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ARTICLE I.

Experiments on carbonated Hydrogenous Gas; with a View to determine whether Carbon be a ſimple or a compound Subſtance *. *By Mr.* WILLIAM HENRY.

THE progreſs of chemical ſcience depends not only on the acquiſition of new facts, but on the accurate eſtabliſhment, and juſt valuation, of thoſe we already poſſeſs: for its general principles will otherwiſe be liable to frequent ſubverſions; and the mutability of its doctrines will but ill accord with the unvaried order of nature. Impreſſed with this conviction, I have been induced to examine a late attempt to withdraw from its rank among the elementary bodies, one of the moſt intereſting objects of chemiſtry. The inferences reſpecting the compoſition of charcoal, deduced by Dr. Auſtin from his experiments on the heavy inflammable air †, lead to changes ſo numerous in our explanations of natural phenomena, that they ought not to be admitted without the ſtricteſt ſcrutiny of the reaſoning of this philoſopher, and an attentive repetition of the experiments themſelves. In the former, ſources of fallacy may, I think, be eaſily detected; and in the latter there is reaſon to ſuſpect that Dr. Auſtin has been miſled by inattention to ſome collateral circumſtances. Several chemiſts, however, of diſtinguiſhed rank have expreſſed themſelves ſatisfied with the evidence thus produced in favour of the compoſition of charcoal; and amongſt theſe it may be ſufficient to mention Dr. Beddoes, who has availed himſelf of the theory of Dr. Auſtin in explaining ſome appearances that attend the converſion of caſt into malleable iron ‡.

The heavy inflammable air, having been proved to conſiſt of a ſolution of pure charcoal

* From the Phil. Tranſ. 1797.

† Phil. Tranſ. vol. lxxx. p. 51.

‡ Phil. Tranſ. vol. lxxxi.

in light inflammable air, is termed in the new nomenclature, carbonated hydrogenous gas. By repeatedly passing the electric shock through a small quantity of this gas, confined in a bent tube over mercury, Dr. Austin found that it was permanently dilated to more than twice its original volume. An expansion so remarkable could not, as he observes, be occasioned by any other known cause than the evolution of light inflammable air.

When the electrified air was fired with oxygenous gas, it was found that more oxygen was required for its saturation than before the action of the electric fluid; which proves that by this process an actual addition was made of combustible matter.

The light inflammable air disengaged by the electrization proceeded without doubt from the decomposition of some substance within the influence of the electric fluid, and not merely from the expansion of that contained in the carbonated hydrogenous gas: for, had the quantity of hydrogen remained unaltered, and its state of dilatation only been changed, there would not, after electrization, have been any increased consumption of oxygen.

The only substances in contact with the glass tube and mercury, in these experiments, besides the hydrogen of the dense inflammable gas, were carbon and water; which last, though probably not a constituent of gases, is however copiously diffused through them. If the evolved hydrogen proceeded from the decomposition of the former of these two substances, it is evident that a certain volume of the carbonated hydrogenous gas must yield, after electrization, on combustion with oxygen, less carbonic acid than an equal volume of non-electrified gas; or, in other words, the inflammation of 20 measures of carbonated hydrogen expanded by electricity from 10, should not afford so much carbonic acid as 10 measures of the unelectrified.

From the fact which has been before stated, respecting the increased consumption of oxygen by the electrified air, it follows, that in determining the quantity of its carbon by combustion, such an addition of oxygen should be made, to that necessary for the saturation of the gas before exposure to the electric shock, as will completely saturate the evolved hydrogen. For, if this caution be not observed, we may reasonably suspect that the product of carbonic acid is diminished, only because a part of the heavy inflammable air has escaped combustion. It might indeed be supposed, that in consequence of the superior affinity of carbon for oxygen, the whole of the former substance contained in the dense inflammable gas would be saturated and changed into carbonic acid, before the attraction of hydrogen for oxygen could operate in the production of water. But I have found that the residue, after inflaming the carbonated hydrogenous gas with a deficiency of oxygen, and removing the carbonic acid, is not simply hydrogenous, but carbonated hydrogenous gas.

In the 2d, 5th and 6th of Dr. Austin's experiments, in which the quantity of carbon in the electrified gas was examined by deflagrating it with oxygen, the combustion was incomplete because a sufficiency of oxygen was not employed; and Dr. Austin himself was aware that in each of them "a small quantity of heavy inflammable air might escape unaltered." It is observable also, that the product of carbonic acid from the electrified gas increased in proportion as the combustion was more perfect. We may infer, therefore, that if it had been complete there would have been no deficiency of this acid gas, and consequently no indication of a decomposition of charcoal. A strong objection, however, is applicable to these as well as to most of Dr. Austin's experiments, that the residues were not examined with sufficient attention. In one instance, we are told, that the remaining gas was inflammable,

mable, and in another that it supported combustion like vital air. I need hardly remark, that a satisfactory analysis cannot be attained of any substance, without the most scrupulous regard not only to the qualities, but to the precise quantities of the products of our operations.

To the 8th and 9th experiments the objection may be urged with additional weight, which has been brought against the preceding ones, that the quantity of oxygen, instead of being duly increased in the combustion of the electrified gas, was on the contrary diminished. Thus, in the 8th experiment 2,83 measures of carbonated hydrogen were inflamed with 4,58 measures of oxygenous gas; but in the 9th, though the 2,83 measures were dilated to 5,16, and had therefore received a considerable addition of combustible matter, the oxygen employed was only 4,09. To the rest of Dr. Austin's experiments, either one or both of the above objections are applicable.

The first and most important step, therefore, in the repetition of these experiments, is to determine whether the carbonated hydrogenous gas really sustains by the process of electrization a diminution of its quantity of carbon; because, should this be decided in the negative, we derive from the fact a very useful direction in ascertaining the true source of the evolved hydrogen. The following experiments were therefore made with a view to decide this question, and the error of Dr. Austin in employing too little oxygen was carefully avoided *.

Experiment 1. In a bent tube standing inverted over mercury, 94,5 measures of carbonated hydrogenous gas from acetite of pot-ash were mixed with 107,5 of oxygen. The total, 202, was reduced by an explosion to 128,5, and was further contracted by lime water to 54. A solution of hepar sulphuris left only 23 measures.

The diminution by lime water, viz. 74,5 measures, makes known to us the quantity of carbonic acid afforded by the combustion of 94,5 measures of carbonated hydrogenous gas. And the residue after the action of hepar sulphuris, viz. 23 measures, gives the proportion of azotic gas contained in the carbonated hydrogen; for the oxygenous gas employed, which was procured from oxygenated muriate of pot-ash, was so pure, that the small quantity used in this experiment could not contain a measurable portion of azotic gas.

Experiment 2. The same quantity of carbonated hydrogen was expanded by repeated electrical shocks to 188 measures. The addition of hydrogenous gas therefore amounted to 93,5. The gas thus dilated was fired at different times with 392,5 measures of oxygenous gas; and the residue after these several explosions was 403 measures. Lime water reduced it to 128,5, and sulphure of pot-ash to 19,5. In this instance, as in the former one, the product of carbonic acid is 74,5 measures.

