Fusible metal is a composition of 8 parts bismuth, 5 parts lead, and 3 parts tin.

Philadelphia, Nov. 14, 1856.

*On the Compounds of Carbon and Iron, and their Influence on the Production of Pig Iron.** By A. GURLT.

(Continued from p. 341.)

After these remarks it will be as well to consider the somewhat modified theory of the production of cast iron, and to follow a charge from the furnace mouth to the crucible. The charge gradually descending as the furnace becomes heated, arrives at the zone of reduction with a temperature of about 400° C. (750° F.) Here the oxides of iron, manganese, sulphur, and phosphorus are gradually reduced, the electro-negative substances combining the moment they are set free with the electro-positive to form metallic sulphites and phosphurets. After the reduction of all the oxides is effected, which is completed about the junction of the belly with the boshes, the charge, now consisting of metal, phosphurets, and sulphurets, with the materials of the slag, enters the zone of carburization, and comes in contact with a large excess of carbonizing gases, viz: oxide of carbon and cyanogen. By its intimate contact with these carbonizing gases and the carbon of the fuel at the high temperature here existing, the reguline metal existing in the state of soft malleable iron uncombined with any electro-negative body becomes carbonized, that is to say, it unites chemically with carbon, which it abstracts from the carbonic oxide and cyanogen gases proportionately as it sinks deeper in the boshes. In most blast furnaces, however, the boshes are considerably contracted at the base, so that the charge is detained, relatively speaking, sufficiently long in this region to combine with its maximum of carbon, passing into the condition of tetracarburet. In the normal working of the furnace then there is always one portion of the iron saturated with carbon when it enters the zone of fusion. In the zone of fusion the pig iron and the earthy matters are melted, and sink together through the hottest part of the furnace, the zone of oxidation, into the crucible, where it collects. If now the temperature existing in the zones of fusion and oxidation were not much higher than the point of fusion of the specular iron, the tetracarburet found in the zone of carburization would arrive undecomposed, and solidify after tapping as white cast iron, with little or no graphite. If the charge remained long enough in the zone of carburization to saturate the whole of the iron with carbon, specular iron would be produced. In either case, however, the whole of the carbon exists chemically combined with the iron, with the occasional exception of that small quantity of graphite separated by silicium which is not visible on the fracture. The reduction of the silicium seems to commence about the melting-point of specular iron as it exists in very small quantity in this kind of iron, and in white cast iron produced from easily fusible ores at a low temperature; in gray cast iron, however, which is known to require a much higher temperature and more refractory ores, it exists in much larger quantity. The very considerable difference of temperature which must prevail in the furnace during the preparation of

* From the Lond. Chem. Gaz., No. 329.

white and gray cast iron, may be judged of from the fact, that with the same ores and fuel the quantity of carbon required to produce gray cast iron will be 50 per cent. greater than is necessary for white cast iron. When, therefore, the temperature of the zones of fusion and oxidation considerably exceeds the melting-point of specular iron, which must always be the case in the preparation of gray cast iron, the tetracarburet formed will be decomposed into octocarburet and carbon, separating in the form of graphite. The melted crude iron arrives in the crucible as octocarburet, and solidifies, after casting, into gray cast iron. By incomplete decomposition of the tetracarburet, mottled cast iron is produced, consisting of a mixture of tetracarburet and octocarburet similar to white cast iron, but distinguishable from this by the particles of graphite disseminated through it.

In order to ascertain how far the views expressed above as to the influence exerted by the carburets of iron on the production of pig iron would agree with the results of analysis, the author calculated a series of the most trustworthy analyses of pig iron by Karsten, Berthier, Bodemann, Bromeis, and others. In this calculation, the fundamental principle was adhered to, that all the electro-negative constituents of the cast iron were chemically combined with the electro-positive according to those known compounds in which the maximum of the latter is contained as $(\text{Fe Mn})^4\text{P}$, $(\text{Fe Mn})^8\text{S}$, and $(\text{Fe Mn})^8\text{Si}$. The only exception being in the case of the specular iron, where, for the sake of analogy with the carburets, a tetrasiliciuret has been assumed.

The following are the results of the calculation :—

I. WHITE CAST IRON.

Specular Iron from Spathose Iron Ore from Saynerhutte. Karsten.

