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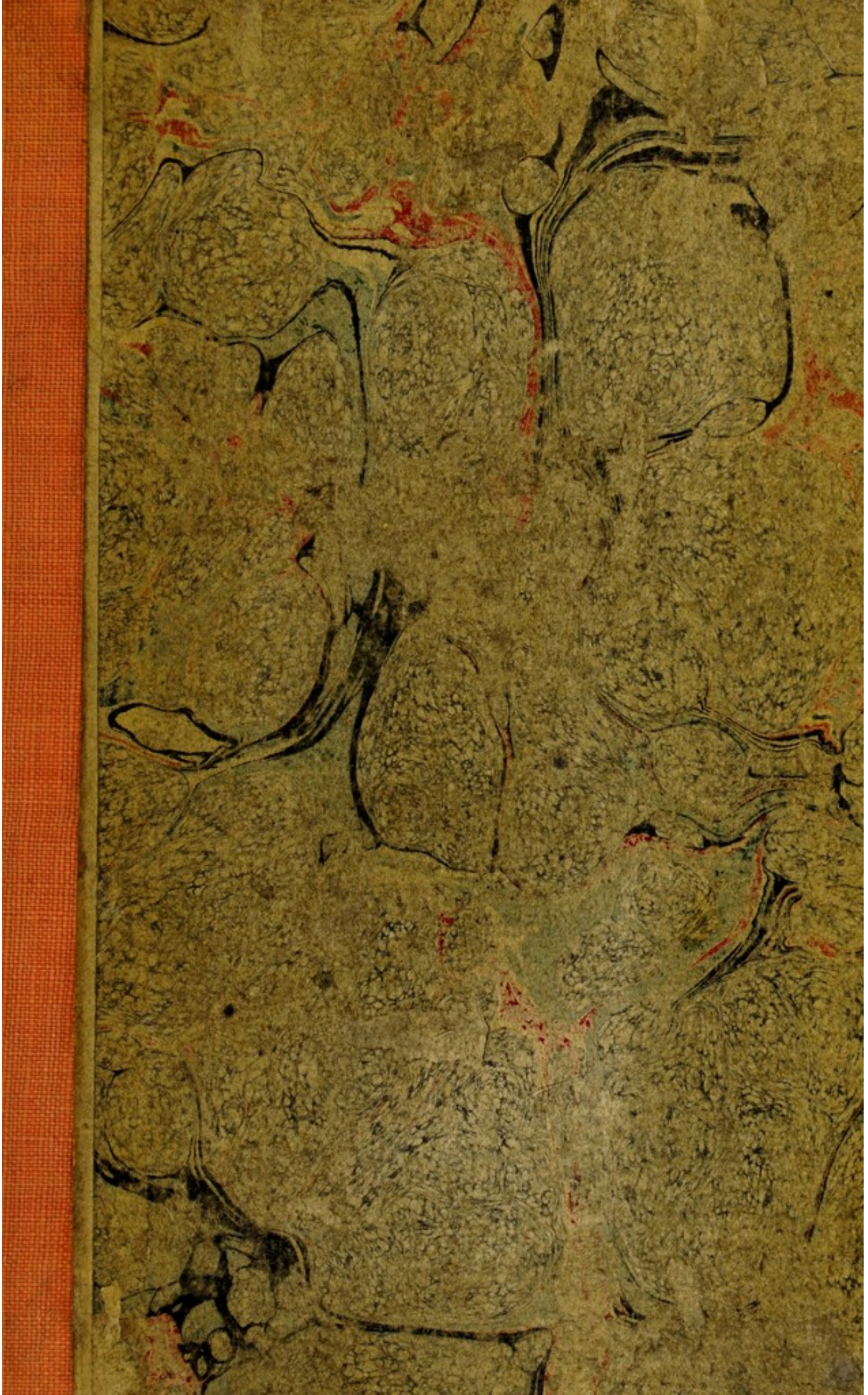

C. P. Russell

BATH.

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ART. LXI. *A Treatiſe on the Bath Waters. By* GEORGE SMITH GIBBES, *M.D. F.R.S. one of the Phyſicians to the Bath Hoſpital.* Twelves, 71 pages. Price 3s. London, 1800. ROBINSONS.

THE principal facts of the preſent Treatiſe have already been before the public, through the medium of Mr. Nicholſon's *Journal of Philoſophy.* It contains an accurate analyſis of theſe celebrated waters; but the account we have lately given of this ſubject, in our analyſis of Dr. Saunders's *Treatiſe on Mineral Waters,* renders it unneceſſary to enlarge in this place.

The author intends ſhortly to publiſh a ſecond part, which will contain an account of the medicinal properties of the Bath waters.

yet produced general conviction.—'By the multitude, as well as by governments, and even by phyſicians,' he obſerves, 'epidemic and peſtilential diſeaſes continue ſtill to be regarded as contagious; and ſhips, arriving from New York, from Philadelphia, and from Egypt, are obliged to perform quarantine, as formerly, in England, in France, and in other enlightened nations.'—We truſt they will long continue ſo to do.

The mode of treatment which the author adviſes for the cure of the plague, and, in general, all epidemic and peſtilential diſeaſes, and which he promiſes will be found ſucceſsful, is founded on the principles laid down in his former work, and which we have already noticed.—'Whether,' he obſerves, 'in treating the plague, mercury, or other ſtimulant powers, be uſed, ſucceſs, I take upon me with confidence to predict, will depend upon the application of them,

A

TREATISE

ON THE

BATH WATERS

BY

GEORGE SMITH GIBBES, *M. D.*

Late Fellow of Magdalene College, Oxford; Fellow of the Royal Society; one of the Physicians to the Bath City Dispensary, &c.

BATH,

PRINTED BY W. MEYLER, IN THE GROVE;

AND SOLD BY MESS. ROBINSON, PATERNOSTER-ROW,

LONDON.

1800.

THE Substance of the following observations has already appeared in Mr. Nicholson's Philosophical Journal. I have repeated most of the experiments with tests of my own preparing, and with others which were made by Mr. Hume, Chemist, in Long-Acre, London, whose accuracy in every kind of chemical preparation is too well established to need any praise or commendation from me.

A

Treatise on the Bath Waters.

THERE is nothing in the character or appearance of the country around Bath which should induce us to suspect that springs, of the nature and properties of those which are there found, should present themselves to our investigation. It is hilly and uneven, but the hills lie in no order. They are generally rocky and steep from South-west by West to North and by North. The country within five and seven miles abounds in coal mines; but there are no considerable mines nearer than Mendip. The hills for the most part afford a freestone.

The three principal sources of the Bath Waters arise within a short distance of each other near the river Avon.

