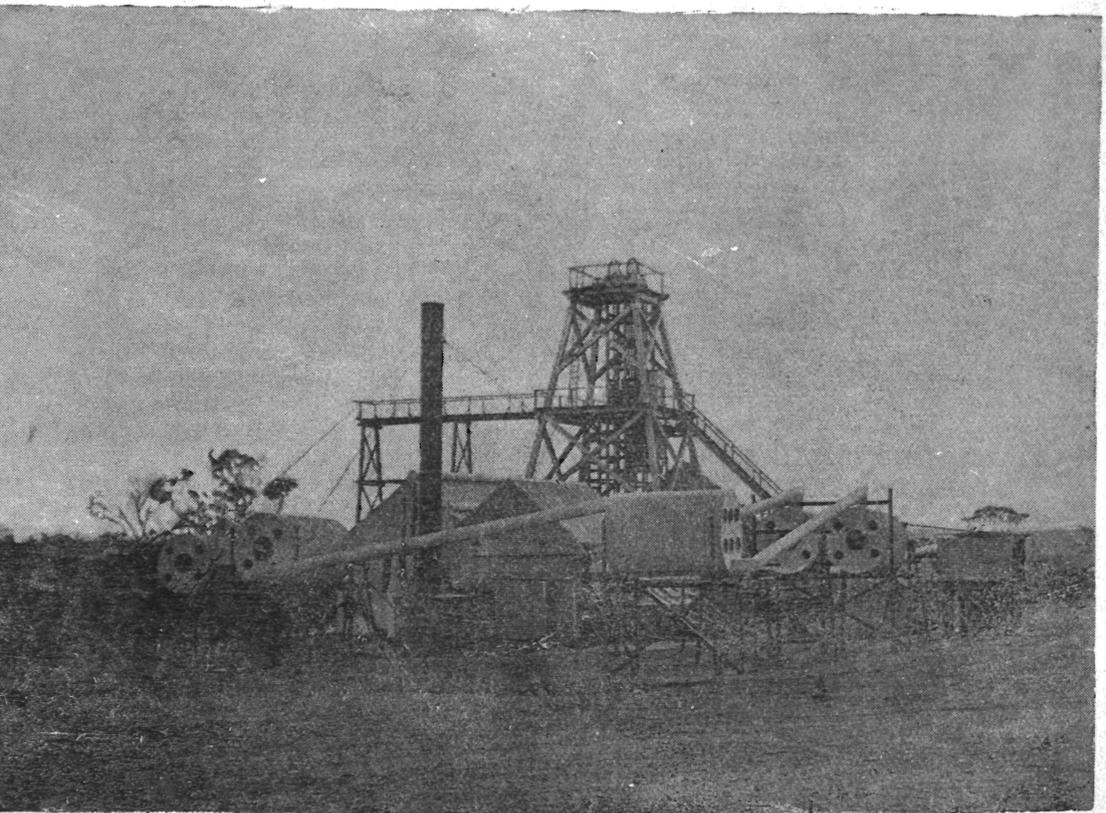


WATER CONDENSER, LAKE VIEW CONSOLS G. M.



MAIN SHAFT AND CONDENSER, LAKE VIEW CONSOLS G. M.

outside the mill into one of two small rectangular boxes, in which they settle, and are finally dug out and bagged for smelting.

The tailings from the battery pass outside the building into one of six circular Oregon settling-vats 20 feet in diameter and 6 feet deep. The launder feeds the pulp into a central iron hopper supported on an iron pivot rising from the centre of the vat. This hopper is fitted with eight radial pipes of different lengths, with flat nozzles at the end, through which the pulp is distributed into the vat. As each of these nozzles opens in the same direction, a rotary motion is imparted to the hopper, and the distribution of the pulp into the vat is very even, and does not tend to disturb the contents.

The water carrying the unsettled slimes is discharged from these vats as follows:—Two battens are fixed vertically against the inside of the vat 15 inches apart. These battens reach from the floor of the vat to the top, and between them at the bottom is the slime discharge pipe. They are grooved on the sides facing one another, so that by sliding a number of short lengths of tongued and grooved board into the grooves, a vertical passage is formed down the side of the vat leading to the discharge. In filling a new vat a single 6-inch board is slid in the grooves to the bottom, and pulp is fed in until the level of the settled sands rises nearly to the top of this board over, which the water carrying the unsettled matter is escaping. A second board is then slipped in on top of the first, the feeding being continued till the sands reach nearly to the top of this, when a third is put in, and so on until the vat is filled, when the pulp is cut off and turned on to another settler. This method has not the same objection that a continuous discharge from the extreme top of the vat always has, viz., that a considerable amount of slimes settles with the sands. The sands separated in these vats form one-half of the whole tailings. They are discharged through the bottom into trucks, and are taken immediately to the cyanide vats. The bottoms of the settlers are protected by a false bottom of pine.