Carbon,	5.112	$\left. \begin{array}{l} \text{Fe}^4\text{C} \\ \text{Fe}^8\text{S} \end{array} \right\}$	Fe	94.188	99.300
Sulphur,	0.001		C	5.112	
Iron,	94.887	$\left. \begin{array}{l} \text{Fe}^4\text{C} \\ \text{Fe}^8\text{S} \end{array} \right\}$	Fe	0.014	0.015
Copper,	trace		S	0.001	
	100.000			99.315	

Specular Iron from Lohhutte. Karsten.

Carbon,	5.411	$\left. \begin{array}{l} \text{Fe}^4\text{C} \\ \text{Fe}^4\text{Si} \end{array} \right\}$	Fe	88.099	97.291
Silicium,	0.366		Mn	4.245	
Sulphur,	traces	$\left. \begin{array}{l} \text{Fe}^4\text{C} \\ \text{Fe}^4\text{Si} \end{array} \right\}$	C	4.947	2.064
Phosphorus,			Fe	1.698	
Iron,	90.797	$\left. \begin{array}{l} \text{Fe}^4\text{C} \\ \text{Fe}^4\text{Si} \end{array} \right\}$	Si	0.366	
Manganese,	4.245				
Copper,	0.179				
	99.998			99.355	

Specular Iron from Spathose and Brown Iron Ores, Hammhutte. Karsten.

Carbon,	5.140	$\left. \begin{array}{l} (\text{Fe, Mn})^4\text{C} \\ \text{Mn}^4\text{Si} \end{array} \right\}$	Fe	89.726	95.606
Sulphur,	0.002		Mn	0.794	
Phosphorus,	0.080	$\left. \begin{array}{l} \text{Mn}^4\text{Si} \\ \text{Mn}^4\text{P} \end{array} \right\}$	C	5.086	3.636
Silicium,	0.560		Mn	3.130	
Iron,	89.720	$\left. \begin{array}{l} \text{Mn}^4\text{Si} \\ \text{Mn}^4\text{P} \end{array} \right\}$	Si	0.556	0.636
Manganese,	4.300		P	0.080	
		$\left. \begin{array}{l} \text{Mn}^8\text{S} \\ \text{Mn}^8\text{S} \end{array} \right\}$	Mn	0.028	0.030
			S	0.002	
	100.002			99.958	

*Mechanics, Physics, and Chemistry.**White Cast Iron, Calder Iron Works, England. Berthier.*

Carbon,	1.90	} $\text{Fe}^4 \text{C} + \text{Fe}^8 \text{C}$ {	Fe	53.750	} 55.671	
Graphite, .	0.50		C	1.921		
Sulphur,	1.40		$\text{Fe}^8 \text{Si}$	Fe	12.108	} 13.308
Phosphorus,	1.20			Si	1.200	
Silicium,	1.20		$\text{Fe}^8 \text{S}$	Fe	19.474	} 20.874
Iron, .	93.42			S	1.400	
Manganese,	0.38	} $\text{Fe}^4 \text{P}$ {	Fe	8.088	} 9.288	
			P	1.200		
			Graphite,	0.500		
	100.00				99.641	

White Cast Iron, Hammhütte. Berthier.

Carbon,	•	2.910	} Fe ⁴ C + 3 Fe ⁸ C {	Fe	95.202	} 98.112	
Sulphur,	•	0.010		C	2.910		
Phosphorus,	•	0.080		Mn ⁸ Si	Mn	0.109	} 0.110
Silicium,	•	0.001			Si	0.001	
Iron,	•	95.202		Mn ⁸ S	Mn	0.140	} 0.150
Manganese,	•	0.890			S	0.010	
			} Mn ⁴ P {	Mn	0.528	} 0.608	
				P	0.080		
		99.093			98.980		

White Cast Iron from Spathose Iron Ore, Magdesprung. Bromeis

Carbon,	2.52	} $\text{Fe}^4 \text{C} + 6 \text{Fe}^8 \text{C}$ {	Fe	88.532	} 91.052	
Graphite, .	0.50		C	2.520		
Sulphur,	trace		$\text{Fe}^8 \text{Si}$	Fe	3.329	} 3.659
Phosphorus,	0.40			Si	0.330	
Silicium,	0.33		$\text{Mn}^4 \text{P}$	Mn	3.270	} 3.670
Iron, .	92.06			P	0.400	
Manganese,	3.27		Graphite } Copper }		0.610	
Copper, .	0.11					
	99.19				98.991	

