

HYDRAULIC ELEVATORS.

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As these very simple and highly efficient machines are not well known in this Colony, I have collected together from various sources a few facts about them which will be useful to mine-owners. They are largely used in California and New Zealand for raising gravel from low-lying situations to such a height as to permit of it being sluiced. For their most satisfactory working both high pressure and large volume of water are required; but these once obtained the cost of working is very small, thus giving these machines a great advantage over most others that can be used for raising gravel.

From an able article on "River Mining," by R. L. Dunn, in the ninth annual report (1889) of the State Mineralogist of California, the following description, and Figure 1 attached hereto, are taken:—

"Deep-bar Mining by Elevators.

"Where it is possible to obtain large heads of water under considerable pressure, the mining of deep bars (except where covered by slides) and extended areas of river-beds that have been opened by fluming, is most economically and rapidly effected by means of what are called hydraulic elevators or lifts. This style of plant has already been incidentally referred to in connection with the Golden Gate and Horseshoe Bar mines." (These references are quoted below.) "These elevators consist of a wrought-iron upraise pipe or barrel, of diameter dependent on the vertical lift and water-pressure available, those at present in use being from 11 inches to 20 inches in diameter. For convenience they are usually set on a 60-degree inclined framing, though the nearer vertical they are set the better they work. The length of the elevator is, of course, determined by the slope it is set on and the vertical lift made. The extreme lift now in operation is 89 feet, though I do not consider that the limit of practical efficiency by any means. The lower end is slightly flared out, set in the bottom of the pit open, and with the nozzle of the pipe, carrying water from the pressure-box from 200 to 500 feet above, projecting into it, and in the line of the elevator. A short distance above the nozzle a throat section is set in, narrowing it from 11 inches to seven and one half to ten, dependent on the amount of wear on the throat section, which, of course, can be replaced when worn too large. The upper end of the elevator is flared out a little, and discharges into a sluice-box with riffles for saving gold. The action of this elevator is by the stream of water coming from the nozzle of the pipe and forced through the elevator by the head from the pressure-box. This stream going through the throat section with its tremendous velocity creates a very strong suction, which lifts water, sand, gravel, and boulders from the pit and discharges them into the sluice, where the gold is caught and the tailings discharged on the dump. For the proper action of the elevator a large amount of water is necessary in the pit all the time. This water is first employed in ground sluicing, piping top gravel and waste off the pay gravel, and in washing the latter in the pit in small boxes with a sluice-head. Large boulders are handled by the derrick, or barrows, and piled in the pit on cleaned bedrock, and the fine material, after screening by a grizzly, goes into the elevator sump or pit and is lifted out of the mine. Where the elevator discharges into the sluice, the latter is covered by a heavy framing lined with green pine and liveoak logs, on which the water and gravel impinge before dropping into the sluice.

"For pumping water, and sand and fine gravel if necessary, another form of elevator is designed and used. In this, the foot of the elevator, placed, if desirable, 30 feet above the sump, is a solid pear-shaped casting, the nozzle screwing into the bottom, and discharging through the throat at the upper end. The suction pipes from the sump enter the sides of this pear-shaped casting.