The water carrying the slimes which comes from the settlers flows into a set of rectangular vats, from which it is drawn off and forced by compressed air into filter presses.

The credit of the introduction of this method of dealing with the slimes or finest portions of the crushed ore in filter presses is due entirely to the metallurgists of the Kalgoorlie field. The system adopted in South Africa of dealing with this material, which it is almost impossible to leach in the ordinary way, is to agitate it in vats with cyanide solution, and then let the contents settle until about half of the solution can be syphoned off clear. More water is then added to the vats and stirred up and again allowed to settle until half of this solution is clear enough to syphon off. This is repeated until it does not pay to try and recover any more gold solution from the vats, when they are emptied. This process entails so much labour, occupies so much time, and results in such enormous quantities of weak solutions, that it is still of only doubtful success in Africa, and its adoption would be quite out of the question at Boulder, where labour is expensive and water scarce.

The method of treating the slimes in filter-presses is at the same time so speedy and economical that it seems probable that a great future is in store for it. There are already ten of these, three feet

square in section, whilst provision has been made for two more to be added, which should be sufficient to deal with the whole of the slimes from the battery.

Each press holds $1\frac{1}{2}$ tons of slimes, and can be charged four or five times every eight-hour shift, so that the capacity is about 25 tons per day of 24 hours. They are charged at a low pressure, and, when full, cyanide solution is forced through to dissolve the gold. The solution is drawn off by a small tap at one side of each section, and falling into a gutter, passes through a pipe to a zinc-box where the gold is precipitated. Wash-water is finally forced through to remove all the gold-bearing liquor, and the press is then opened, and the pressed cake knocked out. It falls through hoppers into trucks, by which it is carried away, and is largely used for brick-making.

The presses are said to be working very satisfactorily, giving daily average extractions of from 80 to 86% on 10 dwt. slimes. This should yield a handsome profit, as the cost of working is not more than a few shillings per ton.

For the quarter ended 31st March, 1898, 14,544 tons of ore were treated in this mill for a return of 22,995 ozs. of gold.

Treatment of Sulphide Ore.

The present method of bagging this ore and shipping it to smelters in the East, will certainly be discontinued before very long, owing to its great expense. Although this ore contains in many instances a large amount of free gold, it will never do to treat it in a battery, since the telluride minerals in it will not amalgamate and are too brittle to be recovered by subsequent concentration. The choice of method therefore lies between smelting locally or roasting and leaching. Of these the former is by far the most expensive, owing to the high cost of suitable fuel on the field,* so that the latter is the one that will probably be universally adopted.

The Lake View Consols and the Associated Gold Mines have already commenced the erection of sulphide works in which the ore will be dry crushed, roasted in mechanical furnaces, and cyanided. The chlorination process can never be employed on this field owing to the very large proportion of carbonates of lime and magnesia in all the un-oxidised ore.

WATER SUPPLY.

Natural Water.

The all-absorbing question which continually crops up in all considerations of treatment on this field is that of Water Supply.

As has been already mentioned, in this district the average annual rainfall is only five inches, and in consequence of this there is no permanent or even seasonal surface water. Owing to the absorbent nature of the soil and surface rocks, and the high annual evaporation, it would be useless to rely for a supply upon the collection of the rain in surface reservoirs. No artesian water is obtainable anywhere, and the only source of water is in comparatively shallow wells, including, under this term, the mines themselves, which tap the reserves of surface water

* Coke costs £5 per ton in the trucks at Boulder.

which has been collecting for ages in the pores and fissures of the rocks. The whole of this water is intensely salt, with one exception, viz. : that obtained in a well 130 feet deep in serpentine on the slopes of Mt. Hunt, a hill $2\frac{1}{2}$ miles to the south of Boulder. This well yields only 800 gallons daily of water, which is slightly brackish, but still fit for human consumption. A sample taken by the author was found to contain 0.279% of solids, of which about one-half was common salt.