II. GRAY CAST IRON.*Mottled Cast Iron from Sphærosiderite, Firmy. Berthier.*

Carbon,	1.00	} $2\text{Fe}^4\text{C} + \text{Fe}^8\text{C}$ {	Fe	24.84	} 25.84	
Graphite,	0.18		C	1.00		
Sulphur,	3.75		Fe^8Si	Fe	13.11	} 14.41
Phosphorus,	0.38			Si	1.30	
Silicium,	1.30		Fe^8S	Fe	52.36	} 56.11
Iron,	93.39			S	3.75	
			Fe^4P	Fe	2.56	} 2.94
				P	0.38	
		Graphite,			0.18	
	100.00				99.48	

Mottled Cast Iron from Königshütte, Hartz. Bodemann.

Carbon,	2.78	} $\text{Fe}^4\text{C} + \text{Fe}^8\text{C}$ {	Fe	77.562	} 80.342	
Graphite,	1.99		C	2.780		
Phosphorus,	1.23		Fe^8Si	Fe	7.164	} 7.874
Sulphur,	trace			Si	0.710	
Silicium,	0.71		Fe^4P	Fe	0.290	} 9.520
Iron,	93.29			P	1.230	
			Graphite,		1.990	
	100.00				99.726	

Mottled Cast Iron, South Staffordshire. Wrightson.

Carbon,	2.72	} Fe ⁴ C + Fe ⁸ C {	Fe	91.310	} 94.030
Graphite, .	0.26		C	2.720	
Phosphorus,	0.37		Fe ⁸ Si	Fe 1.109	} 1.219
Sulphur, .	trace		Si	0.110	
Silicium,	0.11		Fe ⁴ P	Fe 2.493	} 2.863
Iron, .	95.80		P	0.370	
Manganese, }	0.74	Graphite, 0.260			
Calcium, }		Mn }	 0.740		
Sodium, }		Ca }			
		Na }			
<hr/> 100.00		<hr/> 99.112			

Gray Pig Iron, Königshütte, Hartz. Bodemann.

Carbon,	1.44	}	Fe^8C	{	Fe	53.726	}	55.166
Graphite,	2.71				C	1.440		
Sulphur,	trace		Fe^8Si	{	Fe	32.388	}	35.598
Phosphorus,	1.22				Si	3.210		
Silicium,	3.21		Fe^4P	{	Fe	8.223	}	9.443
Iron,	92.42				P	1.220		
			Graphite,				2.710	
	101.00						102.917	

Gray Cast Iron from Spathose and Brown Iron Ores, Hammhütte. Karsten.

Carbon,	2.08	} (Fe, Mn) ⁸ C {	Fe	78.70	} 80.78
Graphite, .	2.37		Mn		
Silicium,	1.31		C	2.08	} 14.45
Phosphorus,	0.08		Fe ⁸ Si	Fe 13.14	
Iron,	86.73		Si	1.31	} 0.83
Manganese,	7.42		Fe ⁴ P	Fe 0.75	
		P	0.08		
		Graphite,	2.37		
	99.99			98.43	

Gray Iron from Lancashire Hæmatite. Miller.

Carbon, . . .	2.217	} $\text{Fe}^8 \text{C}$ {	Fe	82.716	} 84.933	
Graphite, . .	0.538		C	2.217		
Silicium, . .	0.951		} $\text{Fe}^8 \text{Si}$ {	Fe	9.595	} 10.546
Sulphur, . .	0.150			Si	0.951	
Phosphorus, .	trace		} $\text{Fe}^8 \text{S}$ {	Fe	2.086	} 2.236
Iron, . . .	95.777			S	0.150	
		Graphite,			0.538	
	99.633				98.253	

A glance at the interpretation of the above analyses will be sufficient to show the close agreement between the results assuming the hypothesis of the two subcarburets of iron, and to prove the probable correctness of the views on the theory of the production of pig iron above put forth.

