THE BRISEIS WATER RACE.

By H. V. Champion, M.C.E., *Consulting Engineer to The Briseis Tin Mines Ltd. Read 6th August, 1902.*

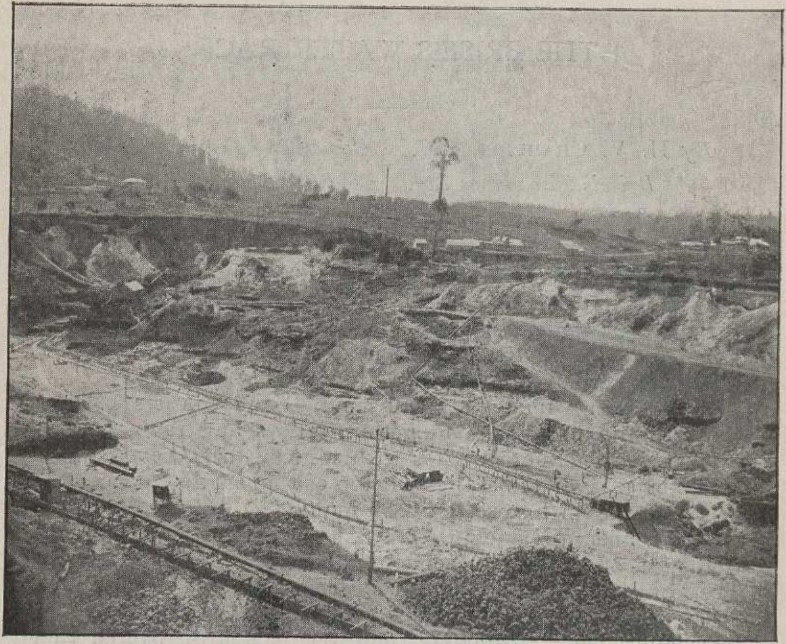
The Briseis Tin Mines are situated about one mile from the township of Derby, in the County of Dorset, in the North-East of Tasmania. A coach drive of 20 miles carries one from Derby to Scottsdale, the nearest railway station, which is 43 miles from Launceston.

The country immediately around Derby consists of very steep granite hills, with numerous valleys and ravines. The latter are filled more or less with alluvial drift, covered generally by a layer of basalt. On top of this shallow deposits of drift rich in tin have often been found.

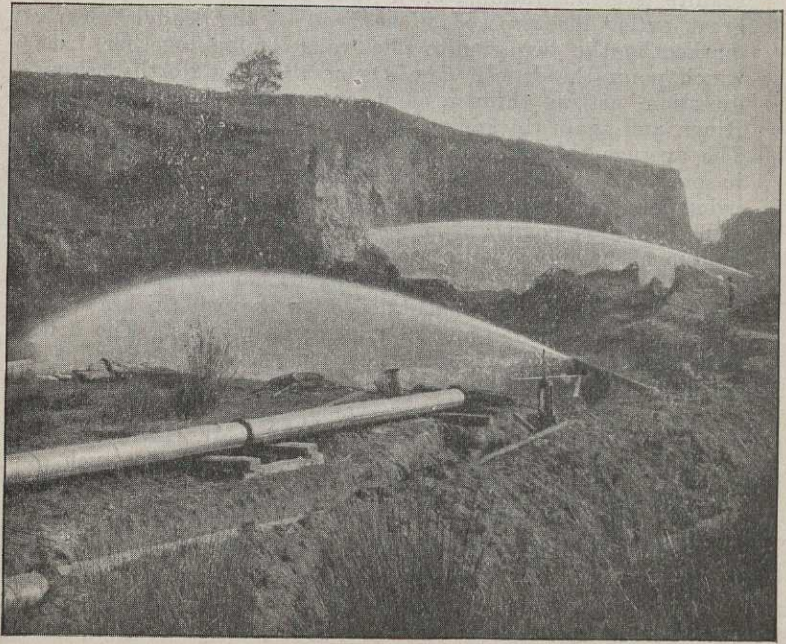
The country is thickly timbered and well watered. The timber is of sufficiently good quality to be used in fluming. The principal river is the Ringarooma.

The property comprises 200 acres, and was originally worked for shallow tin. Ultimately, however, it was discovered that a great and rich deposit existed under the basalt. It consists of alluvial drift, filling a natural deep valley in the granite (see illustration, No. 1). The basaltic covering is to a great extent decomposed. The head of the lead is clearly marked by the two granite side walls coming together, from which point the deposit trends generally in a North-Easterly direction, getting thinner as it approaches the Ringarooma River, and again thickening on the other side of that stream. The average thickness of tin drift is computed at 80 feet—in some parts it is over 160 feet thick. The width also varies, being in some places as much as 900 feet.

The drift is composed of coarse white quartz wash, with occasional bands of white pug from a few inches to 2 feet thick, not very tenacious, and easily broken down by water. Thin bands of an iron cement less than an inch thick also occur in patches, with beautiful manganese crystals. The drift carries tin throughout, getting richer with the depth. Towards the bottom streaks of solid tin stone occur frequently, greatly increasing the average value. The metal occurs in grains of cassiterite or tin oxide ($Sn\ O_2$). Mr. David Currie, in his report of 23rd November, 1899, from which much of this descriptive information is derived, tested a number of samples from the whole thickness of the wash. The total averaged over 1 per cent. tin oxide. He states that he tested



1—The Briseis Tin Mines.



2—Hydraulic Sluicing.

the wash at all different points, always with excellent results, and never once failed to find tin present in respectable quantity.

Mr. Currie estimated the total quantity of mineral drift at 4,500,000 cubic yards, containing metallic tin, at £100 per ton, worth £3,375,000.

The great difficulty in properly developing this mine has been the lack of a sufficient supply of water. The method of mining is that of hydraulic sluicing (see illustration No. 2). Water is conveyed by races to pipe head tanks in convenient positions at the necessary elevations, and thence by pipes to nozzles brought to bear upon the face. The drift and overburden are then sluiced down, and the tin ore intercepted in long boxes or tail races, the tailings passing on to leased lands, and partly with the waste water to the Ringarooma River.

In discussing the question of water supply it will be convenient to use the unit generally employed in mining, namely, a sluice head.

In Tasmania this is defined as "the quantity of water which shall pass through an aperture 16 inches long, and 1 inch deep in the outlet end of a gauge box when the surface of water is 6 inches above the centre of the aperture." This is usually accepted as equivalent to 24 cubic feet per min.

Prior to the construction of the Ringarooma and Maurice Water Races, the company owned rights as follows:—

On the Cascade River—33 sluice heads;

On the Main Creek—7 sluice heads;

and in addition 80 heads on the Cascade River, conjointly with the Brothers' Home, No. 1 Co. These rights do not represent anything like the quantity of water at all times there available. As a rule, the quantity did not exceed 25 sluice heads.

The present scheme proposed to increase the supply by 100 sluice heads. As no plans of the watershed area were available, it was not possible from a study of the records of rainfall and the nature of the country to form a reliable estimate of the quantity of water available. On the 10th December, 1900, before any contracts were let, the flow in Ringarooma River was gauged at the offtake at 39 Tasmanian sluice heads. On the 12th December, 1900, Dunn's Creek, a tributary of the Maurice River, at 29 sluice heads, and on the 15th December, 1900, the Maurice River, above its junction with Dunn's Creek, at 39.3 sluice heads. Prior to these gaugings there had been no rain for some time, and it was urgently required by the farmers. These were the streams that it was proposed to tap, and it was anticipated that in ordinary dry seasons a supply of 100 sluice heads might be obtained from all these sources.

The works to deliver this water to the mines were designed and carried out by Mr. Donald Fraser, brother of Mr. J. H. Fraser, C.E., of Melbourne University, and Victorian Railway Department.

The design embraces two main features, first the interception and utilisation of the waters of the Ringarooma River, and secondly, those of the Maurice River and Dunn's Creek.

The dam site on the Ringarooma River is about 20 miles from the mine, the total length of race constructed being 19 miles, 38 chains, and 40 links. This work was first undertaken. Afterwards the Maurice River race, about 10 miles, 35 chains, was constructed as a branch to intercept Maurice River and Dunn's Creek, and to discharge into the main race at a point about 70 chains below the dam site.

The main race follows generally the line of the Ringarooma River, cutting off, however, a great bend at Branxholme. The fall is 4 feet per mile, or 0.05 per chain.

