Geological Survey Office,

LAUNCESTON, Tasmania,
17th June, 1918.

Sir,

I have the honour to report as requested upon ore deposits and raw materials likely to be of use as the basis of electro-metallurgical industries in connection with the Government hydro-electric installation.

The applications of electrical energy to industry divide themselves into two classes of work. One of these is electrolytic, in which metallic combinations are split up and separated; the other is thermal, in which the electric current is used as a source of heat. In the former class are such processes as metal extraction and refining (in which the two methods are sometimes combined; for instance, producing pig iron from ore electro-thermally and refining pig iron for the production of steel - and electrolytically refining steel or wrought iron for the production of chemically pure metal), electro-galvanising, recovery of tin from tin scrap, the manufacture of aluminium, etc. On the other hand, the production of pig iron or pig steel from ore, the manufacture of calcium carbide, ferro-alloys, carborundum and quartz-glass involve the use of heat derived from the electric current.

Deposits of Iron-Ore.

I will consider these deposits first, as, apart from the zinc industry which is already being established, they will provide the most important metallurgical outlet for our State-produced electric energy. Hopes may be entertained that the character and incidence of the adverse conditions which have so long prevented the initiation of an iron industry will be changed by the provision of electric current cheap enough to admit of profitable smelting. Information bearing on the progress made elsewhere in electric smelting of iron ore will be given later on in this report.

The deposits are situate in different parts of Tasmania; some are favourably placed for exploitation; others are less favourably situated. Tasmania has raised to date upwards of 60,000 tons of iron ore, of which over 20,000 tons were smelted in the seventies at the West Arm on the Tamar and on the Middle Arm from deposits on Anderson's Creek and near Beaconsfield, and the balance shipped to the mainland and disposed of as a metallurgical flux.

The better known deposits are:-

The Blythe River deposits.
The Dial Range deposits.
The Anderson's Creek deposits.
The Sugar Loaf deposit near the Ilfracombe tramway.
The Balfour or Nelson River deposit.
The Comstock deposit.

All these have been reported on at one time or another by officers of this department. The following remarks will summarise the present state of our knowledge in reference to each deposit.

Blythe River.

This deposit has been reported on by:-

Mr. A. Montgomery, 5th March, 1894.
Mr. J. H. Darby, 7th December, 1900.
W.H.Twelvetrees, 30th January, 1901.

Mr.Darby, an ironmaster of world-wide repute, was engaged by the Blythe River Iron Mines Limited to report on the property and advise the lessees.

All reports agree in confirming the existence of a large outcrop of haematite situate between 6 and 7 miles south of the mouth of the Blythe. The deposit or lode has been cut through by the river, which forms a gorge some 600 feet deep, showing steep cliffs of ironstone down to the level of the stream. The ore formation varies in width from 30 to 150 feet, and further work may show even this width to be exceeded.

A couple of tunnels initiated by Mr.Darby have been put into the ore body, one near the bridge, and the other 650 feet high below one of the northern outcrops, with a view of testing the continuity and quality of the ore. The tunnels and outcrops have shown the ore continuing fairly solid underground.

Calculations of quantities likely to be available have been based on the information derived from the outcrops and these tunnel works. The estimates formed from time to time have been as follows:-

Mr.Montgomery	30,000,000	tons	treatable	ore.	
W.H.Twelvetrees	23,000,000	"	"	"	"
Mr. J. H. Darby	24,500,000	"	"	"	"

My estimate was based on an allowance of 33% for waste rock, which I thought might be a safe deduction. Mr.Darby deducted 50% for waste. This would reduce my total estimate to about 17,000,000 tons. I stated to the Iron Bonus Commission in 1902 that I believed 25,000,000 tons would prove a maximum and 20,000,000 tons a minimum. The latter tonnage ought to yield about 12,000,000 tons of iron.

The quality of the ore, as far as can be judged from the samplings which have been made, is excellent. The following are assays of samples which I took from the outcrop and tunnels in 1900 and 1901:-

	Iron %	Silica %	Phosphorus %	Sulphur. %
From upper quarry outcrop	68.4	2.2	0.04	traces.
From Mr Darby's low tunnel:				
Crosscut at 66 feet	46.0	34.2		
" " " 77 "	65.0	7.0		
" " " 142 "	67.2	3.8		
" " " 167 "	68.1	2.4		
" " " 199 "	68.5	2.0		
" " " 225 "	68.7	1.6	0.04	traces.
From Mr Darby's upper tunnel	59.8	14.4		
From Central tunnel	56.7	18.8		
From Lower South Crag ...	61.5	12.0		
From Purple Cliff	68.6	1.8	0.09	traces.

Mr. Darby reported an analysis of an average sample over the whole deposit as follows, showing 63.259% iron and 0.036% phosphorus:-

	%	%
Ferric Oxide	86.954	63.259 Iron.
Ferrous oxide	3.074	
Silica	7.312	
Alumina	1.756	
Lime	0.068	
Magnesia	0.071	
Sulphur trioxide	0.060	
Phosphorus pentoxide	0.083	
Titanic acid	0.03	
Copper	trace	
Arsenic	trace	
Manganese	trace	
Chromium	absent	
Combined water	0.324	
Moisture	0.160	
	99.892	

His samples were from the outcrop, as the tunnels had not then been driven, and the hard outcrop stone may have yielded a unit or two more iron than the bulk would show. He stated without hesitation that the average sample which he treated was capable of producing with good coke and limestone very superior haematite pig iron, suitable for the manufacture of high class steel, and that the deposit or lode is capable of supplying iron and steel works making 3000 tons of steel per week for many years to come.

Mr.Darby reported Sydney as being the place best situated for the blast and steel furnaces, as he was of opinion that Tasmania possessed certain disadvantages, namely distance from fuel, distance from a distributing centre, and want of cheap electric energy.

Distance from fuel:

The fuel question is an important one. About 16 cwts. of coke are required to produce one ton of pig iron in the modern blast furnace, 6 to 7 cwts. of which are necessary for reducing the iron oxide to metal, which of course means that the use of electricity would save in coke nearly half a ton per ton of pig iron. It is generally accepted that electric smelting requires only one third of the blast furnace consumption of coke; consequently with electric smelting, the axiom "the ore goes to the fuel" can be disregarded.

A blast furnace producing 50,000 tons of pig iron per annum would therefore consume some 40,000 tons of coke; electric furnaces, say nearly 14,000 tons.

Charcoal blast furnaces are usually small, with a capacity of about 15,000 tons pig per annum. This fuel gives a high class iron, sulphur-free, but as from 2 to 4 tons of wood are necessary to produce one ton of charcoal, a large area of timbered country has to be kept afforested. Charcoal is generally looked upon as an item pertaining to an early period in the history and development of iron smelting, and admissible only where moderate quantities of ore are treated, where coke fuel is unobtainable and for special markets. In these days it has been practically supplanted by coke, except where coal is scarce and plenty of timber exists (Sweden, Norway, and Austria). In Scandinavia the use of charcoal for smelting goes with the utilisation of the forests in other directions at the same time. The best quality wood is used for pulp making; the second quality stuff goes to the sawmill, and the lowest grade is burned for charcoal.