* The apparatus employed in these experiments was the ingenious contrivance of Mr. Cavendish, and is described in the lxxvth vol. of the Philosophical Transactions. In dilating the gas, I sometimes used a straight tube, furnished with a conductor in the manner of Dr. Priestley (see his Experiments on Air, vol. i. plate 1. fig. 16.) The bulk of the gases introduced, and their volume after the various experiments, were ascertained by a moveable scale, and by afterwards weighing the mercury which filled the tube to the marks on the scale; by which means I was spared the trouble of graduating the syphons. Each grain of mercury indicates one measure of gas; and though the smallness of the quantities submitted to experiment may be objected to, yet this advantage was gained, that the electrified gas could be fired at one explosion, as was done in the 4th, 6th and 8th experiments. Errors from variations of temperature and atmospherical pressure were carefully avoided.

Finding from the first experiment and other similar ones, that the carbonated hydrogenous gas which was the subject of them contained a very large mixture of azotic gas, I again submitted to distillation a quantity of the acetite of pot-ash, with every precaution to prevent the adulteration of the product with atmospherical air. Such an adulteration, I have observed, impedes considerably the dilatation of the gas, and for a time even entirely prevents it. This explains the failure, which some experienced chemists have met with in their attempts to expand the carbonated hydrogenous gas by electricity. Gas which is thus vitiated becomes, however, capable of expansion after exposure to the sulphure of pot-ash.

Experiment 3. Carbonated hydrogen 340 measures were exploded with the proper proportion of oxygenous gas. The carbonic acid produced amounted to 380 measures, and the residue of azotic gas was 20 measures.

Experiment 4. The same quantity, when expanded to 690, gave on combustion 380 measures of carbonic acid, and 19,8 of azotic gas.

Experiment 5. Three hundred and fifteen measures of carbonated hydrogen yielded 359 measures of carbonic acid, and 18,5 measures of azote.

Experiment 6. The same quantity, after expansion to 600, afforded the same products of carbonic acid and azotic gases.

Experiments 7 and 8. As much carbonic acid was obtained by the combustion of 408 measures of carbonated hydrogenous gas, expanded from 200, as from 200 measures of the non-electric fired gas; and the residue of azotic gas was the same in both cases.

It is unnecessary to state the particulars of several other experiments similar to those above related, which were attended with the same results. They sufficiently prove that the action of the electric spark, when passed through carbonated hydrogenous gas, is not exerted in the decomposition of carbon; for the same quantity of this substance is found after as before electrization. Even granting that charcoal is a compound, the constituents of which are held together by a very forcible affinity, it does not appear likely that the agency of the electric shock, which seems in this instance analogous to that of caloric, should effect its decomposition under the circumstances of these experiments. For it is a known property of charcoal to decompose water, when aided by a high temperature; and its union with oxygen is a much more probable event when this body is present, than a separation into its constituent principles. As an argument also that water is the source of the light inflammable air in this process, it may be observed that the dilatation in Dr. Austin's experiments could never be carried much farther than twice the original bulk of the gas *. This fact evidently implies that the expansion ceased only in consequence of the entire destruction of the matter whose decomposition afforded the light inflammable air; and this substance could not be carbon, because Dr. Austin admits that a large portion, and I have shewn that the whole of it, still remains unaltered.

If the dilatation of the carbonated hydrogenous gas arose from the decomposition of water, the effect should cease when this fluid is previously abstracted. To ascertain whether

* "After the inflammable air has been expanded to about double its original bulk," says Dr Austin, "I do not find that it increases further by continuing the shocks. Conceiving that the progress of the decomposition was impeded by the mixture of the other airs with the heavy inflammable, I passed the spark through a mixture of the heavy inflammable air and light inflammable; but the expansion succeeded nearly as well as when the heavy inflammable was electrified alone." Phil. Trans. vol. lxxx. p. 52.

this

this consequence would really follow, I exposed a portion of the gas for several days before electrization to dry caustic alkali. On attempting its expansion, I found that it could not be carried beyond one sixth the original bulk of the gas. By 160 very strong explosions it attained this small degree of dilatation, but 80 more produced not the least effect; though the former number would have been amply sufficient to have dilated the gas in its ordinary state to more than twice its original volume. A drop or two of water being admitted to this portion of gas, the expansion went on as usual; and I may here observe, that when a little water gained admission into the tube along with the gas, in any experiment, which often happened before I had acquired sufficient expertness in transferring the air from water to mercury, the dilatation went on with remarkable rapidity.

Carbonic acid gas, according to the discovery of M. Monge *, undergoes, when submitted to the electric shock, a change similar to that effected on the carbonated hydrogen; and the expansion has been shewn by Messieurs Landriani, and Van Marum †, to be owing to the same cause, viz. the extrication of light inflammable air. The added gas, M. Monge ably contends, cannot proceed from any other source than the water held in solution by all aëriform bodies, the oxygen of which he supposes to combine with the mercury. That the decomponent of the water, however, in the experiments which I have described, is not a metallic body, will appear highly probable, when we reflect that there is present in them a combustible substance, viz. charcoal, which attracts oxygen much more strongly than metals; and the following experiments evince, that the mercury by which the air was confined had no share in producing the phenomena.

Experiment 9. A portion of carbonated hydrogenous gas was introduced into a glass tube closed at one end, into which a piece of gold wire was inserted, that projected both within and without the cavity of the tube. The open end of the tube was then closed by a stopper perforated also with gold wire, so that electric shocks could be passed through the confined air without the contact of any metal that has the power of decomposing water. On opening the tube with its mouth downwards under water, a quantity of air immediately rushed out.

Experiment 10. The dilatation of the gas was found to proceed very rapidly when standing over water, and exposed to the action of the electric fluid, conveyed by gold conductors.

We have only, therefore, in the two preceding experiments, one substance in contact with the gas which is capable of decomposing water, viz. charcoal. The union of this body with the oxygen of the water would be rendered palpable by the formation of carbonic acid; but Dr. Austin did not observe that any precipitation was occasioned in lime water by agitating it with the electrified gas. On passing up syrup of violets to the electrified air, with the expectation of its indicating the volatile alkali, as in the experiments of Dr. Austin, no change of colour took place, though the test was of unexceptionable purity. On examining, however, whether any alteration of bulk had been produced in the air by the contact of this liquid, it appeared that of 709 measures 100 had been absorbed. Suspecting that the absorption was owing to the presence of carbonic acid, I introduced some lime water to a volume of the expanded gas, amounting to 556 measures, when they were immediately reduced to 512. The contraction would probably have been still more remark-

* Journal de Physique, xxix. 277. † Annales de Chimie, ii. 273.

able,

able, if the gas had been farther expanded before the admiſſion of the liquid. The change in the lime water was very trifling; but my friend Mr. Rupp, who witneſſed this as well as ſeveral of the other experiments, and who is much converſant in the obſervation of chemical facts, was ſatisfied that after a while he ſaw ſmall flocculi of a precipitate on the ſurface of the mercury. This contraction of bulk cannot be aſcribed to any other cauſe than the abſorption of carbonic acid; for, beſides the fact, that the colour of ſyrup of violets and of turmeric, which I alſo tried, were not affected by expoſure to the electrified gas, I have this objection to the abſorbed gas being ammoniac, that no diminution either of bulk or tranſparency occurred on the admixture of muriatic acid gas with the electrified air; whereas ammoniac would have been exhibited under the form of a neutral ſalt. When water was paſſed up to this mixture of the two gaſes, there was an abſorption not only of the muriatic gas but of ſomething more.

