together with a plan of the whole, as he believes it appeared in its original ſplendor and perfection; that poſterity may not be deprived of informations, which are of ſo great benefit and importance to all lovers of architecture. It is alſo ſaid, that the engineer [carpenter], who invented the ſcaffolding, has made an exact model of it for him; which he intends to publiſh as a part of the work before-mentioned.

XVII. *An Account of a new medicinal Well, lately diſcovered near* Moffat, *in* Annandale, *in the County of* Dumfries. *By Mr.* John Walker, *of* Borgue-Houſe, *near* Kirkudbright, *in* Scotland.

Read Feb. 10, & Mar. 3, 1757.

THIS mineral ſpring was found out by one Mr. Williamſon, a few years ago, when he was overſeeing a mine, which was at that time carrying on in its neighbourhood. It is ſituate about four miles diſtant from Moffat, in the bottom of a deep ſcar, which is on the weſt ſide of a large mountain called Hartfell, from which it has acquired the name of Hartfell-ſpaw. This ſcar is a part of the mountain, thro' which a ſmall ſtream of water has worn its way to a conſiderable depth; by which it has laid open, and expoſed to view, the ſtrata of the earth on each ſide: and in the bottom of this ſcar, and near to the brink of this ſmall brook, the mineral water ſprings up.

When

When I ſaw it, it conſiſted of two ſprings, which were very well ordered by Mr. Williamſon, ſo as to run from two wooden ſpouts, immediately at their riſe out of the earth; which indeed muſt be of very great advantage to all mineral waters: and I am perſuaded there are many, whoſe medical qualities are greatly impaired by falling into reſervoirs, and continuing in them for ſome time after they ſpring from the earth. The one of theſe ſprings was ſituate about ten or twelve yards further up the brook than the other; and they were then diſtinguiſhed by the names of the upper and lower ſpring: but I have been ſince informed, that their ſituation is now altered. Each of theſe ſprings did at that time run nearly the ſame quantity of water, which, as I thought, was above an Engliſh quart in a minute, and that during a ſeaſon of very dry weather.

As there are many inſtances of mineral waters ſpringing out of the earth very near each other, which at the ſame time are impregnated with very different principles; it therefore ſeemed not at all improbable, that as theſe waters did appear to run, for ſome part of their courſe, in different channels, they might in ſome reſpects be different from each other. And this ſuſpicion I found not to be altogether groundleſs with regard to theſe ſprings, as will be ſhewn afterwards. For which reaſon it may be obſerved, that the following trials were all made upon the water of the upper fountain, except where the other is particularly mentioned; and alſo that they were made within 24 hours after the water was taken from the ſpring, being carried to Moffat in bottles carefully ſealed.

According

According to what may be inferred from the following experiments, it may be premiſed, that this water appears to contain in it a large proportion of iron, but in two different forms; and an aluminous ſalt, which is conjoined with a terreſtrial principle.

As the contents of ſeveral mineral waters have been the cauſe of many different opinions, and of great diſputes among phyſicians and chymiſts; as the inquiry I made into the principles of theſe waters, which I am now conſidering, was not performed with that nicety and exactneſs I could have wiſhed; and as I am perſuaded, that to dogmatize in any branch of philoſophy can never tend to its advancement; I ſhall not therefore pretend to determine with certainty in any part of this ſubject, where the contrary opinion can be admitted with the leaſt degree of probability. Theſe trials are indeed but few and imperfect, and are no-way ſufficient to form an exact account of this mineral water; yet I believe they may afford ſome concluſions, which may be ſerviceable in compiling a more compleat hiſtory of it. They render it pretty evident, that the abovementioned principles are contained in theſe waters: and tho' I will not pretend abſolutely to exclude all others, yet I muſt ſay, that, by what inquiry I made, I could not obſerve them to be in the leaſt impregnated with any other kind of mineral ſubſtance.

After a good deal of obſervation upon the water of this Spaw; and after many fruitleſs attempts, which I have at different times made upon ſeveral other waters of the chalybeat kind in Scotland, in queſt of the volatile ſpirit, which has been commonly artributed to them; I muſt own, that I have been induced

induced to think, that there is no ſuch thing exiſts in theſe waters at all. What has been generally called the ſpirit of ſteel waters, ſeems to me to be very unintelligible; altho' the exiſtence of it in theſe waters has been aſſerted by all the writers on this ſubject, which I have yet had occaſion to ſee. The ſpirit of a mixed body is commonly taken to be a ſubtile, penetrating, light, and volatile ſubſtance, more ſuſceptible of motion than any other of its parts, and moſt eaſily ſeparable from them by avolation. But that any chalybeat water contains ſuch a ſubſtance, I think has never been made evident, unleſs where the water has been found to be impregnated with ſome other mineral principles. Some ſteel waters, I believe, contain a large proportion of air, whoſe elaſticity may occaſion it to break forth with an exploſive force; ſome others there are, which contain a volatile and ſulphureous halitus; and to one or other of theſe two cauſes, or to ſome other mineral principle, I think moſt of the phænomena may be referred, which have been attributed to a ferrugineous or vitriolic volatile ſpirit.