Gas is extracted from the sawdust and bark and used for converting charcoal iron into open hearth steel. Everything is turned to account. The kind of timber for charcoal is selected with extreme care, that being chosen which contains the least phosphorus. The extent to which this care proceeds may be illustrated by the fact that in Sweden birch forests have been destroyed in order to be replaced by pine because the latter contains a little less phosphorus than the former and a reduction of 0.001% could be effected. The forests in Sweden are in course of exhaustion by smelters and the demands of the wood pulp industry. It may be taken that throughout the world, the manufacture of charcoal pig is decreasing and will inevitably continue to decrease.

Mr.Darby estimated that for producing 3560 tons iron and steel per week, the following quantities of raw materials would be required:-

Iron ore for blast and steel furnaces	6500 tons
Limestone flux	1250 "
Slack from Newcastle and Port Kembla	5835 "
Coal from Port Kembla for gas producers and heating furnaces	2136 "

The ore would cost in Sydney 5/10½d. per ton at that date.

If it is intended to use coke as fuel, it would be necessary to carry out an investigation of the coking properties of the coal of the Preolenna field south of Wynyard. Some coal from those seams, on being treated at the Launceston Gas Works, yielded in a test 62% of "good clean marketable coke superior in quality "to any yet obtained in these works from any other Tasmanian coal". (Mr.Arthur Green's report, December 6, 1902). A second sample gave 52.81% of excellent coke.

This coal however contains from 4 to 5 per cent of sulphur. Some of this could, no doubt, be eliminated by washing; but for further remarks on this subject see later on in this report. It may be mentioned here that with electric smelting sulphurous charges can be reduced to pig iron containing only minute traces of sulphur.

There is some limestone visible on the road going down from Stowport to Dicker's bridge; its extent would have to be ascertained in view of local smelting, as it is the nearest to where the works will probably be.

In 1901 I estimated the ore would cost 4/- per ton delivered at Burnie: Mr.Darby estimated 3/6 per ton. But costs in every department of labour have materially advanced since then. Since my report a tramway was constructed from the mine to the coast, but I believe the rails were subsequently taken up.

The site for works for local smelting would probably be at the mouth of the Blythe River. Water is obtainable there, and railway facilities exist for transport to Burnie for export of the product and from Burnie for carriage of works material. This position would ensure connection with all the Tasmanian railways.

Referring again to the question of fuel, the Mersey coal also is highly sulphurous, about 4%, which is greatly in excess of the 0.5% to 1% sulphur characteristic of good quality furnace coke. The presence of much sulphur in the fuel leads to the production of a sulphurous pig iron, to avoid which more limestone flux is required in smelting, and necessarily more fuel.

In coking, a reduction of the sulphur takes place to the extent of from 20% to 40%, the greater part of the sulphur originally present in the coal being still retained in the coke. Numerous processes for eliminating the sulphur during coking have been tried, but unsuccessfully. Of course, the coal could be washed and some sulphur got rid of, perhaps to the extent of 20%.

Smelters avoid using a too highly sulphurous coke. If forced to do so, they have to partially desulphurise the iron afterwards by puddling.

If we had to wash our Tasmanian coal, we should have to consider what extra cost it could bear for manipulation and still compete with coal from New South Wales. If the Blythe enterprise is initiated by private owners, I am afraid that the fuel difficulty may lead them to cast their eyes on New South Wales as offering sites for works nearer to good coal, unless the cheapness of electric energy will compensate for freight of fuel.

There remains the question of charcoal fuel. The absence of sulphur in charcoal is a great advantage, for there is a saving in fluxing materials; also the blast required for furnaces of equal capacity is less when using charcoal than in the case of coke.

One great drawback is the acreage of land required for the growth of timber. Enquiries on the West Coast have disclosed varying estimates of the number of tons of suitable wood that could be got per acre, ranging from under 100 up to 160 tons. This seems a high estimate, and I fear it would not hold good over any large area. Mr.R.Sticht, General Manager of the Mount Lyell Company has been good enough to make some enquiries for me, and has informed me as follows:-

> "The average timbered portions of the West Coast will cut from 60 to 80 tons of 80 cubic feet each of 6 ft. split firewood per acre.
>
> Ten tons of 80 cubic feet each of split timber should yield 30 bags of charcoal, a bag being a 4-bushel bag well filled and sewn.
>
> The best timber for charcoal is peppermint gum, but any sound gum timber is suitable. Myrtle or the different kinds of pine are never used in the Lyell district. Manuka is also an excellent charcoal timber.
>
> The cost of burning charcoal in 1907 in the Queenstown district (the date of the latest burning of which reliable information is to hand) was 2/6 per 4-bushel bag for labour only. The cost is perhaps up to half as high again at the present time."

Reports from other localities state a cost of a little under or over £3 per ton. Mr.R.Grubb, Inspector of Roads on the West Coast considers that a ton of wood will produce ten bags and that an acre of forest would give 100 tons of charcoal. Mr.J.W.Carroll of Linda estimates the yield in charcoal is about 30% of the wood burned. It is probable that in Tasmania at least 1000 acres of timber would be required to supply a moderate sized blast furnace for a year. Allowing 30 or 40 years for regrowth, 30,000 to 40,000 acres would have to be permanently set aside for the industry, or if electric smelting were adopted, 10,000 to 14,000 acres of suitable timber. The acreage might possibly have to be largely increased, as all the timber might not be suitable, or, if suitable, of lighter growth. At first glance, the conditions do not seem to be reasonable for charcoal fuel.

Distance from a distributing centre:

Mr.Darby's objection to a Tasmanian works site under this head has to be considered. He had a very strong opinion that Sydney will be the business centre of federated Australia, with centralised railways, varied shipping, and direct communication with most parts of the world, as well as being in close touch with consumers. He thinks therefore that Sydney will stand unrivalled in Australia as regards the distribution of finished steel. A good deal of his argument is influenced by the comparative proximity of the coal mines and the existence of ideal sites with deep water accommodation.

It might be argued on the other side that Melbourne has strong claims to be considered as a distributing centre, and that Tasmania is within easy reach of Melbourne, and that any disadvantage arising from the interposition of Bass Straits will be counter balanced by the availability of the hydro-electric current. Of course the distribution factor has to be taken into account, but it is questionable whether it would overweight the enterprise. The main question in my opinion is not whether any better distributing centre could be found, but whether the Tasmanian product could be arranged to be such as would not be fatally interfered with by mainland production; that is to say, whether we could not turn out a different class of product from that being put on the market by Australian works:

Want of cheap electric energy:

Mr.Darby's last objection to local works on the ground of absence of electrical energy bids fair to be removed by the hydro-electric enterprise. If electro-thermal smelting can be relied upon as a successful proposition, it would immediately weigh down the scale in favour of works being erected on the North-West Coast. In any case, whether smelting electrically or not, electric steel furnaces would be an integral part of the works for melting and refining the product of the shaft furnaces.

Electric iron ore smelting elsewhere:

In order to give a general idea of the progress being made in smelting iron ore electro-thermally, I give the following citations from various sources, which tend to show that while it has merged from the purely experimental stage, it is only successful in peculiarly favourable circumstances and where the conditions do not favour ordinary blast furnace practice.

