it might be supposed, had been copied from the drawings which I sent you. While the coal could not be used in the first process, that of puddling was of minor importance—now it must become of value.

In using the plural, *we*, I mean my Sons and myself.

Yours, &c. B. B. HOWELL.

P. S. The maximum of heat used in England and France, appears to have been 700° of Fahr. and but seldom above the melting point of lead. In the course of our recent experiments we reduced the Rhode Island sand stone (you know what that is) to a *soft paste*, and cast iron exposed to the current of heated air, was melted in half a minute; some of the effects produced by this intensely hot blast require to be seen; they can hardly be realized otherwise. It seems to me, that the use of the hot blast is destined to revolutionize the iron manufacture. The diversity in the accounts of its results in England and France may I think be accounted for, without impeaching the veracity of either of the parties in the controversy, as to its real value and influence on the quality of the iron. B. B. H.

Physical Science.

Observations on the Absorption of Gases by Water. By W. H. GOODE, Hampden Sydney College, Va.

The tables of the absorption of gases by water are found in Dr. Turner's chemistry, page 163; one of which is given by Drs. Dalton and Henry, the other by M. De Saussure.

"One hundred cubic inches of distilled and recently boiled water at the mean temperature and pressure, absorb of

	Dalton and Henry.	Saussure.
Sulphuretted Hydrogen,	100 cubic inches.	253 cubic inches.
Carbonic Acid,	100	106
Nitrous Oxide,	100	76
Olefiant Gas,	12.5	15.3
Oxygen	3.7	6.5
Carbonic Oxide,	1.56	6.2
Nitrogen,	1.56	4.1
Hydrogen,	1.56	4.6

The estimate of Saussure," Dr. Turner remarks, "is in general too high. That of Drs. Dalton and Henry, for nitrous oxide, according to the experiments of Sir H. Davy, is considerably beyond the truth."

It is of some practical as well as theoretical importance to determine the actual quantity of any gas, that pure water deprived of the atmospheric air it usually contains, will absorb; and whether the absorption of gases by water, obeys any general law.

These points cannot be considered as settled, when the numerical results obtained from one set of observations so far exceed those obtained from another. The disparity between the tables quoted above, is such as to warrant the opinion that one, and perhaps both are erroneous; and leads us to infer that the methods by which they were obtained were as diverse as the tables are wide of a coincidence.

With the plan of manipulation pursued by Drs. Dalton and Henry, to

obtain their results, I have no means of becoming acquainted. That of Saussure was as follows.

A flask, *m*, holding 250 cubic centimetres, was filled over the pneumatic trough with the gas to be absorbed, and held inverted for half an hour under the water of the trough, that it might acquire the temperature of this liquid, which ought to be nearly that of the atmospheric air. The mouth of the flask was then closed with a conical ground glass stopper. The weight of this flask empty and full of water was accurately determined.

From this flask about a sixth portion of the gas was poured over the mercurial trough into a receiver filled with mercury. This portion was then poured over the water trough into a flask, *n*, filled with water. The weight of this flask before and after the introduction of the gas gave the volume of this last. This volume being abstracted from that in the flask, *m*, originally, gave the volume of gas still remaining in that flask.

Into the flask, *m*, a quantity of distilled, well boiled, water was poured through the mercury, sufficient to expel all the mercury that had been introduced by the third operation. This flask was then closed at the surface of the mercury, and weighed. This gave the volume of water introduced into the flask.

The gas with the water was now strongly agitated for fifteen minutes, while the flask *m* was held by a pair of pincers, to prevent the introduction of heat by the hand. It was then plunged under the water of the trough, to bring it exactly to its original temperature, opened in an inverted position and closed again under water. Now the water which occupied the place of the gas absorbed, and [or] the difference between the weight of the flask, *m*, now and when it was full of water enabled me to know the volume of gas absorbed." (*Annals of Philosophy*, Vol. VI, p. 347.)

This method of obtaining the absorption of gases by water appears to be liable to some objections.

The capacity of the flask, *m*, as has been noticed by Dr. Dalton, (*Ann. Philos.* Vol. VII, p. 218.) "was ascertained when it was dry within; but when filled with air for the experiment, it was wet within, and consequently did not contain as much air, by the quantity of water adhering to the glass."

The water of an ordinary pneumatic trough, is scarcely ever of the same temperature at the surface and at a few inches beneath; by contact with the atmosphere, the particles on the surface acquire its temperature, which causes them to become lighter than those below, and to retain their places: the nonconducting material of which pneumatic troughs are usually constructed, preventing the particles beneath the surface from suffering those alternations of temperature to which the atmosphere and the surface of the trough are subject.

The density of the gas in the flask, *m*, after it had been half an hour under the water is increased; the flask will then hold more gas than it held at the atmospheric temperature.

After the flask is placed on the mercury trough, the gas in passing from the temperature of the water to that of the atmosphere, expands; but the removal of the stopper gives it an opportunity of expanding, without affording any means of detecting the amount. Consequently, the volume of gas in *m*, when it was under the water, was less than the volume in *m* and *n*. This is due to the expansion occasioned by the temperature of the atmos-

phore; which is higher than that of the water under the surface of the pneumatic trough.