With such powerful effects as the Bath Waters are known to produce on the human constitution, it is astonishing to find that so few active principles should have been discovered by those learned men who have made them the subject of their inquiries. It has been alleged that all attempts to discover the properties or effects of mineral waters on the human body by chemical experiment or analysis are vain and insignificant, as many effects are produced by them not to be accounted for from any discoverable impregnation. The learned Doctor Falconer very justly combats this opinion. He observes "that such reasoning, if applied equally to all branches of learning, would preclude all search whatever; and, had it formerly obtained, would have prevented our acquisition of many useful and important discoveries which we now enjoy." The Doctor, with that liberality which distinguishes the character of the man of learning, observes that in discussions on subjects of science, when opinions alone are controverted, it may be alleged, that no apology

is necessary ; as candour should be the inseparable attendant on learning ; and no man of science should be ashamed to receive information, from whatever channel it may be derived. As an apology for offering to the World the present performance, it ought to be recollected that the science of chemistry has within these few years made very rapid advances, and the cultivators of it have now many more fixed principles, on which to found their reasonings, than could have been suspected by those who applied to it but a few years since. Even the existence of many very active substances was then totally unknown. Many agents and principles, which, a few years back, were believed to regulate the phenomena of nature, are now proved to have had no existence, but in the imaginations of the cultivators of this science. A science which comprehends so large a field of inquiry must doubtless be subject continually to changes, according to the advances which are made in it. The detection of a new principle must, in every science, alter the reasonings respecting the phenomena which it presents.

The difficulty, which has been ever acknowledged, of analysing mineral waters, arises from the multiplicity of agents which nature employs in their production. As water is an universal solvent, its impregnations must be numerous and complicated. It is hardly ever to be found free from any admixture. Even the air of our atmosphere contains substances which water collects and precipitates in its descent from the clouds. In the bowels of the earth, this wonderful agent gives form and stability to the numerous substances contained therein by its power of dissolving and arranging the principles they contain. On the surface of the earth, the substances composing mountains are dissolved and brought down into the valleys, and by the agency of water are elaborated into the vessels of organized beings. Leaving the surface, it descends into the hidden recesses of the earth, and is pent up in reservoirs, from which it is gradually suffered to flow in springs, that the irregular supplies of the seasons may be corrected by its presence. Owing to the

solvent power of water, it seldom leaves the bowels of the earth without bringing with it many substances, which it meets with in its course. Hence spring water is never entirely free from foreign admixture. Salts, earths, minerals, even animal and vegetable substances, have been found to flow forth dissolved in the water of springs. As water free from such impregnations, is the desirable object of common life, too great attention cannot be given to ascertain the nature of this fluid in every situation. The common powers of perception will, in many instances, detect the more dangerous mixtures of deleterious substances. The taste, appearance, and some other qualities, will sometimes distinguish its purity or dangerous properties. But there are numberless instances where these modes of discrimination will fail. The sight cannot detect many noxious qualities, where the substances are held in perfect solution; and even the taste may not always discriminate between noxious and salubrious ingredients. If there arise this difficulty in judging of the nature of the

water which is used for the purposes of common life; how much more difficult must it be to judge of those waters whose medicinal qualities are the object of research. The impregnations of water are almost as various as the substances which form the globe. Many are the instances where it flows fully saturated with some of the strongest mineral poisons; in the Isle of Anglesea, the labour of the metallurgist is rewarded by extracting the copper, with which the spring water is impregnated.

How admirably ordered is the distribution of the strata of the earth, and the impregnations which in consequence take place in water! The upper strata are in general of such substances as permit the water to flow into the valleys without becoming impregnated with deleterious materials, and to be the proper vehicle for the food of plants and animals. That which sinks deeper, and which is in much smaller quantities meets with minerals of various kinds, and becomes mineral waters. It would open a large field

of inquiry, to trace the varieties which obtain in the phenomena attendant on springs. They vary according to the situation of the strata, and according to the nature of the substances of which the strata are composed. Remarkable effects have arisen from the operation of slight causes at depths in the earth; a morassy country has been known to be drained by a stroke of a workman's pickaxe, in a deep mine. Water finds its level, and rises in the vacuities of rocks till it finds an outlet, or proceeds to great distances till those vacuities terminate on the surface of the earth. Correspondent strata, which are far from level, may send forth water which, at a distance, may have been received from the clouds. Though mountains be elevated to such great heights, their summits are composed of materials which existed below the stratified surface. Hence the strata on the sides of such mountains form a large angle with the horizon. The tops of inferior hills correspond with strata which are on the sides of mountains exposed to rains; hence springs break out on many

very high stratified hills. The regularity of most springs, and the quantities of water which they pour forth, evince that these operations are of great extent, and that an average effect is produced by the operation of a number of causes.

These circumstances result from the known laws of hydrostatics, and from the solvent power of water. Mechanical mixture, chemical solution, decomposition, and deposition, give a never failing variety to the phenomena of water in an active state. Thus, charged with calcareous earth, as most waters are, by finer and finer filtrations it forms the roughest lime stone, and the finest dense and crystalized water-icle.

Mr. Kirwan has given us a very complete account of the uses which may be made of an attentive examination of the phenomena presented by mineral waters. He remarks that "There is a point of view in which an acquaintance with the contents of mineral waters must be deemed of some importance;

arising from unknown depths, they alone announce to us several of the substances therein existing, and frequently the awful operations therein transacted. Thus several valuable ores have been discovered, witness the copper ores, of the county of Wicklow, in Ireland, and the various mines of salt alum, &c. The waters of Bath, Aix-la-Chapelle, Carlsbad, and many more, manifest the secret operations of heat at depths hitherto inaccessible, and by the nature of their contents, suggest the causes that most probably maintain it. In mineral waters we find many substances dissolved, whose existence, in a state of solution, hath, until of late, been thought impossible. Thus the Sprudel springs at Carlsbad, in Bohemia, annually afford seventeen thousand three hundred and sixty-nine pounds of siliceous earth held in solution, and though this water also contains fossil alkali, yet that earth does not owe its solubility to this salt, as the alkali is fully saturated. To say nothing of the waters of Geyzer, in which this earth also abounds, in quantities, utterly disproportionate to the quantity of alkali also contained in it."

That liberal and enlightened patron of science, Sir Joseph Banks, by his great zeal and indefatigable ardour for the advancement of natural history, led the way to the knowledge of impregnations in mineral waters, which were not suspected to exist in them in any large quantity, till he returned from Iceland. From thence he brought the incrustations from the edges of the volcanic springs in that island.

These productions were found to consist of siliceous earth. In consequence of this discovery in 1772, the world was presented with a master-piece of chemical analysis in the famous investigation made by Dr. Black, on the waters of Geyzer and Rykum. The wonderful phenomena which these volcanic springs present have been admirably described by Mr. Stanley.*

I shall now attempt an explanation of the phenomena which the Bath waters continue uniformly to present, and I shall, as far as I

* Transactions of the Royal Society, Edinburgh, Vol. 3.

am able, deduce my reasonings from an experimental inquiry into their component parts. Former writers have attributed too much to mysterious powers, thereby, as I conceive, acknowledging the difficulty of investigating the subject now under consideration. As this method cannot be admitted in our inquiries after natural knowledge, I hope this attempt will be received with candour, and that my errors may, in the minds of learned men, find a ready excuse in the difficulty of the subject.