There are four inverted siphons in the design, namely:—

1. Krushka's Creek
2. Dorset River
3. Ringarooma Valley
4. Black Creek

The pipes are constructed of mild steel plates 3-16 ~~diameter~~ thick, lapped and riveted with steel rivets. Nos. 1 and 2 are single riveted throughout. Nos. 3 and 4 are single riveted on the upper portions of their length, and double riveted on the longitudinal seams for the lower portions, where the pressure is at a maximum. No reduction in thickness of metal was recommended in the case of the Krushka and Dorset siphons or in the upper portions of the Black Creek and Valley siphons, where the factors of safety are slightly high, as 3-16 inch was considered thin enough, having regard to durability.

The discharging capacity of the siphons was carefully investigated, formulae by Box, Beardmore, Merriman and Kutter having been applied, and the results compared. As there appeared to be considerable variations in these results owing to the inexact condition of hydraulic science with respect to the discharge of pipes of so great diameter, made of steel lapped and riveted, much importance was attached to the 115 experiments upon the flow of water in large riveted metal conduits carried out by Mr. Clemens Herschel in the United States. The experiments of C. D. Marx, C. B. Wing, and L. M. Hoskins, on the flow of water in 6 feet riveted steel pipes on the aqueduct of the Pioneer Power Company, Utah, U.S., were also noted. (Trans. Inst. Civil Engineers, England, Vol. 134, Page 437.)

The Chézy formula, $v = c\sqrt{rs}$, used by Herschel as a convenience in the classification of his results, was ultimately applied in this case with such values of C as appeared to be suitable to the particular circumstances obtaining.

For new pipes the carrying capacity of the siphons as computed by Herschel's method was found to agree very fairly with the results obtained by Kutter's formula, using the coefficient of roughness N = .013

The opinion was finally held from these investigations that the discharge of the siphons, when new, if the internal coating had been carefully applied, would cover the requirements which, according to Mr. Fraser, were necessary to provide for ordinary losses of water "en route."

The following table gives particulars of siphons and of the discharges required:—

Locality of Siphon.	Length. Feet. Inches.	Fall, Feet.	Diam. in Inches.	Discharge required to provide for losses in race as estimated by Mr. Fraser. Tas. Suice Heads.
1. Krushka's Creek	905′ 6″	3·15	10	118
2. Dorset	3748′ 6″	11·51	40	115
3. Black Creek	3480′ 0″	11·31	38	105
4. The Valley	2618′ 0″	8·37	38	103

The lengths given are for built pipes.

After the pipes have been in use for some years the experiments of Herschel, and indeed the general experience of engineers, show that the discharge becomes less, owing to the accumulation of slime, rust, or tubercles in the interior of the pipes. This reduction might reasonably be expected to be greater in the Krushka and Dorset siphons, which are nearer to the point of offtake than in the Black Creek and Valley Works.

It was thought that the results of Herschel on this phase of the question should not be rigidly applied in this case, but with the diameter of pipes proposed to be used it was considered injudicious not to contemplate the possibility of a reduction of the discharge in the Krushka and Dorset siphons of, say, 4 per cent. per annum, and in the Black Creek and Valley siphons of, say, 2 per cent. per annum.

In four years this might bring the discharge of the Krushka siphon about 7 per cent., the Dorset about 5 per cent., the Black Creek about 5 per cent., and the Valley about 1 per cent. below the tabulated requirements above set forth, but these amounts could not be predicted with exactitude. Experience shows that no further diminution of discharge would be likely after four or five years.

Mr. Fraser provided for coating the pipes internally and externally with a mixture of Trinidad Asphaltum and coal tar. As long as the coating is preserved little or no damage is to be apprehended from rust, and other accumulations may be removed by blowing out, or by shutting off the water and sending men through without boots to remove them with brush scrapers.

In computing the discharges the losses of head due to velocity, entry, bends, etc., were considered, as well as those due to friction. The siphons were designed to reduce those losses to a minimum.

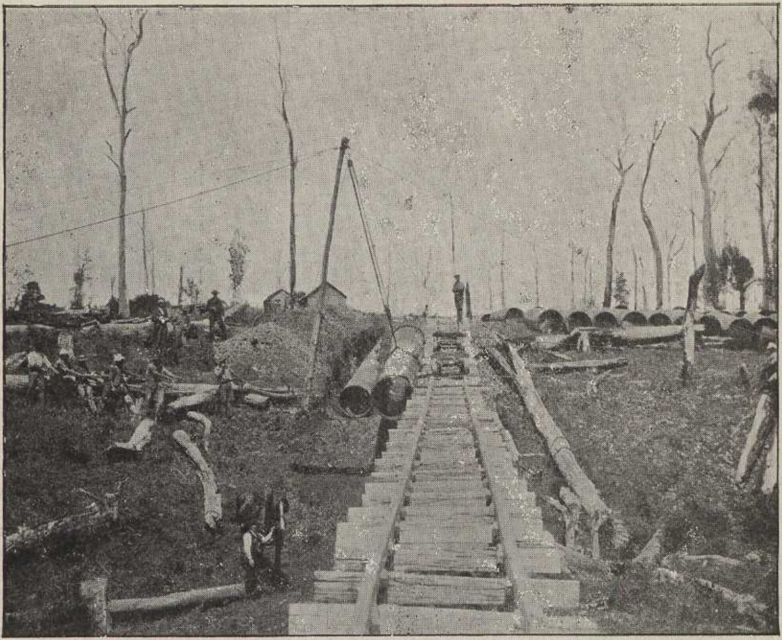
The method of supporting the pipes was subjected to some criticism, but finally the matter was referred to Professor Kernot, who approved of the design.

The steel plates were manufactured and punched in Pittsburgh, U.S.A., and were rolled and riveted in Tasmania by Mephan Ferguson, who also erected the siphons. The spigots, faucets and rivets were also imported from America.

The question of expansion was considered. In the case of the Krushka and Dorset siphons, as most of the pipes were covered, no inconvenience was to be feared with the leaded joints. In the case of the Black Creek and Valley siphons, considerable lengths are exposed above the surface, and may be subject, when filled, to changes of temperature of 40 deg. As the pipes were secured to the supports, the joints were relied upon to take up the expansion, and no difficulty has arisen in connection therewith, except at the Valley and Black Creek siphons, which were laid in the intense heat of last summer. Some trouble was caused by contraction when the water was turned on. This was remedied by cutting a pipe in two near the bottom, and forcing the other pipes home with jacks. The opening was afterwards covered with a special plate cut to the required size, and riveted up by hand on the spot.

The Valley and Black Creek siphons (see illustration No. 4) were introduced by Mr. Fraser in lieu of the detours otherwise necessary to turn the heads of these depressions. A saving of over 3½ miles in length of race was effected by the adoption of these siphons, but with little, if any, reduction in first cost. The length to be maintained was, however, reduced by that distance, and work of a more permanent character constructed. The deviations would have consisted very largely of fluming, traversing heavily timbered and very difficult country, in which there was ample evidence of the destructive effect of bush fires.

It was considered impracticable to reduce the size of these siphons by increasing the fall in them. The Dorset Valley imposed an insuperable obstacle to such a proceeding, for although it was possible to locate the line at a higher level from Black Creek to the Dorset, the latter stream could not be crossed near the line at this high level. A great detour to the east would have been necessary, of such a character as to considerably increase the cost of the work.



3— Building a Syphon.

The Krushka siphon is short (see illustration No. 5), saves a considerable length of race, and reduces the amount of compensation to be paid to land-owners. The fall in this siphon might have been increased from 3 feet 2 inches to 8 feet 1 inch, by throwing the fall in the drop at 6 M. 47 C. into the siphon and lowering the race about 5 feet from the outlet of the siphon to the drop, a distance of about 1 M. 35 C. 34 L. The reduction in the cost was, however, scarcely worth the loss of time in altering the surveys, and fresh plans would have been required for excision of land.

As I have recently received from Mr. Fraser, a letter written 29th July, 1902, I am able to describe in some detail the methods adopted in constructing the various parts of the work.

With respect to the siphons a separate description of every pipe required, with drawings, when necessary, was supplied to Mr. M. Ferguson's foreman, the list also showing to what test each pipe had to be subjected. A detailed section of each valley crossed by the siphons was made, showing the pipes in position, each pipe in the drawing being figured with the number and test placed on the actual pipe.

Three special road trucks were made for carrying three pipes each in one load.

