

**Harrogate and its resources : chemical analysis of its medicinal waters : report addressed to the chairman of the Harrogate Water Committee / by A.W. Hofmann.**

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# H A R R O G A T E

AND ITS RESOURCES.

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## CHEMICAL ANALYSIS

OF ITS

## MEDICINAL WATERS.

REPORT ADDRESSED TO THE CHAIRMAN

OF

THE HARROGATE WATER COMMITTEE,

By A. W. HOFMANN, F.R.S.

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WITH AN APPENDIX,

ON THE MODES OF THEIR ADMINISTRATION.

BY THE COMMITTEE.

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LONDON:  
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## ADVERTISEMENT.

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AT a public meeting of the Inhabitants, seven Gentlemen were elected to form a Committee for carrying out the objects which have led to this Report. Four of these were lay-members, and three medical men. Professor Hofmann was requested to undertake the Chemical investigation, and the Committee has now the pleasure of publishing his results. Some remarks similar to those which are appended seemed necessary in the judgment of the Committee to make this Report complete and useful; and though expressed in very general terms, it is trusted that they will prove satisfactory.

HARROGATE, 1854,





# EXAMINATION OF THE MEDICINAL WATERS OF HARROGATE.

BY A. W. HOFMANN.

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OF the mineral springs which abound in the neighbourhood of Harrogate, the following ten were selected for examination, as representing the principal varieties occurring in that locality.

## A. SULPHUR WATERS.

1. Old Sulphur Well.
2. Montpellier Strong Sulphur Well.
3. Montpellier Mild Sulphur Well.
4. Hospital Strong Sulphur Spring.
5. Hospital Mild Sulphur Spring.
6. Starbeck Sulphur Spa.

## B. CHALYBEATE WATERS.

1. Montpellier Saline Chalybeate.
2. Cheltenham Saline Chalybeate.
3. Tewitt's Well.
4. St. John's Well.

The waters used for the estimation of the solid constituents were collected during the months of May, 1853 and 1854; the gases, partly in November, 1853, partly in February, 1854.

Qualitative analysis, performed in the usual manner, exhibited the presence of the following substances.

### BASES.

Potassa  
Soda  
Lime  
Magnesia  
Protoxide of iron  
Protoxide of manganese  
Alumina  
Ammonia

### ACIDS, OR ELEMENTS REPLACING THEM.

Chlorine  
Bromine  
Iodine  
Fluorine  
Sulphur  
Sulphuric acid  
Carbonic acid  
Silicic acid

Organic matter.



GASES DISSOLVED IN THE WATERS, OR RISING IN BUBBLES FROM THE WATERS.

Oxygen  
 Nitrogen  
 Carbonic acid  
 Carbonetted hydrogen (marsh gas)  
 Sulphuretted hydrogen

These are, with the exception of fluorine and manganese, the same constituents, the existence of which, in the Harrogate waters, has been pointed out by Mr. West. Iodine and bromine have been traced by the same chemist in the Old Sulphur Well; these elements are, however, present in nearly all the waters.

If the above-mentioned constituents be arranged according to the solubility of their compounds in either pure water, or in water containing free carbonic acid in solution, it may be assumed that the Harrogate waters contain

*a.* COMPOUNDS  
 SOLUBLE IN WATER.

Sulphate of lime  
 Fluoride of calcium  
 Chloride of calcium  
 Chloride of magnesium  
 Chloride of potassium  
 Chloride of sodium  
 Sulphide of sodium  
 Iodide of sodium  
 Bromide of sodium  
 Carbonate of soda  
 Carbonate of potassa  
 Silica  
 Ammonia.

*b.* COMPOUNDS  
 SOLUBLE IN WATER CONTAINING  
 FREE CARBONIC ACID.

Carbonate of lime  
 Carbonate of magnesia  
 Carbonate of iron  
 Carbonate of manganese  
 Alumina

The method of quantitative analysis which was followed, requires scarcely any special notice since it differed in no essential point from that usually adopted for this purpose. Chlorine and sulphuric acid were determined in separate quantities of the water by means of nitrate of silver and chloride of barium; lime and magnesia together in the same portion of water respectively by oxalate of ammonia, and ammonio-phosphate of soda. The silica was estimated by evaporating a separate portion, and treating the residue with hydrochloric acid;



the alkalies by precipitating iron, lime and magnesia, by baryta-water, repeatedly evaporating to dryness in order to remove small quantities of baryta from the solution, and weighing the mixed chlorides; the separation of the alkalies was effected in most cases by bichloride of platinum, in some cases their relative proportion was determined by the indirect process. The iron had been partly deposited from some of the waters, by the time they arrived in London; it was, therefore, precipitated in a special experiment at the well by means of sulphide of ammonium from pretty large quantities of the waters and ultimately weighed as sesquioxide. Lastly, the total amount of solid residue was obtained by evaporating the water, to which a weighed quantity of carbonate of soda had been added, and carefully drying at a temperature of from  $248^{\circ}$  to  $266^{\circ}$  F. ( $120^{\circ}$  to  $130^{\circ}$  C.); exposure of this residue to a low red heat in contact with the air gave the amount of organic matter.

*Bromine and iodine.*—Bromide and iodide of sodium although present in quantities so small as to be incapable of being quantitatively determined with accuracy, were easily *detected* in most of the waters: from 1000 to 1500 grains of the solid residue obtained on evaporation were exhausted with water, the solution evaporated and the residue boiled out with spirits of wine; the extract left on evaporation was again exhausted with stronger alcohol. In the residue left on evaporating this extract both bromine and iodine were generally traced without any difficulty; in some cases, however, the treatment with alcohol had to be repeated. The bromine was detected by dissolving the residue, left on distilling off the alcohol, in a small quantity of water, decomposing the bromide by chlorine-water, and taking up the liberated bromine in a small quantity of ether, with which the liquid was agitated: the yellow colour which the ether assumed indicated the bromine. In order to trace the iodine, a portion of the same residue was dissolved in a small quantity of water, mixed with starch paste, and evaporated to dryness in a porcelain capsule, at a gentle heat; on adding a drop of concentrated nitric acid to the mixture, the blue colour of the compound of starch and iodine made its appearance; in the presence of a bromide, the starch, where it came in contact with the *liquid* nitric acid, assumed a deep orange yellow colour, and the colour of the iodine-compound appeared distinctly in those parts of the saline residue, which were exposed only to the *vapour* of the bromine and the nitric acid; in this manner both elements could be readily detected in the same experiment.



The quantities of bromine and iodine appear to vary in the several waters, but I am unable to make a positive statement as to this fact, in as much as the different quantities of saline residue left on the evaporation of equal amounts of water compelled me to use very unequal portions for the purpose of testing for bromine and iodine. The quantities of saline residue actually employed were 1500 grains, in the case of the Old Sulphur Well, the Hospital Strong Sulphur Spring, the Montpellier Saline Chalybeate, and the Cheltenham Saline Chalybeate Wells; 750 grains of that of the Montpellier Mild Sulphur Well; and 500 grains in the case of the Montpellier Strong Sulphur Well, the Hospital Mild Sulphur Spring, and the Starbeck Sulphur Spa; and lastly 100 grains of the Tewitt's Well residue.

*Fluorine.*—The fluorine had to be sought for in the insoluble portion of the saline residue of the waters. This residue was tested by Dr. G. Wilson's excellent process. From 400 to 600 grains of the residue, consisting chiefly of calcareous and magnesian salts, were mixed with a small quantity of pure finely divided quartz, and boiled for about an hour with concentrated sulphuric acid. The terfluoride of silicium disengaged in this manner was passed into water, the resulting hydrofluo-silicic acid decomposed by ammonia, and the fluoride of ammonium, after separation of the silica by filtration, evaporated; gently heated with concentrated sulphuric acid in a platinum crucible, this residue disengaged hydrofluoric acid which was recognised by its action upon glass. In the examination of several of the waters, which had deposited rather a large quantity of insoluble matter, the presence of fluorine became at once perceptible on passing into water the gas evolved by boiling, with concentrated sulphuric acid, a mixture of the residue and quartz: a flocculent precipitate of silica was thrown down which was considerably augmented on addition of ammonia. In those cases the etching was very rapidly effected, and to a considerable depth; in other cases, however, the separation of silica was scarcely perceptible and the etching very faint. In some cases the etched lines became visible only in the film of moisture produced by breathing upon the glass plates. In none of the waters was found a sufficient amount of fluorine to admit of quantitative estimation.

*Manganese.*—Of all the methods suggested for the detection of small quantities of manganese, none yields more accurate results than the one discovered some years ago by Mr. Walter Crum. It consists in treating the iron precipitate which may contain the manganese



with nitric acid, and adding a small quantity of binocide of lead. If manganese be present, the liquid exhibits, as soon as the precipitate has subsided, the magnificent colour of permanganic acid. By applying this method to the insoluble portion of the saline residue the presence of manganese in the Harrogate waters could be proved without difficulty, but the amount was not sufficient for quantitative determination.

*Ammonia*, which could be detected in all the waters, if considerable quantities were evaporated, with a few drops of hydrochloric acid, on mixing the residue with recently slacked lime, was likewise present in such a minute proportion that quantitative determination became impossible.

*Alumina* was detected only in one case by means of the blow-pipe reaction with nitrate of cobalt, after separation of silica and iron, and in this case not more than a mere trace was found.

All the waters were very carefully examined for *arsenic*, *antimony*, and *tin*, which have been found of late in so many mineral springs. But although large quantities of the solid residue obtained by evaporation were submitted to analysis, no trace of these metals could be detected.

Not more successful was the attempt to trace the presence of *nitric* and *phosphoric acids*, or of *lithia* and *strontia* in the Harrogate waters.

The *nitric acid* was tested for by means of sulphuric acid and sulphate of iron in the residue of a large quantity of water, evaporated with a few grains of carbonate of soda. *Phosphoric acid* had to be looked for both in the soluble and insoluble part of the solid residue obtained by evaporating the water. Both were carefully tested by means of molybdate of ammonia, the insoluble portion after the removal of the iron.

In order to find *lithia*, the solid residue of the waters (the experiment was made with the following three waters, viz.: the Old Sulphur Well, the Hospital Strong Sulphur Spring, and the Cheltenham Saline Chalybeate) was repeatedly boiled out with water, the solution neutralised with a few drops of hydrochloric acid, evaporated to dryness and the residue exhausted with alcohol. The saline residue obtained by distilling off the alcohol was then treated with a mixture of alcohol and ether. The solution thus formed neither exhibited the crimson red lithia-flame when lighted, nor was it possible to obtain from it the difficultly soluble double salt of phosphate of soda and lithia.



*Strontia*, when existing in the waters, was probably present in the form of sulphate, and had therefore to be sought for principally in the insoluble portion of the saline residue. According to recent observations, however, sulphate of strontia is slightly soluble in water containing a considerable quantity of chlorides. In order therefore not to lose any strontia, the whole saline residue was submitted to the action of sulphuric acid, the excess of this acid expelled by ignition, and the residue of sulphates exhausted first by water and then by hydrochloric acid. The residue consisting chiefly of silica was fused with carbonate of soda, the product of the fusion exhausted with water, and the insoluble residue, which was left dissolved in hydrochloric acid. Addition of sulphate of lime to this solution, produced the faintest turbidity, which may have been occasioned by strontia. But unless the experiment be repeated on a very large scale it would be hazardous to assert the presence of strontia. The experiment was made with the residue of the Old Sulphur Well which contains a very large amount of saline matter.

In collecting and analysing the *gases* contained in the Harrogate waters, I have availed myself of the processes invented by Professor Bunsen, and so remarkably perfected within the last few years by his admirable researches. Since these processes, especially those of collecting the gases, differ from the methods formerly adopted for this purpose, and since any accurate information regarding the nature of the gases, however precise our methods of analysis may be, depends in the first place, on the means we employ of collecting and measuring their total amount, I will briefly describe here the principal features of Bunsen's process, which consists in expelling the gases by ebullition *in vacuo*.