Conceiving that the demolition of charcoal, by the action of the electric fluid, was ſufficiently proved by his experiments, Dr. Auſtin aſſigns the evolved hydrogen as one of its conſtituents, and the other he concludes to be azote. This inference, however, reſts almoſt entirely upon eſtimates in which material errors may be diſcovered. Some of theſe it may be well to point out for the ſatisfaction of ſuch as have acquieſced in Dr. Auſtin's opinion.

The carbonated hydrogenous gas ſubmitted to Dr. Auſtin's experiments, clearly appears from his own account to have been largely adulterated with azotic gas. One ſource of its impurity he has diſcloſed, by informing us that the gas "had been very long expoſed to water*;" for Dr. Higgins has ſomewhere ſhewn, that the heavy inflammable air, after ſtanding long over water, leaves a larger reſidue of azote, on combuſtion, than when recently prepared †. It is probable alſo, that the proportion of azote derived from the water would increaſe with the time of its expoſure; and thus a fertile ſource of error is ſuggeſted, which appears wholly to have eſcaped Dr. Auſtin's attention. In repeating his experiments, I was careful that comparative ones, on two equal quantities of the electrified and unelectrified gas, ſhould be made without the intervention of any time that could vary the proportion of azote in either of the gaſes.

To the 9th experiment, in which the quantity of azote ſeems to have been increaſed to electrization, I muſt repeat the objection, that a ſufficiency of oxygenous gas was not uſed in the combuſtion. In the 8th experiment, 2,83 meaſures of the unelectrified air were fired with 4,17 oxygenous gas, and only 0,15 of the latter remained above what was ſufficient for ſaturation; but in the 9th, though the 2,83 meaſures were expanded to 5,16, the quantity of oxygen employed was 0,08 leſs than in the former experiment; and it may therefore be preſumed, that a ſmall quantity of inflammable air might eſcape unaltered, and might add apparently to the product of azote. In the 8th experiment, alſo, the portion of oxygenous gas that was more than ſufficient to ſaturate the carbonated hydrogen, would probably combine in part with the remaining azote, as in the experiments of Dr. Higgins ‡ and Dr. Prieſtley §. But in the 9th, the quantity of oxygenous gas was hardly ſufficient to ſaturate

* Phil. Tranſ. lxxx. 54.

† Similar facts reſpecting the deterioration of other gaſes by ſtanding over water may be ſeen in Dr. Prieſtley's Experiments on Air, vol. i. p. 59. 158. I found that oxygenous gas from oxygenated muriate of pot-aſh acquired by expoſure a few weeks to water, .125 its bulk of azotic gas.

‡ Experiments and Obſervations on Acetous Acid, &c. p. 295.

§ Phil. Tranſ. lxxix. 7.

 both

b kinds of inflammable air after electrization, and could not therefore diminish the azo gas. When the proportion of oxygen is duly increased, and the inflammation of the electrific air is performed in small portions, there is no augmentation, but on the contrary a decrease of the quantity of the azote, as will appear on comparing the 1st and 2d of the experiments which I have related.

Two circumstances were observed in the experiments of Dr. Austin, which have not been noticed in the preceding account of the repetition of them, viz. the appearance of a deposit from the carbonated hydrogenous gas during its electrization, and the formation of ammoniac by the same process. In some experiments which I made on the first portion of gas, both these facts were sufficiently apparent; but neither of them occurred on electrifying the gas which was afterwards procured. Suspecting that the cessation of them arose from the superior purity of the latter portion from azotic gas, I passed the electric shock through a mixture of carbonated hydrogen, with about one fourth of its bulk of azote, and thus again produced the precipitate, which would have been of a white colour, if it had not been obscured by minute globules of mercury, that were driven upwards by the force of the explosion. An infusion of violets was tinged green, when admitted to the electrified gas; but the change of colour did not occur instantly, as happens from the absorption of ammoniacal gas; and required for its production, that the liquid should be brought extensively into contact with the inner surface of the tube. From this effect on a blue vegetable colour, we may infer that the precipitate was an alkaline substance, and probably the carbonate of ammoniac; but the quantity was much too minute to be the subject of a more decisive experiment.

I shall conclude this memoir with a brief summary of the facts that are established by the preceding experiments *. Those included under the first head are deducible from the experiments of Dr. Austin.

1. Carbonated hydrogenous gas, in its ordinary state, is permanently dilated by the electric shock to more than twice its original volume; and as light inflammable air is the only substance we are acquainted with, that is capable of occasioning so great an expansion, and of exhibiting the phenomena that appear on firing the electrified gas with oxygen, we may ascribe the dilatation to the production of hydrogenous gas.

2. The hydrogenous gas, evolved by this process, does not arise from the decomposition of charcoal; because the same quantity of that substance is contained in the gas after as before electrization.

3. The hydrogenous gas proceeds from decomposed water; because, when this fluid is abstracted as far as possible from the carbonated hydrogenous gas, before submitting it to the action of electricity, the dilatation cannot be extended beyond one-sixth its usual amount.

4. The decomponent of the water is not a metallic substance, because carbonated hydrogenous gas is expanded when in contact only with a glass tube and gold, a metal which has no power of separating water into its formative principles.

5. The oxygen of the water (when the electric fluid is passed through carbonated hydrogenous gas, that holds this substance in solution) combines with the carbon, and forms car-

* Since this paper was written, I have extended the inquiry to phosphorated hydrogenous gas, which expands equally with the carbonated hydrogen; loses its property of inflaming when brought into contact with oxygenous gas, and affords evident traces of a production of phosphorous or phosphoric acid.

bonic

bonic acid. This production of carbonic acid, therefore, adds to the dilatation occasioned by the evolution of hydrogenous gas.

6. There is not, by the action of the electric matter on carbonated hydrogenous gas, any generation of azotic gas.

7. Carbon, it appears, therefore, from the united evidence of these facts, is still to be considered as an elementary body; that is, as a body with the composition of which we are unacquainted, but which may nevertheless yield to the labours of some future and more successful analyst.

II.

Observations on Bituminous Substances, with a Description of the Varieties of the Elastic Bitumen. By CHARLES HATCHETT, *Esq. F.R.S. Lond. and Edin. F.L.S. &c.*

[Concluded from Page 209, Vol. II.]