As the firſt thing obſervable in a mineral water is its outward form, we muſt therefore take notice, that the water of this Spaw equals the cleareſt ſpring-water in tranſparency; and is likewiſe as free of any colour or odour: yet its taſte is very ſtrong, and may be diſcerned to be compounded of a ſweet, ſubacid, and aſtringent taſte. Its ſweetneſs and acidity appear ſenſibly to ariſe from alum; and its high ſtyptic and aſtringent taſte does as evidently proceed from that mineral ſalt, joined with ſome earthy or ferrugineous parts. I muſt likewiſe obſerve, that when

I firſt

I firſt compared the taſte of theſe two ſprings, I could plainly diſcern, that the water of the lower ſpring was more acid, and leſs aſtringent, than that of the upper one; and, on the contrary, the water of the upper ſpring ſeemed more aſtringent, and leſs acid. This induced me to think, that the mineral parts, which cauſed the acid and aſtringent taſtes, were mixed in the waters of theſe two ſprings in different proportions. And what I obſerved of them afterwards ſtill confirmed this conjecture.

But, in order to give ſome evidence for the exiſtence of the above-mentioned minerals in the waters of theſe ſprings, we ſhall conſider them ſeparately, by relating the experiments, which ſeemed to indicate, that they are contained in theſe waters in a very conſiderable proportion, and by offering ſome concluſions, which may be reaſonably drawn from them.

And as the firſt trials were made in queſt of iron, it may perhaps be moſt proper to conſider it in the firſt place.

Experiment 1. Some pieces of galls being added to equal quantities of the water of the two ſprings, an exceeding deep and bright blue colour was immediately produced in the water of the upper ſpring, which in a little time turned to a perfect black. The water of the lower ſpring, tho' indeed it was turned of the ſame colour, yet was not of ſo deep a ſhade, but was ſomewhat lighter than the former. The tincture of galls cauſed the ſame appearances.

2. A tincture of balauſtine-flowers produced the above blue colours in both waters.

3. A quantity of the water being thoroughly tinged with galls, was allowed to ſtand 24 hours: being then filtrated thro' brown paper, the water, tho' almoſt quite colourleſs, would not again receive any tincture with galls.

4. After elixation the water became of a turbid yellow colour with ochre, and afforded very little tincture with galls.

5. A ſolution of ſal Martis, chemically prepared, being mixed with galls, immediately turned of a bright dark blue colour, exactly ſimilar to that produced in the water.

6. A ſolution of common and rock alum was noways changed in its colour with galls.

7. A ſolution of ſal Martis and alum being mixed in equal quantities, the mixture was turned of a bright blue colour with galls; yet not of ſo deep a hue, but of a more diluted colour than the ſolution of ſal Martis, without alum.

From theſe experiments we muſt firſt of all obſerve, that the colour, which theſe waters afford with galls and pomegranate-flowers, is very uncommon. The more iron, that any mineral water contains, it will afford the deeper colour with ſuch aſtringents: but tho' I have tried this experiment upon a great many of the ferrugineous waters in Scotland, and alſo upon the water of ſome of the foreign Spaws, I never obſerved one, that afforded ſo deep a colour as this, which we now conſider. Some of the weakeſt of them gives only a red or faint purple tincture, and the ſtrongeſt only a deep purple: but I never ſaw or heard of any chalybeat water, but this, either in Scotland

Scotland or elſewhere, that afforded an intenſe black and inky colour with galls. From which, I think we may venture to conclude, that the water of this Spaw contains a far larger proportion of iron than moſt, or perhaps than any, other chalybeat water hitherto diſcovered: and for this reaſon, I dare ſay, it will likewiſe be ſo much the more preferable to moſt others in medicinal virtues; which has indeed already appeared by many ſurpriſing cures it has performed, and which, I am perſuaded, will more fully appear, when its medicinal effects ſhall be better known.

There muſt needs be a very great quantity of iron in this water, when it yields as deep a colour with galls as a ſtrong ſolution of ſal Martis. I was indeed at firſt apprehenſive, that this perhaps might not be owing ſo much to a large and uncommon proportion of chalybeat parts, as to the commixture of alum, which I judged to be in the water. But we ſee the contrary appears by theſe trials: for alum of itſelf affords no tincture with aſtringents, and, inſtead of rendering a ſolution of ſal Martis with galls of a more intenſe colour, rather makes it lighter and more diluted.

We ſee here, that the ferrugineous matter is intirely ſeparated from the water by an infuſion of galls. The like alſo happens by elixation; after which it is almoſt deprived of its tinging quality. Yet other chalybeat waters loſe this quality by a much leſs degree of heat.

As there is an ochrous earth ſeparated from all ſteel waters, when expoſed to the air, which ſubſides

to the bottom, and a metalline ſcum or cremor, which ſwim on their ſurface; we ſhall next conſider the appearances, which they make in this water.

Exp. 8. A ſolution of ſaccharum Saturni being dropt into common ſpring-water, left the upper parts of the water clear and colourleſs, but formed a lacteſcency towards the bottom. The ſame ſolution being added to the mineral water, ſoon turned it of a turbid yellow colour, which afterwards ſubſided, and formed a deep yellow cloud in the bottom of the glaſs; and below this yellow ſediment there adhered to the bottom of the glaſs a whitiſh ſubſtance, which I took to be the metalline parts of the ſaccharum Saturni ſeparated from the purer parts of the ſalt, which were ſtill ſuſpended in the water, and which made it of a muddy whitiſh colour.

9. Forty drops of oleum tartari per deliquium being added to an ounce of the water, made it of an uniform light yellow colour; but in an hour afterwards there were many ſmall yellow terrene *nubeculæ* formed in it. Theſe the next day were more conſpicuous, being thoroughly ſeparated from the water, and precipitated to the bottom, leaving the water quite clear, as it was before the mixture. A ſmall quantity of this limpid water being taken, it would afford no tincture with galls. It was then all poured off, except ſo much in the bottom of the glaſs as contained the above-mentioned clouds: to this there were ſome galls added, which in half an hour turned theſe clouds from a light yellow to a deep red colour, but did not change the colour of the water, in which they ſwam.