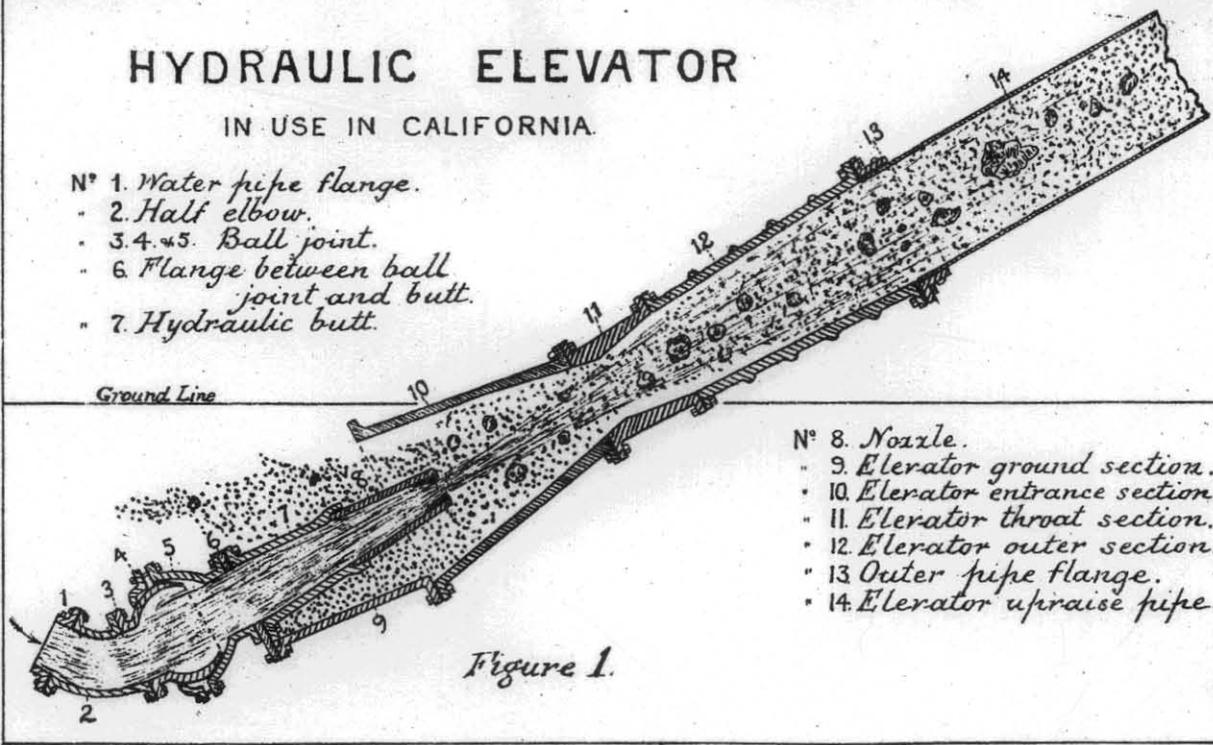
"This class of machine is exceedingly efficient for pit mining. With it the problem of drainage is practically reversed, and the difficulty is not so much to get the water out of the pit as to get sufficient in to mine with. Quicksands and barren top dirt offer no serious obstacles to thorough mining, and the machine does the work of more men than could be practically worked on the same ground, and in a fraction of the time.

"The Mammoth Bar Mine in Placer County has been successfully exploited by means of an open pit, working through elevators, after unsuccessful attempts for 30 years to mine the same ground by drifting, and it is to this mine more than to any other that the credit of demonstrating the utility of these machines is due. The pit excavated in 60 feet depth of sand and gravel is now very large, and has increased the facility of working. Instead of sweeping all the top dirt through the elevators to the dump, it is sluiced back on worked-out ground, and only the pay gravel washed into the sump, at a considerable economy of water and time. This mine uses 400 inches of water under 450 feet head for its elevators; but its

HYDRAULIC ELEVATOR

IN USE IN CALIFORNIA.

- N° 1. Water pipe flange.
- " 2. Half elbow.
- " 3, 4, & 5. Ball joint.
- " 6. Flange between ball joint and butt.
- " 7. Hydraulic butt.