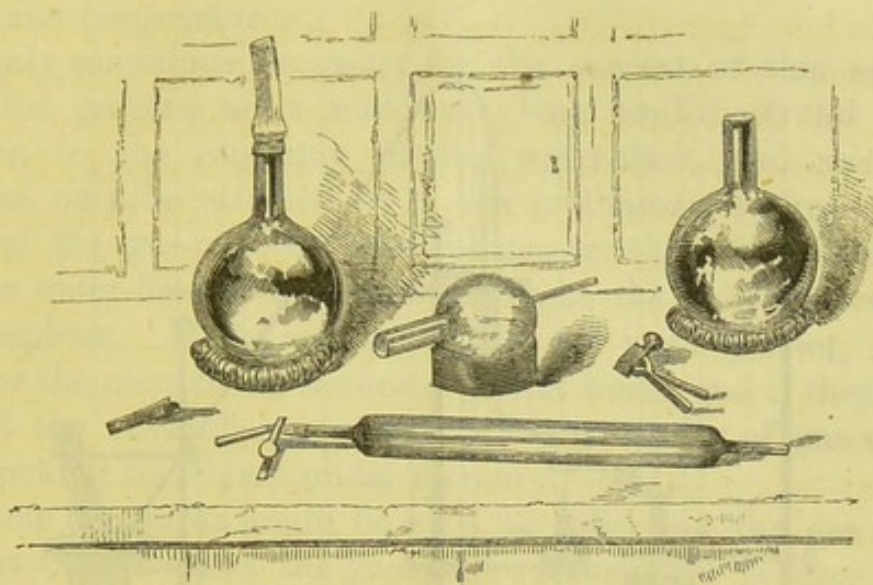
For this purpose a globular glass flask, over the neck of which is fitted a strong vulcanized caoutchouc tube, (*see* Fig. 1), is immersed into the water until it is filled, and the tube is then closed by means of a brass screw-clamp which is screwed immediately above the neck of the flask.

In this manner a quantity of water is secured which has not been in contact with the air, and the exact volume of which may be readily determined by experiment. The caoutchouc tube is then connected with a small glass globe partially filled with water, and provided with two necks opposite each other, the one corresponding in diameter to the neck of the flask, the other of the size of an ordinary quill pen. By the latter, the globular vessel, which for the sake of shortness I will call the "boiler-globe," may be connected with a glass-tube



about 10 inches long, and  $\frac{3}{4}$  of an inch wide, and terminating on each side in a narrow open connecting tube, corresponding in width to the narrow tube of the boiler-globe. The connection of the latter

FIG. 1.



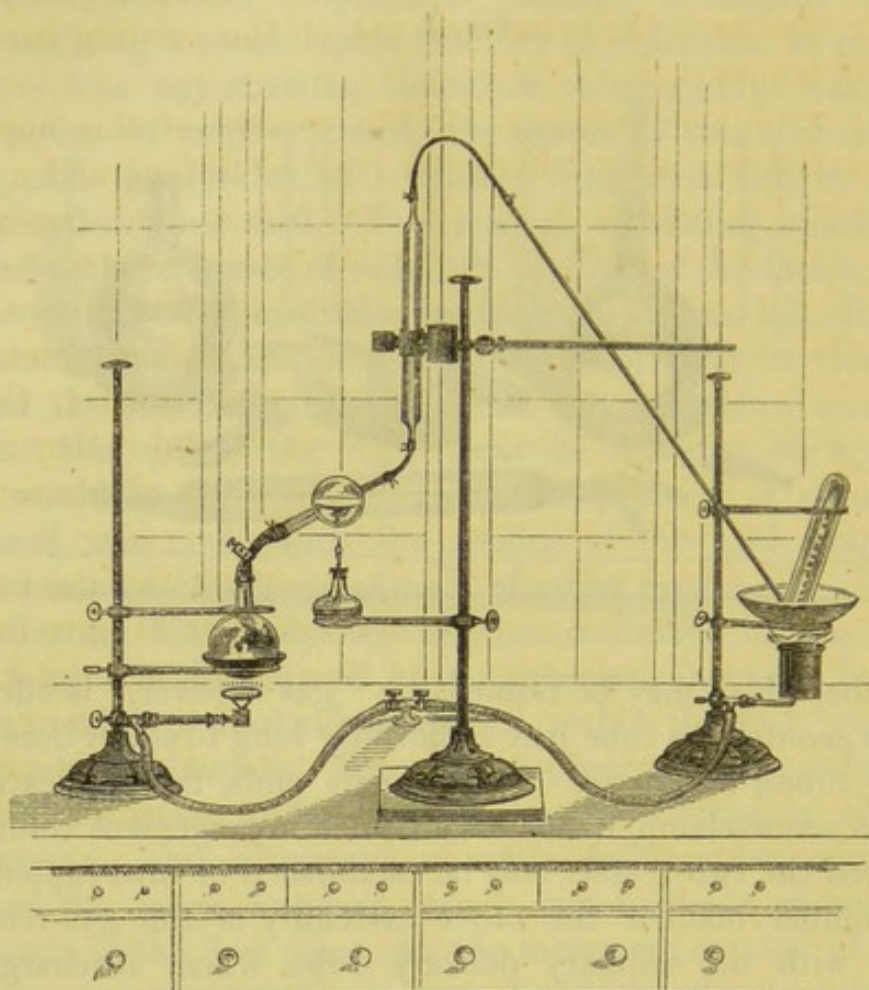
and the tube, which may be termed the "gas receiver," is effected by means of a caoutchouc tube just sufficiently long to admit between the two glass tubes, which are fixed into its ends, the application of a small brass screw-clamp, by means of which arrangement communication between the two vessels may be established or interrupted. In a perfectly similar manner the other extremity of the gas-receiver is connected with an ordinary delivery tube which discharges into water.

Fig. 2 represents the apparatus fitted up, and fixed upon an ordinary gas-stand. The water-flask is closed with a screw-clamp, but the communication between the boiler-globe, gas-receiver, and delivery-tube is perfectly free. The water in the boiler-globe is heated to ebullition by means of a spirit-lamp, and kept boiling for about a quarter of an hour, by which time all the air in the apparatus is perfectly replaced by steam, which may be ascertained, moreover, by not a trace of air collecting if the delivery-tube be made to discharge for a few minutes under an inverted bell-jar, filled with water. The caoutchouc tube, at the upper end of the gas-receiver, is now closed by a brass clamp, and the spirit-lamp simultaneously removed, when the ebullition *in vacuo* will continue for a considerable time. The boiling-out of the water in the flask may now commence. For this purpose the brass clamp is removed, and the flask submitted to a gradually increasing heat. Air bubbles soon make their appearance, but a quarter of an hour generally elapses before the caoutchouc tube,



which is collapsed and almost flattened by the atmospheric pressure,

FIG. 2.



is sufficiently expanded to admit of a free communication between the flask and the upper part of the apparatus. The water gradually enters into violent ebullition, in which state it is kept for about an hour, so as to ensure the complete expulsion of every trace of gas. When this point has been reached the heat is increased for a moment, and a good deal of steam is generated in the flask, which causes the water gradually to rise from the boiler-globe into the narrow end of the gas-receiver. At this moment the flask is closed with the clamp and the source of heat removed; the water in the boiler-globe begins to cool, gradually contracts, and descends in the narrow-tube of the gas-receiver; the very moment its level disappears under the caoutchouc connector, the clamp between the boiler-globe and gas-receiver is fastened, and the whole apparatus disconnected. The gas-receiver closed at both its extremities by caoutchouc contains the whole of the gas, together with a few drops of water; the volume of the gas may be readily measured by opening one of the clamps under mercury, and allowing

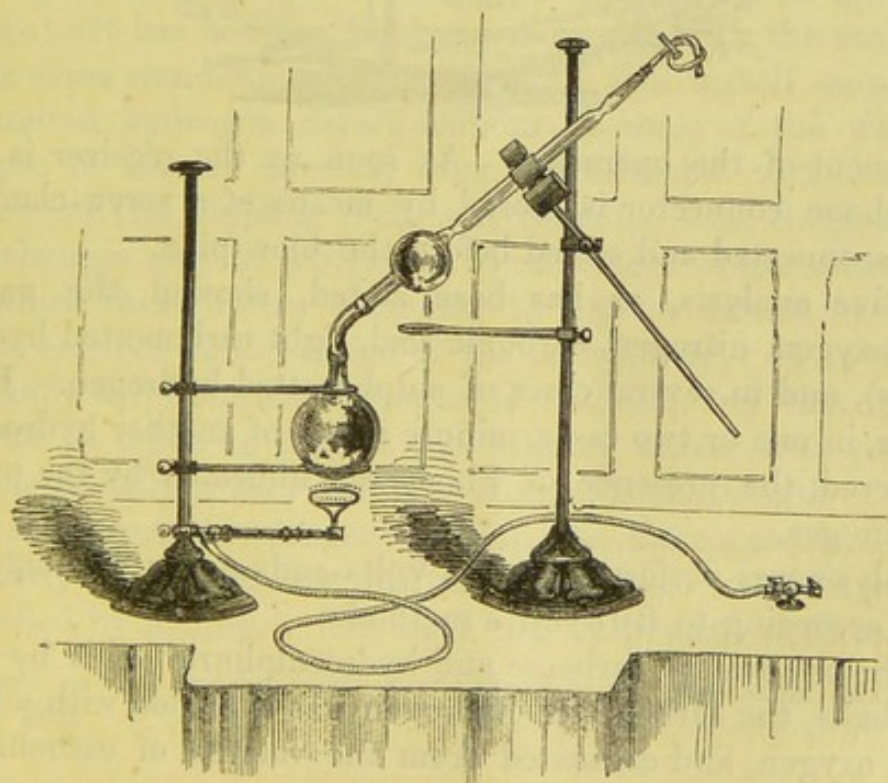


the metal to enter the gas-receiver, until it stands at the same level, within and without the tube; the clamp is then secured again, and the mercury transferred into a graduated cylinder. The difference between the volume of mercury, and the known capacity of the gas-receiver represents the volume of gas, at the existing barometric pressure and temperature.

The only conditions necessary for the success of this apparently complicated process, are a sufficiently long ebullition, and a proper proportion in the capacities of the water-flask, and gas-receiver, which can only be attained by a few preliminary operations. The capacity of the gas-receiver must be greater than the volume of the gas in the water-flask, when measured under the ordinary pressure of the atmosphere. If the volume of the gas were greater, the gas-receiver or the caoutchouc connector might burst, and if they actually withstood the outward pressure, a certain quantity of gas would be lost on opening the clamp under mercury.

The same apparatus might be used for collecting the gas intended for analysis, but unless the gas can be transferred at once into the eudiometer, it is better to construct the boiler-globe and gas-receiver of one piece of glass, and to have the ends of the receiver so far drawn out that they may be sealed by means of a blow-pipe jet. This tube, in the moment before sealing it, is represented in Fig. 3, which requires no farther explanation.