10. Im-

10. Immediately after the affuſion of ol. tart. p. d. to the water, galls were added to the mixture, which tinged it of a deep and bright red colour. After ſtanding for ſome time, there were red clouds precipitated to the bottom, and the water continued of a duſky opake red colour.

11. There is a ſmall brook, formerly mentioned, which runs near by theſe ſprings; into which the water, that flows from them, is diſcharged. I obſerved the ſtones and channel of this brook all tinged with ochre of a deep yellow colour, ſo far up as the water of theſe ſprings flowed into it; but the channel, which the mineral water ran over before it was mixed with the water of the brook, was very little or nothing diſcoloured with ochre. As I conjectured what this was owing to, I afterwards took two equal quantities of the mineral water, into one of which I put an equal quantity of common water. In two hours the mixture became leſs tranſparent, and appeared yellowiſh, while the ſimple mineral water retained its clearneſs. Next day there was much ochre ſeparated from the mixture, which ſubſided to the bottom of the glaſs: but the unmixed mineral water remained ſtill clear and colourleſs, as at firſt.

All chalybeat waters ſeparate their ochrous parts, when expoſed ſome time to the air; but this ſeparation is made ſooner by the commixture of ſeveral kinds of ſalts. Thus we ſee the ochre in this water is immediately ſeparated and precipitated by the ſolution of ſaccharum Saturni.

The oil of tartar cauſes a precipitation of theſe ferrugineous parts in the ſame manner. Which parts muſt

muſt be the ſole cauſe, that the water receives a tincture from galls; ſince, after they are precipitate, it loſes that quality, which they notwithſtanding retain even after they are ſeparated from the water. This precipitation of the ochrous parts of the water were the only viſible effects that I could perceive to follow from the affuſion of the ol. tart. p. d. I remember indeed, when I was at Moffat, I ſaw the manuſcript of Dr. Horſburgh's experiments upon this mineral water; which appeared to be very accurate; and which I underſtand are ſince printed, in a volume lately publiſhed by the Philoſophical Society at Edinburgh. Amongſt theſe I obſerved one, which I thought ſo very remarkable, that I particularly adverted to it. It was the effects of the affuſion of ol. tart. p. d. to the water, producing in it clouds, or a coagulation of a green or graſs-green colour. I think theſe were the words; and I own I was ſomething ſurpriſed at them. A ſolution of vitriolum Martis, mixed with this alkaline oil, does indeed produce a green coagulum: but I could ſcarcely think, that this, or any other chalybeat water, contained ſo large a proportion of that vitriol, as to be ſufficient to produce theſe effects, when I conſidered, that ſo many writers, which I had ſeen, upon this ſubject, have all failed in their attempts of extracting a conſpicuous martial vitriol from ſuch mineral waters. I had tried this experiment upon four or five chalybeat ſprings in Scotland, and likewiſe upon the Spa and Pyrmont waters, which had been well preſerved; but there never reſulted any ſuch effects from the mixture of theſe with oil of tartar, as are related in the above experiment. All the alteration it pro-

duced in theſe waters was the precipitation of an ochrous earth, but without the leaſt appearance of any green colour. As I looked upon this as a leading experiment in the hiſtory of vitriolic waters; as I had often tried it, and as often ſeen the green coagulum produced with the ſolution of the factitious vitriol, and never could obſerve it produced in any of the above water; I began to ſuſpect, that theſe waters were either not poſſeſſed of a vitriolic ſalt at all, or elſe, that it was in ſome reſpects very different from the factitious vitriol. For theſe reaſons, Dr. Horſburgh's experiment appeared very extraordinary; tho' at the ſame time I was greatly pleaſed, that I ſhould have the opportunity of repeating it, and of obſerving thoſe phænomena in this ferrugineous water, which I had ſought for in vain in ſeveral others. But when I came to make the trial, I was yet more ſurpriſed, when I found it miſgive, and that the ol. tart. p. d. produced no green colour or coagulum in this mineral water, nor cauſed any other alteration in it, than the ſeparation of a large quantity of ochrous earth of a yellow colour, exactly the ſame with what I had obſerved in the other ſteel waters. This failure made me immediately conclude, that I had ſomehow or other committed an error in the experiment: and tho' I was pretty ſure, that the mineral water, which I had uſed in it, was quite freſh, yet I could not be ſo poſitive as to the oil of tartar, which I ſuſpected to have been long kept. Yet that this could have been the cauſe of my being ſo unſucceſsful, I could ſcarcely believe, tho' indeed I could aſſign no other. I was ſorry, that I had not afterwards an opportunity of repeating this experiment with more

accuracy,

accuracy, from which I might have expected to reap more ſucceſs, as it is perhaps one of the moſt conſequence, that can be performed on this mineral water, as it is capable of demonſtrating the exiſtence of a ſubſtantial vitriolum Martis in it; which is more than has been hitherto done, or perhaps ever will be done, concerning any one of the vaſt number of chalybeat waters, which have been yet diſcovered.

When galls are added to the water, at the ſame time with oil of tartar, inſtead of its deep blue colour, it affords only a red tincture.