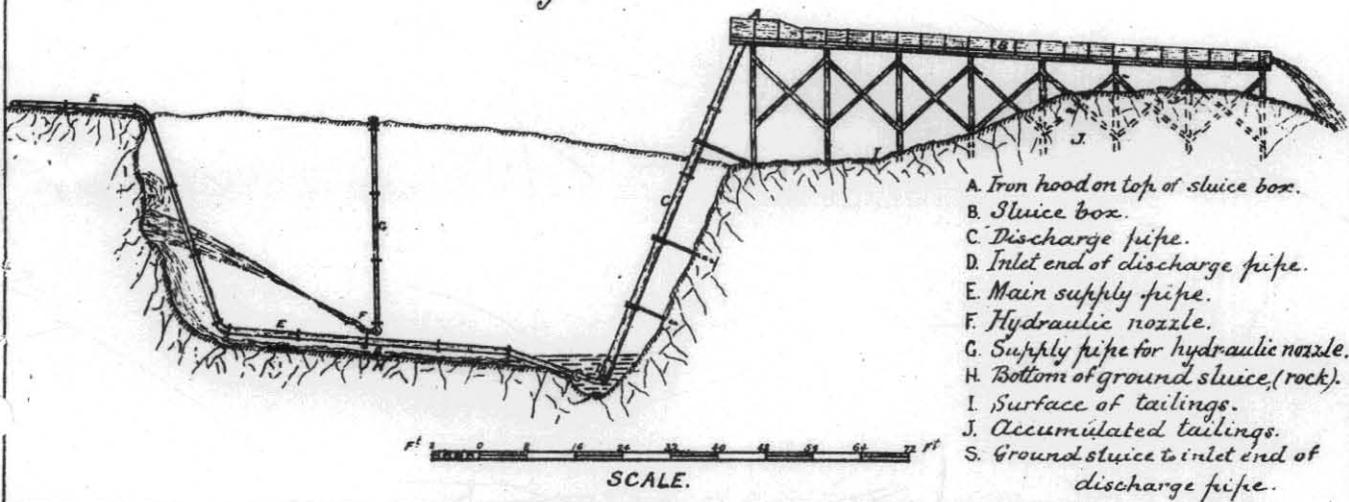
- N° 8. Nozzle.
- " 9. Elevator ground section.
- " 10. Elevator entrance section.
- " 11. Elevator throat section.
- " 12. Elevator outer section.
- " 13. Outer pipe flange.
- " 14. Elevator upraise pipe.

Figure 1.

PERRY'S ELEVATOR

AT GABRIEL'S GULLY, N.Z. (1886).

Figure 2.



- A. Iron hood on top of sluice box.
- B. Sluice box.
- C. Discharge pipe.
- D. Inlet end of discharge pipe.
- E. Main supply pipe.
- F. Hydraulic nozzle.
- G. Supply pipe for hydraulic nozzle.
- H. Bottom of ground sluice, (rock).
- I. Surface of tailings.
- J. Accumulated tailings.
- S. Ground sluice to inlet end of discharge pipe.

SCALE.

SKETCH SECTION OF THE CAST IRON BOTTOM PIECE OF THE GABRIEL'S GULLY ELEVATORS (1891.)

