserted into the lower end of the screw ; this end can be made to work either in an iron socket or, if the nature of the rocks renders it necessary, in a block of soft wood, so that the greatest possible strain can be put upon this wooden block in order to withstand the concussions put upon the bar and drill combined.

General Directions for Working Power Drills.

1. Before starting, all parts of the drills ought to be carefully lubricated.
2. The bar should then be rigidly fixed by means of the lever, and, should it slacken as the work progresses, "lever up" to take up the slack as required.
3. Let the piston drop down on the upper end of the drill-bit, and let the "bit" touch the rock where the hole is to be bored. If, after the first stroke, the piston stops, the valve gland must be tightened to prevent the valve moving back over the port, and thus cut off the motive-power—which in future shall be compressed air—then start again, and attention with accu-

mulating experience will guide any intelligent miner how to work and how to guard against any further interruptions.

4. On changing sharp for blunt bits, run back the feed, unscrew the chuck holding the drill, remove the latter and pass the new and longer drill at the side of the cylinder until it enters the chuck for rescrewing.

5. The bit should always be kept quite cool, and though in the first few inches a deal of splashing of water and bore meal takes place, such will altogether cease with a greater depth of the hole.

The miners, I have no doubt, will experience a relief when working these boring machines in pure and wholesome air, and will afterwards regard the beating of the drills by hand hammers with disgust.

As regards the actual amount of work performed by some of the more popular drills in California, I caused a trial to be made at the Idaho mine, and as the results were arrived at under precisely the same conditions as regards air pressure, time of performance, and character of quartz to be bored, some valuable information was gathered in these matters connected with economic and rapid mining. The trial took place in the stopes at the back of the 800 and 900-feet levels ; the amount of air pressure used was only 40 lbs. per square inch ; and the quartz in the lode was equal in both cases, and much harder than any on Bendigo. The Ingersoll drill was started in a fairly favorable spot at slow speed of piston, increasing as soon as a hold had been obtained at an angle of 15 degrees below level. This drill bored in one hour, inclusive of stoppages for exchange of sharp for blunt bits and "levering up," &c., at the rate of 7 *feet and* 6 *inches* in a hole measuring 2 inches in diameter.

Meanwhile and under full view, the National drill was also set going on a "slant" with the face of the stope, and where the four points of the "crown" bit used in both cases could not strike until a hold had been obtained, which latter would take a miner with hand hammer and drill half an hour to accomplish, and with exactly the same pressure, stoppages, levering up as with the Ingersoll drill, this National drill bored 9 *feet* 3 *inches* in the hour allotted to the Ingersoll. The latter result, it would take two miners in two shifts of ten hours each to finish ; and it is therefore in the face of the disadvantages relating to a fair starting point, &c., perfectly satisfactory to all concerned, and especially to those in this colony who cannot work mines cheaply and rapidly on account of the greater expense and slow progress attached to manual labor, whereby numbers of promising mines are "shut down," as the Californians say, to the loss of the district.

DIAMOND DRILLS.

These, then novel kind of rotary perforators, were found at work in several parts of the two States visited, and immediately after, I recommended these machines to the notice of mine owners, as that class of *mining* diamond drills had proved of immense advantage in prospecting ahead of deep workings. These mining diamond drills are of a portable description, and they are worked by means of water-power in Mariposa and Nevada counties, California, and exclusively so by means of compressed air in the hot mines at the Comstock lode, Storey County, Nevada. Since then, three *surface* diamond drills have been introduced by the Victorian Government, worked by "*steam*," and as the principle of these modern "miners' telescopes" is now well understood, I omit any further description, only adding that, for cheap and expeditious exploitation, for gaining correct and reliable knowledge of the country beneath and ahead of past explorations in our mines, they cannot be surpassed, after the method of working them is once understood and has been mastered. As regards the cost of boring by means of these mining diamond drills, I found in the regular official vouchers that in California the total expenses varied from 90 to 108 cents per foot, in which amount, however, all expenses were charged together, with interest on original purchase-money (for each drill about £400). At the Comstock lode, a great number (the California United and Virginia Consolidated companies employ alone from eight to ten drills continuously) of mining drills are at work testing the ground in every direction, and the actual value of these mines are to a great extent gauged by the results obtained by their assayers from the "cores" obtained in boring. Owing to the higher rate of wages and other requisites prevailing at these celebrated mines, boring would cost about 50 per cent. more per foot than in California.

Remarks respecting the Use of Power and Diamond Drills.

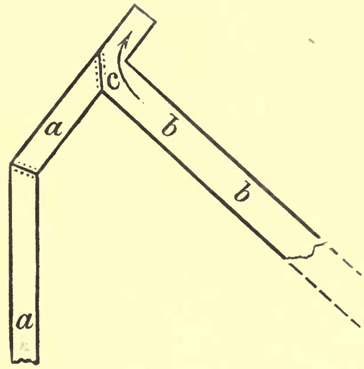
In California, I found that the miners had already found it necessary to alter their usual style of working, in consequence of the introduction of the power drills; in the stopes especially, a number of holes would thus be drilled to the best advantage from 4 to 10 feet deep each; those near the foot wall would be charged and fired first, leaving the others for a similar procedure, but fired eventually and simultaneously with strong charges of black prismatic powder. This would not bring down any ore, owing to the depth and strength of the holes—merely "cracking" the ore; these holes would then again be charged with nitro-glycerine explosives, which on ignition would throw down the whole stope to the full depth of the holes and in large blocks.

With the mining diamond drills, which are destined to work very advantageously on Bendigo and other mining districts, great advantages may be achieved in the way of saving expense in nearly all kinds of mining operations, because, in cases where valuable ore bodies or auriferous quartz has been discovered by means of these drills, it becomes necessary to follow up such discoveries, and as the character of the country has been proved by means of the "cores" obtained in boring, contracts may be let or miners employed at wages for this work, without spending too much money for that class of work on account of the knowledge obtained of the nature of the strata about to be driven or sunk into. The tapping of new lodes is frequently attended by bursts of water interfering with other works in the mines through their sudden submersion, but these clear bore holes will effect a gradual drainage, and thus new ground would be opened much quicker, and more room found for miners in less time than this would take by miners "beating" the hand drills.

VENTILATION.

Besides the "blowers," *i.e.*, a kind of centrifugal pump on the "Root's" principle, by means of which the impure air in deep and hot mines is forced out by wholesome air, their ventilation is also effected by drawing the depraved air from such workings.

One instance, which came under my notice at a mine near Nevada City, in which the unwholesome air was successfully removed from the bottom of an underlay shaft, deserves mentioning:—*a a* represents the exhaust pipe of a steam engine, 4 inches diameter, and *b b* the suction pipe from the bottom of the shaft, 700 feet deep; these two pipes were joined together



at *c*, leaving in *a* an open orifice for *b*. The exhaust steam would pass by this orifice, create a vacuum, and thus induce suction at the lowest end of pipe *b* in the shaft.

Section III.

BOILERS.

These steam generators in California and Nevada belong exclusively to the tubular kind, or what is termed the "return tubular;" and, after close observation, I came, like Mr. Bland, of the Port Phillip Company, Clunes, to the conclusion of their superiority over the single or double-tubed Cornish boiler, but that those used by the Clunes Company were surpassed by those of California for the following reasons, some of which are, however, applicable to both kinds of boilers, viz.:—The heat as produced by the combustion of fuel is distributed throughout the water more perfectly and generally, on account of the greater heating surfaces presented to the burning fuel and gases. They also require less length for the same capacity, and also cost not so much in California as Cornish boilers of equal horse-power. For instance, a boiler, 42 inches diameter, 12 feet long, with 32 4-inch tubes, "steam-drum" on top, 5 feet long, 2 feet diameter, "mud drum" at bottom, 7 feet long, 18 inches diameter, fire front lined with firebricks, smoke stack, fire bars, steam gauges, blow-off cocks, safety-valve, complete, and made of the best materials, costs only 900 dollars; whereas a Cornish boiler would at least cost 30 per cent. more in that State. The difficulties attending the cleaning and the repair of the tubes are considerably overrated with these kinds of boilers; with proper care, such a boiler, as specified, will last six years or more, and about four years longer if repaired occasionally. A tubular boiler will also effect a saving of at least 20 per cent. in fuel alone, on account of the better circulation of the water in the boiler through the interference of the tubes, and the latter add considerably to the steaming power of such boilers. This in itself should be a question of grave importance in districts where fuel is becoming more and more scarce and dearer every day.

Generally speaking, the Californian return tubular boilers are worked in couples, *i.e.*, each pair is connected, top and bottom, by means of the "steam" drum and "mud" drum. The first named has been adopted in place of our common dome for the drying of the steam, and the other is constructed for the receival of all saliferous and calcareous sediment that may separate from the mine waters used in such boilers. For instance, a couple of boilers, each 16 feet long, and 54 inches diameter, the steam-pipe connects with each boiler in their centre, and here the safety-valve is also placed on the branch connecting with the steam cylinder. The "mud" drum underneath these boilers is connected and placed rectangular with the boilers, about 18 inches from the stack end. It measures 14 feet 9 inches in length, with a diameter of 30 inches, and a cast-iron pipe leads from the bottom of the mud drum outwards, the same as with ordinary blow-off pipes, with a proper stop-valve. The steam drum, placed on top and also connected by means of a short cast-iron pipe with the boilers, besides drying the steam as with our domes, assists also in the general circulation of the water, whilst the mud drum prevents, in a very considerable degree, the incrustation of the boilers, tubes, and drums, thus obviating altogether the frequent necessity of their being cleaned ; because, likewise, the more rapid circulation in these boilers prevents sediments forming as in boilers where the water is less subjected to ebullition whilst under great temperatures and steam pressure.

WINDING OR HOISTING MACHINERY.

The American winding machinery for very deep mining is characterised by a proportionate strength, great weight of metal, compactness, and unusually effective brake power. Amongst these winding machines, one had just been built in San Francisco by the Messrs. Prescott, Scott, and Co., who very kindly afforded me every opportunity to inspect same, and to procure full working tracings, with other particulars. As this machine had been calculated to wind from the future 4,000-foot level by the Yellow Jacket Company, Comstock lode, if required, I was very glad to get this information as a guide for our future endeavors in the same directions. The two coupled cylinders were each 26 inches in diameter, with a stroke of piston of 6 feet ; and both cylinders, drums, and gear are all fixed to one solid bed-plate. The cranks—Californian engineers discard cranks, and have solid hammered-iron "discs" instead—and the winding shaft is made of best hammered iron, splendidly finished. The winding shaft, 16 inches in diameter, is round, except at the boss for spiders, where it obtains an octagon shape for a diameter of 18 inches. The ordinary speed for winding is not less than 55 feet per second, and by means of clutches winding can be done from any given depth, or also at various speeds. These large engines are all worked, in California and Nevada, and looked after by a double set of drivers each shift, or, in other words, each driver has one drum and half the machine under his control, whilst firemen look after the boilers. The machine in question, inclusive of an equally powered pumping engine, would consume 30 cords of firewood (pine and oak) every twenty-four hours, which fuel is delivered at the mines at 14 dollars per cord, or about 55 shillings. The poppet-heads, or "gallows," for this same plant are to be of clear sugar-pine, the two principal supports, or legs, measuring 18 inches by 24 inches diameter, and 50 feet high. These are to be fixed, like all others in those mines, 10 feet clear of the ends of the shaft, thus being—as the shafts are generally 20 feet long in the clear of timber—40 feet apart, giving good room all around the pit's mouth. The sheaves are of cast iron, with wrought-iron "rims" shrunk on, and measure from the centre of the spindle 6 feet to outer rim, or periphery. All the appurtenances are constructed with a view of doing a very large amount of work in a short time; and as the companies generally enter into contracts with the crushing mills for the supply of regular quantities of ore per diem, some such precautions are essentially necessary. The "cables" or flat steel ropes used there are of various sizes; for instance, that at the pump-shaft, for special use by the sinkers in the combination shaft of the Virginia and California companies, Comstock, measures but 4 inches by ½ inch, whilst the two winding ropes in their respective shafts are 5 inches by ⅝ inch. The average amount of work of these three winding drums amounts to 800 tons lifted in 24 hours from a depth of 1,500 feet, but as many as 445 "cars," or trucks, weighing 1,900 lbs. each, have been landed in eight hours at the pit's mouth. These steel cables are not only flat, but they also "taper" from their centre to the ends, on account of the ever-varying weight of that cable end which is deepest in the shaft. *For instance, in a shaft 2,000 feet deep, a steel cable of the kind described weighs about 53 cwt., which, if 10 cwt. is deducted for the distance between the engine, sheaves, and mouth of shaft, leaves 43 cwt.* in the shaft; this weight changes continually, so that when the bottom cage reaches the surface the weight of rope will be reversed. During the first part of the winding the power much exceeds that required half-way up, and at the latter end the engines have actually to be "braked" in order to meet the increasing and more than counterbalancing weight of the descending cage and longer rope together. What strikes one as most unusual, was the extreme care which the mine surperintendents generally bestowed on these wire ropes, and the observation of these officials, that "*they (the ropes) formed the only link by means of which many valuable lives could hope to see daylight again,*" appears very appropriate under the circumstances. All these ropes are stored in a drying shed, after each rope had run "*four months*" over the sheaves; they are then taken off, cleaned, and carefully repaired wherever necessary, and finally they are given a good coat of coal tar mixed with asphaltum warmed to liquidity. After that, they are rolled upon wooden spiders, and allowed to dry for the next eight months, during which frequent examinations are made to see whether they show signs of rust, whereupon they are again cleaned and coated as before; thus each rope is used but four months out of twelve.

Each drum is geared with an indicator to show the position of the cages in the shaft; this is effected by keying a small bevel wheel on the end of the winding shaft, or next to the clutch and close to the spiders, which works another wheel at right angles, also keyed on the bottom end of a vertical shaft 20 feet in height, 3 inches thick, with three square threads cut into it to the inch vertical; this screw grips into two kinds of hands at each side of the main screw, and as this screw exhibits 15 feet for every inch, the total depth, and over, of the shaft is covered, and these hands show very correctly what the position the cages are in, by their being either raised or depressed, so that the index provided and divided into feet, as painted in large figures, forms a correct guide for the driver.

SAFETY CATCHES AND SAFETY HOOKS.

All the cages in California and Nevada are provided with some kind of safety gear; in the underlay shafts this appears, however, unnecessary, because the miners are lowered and raised by means of a separate carriage (giraffe) of considerable capacity, holding as many as sixteen men at a time, which is simply a very long truck, the four wheels of which run on the tramway provided. Their trucks, or "cars," are much more capacious than ours in Victoria generally, and they are made in the old style, whereby the body of the truck is only lifted, whilst the wheels remain on the rails. In connection with winding machinery I may add that the Americans, as a rule, prefer steam to animal or manual power; consequently whims, whips, and windlasses are not seen anywhere, but compact coupled engines of various sizes and different power form the first steps towards speedy mining. This is rather an important matter for the engineering trade, and when it is considered how much time and expense is lost with the whim or whips, there cannot be the least doubt of the preference that should be given to *suitable engines* for preliminary opening of mines and their future exploitation, either from the surface or underground. The chief engineer of the Belcher Mining Company reports : "That a shaft having two compartments of 6 feet by 6 feet each had been sunk 1,000 feet vertical and 400 feet on the incline in seventeen months by means of a coupled 7-inch cylinder winding engine with an expenditure of only one cord of firewood for each twenty-four hours." To continue the subject of safety catches and hooks, I may state that quite a variety of these appliances are in use, inasmuch as mine superintendents are, in the absence of specific laws relating to mining accidents, liable at common law for any want of preventative for avoiding accidents. Some of these apparatus are geared with two pairs of coupled concentric springs acting on levers, which force grips or catches against the guides centrically or at their two sides ; hand levers are also in use besides. The experience, however, with steel springs has been to prove their losing the elasticity needed, through the steel crystallizing and acquiring a subsequent brittleness from the continuous vibrations they are subjected to. Rubber bands, spiral springs, buffers of the same material, are preferred in many cases where intense cold does not interfere with their utility. In some very deep shafts, where the ordinary rigid wood or iron guides or skids are dispensed with, four wire ropes are instead stretched at the corners of the shaft or compartment, and, as the cages have each eight loops fixed at the top and bottom corners, much room is gained, and, instead of four grips, as in the old manner, eight grips are provided by the use of rubber bands, springs, or buffers, acting on levers, which force wedge-like grips outwards and underneath each loop, thereby arresting the falling cage without that dangerous shock common to most other catches.

The safety hooks were of the ordinary kind, and therefore call for no remark.

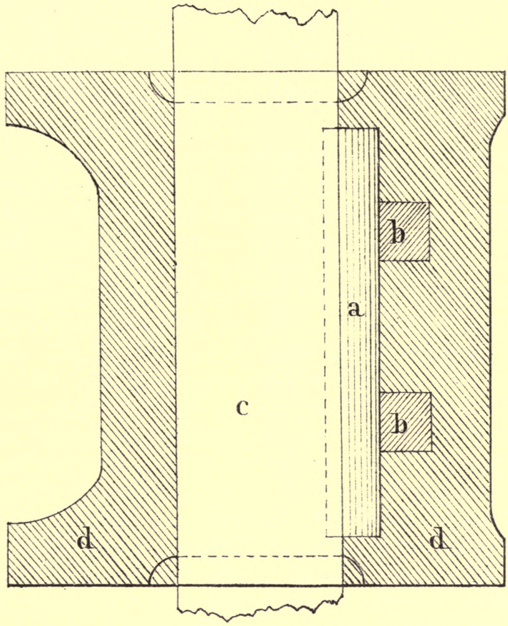
Section IV.

MINING AND CRUSHING OF AURIFEROUS ORES.