THE characters of bitumen are much more apparent in turf and peat, than in the greater part of the fossil woods. Turf is well known to be composed of the parts of vegetables, such as small roots, twigs, &c. mixed with a portion of petroleum; and peat is the same, excepting that it generally contains more of earthy matter, or that the vegetables have undergone a more complete decomposition.

The boggy nature of the places in which they are found, proves that a certain degree of maceration is necessary to form the bituminous matter which they contain; and I have already noticed, that every fact appears to demonstrate, that the bitumen is a product of those vegetables, the remains of which constitute the other ingredient of turf and peat.

The different proportion of vegetable matter, of bitumen, and of earth, together with the different state of the bitumen, as well as the degree of perfection respecting the formation of it from the vegetable principles, contribute to alter the properties and characters of the compound, and thus produce varieties. It is believed that these substances have been materially concerned in the formation of pit-coal, and some eminent mineralogists maintain that there is an uninterrupted series which connects the varieties of turf and peat with those of coal *.

SECT. V.

LITTLE need be said concerning those mixtures of bitumen with metals or their oxides which are sometimes called the bituminous ores of mercury, copper and iron, for they should rather be arranged with the adulterated or impure bitumens. Few of them contain the metallic ingredient in a proportion sufficient to cause the compound to be worked as an ore; and the only exception with which I am acquainted, is the substance found at Idria, in Carniolia, composed of mercury mixed with bituminous matter, a quintal of which, according to Mr. de Born, affords from fifteen to twenty pounds of mercury †.

* Man findet in der natur einen ununterbrochenen übergang von dem rasen und papiertorf durch den moor oder sumpftorf in den pechtorf, und von diesem in die braun schiefer und pechkohle.—Widenmann, p. 630.

† Catalogue de la Collection des Fossiles de Mlle. de Raab, tom. ii. p. 294, 348, and 400.

SECT. VI.

SECT. VI.

FROM the preceding obſervations it will appear, that although I have firſt mentioned naptha in order that I might be better underſtood in reſpect to the degree of connection prevailing between the bituminous ſubſtances; yet, to have followed them from their origin and the period of their formation, I ſhould rather have begun with thoſe ſubſtances which moſt clearly point out how much the vegetable kingdom has contributed to the production of them, with the probable occaſional concurrence of animal ſubſtances.

That the latter have contributed in ſome meaſure to the forming of bitumen, we can only infer from the veſtiges and exuviæ of animals, which ſo commonly accompany bituminous ſubſtances: but no doubt can be entertained in reſpect to vegetables; for it appears that bitumen is formed from them by long maceration, and by other proceſſes at preſent unknown to us:

That when certain portions of vegetable matter remain undecompoſed, and are mixed with the petroleum thus produced, the varieties of turf and peat are formed:

That wood in general contributes to the production of bitumen; but does not ſeem to retain it, after the formation of it, in ſo conſiderable a proportion as the foregoing ſubſtances:

That the bituminous matter thus formed, and occaſionally ſeparated, is in different ſtates according to the degree of inſpiſſation:

And laſtly, with various proportions of carbonic and earthy matter, it forms jet, coal, and bituminous ſchiſtus; and with metallic ſubſtances it produces thoſe compounds called bituminous ores.

SECT. VII.

ABOUT the year 1786 a new ſpecies of bitumen was diſcovered near Caſtleton, in Derbyſhire, which much reſembles, in elaſticity and colour, the ſubſtance known by the name of cahout-chou, or Indian rubber.

M. de Born was, I believe, the firſt who mentioned it *; but, as he appears to have known only one variety of this ſingular ſubſtance, I am induced to hope that a deſcription of many other varieties, which have ſince been found, will not be unacceptable to this Society.

The elaſtic bitumen, which reſembles the cahout-chou, was firſt diſcovered in the cavities of a vein in the lead-mine called Odin, which is near the baſe of Mamtor, to the north of Caſtleton. The ore of this mine (which is ſuppoſed to be one of the moſt ancient in England) is galena, accompanied by fluor, calcareous and heavy ſpars, quartz, blende, calamine, ſelenite, aſphaltum, and the elaſtic bitumen, although the latter is now rarely found †. Another ſpecies of the elaſtic bitumen has within about three years been found in a neighbouring rivulet; but I ſhall not at preſent notice it, as I intend firſt to deſcribe the varieties of that which was firſt diſcovered, and which reſembles the cahout-chou. In order to do this with more perſpicuity, I ſhall deſcribe the ſpecimens belonging to my collection, according to the mode in which I have arranged them.

* Catalogue de la Collection de Mlle. de Raab, tom. ii. p. 77.

† I am indebted to the ingenious Mr. White Watſon, of Bakewell, for much information reſpecting the local circumſtances which attend this bitumen.

SPECIES THE FIRST.

A, No. 1.—Elastic bitumen of a yellowish brown colour, part of which is almost liquid like petroleum, and adheres to the fingers; the other part is of a darker colour, of a mammillary form, does not adhere to the fingers, and is soft and elastic. This is on a grey bituminous limestone, with white calcareous spar in the figure of hexaedral pyramids, forming that which is called the dog-tooth spar.

A, No. 2.—Bitumen of a yellowish brown, partly liquid, and partly elastic, which, however, adheres to the fingers; on pale grey limestone, with crystals of white fluor spar, blende, and galena.—On another part of the limestone are some globules of bitumen of a reddish brown, perfectly hard and brittle.

A, No. 3.—Dark brown bitumen of a stalactitical form, hard, but in some degree elastic.

A, No. 4.—Bitumen of a reddish brown, in the form of globules, some of which are elastic, and others hard: on brownish-grey limestone, accompanied by crystallized white fluor, dogtooth calcareous spar, and pyrites in small crystals, some of which are on the surface of the globules of bitumen.

A, No. 5.—The same of a darker brown, of a stalactitical form, hard and brittle; on pale brown calcareous spar, impregnated with bitumen.

A, No. 6.—Bitumen of a dark reddish brown, very hard; on pale brown sparry stinkstone, with grey limestone, in which are some coralloides.

A, No. 7.—Bitumen of a dark yellowish brown, elastic, but very soft, so that it adheres to the fingers.

A, No. 8.—The same thinly spread over grey sparry stink-stone.

A, No. 9.—Bitumen of a brownish olive colour, which becomes reddish brown by the air, but when opposed to the light it appears semi-transparent, and of a yellowish brown inclining to orange. It is soft, very elastic, and (when recently cut) adheres to the fingers.

A, No. 10.—The same of a darker brown, and harder in a small degree. The specific gravity of this specimen is 0,9053; water being estimated at 10,000 (q. 1,000?) at temp. 60°.

A, No. 11.—Bitumen of a dark brown, harder than the former. This exactly resembles the cahout-chou in the degree of elasticity, and in the property which it possesses of removing the traces of black-lead.