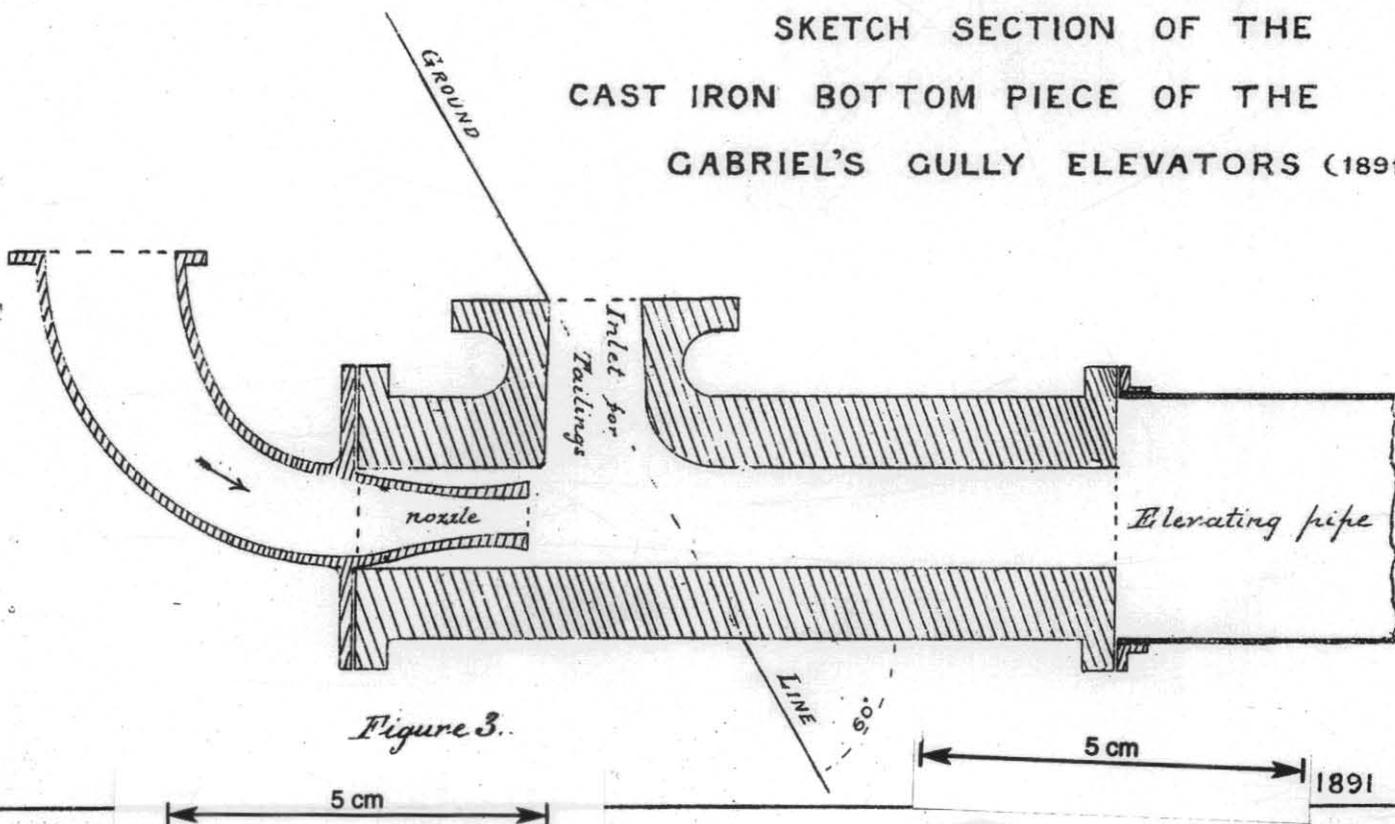


Figure 3.

5 cm

1891

experience has demonstrated that larger elevators and a larger supply of water would be still more economical, as the cobbles now moved by hand labour slowly and expensively could be then handled by the elevator rapidly and cheaply."

The references above alluded to are as follows:—

Golden Gate River Mine: "The pumping plant consisted of two elevators, two Chinese pumps with boxes 3 by 28 inches, and a centrifugal pump. The lift for the pumped water was 28 feet. The elevators had columns or barrels 11 inches in diameter, with a 10-inch throat, this latter proving too large for good work. They were operated with 275 feet head of water from the Palermo Ditch. One of them, with a 2½-inch nozzle, used 175 inches of water; and the other, with a 3-inch nozzle, took 208 inches."

Horse-shoe Bar River Mine: "The mass of sand and gravel overlying the pay gravel on the bars is so great that pitting by the usual method of hand labour is both too uncertain and too expensive to be advisable. The method of work approved and decided on by the owners of the property is the use of hydraulic elevators run by water under high pressure."