It appears from the 11th experiment, that an addition of common water cauſes the mineral water to precipitate its ochre; and the reaſon of this is obvious: for if theſe ochrous parts be altogether terrene, as they appear to be, and exiſt in the water unconnected with any other principle, then it muſt happen, that as theſe parts are uniformly diffuſed thro' the water, in which they are ſuſpended as in a menſtruum; by the addition of common water, this menſtruum being diluted, the coheſion of theſe terrene parts muſt be thereby weakened, and their contact deſtroyed; ſo that their menſtrual equilibrium being thus taken off, they can be no longer ſupported in the fluid, but muſt be precipitated by the force of their own gravity.

Exp. 12. When the water was expoſed for ſome days to the air, there was a cremor ſeparated from it of a ſhining chalybeat colour. This, like other kinds of cremor, takes a conſiderable time to compleat its intire ſeparation from the fluid, out of which it is expelled: for when it was deſpumated, a new cremor

cremor always ſucceeded, until the whole quantity, which the water contained, was exhauſted.

13. When this cremor firſt appeared on the water, it was of a faint blueiſh colour: but as it increaſed, it changed into a deeper and more bright ſhining blue: and, after longer ſtanding, it became blotched with various colours, as red, orange, yellow, green, blue, purple, and violet.

14. A quantity of the water being put in a gentle heat, this cremor was quickly ſeparated from it, and appeared on the ſurface of the water. A like quantity of the water, with its cremor already upon its ſurface, was put over a gentle heat, which by degrees broke the cremor into very ſmall parts; but whether they did evaporate, or precipitate in the water, I could not be certain. But, by other trials, this cremor was found to have a great degree of fixity, bearing a conſiderable heat without avolation; yet not without the appearance of ſome of its parts flying off, altho' moſt of them were fixed; becauſe what remained loſt its fine colours, and was changed into a ſhining chalybeat colour.

15. The water of the lower ſpring afforded a much leſs quantity of the cremor, than the water of the upper ſpring. It took alſo a longer time to ſeparate, was of a blueiſh colour, and had not the vivid colours, which the water of the upper ſpring ſhewed.

16. When ol. tart. p. d. and ſpirit of ſal ammoniac were added to the water, it did not ſeparate its cremor.

This cremor, which is ſeparated from the water, is the ſame with that, which appears on the ſurface of

a ſolution of vitriolum Martis, when expoſed for ſome time to the air: and an infuſion of iron in common water alſo emits a cremor of the ſame kind. I remember, as I was once carefully obſerving a large glaſs full of a chalybeat water, which contained much of this cremor; ſoon after it was expoſed to the air, I obſerved a tenuious blueiſh vapour riſing in the parts of the water next the ſurface, which very much diminiſhed its tranſparency; and by degrees this vapour was emitted by the loweſt parts of the water: but as the cremor increaſed on its ſurface, the water became gradually deprived of the blueiſh tincture, which it received from this halituous body; which was apparently nothing elſe but the parts of the cremor ſeparating from the water, and aſcending upwards. From whence we may conclude, that this cremor conſiſts of the very fineſt parts of iron attenuated to the higheſt degree.

It has been the opinion of moſt naturaliſts, that theſe kind of mineral waters do abound in ſulphureous parts. This they have conjectured from the foetor, that often attends them. But in what quantity or form theſe parts exiſt in the fluid, or by what means they can be rendered conſpicuous, has not as yet been ſufficiently determined. Yet, I think, we may ſuſpect ſome of the parts of this cremor to be ſulphureous. They are volatile, and, being heated, do fly off from the pure metalline parts, which being more fixed, are thereby left deſtitute of thoſe vivid colours, which they enjoyed from the ſulphureous parts. Theſe are evident marks of ſulphur, and are altogether analogous to ſome other appearances of that mineral. Another obſervation tending to ſupport this is the want of thoſe vivid colours in the cremor,

cremor, which appears on an infuſion of iron; the reaſon of which ſeems to be the loſs of the ſulphureous parts of the chalybeat minerals by avolation, during the operations of the fire, which they undergo in refining.

It appears from the fifteenth experiment, that the water of theſe two ſprings contains a very different proportion of this cremor: and from the laſt, that it is precipitated along with the ochrous parts, which happens upon the affuſion of theſe alkaline liquors.

The next trials were in queſt of alum.

Exp. 17. A quantity of the water being kept for ſome time in a boiling heat, and after it was cool being filtred quite clear from its ochrous matter, it ſtill retained a ſubacid and aluminous taſte in a very ſtrong degree.

18. To an ounce of common ſpring-water there was added two gutts of freſh ſweet milk. This mixture being ſhaken, the milk mixed intimately with the water, without any kind of coagulation.

19. The ſame experiment being made with the mineral water, the milk, upon its affuſion, was ſo curdled, or ſeparated into clouds, that the greateſt ſhaking could not mix or incorporate it with the water.

20. This experiment being alſo made with a weak ſolution of alum in ſpring-water, its effects upon the milk were not in the leaſt different from thoſe of the mineral water.

21. And the ſame trial being again repeated with

the water, when boiled and filtred from its ochrous parts, the milk was in the ſame manner coagulated as before elixation.

22. One part of ſweet milk being added to four parts of the mineral water, the milk ſubſided, and formed a cloud in the bottom of the glaſs, leaving the upper parts of the water clear. This mixture being heartily ſhaken, the milk mixed ſo well with the water, that it appeared to be but a very little curdled.

23. When a larger quantity of milk was added to a ſmaller quantity of water, and even when equal parts of the milk and mineral water were mixed and ſhaken together, there could be no curdling or coagulation obſerved.