The uniformity, as to temperature, quality, and quantity, observable in the Bath springs, shews that they are caused by continued and regular operations of extensive agents in the bowels of the earth. Various have been the opinions respecting the cause of the heat of these waters. Subterranean fires, fermentation, the decomposition of pyrites, &c. have each had their advocates. As our researches into the operations which are going on in the interior of the globe, must be limited, actual experiment must, in many in-

stances, be assisted by analogy, and our reasonings must be often taken from remote data. It is hardly possible for the human mind to conceive the extent to which nature goes in the application of some of her laws. Principles, which on the surface of the earth act without interruption, and thereby require much investigation to detect, in the bowels of the earth become formidable, and produce some of her boldest features. The matter of heat, for example, which meets with but little interruption in its course through the substances forming the superficies, in the interior, causes convulsions which shake large continents, or bursts forth in tremendous volcanoes, Water also, when unconfined, produces but little apparent effect; but when subjected to heat and pressure, its energies are excessive. Where every agent is so varied, and where every thing assumes such irregular modes of action, the cause of uniformity must be a difficult question. That all operations contribute to form a perfect whole must be acknowledged, but when we find, as it were a stop in the suc-

cession of events, great perseverance must be required to solve such a phenomenon.

There are daily poured forth from the springs at Bath, upwards of two thousand hogsheads of water; which water is heated considerably above the temperature of ordinary water. As a matter of curiosity, I find that the quantity of heat which is evolved by them in the course of one year, above the medium heat of other springs, would render above seven hundred million of cubic inches of iron red hot.

The following is a statement of the heat and quantity of the Bath waters:

	Tuns.	*Hhds.*	*Gal.*
The King's Bath contains ..	314	0	36
The Queen's Bath	81	3	11
The Cross Bath	53	0	47
The Hot Bath.....	54	0	27
	502	4	58

Sixteen ounces or forty cubic inches of water at 55° of heat were raised by a cubic inch of iron red hot to 90°.

One cubic inch, of red hot iron, would raise fifteen cubic inches of water, at 55° of heat, to the heat of the Bath waters.

Two thousand hogsheads of water every day from the springs.

2000
63 Gallons in a hogshead.

6000
12000

126000
231 Solid inches in a gallon

126000
378000
252000

29106000 Solid inches in a day from the springs.

15

141
135

60
60

60
60

00

The number of cubic inches of water, at the heat of the Bath springs, are required by a reverse calculation, to render one cubic inch of iron red hot.

1940400 cubic inches of iron red hot in the course of a day, by the Bath waters.

1940400
365

9702000
11642400
5821200

708246000 Cubic inches in one year.

The temperature of the King's Bath, and Hot Bath, is about 114° of Fahrenheit; by pumping a considerable time they have been found to raise the thermometer to 116° and even 118°. The Cross Bath is of some what a lower temperature, about 110° or 112°.

It is difficult to ascertain with precision the heat of the Bath waters. When examined under the same circumstances, their temperature appears uniform. The regular temperature of the Bath waters, and the length of time that they have been known to pour forth their hot streams, would induce us to think that the cause of their heat is uniform, and very deeply situated in the bowels of the earth. I beg leave to offer a conjecture respecting that regularity of their

temperature; which is, that at some great depth in the earth, they are at a very high temperature, and that in coming up to the surface of the earth, their temperature is lowered to the degree they are found to possess. Thus it should seem that they are analogous to the Geyzer in Iceland, and that at a certain depth, they would be found to have nearly the same appearances. That they are not of the nature of common springs of water is evident from their not being affected by the vicissitudes of weather, nor from the alternation of wet or dry seasons.

The following extract, however, from Lord Gardenstone's travelling memorandums, seems to shew that water does sometimes acquire a considerable temperature at no great distance from the surface of the earth.

"AIX IN PROVENCE."

"Dr. Philips informed me of a remarkable fact relative to these waters. About three or four years ago, the inhabitants

were alarmed by a sudden and great defect in the usual flow of water from their fountains. The flow gradually diminished, and in a few days they were almost dry; happily the cause of this scarcity was soon discovered and easily remedied. In fact a farmer about the distance of half an English mile from Aix, had, at this time, on some scheme of improvement, dug up part of his ground, when, at a small depth from the surface a body of water rushed out and continued to flow very plentifully. The fact being reported at Aix, they conjectured that the farmer had thus accidentally fallen upon and diverted the stream which supplied their fountains; but, upon inquiry, the farmer's stream was found to have no degree of heat; on the contrary it was a very cold spring water.

"The experiment however was made. The farmer's stream was replaced, and immediately the fountains of Aix were replenished with the same plenty and quality of water as

formerly. Thus it appears, with certainty, that this water acquires its heat in the course of running from the farmer's ground to Aix; but how or where it is impregnated with the quality of heat, is not yet determined."

Bath Water when viewed by itself in a small quantity appears clear and transparent; but when beheld in the Bath, the surface is of a sea-green colour. The smell is not very agreeable, especially in the Hot-Bath; but when quite fresh it has a soft and milky taste. There are four Baths which differ from each other chiefly in their degree of heat, namely the Cross-Bath, the Hot-Bath, the King's and the Queen's-Bath. The two last are supplied from the same spring.

Dr. Falconer has given the following statement of the specific gravity of the Bath Waters:

The King's and Hot-Bath	1,0020
Cross-Bath	1,0013

The Pump water....	1,0016
Avon water	1,0008

The Bath Waters do not produce any change of colour by means of vegetable tests, consequently they do not contain any acid or alkali in an uncombined state. I added one drop of diluted sulphuric acid to two ounces of each of the Bath Waters, which, with that small quantity of acid, changed the colour of turnsole. Had there been any disengaged alkali or earth, it would have most probably destroyed the effects therein produced.

I have hesitated in giving this account of the absence of any acid or alkali in a disengaged state in the Bath Water, as it contradicts the statement of other writers on this subject, and in some measure that which I shall hereafter produce. These experiments I have often repeated with the same results and it appears either that the carbonate of lime in so small a quantity of the water is

insufficient to neutralise the acid added, or that, as the experiment was tried after the water was cold, it had undergone some new arrangement.

Two ounces of the King's-Bath Water experienced no change of colour when a few drops of a spirituous tincture of galls were added to it: on the addition of one drop of a solution of sulphate of iron, it became of a purple colour. The water which served for this experiment had been carefully preserved in a well closed bottle. A bottle was filled with the King's-Bath Water, and carefully closed by tying a piece of bladder over the cork. After remaining for some weeks, and being again heated to the temperature of the springs, on the addition of tincture of galls it shewed no signs whatever of the presence of iron. I put the water fresh from the springs in clear white glass vessels, but I never could observe that any iron had subsided in the form of an oxyde, after they had remained cold for many days.

I have indeed remarked that after the waters have remained for some time in glass vessels there is a deposition of a white matter, which appeared to me to be carbonate of lime rendered insoluble by a separation of some of the carbonic acid with which it had been before sursaturated.

Two ounces of the water fresh and warm from the springs, experienced a considerable change of colour on the addition of the tincture of galls, evidently shewing the presence of iron. Under precisely the same circumstances, the water of the two other springs which I examined, viz. the Hot and Cross-Bath Water produced the same appearances.

Dr. Baynard mentions this fact respecting the Bath Waters, and the nature of their impregnation by iron. He is speaking of the quantities of these waters which are sent to a distance.

" Witness the prodigious quantities that are sent daily away to Scotland, and Ire-

land, and many other parts; although they are of much more efficacy drank hot at the place than sent abroad, as clearly appears by the volatile vitriolic gas seen in them by the trial of galls, oak leaves, tea, bistort, or any austere alkali; which volatile vitriol flies off as it cools; and although you warm the water to the just heat of the Bath, yet 'tis never to be seen more."