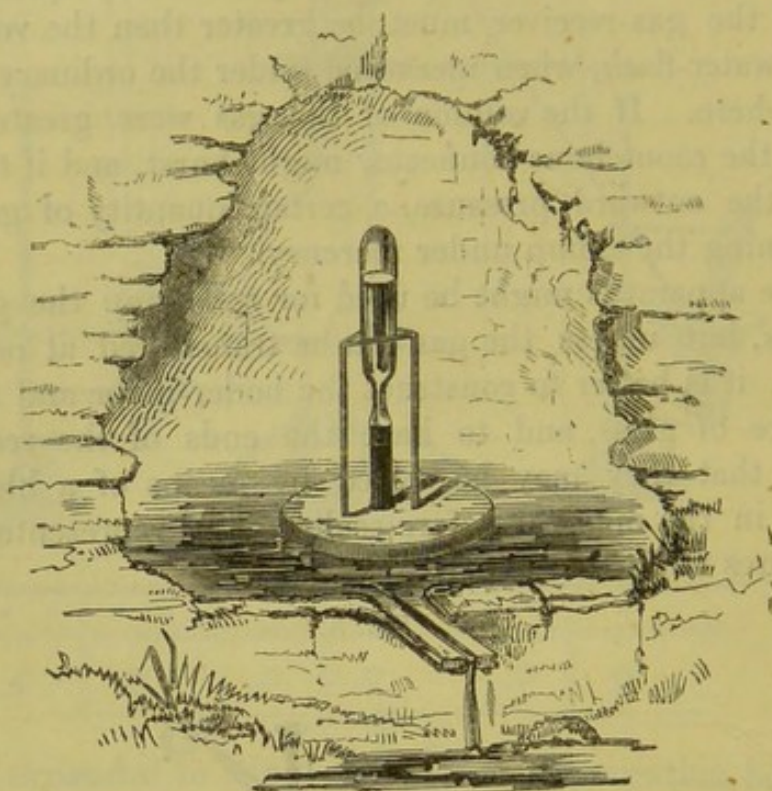
FIG. 3.





The above process furnishes the gases which are dissolved in the water. The gases, however, which rise in bubbles from several of the waters, were collected in a small glass-receiver constricted at one point to facilitate the subsequent sealing. This receiver is supported by an iron tripod, and fixed by means of a strong caoutchouc connector into a large perforated wooden float, the lower surface of which is hollowed out so as to collect the gas bubbles, and caused them to ascend into the receiver which is filled with water at the

FIG. 4.



commencement of the operation. As soon as the receiver is filled, the caoutchouc connector is closed by means of a screw-clamp, the receiver disconnected and sealed before the blow-pipe.

Qualitative analysis, as has been stated, showed the gases to consist of oxygen, nitrogen, carbonic acid, light carbonated hydrogen (marsh-gas), and in several cases of sulphuretted hydrogen. Besides these gases, in one or two cases, minute traces of another hydrocarbon were observed, the presence of which was indicated by the peculiar smell of the gas.

The analysis was performed in the Volta-eudiometer, graduated and calibrated according to Bunsen's method.

After the removal of carbonic and hydrosulphuric acids by means of potash-balls, the carbonated hydrogen was exploded with a known volume of oxygen, and estimated from the volume of carbonic acid



produced after explosion. The subsequent explosion, with a known volume of hydrogen, of the residue, freed from carbonic acid by means of a potash-ball, showed the presence, and indicated the quantity of oxygen. The nitrogen was determined by difference.

The amount of sulphuretted hydrogen in the gases was determined by a graduated solution of iodine in iodide of potassium, added from a burette to a solution of the potash-ball (which had served for the absorption of this gas and of the carbonic acid) in water, acidulated with acetic acid.

The total quantity of sulphuretted hydrogen which is present in the gas is never obtained by ebullition; for, in the first place, a certain quantity is destroyed by the air which is in contact with the water; and, secondly, because a certain quantity is present in the form of sulphide of sodium which is but imperfectly decomposed by the ebullition of the water. On this account, the total amount of sulphuretted hydrogen was also separately determined at the well, by means of the graduated solution of iodine in iodide of potassium which has been already mentioned. This method, originally proposed by Dupasquier and lately improved and expanded by Bunsen, is equally remarkable for its precision, and the rapidity of its execution.

All the determinations of sulphuretted hydrogen were made in the middle of February, 1854, and I mention this particular since the amount of this compound appears to be subject to considerable variation. My attention was first directed to this subject by Dr. Bennett, whose valuable researches leave no doubt in this respect.\* Dr. Bennett has had the kindness to repeat, with the same burette, and the same standard solution, which I had myself employed, the sulphuretted hydrogen determinations in some of the waters, after the lapse of several months, when considerable variations became manifest (see Old Sulphur Well, and Hospital Mild Sulphur Spring.) These changes may be partly due to influences which affect the strata from which these waters emanate; to a great extent, however, they must be ascribed to the action of the atmosphere. It is well known how readily sulphuretted hydrogen is oxidised, and that the greatest care must be taken to protect the sulphur waters from contact with the air, especially if they are to be stored for any length of time.

The sulphuretted hydrogen exists in the Harrogate waters, partly free, partly in combination with metallic oxides. Only a portion can be expelled by boiling. We have not at present sufficient data to

\* Report on the Sulphur springs of Harrogate, for the years 1841 and 1842. London, 1843.



calculate with any degree of certainty the amount of sulphuretted hydrogen which is free and that which is combined, and I have, therefore, introduced into the report the whole quantity in the form of sulphide of sodium, the total amount of sulphuretted hydrogen gas being moreover expressed in cubic inches.

I now proceed to the analyses of the several waters.

### A. SULPHUR WATERS. No. 1.

#### OLD SULPHUR WELL.

Temperature of the air—50° F. (10° C.)

Temperature of the water—48·2° F. (9° C.)

Specific gravity—1·01113.

Reaction—powerfully alkaline.

#### DIRECT RESULTS OF ANALYSIS, CALCULATED IN 1000 GRAINS.

##### *α.* BASES.

Experi- ment.	Sesqui- oxide of Iron.	Manga- nese.	Lime.	Magne- sia.	Alkaline Chlo- rides.	Potassa.	Soda.	Ammo- nia.
I	trace	trace	·6816	·3321	13·4862	·4844	6·6587	trace
II			·6816	·3304	13·4807	·4749	6·7367	
Mean	trace	trace	·6816	·33125	13·4834	·4795	6·6977	trace

##### *β.* ACIDS.

(OR ELEMENTS REPLACING THEM.)

Experi- ment.	Sulphu- ric Acid.	Sulphu- retted Hydro- gen.	Chlo- rine.	Bro- mine.	Iodine.	Fluo- rine.	Silica.
I	·0011	·0961	9·1900	marked trace	marked trace	distinct trace	·0043
II	·0019	·0948	9·1878				·0026
Mean	·0015	·0954	9·1889	m.trace	m.trace	d. trace	·0034

Experiment.	Mineral Residue.	Organic Matter.	Total Residue.
I	15·4754	trace	15·4754
II	15·4816		15·4816
Mean	15·4780	trace	15·4780



## SALINE CONSTITUENTS, CALCULATED IN 1000 GRAINS.

Sulphate of lime . . . . .	·0258
Carbonate of lime . . . . .	·1747
Fluoride of calcium . . . . .	trace
Chloride of calcium . . . . .	1·1548
Chloride of magnesium . . . . .	·7866
Chloride of potassium . . . . .	·9141
Chloride of sodium . . . . .	12·2378
Sulphide of sodium . . . . .	·2187
Bromide of sodium . . . . .	trace
Iodide of sodium . . . . .	trace
Carbonate of iron . . . . .	trace
Carbonate of manganese . . . . .	trace
Silica . . . . .	·0034
Organic matter . . . . .	trace
Ammonia . . . . .	trace
	<hr/>
	15·5159
Fixed residue (by experiment) . . . . .	15·4780

## SALINE CONSTITUENTS IN THE GALLON (IN GRAINS).

Sulphate of lime . . . . .	·182
Carbonate of lime . . . . .	12·365
Fluoride of calcium . . . . .	trace
Chloride of calcium . . . . .	81·735
Chloride of magnesium . . . . .	55·693
Chloride of potassium . . . . .	64·701
Chloride of sodium . . . . .	866·180
Sulphide of sodium . . . . .	15·479
Bromide of sodium . . . . .	trace
Iodide of sodium . . . . .	trace
Carbonate of iron . . . . .	trace
Carbonate of manganese . . . . .	trace
Silica . . . . .	·246
Organic matter . . . . .	trace
Ammonia . . . . .	trace
	<hr/>
	1096·580

Cubic inches of sulphuretted hydrogen, at 60° F. (15.5° C.) temperature, and 30 inches barometric pressure, in the gallon.

In February	.	.	.	24.00
In March	.	.	.	26.9 (Dr. Bennett)

Gases dissolved by the water and expelled by ebullition *in vacuo*.

Volume of gases calculated to 30 inches barometer, and 60° F (15.5° C.) temperature.

Cubic inches in 1000 grains of water :

I.	II.	Mean.
0.504	0.516	0.510

Cubic inches in the gallon of water :

36.09.

COMPOSITION OF THE GASES IN 100 VOLUMES).

Carbonic acid	.	.	.	.	.	61.06
Carbonetted hydrogen	.	.	.	.	.	16.17
Sulphuretted hydrogen	.	.	.	.	.	14.69
Oxygen	.	.	.	.	.	—
Nitrogen	.	.	.	.	.	8.08
						<hr/>
						100.00

CUBIC INCHES OF THE SEVERAL GASES IN THE GALLON OF WATER.

Carbonic acid	.	.	.	.	.	22.03
Carbonetted hydrogen	.	.	.	.	.	5.84
Sulphuretted hydrogen	.	.	.	.	.	5.31
Oxygen	.	.	.	.	.	—
Nitrogen	.	.	.	.	.	2.91
						<hr/>
						36.09

COMPOSITION OF THE GASES RISING FROM THE WATER IN BUBBLES (IN 100 VOLUMES .

Carbonic acid	.	.	.	.	.	3.28
Carbonetted hydrogen	.	.	.	.	.	40.00
Sulphuretted hydrogen	.	.	.	.	.	trace
Oxygen	.	.	.	.	.	—
Nitrogen	.	.	.	.	.	56.72
						<hr/>
						100.00



## No. 2.

## MONTPELLIER STRONG SULPHUR WELL.

Temperature of the air—44·6° F. (7° C.)

Temperature of the water—46·4° F. (8° C.)

Specific gravity—1·01045.

Reaction—alkaline.

## DIRECT RESULTS OF ANALYSIS, CALCULATED IN 1000 GRAINS.

*a.* BASES.

Experi- ment.	Sesqui- oxide of Iron.	Manga- nese.	Lime.	Magne- sia.	Alkaline Chlo- rides.	Potassa.	Soda.	Ammo- nia.
I	trace	trace	·6342	·3275	11·7403	·0521	6·1805	trace
II			·6388	·3273	11·7462	·0510	6·1775	
Mean	trace	trace	·6366	·3274	11·7432	·0515	6·1790	trace

*β.* ACIDS.

(OR ELEMENTS REPLACING THEM.)

Experi- ment.	Sulphu- ric Acid.	Sulphu- retted Hydro- gen.	Chlo- rine.	Bro- mine.	Iodine.	Fluo- rine.	Silica.
I	·0055	·0899	8·0584	marked trace	marked trace	trace	·0261
II	·0044		8·0691				·0262
Mean	·0049	·0899	8·0637	m.trace	m.trace	trace	·0261

Experiment.	Mineral Residue.	Organic Matter.	Total Residue.
I	13·5622	trace	13·5622
II	13·5541		13·5541
Mean	13·5581	trace	13·5581

## SALINE CONSTITUENTS CALCULATED IN 1000 GRAINS.

Sulphate of lime	·0084
Carbonate of lime	·3419
Fluoride of calcium	trace
Chloride of calcium	·8753
Chloride of magnesium	·7729
Chloride of potassium	·0813
Chloride of sodium	11·3542
Bromide of sodium	trace



Iodide of sodium . . . . .	trace
Sulphide of sodium . . . . .	·2038
Carbonate of iron . . . . .	trace
Carbonate of manganese . . . . .	trace
Ammonia . . . . .	trace
Silica . . . . .	·0261
Organic matter . . . . .	trace
	<hr/>
	13·6639
Total residue (by experiment) . . . . .	13·5581

## SALINE CONSTITUENTS, IN THE GALLON (IN GRAINS).

Sulphate of lime . . . . .	·594
Carbonate of lime . . . . .	24·182
Fluoride of calcium . . . . .	trace
Chloride of calcium . . . . .	61·910
Chloride of magnesium . . . . .	54·667
Chloride of potassium . . . . .	5·750
Chloride of sodium . . . . .	803·093
Bromide of sodium . . . . .	trace
Iodide of sodium . . . . .	trace
Sulphide of sodium . . . . .	14·414
Carbonate of iron . . . . .	trace
Carbonate of manganese . . . . .	trace
Ammonia . . . . .	trace
Silica . . . . .	1·846
Organic matter . . . . .	trace
	<hr/>
	966·456

Cubic inches of sulphuretted hydrogen, at 60° F. (15·5° C.) temperature, and 30 inches barometric pressure, in the gallon of water.