In another article in the same valuable Report, on "The Auriferous Gravels of California," the writer, Mr. John Hays Hammond, also refers to hydraulic elevators, and gives a photograph of those in use at the North Bloomfield Mine. "The capacity of this elevator is, according to Superintendent Radford, 2400 cubic yards per 24 hours. The gravel is elevated 87 feet vertically. One thousand three hundred miner's inches of water are required under a pressure of 530 feet. In addition to elevating the gravel, the 800 inches of water used in piping the 2400 cubic yards of gravel is also raised with the gravel." In a footnote, however, Mr. Hammond adds:—"Since writing the above I learn from Mr. L. L. Robinson, the President of the North Bloomfield Company, that the hydraulic elevator has been abandoned because of the great expense attending its operation. He thinks, however, that for heights up to about 40 feet the elevator would work to advantage under favourable conditions as to cost of water, &c. The company is making other experiments in this direction at present."

In reducing the Californian miner's inch to Tasmanian "sluice-heads," the former may be approximately estimated as 1½ cubic feet a minute, while the latter are 24½ cubic feet a minute. A Tasmanian sluice-head is therefore about 16 miner's inches. The expense of the enormous volume of water required for the North Bloomfield Company's large elevator, and the rapid wear of the elevator pipe, appear to have been the principal causes of giving up its use.

Elevators are much used in New Zealand in the sluicing districts of Otago and the West Coast. They were first introduced by Mr. J. R. Perry at Gabriel's Gully. "The Handbook of New Zealand Mines," published in 1887, gives opposite page 32 a diagrammatic sketch of the apparatus which is reproduced herewith (figure 2.) The following description is given by Mr. H. A. Gordon, Inspecting Engineer of the Mines Department, in his Annual Report of 1886 on the Mining Industry of New Zealand, page 73:—

"A large paddock is excavated out of the bedrock, and into this paddock the whole of the material is sluiced from the face. An upright or slightly inclined pipe, 15 inches in diameter and 47 feet long, is placed from the bottom of this paddock to a flume which extends for about two chains, and empties into another small tank where a second inclined pipe of same diameter is placed, having a vertical height of 37 feet; thence the whole of the water and sluiced material goes into a large flume, and is carried away as in an ordinary sluice-box, having ripples and false-bottoms to save the gold, the tailings being deposited in the bed of Gabriel's Gully. By these two lifts the whole of the water and tailings are raised a vertical height of 84 feet. To accomplish this about 20 sluice-heads of water" (the New Zealand sluice-head is 60 cubic feet a minute) "are required, having a head from 350 to 400 feet. Five sluice-heads are employed in breaking the cement and sluicing it into the lower paddock. Then seven and a half sluice-heads are employed to raise the water and tailings to the first flume, 47 feet in height, and another seven and a half heads are employed to raise it from the second tank or paddock up to the main sluice-box, 37 feet in height."

In his report of 1890 Mr. Gordon gives further information about the Gabriel's Gully elevators, as follows:—"At the time of my visit there was a scarcity of water and only two nozzles were at work. The bottom elevating-pipe lifted the material 14 feet into a flume 84 feet long and three feet wide, and then there was another elevating-pipe at the end of this flume which lifted the material 60 feet into another line of boxes, which carried the tailings clear of the paddock and workings and deposited them in the bed of the gully. . . . There are two elevating-pipes at the upper paddock; the lower one lifts the material about 12 feet and the upper one 25 feet, and the tailings are deposited in the old worked ground." . . . In reference to the quantity of material lifted, the manager stated that when he was lifting the material 87 feet 8 inches in two lifts, namely, one 62 feet 8 inches and one 25 feet, in 85 shifts, comprising 680 hours, he moved 26,920 cubic yards, which would be equal to 40,380 tons; and the gold obtained was 115 oz. 11 dwt. 16 grs., representing a value of £433 8s. 9d., and the expenditure in connection with this work was £198 18s. This, therefore, shows that the quantity lifted to the height mentioned was equal to about 59.4 tons per hour, and that the value of the material was equal to about 2.58 pence per ton, and the cost of the work was equal to about 1.18 pence per ton. The quantity of water used was 350 inches—8½ sluice-heads—with a head of 450 feet on the 62 ft. 8 in. elevating-pipe, and 400 inches—10 sluice-heads—with a head of 375 feet, on the 25 ft. pipe. The quantity of water used on the nozzle for bringing the material to the well where the bottom elevating-pipe was placed was 150 inches—3½ sluice-heads—with a head of 375 feet.