24. An equal quantity of the water and milk being boiled together, the greateſt part of the milk was coagulated into a thick white curd; and the remainder, with the mineral water, turned of a pure white milky colour, which drank like whey, and was very agreeable.

25. Eight gutts of ſweet milk being added to four ounces of the water, and the mixture boiled, part of the milk was thereby curdled, and ſwam upon the top of the water. The ochrous parts of the water were likewiſe ſeparated, and falling to the bottom, their colour did not appear of a clear yellow, as uſual, but was ſomething milky.

All theſe experiments ſtrongly indicate the exiſtence of alum in this water. It retains its aluminous taſte, and coagulates milk, after the chalybeat parts are almoſt all expelled by elixation. The coagulation.

tion of the milk demonſtrates an acidity in the water, and the other appearances ſhew that acidity to be owing to an aluminous ſalt.

It appears, that the milk requires a large quantity of the water, to make a ſenſible coagulation in it: for, in the 22d experiment, one part of the milk being added to four parts of the mineral water, the coagulation was ſcarcely diſcernible: and in the 23d, when an equal or larger quantity of milk was added to the water, the coagulation was not at all obſervable. I have heard it confidently averred, that this mineral water did not at all curdle milk; which, I ſuppoſe, has been thro' a miſtake in the experiment, in adding too large a proportion of milk to the water: for in this way the coagulation cannot be obſerved.

I imagined, that when the water was boiled with milk, the mixture would have become of a muddy yellow colour, by the ſeparation of the ochre: but it did not even appear, that the ochre was at all ſeparated from the mixture, as it is from the water when boiled by itſelf. On the contrary, not only the coagulum, but alſo the liquor, was of a pure white colour, and of a pleaſant taſte: and this makes me think it worth the inquiring into, whether or not the water does retain its medical qualities after it is prepared in this manner with milk? For, if it does, ſuch a preparation might certainly be very ſerviceable in many caſes.

Theſe experiments, which we next relate, do not only aſcertain the exiſtence of alum in the water with greater certainty, but alſo, that there is a particular kind of earth conjoined with this ſalt.

Exp.

Exp. 26. An Engliſh quart of the water being kept boiling for a quarter of an hour, it turned thick, muddy, and yellow, by the ſeparation of its ochrous parts; and, being ſet to cool in a clean bowl, the next day all the ochre was ſubſided to the bottom, from which the water was carefully filtred: whereby it became almoſt as clear and limpid as before the elixation, retaining a ſharp aluminous taſte, but was deprived of the ſtrong ferrugineous taſte, which it had at firſt. This water was again boiled; by which means it was again turned a little yellow, by the ſeparation of ſome more ochre. It was therefore again filtred, and rendered clear, and its aluminous taſte was ſtronger than before. After this filtration, the water was evaporated in a ſand-heat to about a ſixteenth part of the original quantity, and then it taſted like a ſtrong ſolution of alum joined with a ſmall degree of a chalybeat taſte. And this being totally evaporated in a glaſs, there adhered upon its ſides a pure white ſalt; and a larger quantity of the ſame ſalt remained in the bottom of the glaſs, which was not ſo white, but more impure than the former, and of a brown colour.

27. This ſalt, thus procured from the water, being mixed with diſtilled vinegar and ſpirit of vitriol, there was not the leaſt efferveſcence produced.

28. Some of the brown-coloured ſalt being put upon a red-hot iron, it did neither ſparkle nor decrepitate; but was turned into a blackiſh cineritious ſubſtance, which in a ſhort time became a white calx. And tho' ſome of the ſalt was put upon the iron finely powdered, yet it concreted, and run together in a cinder, whoſe coheſion was afterwards deſtroyed when calcined by a further degree of heat.

29. As

29. As I was accidentally deprived of the opportunity of obtaining the cryſtals of this ſalt, which would have been the beſt means of knowing to what ſpecies it was to be referred; I diſſolved the whole maſs in a ſmall quantity of ſpring-water, and, by filtrating this ſolution, I obtained a large proportion of fine earth of a brown colour.

30. This ſolution of the ſalt afforded a deep blue tincture with galls.

31. The ſame ſolution, being mixed with ſyrup of violets, became of a reddiſh colour.

32. Saccharum Saturni being added to the ſolution, precipitated a thick lacteſcent cloud.

33. Ol. tart. p. d. being alſo added to this ſolution, it cauſed no viſible efferveſcence, yet raiſed ſome bubbles of air, and cauſed a coagulation of many ſmall brown terrene nubeculæ in the water; which, after ſtanding ſome time, ſubſided to the bottom, and left the water clear.

Theſe experiments do plainly evince, that this water contains an aluminous ſalt, conjoined with a fine terrene ſubſtance, which is probably a part of the matrix, from whence the ſalt has been formed.

This ſalt gives no ſigns of any alkaline principle; but, on the contrary, of an acidity, as its ſolution reddens with ſyrup of violets.

With this ſalt there are alſo intimately conjoined ſome very ſubtile chalybeat parts, which are not ſeparable from it by elixation or evaporation.