From the experiments which I have made and which I have varied in every way I could devise, it seems that the celebrated Philosopher Mayow made his experiments on the waters after they had been suffered to cool: He says, "Quod ad vitriolum denique spectat, Balneum vulgo dictum Balneum Crucis, item alterum præfervidum nominatum, vitriolum plane nullum continere videntur, etenim si Gallæ contusæ aquis Thermarum dictarum infusæ fuerint; aquæ istæ colorem purpureum aut nigrum nequaquam habituræ sunt; quod tamen omnino contingeret, si thermæ istæ vitriolo imbutæ essent. Quod ad Balneum Regis, (sic dictum) istoc vitrioli

tantillo imprægnari videtur ; quippe si Gallæ contusæ, ejus aquæ injiciantur, eadem colore atro-purpureo leviter tingetur." I have found upon repeated trials, that the King's-Bath Water will assume a purple tinge on the addition of tincture of galls, when warm and when it has been recently cooled, but not the least colour after it has remained cold for any length of time. It may appear from the experiments I have made, that a small portion of iron is dissolved by the carbonic acid gas, and that this acid by evaporating leaves the iron unsusceptible of any change of colour by the addition of galls ; but I think we shall be able to discover some more probable mode of combination. Mayow's observations on this subject are truly interesting and are perfectly consistent with the facts I have observed.

He says, " Annotandum est autem, quod minera quædam indolis metallicæ una cum Thermarum prædictarum Scaturiginibus e Terra prorumpat ; quæ facile in vitriolum converti potest : etenim si sabulo (quod

una cum aquis Thermarum e terra erumpens in Fundo Balneorum reperitur) liquor quivis acidus superfundatur, idem non sine effervescentia satis insigni a mentruo acido corrosum, ex parte aliqua in vitriolum convertetur; haud secus ac limaturæ ferri a liquore acido corrosæ, contingit; quippe si sabulum istoc Balneorum liquore acido imprægnatum, infusioni Gallarum injiciatur, liquor mox colorem atro-purpureum acquiret: cum tamen, si infusio Gallarum sabulo isti recens a Balneis exempto, non vero a liquore acido jam corroso, affundatur, ea nequaquam colorem purpureum obtinebit, indicio utique manifesto, sabulum Balneorum metallicum, non nisi a menstruo acido corrosum, indolem vitriolicam induere.

Advertendum est autem, quod sabulum istud Thermarum aliquamdiu servatum, aerique expositum sponte sua in vitriolum commigrabit; quippe si istiusmodi sabulum Gallarum infusioni injiciatur, aqua mox colorem atro-purpureum habitura est. Quinimo si idem linguæ imponatur, sapor vitrio-

licus satis manifeste se prodet. Nimirum spiritus nitro-aereus cum minera metallica, sive marchasita salino-sulphurea (e quali vitriolum confici solet), Sabulo dicto admista tractu temporis congreditur, et effervescit; eamque tandem modo alibi ostenso, in vitriolum convertit."

We cannot avoid in this place admiring the sagacity of Mayow's mind, who, without the aid of modern science, could so accurately describe the causes, which produce the vitriol he speaks of. Allowing his spiritus nitro-aereus to be oxygen, his theory is perfectly consistent with all the modern discoveries; the iron, by acquiring the spiritus nitro-aereus or oxygen, becomes ochre or rust, and is then soluble in acids; or if it (as he observes) be united with sulphur, the sulphur acquires his spiritus nitro-aereus, is converted into vitriolic acid, which combining with the iron, forms vitriol of iron, and is then affected by an infusion of galls.

One of the most curious circumstances attending the composition of the Bath

springs, and the sand which rises with them, is that the iron contained therein is nearly in a metallic state. It is attracted by the magnet. Many people as well as myself have observed this fact. I have been assured by Doctor Fothergill, that he has successfully repeated this experiment on the sand which had recently been taken from the reservoir.

I shall relate some further experiments which I made to ascertain the presence of iron in these waters:

To two ounces of the King's-Bath Water I added a few drops of a solution of prussiate of potash and no change of colour took place. On the addition of one drop of a solution of sulphate of iron, an evident blue colour appeared. The same results attended these experiments on the Hot and Cross-Baths. The hepatic water, which is composed of sixteen grains of sulphuret of lime, and ten grains of the acidulous tartarite of potash, is an excellent test for discovering metals which are held in solu-

lution. Iron precipitated by it is re-dissolved by the sulphuric acid. With this test I could not perceive the least quantity of iron in any of the three waters. As iron may be held in a state of combination in which it may resist the action of the foregoing tests, I have used the following means for discovering its presence:

In Professor Bergmann's table of attractions, I find that the sulphuric acid has, after the acids of sugar and tartar, the strongest attraction for iron; I have, therefore, first added a very small quantity of the sulphuric acid, and after a due time for combination, a few drops of the hepatic test: still I could not perceive the least trace of iron. This experiment was repeated with other tests with the same result. Thus it is evident that these waters when cold do not shew any trace of iron by any reagent we can employ. All the tests will not detect the iron even when they are warm from the springs. The prussiate of potash does not change its colour when added to them in that state.

The high temperature of these waters gives to the iron an extraordinary degree of activity. Although iron is not to be discovered in them when they are suffered to cool, yet when hot and fresh from the springs, no preparation of steel appears equally diffusible with this in the human body. It is so much divided, nay even so volatile that it very quickly shews its character as a medicine with those who use it.

There are large quantities of selenite contained in the Bath Waters. Rectified spirits of wine added to an equal quantity of these waters, produced a considerable milkiness. A solution of carbonate of potash causes a large precipitation in the water of the three Baths. A solution of pure potash produces a much weaker precipitation. Solution of carbonate of ammonia produces a much greater precipitation in the Hot-Bath Water than in the other two. In Professor Bergmann's table of affinities we find that lime has a much greater attraction for the sulphuric and marine acids, than the volatile

alkali. Upon a solution of muriate of lime in distilled water, I poured a solution of pure ammonia, and no precipitation ensued ; but on adding a solution of carbonate of ammonia in distilled water, a precipitation was perceptible. This last experiment shews that a double decomposition took place, in which the carbonic acid left the ammonia to unite with the lime, and the muriatic acid left the lime to unite with the ammonia.

The power of sulphuric acid in detecting calcareous earth is not extensive, for the resulting selenite is soluble in five hundred times its quantity of water, and if an excess of acid supervenes in much less. Mr. Kirwan observes that even in the decomposition of muriates and nitrates of lime by sulphuric acid, the selenite is rendered more soluble, and that three or more grains of lime must be present in one thousand of water to form a precipitate.

Hence I was induced to try the following experiment ; where I added equal quanti-

tities of strong sulphuric acid, and Bath Waters together. A precipitation ensued, which had none of the apparent characters of selenite, and which future experiments will prove to be silex. For as a closer union takes place between sulphuric acid and water when united, than they have when by themselves, this substance which is diffused through the water is thereby separated. A great deal of knowledge respecting the nature of the Bath springs is derived from the discovery of silex which enters into their composition. Although on evaporating these waters, I did not find any particular odour indicating the presence of alkali ; though I never observed that the dry extracts from the Bath Waters attracted moisture from being exposed a long time to the atmosphere, yet I think the following experiments will demonstrate that silex forms a very considerable part of their solid ingredients.