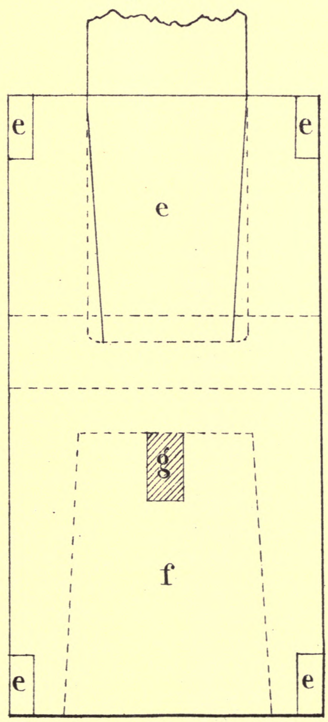
The general use of modern rock-boring machines and nitro-glycerine explosives necessitates, in California, the reduction of these so produced massive blocks of stone by means of "stone-breakers" as in use at Clunes and Bendigo. These supply the circular self-feeders with small ore, and the latter is fed, as needs be, into the boxes, or "mortars." The Californian and Nevadian batteries are arranged in mortars with five stampers in each ; their round stamp-heads and shoes are fixed to the turned "stems," or shanks, in a similar manner as ours, and the following parts form a stamper :—Plate II., the stem, the tappet and gib, the stamp-head or socket, and the shoe ;

PLAT

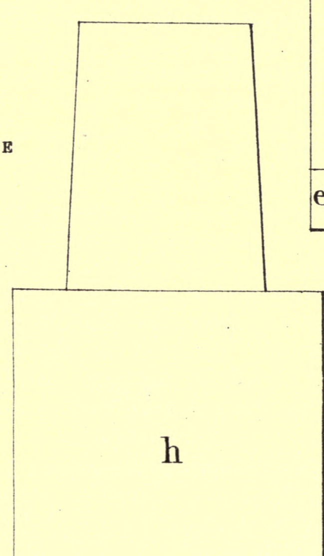
Disc (Tappet)



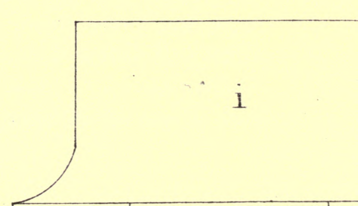
Stamp Head



Shoe



False Bottom (Die)



the "die," or our "false bottom," is somewhat different in form, as its base for 2 inches thick is made in an octagonal form and then contracted to a solid cylinder of the same diameter as the shoe falling upon it, and both are cast of the best white iron. The stem is mostly made of 3 to 3½ inch diameter round wrought iron, 12 feet long, and finished off in a lathe so as to be true cylindrical, and, except at the lower part, which tapers a little, is equal in diameter everywhere, so that its fall or rotation is not impeded in the guides. This taper fits the shoe, and both are secured in the ordinary way, thus resembling ours with exception of the disc, or "tappet," which is secured to the stem in a very effective manner, and this is preferred to our screw-threaded shanks, which were found in America to wear out too quickly from the continual jarring, and the repairs of which added unnecessarily to the expenses for keeping them in working order. The American smooth stem *c* receives the tappet *d d* as it is pushed down from the top to its proper place; the tappet is of cast iron (except at the bottom, where a wrought-iron ring is let into it), and it has in the inner side of the round hole for the stem *c* a cavity or recess *a* for about two-thirds of its height; a piece of wrought iron completely fills that recess and also surrounds the segment of the stem opposite same for the whole width of this gib *a*, as it is termed. A couple of square holes are left at the back of the gib in the solid tappet, where the latter is square, and into these holes two steel keys *b b* are driven from opposite sides, thus fixing by means of this gib the tappet or disc more securely to the stem than such could perhaps be effected by any other method, whilst permitting likewise its shifting as required by simply driving back the two keys mentioned. The weight of these stampers varies greatly throughout the mining regions I visited. At Grass Valley they ranged from 720 lbs. to 1,000 lbs. each; of these, those of the Idaho Company weigh 830 lbs. each, they have 70 drops of 11 inches per minute, with a duty of 1¾ tons of quartz crushed per diem. The Empire Company's stampers are very heavy at 1,000 lbs. each, with 70 drops of 9 inches per minute, and they put through, during the same time, 40 tons with the 20 heads employed. Without particularizing the very many machines I have inspected, I would observe that the *heavier* stampers are preferred in California, and that the drop ranges from 8 to 12 inches in depth, or taking it on the average of 10 inches; the curve of the cams would measure 21¼ inches. The stampers are all revolving the same as in Victoria, and they fall through their guides of sugar-pine, which last, if well seasoned, over eight months in a perfectly satisfactory manner. The water used for crushing is conveyed to the mortars in a similar way to ours, but instead of one or even two jets feeding each mortar, it has been found judicious to give each head a separate jet, so that the gratings are equally washed and cleared in order to facilitate a rapid discharge of the crushed quartz or ore through the same. The quantity of water needed of course depends on the character of the ore, which, if heavily charged with pyrites, requires more, or, if not so, less water. The boxes, *i.e.* "mortars," are similar to ours, but a few improvements are worthy of our attention. They are fed, as already stated, by circular self-feeders (Hendy's*), and the Americans make it a rule to feed "*very thin*," in order to give the gratings or "*screens*" every opportunity to discharge the pulverized ore quickly, because of the very great fineness or extra numbers of holes per square inch in such gratings. These mortars average over 4 feet in length,

* These self-feeders were imported since, patented in this colony, and can be seen at Sandhurst.

by a similar height, and they weigh each about 3,000 lbs. The usual "lip" is cast on to the under part of the feed-hole to prevent the back-splash; the opposite opening or discharge, as intended for the gratings, extends, in order to increase the capabilities of these boxes, for the whole length of same, and the gratings form one piece only, without the usual central dead division, as with us; besides that, the gratings on the top lines *overhang* their base lines, in order to their still further freeing the passage of the fine ore by means of the then more effective splash. Outside the mortars a splash-board is screwed on to the lower part of the discharge rim, in order to deliver the regularly distributed crushed ore on to the blankets or into the launders, which convey it into the "pans." The false bottoms are set inside the mortars on a layer of quartz gravel, and the octagonal form of their bottom renders their removal, on cleaning up, by means of chisels a very easy matter. Those proprietaries which crush their ore *with* quicksilver in the mortars—there are others who prefer not doing so—have found it most advantageous to adopt means by which a much larger percentage of the *free* gold is arrested inside the mortars (Plate III.), and I very soon became convinced that this new method of "*lining*" of boxes or mortars with properly prepared copper plates needed but explanation on my part to lead up to its general adoption in Victoria. There are two ways of fixing these copper plates in such a position as would bring them into constant contact with the crushed ore and the thereby liberated particles of gold.

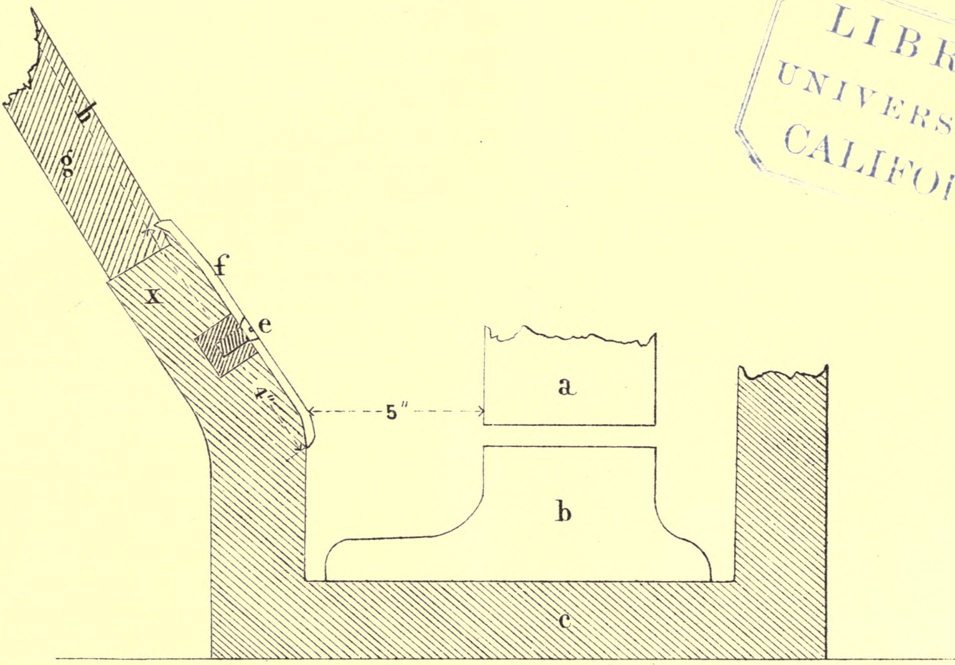
Firstly, the mortars are cast purposely to receive, on proper shelves, this copper-plate lining; and, secondly, the old boxes may be at once adapted for the same purpose until a renewal is necessary, when the first-named should be obtained and no other. It may be mentioned in passing that those mortars prevent any possibility of peculation of amalgam.

The first-named kind of mortars (*see* Plate III.) are cast to a pattern, so as to introduce beneath the rim for the gratings (inside the mortars) a kind of sloping shelf 4 inches wide for the whole length of its front discharge, at an angle of from 30 to 35 degrees towards the false bottoms. Into this shelf four holes *e* are drilled, or recesses cast half an inch in diameter and $1\frac{1}{2}$ inches deep, which are plugged with dry and soft wood. A copper plate of the exact size of this shelf, $\frac{1}{4}$ inch thick, is then laid on a strip of blanketings equal in size, and then four copper screws are inserted through corresponding holes $\frac{1}{8}$ inch diameter, and the copper-plate blanketing into the wooden plugs, which, on getting wet, will swell, and thus the plates are securely screwed down until the next cleaning-off, when they are unscrewed and so forth. Both the upper and lower edges of the plates should receive a batter, in order to make a good joint, and to prevent the fine-crushed ore getting behind same. Any subsequent repairs should be made with copper rivets, and, in fact, the more battered these plates become, the better are they for the interception of gold.

The other method does not necessitate the immediate change in the pattern of the boxes in use until they are unfit for use, and the adaptation of old boxes for these copper plates does not, so far as I could judge, interfere with their efficacy. The ordinary frame *g*, which holds the gratings, is not quite so high, in order that a piece of soft wood *d* (Plate IV.) may be screwed on to its lower part at *d*; it is $3\frac{1}{4}$ inches high and $1\frac{3}{4}$ inches wide; and at the same time lug *c* is made higher by broad strips of boiler-iron, so as to catch both the wooden insertion and the gratings frame properly. At the inner side of the piece of wooden insertion *d* a triangular strip of soft wood *e* is screwed on, which has the prepared copper plate *f* fixed

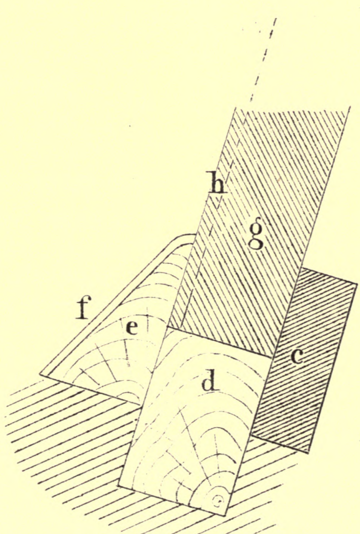
COPPER PLATES IN BOXES.

PLATE III.



a *Shoe.*
b *Die.*
c *Boxes.*
e *Holes plugged with soft wood.*
" *Screw countersunk in Copper Plate.*
f *Copper Plate.*
g *Gratings Frame.*
h *Line for Gratings.*

PLATE IV.



to it, and in this manner the plates will act nearly as well as in the other case.

These "*copper plates*" used for this purpose, and also outside the boxes, are, however, prepared specially with a view of their intercepting nearly all the gold that is splashed over their surface, and, as stated already, the inside plates are from ¼ inch to ⅛ inch thick, whilst outside 1-16 inch thick or ordinary copper plates are used. All these plates are prepared in the following manner, viz.:—They are well cleaned and burnished with very coarse sandpaper, after being straitened out; a coat of good beeswax is then given to the side not cleaned, in order to confine the process to the one side only. The copper plates so prepared are then hung in a bath containing a solution of silver of regulated strength, then they are connected with a battery, and thus electro-plated with pure or coin silver on one side in such a manner and with such a quantity of silver, as will not amount to less than one ounce of silver per square foot; any larger percentage is preferable if the coating presents as *rough as possible* a surface. Without exception, all the superintendents I spoke with declared that no battery is complete without them. The reason why these silvered copper plates are held in such high esteem, is simply as follows:—The copper and silver form, as soon as the quicksilver is added in the usual way for amalgamation, a powerful galvanic battery, the action of which is much increased by the slightly aciduous water generated through crushing pyritous ores passing over these combination plates, and of course any metal such as gold or silver, already susceptible to amalgamation, would at once be absorbed by this very particularly lively mercury.

The following account for the ingredients used in the solution with a five-head battery—less the silver and the battery—sufficed for over ten months, and gives the articles at Californian quotations:—

	dols.	cents.
6 Bunsen's elements	24	00
4 glass cylinders	3	20
5 lbs. cyanide	4	25
1 porous cup	0	50
7 lbs. nitric acid	1	15
50 lbs. cyanide (fused)	37	50
14 lbs. nitric acid	2	50
	73	10

or £14 12s. 1¼d. sterling.

Section V.

VARIOUS MODES FOR TREATING CRUSHED QUARTZ.

The crushed quartz, after it has once passed through the gratings, is manipulated in a much more scientific and thorough a manner than we are accustomed to do on Bendigo. The Californian quartz-miller is evidently imbued with the idea that the collection of gold from the crushed quartz is chiefly dependent on the gradual reduction of these grains of sand to the *greatest possible* fineness, and that, whilst this is going on in various ways, the collection of gold should be proceeded with at different periods of the process, until as near as possible all metalliferous substances have been obtained therefrom, inclusive primarily of the gold they are impregnated with. In order to facilitate this, and meanwhile to save manual labor, the plates are ready from the very commencement of crushing, owing to the lively amalgamating agents introduced, and the amalgam so collected inside the mortars presents a fine hard appearance, needing hammer and chisel to separate it from the plates ; outside, on the tables, a peculiar kind of fine steel wire brushes are used, and acids or knives are altogether avoided in cleaning up. This relates to the heavier portion of the gold liberated by crushing ; the other kind, known in California as "float gold," passes away in the blue muddy water with the tailings, but it is subsequently intercepted on other copper plates, as will be described below.

The Screens (Gratings).—It appears to anyone studying the reduction of the ores in California, as if their experts could not rest satisfied with any kind of appliance, machine, or process they operate with, but that they must vary them or invent something fresh ; the effects thereby obtained are carefully observed, and a large portion of their otherwise unoccupied time is given freely with that end in view. This is the result of their most liberal code of patent laws, which induce the people to exert themselves to invent something new, well knowing that their capitalists are ever willing to assist and purchase new inventions if proved valuable after trial. In this instance we know that gratings are made here chiefly of iron plates, perforated by machinery ; in California, however, the same plates are also used, but they are made without a " burr " like ours at one side ; secondly, they make their holes oblong and either horizontal or diagonal. The American "screens" are likewise made of brass and steel wire gauze ; the brass-wire gauzes are manufactured up to No. 40 ; for instance, in the Empire Company's batteries the screen frames are 4 feet long by a height of 9 inches, and, as their screen number indicates, there are not less than 1,400 holes per square inch, and still they crush on an average 40 tons per diem with their 20-head battery. The Californian iron-plate screens are made of the best Russian iron, which is of a very tenacious character, and the size of the holes and number per square inch is ascertained and regulated by various sizes of sewing needles, which also perform the work as punchers. The narrow slit screens are also a novelty, possessing, however, obvious advantages over those with round holes ; raw quartz, or ore when crushed, presents oblong particles chiefly, and thus the "*slotted*" screens discharge the particles with much greater speed than those of any other description, and they are therefore very highly esteemed. The slits are from ⅜ of an inch in length, and the ordinary width, and as they are either horizontally or diagonally placed, they clear themselves very rapidly. Considering the heavy Californian stampers, which reduce their quartz very quickly, more than we can do with our lighter stampers, these slotted screens, placed in their frames with a "hang" forward on top, permit them to get through as large, if not larger, quantities of ore per head, than we can expect to do with gratings in a vertical position and a very much less number of holes per square inch. In point of fact, they crush finer, and therefore liberate more gold for amalgamation on their copper plates.

In order to do all this at the least expense of manual labor the quartz-miller locates his machinery at an elevation which, as a rule, is never less than 25 feet above the tailings shoots, which latter are also calculated for a fall of from 3 inches in the foot. The floors of the mill are arranged in terraces, in order to facilitate the passage of the ores under treatment from one machine to the other without too much manual labor.

The Empire Company have adopted a treatment of their ore entirely different from others, though quite as satisfactory, as proved by the results of periodical assays made both of the ores and their "*wastes.*" The crushed ore, after passing through the screens, is passed over a series of copper-plate (electro) ripples into four grinding pans. Before I proceed any further I am compelled to notice what the American mine superintendents term their "*pan system*," which is the successor of the old arastras, then Chilian mills, Berdan's basins, until eventually the present "*pans*" were perfected to such a degree of usefulness as to give not only every satisfaction but likewise prove their admirable utility with both gold and silver ores; their general adoption is therefore, in California, the outcome of well-tested work against many other appliances invented for similar purposes, but which could only be successful with this "*pan system.*" To resume, these grinding pans are of cast iron, 5 feet 6 inches in diameter, and 1 foot 9 inches high. Their central spindle is set in motion by a bevel gear running underneath each pan, and a vertical spindle sets in motion the "*muller*," a kind of inverted cone that can be raised or be depressed, as required, by the screw thread cut into the central spindle. This muller communicates the required circular motion to a double layer of triangular, bevelled, and perforated plates of chilled cast iron, so that the sand is subjected to a severe grinding and thorough mixing for such time as is requisite at this stage. The pans have a false bottom, furnished with grooves and recesses for the mercury, so that any gold ground out of this already very fine sand is readily amalgamated. Of course, the speed to be given to the muller depends on the character of the ore, but a higher speed is generally preferred, because by it the golden particles are freed from films coating same and burnished for immediate action by the mercury. This "*pulp*," as it is termed, is regularly removed and placed into the "*settlers*," which are also pans worked the same way, but instead of grinding plates four equi-distant arms extend from the muller, from which arms depend a series of iron teeth and plates, by means of which this pulp is stirred with a graduated and copious supply of water, so that all particles of amalgam and mercury fall to the bottom of their own gravity, and are then further dealt with. At certain times, which suggest themselves by practice only, the so enriched strata of the pulp is removed into the last set of pans, termed the "*concentrators;*" these are double the size of the last, viz., 10 feet diameter by 3 feet 4 inches high, and they are made of wooden staves at the sides only, the bottom being cast iron. In these concentrators the weekly results of the treatment are collected in the shape of amalgam, to be retorted monthly; besides that, the pyrites are principally obtained also from these concentrators. The above process, so much more complicated than ours, includes therefore the following features, viz.:—Crushing through gratings, 1,400 holes per square inch; electro-plated copper plates and shallow ripples with mercury; grinding the fine sand still finer; stirring the pulp to deposit amalgam; concentration of amalgam, and finally collection of it and of the pyrites.