Alum is diſtinguiſhable from all other mineral ſalts, by liquifying and bubbling upon a red-hot iron, and turning into a white calx. But this could not be well expected from this aluminous ſalt, which we

had extracted from the water, becauſe it was extremely foul, by being combined with ſo large a proportion of earth; which earthy parts were the occaſion of turning the ſalt of a blackiſh colour upon the iron. However, we ſee it turns white by a further degree of heat. But if the ſalt had been diſſolved, filtrated, and cryſtallized, till it had been purified and freed from this terrene matter, it would then certainly have had the ſame appearance upon the red-hot iron, as a pure aluminous ſalt. Again, as it is peculiar to an aluminous ſalt to liquify in ſome degree with fire, ſo we ſee, that this was evidently the caſe of this ſalt. Its eliquation indeed could not be ſo remarkable, as in pure alum, becauſe of its being mixed with ſo much earth; but that it did liquify in ſome degree is plain, becauſe the whole maſs of ſalt and earth, even when reduced to a powder, ran all together like a cinder.

The experiment upon the ſolution of this ſalt with ol. tart. p. d. is alſo a further proof of what we have already aſſerted: for tho' there was no viſible effervescence, yet the bubbles of air ſhew, that there was an inteſtine conflict of the oil with the acid principle in the ſolution; which being abſorbed by the alkali, the earth was precipitated, to which it formerly adhered.

The two next experiments were made in order to diſcover, whether an acid or alkaline principle prevailed in the water.

Exp. 34. Forty gutts of the ſyrup of violets being added to an ounce of the water, the mixture became of a bright ſea-green colour.

35. A quantity of the water being kept boiling for five minutes, and afterwards allowed to ſtand till it became clear, was carefully filtrated from its ochrous ſediment: after which, upon its mixture with ſyrup of violets, it turned of a faint reddiſh colour.

From theſe experiments we infer, that this mineral water contains both an alkaline and an acid principle; the former conſiſting of the ochrous and ferrugineous parts, which are ſeparated from the water by elixation; and the latter of the aluminous ſalt, which remains in the water after elixation.

The following trials were made in order to know what effects are produced in the water by being expoſed to the air; and in what reſpects the waters of the two ſprings differed from each other.

Exp. 37. An Engliſh quart of the water of each of the ſprings being fully expoſed to the air in two China bowls, the next day that of the under ſpring was neither altered in its taſte, colour, or tranſparency, nor in any other ſhape whatever; but that of the upper ſpring appeared of a yellowiſh colour, altho' it was clear and tranſparent as the other.

On the ſecond day the taſte of the waters ſcarcely appeared to be any way diminiſhed. No ſenſible change could be obſerved in the lower water; but the upper water was become more yellow than it was the day before, yet without any loſs of its tranſparency. They both tinged of a deep blue colour with galls; which tinctures appeared equally deep

and ſtrong, as they did before the waters were expoſed to the air.

The third day the lower water appeared clear and colourleſs as before, only its ſurface was covered with a few ſmall ſpots of cremor. The upper water appeared more yellowiſh than formerly, and its ſurface was almoſt wholly covered over with the cremor. They both afforded a tincture with galls, which was not ſenſibly different from what they gave before their expoſure.

On the fourteenth day the water of the under well had precipitated a yellow ochrous ſediment, but the other water a more conſiderable quantity. A large quantity of cremor continued alſo to ſwim upon the ſurface of the upper water, but there was very little ſeparated from the water of the under well. Both waters being now tried with galls, inſtead of the deep blue colour, which they did formerly exhibit, they now became only of a deep purple colour.

On the twentieth day the viſible appearance of both waters was the ſame as when laſt obſerved.

On the thirty-eighth day they both afforded as deep a purple colour with galls, as they did three weeks before; and during that time alſo they had not precipitated any more of their ochrous parts, nor ſuffered any other ſenſible alteration.

The water of the upper well being filtrated from all the ferrugineous matter, which it had ſeparated during theſe thirty-eight days, was rendered almoſt as limpid and clear as when newly taken from the well: but, being boiled for ſome time, it became of a turbid yellow colour; and being allowed to ſtand,

it

it again precipitated abundance of an ochrous ſediment; and being filtrated, and mixed with galls, it received a faint purple colour of a blueiſh hue.

38. A bottle of the water of each of theſe ſprings, being carefully ſealed, carried to Moffat, and kept for two months, ſuffered not the leaſt alteration during that time, but was as freſh as when immediately taken from the fountain. And I am informed, that after it is carried to Edinburgh, and to places at a greater diſtance, it will keep a much longer time without being any way ſpoiled.

I believe it will appear from theſe obſervations, that this mineral water continues longer intire, and particularly that it retains the quality of tinging with galls longer, than moſt others of the chalybeat kind: at leaſt, of a great number, which I have ſeen deſcribed, I do not remember one, that retains it near ſo long, when expoſed to the open air. Many of them loſe this quality intirely in a few hours; and it is greatly impaired in the ſame time, even in thoſe which retain it longeſt. But this water, we ſee, remains expoſed to the open air for days, without almoſt any alteration. This may perhaps be owing either to the larger proportion of ferrugineous parts, with which it is impregnated; to their being attenuated to a greater degree; or to their more perfect commixture with the water, by means of the aluminous ſalt. The longer time, that any mineral water does remain intire, without any ſeparation of its mineral parts; or the longer it retains the ſame form, which it has when newly taken from the ſpring; the more perfect is the commixture of theſe parts with their

fluid vehicle: and I believe, upon that account, will be more effectual for medicinal uſes: for which reaſon, I ſuppoſe, theſe waters may prove a more beneficial medicine, than any others of the ferrugineous kind, whoſe mineral contents are not ſo intimately commixed with the aqueous fluid.

