stirring it well in the ladles before filling the moulds. Iron when remelted has a greatly increased power of absorbing gases and iron oxide. For homogeneous castings it is necessary that all pig iron should be used, without admixture of old castings. Spongy castings are also caused by an improper moulding material, which leads to the formation of surface cavities. The bubbles produced by dissolved gases, however, have a bright, metallic surface, while those due to the moulds are covered with a dull film of oxide.

THE VAPORS OF METALS.

THE SPECTROSCOPIC EXAMINATION OF THE VAPORS EVOLVED ON HEATING IRON, ETC., AT ATMOSPHERIC PRESSURE.*

By Mr. JOHN PARRY, Ebbw Vale.

METALLURGISTS favored with opportunities of observing the behavior of metals while being heated or fused are of opinion that the fumes usually seen are due to the volatilization of the metal itself, or of some more volatile constituent.

In casting alloys of the more fusible metals, this dissociation or volatilization is an accepted fact, and is usually considered when adjusting the proportions of the constituents. Alloys of the more infusible metals, such as iron, manganese, nickel, cobalt, etc., have not been studied, but those who have observed the behavior of crude iron and steel while being fused, or otherwise manipulated at high temperatures, have noted that, in addition to the well known evolution of gas, fumes are given off, which has led to the inference that, as before stated, some more volatile constituent is being evolved; and Professor Ledebur asserts that even iron is volatilized. The chemical composition of a metal may therefore be changed, presumably, within certain narrow limits. It may be that crude iron is slowly dissociated, and certainly at the high temperature of the Bessemer process iron is volatilized, and may be seen far above the mouth of the converter, forming a red cloud, quite unlike ordinary smoke or vapor.

The spectroscopic examination of the flames issuing from blast and other furnaces shows only continuous spectra, with but few lines, very similar to the spectrum of the ordinary Bunsen flame, with the exception of the Bessemer flame, which gives the carbon spectrum, together with (according to some observers) that of manganese.

I have, however, found that many of the metals are volatilized at a comparatively low temperature, but give only continuous spectra when examined in the flame. The vapor requires the intense heat of the electric spark to be passed through it to insure complete dissociation, and consequent production of the usual line spectra. (A list of metals thus tested is given below).

Spiegelisen fused in a crucible evolved a fume in which I detected zinc, copper, manganese, calcium, and with less certainty, magnesium.

Bessemer pig iron, similarly treated, gave copper, manganese, calcium, and either lead or arsenic, as well as gas burning with a flame resembling that of carbonic oxide.

Bessemer pig iron burnt in a stream of oxygen at a dull red heat gave copper, manganese, etc., as before, but more intensely; also a great number of lines which appear to be derived from iron. This spectrum requires careful study, and, when developed, may throw some light on the reactions occurring during the Bessemer blow.

Spanish iron ore reduced in a crucible with charcoal, at a heat sufficient to form a button of fused metal, evolved zinc, copper, and manganese.

It is therefore probable that matter may be evolved during the ordinary heating processes in the manufacture of iron and steel, as previously explained, but giving no visible indications of the fact, in consequence of the heat being sufficient only to volatilize without effecting dissociation.

With my present limited experience, I am of opinion that the actual quantity of matter evolved from iron, steel, etc., is very small, and not at all likely to affect the quality of the coarser kinds of iron and steel, although it may be otherwise when a material of even quality and great purity is required.

The germ of the foregoing is to be found in the recent work of spectroscopists, more especially of Mr. Lockyer, who, in his "Studies of Spectrum Analysis," a volume abounding with suggestions which should, in my opinion, be carefully studied by those practically engaged in the iron manufacture, says: "Depend upon it, that as spectroscopy becomes the daily work of ironfounders and the like, it will be found to be bristling with scientific truth which may be used in these practical applications."

Notes.—Spanish iron ore evaporated to dryness with hydrochloric acid. The dried chlorides were carefully and gradually heated in the blowpipe, and copper, zinc, calcium, barium, lead, silver, and manganese lines successively detected in volatilized chlorides. At the highest obtainable heat, iron lines are seen.

The impure ferric chlorides, obtained by digesting steel or iron in hydrochloric acid and evaporating to dryness, heated as above, show, first, copper and calcium; second, manganese; next, with less certainty, chromium and magnesium. On increasing the heat, the iron spectrum is vividly seen.

Steel or iron filings, mixed with ammonium chloride, and heated also, gives the foregoing series of spectra, which last longer, and may be repeated by successive additions of the chloride.

Very fine spectra of sulphur and phosphorus may be obtained by slightly heating either, on a moderately hot plate of iron, placed just below the spark from the coil. None of the lines have been detected in the fumes evolved from iron and steel.

Notes on the Volatility of the Metals in Heated Crucibles. Fletcher's "Injector Blowpipe," Used.