23·35 (In water sent to London.)

25·40 (At the well: Dr. Bennett.)

Gases dissolved in the water, and expelled by ebullition *in vacuo*.

Volume of gases, calculated to 30 inches barometric pressure, and 60° F. (15·5° C.) temperature.

Cubic inches in 1000 grains of water:

I.	II.	Mean.
0·279	0·284	0·2815

Cubic inches in the gallon of water.

19·84.



## COMPOSITION OF THE GASES IN 100 VOLUMES.

Carbonic acid	.	.	.	.	.	70.62
Carbonetted hydrogen	.	.	.	.	.	2.71
Sulphuretted hydrogen	.	.	.	.	.	—
Oxygen	.	.	.	.	.	2.46
Nitrogen	.	.	.	.	.	24.21
						<hr/>
						100.00

## CUBIC INCHES OF THE SEVERAL GASES IN THE GALLON OF WATER.

Carbonic acid	.	.	.	.	.	14.01
Carbonetted hydrogen	.	.	.	.	.	.53
Sulphuretted hydrogen	.	.	.	.	.	—
Oxygen	.	.	.	.	.	.48
Nitrogen	.	.	.	.	.	4.82
						<hr/>
						19.84

## No. 3.

## MONTPELLIER MILD SULPHUR WELL.

Temperature of the air—41° F. (5° C.)

Temperature of the water—42.8° F. (6° C.)

Specific gravity—1.00314.

Reaction—alkaline.

## DIRECT RESULTS OF ANALYSIS, CALCULATED IN 1000 GRAINS.

*a.* BASES.

Experi- ment.	Sesqui- oxide of Iron.	Manga- nese.	Lime.	Magne- sia.	Alkaline Chlo- rides.	Potassa.	Soda.	Ammo- nia.
I	trace	trace	.2358	.1239	3.4357	.0367	.1789	trace
II			.2323	.1262	3.4424	.0346	.1795	
Mean	trace	trace	.2340	.1250	3.4390	.0356	.1792	trace

*β.* ACIDS.

(OR ELEMENTS REPLACING THEM.)

Experi- ment.	Sulphu- ric Acid.	Sulphu- retted Hydro- gen.	Chlo- rine.	Bro- mine.	Iodine.	Fluo- rine.	Silica.
I	.1013	.0209	2.2193	very distinct	very distinct	distinct trace	.0016
II	.1013	.0213	2.2179	trace	trace		.0032
Mean	.1013	.0211	2.2186	d. trace	d. trace	d. trace	.0024

Experiment.	Mineral Residue.	Organic Matter.	Total Residue.
I	4·1025	trace	4·1025
II	4·1034		4·1034
Mean	4·1029	trace	4·1029

## SALINE CONSTITUENTS CALCULATED IN 1000 GRAINS.

Sulphate of lime . . . .	·1723
Carbonate of lime . . . .	·2913
Fluoride of calcium . . . .	trace
Carbonate of magnesia . . . .	·0463
Chloride of magnesium . . . .	·2447
Chloride of potassium . . . .	·0566
Chloride of sodium . . . .	3·3098
Bromide of sodium . . . .	trace
Iodide of sodium . . . .	trace
Sulphide of sodium . . . .	·0484
Carbonate of iron . . . .	trace
Carbonate of manganese . . . .	trace
Silica . . . .	·0024
Ammonia . . . .	trace
Organic matter . . . .	trace
	4·1718
Total residue (by experiment) . . . .	4·1029

## SALINE CONSTITUENTS, IN THE GALLON (IN GRAINS).

Sulphate of lime . . . .	12·104
Carbonate of lime . . . .	20·457
Fluoride of calcium . . . .	trace
Carbonate of magnesia . . . .	3·251
Chloride of magnesium . . . .	17·140
Chloride of potassium . . . .	3·975
Chloride of sodium . . . .	232·413
Bromide of sodium . . . .	trace
Iodide of sodium . . . .	trace
Sulphide of sodium . . . .	3·398
Carbonate of iron . . . .	trace
Carbonate of manganese . . . .	trace
Silica . . . .	·165
Ammonia . . . .	trace
Organic matter . . . .	trace
	292·903



Cubic inches of sulphuretted hydrogen, at 60° F. (15·5° C.), and 30 inches barometric pressure, in the gallon.

5·262.

Gases dissolved in the water, and expelled by ebullition *in vacuo*.

Volume of gases calculated to 30 inches barometric pressure, and 0° F. (15·5° C.) temperature.

Cubic inches in 1000 grains of water :

I.	II.	Mean.
·322	·329	·325

Cubic inches in the gallon of water :

22·85.

COMPOSITION OF THE GASES IN 100 VOLUMES.

Carbonic acid	.	.	.	.	62·50
Carbonetted hydrogen	.	.	.	.	3·99
Sulphuretted hydrogen	.	.	.	.	—
Oxygen	.	.	.	.	—
Nitrogen	.	.	.	.	33·51
					<hr/>
					100·00

CUBIC INCHES OF THE SEVERAL GASES IN THE GALLON OF WATER.

Carbonic acid	.	.	.	.	14·28
Carbonetted hydrogen	.	.	.	.	·90
Sulphuretted hydrogen	.	.	.	.	—
Oxygen	.	.	.	.	—
Nitrogen	.	.	.	.	7·67
					<hr/>
					22·85

No. 4.

HOSPITAL STRONG SULPHUR SPRING.

Temperature of the air—35·6° F. (2° C.)

Temperature of the water—41·9° F. (5·5° C.)

Specific gravity—1·00515.

Reaction—powerfully alkaline.

## DIRECT RESULTS OF ANALYSIS, CALCULATED IN 1000 GRAINS.

*a.* BASES.

Experiment.	Sesquioxide of Iron.	Manganese.	Lime.	Magnesia.	Alkaline Chlorides.	Potassa.	Soda.	Ammonia.
I	·0166	trace	·23713	·11327	5·5406	·096	2·773	trace
II	·0251		·23037	·10424	5·5629		2·947	
Mean	·0208	trace	·23375	·10864	5·5517	·096	2·860	trace

*β.* ACIDS.

(OR ELEMENTS REPLACING THEM.)

Experiment.	Sulphuric Acid.	Sulphuretted Hydrogen.	Chlorine.	Bromine.	Iodine.	Fluorine.	Silica.
I	·0429	·0446	3·3859	marked trace	marked trace	distinct trace	·0075
II	·0431	·0432	3·3713				·0076
Mean	·0430	·0439	3·3786	m. trace	m. trace	d. trace	·00755

Experiment.	Mineral Residue.	Organic Matter.	Total Residue.
I	6·2259	·018	6·2439

## SALINE CONSTITUENTS, CALCULATED IN 1000 GRAINS.

Sulphate of lime	·0734
Carbonate of lime	·363
Fluoride of calcium	trace
Chloride of magnesium	·1648
Carbonate of magnesia	·0824
Chloride of potassium	·1527
Chloride of sodium	5·2446
Bromide of sodium	trace
Iodide of sodium	trace
Sulphide of sodium	·1017
Ammonia	trace
Carbonate of iron*	·0150
Carbonate of manganese	trace

\* Corresponding to the sesquioxide which had been deposited before evaporation.



Silica . . . . .	·0075
Organic matter . . . . .	·0180
	<hr/>
	6·2231
Total residue (by experiment) . . . . .	6·2439
Carbonate of iron . . . . .	·0150
	<hr/>
	6·2589

## SALINE CONSTITUENTS, IN THE GALLON (IN GRAINS).

Sulphate of lime . . . . .	5·166
Carbonate of lime . . . . .	25·56
Fluoride of calcium . . . . .	trace
Chloride of magnesium . . . . .	11·595
Carbonate of magnesia . . . . .	5·797
Chloride of potassium . . . . .	10·751
Chloride of sodium . . . . .	369·014
Bromide of sodium . . . . .	trace
Iodide of sodium . . . . .	trace
Sulphide of sodium . . . . .	7·155
Ammonia . . . . .	trace
Carbonate of iron . . . . .	1·060
Carbonate of manganese . . . . .	trace
Silica . . . . .	·535
Organic matter . . . . .	1·327
	<hr/>
	437·960

Cubic inches of sulphuretted hydrogen, at 30 inches barometric pressure, and 60° F. (15·5° C.) temperature in the gallon.

10·888.

Gases dissolved in the water, and expelled by ebullition *in vacuo*.

Volume of gases calculated to 30 inches barometric pressure, and 0° F. (15·5° C.) temperature.

Cubic inches in 1000 grains of water :

I.	II.	Mean.
·426	·427	·4265

Cubic inches in the gallon of water :

30·01.



## COMPOSITION OF THE GASES IN 100 VOLUMES.

Carbonic acid	.	.	.	.	.	31.79
Carbonetted hydrogen	.	.	.	.	.	0.52
Sulphuretted hydrogen	.	.	.	.	.	1.81
Oxygen	.	.	.	.	.	—
Nitrogen	.	.	.	.	.	65.88
						<hr/> 100.00

## CUBIC INCHES OF THE SEVERAL GASES IN THE GALLON.

Carbonic acid	.	.	.	.	.	9.54
Carbonetted hydrogen	.	.	.	.	.	.15
Sulphuretted hydrogen	.	.	.	.	.	.54
Nitrogen	.	.	.	.	.	19.78
						<hr/> 30.01

## COMPOSITION OF THE GASES (IN 100 VOLUMES) RISING FROM THE WATER IN BUBBLES.

Carbonic acid	.	.	.	.	.	0.09
Sulphuretted hydrogen	.	.	.	.	.	trace
Nitrogen	.	.	.	.	.	99.91
						<hr/> 100.00

## No. 5.

## HOSPITAL MILD SULPHUR SPRING.

Temperature of the air—45.5° F. (7.5 C.)

Temperature of the water—44.6° F. (7° C.)

Specific gravity—1.0026.

Reaction—alkaline.

## DIRECT RESULTS OF ANALYSIS, CALCULATED IN 1000 GRAINS.

## α. BASES.

Experi- ment.	Sesqui- oxide of Iron.	Manga- nese.	Lime.	Magne- sia.	Alkaline Chlo- rides.	Potassa.	Soda.	Ammo- nia.
I	trace	trace	.165	.0722	3.5048	.2041	1.6684	trace
II			.164	.0722	3.5040	.2441		
Mean	trace	trace	.1645	.0722	3.5044	.2241	1.6684	trace
III*	trace	trace	.162	.0745	3.504	trace	1.8568	trace
IV			.163	.0754	3.518		1.8642	
Mean	trace	trace	.162	.0749	3.511	trace	1.8605	trace

\* The estimations given under III and IV were made in a quantity of water that had been collected in May, 1854.

$\beta$ . ACIDS.

(OR ELEMENTS REPLACING THEM.)

Experiment.	Sulphuric Acid.	Sulphuretted Hydrogen.	Chlorine.	Bromine.	Iodine.	Fluorine.	Silica.
I	·0116	·0166	2·0797	marked trace	marked trace	trace	0·0166
II	·0105	·0133	2·0797				0·0250
Mean	·01105	·0149	2·0797	m.trace	m.trace	trace	0·0212
III	·0050		2·1441	trace	trace	trace	trace
IV	·0053		2·1369				
Mean	·0051		2·1405	trace	trace	trace	trace

Experiment.	Mineral Residue.	Organic Matter.	Total Residue.
I	3·8593	trace	3·8593
II	3·9277		3·9277
Mean	3·8935	trace	3·8935
III	3·9449	trace	3·9449
IV	3·9129		3·9129
Mean	3·9289	trace	3·9289

SALINE CONSTITUENTS CALCULATED IN 1000 GRAINS.