A, No. 12.—The same, but rather harder.

A, No. 13.—The same of a blackish brown, which is slightly elastic when the weather is warm, but is brittle when cold.

A, No. 14.—The same of a blackish brown, nearly black, which scarcely possesses any elasticity; it breaks, and resembles asphaltum in lustre, colour and fracture.

A, No. 15.—The same of a reddish brown, perfectly hard and brittle. The characters of asphaltum are complete in this specimen. The specific gravity is 10,233. (q. 1,233?)

The other species of elastic bitumen, which I shall distinguish by the letter B, has been found during the last three years in a rivulet which runs at the base of Mamtor, from west to east, at a small distance from Odin mine.—The varieties of it, in my possession, are as follow:—

SPECIES THE SECOND.

B, No. 1.—Elaſtic bitumen, which, recently cut, exactly reſembles fine cloſe cork in colour and texture, but, by the air, in a few days it becomes of a pale reddiſh brown.—This forms a thin coat, which completely covers a maſs of elaſtic bitumen, which is ſoft, and of a brownifh olive colour, like A, No. 9.

B, No. 2.—The ſame, excepting that the coat or cruſt is much thicker.

B, No. 3.—The ſame, but the coating is thicker than that of No. 2, and the browniſh olive-coloured bitumen much leſs in quantity.

B, No. 4.—The ſame, excepting that the greater part of the maſs reſembles cork, ſo that only a very ſmall nucleus of the brown bitumen remains *.

B, No. 5.—The ſame, excepting that the bitumen, which is coated, is in the ſtate of aſphaltum. The ſpecific gravity of this ſpecimen is 0,9881.

B, No. 6.—Elaſtic bitumen, the whole maſs of which reſembles fine cork.—The ſpecific gravity is 0,9748.

B, No. 7.—The ſame, but friable, and apparently paſſing by decompoſition into an ochraceous coloured powder.

THE varieties of the firſt ſpecies of the elaſtic bitumen, or that which is like the cahoutchou, evidently appear to be formed from a naptha or petroleum, which, like that which produces the other ſimple bituminous ſubſtances formerly mentioned, is ſuſceptible of various degrees of inſpiſſation.

All the varieties of the firſt ſpecies, from No. 1, to No. 15, may be regarded as thus formed; for in theſe we can trace all the modifications comprehended between petroleum and aſphaltum: with this difference, that the intermediate modifications of this ſpecies have the remarkable property of elaſticity which is the moſt complete in the variety which occupies the middle place between petroleum and aſphaltum.

The ſecond ſpecies B, or that which reſembles cork, appears ſo different from that marked A, that it is not at firſt eaſy to conceive how they are connected, or at leaſt the difficulty muſt appear great to thoſe who have only ſeen ſpecimens of each ſpecies complete in their reſpective characters. But, from an attentive examination of many ſpecimens, and particularly of thoſe which I have deſcribed, I am convinced that the varieties of the ſpecies B are only modifications of the ſpecies A, produced probably by long maceration in the water of the rivulet in which this ſpecies is found, to the effects of which we may, with ſome appearance of reaſon, add the viciſſitudes of the ſeaſons, of air, and of the weather in general, as well as thoſe of reiterated moiſture and dryneſs occaſioned by the riſe and fall of the water of the rivulet; and what ſeems to corroborate this opinion is, that the ſubſtance, like cork, incruſts the ſpecies A, and appears to be only a change which has penetrated deeper into the ſubſtance of it in proportion to the duration of the cauſes which I have mentioned, ſo that at length the original ſubſtance no longer remains in its primitive ſtate. I do not believe, however, that this change ariſes from any alteration in the conſtituent principles, but merely from

* One of the ſpecimens in my poſſeſſion, ſimilar to B, No. 4. weighs between 13 and 14 pounds.

from a partial and minute dis-union or disintegration of the particles of the original substance, as both species melt into one which is perfectly similar. I must also add, that the species A burns easily, and with rapidity; but the species B burns with some difficulty, and crackles as if it had imbibed a quantity of water.

I have remarked, when the different varieties of the elastic bitumen were melted, that they completely lost the elastic property, and a quantity of air or gas appeared to be disengaged, particularly from the species B. I also observed, that the substances which remained after this operation, corresponded, in respect to consistence, with those which had been employed, as the following table will shew:

A, No. 7 and 8	produced a thick liquid petroleum, not apparently different from that which is commonly known.
A, No. 9	produced a thicker petroleum, approaching to mineral tar.
A, No. 11 and 12 . . .	produced mineral tar.
B, No. 6	produced the same, approaching to mineral pitch.
A, No. 13	produced mineral pitch.
A, No. 14 and 15 . . .	did not suffer any change, but remained as at first, with all the characters of asphaltum.

From what I have related, I suspect that the elastic property is occasioned by the interposition of very minute portions of air or some other elastic fluid between the parts of the bitumen, and that this takes place by reason of some unknown cause at the time of formation; but when these bitumens are melted, the elastic fluid is liberated, and the mass loses that fine spongy texture which I suspect to have been the cause of the elastic property *.

Derbyshire is well known as a country which exhibits, in the most striking manner, the remarkable changes which our globe has suffered. In every part of it, the most indisputable evidences appear of some great and extraordinary revolution; and there is not any place where extraneous fossils, such as the remains and impressions of vegetables and animals, are more abundant.

Bitumen, in other countries, is most commonly found where these present themselves; and, in like manner, there are few countries which abound so much with bitumen as Derbyshire.

Whoever has examined the limestone rocks about Matlock, and most other places in this county, must be convinced of the truth of this assertion.

The limestone and calcareous spars also, where the elastic bitumen is found, are, for the greater part, in the same state; so that no doubt can be entertained but that this bitumen has had the same origin as those which are more generally known; and it would undoubtedly have been confounded with them, had it not been discovered when passing from the liquid to the solid state.

* The elastic bitumen, A, No. 9. when digested in sulphuric ether in a temperature of about 55°, is partly dissolved. The solution is yellowish brown when opposed to the light; but, when otherwise viewed, is like the bitumen, that is, of a brownish olive colour. By spontaneous evaporation, the etheric solution leaves a yellowish brown bitumen, which is totally devoid of elasticity. The undissolved portion (like the cahout-chou under similar circumstances) is softened, and is much increased in bulk.

The species B, No. 6. cut into very thin slices, communicates a yellow tinge to sulphuric ether; in other respects it is but little affected.

The

The elementary principles of bitumen are, hydrogen, carbon, sometimes azote, and probably some oxygen, which, by its action on the other principles, tends to form the concrete bitumens, and also produces that portion of acid obtained by chemical operations. These same principles, hydrogen and carbon, constitute the vegetable oils and resins; and the same, with some azote, form the oils and grease of animals. Now it is known that very small changes in the respective proportions of these ingredients, and in the circumstances which attend the combination of them, will cause considerable variations in the nature of the products; and in like manner, it appears very probable, that when the organized bodies in their recent state, and in the full possession of the above-mentioned principles, have been buried in a situation where these principles have been long elaborated under certain favourable circumstances, and subjected to the action of mineral bodies; I say that it appears highly probable, that a new combination, which we call bitumen, may be formed, which, although different in some respects from the vegetable and animal products, still, however, retains many characters of those substances from the principles of which it has been formed.