At the Lake View and Boulder Junction Mine, the main shaft yields 20,000 gallons per diem of water containing 4.931% of solids, three-quarters of which is common salt. The main shaft of the Lake View East Mine yields 15,000 gallons per diem of water of similar quality, whilst other shafts in the neighbourhood also yield quantities varying up to 70,000 gallons per diem. At the Lake View Consols and Great Boulder Proprietary, ample salt water is obtained from the mines for battery purposes, but the Australia Mill is dependent upon water pumped up from a well on the edge of Hannan's "Lake." This water is probably the densest on the field ; it has a specific gravity of 1.12012, and contains over 17% of solid matter.

The salt water from the mines is used everywhere for metallurgical purposes with good results. At the cyanide works the magnesia in it has to be precipitated by limestone owing to its decomposing effect upon the stock solutions, but otherwise the only objections to its use are the gradual choking up of pipes and corrosion of metal work coming in contact with it. In the early days of the field this water was also used for boiler purposes, but is now replaced by the condensed water used for drinking.

Condensed Water.

To the visitor from the other colonies the water condensing plants, of which every mine possesses one or two, are one of the most striking features of the fields, and since they will always have to be used extensively in Western Australia, if not elsewhere, some notes on their construction may be found useful.

They consist essentially of one or more boilers, in which the salt water is evaporated, and from which the steam passes into a series of air-cooled surface condensers. Economy of fuel and water are two absolute essentials to a successful condenser, since both of these requisites are usually too valuable to allow of any waste.

Boilers.

In all but the newest condensing plants the boilers consist of 400 gallon ship-tanks. They are generally set on edge, but occasionally flat on one side, over brick fireplaces. A good example of this description is the plant at the Lake View and Boulder Junction Mine. The boilers are built in pairs, one behind the other, on brickwork, two side walls supporting the outer edges of the tanks, whilst a centre wall supports the lower edge, and at the same time divides the fire-grate from a return flue leading to a short brick and sheet-iron chimney in front. A large heating surface is thus obtained, consisting indeed of two whole sides of the boilers.

Each of these is provided at its lowest point with a three-inch iron blow-off pipe with a tap, through which the sediment can be sluiced out every few hours. Every week or ten days the fire is drawn, and the boiler chipped inside to remove all the scale. This condenser is typical in that no attempt is made to economise by utilizing the escaping steam to heat up the feed water, which, contrary to the general usage, is pumped into the boilers. The usual method of feeding is to have an open tank kept filled with water to the level required in the boilers, with which it is connected by a piece of gas pipe; the level of the water is thus kept constant, since the evaporation is conducted at atmospheric pressure. The steam is drawn off by two vertical sheet-iron pipes, and passes immediately into the condensing chambers which are described below.

As an example of a condenser with boilers of a more recent type, that at the Kalgoorlie Mint and Iron King Mine may be quoted. The boilers in this plant, are two cylindrical rivetted-steel shells 15 feet long and three feet six inches in diameter, with slightly convex ends. They are built in stone and brick work two feet apart, with a fire-grate between. The flames pass along to the back of the boilers, where the current is divided, returning along the outer side of each boiler to the front, where they are again turned and pass underneath the boilers to the back, and then up a sheet-iron chimney. The whole of the heat generated by the burning fuel is thus utilized for evaporation. Each boiler has a 12 x 9 inch man-hole in the front closed by an iron casting. There are three short three-inch vertical pipes at equal distances along the bottom of the boilers, which are always open into a horizontal blow-off pipe closed by a tap at the back of the boilers. By blowing off a little water through this pipe every hour or so, very little sediment is allowed to collect, and it is only necessary to chip the boiler once every three weeks. At the Australia Mill, where the system of blowing off a little and often is not followed, the boilers have to be cleaned out every week.

This condenser is the only one on the field where an attempt has been made to economise fuel by heating up the feed water by the escaping steam. The steam passes from the two boilers through two short sheet-iron pipes into an annular condensing chamber 12 feet long, through which the feed-pipe passes twice from end to end, thence by a "T" piece it is connected to the boilers, one of which is provided with a gauge glass, a luxury unknown on most other plants.

Before the feed water was heated, the capacity of this condenser was 1,000 gallons per day, with a consumption of two cords of local hardwood; now it is nearly 1,500 gallons per day with a consumption of three-quarter cord of wood. A somewhat startling economy to be effected at very little expense.

The water for condensing is obtained from the mine, and is extremely salt. The condensed water is excellent for drinking, and is sold for that purpose at about 12s. 6d. per 100 gallons.

Condensing Chambers.

The steam derived from the boilers is passed through a series of condensing chambers, the surfaces of which are cooled simply by the

air. Water is not used for this purpose for three reasons:—First, it is too scarce; second, a partial concentration would be effected of the water thus used, which would render it still denser before use in the boilers; third, when heated by the steam inside, the salt water is found to have a very energetic corroding action on either plain wrought or galvanized iron, the usual material of which the chambers are constructed.