(FROM ANALYSIS I AND II.)

Sulphate of lime . . . . .	·0173
Carbonate of lime . . . . .	·2820
Fluoride of calcium . . . . .	trace
Chloride of magnesium . . . . .	·0048
Carbonate of magnesia . . . . .	·1469
Chloride of potassium . . . . .	·3557
Chloride of sodium . . . . .	3·1435
Bromide of sodium . . . . .	trace
Iodide of sodium . . . . .	trace
Sulphide of sodium . . . . .	·0043
Ammonia . . . . .	trace
Carbonate of iron . . . . .	trace
Carbonate of manganese . . . . .	trace



Silica . . . . .	·0212
Organic matter . . . . .	trace

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 3·9757

Total residue (by experiment) . . . . .	3·8935
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## SALINE CONSTITUENTS, IN THE GALLON (IN GRAINS).

Sulphate of lime . . . . .	1·215
Carbonate of lime . . . . .	19·794
Chloride of magnesium . . . . .	·336
Carbonate of magnesia . . . . .	10·310
Chloride of potassium . . . . .	24·970
Chloride of sodium . . . . .	220·630
Bromide of sodium . . . . .	trace
Iodide of sodium . . . . .	trace
Sulphide of sodium . . . . .	·301
Ammonia . . . . .	trace
Carbonate of iron . . . . .	trace
Carbonate of manganese . . . . .	trace
Silica . . . . .	1·49
Organic matter . . . . .	trace

---

 279·046

Cubic inches of sulphuretted hydrogen, at 60° F. (15·5° C.) temperature, and 30 inches barometric pressure, in the gallon of water.

In February . . . . .	0·368	
In March . . . . .	3·549	(Dr. Bennett)
In May . . . . .	2·310	„

Gases dissolved in the water, and expelled by ebullition *in vacuo*.

Volume of gases calculated to 30 inches barometric pressure, and 60·0° F. (15·5°) temperature.

Cubic inches in 1000 grains of water :

I.	II.	Mean.
·326	·334	·330

Cubic inches in the gallon of water :

23·16.

## COMPOSITION OF THE GASES IN 100 VOLUMES.

Carbonic acid . . . . .	44·07
Carbonetted hydrogen . . . . .	22·80
Sulphuretted hydrogen . . . . .	—
Oxygen . . . . .	7·82

Nitrogen . . . . .	25·31
	<hr/>
	100·00

## CUBIC INCHES OF THE SEVERAL GASES IN THE GALLON OF WATER.

Carbonic acid . . . . .	10·20
Carbonetted hydrogen . . . . .	5·28
Oxygen . . . . .	1·81
Nitrogen . . . . .	5·87
	<hr/>
	23·16

## No. 6.

## STARBECK SULPHUR SPA.

Temperature of the air—47·3° F. (8·5° C.)

Temperature of the water—48·2° F. (9° C.)

Specific gravity—1·0018.

Reaction—alkaline.

## DIRECT RESULTS OF ANALYSIS, CALCULATED IN 1000 GRAINS.

*a.* BASES.

Experi- ment.	Sesqui- oxide of Iron.	Manga- nese.	Lime.	Magne- sia.	Alkaline Chlo- rides.	Potassa	Soda.	Ammo- nia.
I	trace	trace	·0632	·0389	1·997	·1299	·9903	trace
II			·0582	·0367	1·9954	·1074	·9669	
Mean	trace	trace	·0607	·0376	1·9962	·1186	·9786	trace

*β.* ACIDS.

(OR ELEMENTS REPLACING THEM.)

Experi- ment.	Sulphu- ric Acid.	Sulphu- retted Hydro- gen.	Chlo- rine.	Bro- mine.	Iodine.	Fluo- rine.	Silica.
I	·00736	·0086	1·0511	trace	trace	faint trace	·021
II	·00727	·0083	1·0560				·0285
Mean	·0073	·00845	1·054	trace	trace	f. trace	·0250

Experiment.	Mineral Residue.	Organic Matter.	Total Residue.
1	2·239	·0248	2·264



## SALINE CONSTITUENTS, CALCULATED IN 1000 GRAINS.

Sulphate of lime . . . . .	·0123
Carbonate of lime . . . . .	·0992
Fluoride of calcium . . . . .	faint trace
Carbonate of magnesia . . . . .	·0768
Carbonate of potash . . . . .	·1740
Chloride of sodium . . . . .	1·7368
Bromide of sodium . . . . .	trace
Iodide of sodium . . . . .	trace
Sulphide of sodium . . . . .	·0244
Carbonate of soda . . . . .	·0732
Carbonate of manganese . . . . .	trace
Ammonia . . . . .	trace
Carbonate of iron . . . . .	trace
Silica . . . . .	·0250
Organic matter . . . . .	·0248
	<hr/>
	2.2465

Total residue (by experiment) . . . . . 2·2638

## SALINE CONSTITUENTS, IN THE GALLON (IN GRAINS).

Sulphate of lime . . . . .	·870
Carbonate of lime . . . . .	6·960
Fluoride of calcium . . . . .	faint trace
Carbonate of magnesia . . . . .	5·390
Carbonate of potash . . . . .	12·207
Chloride of sodium . . . . .	121·798
Bromide of sodium . . . . .	trace
Iodide of sodium . . . . .	trace
Sulphide of sodium . . . . .	1·711
Carbonate of soda . . . . .	5·133
Carbonate of manganese . . . . .	trace
Ammonia . . . . .	trace
Carbonate of iron . . . . .	trace
Silica . . . . .	1·753
Organic matter . . . . .	1·740
	<hr/>
	157·562

Cubic inches of sulphuretted hydrogen, at 60° F. (15·5° C.) temperature, and 30 inches barometric pressure, in the gallon.

2·103.

Gases dissolved in the water, and expelled by ebullition *in vacuo*.

Volume of gases, calculated to 30 inches barometric pressure, and 0° F. (15·5° C.) temperature.

Cubic inches in 1000 grains of water :

I.	II.	Mean.
·270	·256	·263

Cubic inches in the gallon of water :

18·62.

COMPOSITION OF THE GASES (IN 100 VOLUMES).

Carbonic acid . . . . .	49·78
Carbonetted hydrogen . . . . .	27·71
Sulphuretted hydrogen . . . . .	trace
Nitrogen . . . . .	22·51
	<hr/>
	100·00

CUBIC INCHES OF THE SEVERAL GASES IN THE GALLON OF WATER.

Carbonic acid . . . . .	9·26
Carbonetted hydrogen . . . . .	5·15
Sulphuretted hydrogen . . . . .	trace
Nitrogen . . . . .	4·21
	<hr/>
	18·62

B. CHALYBEATE WATERS, No. 1.

MONTPELLIER SALINE CHALYBEATE.

Temperature of the air—44·2° F. (6·8° C.)

Temperature of the water—46·4° F. (8° C.)

Specific gravity—1·0094.

Reaction—markedly alkaline.

DIRECT RESULTS OF ANALYSIS, CALCULATED IN 1000 GRAINS.

a. BASES.

Experi- ment.	Sesqui- oxide of Iron.	Manga- nese.	Lime.	Magne- sia.	Alkaline Chlo- rides.	Potassa.	Soda.	Ammo- nia.
I	·0585	trace	1·1348	·4952	9·460	·1023	4·9270	trace
II	·0505		1·1397	·4985	9·454	·1013	4·9248	
Mean	·0545	trace	1·1372	·4968	9·457	·1018	4·9259	trace



$\beta$ . ACIDS.

(OR ELEMENTS REPLACING THEM.)

Experi- ment.	Sulphu- ric Acid.	Chlo- rine.	Bro- mine.	Iodine.	Fluo- rine.	Silica.
I	absent	7.5336	trace	trace	absent	.0134
II		7.5363				.0134
Mean		7.53495	trace	trace		.0134

Experiment.	Mineral Residue.	Organic Matter.	Total Residue.
I	12.7961	trace	12.7961
II	12.6372		12.6372
Mean	12.7166	trace	12.7166

## SALINE CONSTITUENTS CALCULATED IN 1000 GRAINS.

Chloride of calcium	2.3530
Chloride of magnesium	.5038
Carbonate of magnesia	.5880
Chloride of potassium	.1611
Chloride of sodium	9.2960
Bromide of sodium	trace
Iodide of sodium	trace
Ammonia	trace
Carbonate of iron*	.0395
Carbonate of manganese	trace
Silica	.0134
Organic matter	trace

12.9548

Total residue (by experiment)	12.71665
Carbonate of iron	.03950

12.75615

\* Corresponding to the sesquioxide which had been deposited before evaporation.

## SALINE CONSTITUENTS, IN THE GALLON (IN GRAINS.)

Chloride of calcium . . . . .	159.278
Chloride of magnesium . . . . .	35.635
Carbonate of magnesia . . . . .	41.796
Chloride of potassium . . . . .	11.383
Chloride of sodium . . . . .	656.838
Bromide of sodium . . . . .	trace
Iodide of sodium . . . . .	trace
Ammonia . . . . .	trace
Carbonate of iron . . . . .	2.790
Carbonate of manganese . . . . .	trace
Silica . . . . .	.947
Organic matter . . . . .	trace
	<hr/>
	908.667

Gases dissolved in the water, and expelled by ebullition *in vacuo*.

Volume of gases calculated to 30 inches barometric pressure, and 60° F. (15.5° C.) temperature.

Cubic inches in 1000 grains of water :

I.	II.	Mean.
.470	.479	.4745

Cubic inches in the gallon of water :

33.56

## COMPOSITION OF THE GASES IN 100 VOLUMES.

Carbonic acid . . . . .	71.83
Carbonetted hydrogen . . . . .	7.15
Oxygen . . . . .	1.52
Nitrogen . . . . .	19.50
	<hr/>
	100.00

## CUBIC INCHES OF THE SEVERAL GASES IN THE GALLON OF WATER.

Carbonic acid . . . . .	24.17
Carbonetted hydrogen . . . . .	2.40
Oxygen . . . . .	.51
Nitrogen . . . . .	6.48
	<hr/>
	33.56



## No. 2.

## CHELTENHAM SALINE CHALYBEATE WATER.

Temperature of the air—46·4° F. (8° C.)

Temperature of the water—40° F. (4·8° C.)

Specific gravity—1·003.

Reaction—very feebly alkaline.

## DIRECT RESULTS OF ANALYSIS, CALCULATED IN 1000 GRAINS.

*a.* BASES.

Experi- ment.	Sesqui- oxide of Iron.	Manga- nese.	Lime.	Magne- sia.	Alkaline Chlo- rides.	Potassa.	Soda.	Ammo- nia.
I	·0925	trace	·4252	·2077	2·6348	·2799	1·1607	trace
II	·0893		·4232	·2063	2·6550	·2121	1·2364	
Mean	·0909	trace	·4247	·2070	2·6449	·2460	1·1985	trace

*β.* ACIDS.

(OR ELEMENTS REPLACING THEM.)