The Heroult Iron-smelting furnace was used experimentally in Canada in 1906 for producing pig iron from haematite and nickeliferous ores. Wood charcoal was also used with success as a substitute for coke in many of the trials. Heroult estimated that he could produce pig iron for £2 per ton. With cheap water power and iron ore at 5s. per ton, it is thought that the process promises well.

The Keller furnace was tried at Livet in France on iron ores with coke and limestone in 1904 by the Canadian Commissioners who produced 16 tons of pig iron in two runs with a mean power expenditure of ·350 e.h.p. year and a total cost of £2-8-3 per ton of 2000 lbs. Since then a larger furnace has been built at Livet and many hundreds of tons produced by the Keller process, but it is not known whether there is any installation outside the Livet works.

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The Kjellin furnace is under a Swedish patent and has been submitted to continuous trials since 1900. It is stated that it is intended to utilise the Trolhatta waterfall in Sweden where deposits of iron ore exist, with a view of establishing a large iron industry there, using this furnace. Other furnaces have also been used for making steel from scrap and pig iron. Greater advances are being made in this direction than in electric iron ore smelting. The latter is no doubt technically successful, but the problem is one of costs.

Since the Sault Ste. Marie experiments in Canada in 1906 not much advance seems to have been made in the electric smelting of iron ores. Dr. Eugene Haanel, Director of Mines in Canada, in his bulletin published in 1910 entitled "Recent advances in "the construction of electric furnaces for the production of pig "iron, steel, and zinc" alludes to the progress made in Norway and Sweden. An electric shaft furnace for smelting iron ores into pig was reported in 1910 as working continuously and satisfactorily at Domnarfvet in Sweden. After the experiments at Domnarfvet, Swedish authorities considered "the electric smelting of iron ore "could be considered practically and economically solved". Water power capable of developing 600,000 horse power was going to be made available by the Government, which controls all the more important water powers in the kingdom. Dr. Haanel states that a second commercial plant for electrically producing pig iron and steel was about to be established at Tysse in Norway. The two furnaces for the reduction of iron ores, each of 2500 horse power capacity were to be of Domnarfvet type. A further electric ore smelting and steel manufacturing plant was to be erected in northern Norway.

L. Yugstrom in a report on the Domnarfvet experiments, dated 1909, concluded:-

> "Judging from the results achieved by the experiments at Domnarfvet, the problem of making pig iron from iron ore in the electric furnace seems to be technically as well as commercially solved, but in order to fully ascertain this matter, further experiments ought to be conducted on a larger scale."

Dr. Haanel states (p.9) that the furnaces operating at Dommarfvet had a yearly output capacity of 2500 tons at a power of 400 k.w. direct current; and that there were in course of construction at the A. S. Norsk Elektrometal, Norway, two furnaces of 1850 k.w. and a yearly output capacity of 7500 tons each furnace. One furnace of the same capacity was under construction at Trolhatten, Sweden.

Norway has natural advantages in the establishment of electric installations, not the least being an abundance of small waterfalls, enabling power to be developed at a comparatively low cost.

Outside Scandinavia, electric iron ore smelters do not seem to have made the headway that was anticipated at one time. The total capacity of those in operation in the United States in 1916 is stated as 47,000 h.p. - and only one pig iron plant of two furnaces with a capacity of about 7000 h.p. (Lyon and Keeney, Electro-metallurgical industries as possible consumers of electric power: Trans. Am. I.M.E. vol.LII, p.829). These authors draw attention to the fact that the electric furnace has the blast furnace to compete with when treating iron ores, while it is free from all competition in the case of aluminium and ferro-alloys; and it would therefore be unreasonable to expect its general adoption for iron ore reduction.

Then again the electric furnace capacity is small; all the United States furnaces together (47,000 h.p.) would only produce the same quantity of pig iron per day as one modern blast furnace of 450 tons output per 24 hours. This is a statement the importance of which cannot fail to arrest our attention when considering the adoption of electric smelting in Tasmania.

On the other hand, the electric furnace consumes only one third of the coke or charcoal which is used in the blast furnace, and where these substances are costly, the electric furnace has the advantage.

In iron ore smelting the power cost has to be as low as possible, while steel and other furnaces are not handicapped to the same extent. Most of the Scandinavian plants are stated to be advantageously situated on tidal waters or navigable rivers, and they have made greater progress than in the United States where conditions for supplying hydro-electric power are not so favourable.

The following extracts from volumes of the Mineral Industry will serve to show the progress made with electric iron ore smelting in successive years of the last decade.

In the Mineral Industry for 1907 page 620, Bradley Stoughton and C. Offerhaus write:-

> "The final report by Dr. E. Haanel, Superintendent of Mines, Ottawa, Canada, on the experiments at Sault Ste Marie on the smelting of Canadian ores by the electro-thermal process was published in 1907. According to this report haematite, magnetites, roasted pyrrhotite, and titaniferous ores were successfully and economically treated, producing iron of various grades of silicon, satisfactorily eliminating sulphur, avoiding the usual objections to titaniferous ores and employing charcoal cheaply produced from otherwise useless refuse. On the basis of a cost of $50 per electric horse power, Dr.Heroult estimates that a plant to produce 120 tons of pig iron per 24 hours could be erected at a cost of $700,000 in which the expense of producing pig iron would be as follows:- ore (55% metallic iron) @ $1.50 per ton, $2.70: charcoal ½ ton at $6 per ton, $3: electric energy, amortisation etc., $2.43: labour $1: limestone $0.20: 18 lbs electrode at 2c. per lb., $0.36: general expenses $1: total $10.69 per ton."

In the Mineral Industry for 1910, Bradley Stoughton writes under head of "Iron Ores and Smelting":-

> "The electric smelting of iron ores has made substantial progress during the year from the commercial standpoint. It would appear that the results obtained at the Domnarfvet iron works are technically and commercially successful, due largely to the isolation of the electrodes from the walls of the furnace and the cooling of the dome of the smelting chamber or crucible by means of blowing in and against it cool gases obtained from the top of the shaft. Similar practice has been developed at America's greatest electric iron ore smelting plant at Heroult, Shasta Co., California. This furnace has gone through a number of changes, and the management is now so much encouraged that it contemplates the installation of additional furnaces. The iron produced is low in phosphorus, with low sulphur when desired."

In Mineral Industry for 1911, Bradley Stoughton writes:-

"That electric smelting of iron ore under special conditions of high priced coke and cheap power is an economic and commercial possibility was still further indicated in 1911 by the installation of a new plant in Sweden and by continued successes of the former plants in Sweden and California."

In Mineral Industry for 1912, the same author writes:-

"The smelting of iron ore progresses satisfactorily in California, and the pig iron produced is of good quality and can be made especially suitable for cheap conversion in the open hearth furnace. In Sweden the ~~high~~ production of pig iron is increasing rapidly and much technical progress is being made with the process."

But Mr.Stoughton sounds the first note of warning in his article in Mineral Industry for 1913, and without going into details, says:- "The smelting of iron ore to produce pig iron "has not yet justified the early expectations of its advocates."