At the siphon sites tramways with the same grades as the pipes were erected, parallel to and at a distance of 10 feet from them.

The pipes were then delivered by road trucks at the lowest point of the siphon in each case, and hauled up by winches, or sometimes by horses, with block and tackle.

When the pipes came opposite to their places they were either rolled across on skids or picked up with a derrick and placed in position (see illustration No. 3).

On each siphon the lowest pipe had a faucet at each end, so that on each side of the valley the faucets were all on the uphill side. The siphons were then completed throughout, except for two pieces at each end, where the distances left were carefully measured and matching pieces made and fixed.

4—A Siphon Completed.

5—Krushka's *Siphon*.

The lead jointing was done by contract, the contractors being made responsible for the tightness of joints, the company supplying lead and materials for gasket. The average price for labour was 13s. per joint.

Mr. Fraser states that the jointing was most satisfactory, the amount of caulking required after the water was turned on being insignificant.

In determining the various cross sections of race and fluming Mr. Fraser used Kutter's formula. In the calculations it was assumed that a Tasmanian sluice head was equal to 24 cubic feet per minute.

A limiting velocity of two feet per second was allowed for in the race, as anything exceeding that amount might prove injurious in eroding the bed of the channel unless protected by some kind of lining.

The computed discharges are to a very large extent influenced by the coefficient of roughness employed. Mr. Fraser experimented upon other races in that part of Tasmania, to determine values for the coefficients of roughness, and finally accepted :—

1. For fluming of unplaned timber ... $n = \cdot 013$
2. For unlined race (see illustrations Nos. 6 & 7) ... $n = \cdot 030$

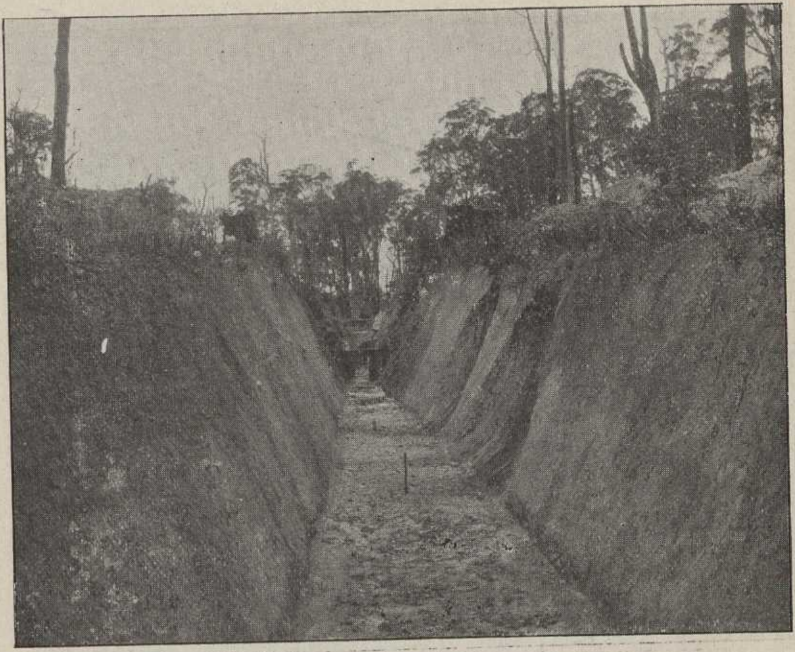
(With natural stones undressed.)

These amounts are higher than those given by Kutter.

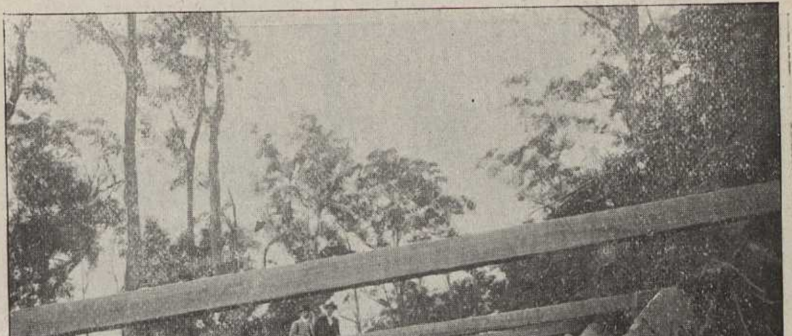
The various cross sections of race may be seen by inspecting the plans herewith. The slope of the sides of the race, $\frac{1}{4}$ to 1, was no doubt attended with economy of construction, but it is doubtful if that slope will be maintained in working. In India it has been found that artificial channels never retain the form in which they were constructed, but gradually approximate to a form having slopes of $\frac{1}{2}$ horizontal to 1 vertical.

The built up portions of the race (see illustrations Nos. 9 and 10) form a type of construction unusual to this State, but there are successful examples of it in Tasmania. I have not examined the race since it has been completed, but I am informed that the built portions are answering satisfactorily, although it might be apprehended that considerable leakages would occur in work of this character. As to its advisability, there is no doubt that if it can be made secure it is of a more

6—Tunnel on Maurice Race.



7—Race in Cutting.



8—Timber Lining.

9—Cutting and Building.

10—Cutting and Building.

durable, though more expensive, character than fluming, and a cheaper method than cutting the race entirely in solid rock.

The double wall building was constructed only across short gullies, and forms no considerable portion of the work.

Unless the soil is of a retentive and stable character it would appear to be advisable in work of this kind to carry the exterior revetment wall down to solid rock, to remove the natural surface soil inside the wall, and fill in the interior space at junction of wall and rock with selected material well rammed, but these precautions must be left entirely to the officer in charge.

The revetment walls were carefully constructed of hand-packed dry rubble masonry. The slope is steep for stone on filling, but has answered well so far.

Mr. Fraser reports that this work, being new to nearly all concerned, was the cause of considerable trouble with sub-contractors, and in some cases had to be condemned two or three times before being passed.

The result, however, has been very satisfactory, there having been no trouble since the water commenced to run.

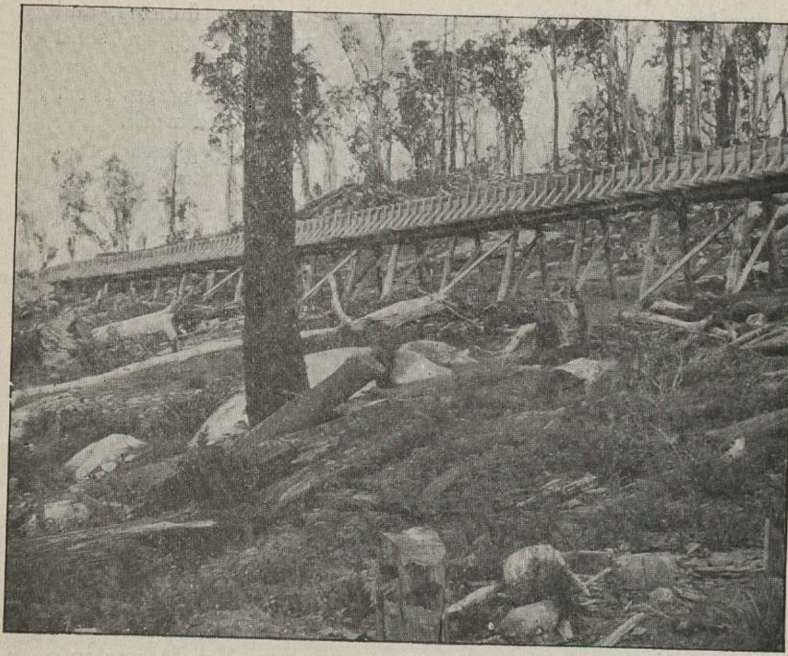
He states that "the race from the intake on Ringarooma River to the mine was carried out according to specifications with very little amendment.

"The principal alteration (see illustration No. 8) was in a length of about 35 chains between the 9 and 10-mile pegs on Section 2. This was in schist, the cross slope being very steep, nearly 1 to 1, and on the lower edge of the race the country was all loose with very little earth. In fact after the race was cut you could poke a stick into it in places to a depth of 3 feet. The bottom was tight.

"This section was lined on the lower face with vertical boarding. The boards were chisel pointed, and driven 4 inches below the bottom. They were then secured to 3 inch x 3 inch runners, top and bottom, and tommed across the race top and bottom. The space behind the board for a width of about 9 inches was well rammed with selected material which was too scarce to allow of a greater width being used. After the boards had shrunk they were caulked with thin battens and strips of bagging.