Experi- ment.	Sulphu- ric Acid.	Chlo- rine.	Bro- mine.	Iodine.	Fluo- rine.	Silica.
I	trace	2·3881	trace	trace	trace	·0242
II		2·3917				·0170
Mean	trace	2·3899	trace	trace	trace	·0206

Experiment.	Mineral Residue.	Organic Matter.	Total Residue.
I	3·9455	·0402	3·9857
II	3·9022	·0398	3·9420
Mean	3·9238	·0400	3·9638

## SALINE CONSTITUENTS, CALCULATED IN 1000 GRAINS.

Carbonate of lime	.	.	.	.	·1590
Fluoride of calcium	.	.	.	.	trace
Chloride of calcium	.	.	.	.	·7351
Chloride of magnesium	.	.	.	.	·4845

Chloride of potassium . . . . .	·3903
Chloride of sodium . . . . .	2·2617
Bromide of sodium . . . . .	trace
Iodide of sodium . . . . .	trace
Ammonia . . . . .	trace
Carbonate of iron* . . . . .	·0659
Carbonate of manganese . . . . .	trace
Silica . . . . .	·0206
Organic matter . . . . .	·0400
	<hr/>
	4·1071
Total residue (by experiment) . . . . .	3·9437
Carbonate of iron . . . . .	·0659
	<hr/>
	4·0096

## SALINE CONSTITUENTS IN THE GALLON (IN GRAINS.)

Carbonate of lime . . . . .	7·604
Fluoride of calcium . . . . .	trace
Chloride of calcium . . . . .	51·629
Chloride of magnesium . . . . .	34·027
Chloride of potassium . . . . .	27·410
Chloride of sodium . . . . .	158·840
Bromide of sodium . . . . .	trace
Iodide of sodium . . . . .	trace
Ammonia . . . . .	trace
Carbonate of iron . . . . .	4·627
Carbonate of manganese . . . . .	trace
Silica . . . . .	1·450
Organic matter . . . . .	·282
	<hr/>
	285·869

gases dissolved in the water, and expelled by ebullition *in vacuo*.

Volume of gases calculated to 30 inches barometrical pressure, 60° F. (15·5° C.) temperature.

Cubic inches in 1000 grains :

I.	II.	Mean
·365	·362	·3635

Cubic inches in the gallon :

25·52

Corresponding to the sesquioxide which had been deposited before evaporation.



## COMPOSITION OF THE GASES IN 100 VOLUMES.

Carbonic acid	.	.	.	.	.	76.4
Carbonetted hydrogen	.	.	.	.	.	19.6
Oxygen	.	.	.	.	.	} 4.0
Nitrogen	.	.	.	.	.	
						100.0

## CUBIC INCHES OF THE SEVERAL GASES IN THE GALLON OF WATER.

Carbonic acid	.	.	.	.	.	19.50
Carbonetted hydrogen	.	.	.	.	.	5.00
Oxygen	.	.	.	.	.	} 1.02
Nitrogen	.	.	.	.	.	
						25.52

## No. 3.

## TEWITT'S WELL.

Temperature of the air—49.1° F. (9.5° C.)

Temperature of the water—46.4° F. (8° C.)

Specific gravity—1.000108.

Reaction—alkaline.

## DIRECT RESULTS OF ANALYSIS, CALCULATED IN 1000 GRAINS.

*a.* BASES.

Experi- ment.	Sesqui- oxide of Iron.	Manga- nese.	Lime.	Magne- sia.	Alkaline Chlo- rides.	Potassa.	Soda.	Ammo- nia.
I	.0270	trace	.0270	.0207	.0389	.0221	.0021	trace
II	.0266		.0235	.0157				
Mean	.0268	trace	.0252	.0182	.0389	.0221	.0021	trace

*β.* ACIDS.

(OR ELEMENTS REPLACING THEM.)

Experi- ment.	Sulphu- ric Acid.	Chlo- rine.	Bro- mine.	Iodine.	Fluo- rine.	Silica.
I	.0047	.01136	rather doubt- ful	trace	absent	.0159
II	.0070	.01148	ful			.0280
Mean	.0058	.01142		trace		.022

Experiment.	Mineral Residue.	Organic Matter.	Total Residue.
I	·1336	·0146	·1482
II	·1195	·0043	·1238
Mean	·1265	·0095	·1360

## SALINE CONSTITUENTS CALCULATED IN 1000 GRAINS.

Sulphate of lime	·0090
Carbonate of lime	·0205
Carbonate of magnesia	·0381
Chloride of potassium	·0189
Chloride of sodium	·0040
Bromide of sodium	trace
Iodide of sodium	trace
Carbonate of potassa	·0151
Ammonia	trace
Carbonate of iron	·0194
Carbonate of manganese	trace
Silica	·0220
Organic matter	·0095
	·1565
Fixed residue (by experiment)	·1360
Carbonate of iron	·0194
	·1554

## SALINE CONSTITUENTS IN THE GALLON (IN GRAINS.)

Sulphate of lime	·697
Carbonate of lime	1·435
Carbonate of magnesia	2·667
Chloride of potassium	1·323
Chloride of sodium	·280
Bromide of sodium	trace
Iodide of sodium	trace
Carbonate of potassa	1·057
Ammonia	trace
Carbonate of iron	1·358
Carbonate of manganese	trace
Silica	1·041
Organic matter	·663
	11·021



Gases dissolved in the water and expelled by ebullition *in vacuo*.

Volume of gases calculated to 30 inches barometric pressure, and 60° F. (15·5° C.) temperature.

Cubic inches in 1000 grains of water :

I.	II.	Mean.
·250	·258.	·254

Cubic inches in the gallon of water :

17·78.

COMPOSITION OF THE GASES IN 100 VOLUMES.

Carbonic acid . . . . .	66·66
Carbonetted hydrogen . . . . .	—
Oxygen . . . . .	2·82
Nitrogen . . . . .	30·52
	<hr/>
	100·00

CUBIC INCHES OF THE SEVERAL GASES IN THE GALLON OF WATER.

Carbonic acid . . . . .	11·85
Oxygen . . . . .	0·40
Nitrogen . . . . .	5·53
	<hr/>
	17·78

No. 4.

ST. JOHN'S WELL.

Temperature of the air—46·7° F. (8·2° C.)

Temperature of the water—46·4° F. (8° C.)

Specific gravity—1·00017.

Reaction—alkaline.

DIRECT RESULTS OF ANALYSIS CALCULATED IN 1000 GRAINS.

*a.* BASES.

Experi- ment.	Sesqui- oxide of Iron.	Manga- nese.	Lime.	Magne- sia.	Alkaline Chlo- rides.	Potassa.	Soda.	Ammo- nia.
I	·0118	?	·0198	·0212	·0593	·0096	·0228	trace
II	·012		·0199	·0202	·0545			
Mean	·01203	?	·01985	·0207	·0584	·0096	·0228	trace

$\beta$ . ACIDS.

(OR ELEMENTS REPLACING THEM.)

Experi- ment.	Sulphu- ric Acid.	Chlo- rine.*	Bro- mine	Iodine.	Fluo- rine.	Silica.
I	·0025	·0134	?	?	?	trace
II	·0025	·0134				
Mean	·0025	·0134	?	?	?	trace

Experiment.	Mineral Residue.	Organic Matter.	Total Residue.
I	·1320	trace	·1320
II	·1227		·1227
Mean	·1278	trace	·1278

## SALINE CONSTITUENTS CALCULATED IN 1000 GRAINS

Sulphate of lime	.	.	.	·0043
Carbonate of lime	.	.	.	·0323
Carbonate of magnesia	.	.	.	·0434
Carbonate of potassa	.	.	.	·0141
Chloride of sodium	.	.	.	·0220
Carbonate of soda	.	.	.	·0191
Carbonate of iron*	.	.	.	·0087
Silica	.	.	.	trace
Organic matter	.	.	.	trace
				·1439
Total residue (by experiment)	.	.	.	·1278
Carbonate of iron	.	.	.	·0087
				·1365

## SALINE CONSTITUENTS, IN THE GALLON (IN GRAINS).

Sulphate of lime	.	.	.	·307
Carbonate of lime	.	.	.	2·264
Carbonate of magnesia	.	.	.	3·039
Carbonate of potassa	.	.	.	·991

\* Corresponding to the sesquioxide which had been deposited before evaporation.



Chloride of sodium	.	.	.	1.543
Carbonate of soda	.	.	.	1.338
Carbonate of iron	.	.	.	.609
Silica	.	.	.	trace
Organic matter	.	.	.	trace
				<hr/>
				10.091

Gases dissolved in the water, and expelled by ebullition *in vacuo*.

Volume of gases calculated to 30 inches barometric pressure, and 60° F. (15.5° C.) temperature;

Cubic inches in 1000 grains of the water:

I.	II.	Mean.
.315	.317	.316

Cubic inches in the gallon of water:

22.12.

#### COMPOSITION OF THE GASES IN 100 VOLUMES.

Carbonic acid	.	.	.	.	67.63
Carbonetted hydrogen	.	.	.	.	.68
Oxygen	.	.	.	.	3.04
Nitrogen	.	.	.	.	28.65
					<hr/>
					100.00

#### CUBIC INCHES OF THE SEVERAL GASES IN THE GALLON OF THE WATER.

Carbonic acid	.	.	.	.	14.95
Carbonetted hydrogen	.	.	.	.	.15
Oxygen	.	.	.	.	.67
Nitrogen	.	.	.	.	6.35
					<hr/>
					22.12

In order to facilitate comparison, I unite the results of the preceding analyses in the following synopsis.

# SYNOPSIS.

## A. SULPHUR WATERS.

	I. Old Sulphur Well.	II. Montpellier Strong Sulphur Well.	III. Montpellier Mild Sulphur Well.	IV. Hospital Strong Sulphur Spring	V. Hospital Mild Sulphur Spring	VI. Starbeck Sulphu Spa.
Temperature of air .	50° F. (10° C.)	44·6° F. (7° C.)	41° F. (5° C.)	35·6° F. (2° C.)	45·5° F. (7·5° C.)	47·3° F. (8·5° C.)
Temperature of water . . . . .	48·2° F. (9° C.)	46·4° F. (8° C.)	42·8° F. (6° C.)	41·9° F. (5·5° C.)	44·6° F. (7° C.)	48·2° F. (9° C.)
Specific gravity . . . . .	1·01113	1·01045	1·00314	1·00515	1·0026	1·0018
Character . . . . .	powerfully alkaline	alkaline	alkaline	powerfully alkaline	alkaline	alkaline

## GRAINS OF SALINE CONSTITUENTS IN 1000 GRAINS OF WATER.

	I. Old Sulphur Well.	II. Montpellier Strong Sulphur Well.	III. Montpellier Mild Sulphur Well.	IV. Hospital Strong Sulphur Spring.	V. Hospital Mild Sulphur Spring.	VI. Starbeck Sulphur Spa.
Sulphate of lime . . . . .	·0258	·0084	·1723	·0734	·0173	·0123
Carbonate of lime . . . . .	·1747	·3419	·2913	·3630	·2820	·0992
Fluoride of calcium . . . . .	trace	trace	trace	trace	trace	faint trace
Chloride of calcium . . . . .	1·1548	·8753	—	—	—	—
Chloride of magnesium . . . . .	·7866	·7729	·2447	·1648	·0048	—
Carbonate of magnesium . . . . .	—	—	·0463	·0824	·1469	·0768
Chloride of potassium . . . . .	·9141	·0813	·0566	·1527	·3557	—
Carbonate of potassium . . . . .	—	—	—	—	—	·1740
Chloride of sodium . . . . .	12·2378	11·3542	3·3098	5·2446	3·1435	1·7368
Bromide of sodium . . . . .	trace	trace	trace	trace	trace	trace
Iodide of sodium . . . . .	trace	trace	trace	trace	trace	trace
Sulphide of sodium . . . . .	·2187	·2038	·0484	·1017	·0043	·0244
Carbonate of soda . . . . .	—	—	—	—	—	·0732
Ammonia . . . . .	trace	trace	trace	trace	trace	trace
Carbonate of iron . . . . .	trace	trace	trace	·0150	trace	trace
Carbonate of manganese . . . . .	trace	trace	trace	trace	trace	trace
Silica . . . . .	·0034	·0261	·0024	·0075	·0212	·0250
Organic matter . . . . .	trace	trace	trace	·0180	trace	·0248
Total . . . . .	15·5159	13·6639	4·1718	6·2231	3·9757	2·2465
Total residue (by experiment) . . . . .	15·4780	13·5581	4·1029	6·2589	3·8935	2·2638