In the Mineral Industry for 1914, Mr.Jas. Aston succeeds Mr.Stoughton as author of the iron and steel articles of that work and gives some hint of the reasons for the slight advance made in electric iron ~~ore~~ smelting. The following is extracted from his chapter on technology:-

"For the production of pig iron from the ore the electric furnace has proved rather disappointing during the past year. Development proceeded to the point where, with charcoal available as a reducing agent, and electrical energy at reasonable cost, pig iron could be produced at profit in competition with existing supplies. However, developments of any magnitude or outside of zones of special local conditions, pointed to the necessity of large furnaces, and especially of a type adapted to the use of coke as a reducing agent."

In the Mineral Industry for 1915, Mr.Aston says:-

"The electric furnace for the reduction of iron ores has made no headway in this country (United States) during the year. The California furnace is reported to be working on ferro-manganese. In Sweden there are a number of electric iron smelting furnaces in operation with an annual production of about 50,000 tons pig iron. All are using charcoal as reducing agent. In Norway efforts to smelt iron ore at Hardanger with coke as fuel and by the Electrometals process were not successful: while at the Tinfos works satisfactory results were obtained with coke."

In the Mineral Industry for 1916, Mr.E.Johnson Jr. writes under the head of technical advances in Iron and Steel:-

"One of the important developments of the past year has been the increase in the use of electric furnaces. These are in practically no case for the production of iron and steel, but merely for melting or refining iron and steel already produced."

The Mineral Industry for the same year states that in three years the world's electric steel furnaces had increased from 149 to 471. At the beginning of 1914 there were in Sweden 5 electric furnaces producing pig iron with 3 more in contemplation. Each had a power of 2000 to 3000 k.w.

The Journal du Four Electrique et de l'Electrolyse states that during the war the electric steel furnaces in Norway have been very active on the production of ferro-chrome, ferro-silicon, carbide and cyanamide, calcium and ammonium nitrate, nitric oxide, aluminium and nickel refining. This French paper says that Germany without new installations produced 130,000 tons of electric steel in 1915, against 90,000 in 1914.

The above represents all the information that I have been able to gather with reference to electric iron ore smelting, and you will obtain from it a rough idea of the advances made year by year for the last decade.

On the whole not much progress has been achieved in electric processes for the production of pig iron from iron ore, except in Scandinavia, and even there there are some records of failure, while most of the electric furnaces are steel furnaces. We have not access here to the full Scandinavian literature of the subject, but undoubtedly some cogent reasons must exist for the comparatively successful developments in that peninsula and the stagnation in, say, the United States. It may be surmised that some of the causes are to be found in the supply of cheap hydro-electric current, favourable works sites, and the greater purity and value of charcoal iron. In the western States of America the want of a coal suitable for metallurgical coke is stated to be a drawback which has retarded progress. The cost of coke and charcoal is directing the hopes of smelters towards discovering a successful process which will admit of the use of local petroleum.

Judging by the accounts given, it would seem that electric ore smelting is an actuality, and at the present time is being carried on with some measure of success in Norway and Sweden where specially favourable local conditions exist. The question for consideration is whether conditions in Tasmania are sufficiently favourable for the establishment of a similar industry here, viz: suitable deposits of ironore, suitably situated, cheap hydro-electric energy, cheap supplies of flux, and cheap fuel available.

It goes without saying that in starting works, initial difficulties will inevitably be encountered which will have to be overcome by trial and experimental work under experienced technical control. An intimate knowledge of the work in Norway and Sweden would appear to be essential before deciding on the enterprise.

The position of the problem of electric iron smelting has been succinctly described by J.B.C.Kershaw in his "Electro-thermal Methods of Iron and Steel Production" (1913) p. 42, as follows:-

> "But even when the power consumption has been reduced to 1500 kw. hours per ton, the electric iron smelting furnace will still be unable to compete with the ordinary blast-furnace methods of producing pig iron, except under the most favourable conditions, as at Trollhatten and at Heroult. As pointed out in the introductory extract from the author's book of 1907, the modern blast-furnace, when worked under the best conditions, only requires 16 cwts. of coke per ton of pig, and of this total 6¼ cwts. are required to reduce the ore to the metallic state. This amount of charcoal or coke has to be provided for by either process. The saving in coke by the adoption of electric heating can therefore only amount to 9·5 cwts. per ton of pig, costing at the present market prices in localities near the coal mines 8/4 to 10/5."

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"Now if 1500 kw. hours can be obtained for 10/5 it signifies that the e.h.p. year must be sold for between 33/6 and 41/8, and there are, as already stated, exceptionally few hydro-electric stations that can produce or sell electric power at this figure. The electric process is also further handicapped by the cost of the carbon electrodes, an item of expenditure which has no counterpart in the ordinary blast-furnace procedure.

"Though the electric iron smelting processes may therefore make headway in those localities, where all the conditions favour their development, and where the price of ordinary pig-iron is artificially increased by freight charges - they are unlikely to undergo extension or development, in other lands or localities, so long as cheap supplies of coal and coke are available for the ordinary blast furnace process of manufacture."

Kershaw at page 41 of the above work gives estimates of power cost and consumption in the Heroult and Gronwall furnaces as varying from 1620 to 1957 kw. hours, and cost of the pig from £2-4-3 to £2-17-4 per ton, reckoning the ore at 6/3 per ton and the power at £2-4-7 to £2-10-0 per e.h.p. year. He thinks that with large furnaces and further reduction of radiation and other heat losses the power consumption may ultimately be reduced to 1500 kw. hours per ton of pig iron.

Rodenhauser in his "Electric Furnaces in the Iron and Steel Industry" quotes (p.372) Crawford of the Noble Electric Steel Company at Heroult, California, as follows:-

"While it is hardly agreed with the prophecies made by some that electric furnaces for producing pig iron will eventually be competitors of blast furnaces even in the regions where economic conditions make the latter possible, Crawford feels that where electric power can be obtained cheaply and where coke and freight rates are high, and for making superior grades of iron, electric furnaces will enable many large bodies of iron ore to be worked which would otherwise remain idle, and that the electric iron furnace, both of the shaft type and of the long and narrow type, each in the field best adapted for it, will make steady progress."

The possibility of producing pig steel direct from iron ore in the modern electric furnace seems to have been established, and if there is a demand for steel, this process could be adopted to advantage instead of converting the pig iron to steel in a second furnace.

The Agent General in a communication to the Hon. the Premier under date November 6th, 1914, stated that he was obtaining a report from the Electro-Metals Limited on a process for producing steel direct from our iron ores, and it would be desirable to look through this report. Sir John McCall thought we might restrict our production to some special class of article, such as wire fencing steel, etc.

I have gone into the matter of the progress of electric iron ore smelting at some length, in order that its present position may be clearly seen and the uncertainties surrounding its adoption realised before assuming that it is going to be a certain success. The questions of fuel and the cost of heat are the ones which call for clear ideas before any commitment is made.

The position of the electric steel furnace is different. This is being used largely all over the world. The process is the most modern method of super refining the steel produced by the Bessemer and open hearth processes, and the steel product is said to be equal in quality to crucible steel. If the cost of power is high, it cannot compete with the crucible process in making steel from pig iron, but if power is cheap, it may be employed profitably for this purpose, though perhaps its greatest advantage will be in super refining.