One hundred and ten ounces of the King's-Bath Water left after evaporation to dryness eighty grains of solid matter.

Dr. Falconer makes the proportion of the solid ingredients in the King's-Bath Water to be about the one 630th part.

The Hot-Bath Water is said not to contain so large a proportion of iron as the King's-Bath but more earth, but where the quantity of iron is not to be appreciated in either, and when even the fresh King's Bath Water has not the power of affecting the prussiate of potash, I think this circumstance is not much to be regarded. The Hot-Bath Water certainly contains a larger proportion of calcareous salts than the other Baths. The Cross-Bath contains more siliceous and insoluble matter than the other two Baths.

The residuum assumed somewhat the appearance of a jelly but not similar to the artificial solution of silex in water. During evaporation the mass divided into separate portions, the fissures between which did not distinctly enlarge according to the progress of exsiccation. The substance adhered to

the sides of the vessels during evaporation, forming circles not easily to be detached. The vessel in which I evaporated this water was of block-tin, and I found that by detaching the substance from its sides the ivory knife which I employed was considerably abraded. This circumstance induced me to examine very particularly the nature of the products, and I found that a large proportion remained insoluble, after I had subjected them to the action of the three strong mineral acids. To this insoluble substance I added above a thousand times its quantity of distilled water; still I perceived that it remained unchangeable. This precipitate fell rapidly to the bottom of the vessel. I separated it by a filter from the water, and I found it to possess no saline or earthy taste.

Upon the residuum after evaporating 168 ounces of the King's-Bath Water nearly to dryness, I poured a considerable quantity of nitric acid, and I left it to stand for above an hour, I then added a large

quantity of boiling water, from which a white precipitate fell rapidly to the bottom of the vessel. I filtered the liquor, and I found after carefully drying the substance left on the filter, that it weighed twenty grains.

The oxalic acid did not decompose it, neither was its quantity diminished by boiling it a considerable time in distilled water.

Professor Bergmann observes, in his analysis of mineral waters, that the portion, when the other ingredients are separated, which resists the action of a sufficient quantity of marine acid is siliceous earth, which may be farther determined by the blow pipe; for this earth when added to the mineral alkali in fusion, unites with it with a violent effervescence, and is thereby totally dissolved.

Mr. Kirwan says, that the general method of discovering the siliceous earth, is to evaporate a large quantity of water nearly to dryness, then to supersaturate and redissolve

all that may have been precipitated by adding a sufficiency of nitrous or vitriolic acids, and then evaporate to dryness. If then the dry mass be once more redissolved in water, and filtered, the siliceous earth will remain on the filter. It is distinguished by its insolubility in most acids, and its vitrescibility with two parts soda.

I exposed six grains of this substance mixed with double its weight of soda, in a small platina crucible to a very strong heat which I urged with a pair of double bellows, and I found that it acquired a vitreous appearance, after having suffered a very considerable effervescence similar to that in making glass. I have already mentioned that this substance resisted the action of the marine, nitric and sulphuric acids. Thus it appears, that the insoluble substance which has been but very slightly noticed by former writers on these waters is siliceous earth; and that this earth forms nearly an eighth part of the solid ingredients discoverable therein.

Doctor Saunders in his late work on mineral waters says that "the discovery of siliceous earth in this water will clear up a difficulty in its analysis which must strike the chemical reader. If twenty-two and a half grains of carbonate of lime were contained in the gallon of water (which is the lowest estimate, and is that of Doctor Lucas) it could not be suspended by only one-sixtieth part of its bulk, or 3,85 cubic inches of carbonic acid.

Mr. Kirwan estimates from very accurate calculations, that where the quantity of this earth is small compared with that of the water, an addition of half of its weight of uncombined carbonic acid would hold it in solution; but if the gallon of Bath Water contained twenty-two and a half grains of carbonate of lime, it would require eleven grains and a quarter, or about twenty-four cubic inches of carbonic acid to keep it dissolved; whereas Doctor Priestley's experiments did not shew an eighth of this quantity. But since Doctor Gibbes finds in this

water fifteen grains and a quarter of siliceous earth in the gallon, all which remains in the residuum that is insoluble in water, as well as the carbonate of lime, we may well suppose that the two have been confounded with each other; and that in fact the Bath Water contains only about seven or eight grains of the calcareous earth, which would require for their solution about as many cubic inches of carbonic acid, which is still however much more than Doctor Priestley's calculation."

From my experiments it does not appear that the carbonate of lime is even in so large a proportion as Doctor Saunders mentions. The selenite in the trials I have made appears to furnish the largest quantity of the calcareous earth.

Doctor Charlton after proving the nature of the acids which help to form the neutral salts discoverable in the Bath Waters, observes that twenty grains of the residuum dissolve in rain water and that fourteen

grains subside. Hence he concludes that the former are salts and the latter earth.

This method of determining the proportions of salt and earth appears to me to be very defective, for we shall see presently that many earths and particularly the one mentioned by Doctor Charlton, the calcareous earth, are very soluble in water.

According to him the Hot and Cross-Baths gave different proportions of salt and earth.

"After these salts (Doctor Charlton continues) are entirely separated from the residuum, there remains an earthy powder of a white colour and a perfectly insipid taste." Doctor Charlton says that the earthy part of the Bath Waters is not derived from lime stone, and this he proves by his experiments; but in the next page he observes that "this powder shews no signs of inflammability whatever; it is merely an absorbent, alcaline, calcareous earth."

Another observation of Doctor Charlton's shews that this part of the residuum was rough and gritty in the mouth.

Such have been the observations of Doctor Charlton on this part of the subject, from which I am clearly of opinion that had he more carefully examined the nature of the substances in the residuum, he would have discovered that it consisted of a combination of principles that would have cleared up this seeming contradiction in the phenomena he observed.

The following experiments made by DoctorFalconer shew that he observed an insoluble substance in the Bath Waters:

"To one drachm of the gross residuum of the King's-Bath Water were added three ounces of distilled water. To this I added twenty drops of the spirit of nitre; a considerable effervescence ensued, and a part of the residuum was dissolved, which was not affected by water alone. But nearly one-

third part remained, which could not be rendered soluble by these means, although I added forty drops of the nitrous acid."

The Doctor has subjoined the following note :—" The nitrous acid was used here preferable to the vitriolic, because the residuum which remained undissolved was probably selenites, which is not affected by the nitrous acid; but on the addition of a superabundant quantity of vitriolic acid dissolves easily in water, although so difficult of solution in the state we generally see it. This may perhaps, account for its being contained more largely in some springs, than its solubility in water would account for by any other means, and is, in my opinion, a presumptive evidence, that the vitriolic acid is present in its separate state in some mineral waters."

To this insoluble part of the residuum I added a large quantity of the strong and diluted vitriolic acid, and I found it remain undissolved. This substance therefore ac-

cording to Dr. Falconer's own experiments cannot be selenites.