Thallium....	Very volatile.	Flame and spark spectrum.
Arsenic.....	"	Spark spectrum.
Copper.....	"	Volatilized from most metals.
		Flame and spark found in most metals.
Cadmium....	Easily volatilized.	Spark spectrum only.
Zinc.....	"	"
Bismuth....	Volatilized at highest red heat.	Ditto.
Antimony...	Easily volatilized.	Ditto.
Potassium...	"	Flame and spark spectrum.
Sodium.....	"	Ditto.
Tin.....	Volatilized at highest temperature of blowpipe.	Spark only.
Lead.....	Volatilized at lower temperature than tin.	Ditto.

* Paper read at the Chester meeting of the Iron and Steel Institute.

Silver..... Not volatile. Copper spectrum seen. Ditto.
Gold..... " " "
Chromium... " " "
Manganese.. Volatilized with difficulty. Ditto.
Aluminium.. Volatile
Selenium... Very volatile. Spectra require further study.
Tellurium... Ditto.
Phosphorus. Easily volatilized on hot plate. Good spark spectrum.
Sulphur..... Ditto.

Notes of Experiments on the Spark Spectra of the Chlorides of the Metals and Alkalies volatilized at Atmospheric Pressure.

The chlorides of lithium, strontium, copper, and calcium are volatile in the flame of an ordinary alcohol lamp, showing the characteristics spectral lines in the spark about 1 in. above the flame.

Zinc, barium, copper, and magnesium chlorides are also faintly seen. Query about arsenic? Filter paper moistened with zinc chloride and placed in the alcoholic flame gave the line W. L. 4809.

Steel filings mixed with ammonium chloride and heated, copper and manganese first appear, next calcium (zinc?), next iron spectra; after heating thirty minutes only, one copper and two manganese lines are seen. Iron lines nearly gone; calcium seen. Further heated thirty minutes, only calcium; traces of copper flashing out.

Spiegelisen as above; in addition, magnesium seen; brighter spectrum throughout.

Sulphur heated on plate with spirit lamp, spark above gave vivid spectrum of sulphur. Phosphorus as above.

Copper chloride mixed with ammonium chloride and heated with spirit lamp in a glass tube 20 in. long, copper distinctly seen in the spark at the top of the tube.

Impure steel chlorides, as above, heated in glass tube 4 in. long, spark at top, calcium first seen, copper, next manganese group. After heating some time, only calcium and copper were visible.

Ordinary nickel, cobalt, bismuth, tin, and antimony show copper spectrum when heated. All metals hitherto tested evolve copper.

Query zinc in steel?

Query magnesium in spiegel? Only first line of magnesium seen on edge of nitrogen line, W. L. 5712.

Compared this line with magnesium, by clamping cross wires down on it; magnesium line distinctly seen on edge of nitrogen, W. L. 5712.

It may be inferred from the results herein given, and from those previously published in the *Journal of the Institute*, that the foreign elements present in iron may be divided into two groups:

First, alloys, solidified solutions of one metal in another, such as iron with hydrogen, carbon or combinations of iron and hydrocarbons, copper, manganese, etc. These are more or less dissociated in accordance with the temperature and time of exposure to a given heat.

Second, other combinations with iron of which sulphur and phosphorus may be considered typical, in which dissociation is not effected at a temperature less than that of the induction coil spark and electric arc.

A third group may be imagined in which the foreign element (according to Deville) is intermolecularly dispersed throughout the metal. Carbonic oxide may thus exist in iron and steel.

I venture, therefore, to suggest that, in addition to the ordinary estimation of carbon, sulphur, phosphorus, etc., in iron and steel, the amount of iron oxide should be determined, and the hydrogen and carbonic oxide evolved on heating *in vacuo* (at a certain fixed temperature to be hereafter determined), should be given in volumes of the metal tested; in other words, that one cubic inch of metal evolved by cubic inches of hydrogen and carbonic oxide.

THE GEOLOGICAL STRUCTURE OF THE SAHARA.

DR. K. A. ZITTEL has published the following facts and conclusions as the preliminary result of his explorations in the Libyan Desert:

The Sahara is distinguished by an exceedingly simple geological structure, by the horizontal position of most of the sedimentary rocks, and by the absence of faults. To the southern slope of the Atlas in Morocco, which forms the northern boundary of the Sahara, there are joined palaeozoic formations (carboniferous and Devonian), upon which follow, further to the south, sandstones, palaeozoic slates, sometimes interpenetrated by granite and porphyry, as also quartzite and azoic clay-slate.

In the depression between the Atlas and the Ahaggar Mountains middle and upper cretaceous rocks form the substratum, while quaternary sandy fresh-water clays, with gypsum and rock-salt, constitute the superficial layers. The same cretaceous deposits form the soil of the Hammada el Homra, and of the Harudj Mountains in Tripoli. In the south it is directly followed by Devonian sandstone. The latter, with the underlying limestones and slates, is the predominant formation to the southern limit of the Desert.