In regard to the amount of work done with the quantity of water used, it appears doubtful if the data supplied are reliable, inasmuch as there is no comparison between the percentage of power employed to lift the material in the 25 ft. elevating-pipe and that used to lift the material in the pipe 62 ft. 8 in. To analyse this, it means that in the bottom 25 ft. pipe 10 sluice-heads of water was used under a head of 375 feet, which, disregarding friction entirely, would be equal to 426 theoretical horse-power, and the quantity of

material lifted, being 59.4 tons per hour, is equal to 2218 lbs. lifted to a height of 25 feet per minute, or 55,450 lbs. a foot high per minute. The quantity of water lifted is equal to the quantity used for elevating plus the quantity used in nozzle for breaking down, namely, $10 + 3\frac{1}{2} = 13\frac{1}{2}$ sluice-heads, or 1,289,062 lbs. lifted a foot high per minute, thus making the total weight to be lifted 1,344,490 lbs., which is equal to 40.7 theoretical horse-power, and shows that 9.46 per cent. of the power is absorbed in friction. Again, the quantity of water used in lifting the material in the upper elevating-pipe is $8\frac{1}{2}$ sluice-heads under a head of 450 feet, which is equal to 44.7 theoretical horse-power. The weight lifted equals the quantity of water formerly used in the lower pipe plus the quantity used in the pipe in question, namely, $10 + 3\frac{1}{2} + 8\frac{1}{2} = 22\frac{1}{2}$ sluice-heads, or 84,375 lbs., together with the weight of the solid material, namely, 2218 lbs., lifted to a height of 62 ft. 8 in., or 5,429,372 lbs. lifted a foot high per minute, which is equal to 164.5 theoretical horse-power, and shows that in this case only 1.71 per cent. of the power is absorbed in friction. Taking into consideration the loss of head due to friction of water in pipes, the quantity of water given for the work done by the upper elevator is too small, or else the quantity given for working the lower elevator is too great. (The percentages of absorbed power in the above calculation are of the actual work done, not of the total theoretical horse-power. In other words, the power lost in the first case is 9.46 times the power used, and 1.71 times in the second case.)

It will be seen from the above calculation, and from other instances that might be cited, that a great deal has yet to be learned as to the amount of head and quantity of water required to lift a given weight of gravel to a given height. Practice seems to vary very much in this respect, and no good working formula seems yet to have been made out.

In a private letter Mr. Gordon has been good enough to give me a few further particulars:—