"This work has been a great success, having been water-tight from the start."

In some portions of the line it was impracticable to use any other construction but fluming. Local timber was used throughout. In the trestle supports round timber is used, with sawn bracing. The stringers are round or hewn logs, the ends being free and overlapping each other over the supports, no end joints being necessary.



11—Fluming.

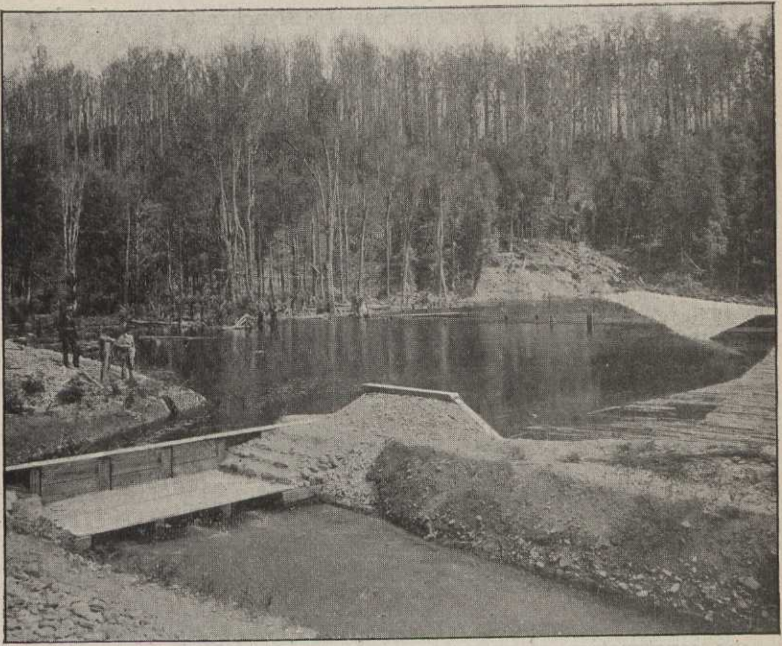
The fluming itself is of sawn timber planking 12 inches x 1½ inches, the joints being covered by 3 inch x ⅝ inch battens fixed inside the flume. It is carried on framed supports of sawn timber at frequent intervals, resting on the stringers. No mortising or checking out was used in the sills. (See illustrations Nos. 5 and 11.)

In the original design the fluming was minimised as much as possible. In construction, however, owing to scarcity of stones and earth for building, fluming was substituted in places for a length of about half a mile.

The dam (see illustrations Nos. 12 and 13) is situated north of the junction of the Ringarooma River with Federal Creek. The dam rests upon river shingle and sand, and the banks of the river are granite, the material on the steep bank being much decomposed. The length of the crest of the dam is 528 feet, and the bed width of bywash 115 feet 6 inches.

The following levels are important in discussing this question:—

Bed of dam at sluice gate	1179
Bed level of race at offtake	1183·44
Bywash bottom (or ordinary water level)	1187
Crest of dam (margin above bywash, 4ft.)	1191



12—General View of Dam, &c.

13—Sluice Gates in Dam.

The height of dam was increased 12 inches to provide for settlement.

The slopes adopted were 1½ to 1 External, and 2 to 1 Internal (against the water), and the whole work was done in accordance with original drawings, the only alteration made being to bywash.

It was not expected that the dam would prove absolutely watertight, as neither the site nor the material was of the most favourable character, but efforts were made to reduce leakage by constructing an internal wall of rammed earth, and using heavy material in the toe of the external slope.

The dam was used merely to head up the water into the race, and to form a settling pond for the deposit of a portion at least of the tailings from mining operations up stream.

The bed width of bywash allowed has been found sufficient. As there was little or no information available as to the dimensions of watershed, or nature of country comprised within its limits, or as to the rainfall, it was impossible at the outset to fix the size of bywash with absolute certainty. Mr. Fraser's observations of flood levels at the site of dam led him to conclude that flood waters would not rise more than 1 foot above the bottom of bywash.

The steep slope of the ground on the left bank was against the construction of an extensive bywash on that side. It is sometimes advisable in cases of this kind to construct a small bywash of, say, 20 feet bed width, on the steep rocky side, at a slightly lower level than the main bywash. The heavy material excavated can be used on the toes of the slope of the dam. The bottom of such a bywash would be in solid ground, and there would be less wear and tear upon the bottom of the larger bywash.

The logging shown to protect the exterior slope of the bywash channel was protected by heavy granite stone packing to prevent cutting under, and the sheeting of abutments of dam was carried down below the bottom of the bywash. It was ultimately found necessary to space the bywash logs close and cover them with 2 inch timber slabs securely nailed. Since then there has been no trouble.

The race was enlarged at the headworks to provide for silting up.

The planking of the head sluice was carried above flood level, and stops were carried down on each side of it to prevent water undercutting it, the curtain or down stream wall 2 feet, and the up stream wall 4 feet deep.

The side stops were extended out to the exterior dotted line, and the cover over filled trench loaded down with stones.

The sluice gates were provided for scouring out the dam and for providing compensation water. Shields were carried out to a width of six feet, and the gates were loaded down with shingle as shown.

In constructing the dam decomposed granite was used, and the foundations stripped of all surface soil, all plants rooted out, all slushy or loose material removed, especially in the bed of the stream, and all steep slopes benched to receive the earthwork.

As there was no knowledge of the depth at which a watertight stratum could be secured, it was not considered advisable to carry the clay trench down deeper than shown. It was also considered that in time the silting up of the bed would sensibly diminish the leakage.

The bed of the trench was roughened to prevent a definite line of subsoil flow.

The natural surface beyond dam was sloped away at a gradient of 1 in 10 from the external toe for a distance of 30 feet, to provide for drainage.

The dam was constructed in layers 9 inches thick, sloping inwards from the outer margins.

Where the dam abuts against the steep left bank benches were cut sloping into it, to give a grip for the earthwork. Each of the benches in plan is divided into sections, breaking joint with each other to prevent the formation during settlement of passages for the creep of water to take place.

Mr. Fraser informs me that the material used in constructing the dam was the decomposed granite into which trial holes had been sunk on the steep left bank of the Ringarooma River. When opened up there appeared a fine quarry of this material, with a face of 30 feet. The stuff was easily handled and carted at a cost of less than 9d. per yard. Very good clay for the puddle trench was found within 30 feet of the inner toe of the dam.

From the natural surface upwards there is no puddle wall, the decomposed granite being well rammed and selected material used. The dam is therefore composed of one material, which, having a fair percentage of kaolin, set well throughout; in fact when trimming the slopes at the finish of the work picks had to be used. . . . .

There was very little trouble in making the dam watertight. For the first week or so there were two or three small spout holes outside the outer toe. These were caused by the water being pressed through the shingle under the clay trench. After a small party of tin miners started work about a mile up stream, the water soon brought down silt, which was deposited over the bottom of the reservoir to a depth of about one inch, and effectually stopped all leakage.

For the purposes of construction the work was divided up into sections, which were described as follows by Mr. Fraser in his report dated 14th February, 1901:—

"Section No. 1 extends from outlet near Briseis Mines to the 5-mile peg. Apart from siphons, the nett distance to be constructed was 3 miles 67 chains. This is undoubtedly the roughest and rockiest portion of the race, there being very little surface soil above the granite rock, which is in places for half a mile completely bare."

"To avoid fluming as far as possible, and also the still more expensive and unsatisfactory rock cutting, I designed stone and earth building walls, which have answered the purpose admirably at the Mount Cameron Water Race, having been substituted for the original timber fluming wherever possible. But in spite of my determination to avoid fluming wherever possible, owing to the scarcity of earth and other materials suitable for building walls, nearly a third of the length of this section will consist of timber fluming.

"Section 2 extends from the 5-mile peg to the 12 miles 13 chains 40 links peg. Apart from siphon, the net distance to be constructed is 6 miles 28 chains. This section presents quite a remarkable change of country, being comparatively easy when compared mile for mile with Section 1.

"I do not anticipate that more than half a mile of fluming will be required. To take the race through a saddle at Ruby Flat a tunnel, or open cut, about 330 feet in length, was designed. Sixty-six feet of this will be a timbered tunnel, and the remainder either a tunnel through granite, or open cut, this being optional with the contractor.