Elaborate as the above process may appear to us on Bendigo, that of the Idaho Company, in the same district, is still more so, and I submit that, by describing these two, all practical purposes are served, because at the other mills inspected, either one or the other, or part of one and part of another, had been adopted by the superintendents in charge.

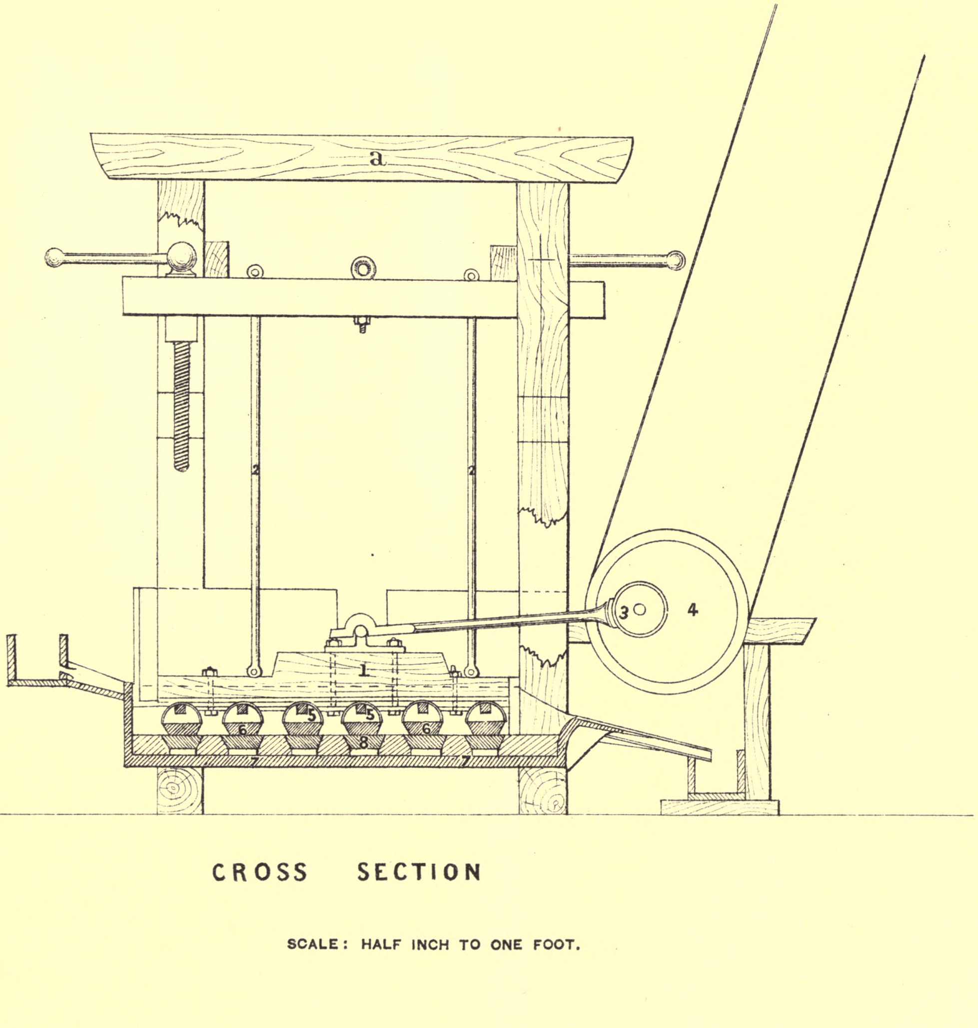
The Idaho Company is the most successful proprietary mining auriferous quartz on the Pacific slopes. Their profits, at the rate of 7½ per cent. per month on their capital, have been regularly paid for the last hundred and twenty odd times (July 1877), and the mine has been opened so as to provide similar work for at least eight to twelve years longer. Their machinery for treating their quartz is on a very comprehensive scale, which will be seen from the fact that their apparatus in the mill extends from the stamp-heads to the tailings-shoots, fully 270 feet. The tailings are subsequently treated as will be seen further on, and as the machinery employed presents many valuable features, quite new to Victorian mine managers, a description of the apparatus will be found interesting and instructive.

Seven batteries, of five heads each, are employed; the stampers weigh 830 lbs. each, and they are worked with a fall of 11 inches, and 70 drops per minute; the screens are of the slotted kind, eight slots to the square inch, and mercury is *not* put into their mortars. Outside the sand runs over the splash-board into the distributors, which feed the blanket strakes of the ordinary dimensions. These blankets are specially woven in San Francisco, of pure wool, and they are of a much more durable and suitable description than ours; one width is sufficient for three breadths of strakes. The blanket strakes are temporarily fixed on trestles, so that they can be taken down and put aside whilst cleaning off, and all the floors are very neatly paved with stone or wooden planks.

Previous to my proceeding further, I would call attention to the Californian method of transmitting motive-power to their batteries and all other working appliances by means of pulleys and belts. The reasons given for doing away with the pinion working direct the cam and counter-shafts were to the effect that, firstly, the engines were injured by the vibrations communicated to them if geared for direct action, and, secondly, that the pans and other apparatus were driven at different speeds, which could only be obtained by means of pulleys of various diameters and corresponding belts. The difficulty of these belts maintaining their constant and uniform tension had been overcome by means of intermediate sliding and bracing pulleys to each belt.

Every twenty minutes the blankets are washed in wooden troughs at the end of the strakes. At this point the treatment or process takes two different directions: one is destined for the treatment of the blanketings principally, and the other for the manipulation of the sand which has passed over the blankets into the launders. Following the blanketings, it will be found that they are shovelled into a machine called the Attwood's amalgamator, such being a kind of inclined table, from the top of which the blanketings are gradually washed down, by means of a hose conveying warm water (110 deg. Fahr.), into two very deep quicksilver wells, each of which contains one hundredweight of mercury. Owing to the incline given to this amalgamator, these wells are located beneath each other, so that the ore which passes out of the top one is washed into the second well. Each well is geared with a barrel of solid wood, 8 inches in diameter, into which eleven rows of round $\frac{1}{4}$-inch spikes are inserted, and both barrels are driven off a pulley, so as to agitate and force the blanketings into this bath of mercury. What passes out of the lower well is simply composed of pure pyrites and such as have particles of very light gold attached to same. These residues pass along a shoot, on to a ripple table 15 feet in length, 3 feet in width, the sides being 5 inches high. This table is lined throughout with strips of electro-copper plates; and the sand then feeds three of Hendy's grinding pans, in which each charge is ground for eight hours, such charge being the quantity collected during the previous eight hours from thirty-five heads in the batteries. The pans are 4 feet in diameter, and 15 inches high at the sides. Superheated steam is occasionally introduced at the joint of the real and false bottom whilst the pan is closed. The false bottom has a ripple cut at the circumference, $1\frac{1}{2}$ inches wide by 1 inch deep, for the mercury; and the

HUNTER'S RUBBER. PLATE V.



CROSS SECTION

SCALE: HALF INCH TO ONE FOOT.

use of superheated steam has been proved exceptionally beneficial, as it accelerates amalgamation, through vaporizing the mercury and keeping it always bright and susceptible for gold absorption. The "mullers" in these pans revolve but ten to twelve times per minute, and the steam is introduced every three to four hours, when the blanketings, or what remains of them, have been ground fine enough. Besides the action of the steam, the pair of pans in each set are opened twice every day, and the following substances, mixed, are added to the "pulp," viz., one part of Sal Ammonia, three parts of saltpetre, weighing about $\frac{1}{4}$ lb. the lot; 1 lb. of quicklime is also given at the same time, by means of which a chemical reaction is produced, which results in the rapid extraction of the free gold. The remaining pulps pass into the principal launder for future treatment.

The expense for grinding and treating blanketings amounts to one dollar per diem each pan, and the daily duty of the eight pans employed amounts to 9,600 lbs., or 1,200 lbs. each of the eight pans employed. It is possible to grind these blanketings and sands so as to deprive them by mechanical means of nearly all the gold they may be charged with; but this has been found both too expensive and not nearly so effectual as if these residues were finally disposed of, after calcination, by the chlorination process. Returning now to the second portion of the crushed ore which passed over the blankets into the shoots, it should be mentioned that the strakes have a "grade" of $1\frac{1}{2}$ inches per foot, and the ripple table 1 inch per foot.

Hunter's Rubbers.—These machines receive the above—viz., crushed ore passed over blankets—which are still impregnated with a good percentage of very light or "float gold," both from the strakes direct and from the grinding pans as already described, but neither steam nor chemicals are used in their manipulation. This Hunter's rubber (Plate V.,) is rather a complicated machine, combining, like most other American gold-saving appliances, two or three different actions, viz., grinding, amalgamation, and concentration. It has a similar appearance, it will be seen, as the old shaking tables, and its motion is also similar; but in detail it differs materially from the former. From the frame-work *a* well stayed, depend two bearers (1), by means of four bars of round iron (2, 2), and these are rocked fifty times a minute by two excentrics (3), and pulleys (4), with a stroke from 5 to 7 inches. Six pieces of pine wood (5.5.5.5.5.5.) are bolted to the bearers longitudinally, their tops being round and the bottom square, where they are armed at the bottom with the same number of shoes (6.6.6.6.6.6.), all these being the really movable parts of the machine. In a strong cast-iron box a false bottom is laid by means of alternate strips of wood and cast-iron dies, in the same longitudinal fashion, so that the shoes rub upon the dies and thereby grind the ores. At the same time the tops of the wooden strips (5) are covered with electro-copper plates, and as they are immersed, any, in fact nearly all the float gold liberated by the grinding is collected at the apex of each cylindrical copper plate, and the pyrites are also concentrated in this box. This is a very valuable machine, as it collects from 10 to 12 per cent. of gold that would otherwise float away with the blue slimy water, which it is well known is allowed to escape elsewhere.

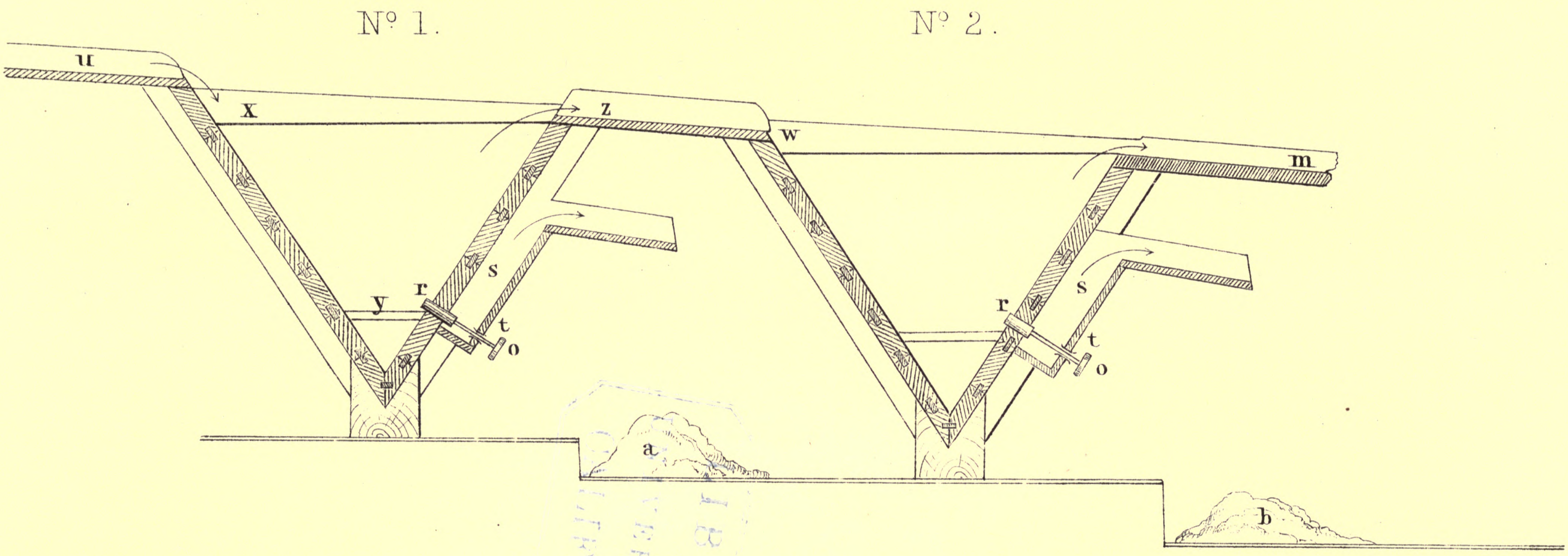
At each operation residues escape, and they find their way from the rubber into the chief launder, where they join those left over from the blanketings treated as detailed. All these residues then pass into the distributor at the head of the "*Hungarian sizing boxes.*"

Plate VI.—The principle of these boxes is governed by the fact that fine sands, if dropped into deep water, will reach the bottom quicker or slower, in accordance with their respective specific gravity. To facilitate the process, these boxes are made with sloping sides (50 degrees) towards a centre, and each set may comprise any number, but in succession, those, after the first box increase in size, and produce of course residues of different values, *a* and *b*. The sizing boxes are filled with water after closing valve *o*, then the residues are allowed to flow slowly into the first box, where the first separation takes place, the metalliferous portions covering the bottom, and the lighter portions rising and eventually flowing through *Z* into No. II. box at *W*, which is a few inches lower at its inlet than at *u*. Both or any of these boxes are provided with a valve *r* at or near the bottom, through which the heavier ores may be withdrawn by turning the handle *o* in the stuffing-box *t*. Inasmuch, however, as this opening of the valve would effect a sudden rush of the total contents out of the box, on account of the great weight of water and sand combined, the launder *S* has been constructed with a view of counterbalancing this pressure by forcing the slimes or sands up to a certain height, where they discharge as class *a*, *b*, or other less valuable resultants, as the case may be, if other boxes are used. The latter residues are again ground in the Hendy's pans with steam and chemicals, and those discharged at *m* from the sizing boxes are passed into the "automatic sluices," which are simply a species of "tyes," which, however, work quite satisfactorily "*without*" any manual labor. They are 15 feet long, 4 feet deep, and 2 feet wide, set at a grade of $1\frac{3}{4}$ inches per foot. At the discharge end, a door is fixed within guides at either side of the sluice, but that door is open when its top is *below* the bottom of the sluices, and the latter are closed by the door rising to its full height of over 3 feet 6 inches. The working of the sluices and of the door is regulated by the amount of supply of sands at the upper end, and accomplished by means of an intricate set of machinery, which is set in motion by a crossed belt from the vertical spindle of the adjacent buddle, and causes this door to rise the 3 feet 6 inches, or more, required within every twenty-four hours. With an extra quantity of water added, the sands fall into the top of the sluices, and the heavier parts remain there, whilst the lighter pass over the door at the end, and in this manner the separation of both goes on without manual labor and very little superintendence, in fact the panmen overlook quite a number of such appliances. The pyrites so obtained are again passed through the sizing boxes, and the residues ensuing therefrom are worked in concave buddles of the ordinary description, of which there are two in each set. These buddles concentrate, generally speaking, only up to a certain percentage, the remainder being sand ; to remove that sand the same pyrites are slowly fed into the "tossing tubs," an old Cornish invention, I believe, but very effective for the purposes intended.

These "*tossing tubs*" are simply open vats constructed of sugar-pine staves and bottom ; the staves are $2\frac{1}{2}$ inches thick, and the tubs generally measure 4 feet 4 inches wide at the top by 3 feet 10 inches at the bottom, inside measurement, by a height of 2 feet 6 inches, a central and vertical shaft passes through the bottom stuffing-box, and it is made to revolve at the rate of fifty-three revolutions per minute. The shaft is furnished with two projecting arms, level with the top of the tub, which are bent down so as nearly to touch the inside periphery, and also the bottom of the tub ; a series of flat pieces of iron fixed on edge are screwed at different heights and angles to these arms, so that by the revolution of the spindle this

PLATE VI.

HUNGARIAN SIZING BOXES.