If we compare the quantity of silex which comes up dissolved in the waters of the Bath springs with what has been found in the analysis of other mineral waters, we shall find that even the quantity from the sprudel spring at Carlsbad as determined by Mr. Klaproth does not exceed that in the Bath Waters.

Every pound of the Bath Waters contains a grain and a half of siliceous earth, or about a four thousandth part its own weight. The silex forms about an eighth of the solid matter and the solid matter to the whole weight of water about a six hundred and sixtieth part. We therefore find that in the course of one year the Bath Waters bring up dissolved in them nearly one hundred thousand pounds weight of silex, whereas the spring at Carlsbad brings up only seventeen thousand three hundred and sixty-nine pounds.

If we examine the analysis of other thermal waters we shall find that the Bath Waters have still the larger proportion of silex.

" Sur les eaux aerees, minerales et thermales du Nivernois ;

" Par M. Hassenfratz."

" J'ai fait evaporer juqu'a siccite 28 livres 8 onces d'eau de Pougues, et j'ai obtenu apres l'evaporation 1 once, 2 gros, 44 grains ou 764 grains de residu. J'ai fait dissoudre ce residu dans l'eau distillee, ce qui n'a point etc dissous, pesoit, apres avoir ete filtre et seche, 403 grains ; la portion dissoute etoit donc de 361 grains. J'ai verse de l'acide nitrique sur la terre insoluble dans l'eau, elle s'y est dissoute avec effervescence, et a laisse un residu noiratre pesant 16 grains. Ce residu s'est dissous en partie dans l'acide sulphurique et a forme des petits cristeaux octaedres, ce qui prove qu'il contenoit de l'alumine. La terre non dissoute qui etoit de la silice melangee d'un peu d'oxyde de fer pesoit 6 grains; J'ai verse de l'eau de Chaux

sur les 387 grains de terre dissoute ; il s'est fait un leger precipite terreux pesant 14 grains : ce precipite etoit facilement soluble dans les acides, etoit insoluble dans l'eau et dans les alkalis purs ; ainsi, il etoit forme de terre magnesiene.

The proportion of silex in these waters is but small compared with those of Bath.

The waters of the Baths at Pisa contain more or less of foreign matter according to the degree of their heat.

In one hundred pounds of the water of the warm Baths of Pozzello are contained ten grains of silex. In one hundred grains of the pellicle which floats on the surface of these warm Baths are contained three grains of silex. The substance which is deposited at the bottom of these Baths contains a larger proportion of silex.

The acidulated waters of Asciano contain in one hundred pounds nine grains of silex.

There are many other springs where siliceous earth has been found to form a component part of the solid ingredients which they contain. Doctor Withering discovered silex in the waters of Caldas. And Doctor Thompson has discovered some curious stalactites composed of silex in the neighbourhood of Naples.

Mr. Kirwan's observation before mentioned is particularly applicable to this part of the subject. The solution of siliceous earth in water announces very powerful operations which are going on in the bowels of the earth. Professor Bergmann, imagines that the silex which is contained in mineral waters rather remains suspended in them by virtue of the subtlety of its parts than by means of a true solution. It is known that water becomes the more capable of dissolving bodies, in proportion to its degree of heat; greater than that of the boiling point or 212° of Fahrenheit. Siliceous earth, exposed in water to a boiling heat for ever so great a length of time, is scarce sensibly di-

minished, so that by this experiment it seems totally insoluble ; but we cannot thence conclude that it is able to resist a greater heat. The efficacy of Papin's Digester has shewn, that many bodies may be dissolved which totally resist boiling in open vessels : at the same time it must be confessed that no one has tried siliceous earth in this way ; so that we should be entirely ignorant what would be the event, had not nature herself spontaneously assisted our ignorance and sloth. Thus at Geyser in Iceland, there springs up a hot water, which upon cooling deposits siliceous earth, and of this very matter has formed for itself a crater, in which columns of water of a stupendous bulk, after they have been thrown to the height of ninety feet and upwards, fall, and are again received. The heat of the water during the explosion cannot indeed be measured ; but after it has risen and fallen through a stratum of air ninety feet thick, it raises the thermometer above 100° ; which evidently shews, that the heat in the bowels of the earth, must be vastly more intense ; and this we shall cease

to wonder at, when we consider, that in this case the subterraneous fire acts upon water in caverns closed up by a very thick strata of stones, an apparatus far more effective than Papin's Digester. The crater was undoubtedly at first formed and is daily strengthened, by siliceous earth, which quits the menstruum on its being cooled, falls down and being in somewhat like a soft state, concretes.

The regularity of temperature observable in the Bath Waters, proves clearly that they are exposed to a very powerful heat in the bowels of the earth. It has been proved by an able Experimentalist, that the earth at a certain depth, observes a medium temperature, between the extremes of the heat of summer, and the coldness of winter. Now this temperature is much lower than that of these springs. They must therefore suffer a diminution of their heat in passing upwards. A still more convincing argument to prove that their heat is intense at a certain depth is their containing so large a proportion of siliceous earth. I believe it will be allowed that

siliceous earth is capable of being largely diffused in water, when that water has been subjected to an intense heat, and great pressure. The earth affords a most efficacious digester for the purpose, and no one can deny the existence of subterraneous fire or heat. To be diffused in water siliceous earth must have been very much comminuted, and in that state it may enter into a more direct solution. Every decrease of temperature, therefore, by bringing these particles within the sphere of their own greater attraction, must occasion a precipitation of some of it. Now this is observable in the reservoirs of the Bath springs, whence the people who attend to them, find it necessary occasionally to remove from the reservoirs the sand which is continually accumulating. A certain portion of the silex remains suspended or dissolved in the waters, doubtless in consequence of its very comminuted state. This by evaporation is obtained, and is again indissoluble in water at the boiling point; because the particles having coalesced, resist as they would at first, so comparatively

low a temperature. This observation is confirmed by the following remarks of Doctor Black:

"When siliceous earth, united with an alkali is dissolved in one thousand times or in more than five hundred times its weight of water, it will not separate or subside from that quantity of water although we separate or disengage the alkali from it. The particles of it, placed at that distance do not act on one another by their attraction of cohesion or concretion. It is necessary, in order to enable them to attract one another, that they be brought nearer, by diminishing the quantity of water, until it be less than five hundred times its weight of the earth."

When this is done, they will enter into a state of cohesion, sooner or later, according as the water has been more or less diminished. But this state of cohesion into which they first enter, is also remarkable, the force of it is extremely weak and it takes place whilst the particles of earth are still at a con-

siderable distance from each other. They therefore retain and entangle among them a large quantity of water amounting to about one hundred times their own weight, and perhaps more than two hundred times their bulk, with which they form a consistent jelly almost perfectly transparent. To avoid this source of error, I have taken particular pains to dry the substance after it had been precipitated by evaporation : indeed the addition of a large quantity of nitric and vitriolic acid, and due time for their coalescence must be sufficient to detach most of the siliceous particles.

Distilled water dissolved a certain portion of the extract remaining after the evaporation of the Bath Waters ; by evaporating this solution, the substances settled in the form of the crystals of common salt and vitriolated soda.

Solution of nitrate of silver produces a copious precipitation, when added to the Bath Waters. The King's-Bath and Hot-Bath

will turn the solution of silver white with a bluish cast, which becomes gradually more dusk-coloured, and then deposits a dark grey sediment.