"Section 3 extends from the 12 miles 13 chains 40 links peg to the intake peg at 19 miles 38 chains 40 links from outlet. Apart from siphons, the net distance to be constructed is 7 miles 11 chains. This is again much easier ground for race construction than Section 1. I do not anticipate that more than 25 chains of fluming will be required. The greater part of this section lies in private property, for which negotiations are now proceeding for lease or purchase.

"Section 4 consists of dam at intake. The dam will be constructed of earth, and will be 528 feet in length by an average height of 12 feet.

"One important feature of this dam will be the bywash, 115 feet 6 inches in length, by 4 feet in depth. This will pass flood waters away from the dam at a minimum of risk."

The construction of Sections 1 and 2 were let on contract, while sections 3 and 4 were undertaken by the Company.

The Maurice River Race was constructed in short sections, mostly let by contract. It lies, speaking generally, in easier country than the Ringarooma Race.

The Company has secured the following rights for water, and it is estimated will have available the following minimum supply:—

Source.	Total Rights.	Minimum (approx.) in exceptionally dry seasons.
Cascade	33	10
Do. (Proportion of Water Trust rights)	72	10
Main Creek	21	5
Ringarooma	100	52
	226	77

Messrs. Lake and Currie, in their report to London Directors, 15th May, 1901, state: "Probably 200 heads, or 1,800,000 gallons per hour, will be available during six months of the year at least, and during the other six months the quantity will diminish gradually, according to the rainfall, but should never fall below the minimum stated above, namely, 77 heads, or 693,000 gallons per hour, which has been based on the records of the driest year, and allows for the 20 heads being left in the river at the junction of the Ringarooma and Maurice branches."

Appended are some notes by Mr. Fraser as to the condition of the Ringarooma Race, and a short description of the Maurice Race.

"Since water was first turned on there have been four slips on race. Three of these occurred in the basalt country in the vicinity of Ringarooma township.

In this part the ground is very treacherous. To all appearances it is splendid country for carrying water, being a rich chocolate soil over decomposed basalt. However, this decomposed basalt in places covers solid basalt, and in others loose basalt boulders, and where the bottom of the race approached these loose boulders, although to all appearance it was sound, yet the crust of good material was so thin that the pressure of water broke it through. When this happened the water could get freely through these loose boulders.

It was impossible to foretell where this treacherous ground existed, and consequently it could only be found out by actual experiment, that is, it had to be found out by the water.

Two of these slips were repaired by flumings, the material being kept in stock in anticipation; the third was repaired very successfully by excavating both on bottom and sides for six feet deeper and wider than the original cross section of race. This six feet was then filled in with good material, well rammed, and faced with stone.

The third slip was on a very steep sideling, and although the water was only running about five hours, it tore a channel down the side of the hill for 5 chains in length by a width of 20 feet, and depth of 5 to 10 feet, completely washing away all surface soil, and showing that underneath there was nothing but loose boulders.

The morning after it occurred there were five carpenters and ten labourers at work, and in six days seven chains of fluming had been put in and the water running.

As an instance of quick work, on the last day it was seen that we would be short of battens; the nearest sawmill was four miles away. There was no steam on, and no logs were cut. An order for a load of battens reached the mill at 12 o'clock noon. Steam was got up. Men were sent out to cut a tree and bring in the log. The battens were cut and carted to fluming, placed in fluming, and the water was running through at 5.30 p.m. the same day.

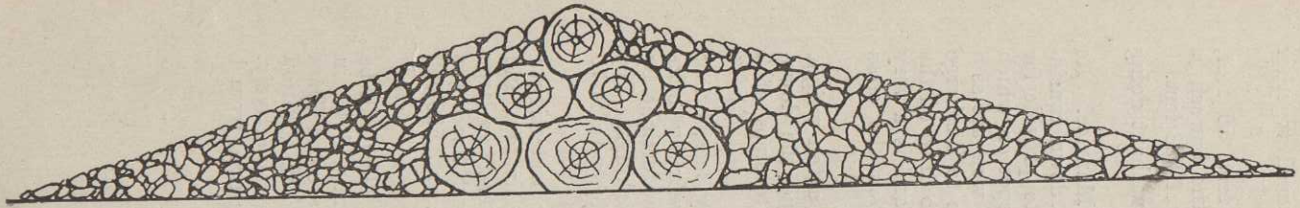
The fourth and last slip occurred at the 4 miles 62 chains peg from the Mine end. It occurred on a very stormy night, the race was running almost a banker, and carrying 120 sluice heads, equal to 1,080,000 gallons per hour. I was determined to give the race a thorough test, so did not give any orders to turn the water off. A tree blew down on to a narrow bank, and thus gave the water an outlet, washing away about 30 feet of the race. This was repaired by fluming in a few days, and the water again turned on.

We are now getting an average of 100 sluice heads daily, and this has been kept up for the last five or six weeks. The race is thoroughly proved, and there is not likely to be any more trouble.

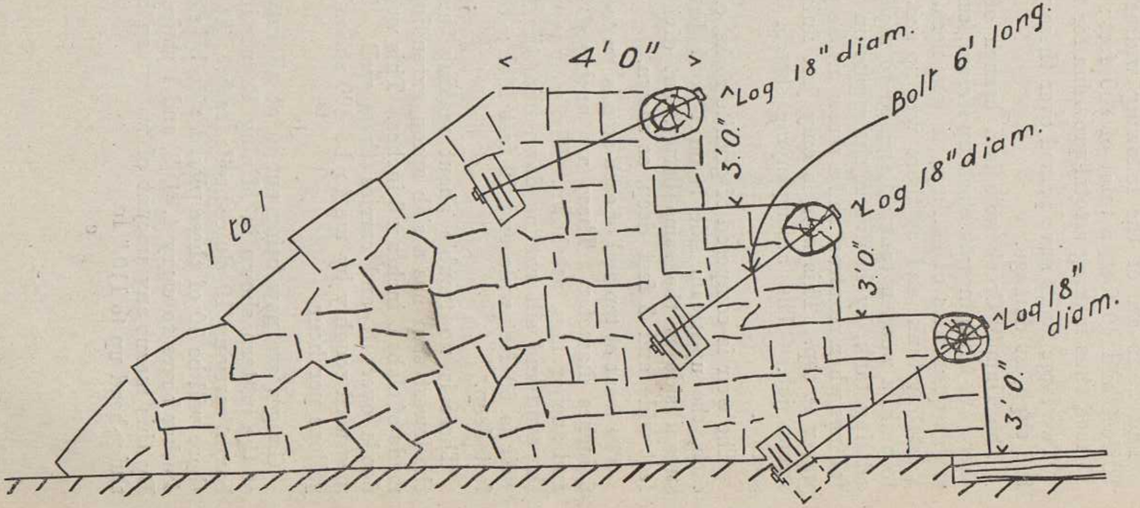
This race is a branch of the Ringarooma Race, and is about 9 miles in length. This race was levelled and traversed while the specifications were being made out for the big race, and the designs for the Maurice Race were made while the big race was under way.

The design for Maurice Race is very similar to that of the big race, but on a smaller scale, to carry 75 heads for half the length, and 50 for the other half. The fall is 1 inch per chain, the depth for 75 heads being 3 feet, and for 50 heads 2 feet 9 inches. The width at bottom being 4 feet and 3 feet 6 inches respectively.

The Maurice River is turned into race from three branches There are altogether four weirs and one bywash. There are also three screw-gates for regulating the water. The weirs are composed of stones, with a core of logs, as shown in sketch A.



Sketch A.—Maurice River Weir.



Sketch B.—Dunn's Creek Weir.

The logs are faced where touching, and fastened together with dumbolts.

The weirs are of the following widths: 50 feet, 50 feet, 60 feet and 40 feet, a total of 200 feet; and the bywash is 33 feet, thus making a total provision for floods of 233 feet.

Two large floods have passed over these weirs without doing the slightest damage.