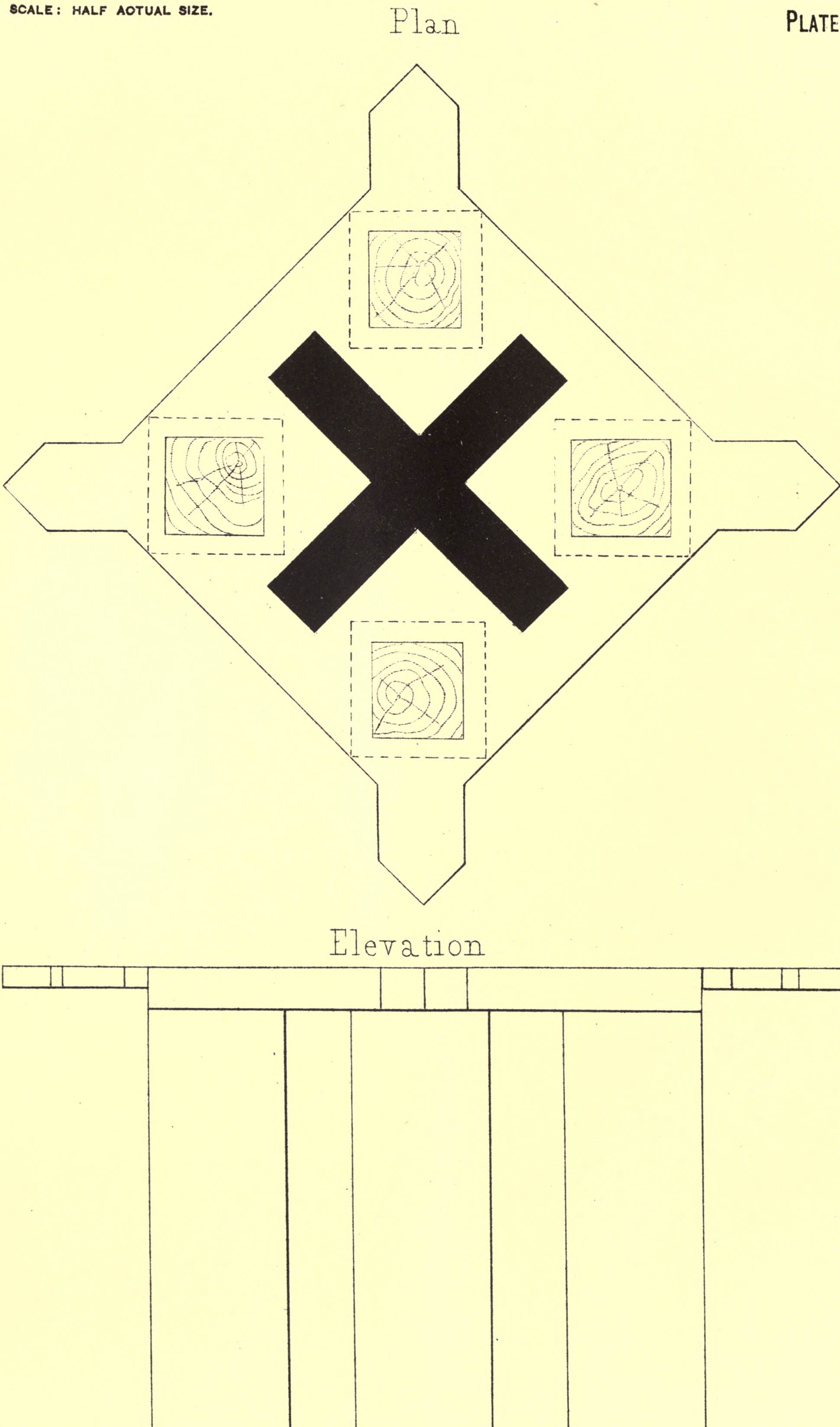


SCALE: HALF INCH TO ONE FOOT.

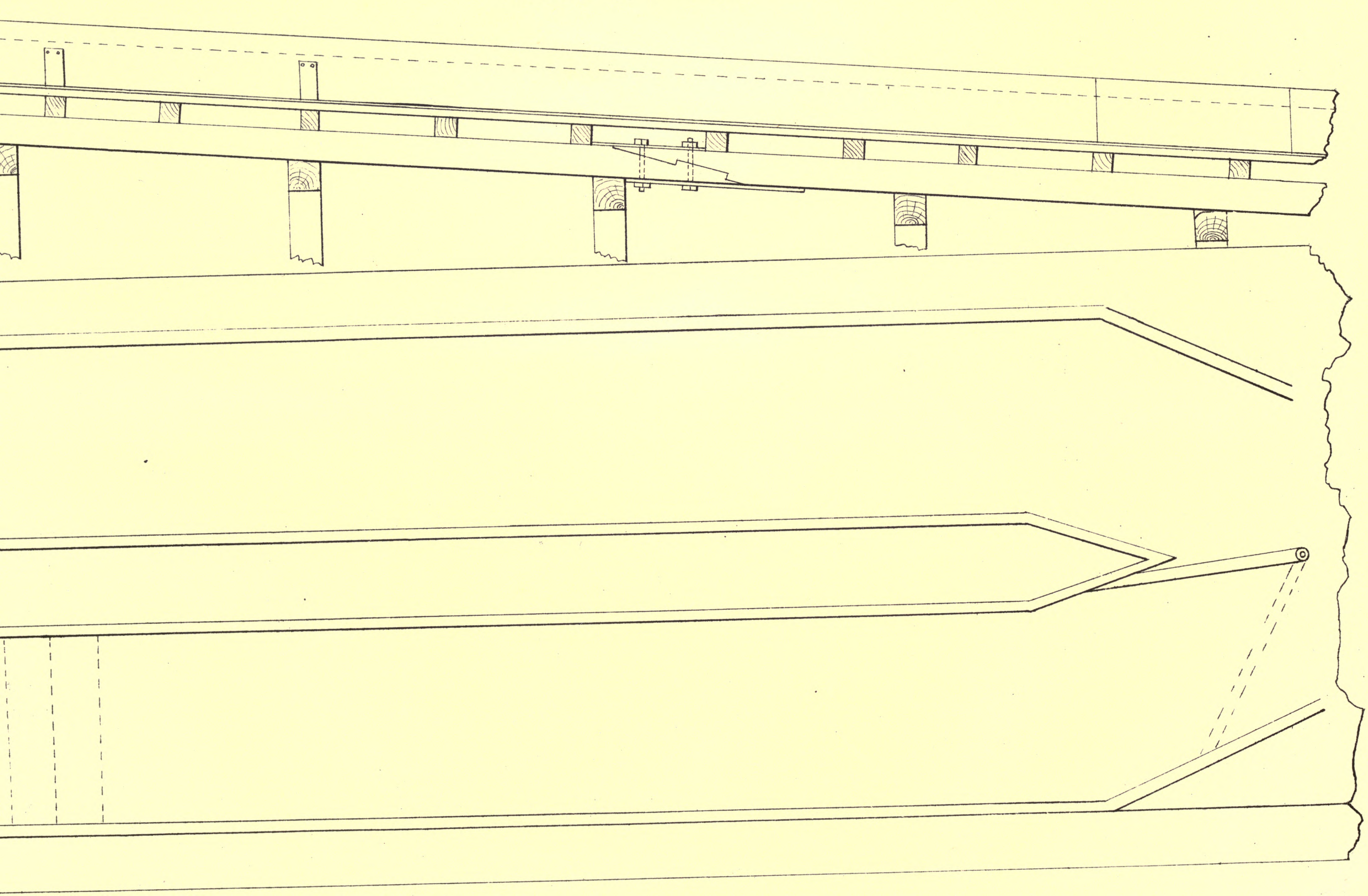
McDOUGALL'S FLOAT GOLD RIPPLES.

SCALE: HALF ACTUAL SIZE.

PLATE VII.



SCALE: HALF INCH TO ONE FOOT.



apparatus agitates the water and pyrites to a very considerable degree, in fact the metalliferous and sandy contents are prevented from settling. While these arms revolve, a contrivance, consisting of two thorns at the driving wheel of the bevel gear, working the whole apparatus off a belt, communicates a rapid striking motion to a compound lever, fixed at the outside of the tub, at the end of which lever a five-pound hammer is fixed, which strikes the outside of the tub in the manner described. These blows tend to settle gradually all the heavier ores first, followed by the sands after, and thus a very complete separation of these products is obtained. On completion of a certain quantity, the spindle is hoisted out of the tub, and below a few inches of sand the pyrites will be found, worth, in the case of the Idaho Company, after paying for working expenses, from 50 to 60 dollars per ton, if manipulated by the chlorination process. There now remain the sands covering the pyrites in the tossing tub, and those flowing over the top of the door in the automatic sluices, which constitute the "tailings" in California.

Inasmuch as these tailings "*on assay*" show some gold, they are submitted to further and final treatment by means of the *McDougall's "float-gold ripples"* (Plate VII.). These are simply sets of tables coupled together, each 18 feet long, 2 feet 6 inches wide, with a pitch of from 6 to 12 inches for every length of each table. They are lined with electro-copper plates, except where they contract in width, and are covered with a kind of shoe of peculiar form (Plate VIIA.). These shoes are set in rows at *B*, close together, and, as they are hollow, their cast-iron pedicles, *a*, *b*, *c*, *d*, four in number, are filled with wooden blocks. The tailings running over them enter the cross-like aperture on top, shown in the diagram, and thus a kind of eddy is formed at the base of their four pedicles, practically resulting in the deposit of something more than two per cent. of the finest float, foam, or leaf gold obtainable by these simple means, and *after* all these variously elaborate processes of gold extraction described above.

To recapitulate the treatment followed, in short, it would stand thus:—

Empire Company's Process:

From stonebreaker to battery by means of self feeders without mercury;

Brass gauge screens (gratings) with 1,400 holes to the square inch;

Electro-copper-plate ripples.

Pan-system:

Grinding, concentrating pans, with concurrent amalgamation.

NOTE.—Distance covered by various apparatus enumerated above, about 180 feet from boxes *without* final treatment of tailings or slimes.

At the Idaho company's mills the process is still more elaborate, though the ore operated on does not materially differ from that obtained by the Empire Company in the same locality :—

IDAHO COMPANY'S PROCESS.

From stonebreaker by means of self-feeders *to* battery with mercury.
Boxes lined with electro-copper plates ; diagonally-slotted iron-plate screens ; movable blanket strakes :—

Blanketings into blanket troughs ; Attwood's amalgamator :

Sands : Over electro-copper plate—ripple tables ; residues into

Metalliferous residues : Hendy's grinding pans using superheated steam and chemicals ; with concurrent amalgamation and concentration of sulphurets ; residues into

Sands passing over blankets into launders ; thence into Hunter's rubbers ; metalliferous residues into

Sands into

Hungarian sizing boxes ; automatic sluices ; concave buddles, and tossing tubs.

Pyrites for chlorination.

Tailings for McDougall's "float-gold ripples."

Final resultants :— Amalgam for retorting. Wastes.

NOTE.—"Total distance taken up by the above gold-saving apparatus, as measured from centre of stamp-heads to float-gold ripples, 270 feet." "It should likewise be stated that the Californian gold in quartz is, on average, of the same coarse or fine character as here, and that every one of the above machines saves a percentage of the gold embedded in the matrix."

I venture to think it would serve the purposes of this paper well, if I were to quote from a late work published by M. Walter A. Skidmore, U. S., Deputy Mineral Surveyor and Assayer, on gold mining and loss of mercury, viz. :—

"The losses of precious metals, in their treatment, may be classed as follows :—

"1st. Fine gold passing the screens and carried by the current of water over the blankets, plates, and other appliances of amalgamation. Some coarse particles are flattened by the stamps, and expose a large surface in proportion to weight ; these also float on the water current.

"2nd. Gold enfilmed with sulphurets of iron, copper, arsenic, &c., whereby it is rendered unamalgamable.

"3rd. Gold held by '*floured*' mercury.

"4th. The incidental loss of mercury.

"5th. Silver, either free or in association with gold.

"Table of the losses sustained in gold-mining countries, giving the authority on which the statements are made :—

Country.	Loss per cent.	Authority.
San Juan del Rey (Brazils)	30	Journal of Society of Arts.
Piedmont	35	" "
Hungary	50	" "
Chili	66	" "
Australia ?	25	Thompson.
Colorado (gold)	40	Reichenecker.
" (silver)	70	Raymond.
California (gold)	27	Deetkin."

Speaking of the fineness of gold in vein matter, he continues :—"A case in point occurring at our works at Grass Valley a few days since is deserving of mention in this connection. A sample of ore of hard, glassy, and flinty appearance was consigned to the Fryers' Company for treatment. . . . . . . The rock attracted attention on account of its barren appearance, and was uniformly pronounced worthless by all to whom it was submitted. . . . . . On pounding . . . . . the visible colors were so fine that they would have passed through an ordinary assay screen of 2,500 meshes to the square inch. This ore yielded on treatment . . . 80 dollars per ton. The elaborate experiments of Mr. Deetkin, of Grass Valley, at the Eureka and Idaho mills, showeth that the 'gold contents' of their rock crushed were $68\frac{67}{100}$ dollars per ton—assay value ; of which $47\frac{40}{100}$ dollars was saved by the mill, and $2\frac{50}{100}$ dollars by the concentrators ; $18\frac{67}{100}$ dollars, or about 27 per cent. of the known contents, was lost in the tailings ; $3\frac{1}{3}$ per cent. being very fine gold ; and yet these two mines are not amongst the 'refractory' mines of the State."

As I am not aware of there having been any observations made on the above important subject, though a Mr. Thompson states the loss at 25 per cent. only in Australia, there are no data to guide one to say from what mines or mills that gentleman derived his observations, and upon what kind of ores he based his calculations, and which, comparing the great pains taken in California, as shown above, with our much less effective efforts in the same direction, ought to be much more than only a 25 per cent. loss ; so that there appears to be much room for enquiry on this and kindred subjects by our practical mining experts. And, consequently, as the loss of mercury in California during crushing may not altogether prove uninteresting :—" Mr. Hague, of the Fortieth Parallel Survey, made numerous experiments at the Sheffield Laboratory of Yale College, which undoubtedly were conducted with great care and consummate skill, and he considers that the loss of mercury may be chiefly considered mechanical, and only to a limited extent chemical. The more the mercury is ground, the greater the difficulty in recovering it. If the consumption of iron is assumed to measure the grinding effect given by the pans, the relation between the loss of mercury and that of iron should be in a certain degree proportionate. According to his experiments, the loss of iron in batteries and pans was from $9\frac{1}{4}$ to $12\frac{1}{3}$ lbs. per ton of ore. The data with respect to the loss of quicksilver . . . . . justify the opinion that the loss is from $2\frac{1}{2}$ to 3 lbs. per ton of ore, and of iron castings, by wear and tear, about 10 lbs. per ton of ore."

Previous to my continuing to report on these and kindred matters, I would respectfully request our mining managers, or experts in mining matters, firstly, to draw their own conclusions; and, secondly, to determine whether or not any similarly severe and elaborate treatment of our quartz has been carried out in this colony. And also whether, with our simple and crude treatment on Bendigo—which produces, as a type for Australia in general, according to the above table, the lowest loss in gold-mining countries—we could not, allowing that table to be correct, which is open to considerable doubt, reduce that loss considerably by adopting some portions or the whole of the more elaborate and effective Californian method, and thus render reefs payable that cannot now, owing to their low yield of gold, be worked remuneratively. It should be remembered that the Californians control their processes step by step by average assays; that they have a full knowledge of what their ore ought to turn out; and that they have added and are still inventing machinery, by means of which they purpose to reduce the loss they suffer, whilst we are altogether too cautious to introduce anything out of the common, or what would require at its initiation a greater amount of skill and care to work successfully for the benefit of the district. Some general idea of loss of gold on working may be obtained at regular intervals during each day by sampling the residues. This can be done by simply placing a bucket, to receive at various stages during the process, under the launders, shoots, &c., and by doing so every two hours, the contents of such buckets should be emptied into a larger vessel, well stirred and allowed to stand for a while, in order to cause the deposition of the suspended matter at the bottom. The water should then be carefully decanted, by means of a syphon, and the slimes and sands dried, thoroughly mixed, and average samples of each submitted to both wet and dry assay. To illustrate the specific gravity of various particles of gold, of either a round, flattened, porous, or float kind of form, take a glass tube 2 feet 6 inches long, and fill it with pure rain-water, then add these particles of gold, and it will be seen, on closing the open end by a stopper and turning it downwards, that the falling speed of the gold varies considerably; the round particles reaching the bottom of the tube first, whereas the float-gold will swim for a considerable while ere it also descends downwards. If this result takes place in "still" water, what a displacement must take place in water violently agitated by the stampers, and flowing over planes constructed at considerable grades or inclines! In my opinion, I submit we have the ore or quartz sufficiently auriferous in large quantities throughout Victoria, and this supply will doubtless be augmented by the deep-ground discoveries; therefore the general introduction of approved methods of treatment, even if such treatment should be surrounded by the difficulties attending "refractory" and "rebellious" substances impregnating such ores, cannot be undertaken too soon. And I may also state that during the whole of my peregrinations in the Californian quartz-mining districts, I have not observed any quartz that would compare unfavorably in that respect with that of our Victorian mines; and I specially took notice of the great scarcity of arsenical pyrites and galena so frequently associated with rich quartz on Bendigo. As it is well known that our gold is both heavier and purer than that of California, any more perfect treatment should, in our case, add proportionally to the yield hitherto obtained, because the Pacific treatment is so superior to that in vogue at most of our crushing machines.

Under these circumstances, and after mature consideration, I would strongly support any movement for a test to be made on a fair and comprehensive basis, between the complicated Californian methods of treatment with gold-bearing and pyritous quartz and that which obtains the most favor on Bendigo or elsewhere. In one of my reports published by the *Argus* I have already given the results of a crushing of quartz, that, owing to its "hungry" appearance, would be held as worthless or nearly so. The return, however, proved a very profitable one indeed, and can only be ascribed to the superior treatment adopted in that State. And it should also be borne in mind that our appliances deal principally with the saving of *free* gold; secondarily, with the rough concentration of pyrites; and, thirdly, with the calcination and grinding of the latter. The exclusive *calcination* and *grinding* of desulphurized pyrites has been abandoned in California for the last twelve years or more.

Having given a concise description, and a few out of the original diagrams prepared for the report, for the purpose of comparing them with our most approved systems, I would now add a few facts concerning machines that are giving great satisfaction under certain conditions, both in crushing and concentrating of ores.

In the opinion of many American mine superintendents, the present stampers are both too costly and require too much power in order to achieve certain results; certain kinds of ore need different kinds of machinery to reduce them than what is done by the fall of the stamp-head. Amongst these the *Bruckner's pulverizer* operates upon ore passed through the stone-breaker, and this machine I saw at work, when it crushed 18 tons of very hard quartz in 24 hours, at an expense of only 6 horse-power; the result was an impalpable powder, and the same amount of work would take 10 heads and 10 horse-power to accomplish. As this machine is very compact, needs no extra foundations, and, besides, requires very little repair, it has been recommended in many cases to take the place of stamping batteries. It is simply a large horizontal cylinder, worked off a belt and pulleys, with a speed of 22 revolutions per minute; there are two central shafts inside of each other, one to receive the coarse ore, and the other is used for the removal of the crushed ore, which latter should be nearly or altogether dry. The inner cylinder, 4 feet in diameter, contains 1,500 lbs. weight of chilled cast-iron balls, each from 1 to 4 inches in diameter, which act as crushers on the ore fed through one of the two hollow shafts; the finer powder thus produced would necessarily interfere with rapid crushing were it not for the lining of this drum or cylinder, which consists of chilled cast-iron ribs laid longitudinally, and riveted so as to provide very narrow slits between. Through these slits the crushed ore falls on to a rather coarse screen and the finer particles on other and much finer screens, so that eventually a very fine sand is produced by these disintegrating balls. This fine sand falls through the inner hollow shaft into a receptacle, whence it is conveyed to the appliances ordinarily used for concentration and amalgamation. Inasmuch as these screens separate the fine from the yet coarse ore, the latter falls into recesses, having direct radial communication with the inner drum, when they are subjected to repeated crushings by means of the iron balls until fine enough. This machine, complete for work as exhibited, would cost in San Francisco about £330, and its work is certainly equal to that of a 10-head battery.