Lastly, to exhibit analytically the influence which the different temperatures at which the respective varieties of cast iron are produced exert on their composition, the author undertook a series of analyses of such varieties of pig iron as were produced from the same ores, fluxes, and fuel, but at different degrees of temperature. These were five varieties from the celebrated iron works of Gartsherrie in Scotland, made from

black band iron-stone with raw coal and limestone from the coal-measures. Their chemical composition was as follows:—

	1.	2.	3.	4.	5.
Carbon, .	1·347	1·021	1·793	1·925	2·451
Graphite, .	3·156	2·641	1·110	1·051	0·877
Silicium, .	2·721	3·061	2·165	1·895	1·124
Sulphur, .	1·267	1·139	1·480	1·614	2·516
Phosphorus,	0·842	0·928	1·171	1·811	0·913
Iron, . . .	88·983	90·236	89·314	91·368	89·863
Manganese,	2·401	0·834	1·596	0·571	2·715
	100·717	99·860	98·629	100·235	100·459

1. Very gray iron, with graphite in large flakes; spec. grav.=7·15.
2. Gray iron with much graphite, but in small flakes; spec. grav.=7·21.
3. Mottled gray iron; spec. grav.=7·21.
4. Mottled gray iron; spec. grav.=7·25.
5. White cast iron, with radiate crystalline fracture; spec. grav.=7·41.

Of these pig irons 1 and 2 were produced at the highest temperature, that is to say, with the largest consumption of fuel, while in the three others it was diminished. The blast had a considerable pressure, and the air was heated above the melting point of lead for the production of the gray pig.

The above analyses plainly show, that with the diminution of the temperature the amount of the graphite and silicium also diminishes, and, on the other hand, that the chemically combined carbon and the sulphur steadily increase, while the amount of phosphorus varies; for the amount of manganese also no law can be discovered. The large amount of sulphur in these Scotch irons is, no doubt, chiefly owing to a considerable quantity of pyrites often disseminated through the coal used as fuel.

The theoretical calculation of the five analyses agrees with the above assumption that the two varieties 1 and 2 are composed of Fe^8C and the three others of mixtures of Fe^8C and Fe^4C , furnishing a new proof of the correctness of the above views on the influence exerted by the carburets of iron on the chemical composition of pig iron.

On the Analysis of Cast Iron.—As the analysis of cast iron is often accompanied with considerable difficulty, and the various methods proposed afford results differing widely from each other, the author gives the following methods made use of by himself, after many comparative trials had convinced him of their advantage and accuracy.

Determination of the Carbon, Graphite, and Silicium.—The substance is placed in a glass flask with about four times its weight of chloride of silver recently precipitated and well washed, a saturated solution of muriate of ammonia poured over it, and allowed to stand ten to twelve days at a moderate temperature. The iron is hereby converted into protochloride and dissolved, but is again decomposed into sesquioxide and sesquichloride by absorption of oxygen. The silicium is oxidized, and the carbon and graphite remain undissolved. When the iron is completely dissolved, the solution is gently boiled with a few drops of hydrochloric acid to redissolve any portions of sesquioxide which may have separated, the contents of the flask are then brought on a filter, and the residue

washed first with water, and afterwards with cyanide of potassium, to dissolve any undecomposed chloride of silver; this must be continued until the filtered fluid no longer exhibits the reactions of silver; the washing is then completed with pure water, and the filter dried and weighed; the weight of the silver, graphite, carbon, and silica is thus obtained; a certain portion of this residue is then boiled for some time with a solution of caustic soda; the silica and chemically combined carbon are dissolved and separated from the silver and graphite, which are weighed, and the difference will give the weight of the former substances.

The solution of soda is evaporated to dryness after being acidulated with hydrochloric acid, redissolved and filtered; the carbon and silica remain on the filter, which is burnt: the weight of the silica is thus obtained, that of the carbon being determined by the difference.

To determine the graphite, it is only necessary to dissolve the silver in dilute nitric acid; the graphite remains unaltered and may be weighed.

Determination of the Sulphur.—It is not advisable to determine the sulphur in cast iron by precipitating the sulphuric acid by a salt of baryta from a solution in aqua regia, as it is difficult to avoid a portion of nitrate of baryta accompanying the precipitate, which cannot afterwards be separated by washing. It is better to dissolve about 1 grm. of the iron in dilute sulphuric acid with the assistance of heat, passing the hydrosulphuric acid gas into a moderately dilute solution of acetate of lead. The sulphuret of lead thereby produced is collected on a filter, well washed, converted into sulphate of lead by means of nitric acid, and weighed.