A duplex method for making steel has been suggested by the Electro-Metals Limited of London, working a basic open hearth furnace and an electric furnace in conjunction. The process consists in drawing the charge of partly refined iron from the open hearth furnace and tapping it into the electric furnace (the latter heated with coke and the electric current) and repeating the operation.

The estimates for the establishment of wire fencing works in Tasmania made by the Electro-Metals Limited show a bare return of interest, and Sir John McCall suggests that the enterprise offering as it does no attraction to private individuals or Companies, might be undertaken by the State, which would reap the benefit of increased population and new manufactories. One gathers from the report in question that the capital expenditure for plant would be £200,000. At the time of the Agent-General's suggestion, the Broken Hill Company had not entered the field, but this month the Acting Prime Minister announced in the House of Representatives that the Company's Steel Works at Newcastle would have produced enough fencing wire for Australian requirements, and that the wire from which wire netting is manufactured would be produced in the same way.

In 1915, I made some remarks on the nationalisation of the iron industry which I may here summarise. It seems to me that a good deal of the disinclination of capitalists to establish works here, has been owing to the large initial cost, to some fear that a regular and uniform supply of raw material may fail, and to fear of industrial trouble. If with regard to industrial upheavals we are not worse off than other countries, this objection loses its force. As regards ore supply, the appearances indicate adequate reserves of ore for many years to come. With respect to the cost, it would seem that here the State with its large resources could advantageously intervene in putting the industry on its feet, provided the trade outlook is satisfactory.

Ironmasters usually consider that the running of iron works is more complicated and makes greater demands on the management than is the case in Government managed establishments generally, and that therefore State ownership would not pay. But this class of objection is now out of date. Similar arguments might be advanced, and with as little force, against Government arsenals and munitions factories.

The nationalisation which I would favour, if arrangements could be made with the other States to prevent unfair competition, would consist in the establishment of works by the Tasmanian Government and utilising the hydro-electric installation for the supply of current for smelting the ore. The alternative would be to subsidise private enterprise. Whether the Commonwealth would subsidise the State enterprise is also a question to be taken into account.

Possibly the difficulties of initiation may take some time to cope with. If pig iron is produced for sale, there would be sure to be a disinclination on the part of some local manufacturers to use the iron at first, because it will not be exactly the same as what they have been working up, and the industry will need State nurturing at every stage, so that the metal can be supplied cheaper than the imported article. There are so many little variations in the nature of iron that manufacturers have prejudices in favour of the particular brand to which they have been accustomed. Then starting works of this kind is always experimental to some extent, and unexpected troubles usually accompany it. These initial difficulties have given rise to the world-wide practice of assisting the industry in its first stages by bonus or duties.

I always considered that the manufacture of steel rails would be the principal item in our works programme, but the establishment of the large steel and iron works on the mainland by the Broken Hill Proprietary Company upsets this scheme and also forestalls Sir John McCall's suggestion.

Whether each State nationalises its own industry or not, and whatever line of manufacture is taken up, Interstate competition is a lion in the path, and I do not know what would be the best method of providing against it.

Whichever way we look, we must recognise that the nationalisation of the industry is the remedy against private control of resources which ought to be at the disposal of the State. The Broken Hill Company has, however, got in first.

A decision by the State to undertake the reduction of our iron ores for any purpose whatever will not only contribute to the Federal welfare, but will also benefit the State, by utilising the power which it has provided at great cost for the advantage of the entire community, and by supplying both Government and people with metal manufactures of first importance to both. The industry will likewise directly furnish employment to a number of hands and will stimulate the general trade of the State.

Our deposits at present lie idle and unproductive. That is an argument in favour of the State controlling the industry. Another reason is to be found in the fact that Australia imports large quantities of steel and iron for Government requirements, and if the initiation of the industry be left to private enterprise, subsidised as it doubtless will be by the Government, the latter will eventually be paying ironmasters, not only the subsidy, but also the enhanced prices which that subsidy will help them to earn on Government contracts. That is to say, instead of paying the British manufacturer his profits, the Government will be paying them to the Australian manufacturer, plus any subsidy.

I know it is frequently urged that Government works cannot produce as economically as private ones, and this is ascribed to various causes: inadequate remuneration, absence of the stimulus of personal relations, Government stroke, political influence, unbusiness-like methods in vogue in Government Departments, restrictive departmental regulations and the like. Some of these may be solid reasons, and where present would mean ruinous loss. It is well to know beforehand what to guard against. If these drawbacks are excluded, Government enterprise ought to be in a superior position.

It would be hoped that the other States would be customers, as the purely local demand would be inadequate to keep the smelters at work. But I am afraid we have been too late in taking action, and that New South Wales will be a serious competitor; unless we can get into the field with some special line of manufacture before it is taken up on the mainland. The outlet for steel rails and fencing wire already appears to be blocked. Had we been two or three years earlier with our hydro-electric installation, the position would have been different. It now seems to me that, before we discuss raw materials and smelting processes, we must decide what class of product we propose to make and what markets we hope to command.

Dial Range Deposits.

For ten years prior to 1908, deposits of a very pure haematite were worked along the course of the Penguin Creek and sent to smelters in New South Wales for fluxing purposes, until other sources of supply were found for the furnaces. Over 40,000 tons were sold in this way. The shipments assayed 66% to 68% iron and only 2 or 3% silica. Only traces of sulphur and phosphorus exist in the ore. The deposits are situated up the creek between three and founr miles from its mouth, but the owner told me in 1903 that there was always some difficulty in locating working spots where there was a sufficient proportion of ore clean enough to meet the demands of the smelting works. Large boulders of high grade ore from 3 to 20 tons weight used to be taken out from softer and clayey portions of the deposit. The ore is found usually just below the surface clay. A white sandstone or quartzite is associated with the ore, and the nodular form in which a good deal of the latter occurs suggests an original pebbly sandstone or conglomerate.

About 6 miles south of the Penguin on the west flank of the Dial Range and not far from the summit, are iron reward leases granted to Jones and Denny. Excavations have been made into a body of haematite. This is in conglomerate, and in fact, is essentially conglomerate transmuted to iron ore. Samples from the different cuts and trenches, which I took in 1903, were assayed with the following results:-

			Iron	Silica	Phosphorus	Sulphur.
			%	%	%	%
No.1	Jones'	section	68	0.5	traces	traces
No.2	Denny's	do.	66	1.6	traces	traces
No.3	do.	do.	69	0.8	traces	0.15
No.4	do.	do.	58	6.8	traces	traces

The quality is not uniform throughout, siliceous boulders of ironstone occurring in the soil between the above cuts, but there seem to be several points in the ore belt where the stone is high grade. The country rock is impregnated with iron for a quarter of a mile to the east, and even on the top of the mountain there is some iron in the conglomerate. It is possible therefore that the present exposures do not exhaust the economic possibilities. A wire haulage would be necessary to take the ore down from the quarries to the basalt plateau, whence an outlet via Sulphur Creek to the railway could be adopted, if the route to Penguin is not preferable. The crude ore could be carried by rail from Sulphur Creek to the Blythe works, a matter of about 3 miles. Some such arrangement as this would have to be made, for with the quantity of ore visible it is doubtful whether the deposit is sufficiently large to warrant a separate enterprise.