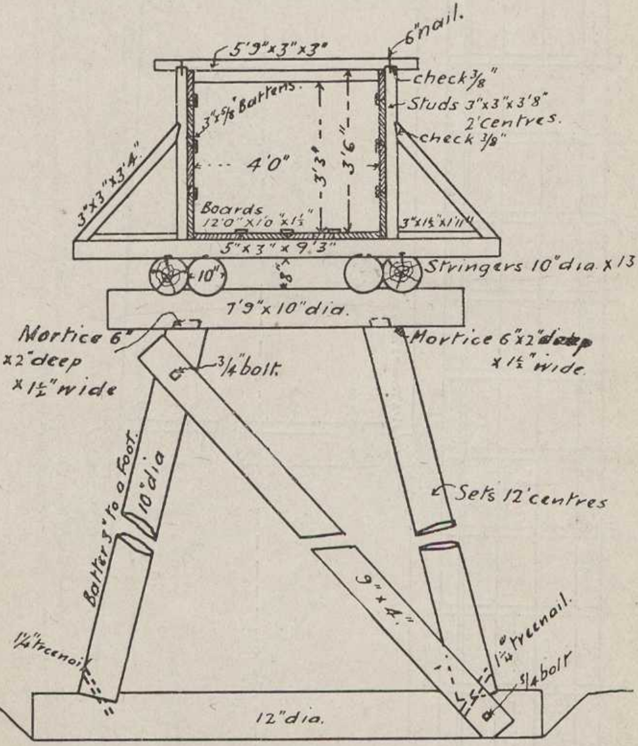
The Dunn's Creek weir is a branch of the Maurice. As there are tin mines at work up-stream, sending down considerable quantities of tailings, it was necessary to provide for a settling tank, and as there was no suitable spot on which to build a wooden tank, I decided to make the weir act as a settling tank, by having a sluice-gate in centre to discharge tailings when required, and a screw intake gate to draw off the water at top. This weir is only just finished, and is a very strong job. The accompanying sketch, B, shows the cross section.

The weir is composed of granite rocks, of half a ton weight each, the up-stream side is on 1 to 1 batter, and the down-stream side is the same batter, but divided into steps of 3 feet wide and 3 feet deep, as shown.

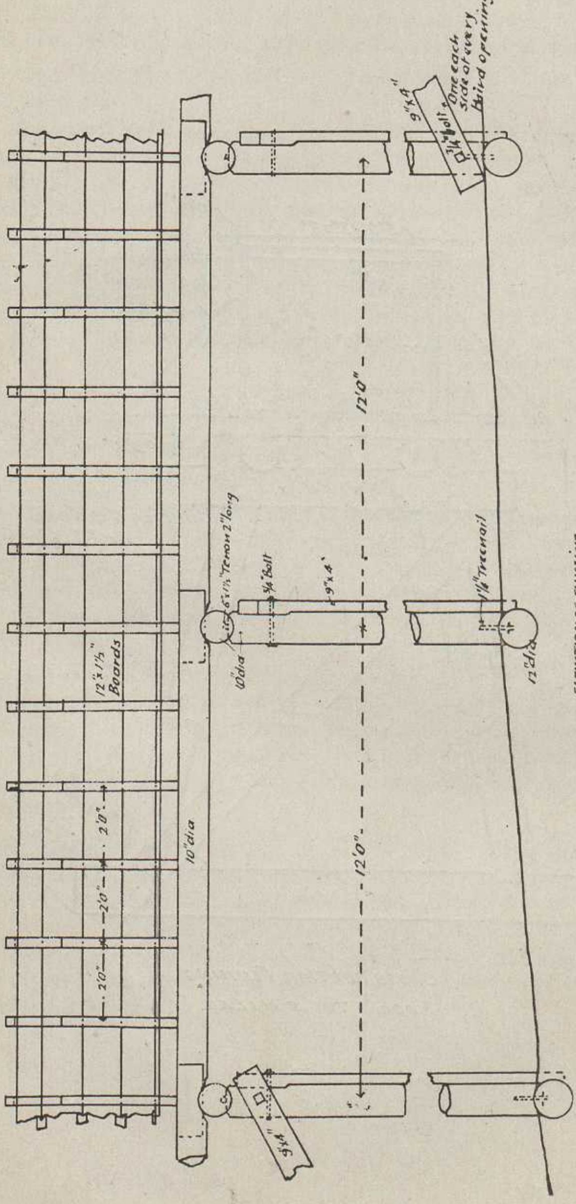
The front of top and of each step is protected by logs, 1 foot 6 inches diameter. These are anchored into weir by bolts and anchor logs, as shown. The weir is made watertight by the sand and silt coming down from the tin workings. The weir is 60 feet wide and 12 feet high; the sluice-gate is 10 feet deep.

There is no trouble about making this weir watertight; the lowest step has a slab apron extending out six feet, and made of slabs 6 inches x 6 inches. This weir has had two large floods over it, and carries them well. The last flood was measured roughly by me to be 400 sluice-heads, or 3,600,000 gallons per hour.

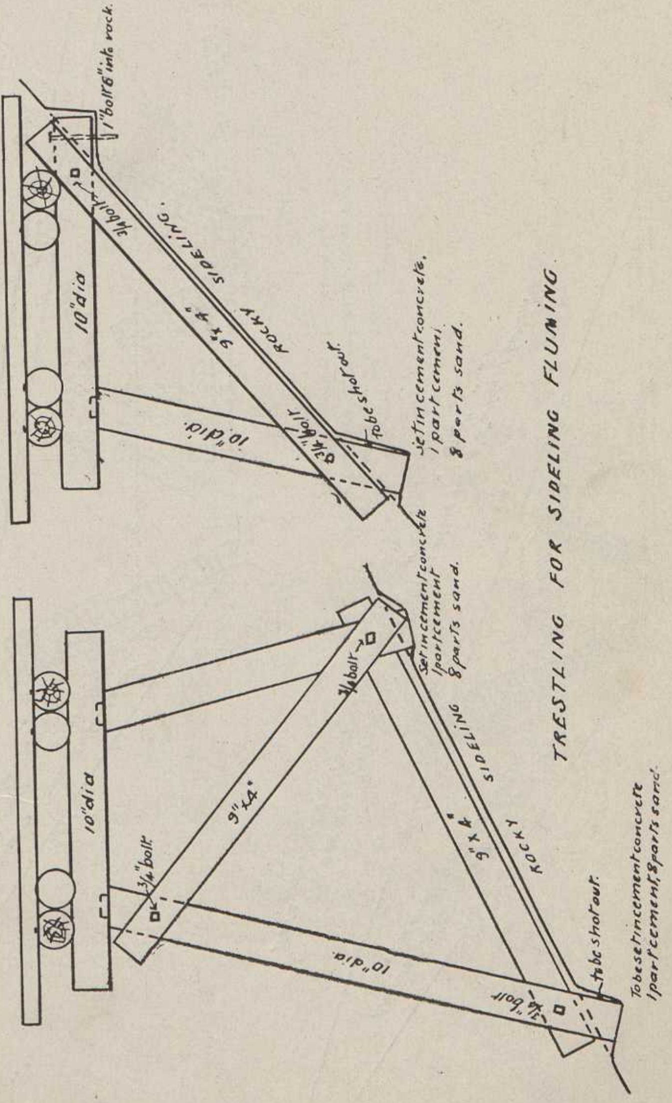
Gauges are now being put in at all intakes. They will be of the pattern shown in Mining Regulations, and will be in boxes carrying 10 sluice-heads each. At Ringarooma Dam there will be 10 of these placed side by side, and in addition 4 other boxes to carry 4, 3, 2, and 1 sluice-heads respectively. By this means any amount of water can be measured from 1 sluice-head up to 110."



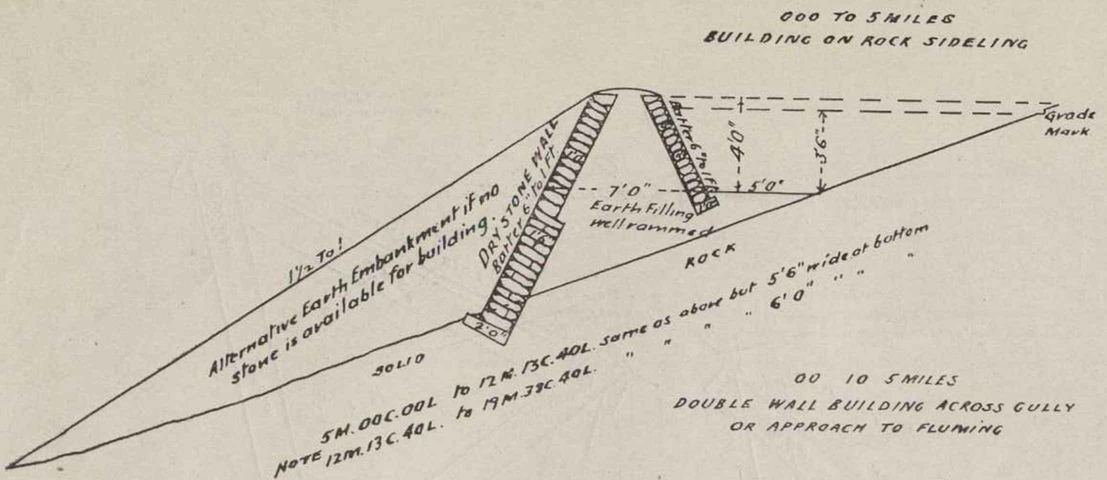
CROSS SECTION FLUMING
000 TO 5 MILES.