HAMMERSMITH,
April 26, 1797.

III.

Observations on the Physical and Political Geography of North Africa. By JAMES RENNEL, *Esq. F. R. S.**

TO our view, North Africa appears to be composed of three distinct parts, or members. The first and smallest is a fertile region along the Mediterranean, lying opposite to Spain, France, and Italy (commonly distinguished by the name of Barbary); and which, could we suppose the western bason of the Mediterranean to have once been dry land (bating a lake or recipient for the surrounding rivers), might be regarded as a part of Europe; as possessing much more of the European than the African character.

The second part is what may be deemed the body of North Africa, comprised between Cape Verd and the Red Sea, on the east and west; and having the Great Desert (or Sahara) and its members, on the North; the Ethiopic ocean and South Africa, on the opposite side. The prominent feature of this immense region is a vast *belt of elevated land* of great breadth, often swelling into lofty mountains, and running generally from west to east, about the tenth degree of latitude. Its western extremity seems to be Cape Verd; the mountains of Abyssinia, the eastern. To the north, its ramifications are neither numerous nor extensive, if we except the elevated tract which turns the Nile to the northward beyond Abyssinia. Towards the south no particulars are known, save that a multitude of rivers, some of them very large, descend from that side and join the Atlantic and Ethiopic seas, from the Rio Grande on the west to Cape Lopez on the east; proving incontestably that by far the greatest proportion of rain water falls on that side during the periodical season of the

* Copied by permission from his "Geographical Illustrations of Mr. Park's Journey," in the Proceedings of the African Association, 1798. On this subject see likewise our Account of Books in the present Number. N. S. W.

S. W. winds; which corresponds in all its circumstances with the same monsoon in India *.

To the north of this belt, with the exception of the Egyptian Nile, the waters conform generally to the direction of the high land; passing at no great distance (comparatively) from its base to the right and left; as if the surface of the Sahara had a general dip to the southward †. These rivers moreover receive all their supplies from the south; no streams of any bulk being collected in the Desert.

In order to produce this effect, there must necessarily be a vast hollow in the interior of Africa, between the high land of Nubia on the east, and Manding on the west; and of which the mountains and desert form the other two sides. Nor is this state of things unexampled in the other continents. In Asia, the hollow, to whose waters the Caspian and Aral serve as recipients, is no less extensive than the one just mentioned; reckoning from the sources of the Wolga to those of the Oxus; (which latter has ever communicated with the Caspian, either throughout the year or during a part of it:) the difference is, that in Asia a greater portion of the hollow is filled up with water than in Africa.

The third part is of course the Great Desert (or Sahara) and its members; consisting of the lesser deserts of Bornou, Bilma, Barca, Sort, &c. This may be considered as an OCEAN OF SAND ‡, presenting a surface equal in extent to about *one half of Europe*, and having its gulfs and bays; as also its islands fertile in groves and pastures, and in many instances containing a great population subject to order and regular government. The great body or western division of this OCEAN, comprised between Fezzan and the Atlantic, is no less than 50 caravan journeys across from north to south; or from 750 to 800 G. miles; and double that extent in length: without doubt the largest desert in the world. This division contains but a scanty portion of islands (or oases), and those also of small extent: but the eastern division has many; and some of them very large. Fezzan, Gadamis, Taboo, Ghanat, Agadez, Augela, Berdoa, are amongst the principal ones: besides which there are a vast number of small ones. In effect this is the part of Africa alluded to by Strabo ‖, when he says from Cneius Piso, that Africa may be compared to a leopard's skin. I conceive the reason why the oases are more common here than in the west, is, that the stratum of sand is shallower from its surface to that of the earth which it covers. In other words, that the water contained in that earth is nearer to the surface; as in most of the oases it springs up spontaneously §. Can any part of the cause be assigned to the prevalent easterly winds, which, by driving the finer particles of sand to leeward, may have heaped it up to a higher level in the Sahara than elsewhere?

The

* A ridge stretches to the south through the middle of South Africa, and forms an impenetrable barrier between the two coasts. M. Correa de Serra informs me, that the Portuguese in Congo and Angola have never been able to penetrate to the coast of the Indian Ocean.

Mr. Bruce learned (vol. iii. p. 668.) that a high chain of mountains from 6° runs southward through the middle of Africa. He supposes the gold of Sofala to be drawn from these mountains. (p. 669.)

† Circumstances have shewn, that it declines to the eastward also.

‡ "A wild expanse of lifeless sand and sky!" THOMSON.

‖ Page 130.

§ Water is found at the depth of a few feet in Fezzan (African Assoc. Q. p. 96. O. p. 146.) The same is said

The ſprings no doubt have produced the oaſes themſelves, by enabling uſeful vegetables to flouriſh, and conſequently population to be eſtabliſhed. That the Deſert has a dip towards the eaſt as well as the ſouth, ſeems to be proved by the courſe of the Niger alſo. Moreover the higheſt points of North Africa, that is to ſay, the mountains of Mandinga and Atlas, are ſituated very far to the weſt.

The Deſert for the moſt part abounds with ſalt. But we hear of ſalt mines only in the part contiguous to Nigritia, from whence ſalt is drawn for the uſe of thoſe countries as well as of the Mooriſh ſtates adjoining; there being no ſalt in the Negro countries ſouth of the Niger *. There are ſalt lakes alſo in the eaſtern part of the Deſert.

The great ridge of mountains and its branches are very productive in gold; but more particularly in the quarters oppoſite to Manding and Bambouk on the weſt, and Wangara on the eaſt. It may perhaps admit of a doubt, whether the gold is brought down at the preſent time by the numerous fountains that form the heads of the Niger and Senegal rivers; or whether it has been depoſited in the lower parts of their beds at an earlier period of the world; and that the ſearch, inſtead of being facilitated by the periodical floods, is on the contrary only to be purſued with effect when the waters are low.

Tombuctoo is reckoned the mart of the Mandinga gold, from whence it is diſtributed over the northern quarters of Africa by the merchants of Tunis, Tripoly, Fezzan, and Morocco; all of whom reſort to Tombuctoo. Moſt of it no doubt afterwards finds its way into Europe. It may be remarked alſo, that the gold coaſt of Guinea (ſo called doubtleſs from its being the place of traffic for gold duſt) is ſituated nearly oppoſite to Manding: but whether the gold brought thither has been waſhed out of the mountains by the northern or ſouthern ſtreams, I know not: it may be both †. Degombah, another country ſaid to be very productive

ſaid by Pliny, concerning this quarter of Africa; lib. v. c. 5. But farther to the N. W. on the edge of the Deſert, and in the country of Wadreag in particular, (Shaw, p. 135.) wells are dug to an amazing depth, and water mixed with fine ſand ſprings up ſuddenly, and ſometimes fatally to the workmen. The Doctor tells us that the people call this abyſs of ſand and water, "the ſea below ground." Exactly the ſame ſtate of things exiſts in the country round London, where the ſand has in ſeveral caſes nearly filled up the wells. (See Phil. Tranſ. for 1797.) The famous well lately dug by Earl Spencer (at Wimbledon), of more than 560 feet in depth, has ſeveral hundred feet of ſand in it.