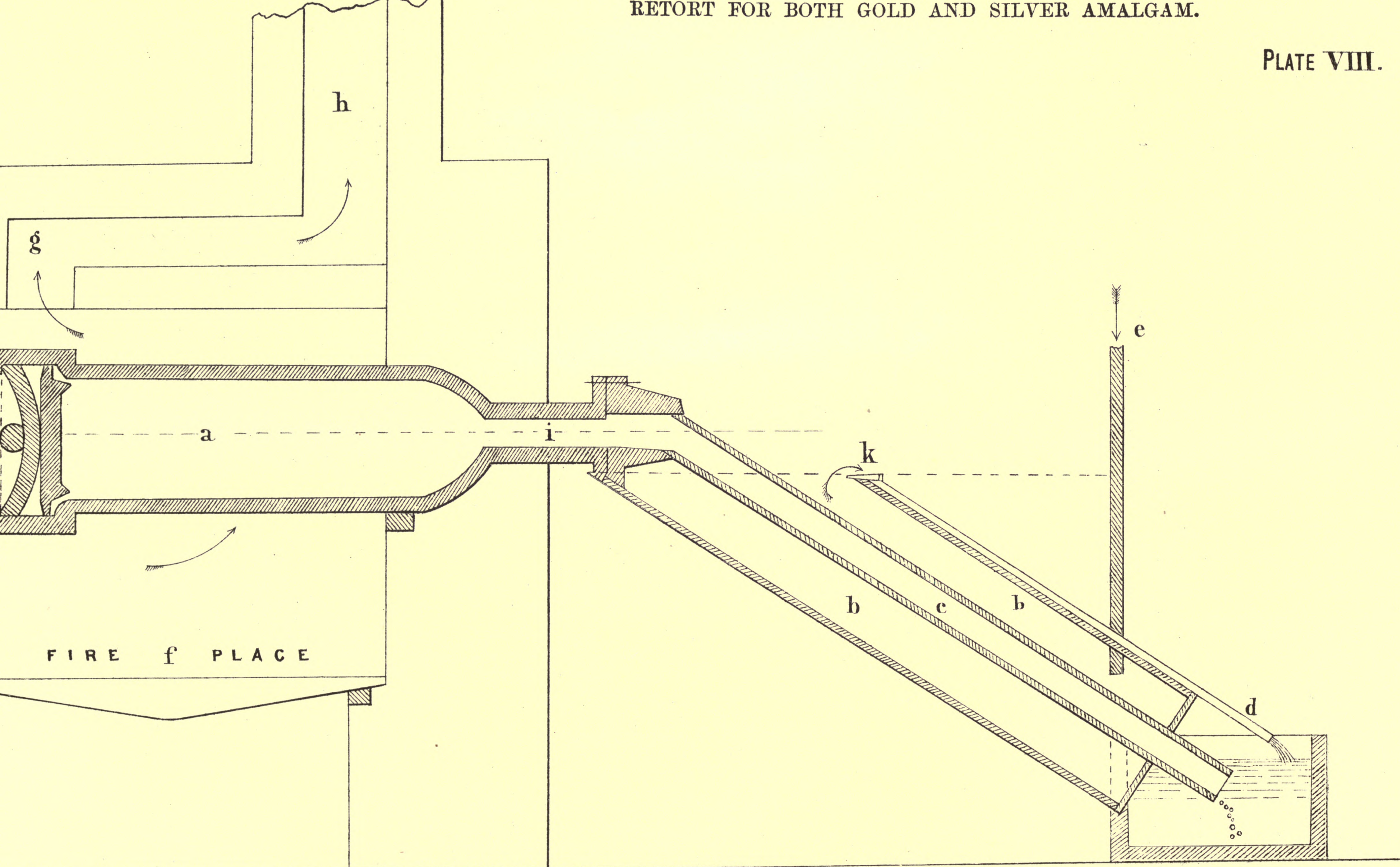
The Frue Ore Concentrator.—This machine is simply an improvement in many respects upon the well-known "*endless blankets*," first brought under notice, I am informed, by Mr. Thomas Carpenter, M.E. Its Californian prototype is on the same principle as a revolving and endless blanket, only, the materials used are of greater durability, and some additional improvemets in working have aided in the perfection of the machine. Two principal rollers at each end of the machine carry the "*belt*," or endless blanket. These rollers are made of galvanized sheet iron riveted together, 13 inches in diameter, and 51 inches in length; and a larger roller, 24 inches diameter, is fixed midways and a few inches below the line of the lower periphery of the two end rollers, so that the belt travels on *top* of the end and *beneath* the intermediate roller. A fourth roller is provided, made of hard wood, which is geared to a movable plummer-block by a screw. This screw is also used to take up any slack on the belt caused by the weight of the stuff and water, thus preventing the "bagging" of the belt. This belt is 4 feet wide by 27½ feet long, and it travels on a number of intermediate wooden rollers, so as to keep an even surface; it is made of vulcanized rubber, A 1 3-ply navy canvas, and it has two rims at the sides, raised to 1½ inches, thus forming an even narrow channel. The sands (crushed or otherwise) are run through a distributor upon this revolving belt in this way, that the belt travels towards the feed, and at the same time an additional supply of water, arranged in irregular drops or jets, is thrown in, so as to prevent the sand from forming ridges or grooves. When working, not less than half an inch of sand should cover the belt; and in order to improve the action of the belt as a concentrator still further, three flat steel springs are provided, which are worked by cranks off the rollers. These springs communicate a quick lateral action—about 190 per minute—to the belt, thus inducing a kind of wavy motion, which results in bringing the lighter sands on the belt to the surface to be washed away. As the belt travels along, carrying the sands, the result is as follows:—The concentration takes place just beneath the feed, where the metalliferous and concentrated parts of same are carried in the opposite direction of the feed, whereas the wastes remain on the belt until they fall into a launder at the opposite end. The concentrated pyrites on the belt are immersed in the vessel provided below, in order to be collected. These machines work very easily, and one lad can attend to more than half a dozen of them, the only thing that wants regulation being the additional supply of pure water during the process. They may be placed immediately beneath the tailings-shoots, where they can treat from 6 to 10 tons per day. Some kindred concentrators require an inordinate amount of motive-power, in some cases up to three or more horse-power each; but, in this instance, from a quarter to half horse-power is quite ample for the purpose. The results of samples of raw sands washed in my presence at San Francisco for concentration were most satisfactory. Both tailings and black sand as thrown up by the Pacific Ocean were tested with equally convincing results as to the capability of this concentrator. As regards the black sand, as mixed with titaniferous iron-sand, and more difficult to separate than free gold and pyrites from tailings, systematic tests were made and average samples obtained for assay, which gave 8·27 dollars per ton of *unconcentrated sand* as found *in situ* at the coast. This sand, after treatment in the Frue's concentrator, had been enriched to 1,935·43 dollars per ton, with but a slight trace of gold in the tailings. This is a machine eminently suited for re-working old tailings.

RETORTING.

The Californian gold retorts are in some districts similar to ours, only that when the old retorts are used the usual syphon pipe is placed at one

RETORT FOR BOTH GOLD AND SILVER AMALGAM.

PLATE VIII.



side of the lid, whereby one clamp is only necessary instead of two, if that pipe was as usual screwed in at the centre. Then, again, the lower end of the syphon pipe is let into a sheet-iron cylinder, 5 inches in diameter by 2 feet long, perfectly watertight at the joints; on top of this cylinder a funnel is riveted leading into the cylinder; also on the top a syphon fixed the same way, taking care that the lower or outlet pipe is at least 1 inch lower in level than the inlet funnel. Water is turned into the funnel preferably by means of a "main," when, after filling the cylinder, the syphon retort pipe supplied with water through the funnel to be constantly removed by the lower syphon at this "cooler," will always remain cool for the purposes of condensation of the vaporised mercury.

In mines where the yields are large, and where consequently a proportionately greater quantity of amalgam (gold or silver) has to be retorted, the above or ordinary method is too tedious, and consequently these mines, like some at Clunes, have retort furnaces specially constructed for the purpose of dealing with their amalgam, and it has been found that these furnaces are more economical, healthy, and almost self-working.

At the Comstock lode, Nevada, the retort house, with a number of furnaces in it belonging to the Virginia Consolidated and California United companies, is quite a fine and substantial structure, where retorting is carried on every day.

The retorts (Plate VIII.), eight in number, are built in fire-brick and connected by furnaces with the flue and stack, care having been taken to construct the fireplaces so as to allow full play and access to the retorts by the flames. They are made of cast iron, cylindrical in form (*a*), in order to permit their being turned round should one side be burnt too much. The most convenient and approved size is 5 feet in length; the inside cylindrical portion of 1½-inch cast iron being 3 feet in length by a clear foot in diameter. The neck *i* gradually contracts to 2½ inches diameter for a length of 2 feet and over; this end of the neck *i* is furnished with a flange to which the condensing pipe *c* is bolted. This condensing pipe does not sit horizontally like the main body of the retort, but it is bent downwards, similar to that of the ordinary portable retorts; and it then passes through a body of water *b* contained in a vessel constructed of boiler-iron, which water is being continually (during retorting) added to through the pipe *c*, whence it escapes at *k*, for the eventual discharge at *d*. The amalgam is placed in the retorts, in cast-iron trays fitting the inner sphere of the lower parts of same, and in three hours retorting with eight retorts at the above quoted mines not less than 13,000 lbs. of dry amalgam were treated simultaneously every day. (1877.)

Section VI.—Reduction of Pyrites.

(*a*.) common roasting and grinding.

The treatment of sulphurets containing gold or silver in reverberatory furnaces to drive off the sulphur, and subsequently the grinding or milling in Chilian mills, Wheeler's, or other pans, and Berdan's basins, with mercury, in order to amalgamate with the thus liberated gold or silver, has become quite obsolete in California these twelve years past or more, and for gold ores specially, a process has been generally adopted by means of which as much as upwards of 97 per cent. of the gold contents of the calcined pyrites, as previously ascertained by careful assays, have been obtained.

And this process is now universally giving every satisfaction, the old reverberatory furnaces having likewise been discarded in favor of the Californian drop furnaces.

(*b*.) CHLORINATION.

This mode of treatment is an adaptation of the German process (Plattner's), and was first introduced by Mr. G. F. Deetken, U. S., Mineral Surveyor and Assayer, Grass Valley, California, to whom many improvements are due in overcoming the difficulties surrounding the utilization of different kinds of sulphurets; and it may be stated that, although it is very effective with gold, it is not at all successful with silver, as the latter metal, on treatment with chlorine gas, passes away as a chloride in the waste residues.

The chlorination process includes calcination in the already mentioned drop furnaces; the previously concentrated sulphurets are roasted "*dead*" in these furnaces, which have for a charge of one ton of sulphurets at a time, an area of 130 square feet, the dome, or cover, rising but 24 inches in the centre above the floor of the hearth. The sulphurets are delivered through a cast-iron funnel at the top of the first hearth, from trucks, cars, &c.; and when they are very fine a "dust-chamber" will save as high as 5 per cent. of the ore calcined. With these drop furnaces from 5 to 6 tons of sulphurets can be calcined at the expense of but 2 cords of soft firewood, in three shifts, or 24 hours—a considerable improvement on our reverbatory furnaces' capabilities, assuming that in both cases the pyrites are delivered in as dry a state as possible. These drop furnaces may be worked in distinctly different ways, viz., for producing sulphuric acids as a by-product, and for oxydation and chloridizing calcination. When for the latter, as interesting ourselves chiefly, the furnaces used, consist of two hearths, constructed at different levels, or one about 12 feet above the other, and placed "end for end;" they are connected with each other by means of a vertical flue, of the same width as that of the hearths; and this flue, 12 inches deep, is constructed so as to lead to the lower hearth, zig-zag fashion, or over a series of terraces built in the flue right down to the bottom hearth. The fireplace, common to both hearths, having been built in front of the lower hearth, the flames therefrom primarily affect the pyrites, as separated only from the lower hearth by a low bridge in that hearth; then these flames, &c., ascend through the flue or drop to the upper hearth, subjecting the pyrites there in a like manner; finally passing out through the damper into the stack and open air. As soon as a charge has been fed into the upper hearth the hopper is closed, the usual burning and raking takes place for a specific period, and then the partly calcined pyrites are raked into the drop-flue, where they descend like a thin sheet into the ascending flames, which latter subject every particle of these sulphurets to severe calcination. At the bottom of the drop-flue is what is termed the back-hearth, whence the roasted ore can be withdrawn for outside treatment by means of a trap-door. If, however, the ore is to be calcined farther in the lower hearth, it is raked into the latter, and the final roasting takes place, including the addition of coarse salt after three hours' work. By means of this salt the gold is freed from its oxydes, and is besides rendered easier for chlorination by removing lead or other sulphates obnoxious to the final process; consequently the quantity of salt to be added depends on the greater or lesser percentage of lead in the ore. To follow the actual working of the furnaces in this paper would take up too much room; but I may say that any ordinary intelligent "roaster" will soon understand the work.

The so thoroughly roasted ore is cooled gradually and placed in wooden vats, holding about three tons each charge, in which they are moistened, and the lids are after a time screwed down, and the joints hermetically closed by means of a dough of flour. There are false bottoms in these vats, which are either kept apart by means of a layer of quartz-gravel or they are a fixture, and then are simply perforated so as to admit, either way, the chlorine gas, conveyed through a leaden pipe at the bottom of these vats, and as soon as about one-fourth of the roasted pyrites have been placed in the latter, the remaining portions of the charge are then quickly filled in to within a couple of inches of the top of these vessels, and then, after putting down the covers, the chlorine gas is allowed to permeate the charges for about eight hours—each charge of 2,000 lbs. (American) having been reduced by calcination to about 1,440 lbs. only. The manufacture of chlorine gas is effected for each charge of, say, three tons of ore in each vat from the following ingredients, viz.:—30 lbs. sulphuric acid, 20 lbs. salt, and 18 lbs. of manganese; these substances are slowly and carefully heated in a leaden vessel placed in a sand bath so as to ensure the non-melting of the gas originator, and the gas so obtained is conveyed thereupon to the vats for action. As soon as the proper time has elapsed for the gas to act, the vats are opened and pure spring or "*rain water*" added until the solution thus obtained and collected in a much larger vat close by exhibits no trace of that greenish tint, which color denotes the presence of the ter-chloride of gold. An indiarubber hose conveys the solution into the large vat in such a way as to produce a rotary motion of such fluid, which facilitates the precipitation and deposition of the gold by the addition of sulphate of iron, at the bottom of the vessels in the form of a brown powder; this is very carefully collected, after removing the fluid parts by a spyhon, and smelted with borax, so as to separate any impurities it may then be associated with.

The charges for "chloriding," as it is termed in California, were as follows:—If three or more tons, 20 dollars per ton; one ton or less, 25 dollars each ton.

It having been demonstrated in the above description that this chlorination process is much superior to our common manipulation with inclined furnaces, which are doing about only one-third of the work of the drop furnaces, and that the collection of gold in grinding pans with mercury is certainly not so effective as if the gold was dissolved by chemical action and precipitated in a simple manner without mechanical power, the strong recommendation of the delegate for its general adoption will, it is hoped, obtain the support of mine owners here.

The only objection that has been urged against the chlorination process, as carried out in California, has been to the effect that the *coarse* gold remains undissolved during the time stipulated, and is consequently lost in the waste. It is only by comparing the gold in the matrices here and in California that we can arrive at the results that make up facts in this and other matters; the gold in the Californian lodes is frequently very fine, but it is also very coarse, so that there is, after all, not so much difference as fancied by us. And, even if this coarse gold remained undissolved, it is certainly very pure after the process and eminently susceptible for collection upon the electro-copper plates over which all wastes are afterwards passed in California, without any additional expense or loss of time.

(*c.*)—OTHER PROCESSES.

Prof. Monnier's Treatment of Sulphurets.

Having already described the geological features observed at the New Providence mine, Nevada City, attention is now directed to their very extensive works in which their ore is manipulated, primarily for the gold, and secondarily for the silver, zinc, lead, copper, and iron such ores contain. These ores resemble somewhat those of St. Arnaud, Percydale, and in a minor degree the Whip Reef, of Sandhurst, in which places a great deal of difficulty has been experienced in finally separating these constituents of a refractory or rebellious combination of metalliferous substances.

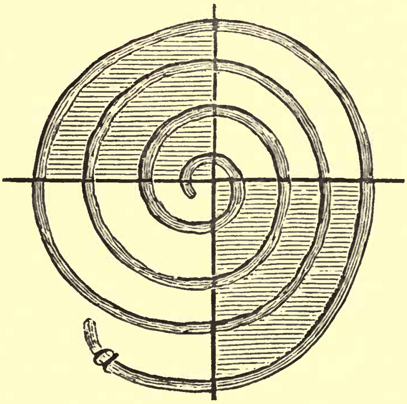
The ore is hand-picked and run through Cornish rollers in the proportion of 80 per cent. of ore and of 20 per cent. sulphate of soda, until it passes through screens with 576 holes per square inch ; it is then fed into one of Bruckner's revolving roasting furnaces, 40 feet long by 5 feet in diameter, with a fall of 6 inches for its length towards the discharge end ; the hearth is at the discharge end, and thus the flames meet the slowly descending ores, whilst the furnace revolves but three times a minute. The chemical reaction in this furnace is as follows :—The oxydation of sulphur produces sulphuric acid, which combines with the soda, forming a bisulphate of soda, and when this substance approaches the vicinity of the hearth, or fireplace, near its final discharge from the furnace, it is decomposed, and the bisulphate gives up sulphuric acid, reacting on the sulphates and oxydes that may have formed, at the same time converting into soluble sulphates silver, copper, lead, &c., iron alone remaining an oxyde. The roasted ore is then placed into large tanks with water for "lixiviation," or leaching, and the liquor obtained is passed through layers of "cement copper" (pure), in other vats, in order to precipitate a portion of the sulphates of silver whilst the liquid retains a low temperature. The remaining solution is then run through an evaporating pan, in order to regain the sulphate of soda for repetitionary use, and in this manner the process is continued until insoluble residues are obtained which contain the gold and some silver ; these are carefully ground in arastras, and finally passed over electro-copper plates and through mercury wells, upon and in which the more precious metals are retained by amalgamation for subsequent retorting. According to the professor's showing, this kind of ore produced results at the rate of from 88 to 93 per cent. on the assay for gold, 70 per cent. for silver, and the copper is wholly extracted. The red oxyde of iron, it should be mentioned, which is thrown aside here in the colony, after roasting and grinding pyrites, was in California utilized as coloring matter, possessing a good body, rendering wood fireproof and protecting iron from rust. Another advantage for Monnier's process consists in the fact that in other processes the miners lose the silver during chlorination, and that chlorination of gold takes forty-eight hours on the average, whereas, by this manipulation, *all* the more valuable metals are collected, and this can be done in about half the time.