Each chamber is provided with a one-inch pipe leading from its lowest point to carry off the water as fast as it is condensed. Their capacity depends upon the extent of surface exposed, and the more or less perfect contact of all the steam with walls. For these reasons they are generally built of corrugated iron, and the steam is led into them at their upper ends and drawn off at the lower.

They are built in one of five more or less distinctive types—first, sheet-iron piping; second, wide corrugated-iron cylinders; third, annular chambers; fourth, wide cylinders with wind-pipes; fifth, rectangular towers. Two or more of these types are invariably combined in each plant, and four of them are frequently to be seen together.

First Type: Sheet-iron piping. This is one of the first forms to be employed. The best example the author has seen was not in the Kalgoorlie field, but at Woolgangie, on the old track from Southern Cross to Coolgardie. A large Government plant there consists of a number of ship-tank boilers in a row, each provided with its own condensing chamber. The steam passes upwards for about six feet through eight inches galvanized iron piping, which then takes a turn and runs on a slight incline downwards for about 70 feet, then two feet vertically downwards, then on an incline underneath the first part of the pipe for about 60 feet, where it enters the top of a small cylindrical chamber of corrugated-iron, from the bottom of which it is taken away again down an incline under the other pipes for 60 feet, when it discharges into an iron gutter which collects the water from all the boilers.

A second example of the use of this form of chamber is to be seen at the Australia Mill, where a series of zigzag pipes totalling about 400 feet in length covers almost the whole roof of the boiler shed. Pipes of this description are invariably used to connect chambers of other types, and where they are of considerable length, as at the Lake View East Mine (*vide* photograph) play an important part in the condensing process. At the Lake View and Boulder Junction plant also the steam from the boilers passes through about 35 feet of piping, the first eight feet of which is 12 inches in diameter, the rest six inches. It is all made of thin galvanized sheet-iron with soldered joints.

The great disadvantage of this type is the large area covered by it, economy of space being necessary on almost all of the Boulder mines. It is giving place, except for connections, to the various forms of corrugated-iron chambers.

Second Type: Wide corrugated-iron cylinders. These frequently take the form of an ordinary circular tank, which was probably their origin. This form, however, gives a comparatively small ratio of exposed area to enclosed space. Later forms are generally like those at

the Hannan's Water and Ore Reduction Co., Hannan's Lake, which consist of cylindrical towers 30 feet high and three feet in diameter formed by the bending round sheets of corrugated-iron, riveting and soldering the joints, and then connecting twelve such sections together end to end. The top and bottom of the tower are blocked by a flat sheet of iron. The steam passes up to the top of one tower, whence it is taken by a six-inch pipe to the base of a second, from the top of which any uncondensed steam escapes through a small opening.

This type of chamber is rarely adopted at any of the more modern plants.

Third Type: Annular chambers. These are a direct outcome of the previous type, and being much more efficient, are in very general use all over the field.

The first chamber on the plant at the Kalgoorlie Mint and Iron King Mine is a good example; it consists of an outer corrugated cylinder two feet six inches in diameter, inside of which is a second one foot six inches in diameter. The steam is condensed in the annular chamber between the two, which is closed at either end by soldering on a flat ring of sheet-iron.

These chambers are usually set at a slight angle with the horizon, to allow the water to fall towards the outlet pipe. An average size for a chamber of this description is 15 x 20 feet long, 2 feet 6 inches to 3 feet outside diameter, whilst the annular space is 6 to 9 inches wide. Cooling goes on very rapidly from the inside surface, even on a hot, sunny day, as it is not heated by the direct rays of the sun.

Chambers of this type are to be seen at the Lake View Consols (*vide* photograph), Lake View South, Great Boulder Proprietary, and many other mines.

Fourth Type: Cylinders with wind pipes. These also are the direct outcome of an effort to make the second type more effective, and are only a modification of the third, from which they differ in having two or more small air-channels through the centre of the cylinder instead of one large one. They may be set either vertically, standing on a wooden platform, or almost horizontal, in which case they are supported by a simple framework of light battens, like the last type.

A typical set of these chambers is in use at the Lake View East mine (*vide* photograph), where five of them are joined in series by sheet-iron pipes. Each of them is 8 feet long, 4 feet in diameter, and set at an angle of about 10° with the horizon. One is fitted with six 6-inch iron wind pipes passing from end to end, whilst the others have one central 15-inch pipe and four 6-inch pipes arranged symmetrically round it.