Anderson's Creek Deposits.

Some iron ore deposits exist on Anderson's Creek three or four miles west of Beaconsfield, which are sufficiently important in extent to invite serious attention.

Mt.Vulcan Deposits:

These are the best known. A few tons of ore were taken away from York Town as early as 1805. In the seventies a blast furnace was put up on the West Arm and about 10,000 tons of pig iron were produced. The product was looked upon as ideal for sundry parts of quartz stamp batteries and for purposes requiring a combination of hardness and toughness. It was soon seen, however, that only a limited local market could be got, and parcels were then sent away to England for trial at the various iron and steel works with a view of securing a larger outlet. The general results of the trials were unsatisfactory, the iron being too hard and brittle and not workable by itself to produce malleable iron, high in sulphur, making brittle castings and excessively hard tool steel. Varying proportions of chrome were found to exist, the pig containing from 2% to 10% of that constituent. Since 1877 no smelting has been carried on. In 1903, I communicated with ironmasters in England so as to obtain some reliable information respecting the utilisation of this class of ore. The result of my enquiries was not encouraging. Messrs.John Brown & Company of Sheffield told me that the composition of the ore is too variable for any reliable work. Krupp's agent informed me that it would not be suitable for their works. Messrs. Chas. Cammell & Company of Sheffield stated that the results of smelting chromic ores had not been very satisfactory owing to the irregularity and great density of the iron produced, also to the extra expense involved in smelting. The Barrow Haematite Steel Company Ltd. were not aware that any great advance had been made in recent years in the way of utilising such ores. They had been making experiments with some ores of this class from Greece, containing 2% to 4% of chromium, but the result was most unsatisfactory and they had to give up all ideas of using ores of that kind, even in small quantities.

In 1897 Mr.W.C.Dauncey, C.E. read a paper before the Royal Society of Tasmania, in which he suggested a mixture of two ores, chromiferous and non-chromiferous, might be used in smelting, or a percentage of the chromium pig might be added to a pure pig when melting for the production of steel. This is in fact drowning the chromium content, and perhaps there is more hope of success in this direction than in an attempt to eliminate the chrome. Some of it perhaps could be expelled in puddling, but the process is described as being difficult, slow, and requiring extra heat; and no malleability nor uniformity in the product can be relied on.

In working the Anderson's Creek deposits, quarries at different points will probably have to be opened, so as to ensure something like a constant average of composition, and if that had been done in the old days one drawback might have been neutralised. Mr.T.C.Just in his account of operations says:-

> "The closest supervision was given and details watched most minutely, but we never could get iron sufficiently grey or soft, nor could we secure uniformity of quality."

Some solid experimental work will have to be put in before launching out into a large enterprise here. Certain ores in Greece carry 2 to 3% chromium and are used in making an iron which is said to be of inferior quality, but it would be desirable to get some information from the Companies operating those mines, say, the Societe Hellenique des Mines, Athens; the Societé des Mines d'Atalanta, Athens; the Societe anonyme des Mines de Skyros, Athens; and the

As regards the deposits on this creek, the results of my examinations may be summarised as follows:-

Mount Vulcan:

This is about 6 miles from the old shipping jetty at Port Lempriere on the West Arm of the Tamar. It is a low hill between 150 and 200 feet high. The summit is strewn with boulders of nodular and concretionary brown and red haematite and magnetite, forming a kind of surface drift. Quarries have been opened in the face of the hill, and from these the ore was taken for the furnace. The face of the large quarry is to some extent obscured by talus, so that the quality of the lower part of it cannot be seen. Some old bores appear to have shown alternations of iron ore and serpentine, which is rather disquieting as indicating that the hill is not a simple mass of iron ore as is generally supposed. It may however be that these alternations of ore are horizontal offshoots from a vertical lode in the central axis of the hill, but it is quite evident that a boring scheme will have to be carried out before work is begun, so as to obtain an approximate notion of what quantities one might expect to have available.

The assays made of the ore show such variable chromium contents that it is quite possible that increased depth may disclose an increase in the percentage sufficient to convert what is now an iron ore with accessory chrome to a chrome ore. The assays vary from traces to 5·90% chromium oxide. It is noteworthy that the Port Lempriere Company found the proportion of chromium to increase as the deposit was worked.

If we could assume that the deposit down to creek level continues of unimpaired quality and is as wide to that depth as the superficial ironstone drift, a million tons would be available, but a useful estimate cannot be made until boring operations have been carried out. At present the only indications available are the surface accumulations of drift and boulders, which it must be borne in mind are essentially derivative and not primary deposits.

Just north-west of Mount Vulcan is Scott's Hill, also situate in the iron belt, with a lot of superficial earthy yellow haematite and concretionary ironstone boulders and drift spread all over the slopes. There are no workings which could guide one to even an approximate estimate of the quantity of ore available.

Barnes Hill:

This is a hill 150 or 160 feet high a couple of miles further up the creek and half a mile south-west of the old Ilfracombe sawmill. Magnetic red ironstone drift and boulders or detached masses of haematite and magnetite as at Mount Vulcan, are scattered over the surface. They also seem to be concretionary and derivative in origin, as shown by small pebbles being cemented within their mass. Tabular masses of ore have been exposed by ripping up the surface drift. On the western edge of the hill, massive blocks of nodular ore are seen for a vertical depth of 40 feet. This hill is also in serpentine country and consequently the ore is contaminated with chromic oxide. An analysis of my samples by the Government Analyst gave the following result:-

Peroxide of iron	72.20	= 50.54% metallic iron.
Silica	6.50	
Sulphur	0.14	
Phosphorus	traces	
Chromium oxide	6.90	
Alumina	4.00	
Loss on ignition	8.70	
	98.44	

Neither titanium nor vanadium was present in appreciable quantity.

The area of surface indications on this hill is about 1000 feet square, and the ore seems to be in more solid masses than on Mount Vulcan. No proper estimate of tonnage can be made, but if the ore deposit continues unimpaired to the depth of 100 feet possible 2,000,000 tons might be got; but the probability is that the drift does not go so deep. Quarries could be opened with ease on the west face of the hill, and the output sent down by gravitation to any level selected for the tramway. The distance to the old jetty at Port Lempriere is 7 miles of easy grade.

Ilfracombe Iron Mine:

On the range of the Blue Peaked Hill south-east of the preceding is a deposit of haematite in sandstone and conglomerate. The strata belong to the Beaconsfield auriferous series and no chrome is present in the ore. A belt of ore extends up the hill on its west side and loose lumps and blocks of the mineral are found in the soil to a depth of 50 or 60 feet. Mr. Gould, a former Government Geologist, stated the length of the outcrop as 300 yards and the average width as 66 feet. He estimated 350,000 tons as existing down to the level of the plain and an average quality of 55 to 60% iron for a large portion of the lode. Samples which I took were assayed by the Government Analyst and reported by him to contain 56.8% metallic iron.

The course of the old Ilfracombe tramway passes this deposit, and the shell of an old blast furnace was still standing in the field at the foot of the hill at the time of my visit. The Ilfracombe Iron Company was formed in the early seventies to work this lode, and a furnace was erected, but the trials were unsuccessful and operations were suspended after incurring a cost of nearly £10,000.