Having now described the principal methods adopted by Californian mine superintendents to work their lodes, and the various processes which their amalgamators and calciners use in the reduction of their ores, it will be conceded, I submit, that on the whole very great pains are taken in that State with the extraction of gold or other metals. And, for these reasons alone, these various matters should deserve the careful consideration of our colonial mining experts, who will find me always in readiness to explain or furnish further details of anything that could not be described without the original diagrams. In describing the various matters connected with Californian mining, embracing the machinery used for the manipulation of quartziferous gold ores, it should also be understood that the delegate could not do more than *describe* them, the practical working in detail of both, though grasped during his inspections, can only be initiated and carried out by him when and wherever required.

(*d.*) SAMPLING AND ASSAYING OF ORES.

In California and Nevada the ores are subjected to periodical tests to check, as much as possible, any loss that may arise from the use of defective machinery, unsuitable manipulation, and carelessness by the employés during reduction. In San Francisco there are establishments which are recognised by the miners as dealing exclusively with all kinds of ores, which may be shipped to them by sea or delivered by rail. Of these ores, average samples are obtained by these firms for the assayers employed by either the miners (vendors) or the purchaser (metallurgists), and, as soon as the assays have been made, the bulk of the ore stored by the "*samples*," is sold by tender, private agreement, or sometimes by auction. This, of course, applies only to such mines located in distant districts, which are, moreover, inaccessible for the transport of heavy machinery, though frequently mine owners dispose of concentrated ores from mines well equipped with the best modern appliances.

The ore as emptied from the bags (each 200 lbs.) is formed into a conical heap upon solid granite floors; these heaps are then spread out and divided into four parts by cutting two passages across the heap. The inner portions of these passages are scraped into the gangways, and this ore is thrown into the centre of the pile, which is then thoroughly mixed, and about 25 lbs. are taken for the next operations following in due course until about one pound of ore is left, which is thereupon crushed upon a cast-iron table with raised sides by means of a Cornish "*bucking*" hammer, and when fine enough to pass through a screen with 3,600 meshes to the square inch, cones are again formed; these are flattened out with a spatula when the final selection is made as follows:—A concentric line *a* (*see* diagram), or furrow, should be



made with the blunt end of a pencil, the heap then cut into four parts; the opposite parts (shaded) are then selected as the *average* sample for the assayers. There are always three parcels made, one for the check assay, and the other two for the two assayers, who will test their parcels either by the humid or fire assay, or both, as the custom may be. It may be observed that this assaying of minerals or ores is held in very high esteem, and it has come under my personal notice of mine superintendents obtaining leave of absence for the express purpose of their acquiring, from competent assayers, the knowledge of testing their own ores, and that the fees for a quarter's tuition ranged from 150 to 300 dollars in these cases.

Section VII.

(*a.*)—HYDRAULIC MINING OF AURIFEROUS GRAVELS.

In reporting upon the manner in which the ancient rivers of California are operated on for the gold these deposits are charged with, it may be stated that these rivers of Pliocene age are, in most cases, located above the present bottom of modern watersheds. To get at the gravels necessitates, therefore, the sinking a series of prospecting shafts, and upon the proper levels having been ascertained, the driving of tunnels through the banks or "*rim-country*," to afford both drainage and tail-races, in order to dispose, by means of such tunnels, of the *débris*. And, as the ordinary puddling and sluicing of such deposits from 150 to 380 feet in height, gold-bearing throughout—the North Bloomfield Company's, Nev. Co., Cal., average yield of gold was only at the rate of 5½ cents. per yard of gravel moved—was out of the question, the present very perfect hydraulic sluicing was introduced, and gives very satisfactory results. Hydraulic sluicing, or "hydraulicking," as it is termed in Californian mining camps, necessarily includes the following :—Construction of large storage and distributing reservoirs in suitable localities, generally in the vicinity of the glaciers of the Sierra Nevada Mountains ; cutting of races (ditches) ; construction of flumes bridging the valleys ; laying of surface pipe tracks ; water-gauges and nozzles." In this portion of my report I would again take a leading gravel mine as a guide for a general description, as such will furnish all the necessary data controlling the others.

At the North Bloomfield mine, the Bowman dam is built to a height of 97 feet, for a length of 400 feet, with a gangway of 2 feet in width on the top ; it consists of rough-hewn stone, and is three times the width at the base of its total height, neither puddle-wall or mortar having been used in its construction. Regular courses of horizontal bearers of pine-wood are laid in the stone-work, and these project a few inches at the water side of the dam. On these bearers, strong ribs are screwed, which are lined with 4 to 6 inch planking, tongued and grooved, which is all the precaution taken to make these reservoirs water-tight for quite a number of years.

This reservoir holds 920,000,000 cubic feet of water, and it cost only 135,000 dollars, or about £27,000, and it is altogether a very substantial and fine piece of work. Repeated failures with dams constructed of earth with puddle trenches, owing chiefly to the different shrinkage of the clays used on the one hand, and the earth in the bank on the other, have led to the general adoption of rough-hewn stone in the construction of the dam described. This reservoir supplies a main-race, or ditch, having a fall of from 12 feet to 20 feet per mile, for a sectional water area of 30 square feet, being 9 feet on top and 5 feet 6 inches wide in the bottom, and it delivers at the rate of 44,000,000 gallons of water per diem, or about, in Californian parlance = 3,200 miners' inches, *i.e.*, one "miner's inch" is equal to a discharge of 2,225 cubic feet of water in twenty-four hours. This main ditch ramifies throughout the country for a total distance of over 40 miles, and it delivers its contents into two mains, or distributing pipes, constructed of sheet wrought iron, three-tenths of an inch thick only, of a diameter of 30 inches each, gradually decreasing, however, at the mines to half their size, in order to attain a greater pressure. These pipes deserve particular attention, on account of their great strength, durability, economy, and portability; they are made of the best Russian charcoal wrought-iron plates, riveted together longitudinally, zig-zag fashion, with a good overlap, and the same laterally. Generally four lengths are "telescoped" together, there being no flanges or faucet joints, making each length a little over 17 feet, weighing about 260 lbs. each length; they are joined together with the help of a screw-jack, and simply laid in a shallow furrow on the surface. Expansion joints are provided by allowing an 8-inch overlap here and there, instead of the ordinary 3 inches; and these pipes are, undoubtedly, under certain conditions, superior to the costly, cumbersome, and short-lengthed cast-iron pipes commonly used in Victoria and elsewhere. They appear to last equally as well also, inasmuch as pipes were inspected that had borne an enormous pressure (when their very inconsiderable thickness of metal is considered) during eight to ten years, and they had still their original tar and asphaltum coating on, as when first laid down. This company washed during 22½ months 4,777,700 cubic yards of gravel with about 3,000 miners' inches of water per day, representing 80 tons of water each day, and their yield of gold averaged about 24½ cents of gold for each miners' inch, or, as stated before, 5½ cents for each yard of gravel. These pipes are divided into "branches," each of which supplies a "nozzle," from which a jet of water issues, which is the principal motor of the gravels operated upon. There are 4-inch to 9-inch nozzles in use, and by means of knuckle, universal joints, and balance-weights, these nozzles may be directed anywhere, without the least labor or difficulty. "Starting in" to "hydraulic" any ancient river like that of this company (North Bloomfield) requires a careful survey, and then a tunnel through the "rim" country from an adjacent and deeper gulch; in this case such a tunnel was driven (and as ample water pressure was available, a *mining* diamond drill was utilized both for prospecting and blasting) for a distance of 8,000 feet, at a cost of 500,000 dollars, or £100,000. This tunnel measures 6 feet by 8 feet in the clear, and with a fall of 5 per cent. reaches the main shaft in the gutter at a depth of 54 feet *below* the gravel. This shaft is exceptionally well secured with very massive timber, in order to withstand the immense strain put upon it by the gravels and large boulders of rock, propelled by the jets from their positions and hurled down the shaft into the tunnel, the bottom of which is lined for 1,800 feet in length with quicksilver wells, set in with a massive "wood pavement," which affords every means for the collection of most of the gold.

In order, however, to dislodge the tenacious "blue" gravel, it has been found requisite to employ explosives to shatter it, and also to break up the immense boulders found invariably in these gravels; and after that the washing down of the enriched gravels, out of the pockets in the bed-rock, proceeds systematically and effectively, without hindrance. It will be observed that, in these cases the tunnels serve not only as an outlet for the *débris*, but also as a means for intercepting the gold liberated by the action of the water. With such enormous quantities of poor gravel, it would not pay of course to use much manual labor, and therefore the concentration, if one might say so, of the gravel still containing gold is performed outside the tunnel by means of self-acting separators of the coarser from the finer gravels, and the repeated subjection of the latter to a manipulation in the "under-currents," which are also charged with mercury, lodged in the irregular ripples, formed of the hardest boulders that can be obtained. Much of the gravel being cemented together, the continuous attrition such suffers in this torrent of water and boulders with gravel, tends to liberate more and more gold, until even the "under-currents" fail to save any more, whereupon the process is considered complete.

Résumé of Hydraulic Mining of Auriferous Gravels.

Reservoirs constructed of rough squared blocks of stone, rendered water-tight by means of wooden casings; ditches (races), 30 feet sectional area; fluming; wrought sheet-iron pipes made from iron $\frac{3}{8}$-inch to $\frac{5}{10}$-inch thick; wrought-iron pipes from 30 inches to 15 inches in diameter; nozzles from 4 inches to 9 inches diameter, throwing streams of water to a distance of from 400 feet to 500 feet; main tunnel and tail-race 5 per cent. grade or incline; depth of tunnel below gravel 54 feet; height of gravel from 340 to 400 feet, all gold-bearing. Modes of saving the gold: in the crevices of the bed-rock; in the wood pavements with mercury in the tunnel; and, lastly, by numerous "under-currents" outside.

In concluding this portion of the paper, I would call attention to a difficulty that was experienced until recently with the working of the nozzles, inasmuch as the water, discharged in some cases with a pressure exceeding 375 lbs. per square inch through a smooth-bore nozzle, obtained a gyrating motion, which destroyed, in a very great measure, the effects of the jets against tenacious gravels. By riveting four "tee" pieces of iron, 2 feet in length each, and equi-distant from each other, inside the nozzle, the water issued with unabated force direct to the point sought to be undermined, thus resembling the bore of a rifle, which acts in a similar manner.

(*b.*) DRIFT MINING BY MEANS OF SHAFTS AND TUNNELS.

With regard to the mining of the ancient rivers, in localities where the "capping of basalts" interferes with the action of the nozzles on account of the too large percentage of these volcanic rocks in the gravels, drift mining, as it is termed in California, has been resorted to in some places (Capt. Godfrey's mine, Grass Valley; Watts' mine, Bloomfield); but in no case has this kind of work been carried on to such perfection or extent as here, at Ballarat, and other districts. For these reasons it is more judicious, on the score of saving time, to describe their tunnelling operations, as meriting our attention; and for that purpose the Bald Mountain Company, Sierra County, California, will serve as a very good example.

That company work their mine by means of a large tunnel, timbered close—4-foot caps, 8-foot legs, with an extraordinary "spread" at the bottom of 12 feet, on account of the bed-rock (serpentine), largely impregnated with lime, swelling continuously in the open air, frequently filling in the whole drive. Two parallel lines of rails (22 lbs. per yard), are laid down in this tunnel, with the necessary sidings, lay-offs, and turns provided. Owing to the rapid ascent of the river-bed, at the rate of 200 feet per mile, neither manual nor animal power could be used in working the tunnel, even if the "cars," *i.e.*, trucks, were geared with the strongest of breaks. And, as they had then already driven 5,000 feet under the adjacent basaltic plateau, which rises 1,100 feet above the main gutter, the company, a couple of years previously, obtained from Baldwin and Co., Philadelphia, Pennsylvania, a mining locomotive for their future work, and I found that these small engines did all the requisite work, in the shape of fetching out "*pay-gravel*" (*i.e.*, washdirt) and to take back timber, tools, and men over these heavy inclines, with great facility. The cars hold about 1,800 lbs. of pay-gravel each, and each train consists of thirty-two cars. The locomotives are a splendid sample of machinery, and each measures 13 feet in length, 4 feet in width, by 5 feet in height, the smoke-stack projecting only 3 inches above the top ; gauge of the lines is but 20 inches in the clear, the two driving wheels being 3 feet, and the four others 2 feet each in diameter. These are "camel back" engines, the tanks being fixed above the boiler. Each locomotive weighs but 7,850 lbs., and it can be worked up to 40-horse power, with a daily consumption of 400 lbs. of best bituminous Pennsylvania coal, which can only be got to this remote region for 40 dollars per ton. The driver sits at the rear of the engine, covered in, and does all the shunting, at slackened speed, by means of an iron crook. A very powerful reflector lights up the otherwise dark tunnel for forty yards ahead of the locomotive, and, during my inspection, the trains going in at 6 a.m. consisted of thirty-two cars filled with mine timber, besides as many as forty-eight miners, and still an average speed of thirteen miles was maintained up the tunnel.

This company was originally organised with twenty shares, at 1,000 dollars each, and these shares were ultimately subdivided into the present 1,360, upon which, during the last five years, 600,000 dollars have been paid in dividends. As regards the working of this large mine, one imagines himself almost at Ballarat, and the whole system reflects highly on the superintendents in charge. Water being very scarce, the pay-gravel is shot down into two large "dumps," or paddocks, during the dry season, which have a capacity of 18,000 and 28,000 tons respectively. These paddocks are floored with thick planks, placed at an incline towards a central line of sluice-boxes, running through the paddocks and for nearly two miles outside ; the ripples in these, charged with mercury, were constructed of chilled cast iron, the annual repairs of which alone exceeded 5,000 dollars during that period. Latterly, however, old worn-out truck or car wheels have been used at less cost and with the same effects, as far as gold-saving is concerned. As soon as the wet season has arrived, the pay-gravel in the paddocks is "hydraulicked" by means of strong rubber hoses and iron nozzles. The gold seen, during the inspection of the workings and outside apparatus, was of a very fine nuggety description, consisting of solid pieces from a few pennyweights each up to one lump 64 ounces in weight. The value of this gold was exceptionally high for California, it being at the rate of 19 dollars 25 cents per ounce.

APPENDIX.

When it is taken into consideration that the investigation of mining in all its collateral branches, as relating to gold principally, had been the object of the delegate's mission, it was, however, not to be said that he should lose sight of or pass over any other matter that could be advantageous to miners not engaged exclusively upon auriferous deposits; and, in a rich metalliferous country like the two States visited, it could not be avoided to see and investigate, though such action has not materially infringed upon the general instructions of the committee under whose authority these matters were proceeded with.

A. *Novel Treatment of Poor Copper Ores.*—About 18 miles north-west of Grass Valley City, California, a cupriferous belt has been discovered, giving rise to extensive operations both in the mines and in their reduction; and, as the new *mechanical* treatment adopted—instead of the older and slower process hitherto in vogue—has given *daily* results from an ore scarcely yielding 6 per cent. of copper, it may be of advantage to introduce that system in Australia with similar low-graded copper ores.

The ore occurs in almost unlimited quantities, in the form of an irregular deposit, having one well-defined wall only; its extreme width has been ascertained at 110 feet, but its extent in the strike of the wall is so far unascertained. The ore is a highly ferruginous copper pyrites, and it yields as low as 2½ per cent., though 6 per cent. appears to be a very fair average, and the mining proper of this ore costs, under contract, but 1 dollar 50 cents per ton. After raising the ore from below, it is piled under very extensive sheds in heaps of 40 tons each, upon large logs, &c., of firewood, and roasted. At the centre of each pile a rough chimney of loose bricks and large lumps of ore is built, upon which a movable stack of stout sheet-iron is placed, so as to project above the roof of the sheds, and thus conduct the very noxious fumes away from the works. This ore, after complete calcination, is allowed to cool for subsequent removal to other sheds. Large wooden tanks are there constructed at the hill side, in the form of terraces, so as to permit the various products falling from one set of tanks to the other without much handling. It may be remarked that in the construction of all these tanks and shoots, iron bolts, nuts, and nails, &c., are entirely covered with lead or wood, to prevent their destruction by the strong liquors obtained. The higher series of tanks are filled with water for 3 inches; the calcined ore is placed in layers therein, each layer receiving a coat of coarse rock-salt; then water is turned on to fill the tanks within a couple of inches from the top. After this, superheated steam is turned on through a leaden pipe at the bottom of each tank for about one hour, when the whole contents begin to boil. Gaseous bubbles rise to the surface, which increase both the ebullition of the liquor, whilst also facilitating and sustaining the dissolution of the ores and other ingredients. The first solution is drawn off every evening from each tank, in order to increase the body of the liquor to about double its strength originally; and this fluid, strongly impregnated with copper, and of a deep-green color, is passed to the large receiving-tank located near the revolving barrel. This tank when once full is kept so, in order to carry on the operations every day in the year (Sundays included), as it is impossible to stop when the processes are once in fair working order. The liquor possesses that well-known acrid taste of copper solutions, and it is periodically gauged by graduated instruments, and it is then pumped into the revolving barrel. This barrel appears to be the principal feature in the process, as it takes the place of the usual shoots in which cupriferous mine or other water is made to run over old iron, which latter is very gradually transmuted into chemically pure or "cement copper." This old style of utilizing the water so impregnated, however, is a very slow process, and the Californian method is much more expeditious and economical. The revolving barrel is 16 feet long by 6 feet in diameter; the staves are 6 inches thick, and so are the two bottoms; inside a false lining of clear pine is inserted, with a view of covering any iron that has been used in its construction. In this huge barrel all kinds of old iron (preferably hoops), nails, &c., are placed with the solution, and the trap-door is at once hermetically closed, whereupon the driving gear is thrown into motion, making the barrel to revolve but three times per hour. As the solution and iron combined generate hydrogen gas, every care has to be taken, in order to prevent explosions, from fire being brought into its vicinity.