## GRAINS OF SALINE CONSTITUENTS IN THE GALLON OF WATER.

	I. Old Sulphur Well.	II. Montpellier Strong Sul- phur Well.	III. Montpellier Mild Sul- phur Well.	IV. Hospital Strong Sul- phur Spring.	V. Hospital Mild Sul- phur Spring.	VI. Starbeck Sulphur Spa.
Sulphate of lime . . .	182	594	12104	51660	1215	870
Carbonate of lime . . .	12365	24182	20457	25560	19794	6960
Fluoride of calcium . . .	trace	trace	trace	trace	—	faint trace
Chloride of calcium . . .	81735	61910	—	—	—	—
Chloride of magne- sium . . . . .	55693	54667	17140	11595	336	—
Carbonate of magne- sia . . . . .	—	—	3251	5797	10310	5390
Chloride of potassium . . .	64701	5750	3975	10751	24970	—
Carbonate of potassa . . .	—	—	—	—	—	12207
Chloride of sodium . . .	866180	803093	232413	369014	220630	121793
Bromide of sodium . . .	trace	—	trace	trace	trace	trace
Iodide of sodium . . .	trace	—	trace	trace	trace	trace
Sulphide of sodium . . .	15479	14414	3398	7155	301	1711
Carbonate of soda . . .	—	—	—	—	—	5133
Ammonia . . . . .	trace	trace	trace	trace	trace	trace
Carbonate of iron . . .	trace	trace	trace	1060	trace	trace
Carbonate of manga- nese . . . . .	trace	trace	trace	trace	trace	trace
Silica . . . . .	246	1840	165	535	149	1753
Organic matter . . .	trace	trace	trace	1327	trace	1740
Total . . . . .	1096580	966456	292903	437966	279046	157562

## GASES,

DISSOLVED BY THE WATERS AND EXPELLED BY EBULLITION IN VACUO.

Composition in 100 volumes.

	I. Old Sulphur Well.	II. Montpellier Strong Sul- phur Well.	III. Montpellier Mild Sul- phur Well.	IV. Hospital Strong Sul- phur Spring	V. Hospital Mild Sul- phur Spring.	V. Starbeck Sulphur Spa.
Carbonic acid . . .	6106	7062	6250	3179	4407	4978
Carbonetted hydro- gen . . . . .	1617	271	399	52	2280	2771
Sulphuretted hydro- gen . . . . .	1469	—	—	181	—	trace
Oxygen . . . . .	—	246	—	—	782	—
Nitrogen . . . . .	808	2421	3351	6588	2531	2251
	10000	10000	10000	10000	10000	10000

## CUBIC INCHES OF THE GASES IN THE GALLON OF WATER.

	I. Old Sulphur Well.	II. Montpellier Strong Sul- phur Well.	III. Montpellier Mild Sul- phur Well.	IV. Hospital Strong Sul- phur Spring.	V. Hospital Mild Sul- phur Spring	VI. Starbeck Sulphur Spa.
Carbonic acid . . .	2203	1401	1428	954	1020	926
Carbonetted hy- drogen . . . . .	584	53	90	15	528	515
Sulphuretted hy- drogen . . . . .	531	—	—	54	—	trace
Oxygen . . . . .	—	48	—	—	181	—
Nitrogen . . . . .	291	482	767	1978	587	421
Total . . . . .	3609	1984	2285	3001	2316	1862

TOTAL VOLUME (IN CUBIC INCHES) OF SULPHURETTED HYDROGEN IN THE  
SEVERAL WATERS.

I. Old Sulphur Well . . . . .	24.0 Febr., 1854.	26.9 March, 1854.
II. Montpellier Strong Sulphur Well . . .	23.35 May, „	25.4 May, „
III. Montpellier Mild Sulphur Well . . .	5.262 Febr., „	
IV. Hospital Strong Sulphur Spring . . .	10.888 „ „	
V. Hospital Mild Sulphur Spring . . .	.368 „ „	3.54 March, „
VI. Starbeck Sulphur Spa . . . . .	2.103 „ „	

COMPOSITION OF THE GASES (IN 100 VOLUMES) RISING FROM THE WATERS IN  
BUBBLES.

	I. Old Sulphur Well.	IV. Hospital Strong Sul- phur Spring.
Carbonic acid . . . . .	3.28	0.09
Carbonetted hydrogen . . . . .	40.00	—
Sulphuretted hydrogen . . . . .	trace	trace
Oxygen . . . . .	—	—
Nitrogen . . . . .	56.72	99.91
	100.00	100.00

B. CHALYBEATE WATERS.

	I. Montpellier Saline Chaly- beate Water.	II. Cheltenham Saline Chalybeate Water.	III. Tewitt's Well.	IV. St. John's Well.
Temperature of air . . . . .	44.2° F. (6.8° C.)	46.4° F. (8° C.)	49.1° F. (9.5° C.)	46.7° F. (8.2° C.)
Temperature of water . . . . .	46.4° F. (8° C.)	40° F. (4.8° C.)	46.4° F. (8° C.)	46.4° F. (8° C.)
Specific gravity . . . . .	1.0094	1.003	1.000108	1.00017
Reaction . . . . .	markedly alkaline	very feebly alkaline.	alkaline	alkaline



## GRAINS OF SALINE CONSTITUENTS IN 1000 GRAINS.

	I. Montpellier Saline Chalybeate Water.	II. Cheltenham Saline Chalybeate Water.	III. Tewitt's Well.	IV. St. John's Well.
Sulphate of lime . . . .	—	—	·0090	·0043
Carbonate of lime . . . .	—	·1590	·0205	·0323
Fluoride of calcium . . . .	—	trace	—	?
Chloride of calcium . . . .	2·3530	·7351	—	—
Chloride of magnesium . . . .	·5038	·4845	—	—
Carbonate of magnesia . . . .	·5880	—	·0381	·0434
Chloride of potassium . . . .	·1611	·3903	·0189	—
Carbonate of potassa . . . .	—	—	·0151	·0141
Chloride of sodium . . . .	9·2960	2·2617	·0040	·0220
Bromide of sodium . . . .	trace	trace	trace	?
Iodide of sodium . . . .	trace	trace	trace	?
Carbonate of soda . . . .	—	—	—	·0191
Ammonia . . . . .	trace	trace	trace	trace
Carbonate of iron . . . .	·0395	·0659	·0194	·0087
Carbonate of manganese . . . .	trace	trace	trace	?
Silica . . . . .	·0134	·0206	·0220	trace
Organic matter . . . . .	trace	·0400	·0095	trace
Total . . . . .	12·9548	4·1071	·1565	·1439
Total residue (by experi- ment) . . . . .	12·7561	4·0096	·1554	·1365

## GRAINS OF SALINE CONSTITUENTS IN THE GALLON OF WATER.

	I. Montpellier Saline Chalybeate Water.	II. Cheltenham Saline Chalybeate Water.	III. Tewitt's Well.	IV. St. John's Well.
Sulphate of lime . . . .	—	—	·697	·307
Carbonate of lime . . . .	—	7·604	1·435	2·264
Fluoride of calcium . . . .	—	trace	—	?
Chloride of calcium . . . .	159·278	51·629	—	—
Chloride of magnesium . . . .	35·635	34·027	—	—
Carbonate of magnesia . . . .	41·796	—	2·667	3·039
Chloride of potassium . . . .	11·383	27·410	1·323	—
Carbonate of potassa . . . .	—	—	1·057	·991
Chloride of sodium . . . .	656·838	158·840	·280	1·543
Bromide of sodium . . . .	trace	trace	trace	?
Iodide of sodium . . . .	trace	trace	trace	?
Carbonate of soda . . . .	—	—	—	1·338
Ammonia . . . . .	trace	trace	trace	trace
Carbonate of iron . . . .	2·790	4·627	1·358	·609
Carbonate of manganese . . . .	trace	trace	trace	?
Silica . . . . .	·947	1·450	1·041	trace
Organic matter . . . . .	trace	·282	·663	trace
Total . . . . .	908·667	285·869	11·021	10·091



## GASES,

DISSOLVED BY THE WATERS AND EXPELLED BY EBULLITION IN VACUO.

Composition in 100 volumes.

	I. Montpellier Saline Chalybeate Water.	II. Cheltenham Saline Chalybeate Water.	III. Tewitt's Well.	IV. St. John's Well.
Carbonic acid . . . . .	71.83	76.4	66.66	67.63
Carbonetted hydrogen . .	7.15	19.6	—	.68
Oxygen . . . . .	1.52	} 4.0	2.82	3.04
Nitrogen . . . . .	19.50		30.52	28.65
	100.00	100.00	100.00	100.00

CUBIC INCHES OF THE GASES IN THE GALLON OF WATER.

	I. Montpellier Saline Chalybeate Water.	II. Cheltenham Saline Chalybeate Water.	III. Tewitt's Well.	IV. St. John's Well.
Carbonic acid . . . . .	24.17	19.50	11.85	14.95
Carbonetted hydrogen . .	2.40	5.00	—	.15
Oxygen . . . . .	.51	} 1.02	0.40	.67
Nitrogen . . . . .	6.48		5.53	6.35
	33.56	25.52	17.98	22.12

I cannot conclude this Report without expressing my thanks to Dr. Bennett of Harrogate. His active co-operation in collecting the waters and gases, and in the analytical determinations which had to be performed at the wells, have materially facilitated and furthered this enquiry. My best thanks are also due to Messrs. A. B. Northcote, and H. M. Witt, Assistants in the Royal College of Chemistry, whose zeal and talent have never failed me during the prosecution of this long investigation.

A. W. HOFMANN.

ROYAL COLLEGE OF CHEMISTRY,  
JULY 1, 1854.





## MEDICAL REMARKS

BY THE COMMITTEE.

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It is matter for public congratulation that the great and important classes of springs in Harrogate have been examined by Professor Hofmann. The results of his elaborate and careful investigation place these mineral waters at the head of all British Spas; and in respect to their number and variety, and the smallness of the circuit which comprises them, there is scarcely a spot in Europe which can worthily rival them. A distance of many miles separates places on the continent where the various springs analogous to our own are to be found; and only at considerable expenditure of money, time, and trouble, are they accessible, whereas here, within a circle of a mile and a half through an extension of that remarkable geological phenomenon, known as *the Craven Fault*, are to be found not far short of a hundred various springs, one fourth of which are made available for medicinal purposes.

The natural features of Harrogate itself are those of a sheltered basin, in which the principal springs issue from the earth, and an elevated plain immediately adjoining, where the pure chalybeates are found. The plain is an open table-land, or 'common' of grass-land, of considerable extent (the 'common' alone consists of 200 acres, by 'the Forest Award'), situated mid-way between the two sea-coasts, and at a mean elevation of about 400 feet above the sea-level. The generally prevailing winds are westerly. In point of climate, the extremes of the thermometric range are less than those of London; and on almost the hottest days a breeze may be found in the open 'common.' Rains seldom leave the paths wet for many hours, as, in addition to their being well gravelled periodically, the natural substratum is for the most part a porous sandstone, which speedily absorbs superfluous moisture. Further; although we have



occasionally heavy rains, the average amount of precipitation is less than that of the neighbourhood.

The advantages which such a locality present to the valetudinarian must be evident. He breathes an atmosphere of remarkable dryness, great purity, and of such rarity, that some persons even suffer from the want of a denser air. The neighbourhood possesses many interesting objects of history and art, many natural scenes of great beauty are within easy riding, and even walking distances; and great facility is afforded by three railways for more distant excursions.