Two ounces of the waters fresh from the springs, were mixed with a solution of sugar of lead ; each produced a considerable milkiness, and the colour remained perfectly white. There is a portion of muriate of soda, or common salt, contained in these waters. The foregoing experiments prove that there is no sulphurated hydrogenous gas produced in these waters. By the most accurate tests I have not been able to detect the least quantity of sulphur dissolved in them. When silver leaf was placed in a vessel containing these waters, fresh from the pump, it remained of the same brightness and white colour, but on the addition of a very minute quantity of sulphuret of potash, the silver immediately was affected by it.

These waters contain sulphuric acid united to both an alkaline and earthy basis. So-

lutions of acetite and muriate of barytes when added to them immediately produced a considerable precipitation. Pure ammonia produces a precipitation in the Bath Waters, which shews very clearly that other earths besides lime are contained in them. Now the marine and sulphuric acids have a less attraction for ammonia than they have for magnesia; it is therefore not magnesia which is separated by the pure ammonia. As clay has a much less attraction for the marine and sulphuric acid than ammonia, it appears that clay is separated in the foregoing experiments. I poured some pure ammonia on a solution of sulphate of alumine, or common alum, and a copious precipitation ensued, In a former experiment I found that a solution of pure potash did not produce so large a precipitation as a solution of carbonate of potash. The reason is obvious; for although the pure potash would separate the sulphuric and marine acids, from lime, yet that lime would be for the most part redissolved by the water, and but a sparing precipitation would take place. This I proved

more clearly by adding to the mixture of pure potash and the Bath Waters, more distilled water, which lessened the quantity of precipitate, though I could not by those means make it entirely disappear. This also shews that other earth, besides lime, is contained in these waters. The precipitate entirely disappeared on the addition of diluted sulphuric acid. The oxalic acid produces a copious precipitation when added to the King's-Bath and Cross-Bath Waters. The Hot-Bath Waters produce a much greater quantity of precipitate with the tests for lime, than the other two. I have now proved that these waters contain a large proportion of lime, and I think I have clearly shewn that the lime is in a great measure combined with sulphuric acid. Having separated by means of a filtre the oxalate of lime formed in the preceding experiment, I added to the clear fluid which came through the filter, a solution of pure ammonia, which caused a precipitation. Now from Professor Bergmann's table, and from direct experiments

before related, I learn that pure ammonia has for the sulphuric and marine acids a less attraction than magnesia, but pure ammonia as before mentioned, has a greater attraction for those acids than clay ; consequently it is evident that this precipitation is clay.

Doctor Saunders has in a note in his book on mineral waters observed that I am incorrect in this part of my experiments. After I had separated the lime from the waters by means of oxalic acid, I found a precipitation on the addition of pure ammonia ; there must therefore be other earths besides lime.

In Professor Bergmann's table of elective attractions under the title vitriolic acid he notes the following order: pure ponderous earth, pure vegetable alkali, pure fossil alkali, lime, pure magnesia, pure volatile alkali, pure clay ; and under marine acid the following pure vegetable alkali, pure fossil alkali, pure ponderous earth, lime, pure magnesia, pure volatile alkali, and pure clay. According to this table therefore it will ap-

pear that clay only could be separated from these acids by pure ammonia. I have repeated the experiments and I find that pure ammonia will decompose sulphate of magnesia. I have however compared the precipitates from these waters, the sulphate of magnesia and sulphate of alumine, and I find that what is separated from the waters is clay. The carbonate of lime which certainly forms a part of the solid contents of the Bath Waters, was in these experiments separated by the oxalic acid, before I added to them the pure ammonia.

There appeared this separation in the three waters, but there is a great difference in the quantity of the precipitate. The Hot-Bath Water contains more than the King's-Bath and the latter than the Cross-Bath.

Diluted sulphuric acid poured into a vessel containing the King's-Bath Water, produced a separation of minute air bubbles ; which I apprehend are carbonic acid gas, as lime water added to any quantity of this wa-

ter, caused a precipitation. The same appearances were observed in the other waters, but their quantities vary considerably. These experiments would lead us to conclude that these waters contain carbonic acid gas, either in a disengaged state or united to some alkaline basis. From some of the foregoing experiments, however, it appears, to be in a disengaged state, as the tests did not shew the presence of any alkali, and the carbonic acid was too small in quantity for them to detect it. I shall hereafter shew that very large quantities of elastic gasses arise with the waters; their heat however prevents any very large quantities of carbonic acid gas from uniting with them. When to the waters of the three Baths I added lime water, an evident precipitation took place; which precipitation I, of course, imagined was owing to the carbonic acid gas being united to the pure lime. When I added a small quantity of diluted vitriolic acid, the precipitation was redissolved, and I observed a separation of air in cooling. This I ascertained by exposing a quantity of the water to some air in a

large close vessel, the water having a communicating tube on the outside. The water in the outside tube was at first on a level with the water within, but after a little time the water sunk in the outside tube, proving that the air in the receiver had been absorbed.

The earthy salts form a much larger proportion of the solid ingredients than the alkaline salts.

Besides the foregoing substances there arises principally during the summer with the waters a vegetable substance like a conferva, which floats on the surface of the Baths. I have collected large quantities of this substance and have no doubt of its being a vegetable.

There is a prodigious quantity of aeriform fluid continually evolved from these springs, which rises in large bubbles, and is dissipated in the surrounding atmosphere. Having collected a large quantity of this gas, I subjected it to the following experiments:

A measure of this gas was added to a measure of nitrous gas, and a very trifling absorption took place; I mixed a larger quantity of it with nitrous gas, and a very trifling discolouration took place. The same quantity of atmospheric air, and the same nitrous gas, were united together, and very red fumes immediately appeared. Into a vessel full of this air I poured some fresh lime water; on agitation the lime water became turbid and of a milk white colour. A small portion of this air was absorbed by water. A burning body was extinguished when placed in the remaining air. On mixing it with atmospheric air, and exposing it to the flame of a taper, there was not the slightest detonation. These experiments were frequently repeated with the same results, and the air was taken from the Baths at different periods of time.

If the experiments of M. Girtanner should be confirmed by future observations, many difficulties may be removed, which now oppose an accurate knowledge of the manner whereby azote is here produced. It results

from his experiments that azote, ammonia, water, atmospheric air, &c. are varied proportions of the same two principles. In analysing atmospheric air, according to him, azote is not separated, but composed by subtracting a part of the oxygene from the fluid hydro-oxygene which constitutes this air.

From the foregoing experiments I am led to believe that the Bath Waters contain some very active principles; besides their heat, which most assuredly increases the action of their other component parts, we find that they lower the purity of the air, by the quantity of azotic gas which is poured forth into the atmosphere over the Bath. Large quantities of this air must be inspired by those who use the open Bath; and as we know that an alteration in the proportions of the component parts of atmospheric air, will produce evident effects on the human constitution, this circumstance may I think be pointed out with propriety as a source of medical inquiry. I have been informed by a very learned and scientific person, that sili-

ceous earth has been found to produce, when dissolved in water, some very considerable effects on the animal economy.