Determination of Iron, Manganese, and Phosphorus.—From a solution of the iron in aqua regia, in which these substances will exist as chloride of iron, protochloride of manganese, and phosphoric acid, the iron is precipitated by the addition of pure dry carbonate of soda in the cold, accompanied by the phosphoric acid as phosphate of iron, while the manganese remains in solution as carbonate of protoxide of manganese dissolved by the excess of carbonic acid. The precipitate is collected without loss of time, and thoroughly washed with cold water; it is ignited and weighed, and gives the amount of iron and phosphoric acid. A weighed portion of this precipitate is fused with four times its weight of a mixture of $3\text{NaO Co}^2 + 2\text{KO CO}^2$, for twenty to thirty minutes, in a platinum crucible, whereby the phosphoric acid is brought into combination with soda; the fused mass is treated with water and filtered, the solution saturated with pure nitric acid, and boiled some time to expel the whole of the carbonic acid; a few drops of acetic acid and solution of acetate of lead are then added, whereupon phosphate of lead is precipitated, which is washed and ignited; it contains in 100 parts, 8.523 of phosphorus. The manganese is easily obtained from the solution in carbonic acid by the addition of caustic soda or potash; the precipitate, which is white, but gradually becomes brown, is collected, ignited, and weighed as deutoxide.

Determination of Zinc.—In some specimens of cast iron minute quantities of zinc are found, which can only be estimated by a separate experiment. From a solution in aqua regia the iron is precipitated by succinate of soda, afterwards the zinc by carbonate of soda; the manganese

remains in solution; the carbonate of zinc is ignited and weighed as oxide of zinc.

Determination of Arsenic and Copper.—Arsenic and copper are precipitated by hydrosulphuric acid from the solution of the iron in aqua regia, separated from each other by sulphide of ammonium, and determined in the usual manner.—*Polytechn. Centralbl.*, 1856, p. 366–379.

*“The Law of the Squares.”—Is it Applicable or no, to the Transmission of Signals in Submarine Circuits?** By WILDMAN WHITEHOUSE.

Referring to the proceedings of this section last year at Glasgow, the author quoted Professor W. Thomson's paper on this subject, where he stated “that a part of the theory communicated by himself to the Royal Society last May, and published in the proceedings, shows that a wire of six times the length of the Varna and Balaklava wire, if of the same lateral dimensions, would give thirty-six times the retardation, and thirty-six times the slowness of action. If the distinctness of utterance and rapidity of action, practicable with the Varna and Balaklava wire, are only such as not to be inconvenient, it would be necessary to have a wire of six times the diameter, or better, thirty-six wires of the same dimensions, or a larger number of smaller wires twisted together, under a gutta percha covering, to give tolerably convenient action by a submarine cable of six times the length.”

Mr. Whitehouse then stated that circumstances had enabled him to make very recently a long series of experiments upon this point, the result of which he proposed to lay before the section, adding that an opportunity still existed for repeating these experiments upon a portion of cable to which he could obtain access, and that he was ready to show them before a committee of this section in London, if the important nature of the subject should seem to render such a course desirable.

Although the subject of submarine telegraphy had many points of the highest importance requiring investigation, and to the consideration of which he had been devoting himself, the author proposed to confine his remarks on this occasion to the one point indicated in the title—inasmuch as a decision of that one, either favorably or otherwise, would have on the one hand the effect of putting a very narrow limit to our progress of telegraphy, or, on the other, of leaving it the most ample scope. He drew a distinction between the mere transmission of a current across the Atlantic (the possibility of which he supposed everybody must admit), and the effectual working of a telegraph at a speed sufficient for “commercial success,” and we gathered from his remarks that there were those ready to embark in the undertaking as soon as the possibility of “commercial success” was demonstrated. He then gave a description of the apparatus employed in his researches, of the manner in which the experiments were conducted, and lastly of the results obtained. The wires upon which the experiments were made were copper of No. 16 gauge, very perfectly insulated with gutta percha, and spun into two cables containing three wires each of equal length (83 miles), covered with iron wires, and coiled in a large tank in full contact with moist

*From the Lond. Civ. Eng. and Arch's. Jour., Sept., 1856.