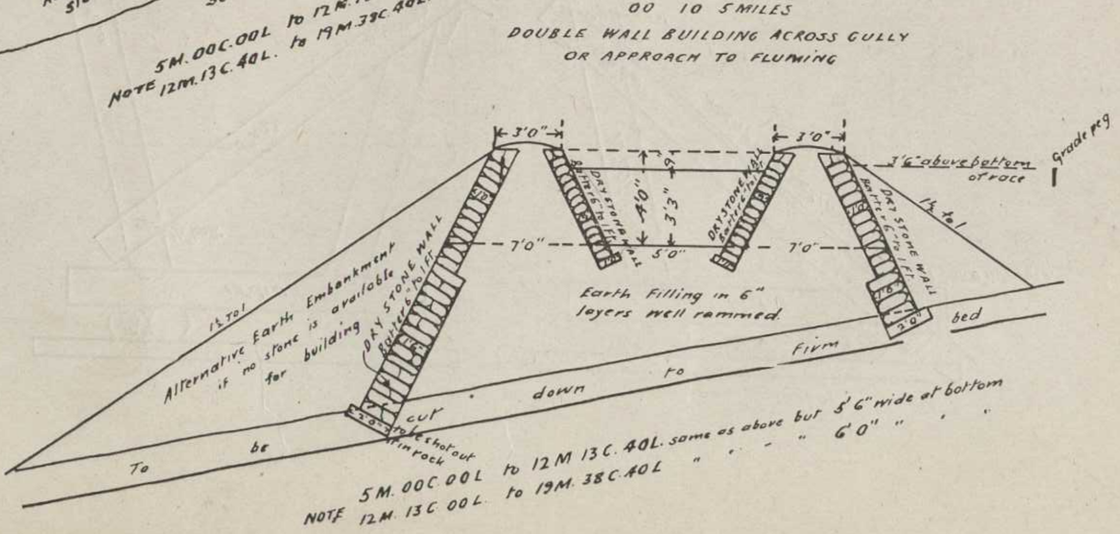


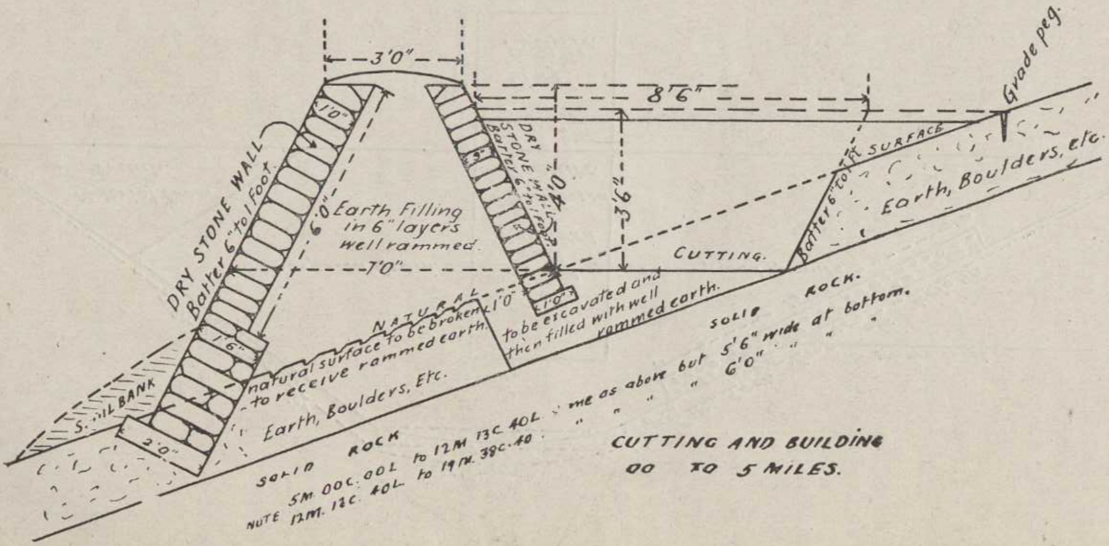
ELEVATION OF FLUMING

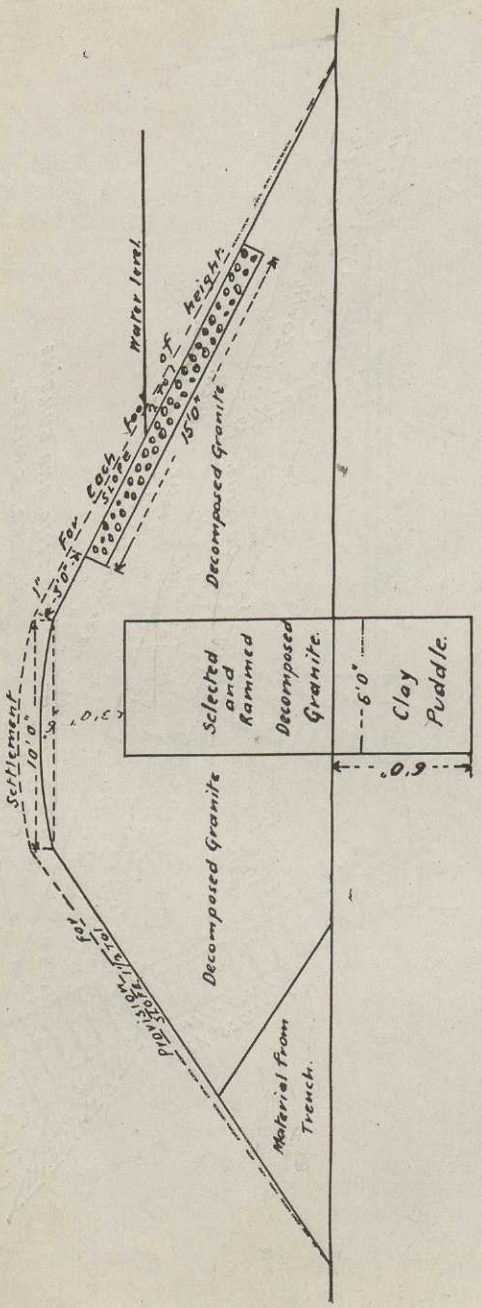


TRESTLING FOR SIDELING FLUMING.


000 TO 5 MILES
BUILDING ON ROCK SIDELING
Grade Mark
4'0"
3'6"
5'0"
7'0"
Batter 6" to 1 Ft
Earth Filling well rammed
DRY STONE WALL Batter 6" to 1 Ft
2'0"
1½ To 1
Alternative Earth Embankment if no stone is available for building.
ROCK
SOLID
5M.00C.00L to 12M.13C.40L. same as above but 5'6" wide at bottom
NOTE 12M.13C.40L. to 19M.33C.40L. " " " 6'0" " "


00 10 5 MILES
DOUBLE WALL BUILDING ACROSS GULLY
OR APPROACH TO FLUMING
3'0"
3'0"
6"
4'0"
3'3"
5'0"
7'0"
7'0"
DRY STONE WALL Batter 6" to 1 Ft
DRY STONE WALL Batter 6" to 1 Ft
DRY STONE WALL Batter 6" to 1 Ft
DRY STONE WALL Batter 6" to 1 Ft
3'6" above bottom of race
Grade peg
1½ to 1
1½ to 1
2'0"
2'0"
Earth Filling in 6" layers well rammed.
Alternative Earth Embankment if no stone is available for building
To be cut down to firm bed
to be shot out in rock
5M.00C.00L to 12M 13C.40L. same as above but 5'6" wide at bottom
NOTE 12M.13C.00L. to 19M.38C.40L " " " " 6'0" " " "


3'0"
8'6"
Grade peg.
SURFACE
Earth, Boulders, etc.
Batter 6" to 1 ft.
DRY STONE WALL Batter 6" to 1 Foot.
1'0"
6'0"
Earth Filling in 6" layers well rammed.
DRY STONE WALL Batter 6" to 1 Foot.
4'0"
3'6"
7'0"
CUTTING.
NATURAL
1'0"
1'0"
1'6"
natural surface to be broken to receive rammed earth.
to be excavated and then filled with well rammed earth.
SOLID ROCK.
Earth, Boulders, Etc.
SOIL BANK
2'0"
SOLID ROCK
NOTE 5M. 00C. 00L to 12M 13C 40L same as above but 5'6" wide at bottom.
12M. 13C. 40L. to 19M. 38C. 40 " " " 6'0" " "
CUTTING AND BUILDING
00 TO 5 MILES.