The actual practical results of the new treatment for this extremely poor copper ore, which would not pay otherwise, and which would therefore be cast aside, consists in the daily production of over 1,000 lbs. of pure cement copper (of a higher price than refined copper metal) from about 18 tons of ore.

B. *Asbestos in its uses.*—This fibrous mineral, which occurs so abundantly in Australia and Tasmania, has been utilized in California in a very remarkable manner, specially as a preventative of boilers, steampipes, and cylinders losing their temperature in cold air, whereby their steam would be condensed and more fuel used than is necessary. The mineral itself is mined for in several places, and cleansed in simple machines ; it is then crushed so as to retain its fibrous character previous to calcination in furnaces, and when at a red heat the mineral is plunged into a bath. After drying, it is again milled with traganth or other pure mucilage, when it is ready for immediate use or shipment. In California all the steam generators, pipes, and cylinders were coated with this substance for a thickness from 1 to 2 inches, and in consequence nearly 20 per cent. of fuel of any kind is saved. As it does not crack, on getting heated, engines, boilers, &c., have a much cleaner marble-like appearance with asbestos coating, and do not rust, as otherwise is nearly always the case.

C. *Wages.*—In California miners receive from 2½ to 3 dollars per diem, six days in the week, for either eight or ten hours' shifts. In some mountainous districts miners are boarded and lodged at the mines, and the amount (never exceeding 7 dollars per week in California) is deducted from their wages. Amalgamators receive from 4 to 5 dollars per day of twelve hours' shifts, and laborers from 1½ to 2 dollars ditto. Mine superintendents are salaried very high, and they receive from 30 dollars per week to 300 dollars per month. As regards miners' and other employés' habitations, it was generally observed that their cottages were built of red pine, and that neat American stoves took the place of open bricked fireplaces and chimneys.

D. *Mine Timber.*—At Grass Valley the round mine timber is delivered at one cent per inch, and the rule is :—To multiply the length in feet by the diameter at the small end in inches, which gives the result desired ; for example : a piece 20 feet long by 8 inches in diameter at the small end = 160 = 1 dollar 60 cents for the piece ; sawn timber or lumber costs at the mines 18 dollars per 1,000 feet ; firewood, 4 dollars 50 cents per cord. Owing to the mining regions being extremely well watered, public or incorporated companies undertake the carriage of all kinds of fuel, mining and sawn timber, by means of extensive channels or flumes, built of timber, along the contour lines of the mountains ; these channels are in section of a V form, the outer diagonal ribs being driven into the surface, or let into solid wooden foundations when the former is impracticable, strongly stayed, bolted, and lined inside with 2-inch tongued and grooved floorings. With an average fall of 7 feet per mile it has been found that all kinds of timber can be floated in these channels on water, and delivered at certain depôts at fully 30 per cent. less than by teams ; at the same time the water, though getting slightly resinous, is still suitable for mining purposes, and in some cases for domestic use.

E. *Mining Laws, &c.*—Under the United States Act of May the 18th 1872, yet in force, the cost of obtaining a *patent* on a mining claim of the following dimensions, viz., 1,500 feet by 600 feet, "with all the dips and angles to any depth," are as follows :—

	Dollars	cents.	
Cost of land (20⅔ acres)	105	00	
Surveyor-General's fees	30	00	
U.S. Registrar's fees	10	00	
Advertising	40	00	
Recorder's fees	5	00	
County Clerk's fees	5	00	
Notary's fees	5	00	
Surveying	50	00	
Attorney's fees	75	00	
Incidental expenses	20	00	
Total	345	00	= £71 17s.

This amount covers all expenses, no farther rent or charges being made against the patentee; at the same time it is the rule that, in accordance with the bye-laws of every county in the State, a certain amount of money is to be expended annually at the mines. If, however, the *patentee*, or claimholder, applies to the nearest county court judge for relief on having expended all his capital and exhausted his means on the patent, *i.e.*, land mined upon, then the judge can order the United States Mineral Surveyor and Appraiser to report on the case, and, after reading the sworn affidavits of these gentlemen and that of the patentee, declare the land open for purchase by the latter at about 1 dollar per acre, when, after payment, he can hold same in fee-simple and without any restrictions whatsoever.

F. *Schools of Mines.*—As this was a subject that I was particularly enjoined to enquire about, the following may not be deemed out of place. There is but one such establishment in California, which forms a distinct branch of the State University at West Berkeley, across San Francisco Bay. There, I found a splendidly appointed mineralogical and geological museum, arranged on the latest principles, thus not only facilitating study, but also enabling the casual visitor to inform himself on any subject required at a glance. The mine superintendents, of which I met a great many at the mines, accorded high praise to the practical assistance they at times derived from this museum and the professor in charge. Previous to my stating any particulars of their school of mines, I may observe that this establishment had not then been appreciated so much as anticipated by those for whose especial benefit it was created; not so much, however, from any desire on the miners' part to discard scientific teachings, but rather otherwise; the fact being in this case, that the Eastern States, Germany, France, and England (lately) furnished an ample supply of highly trained mining engineers, metallurgists, and geologists from their celebrated mining academies at Freiberg and Clausthal, Paris, and London, as well as from Harvard and Yale Colleges in America, to the detriment of the California School of Mines, but recently constituted as a part of academical tuition. In going through the great number of mines and mills one became convinced that these American mine superintendents could not possibly have carried their many difficult and varied processes, mechanical contrivances, &c., to the success they generally obtain, without their having received a sound education and careful training in schools of mines. At Berkeley the students are dressed in a becoming uniform, they have certain privileges on the ferry-boats and railways, and the course of study assimilates to that of the London School of Mines in part; that of Clausthal in the practical branches, and the professor for mining, technology, and mechanics has graduated at the Freiberg Mining Academy. This Californian School of Mines includes the following subjects in its syllabus:—Mining (theoretical and practical), technology, mechanics, mensuration, geometry, and mathematics; geology, including field work, mapping, and surveying; mineralogy, with oryctognosy and blow-pipe analysis; free-hand and engineering drawing; organic chemistry and metallurgy, with special attention to the assaying of rocks, ores, and mining products; German, French, and English languages. These subjects form a regular course extending over two years, but, after a student has grounded himself in the preliminary subjects, he may, at his own option, elect such subjects only as would enable him to pass the severe examinations either as mining engineer, civil engineer, geological surveyor, metallurgist, analytical chemist, or as a general mining superintendent. It may be added that there are several "*business colleges*" in California, where young men are specially educated for commercial pursuits, including book-keeping, &c., thus paving the way for the higher-class training at the university and its affiliated school of mines and others.

Part II.

NEVADA.

Section I.—Geological Features.

An examination of the celebrated Comstock lode was made during the latter period of my stay on the Pacific slopes, and I regret that circumstances beyond my control had intervened previously which limited the time at my disposal at Virginia City. The outcrop of this magnificent deposit is situated 6,200 feet above the sea-level, at the base of Mount Davidson, 7,240 feet above the bay of San Francisco. The lode is essentially of a quartziferous nature, and the "*ore*" occurs therein irregularly distributed. At some places along this vein, or lode, accumulations of very rich ore are found, however, and are well known under the term "*bonanza*," or ore bodies; these assume, with a northerly dip in the line of strike, a lenticular form, and are therefore not to be depended on for a regular supply of ore. Considering the great length of this lode, which has been proved ore-bearing for over 20,000 feet, there would be rather more ground from payable to very rich, than that which has been proved unprofitable to work. Portions of the lode, nearer to and at the surface, consist of a friable and reddish kind of quartz, in which silver is not traceable until at a greater depth; gold of the ordinary purity (Californian) predominates in this crystalline quartz. This lode differs in every respect from any found, to my knowledge, in Australia, and it constitutes simply what is known as a "contact vein," *i.e.*, a deposit of ore bearing all the characteristics of a "true" lode, occurring, however, between walls of two different kinds of rock, which are also of different age in geological time. The west or hanging wall of the older "syenite" averages 45 degrees underlay, and is, in its very regular descent, accompanied by a strong fluccan, or "dig." The opposite eastern hanging wall of the more recent "propylite," 600 feet east at the outcrop, that being the *width* of the lode at the surface, has no such defined division with the lode, which gradually loses its solidity by breaking up into numerous bands, bunches, and cross-veins in that direction; practical observers hold that, owing to the absence of any defined wall, other ore bodies may be found against a proper limit, or defined wall, should such exist to the east. The Comstock lode is subject to the intrusion of "horses," or detached masses of wall rock, in its regular occurrence, besides which, the ore therein is traversed by strong clay veins, which dam the surface or other water to the detriment of mining operations, inasmuch as by any level or shaft inadvertently piercing these clays, disastrous swamping of the workings has taken place, though latterly the mining diamond drills have been used with excellent effect, both for prospecting the ground hundreds of feet ahead of the workings, and by tapping these subterranean and pent-up waters.

The eastern wall rock (propylite) causes the diminution in width of the lode from 600 feet at the surface to 260 feet at the 1,400-foot level, owing to such wall rock assuming firstly a western underlay of 75 degrees, which lower down, however, curves round to nearly the same eastern underlay as that of the western foot wall at 45 degrees. This propylite is joined or passes at its eastern extension into a coarse feldspathic porphyry. At the lower levels, however, there are strong indications of the lode increasing its width considerably.

Section II.—Mining Operations.

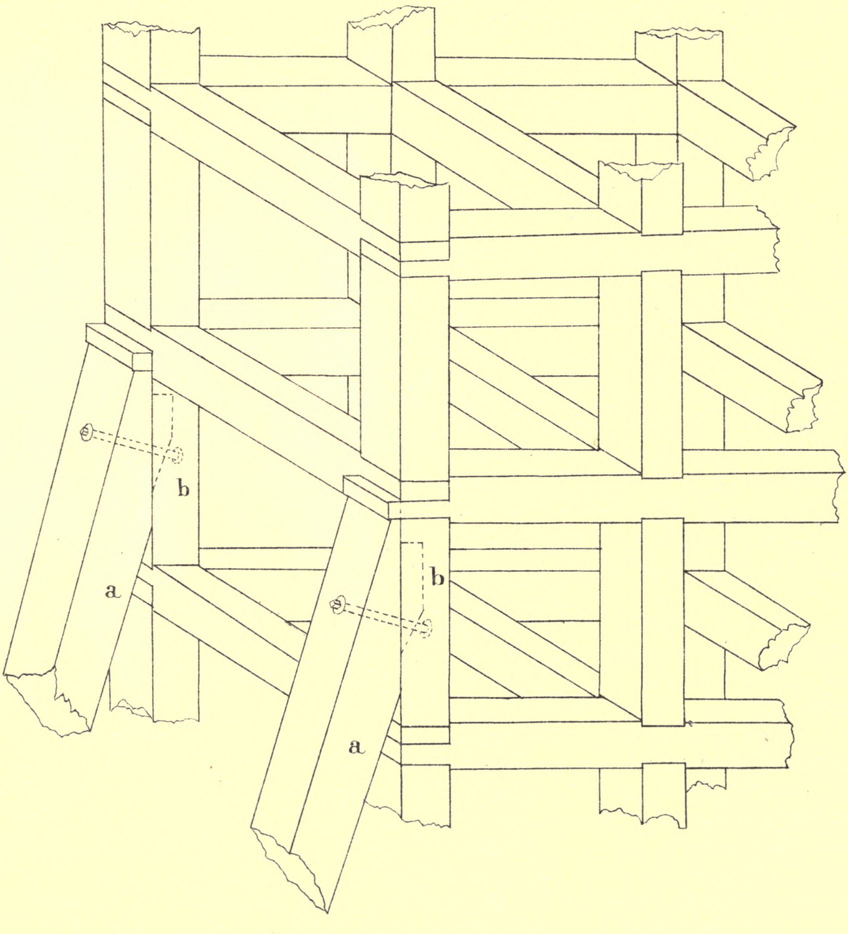
According to a late return in 1877, during a period of seventeen years previous to the end of July in such year, rather more than twenty incorporated mining companies, holding ground of more or less extent each, for an aggregate length of about 20,000 feet, produced 237,000,000 dollars worth of bullion, from about 659,000 tons of ore raised. At the same time, there still remains a very large quantity of inferior ore in the "backs" that cannot profitably be treated until the general mining expenses—which are, in this desolate region, excessively large—have been considerably reduced. During the above-cited period, the average value of the bullion retorted stands, per ton of ore crushed and treated, at 39 dollars 10 cents, or about £7 3s. 6d., which is certainly very good. Nearly a score of distinct "bonanzas" have been discovered, of which nearly half commenced right from the surface; but it is a significant fact, that bonanzas were also discovered in the deep ground at the 900, 1,100, and 1,300-foot levels. These deep bonanzas have no connection with nor possess any outlet at the surface, and some of these ore bodies have attained dimensions exceeding any known elsewhere. The deepest bonanza, at the 1,300 to 1,750-foot levels, measured 300 feet in length by 30 feet in width; others were limited to the same width by a length of 1,000 feet and a depth of 450 feet. The greatest quantity of ore from any one of these bonanzas, averaging 42 dollars per ton, was raised by the Crown Point and Belcher Company, of 1,374,528 tons, for a value of 58,110,240 dollars. The celebrated Consolidated Virginia and California United companies eclipsed that yield from a lesser quantity of ore, viz., 699,453 tons, which averaged 96 dollars per ton, or a value of 67,168,376 dollars. There are about thirty companies at work, which employ from 1,200 men down to a few each only, so that, if one shaft only is allotted to each company, ranging from say 800 to 2,200 feet in depth, it must be admitted that their mining operations have been carried out on a scale scarcely ever equalled, during their seventeen years, especially when the great difficulties are considered which hindered, and do now more than ever, the projected works.

The winning of ore from so large a deposit, as long as the mines were not very deep, was not very difficult, but, with greater depth, another feature or drawback presented itself, which rendered it necessary that more than ordinary care and skill should be exercised, and which suggested itself mainly by the observance of the principles of mechanical science. In the lower levels, the rocks and ores are much impregnated with lime, and at the same time there are large quantities of iron pyrites existent, and through the decomposition of the latter a chemical reaction takes place with the former, causing the lime to be "slacked;" and thus it is explained why the temperature increases so rapidly with greater depth, exceeding that of the ordinary increase observed in deep mines. Another obstacle is presented by the impossibility to fill the large excavations with waste rock, as is usually done; the available waste being too costly to obtain, consequently these open spaces are secured by solid timber, of which more hereafter.

The following remarks as to the principal shafts, plats (stations), and workings will perhaps deserve attention. The west shaft of the Virginia Consolidated and California United companies measures 20 feet in length by 5 feet 6 inches in width; there are three compartments for winding, with double-storied cages, *i.e.*, each cage raises two trucks every trip; two of these are for ordinary work, and the third is worked specially for the

SHAFT TIMBERING (ON COMSTOCK LODE),
VIRGINIA CITY, NEVADA.

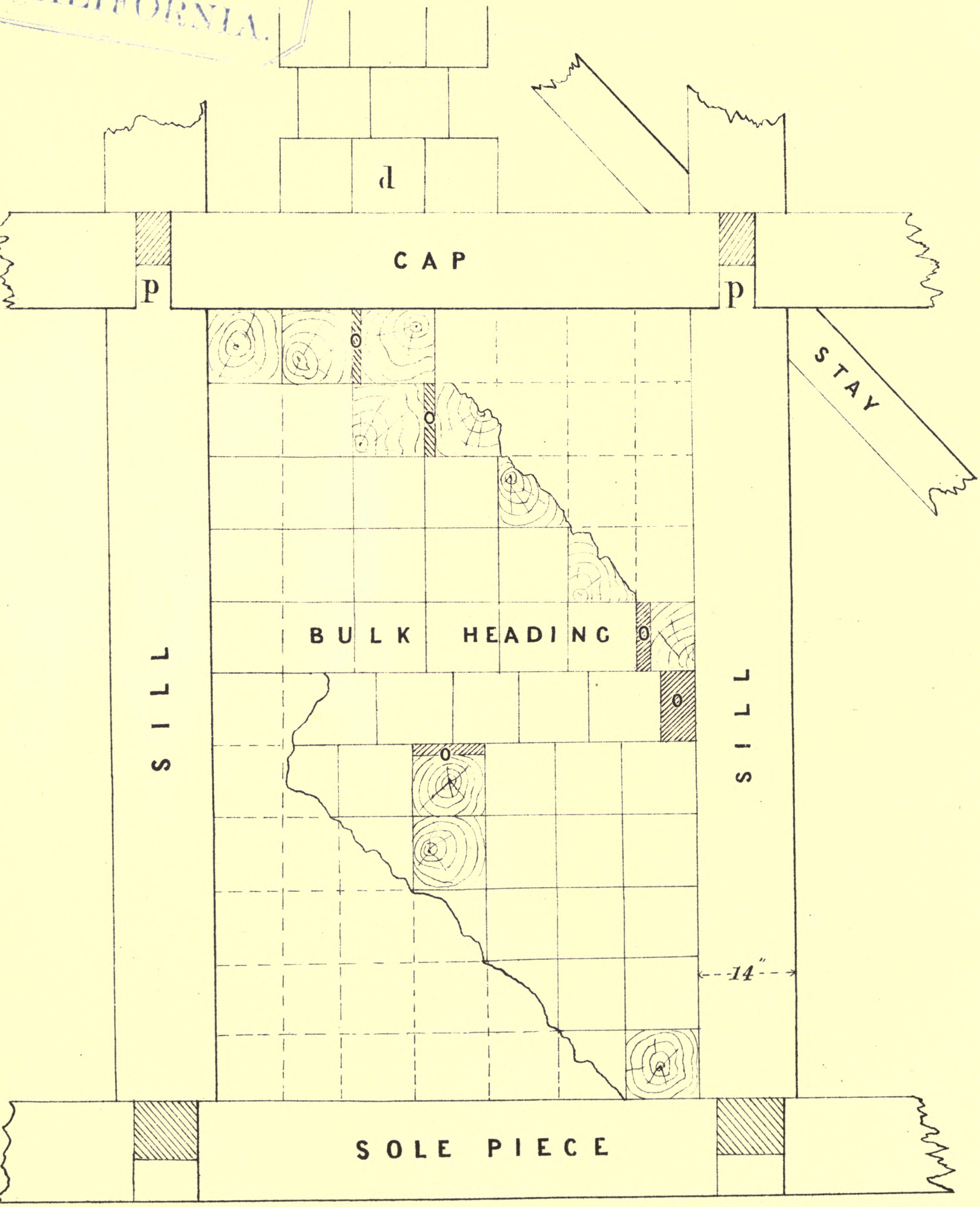
PLATE IX.