"The elevating pipe is generally set on an inclination of from 55° to 60° , and the flange on the upper end is bolted on to the sluice-box. The pipe is made of steel plate of from 14 to 16 B.W.G. rivetted, with angle iron flanges every 16 feet, that is, the pipes are made in about 16 feet, or sometimes 18 feet lengths, with angle iron flanges at each end, and are bolted together with $\frac{1}{2}$ -inch screw bolts. The bottom pipe is generally made of cast iron about 4 feet long in the following manner." (See Figure 3 attached hereto.) "The pipes are generally about from 12 inches to 15 inches in diameter inside. The bottom pipe has a liner inside made of hematite iron. When the liner is new it is only about 6 inches inside diameter, that is, it has $4\frac{1}{2}$ inches thickness of metal, and wears down until the internal diameter has about 9 inches diameter. I will give you the dimensions of the Blue Spur elevators. One of them is 83 feet long, set on an angle of $55^{\circ} 30' = 68' 5"$ vertically. The quantity of water used for elevating in this pipe is 500 inches, equal to $12\frac{1}{2}$ sluice heads, with a pressure or head of 450 feet. This lifts about 56 cubic yards of tailings per hour, and also 300 inches of water (7.5 sluice-heads), which are used in the bottom elevator and sluicing nozzle, namely 150 inches ($3\frac{3}{4}$ sluice-heads), which elevate 14 feet, and 150 inches which sluice down the tailings into the bottom of the pipe. They have another elevator of similar character. Two elevators are used where the vertical lift for one is too great. In the instance quoted the bottom elevator lifts the material and water 14 feet into sluice-boxes, and at the end of the sluice-boxes there is a well in which the other elevator is placed. If you can get water at a high elevation these elevators are splendid things, but they require a large body of water. A large number are now used here, and considerable improvements have been made on the first introduced. The head required to elevate gravel is in proportion to the height required to be lifted, which is from 10 feet to 13 feet for every 100 feet of head. Of course the quantity of water used also enters into the question greatly. If you can only get from 100 to 200 feet of head you could not calculate on lifting the ground more than 26 feet with the greatest head. The atmospheric elevators mentioned in my Report did not prove so effective as was anticipated,—indeed they are of no service except the intake orifice for the tailings or gravel is submerged, and this does not often take place. If the elevators were used in the bed of a river where the orifice was always submerged the atmospheric nozzle would be a great improvement. . . . The diameters of the elevating nozzles vary from about $2\frac{1}{4}$ inches to 3 inches, but very seldom is the latter size used: $2\frac{1}{4}$ " and $2\frac{3}{4}$ " are about the diameters used in all the hydraulic elevators here."

The atmospheric elevators referred to are described in Mr. Gordon's Report for 1889 at pages 62 and 73. In describing the Fair Maid and Gladstone claims at Addison's Flat, in the Charleston District, he says:—"A water-race is constructed from the dam to the edge of the terrace, and from this point the water is brought down to the claim in wrought iron pipes, $18\frac{1}{2}$ inches in diameter, made of Nos. 12 and 10 B.W.G. iron. At the bottom of the terrace there are two branch pipes, 11 inches and 15 inches in diameter respectively, one for supplying water to the elevating nozzle, and one for supplying water for the breaking-down nozzle, both nozzles being $3\frac{1}{2}$ inches in diameter. There is 240 feet head of water at the claim, and it is proposed to lift the material with this head to a height of 36 feet 6 inches, which is too high for the head to work satisfactorily, unless a current of air is admitted into the bottom of the elevating pipe. It has been clearly demonstrated that the lifting capacity of the water is greatly reduced when the water and tailings are allowed to cover the opening at the bottom, showing that a current of air mixed with the water increases the force, and it is almost impossible to prevent the opening at the elevating pipe being choked at times. A patent has been obtained in the Colony by Mr. Robertson for an air-pipe connected with the bottom of the elevating pipe to remedy this defect. . . . I have since learned that working has been commenced, and that there are about 80 cubic yards of material lifted by the elevating pipe per hour, about one-half of which is stones and pebbles, which go into the hopper. Everything works extremely satisfactorily."

The other reference to atmospheric elevators is in describing Mr. John Ewing's claim at St. Bathans, Otago:—"Mr. Ewing has made arrangements to have two patent atmospheric elevators fixed, which are guaranteed to lift the material 30 per cent higher than the ordinary elevator, such as is used at Gabriel's Gully. The difference in this elevator is that there is a double nozzle, having a small space between them. The outer nozzle does not stand so high as the inner one, through which the water passes, and it is connected with a gas-pipe, which, when screwed into the casting forming the nozzle, stands above the water in the well in a vertical position. The velocity of the water passing through the nozzle causes the air to rush in through