As my experiments lead me to believe, that this earth forms a large proportion of the solid contents of these waters, as it appears to be very minutely divided, and as the high temperature may give it activity, I think this circumstance also may be regarded as worthy the attention of medical practitioners.

Doctor Saunders, in the following note, haswith great clearness and precision removed the objections which may be offered to my suggestion, and has placed in a very strong point of view the reasons for which it ought to be considered as probable.

" Doctor Gibbes suggests the probability that the siliceous earth assists materially in the general effect of the Bath Waters. After what has been said of the great powers of very minute quantities, it will not be thought a sufficient objection against this opinion that no more than a grain of silex, according

Doctor Gibbes' own calculation, is contained in half a pint of the water; nor will its general insolubility in any of the animal fluids be an objection, since it is already presented to the stomach in a state of solution; nor its want of the sensible properties of taste and smell in any of its known combinations, since we know of some indisputably powerful medicines which have little of either; and, therefore this opinion, though it does not impress the mind with any great degree of probability, certainly remains to be confirmed or refuted by further investigation."*

I could mention a great variety of instances where the Bath Waters have produced great effects in disease; but as I intend to make the medical properties of these waters the subject of the second part of this treatise, I must content myself at present with expressing a hope that even those who have hitherto considered these waters as inefficacious, will be inclined to agree with me, in allowing that these principles must have great medical powers.

* Saunders on Mineral Waters, page 191.

It seems difficult to account for the azotic gas which rises with these waters. The country round Bath contains large quantities of lime stone, in the greater part of which I have been able to detect the exuviæ of sea animals. As there must have been a great deposition of animal substances, and as these waters apply a continued and powerful heat to the lower strata of lime stone, the azotic gas may thereby be detached and brought to the surface with them. It may also happen, that the atmospheric air may find a passage into the bowels of the earth, so that assisted by the great heat of these waters, the oxygene may be combined with substances for which it has a great attraction, allowing the azotic gas to pass and appear by itself at the surface. Hence may arise the carbonic acid, which may be detached from the lime stone by the acids formed by the combinations with the oxygene, producing thereby the sulphate of lime, &c. so easily detected in the Bath Waters.

I shall now recapitulate the several facts related in the foregoing experiments and ob-

servations, and shall compare them with what other authors have said on the subject. I find in most works on Mineralogy that mention is made of the lime stone about Bath being not fully saturated with carbonic acid. It has been stated, that when sulphur is united with it in the manner in which calcareous sulphuret is made, that a true hepar was produced. This experiment I have repeated, and the stone which I made use of, and which was fresh from the quarry, shewed no signs of its containing pure lime. The internal part of a large mass was taken for the experiments I made to ascertain this fact. It is possible however that the lime stone round Bath may vary in its composition.

The Bath Waters contain a large proportion of selenite or sulphate of lime. This appears from the crystals which are formed on evaporating these waters and from the tests which have been employed. Doctor Falconer has made some observations on the crystallization of selenite. To produce large crystals of this substance I find the following

process will succeed : I take a large bottle filled with a solution of sulphuret of lime, and I leave a small communication between the surface of the solution and the external air, by means of a small hole through the cork. The sulphur by these means very gradually combines with the oxygene of the atmosphere, forming sulphuric acid. This acid with the lime forms selenite, and in consequence of the slowness with which it is formed a very gradual crystallization takes place. In the trials I have made the crystals of selenite were of a considerable size. Carbonate of lime accompanies the selenite in the Bath Water. It however forms but a small part of the solid ingredients. The addition of lime water and the consequent precipitation, seem to shew that the lime is sursaturated with carbonic acid. Doctor Saunders mentions that the pure ammonia would throw down the calcareous carbonate by depriving it of some of the carbonic acid with which it is supersaturated, and hence he thinks that I am in an error with respect to the clay. I have frequently repeated the

experiments and I find that after all the lime has been separated by oxalic acid and filtered, there is always a precipitation on the addition of pure ammonia. From these experiments and from others before related, I conclude that these waters contain a salt whose basis is clay.

The Iron in the Bath Waters is in small quantities, but it is in a state of great activity and of very minute division. As the iron disappears on cooling the waters, there is of course no possibility of being certain as to its precise quantity. There is no sulphur contained in the waters, although the sand in the Bath contains a small portion of it.

Doctor Lucas makes the following estimate of the several ingredients of the Bath Waters:—Of sulphate of lime thirty-one grains and a half; of carbonate of lime twenty-two grains and a half; of sulphate of soda twenty-six grains; of common salt fifty two grains; and of oxyde of iron about one thirty-eighth or not quite a quarter of a grain

in the wine gallon. Total one hundred and thirty-two grains nearly, of which fifty-four are earthy, and little soluble in water, and seventy-eight are neutral alkaline salts, and very soluble.

Doctor Charlton's analysis comes very near to that of Doctor Lucas. He obtained thirty-four grains of residuum in a quart of the King's-Bath Water, of which twenty parts were soluble in rain water and fourteen subsided.

From six gallons of King's-Bath Water Doctor Falconer obtained seven drachms and half scruple or four hundred and thirty grains of solid residuum, which is only about seventy-one grains in the gallon. According to Doctor Falconer, out of eighty grains of solid residuum, warm water, repeatedly added, would dissolve only thirty-one grains, leaving therefore forty-nine for the insoluble part. This, if brought to the proportion of the seventy-one grains of total residuum in the gallon, will give about twenty-seven

grains and a half of the neutral salts, and forty-three and a half of the selenite and insoluble calcareous earth.

Doctor Falconer has given the general results of his experiments in the following order:

1. Saline Bodies.	Simple 1. Vitr: acid per se very dubious.
	Compouud 2. Common salt in small quantities.
2. Inflammable Bodies.	3. Hepar sulphuris cum calce viva, in large quantity.
3. Metallic Bodies	4. Iron, 1-37½ of a grain in a pint of water.
	5. Lead, Qu. if this be not an accidental impregnation.
4. Earthy Bodies.	6. Selenites in large quantities.
5. Aerial Bodies.	7. Common air probably both in solution or mixture and diffusion.
	8. Mephitic air in large quantities.

According to my experiments I beg leave to make a statement of the Bath Waters in the following manner:

1.—The temperature at a medium in the King's-Bath 114°, in the Hot-Bath a little above that of the King's-Bath, and in the Cross-Bath about 96°.

2.—In the water carbonic acid gas and azotic gas in very small quantities. The carbonic acid sursaturates the carbonate of lime which is evolved by boiling. The following aeriform fluids escape from the springs through the water and appear in bubbles on the surface:

a.—Azotic gas - - - - ,80.
b.—Carbonic acid gas ,15.
c.—Oxygene gas - - ,05.

3.—Iron in a state of extreme division, the quantities in consequence of its apparent volatility not to be estimated. According to some writers the King's-Bath contains the largest portion.

4.—Sulphate of lime or selenite in the proportion of ,40 of the solid residuum.

5.—Supersaturated carbonate of lime ,20.

6.—Silex ,15.

7.—Alum, or sulphate of alumine ,05.

8.—Common salt and sulphate of soda ,20.

The solid matter forms about a 660th part of these waters.

The sand which is thrown up by these springs is composed of silex, selenite, carbonate of lime, some sulphur, and some particles of iron which have been found to be attracted by the magnet.

THE END.

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