in II. The results of the two trials were :—NiO, 23.76 and 28.29 per cent.

V. The same as in III., only the nickel hydroxide solution used in IV. was employed in this case also. The results of the two trials were :—NiO, 8.61 and 10.12 per cent.

VI. In this case nickel hydroxide was dissolved in liquor ammonia fort. and tannic acid solution was added in excess. Owing to the presence of excess of ammonia, the salt precipitated was completely dissolved. The solution became dark brown out of which a deep brown salt was precipitated by adding an excess of alcohol. The precipitate was filtered and washed completely with alcohol and dried at 100° C. till constant. On incineration this salt gave 10.25 per cent. of NiO.

Though it has not been possible to obtain absolutely pure salts, it can safely be said from the results obtained that only two theoretical salts have been formed. The one with lower nickel content is the normal salt represented by the following equation :—

According to this formula the calculated NiO in this salt is 10.69. The salts prepared on different occasions have towards the end of these experiments yielded 10 per cent. NiO.

The second salt with the higher nickel content comes nearest to the empirical formula $Ni_2(C_{14}H_9O_6)_2$. The percentage of NiO required by this formula is 27.53. The average result of the incinerations mentioned in II. is 28.33 per cent. This percentage is also supported by the final result given in IV., viz., 28.29.

DISCUSSION.

Professor DONNAN thought the author had not brought much evidence forward to show that the amorphous substances which he analysed were really definite and pure chemical compounds, and not mixtures or "adsorption-complexes."

Dr. E. K. RIDEAL said he had found they could not get any definite compound by the action of an iron salt on tannic acid, although he had tried for a long time. The exact composition of tannic acid was unknown; indeed, according to some investigators chemically pure tannin contained at least three distinct acids. When in solution, tannin was present, partly, at any rate, as a colloid, as was evident from the hide powder test.

THE OXYGEN CONTENT OF THE GASES FROM ROASTING PYRITES.

BY LEWIS T. WRIGHT.

(This J., Feb. 16, 1914, pp. 111—113).

DISCUSSION.

Page 112, col. 1, lines 8 to 5 from bottom, for "D. M. MacKeehnie" read "R. D. MacKeehnie," and in place of the last two lines of the paragraph, read "ferrous oxide was usually present in small quantity."

Newcastle Section.

Meeting held at Armstrong College, on Wednesday, November 12th, 1913.

MR. T. W. LOVIBOND IN THE CHAIR.

SOME OF THE TERNARY ALLOYS OF IRON, CARBON AND PHOSPHORUS.

BY J. E. STEAD, D.SC., D.MET., F.R.S., ETC

INTRODUCTION.

Part I.

NOTE.—A Bibliography of the researches referred to is given in Appendix III.

In order to understand intelligently the alloys of iron, carbon and phosphorus, it will be necessary to allude

briefly to the binary alloys iron-carbon and iron-phosphorus.

Since my original work on iron and phosphorus was published, together with notes on the ternary alloys Fe, Fe₃C, Fe₃P, much careful work has been done, mainly in Germany. Saklatwalla repeated my own experiments on the alloys of iron and phosphorus and supplemented them with an equilibrium diagram.

Iron and phosphorus—binary alloys.

First.—Iron and iron phosphide form solid solutions (see Appendix I.) in all proportions up to the point of saturation when about 1.7 per cent. phosphorus and 98.3 per cent. iron, or 10.0 per cent. phosphide of iron (Fe₃P) and 89.1 per cent. iron are associated. It is, however, only by long continued heating at temperatures above 1000° C. of rapidly solidified alloys containing 1.7 per cent. phosphorus that saturation can be effected.

Alloys containing between 1 per cent. and 1.7 per cent. phosphorus, if cast in small moulds, will not be homogeneous but will consist of an aggregate of crystal grains enveloped by a eutectic. The centre portions of the crystals will contain relatively less phosphorus than the outer parts, the proportion increasing gradually with the distance from the centres of the crystals and are saturated at the points where they meet the eutectic envelopes.

By long continued heating of these eutectic enveloped alloys at temperatures just above the fusion point of the eutectic, the phosphide will diffuse towards the centre of the crystals and eventually the whole mass will consist of homogeneous crystals which will meet without there being any intervening eutectic.

On annealing alloys containing 2 per cent. phosphorus and 0.12 per cent. carbon in ore so as to remove the carbon, or even in charcoal at temperatures below 1000° C. much of the phosphide will separate and will be found in the cold alloy, apparently along the cleavages of the iron crystals.

Second.—When the proportions of phosphide and iron saturated with phosphide are as given below :—

Constitutional Composition.	
Iron saturated with phosphide 38.6	= 0.65 per cent. phosphorus
Free iron phosphide	61.4 = 9.55 " "
100.0	10.20 " "

the mixture will be the binary eutectic which has only one freezing point at about 1000° C., and when cold is composed of cells of iron saturated with phosphorus in a mass of iron phosphide.

In very grey pig irons containing little manganese and much silicon the phosphorus always exists in the binary eutectic derived by decomposition of the ternary eutectic which is the last portion to freeze in all phosphorettic pig irons, whether grey or white in fracture. (Photo I.)

It not infrequently happens that the cell substance of the binary eutectic in grey pig iron consists of pearlite. In such cases it is certain that at the point of solidification the cell substance can contain little phosphide in solid solution and must consist of austenite. Whether phosphide diffuses into the cells in cooling down cannot be determined, but judging from the way austenite resists the diffusion of phosphide into it, it may be accepted that until the carbide separates at Ar. 1.2-3 (700° C.) it would not, and at lower temperatures than 700° C. the diffusion would be exceedingly slow.

The eutectic containing pearlite cells, although three elements are present, would at the point of solidification contain only two constituents, viz., phosphide, and solid solution of carbide in iron, and must therefore be considered as binary, not ternary. If the carbide entirely replaced the phosphide in the cell substance it would probably have the following composition, viz. :—

Free iron phosphide	61.4 per cent.
Austenite	38.6 = 0.35 carbon
100.0	

Phosphorus about 0.55 per cent.

All the alloys containing between 1.7 per cent. and 10.2 per cent. contain crystallites of iron more or less saturated with phosphide of iron which crystallise out in advance