Permian, triassic, jurassic, and subcretaceous formations have been hitherto detected neither in the Sahara nor the Egyptian frontier mountains. The great plateau-mountains of Ahaggar in Air and Tibetsi seem principally to consist of palaeozoic sandstone, clay-slate, gneiss, granite, and recent eruptive volcanic rocks. Tertiary deposits of marine origin are to be found only to the north of the Chotts of Tunis. They occur also to a considerable extent in the Libyan and Arabian Deserts. In the north-eastern Sahara and in Egypt the eocene nummulitic rocks extend southward to the latitude of Esneh; the miocene rocks have their southern limit at the oasis of Sinah, and the hills between Cairo and Suez.

The southern and a part of the central Sahara have been dry land since the end of the Devonian period; the greater part of the remaining Sahara was left dry after the cretaceous epoch. The sea still maintained itself in the Libyan Desert during the eocene, and in the northern part of that region down to the middle miocene.

The eruptions of the basaltic, phonolitic, and trachytic rocks in Tripoli, the Libyan and Arabian Deserts, as also probably those in the mountain-lands of Ahaggar and Tubu, occasioned but little disturbance in the adjacent formations, and must have ensued chiefly in the later tertiary times.

During the diluvial period the Sahara, as well as a part of the southern and eastern Mediterranean, was dry land. The hypothesis of a diluvial Sahara sea is confirmed neither by the geological structure nor the surface appearance of the Desert. At the utmost the region of the Tunisian Chotts may have been connected with the Mediterranean, and perhaps the narrow depression between Alexandria and the Ammon oasis with the Red Sea.

During the diluvial period there prevailed in North Africa

a moist climate, which probably continued until the beginning of the present epoch.

The characteristic formation of the surface of the Desert, the elaboration of many dry valleys, the formation of basin-shaped depressions, the origin of steep banks, insulated mountains, etc., are due to the erosive action of fresh water.

The sand of the Desert has been produced by the decomposition of sandstone, which predominates everywhere in the middle and southern Sahara. Its distribution and accumulation in dunes has been effected by the wind.

The salt-marshes, and the saline and gypsiferous superficial deposits, have been formed by the evaporation of waters which had collected in the hollows. There is no proof of any essential change in the climate of the Sahara during the historical period.—*Jour. Science.*

A PETROLEUM ENGINE.

AN electro-petroleum motor, in which an extra current spark is made to ignite the explosive mixture, has been invented by Herr Siegfried Marcus, of Vienna. Inside the chamber where the explosion is to occur, the ends of the coil wires, between which the spark is produced, slide over each other, the action being regulated in accord with the rotation of the magneto-electric apparatus, the ends of the wires being in contact while they are magnetized and separating at the moment of demagnetization or change of polarity, producing the extra current spark.

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TABLE OF CONTENTS.

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	PAGE
I. CHEMISTRY AND METALLURGY.—Examination of Bread and Flour.—Foreign substances found.....	7482
Experiments in Gaseous Combustion.....	7483
Influence of Light on the Development of Yeast.....	7490
The Fusion of Iron.....	7490
The Vapors of Metals.—The spectroscopic examination of the vapors evolved on heating iron, etc., at atmospheric pressure.—By J. PARRY.....	7491
II. ENGINEERING AND MECHANICS.—Steam Yachts.....	7485
Center-board Catamaran.—2 illustrations.....	7485
The Working of Gas Engines.—Vertical tandem condensing engine.—3 figures.....	7487
Vertical Cold Air Machine.....	7487
III. TECHNOLOGY.—Fustian, Beaverteen, Moleskin.—Manufacture of same.....	7488
Utilizing the By-products from Coke Ovens.—By Dr. C. OTTO.—With 4 figures representing Hoffmann's regenerator coke ovens.....	7489
Preparation of Maltose.....	7490
IV. ARCHITECTURE, ETC.—The New Observatory at Nice.—With engraving.....	7479
Castle Hummelshain, near Kahla, Thuringia.—With engraving.....	7490
V. ASTRONOMY.—On the Constitution of Gaseous Heavenly Bodies.....	7479
VI. GEOLOGY.—The Geological Structure of the Sahara.....	7491
VII. NATURAL HISTORY.—The Fresh Water Flora and Fauna of Central Park.—Preliminary paper.—By L. P. GRATACAP and A. WOODWARD.....	7480
VIII. HYGIENE, MEDICINE, ETC.—The Removal of Tattoo Marks.....	7482
Pastur on the Prevention of Hydrophobia.....	7482
How to Dispose of House Sewage.—By M. T. CLARK.....	7482
IX. MISCELLANEOUS.—The Antiquity of Man.—By ED. CLODD.....	7483
Nitro-glycerine in the Oil Regions.—Advantages gained by its use.—Accidents caused by the same.....	7484
X. BIOGRAPHY.—The Late Right Hon. Henry Fawcett.—Postmaster-General of Great Britain.—With portrait and other engravings.....	7483

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