* This quality of the African Deſert was familiarly known to Herodotus (Melpom. c. 181, et ſeq.) He knew alſo that there was ſalt in abundance in the northern parts. But, as the inhabitants in that quarter can furniſh themſelves with ſalt of a better quality from the ſea, the mines are not wrought.

† Some writers have ſaid, that there are gold mines in the neighbourhood of Mina, on the gold coaſt; others that the gold is rolled down by the rivers to that neighbourhood. Both may be true. But, on the other hand, it is ſaid that the gold of Wangara is alſo brought for ſale to the ſouthern coaſt.

It is difficult to conceive any other adequate cauſe, than the exchange of the gold of the inland countries for the introduction of ſo vaſt a quantity of kowry ſhells, which are carried from Europe to the coaſt of Guinea, and paſs for ſmall money in the countries along the Niger from Bambara to Kaſſina, both incluſive.

I am informed from authority, that about 100 tons of kowries are annually ſhipped from England alone to Guinea. Theſe are originally imported from the Maldive iſlands into Bengal; and from Bengal into England. In Bengal 2400 more or leſs are equal to a ſhilling: and yet, notwithſtanding the incredible ſmallneſs of the denomination, ſome article in the market may be purchaſed for a ſingle kowry. But in the inland parts of Africa they are about ten times as dear, varying from 220 to 280. Mr. Beaufoy was told, that in Kaſſina they were at the rate of about 250. And Mr. Park reports, that they are about the ſame price at Sego: but cheaper ductive in gold *, must by its situation lie directly opposite to the gold coast: for it lies immediately to the east of Kong (the Gonjah of Mr. Beaufoy and the Conche of D'Anville †.) The people of Fezzan trade to Kong.

The triangular hilly tract above commemorated, (p. 71 of the "Illustrations") which projects northward from the highest part of the belt, and contains Manding, Bambouk, &c. is also abundant in gold; particularly in the quarter towards Bambouk, where it is found in mines; and that chiefly in the middle level ‡. (See also p. 71.)

Wangara appears to have been in its time nearly as rich as Manding in this metal. The Arabs name it *Belad al Tebr*, or the *country of gold* ‖. Edrisi, Ibn Al Wardi, and Leo, bear testimony to its riches. They say that the gold is found in the sands after the periodical inundation of the Niger (which is generally over the country) is abated §. Leo alone ** says, that the gold is found in the southern quarter of the kingdom; which appears very probable, as the mountains lie on that side: so that it may be concluded, that the gold sand has not been brought there by the Niger, but by smaller rivers that descend immediately from these mountains. That a part of Wangara is bounded by mountains, we learn from Edrisi: for the lake on which Reghebil stands has mountains hanging over its southern shore ††.

It is supposed that most of the countries bordering on these mountains share in the riches contained within them, by means of the rivulets ‡‡. But considering how amazingly productive in gold the streams of this region are, it is wonderful that Pliny should not mention the Niger, as one of the rivers that rolls down golden sands: for although he speaks of the Tagus and others in different quarters, no African river is mentioned ‖‖. And yet Herodotus knew that the Carthaginians bartered their goods for gold, with the Africans on the sea coast beyond the pillars of Hercules; which was contrived without the parties seeing each other §§.

The common boundary of the Moors and Negroes in Africa forms a striking feature, as well in the moral as the political and physical geography of this continent. The Moors descendants of Arabs, intermixed with the various colonists of Africa from the earliest to the

cheaper at Tombuctoo, which is about the centre of the kowry country; dearer towards Manding, which is the western extremity of it. Hence they are probably carried in the first instance to Tombuctoo, the gold market; and thence distributed to the east and west. Their circulation seems to be confined between Bornou and Manding. In Bornou they have a coinage of base metal.

* African Assoc. Q. p. 176. O. p. 264.

† Mr. Park says, that Kong signifies mountain in the Mandinga language; which language is in use from the frontier of Bambara to the western sea.

‡ Labat, vol. iv. ch. 2.

‖ Bakui, and Herbelot; article Vankara.

§ See Edrisi in particular, pages 11 and 12.

** Page 254. †† Edrisi, page 12.

‡‡ Mr. Bruce, vol. iii. p. 647, says the same of the mountains of Dyre and Tegla, which are a continuation of the great belt, towards Abyssinia.

‖‖ Pliny, lib. xxxiii. c. 4. §§ Melpomene, c. 196.

Dr. Shaw (p. 302) speaks of the same mode of traffic at present between the Moors and Negroes; whence the place of traffic ought to be very far removed from the Mediterranean. There is a similar story related by Cadamosta of the exchange of salt for gold in Melli; and by Dr. Wadstrom on the windward coast of Guinea.

latest

latest times overspread the habitable parts of the Desert, and the oases within it; and have pushed their conquests and establishments southward; pressing on the Negro aborigines, who have in several instances retired to the southward of the great rivers; but in others preserve their footing on the side towards the Desert; according to the strength or openness of the situation. It is probable, however, that the Negroes, who are an agricultural people, never possessed any considerable portion of the Desert, which is so much better suited to the pastoral life of the Moors. It appears as if matters had not undergone much change in this respect since the days of Herodotus; who fixes the boundary of the Libyans and Ethiopians, in other words, of the Moors and Negroes, near the borders of the Niger; and he apparently pointed to the quarter in which Kassina or Ghana are now situated *.

The Negroes in the western quarter of the continent are of two distinct races, of which the least numerous are named Foulahs or Foolahs. These, although they partake much of the Negro form and complexion, have neither their *jetty* colour, *thick* lips, or *crisped* hair. They have also a language distinct from the Mandinga, which is the prevailing one in this quarter.

The original country of the Foulahs is said to be a tract of no great extent along the eastern branch of the Senegal river; situated between Manding and Kasson; Bambouk and Kaarta: and which bears the name of Foola-doo, or the country of the Foulahs. But whether this be really the case, or whether they might not have come from the country within Serra Leona (called also the Foulah country), may be a question; of which, more in the sequel. The Foulahs occupy at least as sovereigns several provinces or kingdoms, interspersed throughout the tract comprehended between the mountainous border of the country of Serra Leona on the west, and that of Tombuctoo on the east; as also a large tract on the lower part of the Senegal river; and these provinces are insulated from each other in a very remarkable manner. Their religion is Mahomedanism, but with a great mixture of Paganism; and with less intolerance than is practised by the Moors.