Chambers of a similar type are in use at the Australia Mill. At the Lake View South mine one chamber of this description is 4 feet in diameter and 10 feet long, and has no less than twenty-seven 6-inch pipes. Vertical chambers, with eleven wind pipes apiece, are used at the Lake View and Boulder Junction plant, as well as inclined ones with four pipes.

Fifth Type: Rectangular towers. Acting on the principle that the best form of condensing chamber is that in which the ratio of exposed surface to total volume is the greatest, a private condenser is being erected near the Brown Hill mine, in which the chambers consist of a series of rectangular towers of corrugated iron, each 2 feet by 6 inches in cross section and about 12 feet high. Each tower takes four sheets of iron bent longitudinally 6 inches from one side, so as to form two sides of a rectangular section. The pieces are riveted and soldered together, and the tower is closed at each end in the usual way, whilst two holes are left in it—one at the top for the pipe by which the steam enters, and one at the bottom for its exit. This type may possibly come into more extended use.

GENERAL OBSERVATIONS ON CONDENSERS.

The capacity of a condenser will naturally vary considerably according to the form of the chambers, the temperature of the air, and the velocity of the wind. No attempt seems to have been made to find out the area of exposed surface necessary to condense a given amount of water per day, so that plants with the same boiler power and capacity are to be seen with widely-differing areas of surface. Since, however, the material for the chambers is cheap, as well as the cost of putting them together, this is not such a very important question from a financial point of view. On an average, about one square foot of exposed area is allowed for every gallon per day to be condensed.

Since the temperature in the sun frequently rises to 130° at Boulder, the practice followed at Hannan's Brown Hill mine and elsewhere of sheltering the chambers from the direct rays of the sun, is worthy of more extended adoption. At this mine the covering is made of a series of narrow frames covered with canvas, and set at such an angle as to direct the wind down on to the pipes below. At the Lake View South mine a cover is made of galvanized iron.

A somewhat extraordinary practice prevails at the Australia and Lake View East mines, amongst others, of keeping all the chambers coated with asbestos paint, in order, it is said, to keep the sun from heating them too much. It is plain, however, that this paint retards the cooling of the steam inside the chambers, and must therefore considerably reduce their efficiency.

As the life of the boilers is comparatively short, it is not economical to use expensive ones, which, besides, are quite unnecessary, since all the evaporation is done at atmospheric pressure. On the whole, the type of boilers at the Kalgóorlie Mint and Iron King mine, which have been already described, are the best, whilst the arrangement of them leaves nothing to be desired. Air-cooled chambers are the only ones practicable under the circumstances, and, for economy of space and material, a set of eight or twelve horizontal annular chambers will be found eminently satisfactory. These should be raised well above the ground on a framework of light battens, and be protected from the sun by a roof kept painted with asbestos paint.

STATISTICS.

A few statistics of the production of some of the leading Boulder mines will give an idea of the amount of work that has actually been done on the field.

Name of Mine.	1st Jan. to 31st May, 1898.		Total to 31st May, 1898.		Date of First Crushing.
	Ore.	Gold Bullion.	Ore.	Gold Bullion.	
1. Great Boulder Proprietary ...	15,219	34,626	65,702	200,533	1895
2. Lake View Consols	25,865	40,906	61,453	136,422	1894
3. Ivanhoe	8,886	14,416	29,073	57,542	1895
4. Associated (Australia Group) ...	10,474	12,600	24,279	44,116	1895
5. Hannan's Brown Hill	4,960	10,894	9,999	41,195	1895
6. Great Boulder Perseverance ...	5,139	7,041	18,433	33,350	1895
7. Great Boulder Main Reef ...	3,936	7,497	7,708	17,977	1895
8. North Boulder ...	4,177	3,475	10,508	15,913	1895
9. Kalgurli	245	2,102	1,299	6,982	—
10. Golden Horse Shoe	—	—	1,567	6,369	—
11. Kalgoorlie Mint and Iron King	110	49	1,883	4,430	—
12. Hannan's Oroya	4,355	2,281	6,820	3,520	—
Totals	83,366	135,887	238,724	578,349	

In the absence of complete official returns, I am indebted for these figures to the Secretary of the Kalgoorlie Chamber of Mines. These figures shew that in three years twelve mines have produced gold to the value of £2,235,000.

My thanks are due to Mr. S. J. Becher, of the Geological Survey of W. A., for the valuable assistance rendered to me in the collection of the material for this paper, and for his kind permission to make use of his photograph of the Lake View main shaft head.