The waters themselves are of course the chief attractions; and their value as remedial agents forms the chief subject of this Report. It is not easy, however, for residents to dilate on these without raising a suspicion of partiality. While such a consideration is not allowed wholly to deter the Reporters from the Essay, it is deemed good ground for withholding much attempt at panegyric. As a *prima facie* argument in their favour, notwithstanding occasional mischief which ensues from a daring or reckless abuse of such powerful agents, appeals may be made to such facts as the constancy with which old *habitués* resort to them, and the annually increasing numbers of those who are induced to follow their example. To the experience of the former class of persons, Professor Hofmann's analysis adds the important confirmation which scientific comparison affords, that the springs of Harrogate, to which many have been so long accustomed to resort with confidence, still remain as they have done for ages, unchanged in their mineral constitution. Much stress may fairly be laid on this fact, inasmuch as, by special request, the severest scrutiny, not only of a scientific, but also of an economical nature, was made by the Professor into the ways and means adopted for their conservation, and for supplying them conveniently and honestly to the public.

The medical classification of the waters may be conformed to the chemical of Professor Hofmann. And it is to be understood that the results given in the Analytical Report are but types of a large class of springs, whose ingredients vary in their proportions. It becomes easy, therefore, from this variety to suit the wants and peculiarities of numerous maladies, and in their many stages, as well as those of constitution, temperament, &c.

Class I. comprises "the Strong Sulphur-Waters," of which two are commonly resorted to; "the Old Well," which is the strongest of all the sulphur waters of the place; and "the Montpellier Strong Sulphur Well," so called in contradistinction to its "*mild* water."

Class II. comprises "the Mild Sulphur Waters," of which there



are seventeen springs made available for the public, thirteen of which are within half a mile of "the Old Well," the others being at a distance—one at Starbeck, sometimes called the Knaresborough Spa, and three in the grounds at Harlow Car.

Class III. consists of "the Saline Chalybeates," of which there are two springs; one in the Montpellier Pump Room, and another in the so-called Cheltenham Pump Room, known formerly as "Oddy's Saline."

Class IV. consists of "the Pure Chalybeates," two of which are on "the common" in higher Harrogate, another at Starbeck, and a fourth at Harlow Car.

The *medicinal* properties of these waters internally administered may be stated thus:

Class I. is stimulant, aperient, diuretic, sedative, and specific.

Class II. is diuretic, alterative, resolvent, diaphoretic, sedative, and specific.

Class III. is stimulant, tonic-aperient, diuretic, and deobstruent.

Class IV. is excitant, tonic, and diuretic.

For external administration, Classes I. and II. are used as baths and lotions: Classes III. and IV. as lotions, collyria, &c.

The direct aperient, diuretic, and diaphoretic virtues are referable primarily to the various more common saline impregnations; and while these effects must of course be secondarily modified to some extent by the rarer salts, this first power, *per se*, is possessed in common with other saline waters.

But this modification of the ordinary action of saline waters, and the prolongation of their effects, are precisely those facts which stamp on these waters their peculiar and specific character. To render the probability of such result apparent, imagine first the influence of so powerful a salt as *chloride of calcium*, which enters largely into the composition of both classes of the stronger waters. Witness again the modification of common aperient salines by further combination with, on the one hand, *bromides* and *iodides*, however small in quantity, and on the other hand, in Class III, with *nascent carbonate of the protoxide of iron*, this last being in an unusually large proportion. And finally, superadd to Classes I. and II. the *sulphide of sodium*, the representative of the sulphuretted hydrogen. Here we have, as the result, four very powerful medicinal agents, in addition to the more common aperient saline substances. To those who are acquainted with the ordinary effects of these salts, it would be superfluous to say anything; but the uninitiated may imagine that such a combination of valuable agents, effected by Nature herself in



her own secret laboratory, prefers strong claims on the hope and the faith of the invalid and his adviser. Nature is not wont to bring such things together, unless she really intend some benefit by them.

The different effects above enumerated, are to be obtained, of course, by differences in the mode of administration.

If a mere aperient action be required, the common practice is adopted of taking, before breakfast, two or three tumblers, of from four to twelve, or even sixteen ounces each, at intervals of fifteen or twenty minutes or more. Moderate lounging exercise should be continued for about half an hour after the last draught, but by no means brisk walking. Breakfast need not be delayed until the operation of the waters has occurred; that they have passed off, into the digestive canal, is all that is requisite.

The influence of the waters, however, does not wholly cease when the aperient action has been effected, because some of their ingredients have been arrested in transit by the organs of the body; yet for the most part, that operation having been secured, all else is little thought of. This is a great error; besides, were merely the purgative operation required, a less disagreeable agent might be employed at home. No doubt then, forasmuch as mineral waters are very commonly resorted to for such purposes, and often at no little trouble and inconvenience, such a fact argues the existence of a power in them, and the experience of a virtue resulting from the use of them, to which artificial medicines cannot lay claim. Nor is this result to be referred only to the auxiliary influences of change of air, scene, circumstances, &c., which, we yet admit, must contribute somewhat to the ultimate effect.

For profounder and more permanent objects, in certain classes of cases, the method adopted is that of giving smaller draughts of the water at wider intervals, and throughout the day. By this means they are retained; time and opportunity are afforded for absorption; the system becomes more or less charged with their ingredients; and thus their alterative effect and specific action are produced. The great object here to be kept in view, and which it is sometimes difficult to accomplish, is to bring the affected organs under the influence of the waters without unduly disturbing the general balance of the system. In these cases, baths of various kinds become very useful; the skin, probably, also conveying the salts largely to the system. The soothing and equalizing influence, too, of the mere warm bath alone promotes this operation of absorption. It is, however, in the adoption of this combined plan that so



much discrimination is required, as well as watchfulness for the effects during its progress.

Having thus specified in general terms the main properties of these waters, their very compound nature being now so fully established by the present analysis, we might here conclude our remarks. For to particularize any form of administration as the best for any given disease, when age, constitution, habits, and idiosyncrasies are so various, is simply impossible. Nevertheless, we think it well to offer a few remarks respecting those cases which, in an especial manner, as experience has proved, are more evidently, as well as directly, under the control of these waters. These are the various forms of skin complaints.

From time immemorial these have been regarded as eminently and peculiarly amenable to the influence of sulphur waters. But, admitting that their fame is well deserved in this particular, much more is claimed than is commonly conceded. Ought this celebrity to have the effect of a disparaging limitation of their virtues? If ailments which many medical men avow to be very difficult of management, and even intractable, do very generally yield more or less to these waters, surely such a fact suggests the probability that their powers embrace a sphere which is not to be limited to the actual disease of the skin. For, in fact, are not skin complaints (such as usually are sent to Harrogate) but mere outward expressions of internal derangement? or, perhaps—still more strongly and correctly stated—complications expressive of, or concomitant with, or sequential to, simpler, but more serious primary maladies? For though it be the fashion with some to say that in a chronic stage the local disease is the main part of the malady, it certainly was not so at first; and even generally, some internal and the external disorder will be found alternately predominating. Nor, in a great majority of cases, will amelioration of the external malady take place, excepting *pari passu* with internal improvement. At least, it may be said that the amelioration, whether great or small, will be permanent or transient, exactly in proportion as the internal has kept pace with, and co-operated towards the external improvement. The aspersion of the character of the waters by the statement that “they are good *only* for skin diseases,” argues no small amount of inattention to what diseased skin really implies. Unquestionably, these waters do cure many skin complaints, they ameliorate most, exasperate none, if judiciously employed; but they exert their influence on the ordinary routine of the economy, and by effecting modifications in the functions of the system *generally*, and not of *the skin only*.



Being so, then, these modifications of the interior may be as confidently predicated in the *absence* of these diseases of the skin, as in their *presence*; only the evidence of such operation is not so palpable, so plain.

But, with respect even to these very diseases, it should be remembered that, for the most part, chronic cases, and these sometimes of very long standing, are those which are sent to Harrogate almost as a *dernier ressort*. Not only have they not yielded to previous treatment, but they have often become more obstinate than they would otherwise have been. Such cases, as may be expected, will generally prove tedious, and sometimes disappointment is the result of a visit; less, however, from deficient virtue in the means employed, than from various causes of inconvenience, want of opportunity, time, means, &c. For when, as in our hospital cases, patients present themselves at an earlier stage of the disease, or even at a later, where *natural*, though *morbid*, processes have been but little interfered with, the amount of good derived in many severe and obstinate cases would even surprise most persons who are conversant with cutaneous diseases.

For the satisfaction of patients, it may be mentioned, likewise, that there are many cases of skin diseases, in which frequently the shortest method of curing them is to fall in, *pro tempore*, with the new habitudes of the system, thus assisting the constitution, and so exhausting, as it were, the seeds of the mischief. In adopting this plan, however, experience and vigilance are very important. During such process, there is a point which may be seized with advantage; yet it is most difficult confidently to describe the characteristics of this point, so as to render others independent of our experience. The numerous cases of what are termed *chronic* disease which are sent to Harrogate strikingly illustrates this fact; for they are often nothing less than a constantly recurring succession of *feebly acute* invasions of the same disease, the more difficult of management by how much the habits and powers of the part have been enfeebled, and become habituated to deterioration.

From such a state of things as we have just named, in respect of cutaneous disease more particularly,—in fact, from this *irritable* and morbidly susceptible form of *local* diseases, the transition is most easy to the corresponding condition of *general* diseases; and, among these, to that great constitutional disease, *scrofula*.

This term comprises a very large class of complaints, in the various stages of which the resources of Harrogate furnish valuable remedies. Our sulphureous waters have especially the supreme value of



being naturally-medicated saline waters ; from which, being both mild and strong, and that too in great variety, we are enabled to make selections for administration according to the requirements of each individual case. And, besides these, we have the various richly impregnated chalybeates, possessing many of the peculiarities of the former, and otherwise more appropriate to feeble constitutions. It is true, these latter have not nearly so much of the free carbonic acid gas, so inviting, so agreeable, so exciting, and yet so evanescent, of which the waters of Kissingen and other places on the continent can boast ; but, in more important ingredients (to say no more of their proximity to our other mineral waters), they are even superior to the waters of the great majority of those places. An inspection of the Analytical Tables shows, moreover, that these stronger waters are not very much less impregnated with saline ingredients than sea-water itself ; whereby much of the advantage of salt-water bathing is afforded by them. Indeed, as Professor Phillips has suggested, it may well be that sea-water, deeply traversing the bowels of the earth, is itself the menstruum for all the additional minerals which are derived from our own more immediate strata. Add, then, to these results, the fact that all our waters are so *variously* impregnated in kind and degree, and the following affirmation must seem more than probable :—That, it is as wrong to deem them only useful in skin diseases as that their aperient properties are their greatest value. These are, in fact, not only the most ordinary, and therefore the least peculiar of their virtues, but they are also quite secondary in importance, as we have pointed out, to their alterative, corrective, tonic, and specific operations.

As to the former error, enough has been said to show the great extent to which these waters can be made available in the treatment of chronic diseases in general, as well as skin diseases. And, probably there are few such cases, if unconnected with organic internal disease, which may not be either relieved or cured.

In general terms we may specify two or three great and important *classes* of disease to which they are especially applicable.

One of these is dyspepsia, in almost all its numerous and varied phases, and whether arising from derangement of the functions of the stomach, the duodenum, the liver, or the bowels.

Next to this, may be named as peculiarly appropriate for treatment by *some* of the waters, those diseases of the blood arising from primary or secondary mal-assimilation, which are the fruitful source of so much suffering and ulterior disease—as gout, rheumatism, chorea, chlorosis, anæmia, and the like.



A third large class is that in which diseases are brought into the system by a foreign agent ; as cases of lead and mercurial poisoning, and those in which the ravages of secondary syphilis are discernible.

It ought not to excite surprise that we lay claim to such extensive utility for these waters, when their number and variety are remembered ; and when we add to these intrinsic virtues the extrinsic advantages of our locality together with the social *réunions* of a watering-place, some idea may be formed of the promise which Harrogate holds out to the invalid and the valetudinarian.

THE END.

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