As theſe waters are ſo long in ſeparating their mineral contents, they appear particularly well adapted for being tranſported to diſtant places: for by this quality they are fitted to undergo a long carriage, and to be kept a conſiderable time, without any diminution of their medicinal virtues. It muſt alſo be noticed, that the water of the under well is by much the beſt of the two for carriage, or for being long kept, as it is longer in ſeparating its mineral contents than the upper one.

From theſe experiments it is evident, that there is a conſiderable difference betwixt the waters of the two ſprings. The upper one contains a much larger quantity of the ochrous earth, and metalline cremor, than the under one; which is the reaſon, why it yields a deeper colour with galls, as may be obſerved in the firſt experiment. I ſuſpected, on the other hand, that the under water contained a greater proportion of alum, than the water of the upper ſpring; but this I cannot affirm, as I find I had neglected to make the experiment, which would have determined whether it be ſo or not. Tho' the mineral contents of theſe two waters be ſimilar, yet, if they be thus mixed in them in different proportions, this muſt certainly create a difference between them, which deſerves to be attended to, as it may be ſufficient to diſallow of their being uſed promiſcuouſly, ſince their medicinal effects may be thereby different.

But

But now, to ſum up the evidence, which theſe experiments, taken all together, do afford, concerning the mineral ingredients of this Spaw; I think they determine, with ſome degree of certainty, that it contains two different principles of iron, both of which are fixed. The one, which is the ochrous earth, is a true *minera ferri*, and, altho' it be a crude mineral, exiſts in the water in a very fine and ſubtile form; the other, which is the cremor or pellicle, whoſe parts are alſo extremely attenuated in the water, appears to be iron, not in its mineral, but in its metalline form, and, when thrown up upon the ſurface of the water, ſhews itſelf like an extreme thin *lamina* of that metal. There ſeems alſo to be ſome ſmall proportion of ſulphur joined with the metalline cremor. The other mineral ingredient, which enters into the compoſition of this Spaw, is a conſiderable proportion of an aluminous ſalt, which is conjoined with a ſmall quantity of a light brown-coloured earth (probably a part of the matrix whence the ſalt is formed), and ſtill more intimately connected with ſome of the chalybeat parts of the water, which are not ſeparable from it either by elixation or evaporation. Whether theſe be ſaline or terreſtrial, I cannot determine.

Having thus endeavoured to diſcover, by ſome plain and ſimple experiments, the mineral principles, with which this medicinal water is impregnated; I ſhall now only add ſome obſervations, with reſpect to the origin of ſteel waters, and particularly of this Spaw, whoſe origin, I think, is thereby diſcovered and aſcertained in a very obvious manner.

Among

Among ſeveral things, that are ſtill deficient in the hiſtory of mineral waters, an exact knowlege of their origin ſeems to be the chief; that is, from what foſſils, and in what manner, theſe waters do acquire the mineral ſubſtances, with which they are impregnated. As this happens in the bowels of the earth, and is therefore far removed from our view, it is not ſurpriſing, that there has been ſo little diſcovered concerning it; tho' indeed there have been many elaborate hypotheſes framed in order to account for it.

The writers on mineral waters have been of very different and oppoſite opinions concerning their origin. They have diſagreed widely amongſt themſelves; and I very much ſuſpect, that the accounts, which moſt of them give of this matter, are not agreeable to truth: particularly with reſpect to chalybeat waters, I have ſeen none, who have given a ſatisfactory account of their origin. They have all agreed, that iron, or the vitriol of that metal, does exiſt in mineral waters; but they have never yet agreed, how they came to exiſt in them, or in what manner mineral waters come to be imbued with theſe foſſils.

Some of the more ancient writers cannot comprehend, how ſimple water ſhould be intimately impregnated with ſo many different kinds of minerals, except by the means of ſome powerful agent. And as they thought nothing more proper for communicating and mixing mineral ſubſtances with water, than violent heat, they therefore termed all mineral waters, of whatever kind, by the name of *thermæ*. They ſaw ſome ſpring from the earth extremely hot, others moderately hot, others tepid, others exceſſively cold:

cold: they concluded from this, that all ſuch various degrees of heat in theſe waters were owing either to the different degree of ſubterranean fire, which they had undergone; or elſe to the great diſtance, which ſome of them had run in the earth, after they had been ſufficiently heated. They therefore maintained, that thoſe waters particularly termed *acidulæ* (the greateſt part of which are impregnated with iron), or thoſe, which, tho' intenſely cold, contained a large proportion of mineral matter, had in ſome part of the earth been impregnated with it, by means of an intenſe heat, which they had been gradually deprived of by a long paſſage thro' the colder parts of the earth.

Some naturaliſts again, of a later date, having exploded the former notion as chimerical, have thought, that a vapour riſing from vitriolic minerals, and mixed with the neighbouring ſtreams of water in the bowels of the earth, has imbued them with ſome of the parts, and with the properties, of vitriol.

Others are of opinion, that the exhalations of vitriolic minerals, paſſing thro' the cavities of the earth, are there condenſed by the ſubterraneous cold into a limpid fluid, containing the very fineſt parts of that mineral ſalt: which fluid, mixing with the præterlabent ſtreams of water, and iſſuing out of the earth with them, produce thoſe mineral ſprings called vitriolic.