A medium sized blast furnace would smelt the ore estimated to be contained in the deposit above plain level in about seven years, which would be a period insufficient to reimburse the owners for the outlay. The only possible plan would be to work jointly with the Barnes Hill and Mount Vulcan deposits, and this would allow some system of blending to be adopted, though the non-chromiferous portion of the blend would have to be supplemented by supplies from some other source.

Swift's Haematite:

There is a small deposit of iron nearer Beaconsfield on the west side of Brandy creek, covering an area of a few hundred square feet. Tabular masses of concretionary haematite and impure ironstone are met with just below the covering of surface drift. The deposit has probably no great downward extension. In 1875 ore from this deposit was smelted in a charcoal furnace on the Middle Arm and yielded an excellent iron. A depression in the iron trade, combined with the small scale of work, made it difficult to continue operations profitably. The deposit was never thoroughly opened out, and it is still impossible to say what quantities are available outside the limited exposure at surface. My samples yielded on assay 51.5% metallic iron. The deposit is not extensive, and if there is anything now left of it, it might be utilised in blending with the chromiferous ores.

Comstock District near Zeehan.

A ridge of magnetite ore courses across the Kynance section (formerly Tenth Legion) below Mt.Agnew, and not far from the terminus of the Comstock railway. The crest of the ridge is timbered, and a profuse talus of blocks of iron ore obscures the actual width of the outcrop. A tunnel however has been driven into the ridge to see what is below this promising outcrop of clean hard ore. After passing through quartzites and hardened slates, it intersected bands of impure magnetite and entered lime silicate rock, and the present end is in the latter rock. The magnetite is nowhere very pure in the drive, which would seem to have passed through a weak part of the lode.

Some further exploratory work is needed, so as to come underneath the large blows of pure magnetite visible on the ridge. The ore is remarkably pure at surface, as may be seen from the following assays of samples gathered by Mr.G.A.Waller:-

	(1) In tunnel	(2) Outcrop.
	%	%
Iron	61.8	70.7
Sulphur	0.2	0.1
Phosphoric acid	traces	traces
Chromium	traces	nil
Titanium	nil	nil

Mr. Waller reported in 1903, "I think it is safe to say "that the amount of high grade ore available, and which can be "mined cheaply by the open cut system, amounts to several millions "of tons."

After examining the occurrence with Mr.L.Keith Ward in 1909, we reported that this outcrop "is very massive and pure, and "with favourable conditions would be a valuable source of iron".

It is too far from present coke supplies to be very inviting, but reduction with charcoal fuel might be a practicable proposition with cheap electric current. Operations would probably be on a moderate scale. Limestone flux exists near the Zeehan smelters and is the nearest available.

Nelson River Iron Lode.

In 1910, Mr.L.K.Ward examined a massive iron lode 6 miles north east of Whale's Head Boat Harbour. The outcrop in its best part consists of haematite mixed with crystalline magnetite and a small amount of quartz. Mr.Ward reported that the "vein stuff "is certainly of considerable value as an ore of iron and for many "chains maintains a high degree of purity. The lode requires "prospecting, and this work could be easily carried out. It is "said that no engineering difficulties of any magnitude would "prevent the ore from being carried by rail to Whale's Head Boat "Harbour." Nothing much is known of this occurrence so far, and until some work has been done, it is impossible to estimate possible tonnages.

Other Deposits.

Large deposits of haematite and magnetite exist at the west end of the Meredith Range and at the Savage River, but they are associated with pyrite and other sulphides, and for the present the occurrences which have been described in this report appear to be the only ones which merit attention as coming within the present range of practical work.

The most favourable deposit for present work.

This would be the Blythe orebody, with or without the Dial Range ore as an adjunct. It would be of advantage to the Anderson's Creek proposition if the ore there were made use of for blending with that of any other enterprise, but it is at least questionable whether other smelters would care about introducing chromiferous ores into their mixtures. It is possible that chromic iron smelting will have to be kept within the boundaries of its own group of properties.

Cost of Production.

Estimates of the cost of producing pig iron and steel from our ores will have to be left to experts after a decision has been arrived at as to what class of manufacture would be undertaken, whether pig iron, steel booms, structural steel rails, fencing wire, etc.

The 1916 Report of the Interstate Iron and Steel Tariff Commission gives some basic figures. The price of imported pig iron under normal conditions is stated at 65/- per ton in Melbourne. The majority Commissioners say:-

> "If the Australian ironmasters are placed in a position to largely increase their present output we are of opinion that pig iron should be manufactured and profitably delivered f.o.b. Sydney or Newcastle at not more than 65/- per ton."

Adding freight from Sydney to Melbourne would mean 76/6 per ton f.o.b. Melbourne. The Commissioners say it would require a tariff of 12/6 per ton to command Australian markets plus a bounty of 10/- per ton for Western Australia.

The Blythe ore required to make a ton of pig may be put down as 1.6 ton. This would cost say 9/- or 10/- at the sea coast; add 20/- for fuel and fluxes and 10/- for electrodes, labour and repairs; total 40/- plus cost of electric current, which would have to be very low to make the undertaking profitable. In addition to a possible Commonwealth tariff, there would have to be a State subsidy towards the cost of electricity.

However, it is useless to pursue this part of the subject further at present before the consideration of the whole question of manufacture has advanced to a further stage.

Ores of Tungsten.

These are wolfram and scheelite. The electric furnace is being used for the reduction of the minerals to metallic tungsten and in the manufacture of ferro-tungsten for steel making. It is said that over 90% of the tungsten produce of the world is made up into ferro-alloy and tungsten steels.

The production of these ores in Tasmania has not been great hitherto, but is increasing. From 1899 to the end of 1916 our output was 718 tons; of late years it has been on the increase, and in 1917 it was 241 tons.

Deposits occur on Ben Lomond, at Lottah, Constable's Creek, Upper Scamander, Middlesex and Forth River, Mount Pelion district, Interview River, and at Gladstone. A scheelite mine is being worked satisfactorily on King Island.

The principal centres of wolfram mining are the Moina and Ben Lomond districts. The S. & M. Mine at Moina is the pioneer mine in that locality and is a steady producer of a mixed wolfram-cassiterite-bismuth concentrate, which is treated magnetically at Launceston, Tasmania. There is no doubt that the product in pre-war times found its way to Germany. Undeveloped deposits exist a little further east on both banks of the River Forth. Higher up the Forth on the Mount Oakleigh and Pelion track some lodes of wolfram have been recently discovered and are being prospected.

The output from Ben Lamond is derived from mines on Story's and Gipp's Creeks, where mixed tin and wolfram concentrates are produced and treated in an electro-magnetic separation plant at Story's Creek Mine. The occurrences near Lottah are unimportant, and those of the Upper Scamander are in an undeveloped state. From the tin-wolfram lode at Gladstone only trivial returns have been received, and it is not very promising.

For electrical reduction of these concentrates there is no necessity for installing a plant at any of the actual mines. It can be erected at the spot most suitable for the supply of the current. At present the output goes all the way to England to be reduced, so the freight to a central furnace in Tasmania would be comparatively a trifle.

