which may be translated thus: Six molecules of permanganate of potash and thirty molecules of hydrochloric acid and eight atoms of gold produce six molecules of chloride of potassium, three molecules of sesquioxide of manganese, fifteen molecules of water, and eight molecules of the trichloride of gold.

The concurrent changes effected in the Black-Skeet process are probably as follows:—

$$6\ KMnO_4 + 24\ NaCl + 30\ H_2SO_4 + 8\ Au = 6\ KHSO_4 + 24\ NaHSO_4 + 3\ Nm_2O_8 + 15\ H_2O + 8\ AuCl_3,$$

which, in plain English, would read thus: Six molecules of permanganate of potassium, twenty-four molecules of common salt, thirty molecules of sulphuric acid, and eight atoms of gold produce six molecules of bisulphate of potash, twenty-four molecules of bisulphate of soda, three molecules of sesquioxide of manganese, fifteen molecules of water, and eight molecules of trichloride of gold.

It has already been stated that the permanganate process does not deal with silver in the ore. That metal, indeed, when present as an alloy of silver and gold, obstructs the solution of the gold by forming a coating of insoluble chloride of silver on the surface of the particles of bullion, and this protects what gold there is in the bullion from the attack of the solvent.

In the case of ores such as the Monowai, City of Auckland (old Sylvia), Great Barrier, the low-level refractory portions of the Waihi and of the Waihi Grand Junction and other Upper Thames mines, where the silver is present chiefly as sulphide rather than as alloy, the permanganate process has proved most successful by numerous laboratory experiments on parcels up to 56 lb. weight, after a dead roasting with 3 to 6 per cent. of salt. By such roasting the silver of these Upper Thames and Monowai ores is converted in the furnace into chloride of silver, which has not, so far as yet observed, had any retarding action at all, in the case of such ores as these, on the extraction of the gold up to from 90 to 98 per cent. Indeed, the most rapid extraction yet obtained has been got from the most refractory parts of the Monowai ore, specially picked out at the mine for its refractory character, as a severe test for the permanganate process. In this case the samples put through contained about 22 per cent. of zincblende (or sulphide of zinc), 8 per cent. of galena (or sulphide of lead), 3 per cent. of copper-pyrites, and 9 per cent. of iron-pyrites. The ore thus contained 42 per cent. of the sulphides of zinc, lead, copper, and iron. The silver was present in the proportion of 546 oz. to the ton, and gold 9 oz. 14 dwt. per ton. The ore was ground and passed through a 40-sieve (1,600 holes to the square inch). It was then mixed thoroughly with 6 per cent. of salt, and roasted to a perfectly dead state in the Permanganate Company's reverberatory furnace at their testing plant in Dunedin. The roasting process occupied eight hours, the temperature being kept low at first, and gradually rising (while the charge was being constantly turned over or rabbled) to a full red heat, and kept so till a portion of it steeped in twice its bulk of the permanganate solution, and shaken up, left the purple-red colour of that solution very little changed.

The roasted charge was then placed on the filter-bed of clean gravel and sand (described above) in a 5-gallon glass cylinder, fitted with the necessary outflow-pipe. The permanganate solution was then put on it, the outflow-pipe being left open, and within ten minutes of the commencement of the outflow the gold was beginning to come through. In one hour from the start it had reached the very rich indication, and retained that for three hours. The gold indication then began to go down very slowly, until at the end of another three hours it was at "black." The leaching (or rather washing now) was then continued with water instead of permanganate until only a trace of gold was coming through. The whole time occupied in the leaching and washing was thirteen hours.

The gold was then precipitated by protosulphate-of-iron solution, washed, collected, melted, and weighed, showing a 96·5 extraction of that metal. The charge was now ready for the recovery of the silver by the hyposulphite-of-lime (thiosulphate of calcium) process. The acid was found to have been well washed out of it by the water used in the last stage of the leaching just described. The hyposulphite-of-lime leaching was continued till, at the end of another period of sixteen hours, only a trace of that metal was coming through. The hyposulphite used was made on the spot by heating flowers of sulphur with slaked lime and water till the solution had a yellowish-brown colour. It was then decanted, and a current of sulphurous-acid gas (sulphur-dioxide) was passed through it till it smelt strongly of that gas. This solution, now colourless, after the subsidence of the free sulphur, was used as the leaching liquid for the silver, as described. The silver was afterwards precipitated as sulphide by the addition of sulphuretted hydrogen and a little ammonia. The black precipitate was then roasted and fused with carbonate of soda and a little saltpetre to recover the silver. The extraction of silver was 97 per cent.

The hyposulphite of lime can, as the materials (lime and sulphur) are cheap, be made in large quantities at little cost, and, with such a fine extraction in rich gold-silver refractory ores such as the Monowai, Sylvia, and the deeper parts of the Upper Thames mines produce, will be a most satisfactory and remunerative adjunct to the permanganate process.

Similar laboratory experimental trials on parcels of ore weighing from 6 lb. to 56 lb. were made at the Dunedin University Laboratory. The ores treated were from nine different mines on the Thames and Upper Thames; the Barewood and Premier concentrates (containing 30 to 50 per cent. of iron and arsenical pyrites and a little antimony), in Otago; the Mount Morgan refractory ore from Queensland, containing about 20 per cent. of iron-pyrites and 2 per cent. of copper-pyrites; the Great Barrier ore; the Beaconsfield concentrates (the richest gold-mine in Tasmania); and about fifteen refractory sulphide-ores from Gippsland, Stawell, and other parts of Victoria; and from the Dromedary Mine, in New South Wales, containing about 30 per cent. of copper-pyrites. In all these cases, the roasting being perfect, the extraction of gold did not fall below 89 per cent., the average being between 93 and 96 per cent.; and where the ore was treated for silver as well as gold, and the salt-roasting preceded the permanganate and was followed by the hypo, the silver-extraction gave from 82 to 98 per cent.

I do not think the process will profitably treat bullion containing, say, half as much silver as gold, but it will (with the salt-roasting) treat ore in which there is any amount of silver as sulphide