The laſt opinion I ſhall mention on this ſubject, and which indeed appears the moſt plauſible, is of thoſe, who think, that the iron is corroded and diſſolved in theſe waters by means of an acid: for, as they imagine ſimple water incapable of doing this,

they ſuppoſe, that it is firſt imbued with an acid in the bowels of the earth; and then, by the corroſion of the chalybeat minerals, thro' which it runs, it comes to be impregnated with them. I once received this opinion, as the moſt probable I could then obſerve, concerning the origin of theſe ſprings: yet not as being ſatisfactory; for there are many objections againſt it, which it is difficult either to elude or to anſwer.

The ſuppoſition of an acidity in ferrugineous waters, I thought but ill confirmed, becauſe, upon trial, they diſcover no veſtiges of it, but rather appear to be alkaline. Beſides, in conſidering the cauſes of mineral waters, it ſeems more probable, that whatever minerals they contain, they muſt be ſuch, as can be received or extracted by common water in its paſſage thro' the earth, by ſolution, abraſion, or the like ſimple operations; and in this way alone I think we may come to account not only for the commixtion of the ſaline and terrene minerals, which are found in medical waters, but likewiſe of thoſe, that are metalline or ſulphureous; for which ſimple water, at firſt ſight, may perhaps ſeem to be an inſufficient ſolvent.

It was this notion, that firſt induced me to make trial upon various mineral and metallic bodies, in order to know how far they could communicate their virtues to common water by infuſion. I thought this might throw ſome light upon the origin of mineral waters: yet, tho' I made a great many experiments of this ſort, and particularly upon ſeveral kinds of native chalybeat minerals, I was as little ſatisfied concerning their origin as before. I at length, however, met,

met, by accident, with what I had inquired after with ſo little ſucceſs.

As I happened to be at a gentleman's houſe near Edinburgh, in whoſe eſtate there was a great deal of coal, and who was at that time working a level or adit, in order to drain off the water, I obſerved, that the current of water, which flowed from this level, ſeparated a great quantity of ochre, and, emptying itſelf into a river ſoon after it came from the entry of the level, tinged all the ſtones and the channel of the river, for a good way, of an ochrous colour. The taſte of this water was exactly like that of a common ſteel Spaw; and it afforded a purple colour with galls *. As I knew, that this water flowed off a great body of coal, I often infuſed that foſſil, taken from the pits near this level, in common water; but the infuſions never yielded any tincture with galls. I tried in the ſame way another mineral, that the miners call *blaes*; which is a cliffery ſtratum of a blueiſh colour, that often lies both above and below the coal: alſo another foſſil of a brown colour, which is very ponderous, and is called by the miners *dogger*; a thin ſeam of which often lies in the midſt of the coal. However, neither of theſe would afford an infuſion, that would tinge with galls. At laſt I got another mineral out of theſe coal-pits, which is ſometimes found amongſt the coal, but is not ſo frequent as any of the former; and this fully

* Within two miles of this place there is a ſteel Spaw of good repute for the performance of ſeveral extraordinary cures, which gives the ſame tincture with galls, and appears in every reſpect to be the ſame with the water, that flows from this level.

anſwered my expectation. It is found either in round or broad pieces, is exceeding ponderous, and of a ſhining yellow colour, and is called by the miners *braſs lumps*. When I infuſed this mineral for a ſhort time in common water, it communicated to it all the properties of a ſteel Spaw; its taſte was exactly the ſame; and it received a tincture from galls, which was of a more diluted or intenſe purple, according to the proportion of the mineral added to the water, or to the time of the infuſion. This ſimple experiment does therefore clearly diſcover to us the origin of ſteel waters, and the manner, in which they are impregnated with their mineral contents in the bowels of the earth.

This obſervation, which I had made concerning the origin of ſteel waters, led me, when I firſt viſited Hartfell-Spaw, to inquire into the adjacent foſſils: which was the more eaſily done, as the ſtrata of the earth about the well, for a conſiderable depth, are expoſed to view. After ſome ſearch among theſe, I found a ſtratum of cliffery rock, about three or four feet thick, of a grey colour, and, I think, about twenty paces from the ſpring. In ſome of the hollow places of this rock, where the rain and wind did not reach, I obſerved a white ſaline efflorescence on its ſurface, which when I had taken off and taſted, I concluded, from its ſtyptic and chalybeat taſte, that it was a native vitriolum Martis, notwithſtanding its white colour; but I found it, upon trial, to be alum, having ſome fine attenuated parts of iron conjoined with it, and the ſame ſalt with that contained in the Spaw water.

Having

Having taken ſome pieces of this rock, which were quite free from the ſaline efferveſcence, and infuſed them in common ſpring-water for ſome hours, this water did thereby acquire the true taſte of the Hartfell-Spaw. It likewiſe in the ſame manner received a deep blue tincture with galls, and contained all the other qualities of that mineral water, without the leaſt difference, that I could obſerve: which, I think, aſcertains the true origin of this mineral ſpring in the moſt obvious and undeniable manner.

I am perſuaded, that this plain and eaſy method of inveſtigating the origin of mineral ſprings is not only ſuperior to the moſt learned diſcuſſions and elaborate theories, but will be found to be the ſureſt, yea, the only way of extending and compleating our knowlege concerning them. As I have not yet had the opportunity of making the experiments, which I deſigned, upon the two foſſils, that we find to be the cauſe of the above mineral waters, and which will be neceſſary to elucidate and compleat theſe obſervations, which we have made concerning their origin; I ſhall now only add one thing, and recommend it to the obſervation of others: " *Whether or* " *not, from ſuch a knowlege of the origin of mineral* " *waters, we may not acquire artificial ones of as* " *great, or perhaps of greater, medicinal uſe, than* " *thoſe, which are naturally produced?*"