SCALE : ONE INCH TO ONE FOOT.

TIMBERING OF STOPES
Comstock Lode Nevada

Plate X.



sinkers as well as to send mining timber below. When necessary, according to the terms of contract, with the crushing mills, all three cages bring up ore, and each drum is under the sole control of a special driver, so as to expedite the work during eight hours shifts. At the new east shaft—these two companies sink their shaft exactly over their boundary lines, and term them "combination" shafts—which is much larger, viz., 27 feet by 6 feet 6 inches, the shaft timber employed is sugar-pine, squared to 15 and 20 inches diameter ; the frames are placed 5 feet from centre to centre with " studdles" at the corners and partitions.

Plate IX. exhibits one compartment and a portion of the second, of which there are four in this and most other shafts. Instead of the "bearers" used with us in difficult ground, which require much time and expense for cutting "hitches" in hard country, the Americans use diagonal stays *a a* instead, tennoned and bolted to the studdles *b b*, and as the hitches can easily be cut obliquely forward, without *undermining horizontally*, as with us, such can be done quicker, and, when wedged up, stand as well, if not better, as a bearer.

Some of the American "stations," *i.e.*, plats, are secured with timber, "arch" fashion ; besides the sole and leg pieces, there are not less than five trapezoid pieces used to complete the "cap" which, it is unnecessary to say, is a very strong and enduring method to secure their stations, which, on the average, measure 30 feet wide, 40 feet long by 11 feet high in the clear. Nearly all their levels and stations underground are lined or floored with stout boiler plates, instead of tramways, in order to facilitate the rapid transit of ore from the passes to the shafts. The main levels are 9 feet in height, the same as their first stopes, and the remainder of the backs above the levels is taken away in stopes 7 feet high ; the whole of the ground is systematically cut up into blocks from the two main levels driven *in* the foot and hanging wall respectively. As already stated, the filling of the stoped backs is accomplished by solid piles of timber, thus explaining the enormous consumption of 500,000 feet per day (American measure, or about one-third of ours) by these two proprietaries.

As will be seen from Plate X., already referred to, the whole space between the legs (cills), soles, and caps, is filled in with spars 10 inches square, and long enough to fill three sets of timber, or about 11 feet, and, in order to render this "*bulk-heading*" quite solid, wedges *o o o o* are driven in wherever necessary. The next stope is secured similarly, but not quite so close, the support of the cap being the chief desideratum, as shown at *d*, besides which, the whole of this timber, so systematically constructed, is strongly stayed against the hanging wall. The shaded places above the tennons *p p* are left open until it is necessary to timber the first stope, and then the lower tennons of these higher cills are put into these mortices, their proper places, and so on.

To describe the mode of working of another mine, I select one of a number inspected, viz., the *Justice*, situated at Gold Hill, two miles south of Virginia City, also on the Comstock line of lode, which employs 630 miners. Their shaft is vertical for 400 feet, whence it follows the usual underlay of the Comstock lode for 1,180 feet, or 1,580 feet in all. The shaft (20 feet long by 5 feet wide) is worked by means of powerful winding engines, and the one surface winding compartment is used for winding from 300 feet only ; the remaining 100 feet vertical are used as an ore chamber, into which the skips empty themselves as they are hoisted from the deep workings ; proper shoots at the 400-foot level supply the trucks to be raised to surface ; the skips are unusually large, containing not less than seven tons, or more, at the time or at each trip. By these means, the pair of coupled engines raise on an average 530 tons in twenty-four hours. The skips are furnished with truck-wheels, which run at an incline to the bottom level, or *vice versâ;* the tram-road is very well constructed, and is equipped with a single line of rails of 45 lbs. per yard. Besides this, the engines likewise work one "blower" and one "air compressor."

At the 1,000-foot level, their lode is 18 feet in width, and it is a remarkable circumstance that their bottom level is now in much richer ore than any had before, and the lode is likewise much more regular. The stopes exhibit the ore as of a fine streaky and laminated character, showing in regular bands black sulphurets of silver, native silver, and some iron pyrites. The average of gold in this mine is about 35 per cent., and of silver 65 per cent.; but sometimes the gold exceeds in percentage that of the silver, and the average value per ton, for some years past, amounted to 26 dollars per ton ; but as high as 13,000 dollars worth has been obtained per ton, of which ore I secured specimens, both for the Mining Department and the Bendigo School of Mines.

Section III.

PUMPING MACHINERY.

At the new eastern "Combination" shaft of the Virginia Con. and California United companies, the new pumping engine deserves particular notice, as being constructed on the "*compound*" principle, of one to three expansion, and at present its duty consists in lifting 95 tons of water per hour from their 1,750-foot level, by means of vertical 12-inch diameter wrought-iron plated plunger columns. This engine's two cylinders are bedded on the same bed-plate, "end for end," the first cylinder nearest the main shaft receiving the steam direct from the return multitubular boilers, and instead of passing this steam at the end of stroke into the exhaust, it is made to supply, by means of a connecting steam-pipe and valves, the second cylinder, where it acts expansively, and thus adds nearly two-thirds power to that exerted by the first cylinder. This first cylinder is 24 inches in diameter, with a stroke of piston of *eight feet;* the second cylinder has a diameter of 40 inches, and of course an exactly like length of stroke. Automatic (Cornish) valves, on a simple but very ingenious principle, regulate, in both cylinders, the supply as well as the exhaust of steam. It has been ascertained, since this engine was set to work, that more than one-third of the fuel ordinarily consumed whilst pumping with beam or horizontal engines elsewhere, was saved, which constitutes a very considerable saving The great difference with compound and ordinary engines, if used for pumping from great depths, consists, however, in the saving of all intermediate gear between the cross-head of the engine and the king-post of the pumping or balance bob at the surface. The cross-head in these cases being simply connected by means of a wrought-iron—girder-fashion—sweep-rod, with the top pin at the king-post, thus securing, at least expense of power, the most direct action by the engine for the pumps ; and the want of vibration when the plungers take the water evidences the practical utility of this arrangement.

With all these large steam engines it becomes a matter of considerable difficulty to keep their working parts well lubricated without the loss of time which the attendants use in the usual hand-oiling ; therefore the addition of Cartwright's valve motor is very beneficial ; inasmuch as the requisite lubricants are forced into and distributed amongst all those parts where friction necessitates the use of oil or other lubricants. The plungers and lifts run from 12 to 20 inches in diameter on the Comstock and are all constructed of riveted boiler plates from $\frac{3}{8}$ inch to $\frac{1}{2}$ inch in thickness.

VENTILATING MACHINES, OR BLOWERS AND EXHAUSTORS.

It is already stated above, that the remarkable occurrence and combination of certain minerals in the deep ground evolves heat, such heat ranging from 90 degrees to 130 degrees Fahr., and consequently it is compulsory, on the one hand, to furnish solid ice in large quantities to the miners during working hours, to cool their system and refresh their bodies, but also to supply them with as good and wholesome air as can be obtained. As regards the latter, the introduction of mining diamond and power drills has been attended by salutary effects, inasmuch as the compressed air used as a motor for these labor-saving machines, in its exhaust ameliorates the atmosphere by removing the depraved and lighter gases into the upcast shafts, or within reach of the exhaustors. The air compressors have already been described, and the ventilating machines used either as forcing or exhausting-fans are all on the same principle (Root's), which assimilates that of the centrifugal pumps if such are driven in one direction, or the opposite with diversifying effects. "Ice chambers" are also constructed for the use of the miners, who reach them after a spell of but few minutes' work in the face of their workings in quite an exhausted state, thus explaining why these mines must be worked seven days per week, as, if they cease operations for a few hours only, the gases would accumulate so quickly and strongly that they could not be got rid of by any known means at present.

SECTION IV.—CRUSHING MILLS.

The ore, as delivered by the "cars," or trucks, into the "dumps," or paddocks, is not of a very coarse nature, and can therefore be fed into the boxes by the circular patent ore-feeders direct, without the intervention of stonebreakers, one young man attending to the feed of from 40 to 50 heads during eight hours shifts. The mortars are of the ordinary size and description; the stampers weigh from 700 to 800 lbs. each, and have a drop of from 7 to 8 inches. The No. 40 screen, or wire gauge, is used for the crushed ores to pass through, delivering the same over the splash-board consecutively into several tanks, 7 feet square by 30 inches in depth. In regular rotation, these tanks are emptied of the sands they contain, which are then placed into a series of pans for grinding, amalgamation, and concentration.

(*a.*) CONCENTRATION AND AMALGAMATION.

These pans (Horn's) receive their charges in quantities of two tons a time, and in these they are worked for five hours; the pans are 60 inches in diameter, each 32 inches deep, and the "muller" revolves 14 times per minute. After working the "*pulp*"—*i.e.*, crushed sand—for three hours, about 400 lbs. of mercury are added, in the form of a thin spray, to each charge, and then the remainder of the time—two hours—is given for thorough mixing. After that the plugs at these pans are successively opened from the top, and the pulps are run into the "*settler*," which is 10 feet in diameter by a depth of 3 feet, and in which the muller rotates at the same speed; then the pulps are "thinned" down by means of jets of pure water, as necessary, and the upper plugs are opened to convey away the waste for future treatment; the lower plugs are not taken out until the amalgam is clear of all sand and slimes. This amalgam, of which there are large quantities, owing to the richness of the ore, is then conveyed in trucks upon a tramway to the "*strainer.*"

The preliminary action taken with this amalgam consists, however, in its being placed in bags of common navy canvas, in order to permit the free mercury to dribble through of its own weight; another bag of canvas, of a conical form, is then used for this dried amalgam, and this bag is placed into the strainer, which is made of strong cast iron, and resembles a very large bucket, smaller at the bottom, which latter is besides pierced with a number of small holes; the lid is then screwed down on the close packing, and, through a pipe leading from a main, water is turned on under great pressure, by means of which all the rest of the mercury is squeezed through the canvas into a vessel placed below. The strainer is furnished, about half way up the two sides, with two spindles and a handle, by means of which it can be tilted over easily, thereby permitting the amalgam to be removed for the retorts, which have already been described.

(*b.*) MODES OF TREATMENT.

The treatment at the Comstock, it will be admitted, is very simple and direct, though in some mills other means are added in order to assist in the reduction of the ores. To recapitulate: crushing through No. 40 gauge screens, sands falling into tanks, 7 feet square by 30 inches in depth; for grinding, amalgamation, and concentration into Horn's pans, 5 feet diameter by a depth of 32 inches, muller rotating fourteen times per minute for three hours, then each charge of two tons is supplied with 400 lbs. of mercury, ending with thorough mixing for two more hours; then plugs are opened successively for settler pan, 10 feet diameter by 3 feet depth, muller a like speed, until amalgam is left pure by jets of water removing impurities.

Where the ore is not working well in the pans, solutions of sulphates of copper and iron are added occasionally, and superheated steam is also forced through pipes in the bottom of the pans with very good results; the consumption of bluestone at the Comstock has reached 4,000 tons per annum.

SECTION V.—TAILINGS.

These residues, accruing in enormous quantities from the mills at the mines—some mills crush and treat from 400 to 500 tons of ore per diem—are treated in a skilful manner in specific tailings mills located on the Carson River, in the Gold Canon, at Silver City, and Gold Hill, and as a matter of fact most of these mills receive tailings which have repeatedly been treated in mills situated higher up the valleys. As far as I could ascertain, these tailings are primarily conserved in large dams, where they gradually settle, and after having remained therein for some months or longer in order to induce spontaneous decomposition in the open air, they are then ground in pans with additional solutions of rocksalt, bluestone, and interjected superheated steam. Inasmuch as they are by this time ground very fine, and are therefore more like slimes than sands, electro-copper plates and blanket strakes complete the process of intercepting the auriferous silver they are charged with. The blanket strakes have a novel appliance attached, viz., every strake is traversed longitudinally by a small gas-pipe perforated at the bottom, discharging a perfect spray of water upon the blankets, whereby the lighter sands are very effectually washed down the strakes. Owing to the great prevalence of lime in the ores, these tailings evince a great disposition to decompose in the open air, so that it is not at all surprising to find tailings which have been repeatedly treated, to repay for all the trouble and expense for extracting the bullion they still continued to contain, after farther manipulations.

Section VI.—The Sutro Tunnel.

This undertaking, now so near its completion (August, 1877*), has been carried on, from its inception to the time I inspected it, with determined energy, and as the work was performed in a very short time, and in the face of many difficulties, the following sketch may be of interest to us in Australia, where certain localities offer similar facilities for such principal adits :—

In some of the lower workings on the Comstock, the temperature exceeds 130 degrees Fahrenheit, and that in the face of a large number of machines which either exhaust (suck) the depraved air to the surface, or others which add good wholesome air directly or indirectly to the heated atmosphere below. There is, besides, every reason to believe that a yet greater heat will prevail, and which will consequently render the future working of these mines almost an impossibility for a much greater depth. The amount of work performed under these circumstances cannot exceed 50 per cent. of what miners would do in a cool and wholesome atmosphere, and thus the working expenses are increased at a rapid ratio with a corresponding decline of profits, for which the extraordinary richness of the ores could only compensate. The cost of raising a ton of ore, for instance, in such mines as yield profits or pay their way amounts to one dollar each ; in mines where no regularly payable ore is getting it costs probably as much as 4 dollars per ton. And it should also be remembered, that mine timber lasts longer in ventilated workings than in less wholesome mines, which circumstance, in the first case, would on the Comstock make a deal of difference, as the mines there have used for years an annual supply of lumber measuring 16,000,000 feet (American measure). Added to this, comes the expensive pumping machinery for the drainage of the mines, and also the increased cost of carriage for all kinds of miners' requisites delivered at a high and almost inaccessible part of the Nevada Mountains.

Mr. Adolph Sutro conceived the idea, sometime before 1869, to start a main tunnel from the banks of the Carson River, at a distance of about four miles east of Virginia City, for the deeper levels of the Comstock lode, and after grappling successfully with legal and local difficulties, ground was broken in the same year, since which time this adit has been in full operation. The expenses have been, on the average, at the rate of £200 per day, and its total length at the time of my visit was 18,000 feet, leaving but 2,000 feet more before the Savage Company's levels would be holed into. As soon as this is done, there cannot be any doubt but what the miners, mines, and all interested will be materially benefited, through a considerable reduction in the working expenses and consequent larger margins of profit, besides

* This tunnel has since been successfully connected with workings (at the 1,922-foot level) on the Comstock lode.—(G. T.)

affording greater facilities for working systematically, and permitting low-graded ores to be worked with profit. The rapid progress made in the tunnel is chiefly due to the powerful drilling machinery employed, and the stimulation given to the miners to their receiving a substantial bonus if a certain number of feet per month were exceeded. The air compressors used have been erected near No. 2 air-shaft, and the therein compressed air furnishes the motive-power to work six percussive drills (Nationals), mounted on a suitable truck or carriage; the drills strike from 300 to 800 times per minute, with a length of stroke of 7 inches, each blow falling upon the drill-head with a force weight of 1,000 lbs. They use from 150 to 200 lbs. of giant powder in twenty-four hours; all blasts are ignited by means of electric batteries and detonators; and that the works are carried on with great energy and despatch is proved by their driving from 300 to over 400 feet per month, the tunnel measuring "in the clear" 14 feet wide in the bottom, 13 feet at the top, by a height of 10 feet from the sole-piece; it is timbered with square sugar-pine logs 12 inches by 10 inches, and laths 3 inches thick. The grade adopted for the tunnel, at 12½ feet per mile, is such as to intersect the Comstock at a vertical depth of 1,922 feet, or about 2,100 feet on the underlay of the lode, below its outcrop; its direction is due west, and the tunnel has been driven in a perfectly straight line. Philadelphian mining locomotives are here also used for traffic purposes, and according to Mr. Sutro's calculations, since confirmed as correct, each load can be delivered at only 10 cents, or 8d., thus saving, in unproductive mines, the sum of 3 dollars 90 cents on the 4 dollars it costs to hoist, pump, &c., a ton from below to the surface on the Comstock lode. It is the intention to erect extensive ore reduction and dressing establishments at the mouth of this adit after its completion, and to utilize the subterranean water in the old shafts, properly "bulk-headed," as a motive-power for pumping and winding engines below the tunnel level, and this water in a similar manner outside, for the working of the crushing mills, pans, and other ore-reduction machinery.

APPENDIX.

A. *Wages.*—On the Comstock the miners' wages are not less than 4 dols. per day, for *seven* days in the week, and by a late agreement come to between most of the mine superintendents and the very powerful "Miners' Union" of Storey County, Nevada, no miner is employed who does not belong to that society. At most mines it is customary to deduct one dollar per month for the hospital fund. Amalgamators, for twelve hours shifts, get 5 dols. per diem; tankmen 4 dols. do.; superintendents receive from 500 dols. per month downwards.

B. *Mining and other Laws.*—The net produce, or the dividends, of mines in this State of Nevada are subject to taxation.

C. *Minerals and Ores.*—The Comstock lode furnishes splendid specimens of calcites. The ores comprise the following, viz.:—Argentite (sulphuret of silver); Proustite (ruby silver); Tetrahedrite (grey copper *cum* silver = Fahlerz); Galenite (sulphuret of lead); and Wulfenite (molybdate of lead).

D. *Mine Timber* ranges from 22 to 35 dols. per thousand feet (lumber).

By Authority: JOHN FERRES, Government Printer, Melbourne.