The following notes which I have been able to collect in reference to this subject may be of interest:-

Before the war Germany controlled the metallic tungsten and ferro-tungsten industry, supplying these metals even to British steel works, though she had to derive her ores chiefly from foreign countries. It is said that the control of two-thirds of the world's production has now passed into British hands. (Mineral Industry for 1916, page 734). The metal from the ores is being extracted in England in three centres, namely at Widnes (The High Speed Steel Alloys Ltd.); at Luton (The Thermo-Electric Reduction Corporation); and at Sheffield; and at Hyde (The Continuous Reaction Company). The Luton Company has acquired certain Australian mines in Queensland.

The usual treatment of tungsten ores, after concentrating them by dressing or electro-magnetic separation (when the latter is possible) is to fuse the ground material in a reverberatory furnace with carbonate of soda and convert it into sodium tungstate. The furnace product is leached with water and the solution evaporated, leaving either pure tungstate of soda or the pure salt. After re-crystallising the tungstate, it is dissolved and treated with dilute hydrochloric acid, with the result that the metal is precipitated in a granular form as tungstic acid (hydrated tungstic oxide). Some modifications of this practice exist.

The oxide has to be further treated to obtain metallic tungsten. The principal processes are (1) reduction in a current of hydrogen, a method which is attended with difficulties of control, and is not so generally followed as the carbon process; and (2) reduction in the electric furnace by mixing the oxide with carbon and heating it in a crucible furnace at a temperature of 1400 deg. C. The cost of the manufacture is stated to be about £80 per ton. (The Rare Earth Industry by S.J.Johnstone 1915, p.67).

The gas fire process has the disadvantage of leaving some carbon in the metal beyond the desirable limit and has been largely replaced by electric treatment in which the concentrates are reduced with carbon in the arc furnace, yielding an alloy of 50 to 80% tungsten with 0.05% carbon. Scheelite offers more difficulty in treatment, and the furnace losses are greater than those of wolfram.

Dr. Fink in Mineral Industry (for 1913) states that an improved process has been adopted by the Electric Furnaces and Smelters Company Ltd. in which 7 to 10 parts of ferro-silicon and 14 to 18 parts of calcium carbide are used with 75 parts of tungstic acid, adding a little lime and fluorspar flux and raising the temperature to 2800-2900 deg. C.

Fink in Mineral Industry for 1915 (page 702) describes the process of tungsten reduction at Luton. After producing sodium tungstate by fusing ground wolfram with soda, it is broken up by HC_1 and precipitated as yellow tungstic acid (WO_3). This after filtering and drying is charged into crucibles with charcoal and heated in a reverberatory furnace. The resulting metal is pulverised, forming a 98% metal. At the same works the alloy ferro-tungsten is produced in electric furnaces.

In recent years a great impetus has been given to the manufacture of ferro-tungsten for making high-speed and self-hardening tool steel. The bulk of the tungsten output is absorbed in this industry. During the war the British Government has prohibited the export of tungsten ores and tungsten in view of the urgency of accelerating the munitions output, which has been materially assisted by the employment of machinery dependent for its extreme speed upon tungsten steel. A tungsten-thorium alloy is used to an appreciable extent in making filaments for electric lamps, an industry which is increasing enormously every year. (Dr.Fink (Mineral Industry, 1916) states that in America alone about 200,000,000 filament lamps were manufactured in 1916.

In producing ferro-tungsten by the carbon process, the concentrates with flux and carbon and a determined quantity of scrap iron or steel are treated in a gas furnace, or a direct reduction is accomplished with carbon in the electric furnace.

Deposits of quartz suitable for quartz glass manufacture.

Quartz glass is a special variety which has special properties making it much sought after for laboratory and chemical purposes generally. It is insoluble in acids, it can be immersed in cold water without breaking even when strongly heated, and it does not take up moisture. An increasing trade is being done in it. At present glass of an inferior quality for these purposes is being imported from Japan, and there would be an outlet for a good product throughout the Commonwealth. Of course, the demand exists only within certain limits, but a good article would command the market, such as it is.

Essentially the manufacture consists of fusing pieces of quartz at a temperature of 2000 deg.C. in a thin graphite box which is heated electrically. This is subjected to a certain pressure by an air compressor, and, on cooling, a block of homogeneous quartz glass remains behind.

The raw material would be the quartz from some of the large barren quartz reefs which are met with in most of our mining districts. Care would have to be taken to select such stone as is absolutely pure and free from contaminating ingredients such as lime, soda, potash, pyrite, or economic minerals.

Particulars of manufacture and the permissible raw material would have to be collected, so as to have some detailed information on the subject. I cannot do more than throw out the suggestion here.

Semi-anthracitic coal and the manufacture of graphite.

I have wondered whether the sub-anthracitic coal at York Plains could not be utilised for the electrical manufacture of graphite. It is well known that graphite is made at Niagara Falls by heating anthracite containing a fair percentage of ash in an electric furnace until the silicon and iron carbides formed by the combination of the anthracite with the silicon and iron of the ash are decomposed again and the silicon driven off as gas and re-deposited, leaving graphite in the furnace.

A soft graphite suitable for lubrication etc., can also be made by heating anthracite, sand, and ordinary coal. Artificial graphite is much used for electrodes and other electrical purposes. The demand is increasing. Other uses are for pigments, crucibles, etc.

Materials for the manufacture of carborundum.

We have the raw materials for this electrical industry, but the market here is inconsiderable and would not warrant an installation. Crushed quartz and pure coke (with sawdust added to keep the charge porous) are charged into the electric furnace and the product is carborundum (with the liberation of carbon monoxide gas).

Calcium Carbide and Electrolytic Zinc.

Works in connection with these are in operation and further installations are contemplated. Consequently the deposits of limestone and zinciferous ores need not be touched upon in this report.

Conclusion.

I have in the above dealt with the deposits of raw materials which are the most likely to be useful in connection with electrical industries in Tasmania. Unfortunately we have no deposits reported yet which can be used in the production of aluminium. The most important industry would be that of iron and steel; and a moderate use of the electric current could perhaps be developed in working a tungsten plant. The other industries mentioned offer more remote possibilities. Even as regards iron ore smelting, it will be seen that the problem is by no means a simple one. Its satisfactory solution depends upon a conjunction of favouring conditions.

I have indicated how these conditions bear upon the question. Expert consideration must determine what direction the industry should take. The question of cost of current will play an important part in deciding whether electric smelting can be adopted in its entirety. If this is satisfactory, it is likely that some direct steel making process and some special class of manufacture will be found to offer the best chances of success, always provided that some Government aid is given to meet competition from overseas, at any rate in the infancy of the industry. But the prospects are not bright of discovering a type of product which will meet our manufacturing requirements, as the Broken Hill Company has taken steps to meet the Australian demand for steel rails, fencing wire, netting, steel blooms, etc. In short, owing to the delay in opening up our ore deposits, when we start smelting, instead of having an open field, we shall find it occupied by powerful competitors. Before anticipating that our enterprise will be profitable, it is absolutely necessary to ascertain how this competition will affect us.

I have the honour to be,

Sir,,

Your obedient Servant,

W. H. Twelvetrees

Government Geologist.

The Secretary for Mines,

<u>HOBART</u>.