CROSS SECTION OF DAM.

Discussion.

Mr. G. A. Turner (Chairman) said that he was exceedingly interested in Mr. Champion's paper. One of the features which struck him was the large proportion of timber used in the fluming, etc. A point that always troubled him was that sooner or later the wood became saturated, the nails rusted and gave away, and the fluming came to pieces. He would like to know if any special provision had been made, such as using copper nails and fastenings. There was ample room for discussion in the paper, but it would be well to leave it until next meeting, so that members might have an opportunity of considering the details.

Professor Kernot said that this race was undoubtedly a great and interesting undertaking. The method of support of the syphons had been questioned in some quarters. Last January he took the opportunity, being in Tasmania, of running round the North-Eastern corner and seeing this work. He went up to the head works on the Ringarooma, and was very pleased with what he had seen. The work was confessedly a temporary one. The mine will be worked out in time, and then the works will not be worth maintaining. It was, therefore, done as cheaply as possible. Of course it would have been absurd to have gone to the expense of a monumental construction. This structure was a great contrast to the last one he had seen not long ago in Birmingham, which was elaborately and solidly built and designed by Mr. Mansergh. The race described in Mr. Champion's paper was built through dense scrub and tremendous forests, rendering the position of the designer a particularly anxious one. Here a great deal had to be done by conjecture, and considering how much there was in question, he was astonished and pleased to see that things had come out so well. The proprietors of the mine are to be congratulated upon having got so cheap a supply of water.

Mr. Champion said he had received a letter from Mr. Fraser, who said he would be glad at any time to give information to the members, and also to show them around the works.

Mr. Higgins said that hydraulic mining was not carried on much here; but in Tasmania and New Zealand a good deal was done. He thought New Zealand led the world in hydraulic mining.

Mr. Champion, in reply to a question, said that only four bursts of any consequence had occurred since the work was constructed, and they had been very quickly repaired. They had occurred in places where the race was supposed to be solid. And in these cases three of the bursts occurred in country where layers of basaltic boulders were struck underneath the surface. The other one was caused by a tree being blown down on a very stormy night.

Discussion, Sept. 10, 1902.

Mr. G. A. Turner said this opened an exceedingly wide field, and he felt sure there were many points that members would like to discuss. Mr. Champion was present, and a good discussion should follow.

Mr. Smith asked if Mr. Champion had any particulars of the nozzles used in this scheme. It seemed to him that the water should be used to the best advantage after having been brought such a long distance.

Mr. Champion said he would answer all questions together later on.

Mr. Turner said that some of the slopes in the side of the rough channels seemed to be exceedingly steep; in ordinary country he did not think they would stand long. If in rock, of course they would be all right.

Mr. Higgins asked if Mr. Champion was aware of any experiments having been made with regard to the efficiency of the hydraulic lifters. In New Zealand he knew of a case of an hydraulic lifter lifting for 90 feet.

A very singular thing was told him by the manager of the Blue Spur Mine in New Zealand. They had about 20 lifters here and they employ 120 or 140 heads of water. He asked the manager what they meant by having a small pipe just above the water level, and he was assured that it very much increased the efficiency of the lifter. Now at first sight it would strike one as being utterly wrong. One would think it was desirable to cause as great a vacuum as possible in order that the atmospheric pressure would send the water and material up the vertical pipe. It was employed in each lifter, and the manager assured him (Mr. Higgins) that the efficiency was very much increased.

The other day he was chatting about centrifugal pumps with Mr. Alexander Wilson, ex-Engineer for Ports and Harbors of this State, and he stated that he found an advantage in one or two cases by the admission of air into the suction pipe on a centrifugal pump. He (Mr. Higgins) thought that if it really did increase the efficiency they might deduce the fact that the vacuum actually acquired in the pump was in excess of that actually required. There was some to spare, and therefore, whatever good result was gained would arise in that way. The air bubbles coming up the pipe would tend naturally to rise, and in travelling up helped with it the water. It seemed to him that the manager at the Blue Spur must have gained his advantage in a similar way; by the introduction of air into the pipe he must have lessened the specific gravity to be lifted, and thereby gained something.

Mr. Alexander Wilson was going to lend him (Mr. Higgins) his notes on experiments on centrifugal pumps, and he would ask his permission to bring them before the institute, because the institute has from time to time dealt with the question, and it would be valuable to have his experiments also.

With regard to Mr. Champion's paper generally, he thought that it was one of the most thorough that had been read at the institute. Although all the diagrams were very interesting, it seemed to him that the weirs, which have stood so well, and which were so simple and cheap, were perhaps the most interesting of the illustrations that Mr. Champion had been good enough to give them. He cordially endorsed the thanks that had been given Mr. Champion for his paper.

Mr. Gordon asked had there been any big floods over the weir (Sketch A). It seemed to him that if there were 2 or 3 feet of water over the top of them they would be apt to be displaced. In the same way he would like to ask the size of the stones that the water fell on in Sketch B; was it all one stone?

Mr. Rowe said he would like to mention something that came under his notice. Some fluming in connection with irrigation in Tasmania was made of 16-gauge galvanised iron, and it had been in operation for 10 years. It was then almost new. It was half circular in shape, the ends form an angle. It was put up very cheaply, and had stood for the period mentioned.

Mr. A. Michell said that this was a question upon which there was very little information available. Last year he had occasion to search for information on the subject, and he had to go through a lot of books before he obtained what he required.

Speaking from memory, he thought he got the co-efficient of roughness as .012 in a similar circumstance to that described on page 23 of Mr. Champion's paper, and for which he gave the co-efficient as .013. If possible, it would be very interesting to have these results confirmed.

As regards the pipes, all particulars had to be determined before they were constructed. There were no pipes of a similar character that could be made use of; but all available sources had to be consulted and the determination arrived at in this way.

Mr. Champion said that Herschel's method was submitted in a work which was available in the Melbourne Public Library, and in the end of this book was appended the results obtained by his methods and the co-efficient which one might use in considering the various experiments which he sets forth. There was no mathematical determination. It was simply the determination of the individual after reading this book. There was no experiment made with the pipes, none could be made. They had only been a few months filled. The present was the time, as Mr. Michell had pointed out, for such experiments to be conducted, and there was no doubt that it would be very beneficial to find out what was the flow of water through these pipes at the present time.

Mr. G. Turner remembered a work similar to the one under review some years ago, in connection with the sugar growing in the Sandwich Islands. Water was conducted for about 50 miles. Great difficulty had been encountered in controlling the leakage on account of the porosity of the soil.

As the hour was late, Mr. Turner (Chairman) thought that it would not be fair to ask Mr. Champion to answer questions at once, but that he might be good enough to do so at next meeting if it would be convenient for him to be present.

Mr. Champion said that there were some points that he would not be ready to reply to at once, but he would be able to obtain the information and place it before the members at a future meeting.

Mr. Champion in reply: With regard to Mr. Turner's remarks, the length of fluming had been kept down as much as possible. The siphons have effected a large reduction in fluming, but the use of the latter had been inevitable in parts of the work as the illustrations would indicate. No special provision had been made for fastenings, ordinary wire nails being used, and local experience showed these were sufficient for all requirements.

He had not been able to secure any particulars of the nozzle used in sluicing for submission to the Institute.

The sluice gates were introduced into the dam to provide a means of getting rid of silt deposited behind them. As there is not a considerable head of water on them no anxiety was felt, especially as proper precautions were taken in loading down and using shields.

In conclusion he had to tender his thanks to Members for the way in which the Paper had been received, and to the Council for the excellent manner in which it had been printed and illustrated.

Author/s:
Champion, H. V.

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