the pipe, which has a cock on the upper end to regulate the supply. The elevating pipe, instead of being fixed down on the casting forming the nozzle, is held a certain distance above by four collar-bolts, having long screws on one end and double nuts to regulate the height. The ordinary elevator has a hole in the side of the pipe, having the bottom end placed down over the nozzle of the elevating jet instead of the pipe being suspended above it. This atmospheric elevator has yet to be tried, and Mr. Ewing is the first to try it. It will cost him £100 for each elevator. The guarantee that he has is that each elevator will lift one and a half times as much water as is used for elevating, together with as much material as can be sluiced down into the well from a height of 25 feet, with a head on the main supply pipe of 280 feet. . . . At St. Bathans Mr. Ewing has arranged to have another atmospheric elevator, making in all three of them; but this one is to lift an equal amount of water to that used in elevating, together with as much material as can be sluiced into the well from a height of 57 feet, the main supply pipe having a head of 440 feet. It will be interesting to know how these patent elevators act, and if they possess the advantages claimed for them."

An interesting example of comparatively high lift with a low head is given in the same report in describing Mace and Bassett's claim, Addison's Flat:—"Their elevating pipe is 10 inches in diameter, with a 3-inch nozzle, and they lift the stuff 15 feet with a head of 75 feet, which is far too small a head to lift the stuff this height satisfactorily; yet they are doing extremely well."

From the above descriptions it will be seen that there are great variations in the practice of hydraulic elevating. The use of two lifts in place of one where the distance required to be lifted is great appears to be a considerable improvement, and, after workings are well opened out, will often permit of a large proportion of the tailings being run back on to the worked-out ground without being lifted right out of the excavation. The first cost of the elevators is small, about £25, and the expense of maintenance is trifling. The liner, or bottom casting where no liner is used, in the bottom of the elevating-pipe, has to suffer a great deal of wear and tear through being battered by the heavy stones thrown against it by the force of the water. The Hercules Company, in Otago, now use solid castings seven inches in thickness, liners having been found not to stand, but to become splintered and broken. Mr. Gordon recommends the use of steel castings for liners and bottoms where heavy gravel has to be raised by a powerful jet. In some parts of the west coast of New Zealand I have seen the upper parts of the upraise pipes made of wood,—simply wooden boxes, in fact. These, however, are not so good as iron pipes, as they cause greater loss of power through friction.

In the following table I have collected all the principal facts that I have been able to obtain as to the working of elevators. The table is by no means complete, full particulars not being always obtainable.

Name of Mine.	Locality.	Size of Elevator Nozzle.	Size of Elevator Pipe.	Head.	Lift.	Material raised per hour.	Water used for breaking ground.	Water used for the Elevator.
Mace and Bassett's	Addison's Flat, N.Z.	Inches. 3	Inches. 10	Feet. 75	Feet. 15	Tons. ...	Tasmanian Sluice-heads.	
Fair Maid and Gladstone.....	" "	3½	11	240	36½	120
Hercules Company	Clutha Valley, N.Z.	3½	?	450	44	38½	11·2	17·7
" " " "	" "	3½	?	450	50	38½	11·2	17·7
Island Block Company	" "	2½	15	760	64	40	9·0	14·3
Gabriel's Gully, Consolidated, } 1890.....	Tuapeka, N.Z.	2½	15	375	25	59·4	7·6	20·4
" " " "	" "	2½	15	450	62½	59·4	...	17·9
" " " " 1891...	" "	2½	15	450	14	84	7·6	7·6
" " " " 1889...	" "	2½	15	450	68½	84	...	25·5
" " " " " "	" "	2½	15	420	12	...	40·8	
" " " " " " 1888...	" "	2½	15	420	35	...	?	25·5
" " " " " "	" "	2½	15	420	30	...	?	35·7
" " " " " "	" "	2½	15	400	47	...	10·2	15·3
" " " " " " 1888...	" "	2½	15	350	37	15·3
Average (Dunn)	California	?	11 to 20	200	89
Mammoth Bar	"	?	?	450	40	...	25	...
Golden Gate River	"	2½	11	275	28	...	11	...
" " " "	"	3	11	275	28	...	13	...
North Bloomfield.....	"	?	?	530	87	150	50	81·3

A. MONTGOMERY, Geological Surveyor.