After agitating the gas and water, the flask was again "plunged under the water of the pneumatic trough to bring it exactly to its original temperature." But when the boiled water was admitted into the flask, the gas in it was at the atmospheric temperature, and not at the temperature of the water under the surface of the pneumatic trough, which ought to be, says Saussure, "nearly that of the atmospheric air." Consequently, a diminution of the bulk of the gas took place when the flask was plunged under the water, and when opened a quantity of water entered sufficient to occupy the place of the gas absorbed, and the diminution of bulk occasioned by lowering its temperature.

These sources of error in his method probably militated against the truth of M. de Saussure's results.

The plan adopted to obtain the results given below, for the less absorbable gases, was to make pure and boiled water absorb as much gas as possible by agitating it in contact with the gas; then liberating the gas from a known weight of this water by boiling; decanting and measuring the gas so liberated with Hare's eudiometer, and determining its bulk by the weight of an equivalent number of measures of distilled water.

A globe about four inches in diameter was fitted with a cap into which a stop-cock was screwed air-tight, the other end of the stop-cock screwing into the plate of the air pump; a small tube reaching nearly to the top of the globe, was cemented into that end of the stop-cock intended for the cap. This tube admitted the globe to be exhausted of its atmospheric air after the boiled water was poured in.

The water used in these experiments was twice distilled, in glass vessels; first over the sand bath, and then slowly over a lamp. After being well boiled, a small portion of it was poured into the globe as hot as could be ventured without endangering the cement with which the cap was fastened. The globe was now screwed to the pump plate, exhausted, and attached to a jar on the pneumatic trough containing the gas to be tried, by means of a connector and stop-cock, cemented into the top of the jar. By depressing it in the water and opening the stop-cocks, the globe was filled with gas, and again exhausted, to free it as much as possible from any atmospheric air that might have remained in it after the first exhaustion.

The time occupied by these exhaustions reduced the hot water originally put in, to the atmospheric temperature.

The globe was then replaced on the jar and again filled with the gas; care being taken that it should remain attached to the jar for a few minutes, in order that compensation might be made for the reduction of the temperature of the gas when it rushed into the void; and that the level of the water within the jar should coincide with the level of that in the pneumatic trough.

The globe was then detached from the jar and agitated briskly for fifteen minutes; during the agitation it was replaced at least once on the jar, and gas admitted to supply the place of any that might have been absorbed.

Another globe about an inch and a half in diameter, with a neck three inches long was counterpoised, and a portion of the impregnated water weighed into it, after the agitation ceased. This globe was then filled with mercury and inverted in a cup of that fluid; it rested on a ring while its mouth dipped under the mercury in the cup. In this position the water which occupied the highest part of the globe was boiled by means of a small

spirit lamp, the gas collecting in the upper part, and an equal bulk of mercury flowing out at its mouth into the cup, and as soon as it was sufficiently cool to be handled without inconvenience, it was taken to a water trough in which a quantity of common salt had been dissolved to prevent the absorption of gases by the water decanted, and measured with Hare's eudiometer. The bulk of the gas thus obtained was then determined by the weight of an equal number of measures of distilled water.

This method did not answer with carbonic acid, and the protoxide of nitrogen, which are so readily absorbed that the greater portion of them liberated by boiling, was re-absorbed before they could be decanted and measured.

These gases were generated in graduated tubes filled with well washed mercury to free it entirely from saline matter; and after a known volume of pure water was introduced, the tubes were left undisturbed for twelve or twenty four hours. The bulk of gas exposed to the water in the graduated tubes was corrected for the mean temperature and pressure. Barometric pressure exerted no influence when the absorptions were performed in the globe; but the bulk of gas measured at the trough was influenced both by temperature and pressure, for which due corrections were made.

Care was taken that the vessels in which these experiments were performed should be perfectly clean, and entirely free from grease, or saline matter. Whenever there was the slightest appearance that grease had been communicated from the cap to the water within the globe, it was rejected; the globe was then washed in a hot solution of potassa, and well rinsed three or four times, the last time in the boiled water prepared for the experiment. The mercury with which the tubes were filled, was well washed, and drained through a funnel to free it from impurities.

Precautions were also taken to have the gases perfectly pure, by passing them through such solutions as would take up the impurities suspected to be in them. The hydrogen was prepared in a Woulfe's apparatus, by the action of sulphuric acid or zinc, and passed through a solution of corrosive sublimate and potassa, to render it perfectly pure. The carbonic oxide was prepared from sulphuric and oxalic acids, and remained twenty-four hours over water with a stick of potash in it, supported by a wire, to free it entirely from carbonic acid. The protoxide of nitrogen was passed through water to free it from nitrous acid and nitrate of ammonia.

With these precautions the following results have been obtained. One hundred volumes of water at the mean temperature and pressure absorb, of

Hydrogen,	1.82	Vols.	Oxygen,	3.01	Vols.
Carbonic Oxide,	1.92	"	Nitrous Oxide,	55.00	"
Nitrogen,	2.24	"	Carbonic Acid,	139.96	"

one hundred volumes of spring water give off by boiling 205 vols. of gas; but the same quantity of pure water absorbs by agitation, 2.44 vols. of atmospheric air.