The principal of the Foulah states is that within Serra Leona; and of which Teemboo is the capital. The next in order appears to be that bordering on the south of the Senegal river, and on the Jaloffs: this is properly named Siratik. Others of less note are Bondou, with Foota-Torra adjacent to it, lying between the rivers Gambia and Falemé; Foola-doo and Brooko along the upper part of the Senegal river; Wassela beyond the upper part of the Niger; and Massina lower down on the same river, and joining to Tombuctoo on the west.

The Moors have not in any instance established themselves on the south of the great rivers. They have advanced farthest to the south in the western quarter of Africa; so that the common boundary of the two races passes, in respect of the parallels on the globe, with a considerable degree of obliquity to the north, in its way from the river Senegal towards Nubia and the Nile. Mr. Park arranges the Moorish states, which form the *frontier* towards Nigritia, together with the Negro states opposed to them on the south, in the line of his progress, in the following order:

The small Moorish state of Gedumah, situated on the north bank of the Senegal river, and the last that touches on it †, is opposed to the small Negro kingdom of Kajaaga, on the south.

* See Euterpe, c. 32; and Melpomene, c. 197.

† The Moors appear to be masters of the northern bank of the Senegal, through the greatest part of its navigable course; the Foulahs the southern bank.

south. This latter occupies the extremity of the navigable course of the Senegal, terminated in this place by the cataract of F'low.

From this point the Negro and Foulah states occupy both banks of the Senegal river to its source; and beyond that both banks of the Niger (or Joliba) likewise, to the lake Dibbie, situated beyond the term of Mr. Park's expedition. This space is divided unequally between Kasson, a hilly strong country, but of small extent; and which has the Moors of Jaffnoo on the north: Kaarta a considerable state, which has Ludamar for its opposite (a country held by Ali, a Moorish prince, who is loaded with infamy on the score of maltreatment of the only two Europeans who appear to have entered his country in latter times): Bambara of still more consideration, having the Moorish kingdom of Beeroo to the north: and Massina, a Foulah state bordering also on the south of Beeroo.

Here Mr. Park's personal knowledge ends; but he learnt that Tombuctoo and Houssa, which succeed in order to Massina, and occupy both sides of the Niger, are Moorish states, though with greatest proportion of Negro subjects: so that the river may be considered as the boundary of the two races in this quarter *.

Of the countries between Houssa and Kassina we are ignorant. The Desert seems to approach very near the river (Niger) in that quarter, whence a Moorish population may be inferred. South of the river, we hear of Kaffaba, Gago, and other Negro countries; but without any distinct notices of position; and beyond these Melli.

Kassina and Bornou, two great empires on the north of the river, appear to divide the largest portion of the remaining space to the borders of Nubia; and extend a great way to the north; this region being composed of desert and habitable country intermixed; but perhaps containing the largest proportion of the latter. In both these empires, the sovereigns are Mahomedans, but the bulk of their subjects are said to adhere to their ancient worship; that is to say, the lower orders are almost universally Negroes †.

From what has appeared, perhaps the boundary of Nigritia as it respects the Negro population may be expressed generally, and with a few exceptions, as follows: beginning from the west, the extent upwards of the navigable course of the Senegal river, generally—thence a line drawn to Silla; from Silla to Tombuctoo, Houssa, and Berissa, along the river Niger; and thence through Asouda, Kanem, and Kuku, to Dongola on the Nile.

Leo ‡ enumerates 12 states or kingdoms of Nigritia: but amongst these he includes Gualata, a tract only 300 miles S. of the river Nun: as also Cano (Gánat), adjacent to Fezzan; and Nubia. Kassina, Bornou, and Tombuctoo, are included of course §.

The kingdom of the Foulahs, before mentioned, situated between the upper part of the Gambia river and the coast of Serra Leona, and along the Rio Grande, has also a Maho-

* The emperor of Morocco is said to have held at one period the sovereignty of some of the countries on the northern banks of the Senegal and Niger rivers. Labat, vol. iii. p. 339, speaks of incursions made by his troops.

† African Assoc. Q. p. 126. O. p. 191.

‡ Page 4.

§ The Arabs and Moors call Nigritia by the general name of Soudan. By Belad Soudan, or the country of Soudan, Abulfeda includes all the known part of Africa, south of the Great Desert and Egypt. With him, Soudan is the southern quarter of the globe. D'Herbelot also allows it a wide range. Affnoo is another term for Nigritia, in use among the natives themselves. (See also Proceedings Afric. Assoc. Q. p. 164, O. p. 246.)

medan sovereign, but the bulk of the people appear to be of the ancient religion. It has been already said, that although they are a black people, they are less black than the Negroes generally, and have neither crisped hair nor thick lips: as also that they have a language distinct from the Mandinga. From these circumstances, added to that of situation, they appear clearly to be the *Leucæthiopes* of Ptolemy and Pliny. The former places them in the situation occupied by the Foulahs; that is, in the parallel of nine degrees north; having to the north the mountains of *Ryssadius*, which separate the courses of the Stachir and Nia rivers (Gambia and Rio Grande), and which therefore answer to the continuation of the great belt of high land in our geography; in which there is moreover another point of agreement, the *Caphas* of Ptolemy being the Caffaba of the map *.

Ptolemy by the name evidently meant to describe a people *less* black than the generality of the *Ethiopians*; and hence it may be gathered that this nation had been traded with, and that some notices respecting it had been communicated to him. It may also be remarked, that the navigation of Hanno terminated on this coast; probably at Sherbro' river, or sound. And as this was also the term of the knowledge of Ptolemy, it may be justly suspected that this part of the coast was described from Carthaginian materials †.

Those who have perused the Journal of Messrs. Watt and Winterbottom, through the Foulah country in 1794, and recollect how flattering a picture they give of the urbanity and hospitality of the Foulahs, will be gratified on finding that this nation was known and distinguished from the rest of the Ethiopians at a remote period of antiquity ‡.

The contrast between the Moorish and Negro characters is as great as that between the nature of their respective countries; or between their form and complexion. The Moors appear to possess the vices of the Arabs without their virtues; and to avail themselves of an intolerant religion, to oppress strangers: whilst the Negroes, and especially the Mandingas, unable to comprehend a doctrine that substitutes opinion or belief for the social duties, are content to remain in their humble state of ignorance. The hospitality shewn by these good people to Mr. Park, a destitute and forlorn stranger, raises them very high in the scale of humanity: and I know of no fitter title to confer on them than that of the Hindoos of Africa: at the same time by no means intending to degrade the Mahomedans of India by a comparison with the African Moors.

* The Soluentii of Ptolemy may also be meant for the Solimani of Mr. Park.

† And it may also have been the scene of traffic mentioned in page 155; as Dr. Wadstrom speaks of such a custom in this quarter at the present day.

‡ Pliny (lib. v. c. 8.) also speaks of the Leucæthiopes, but seems to place them on this side of Nigritia. May it not be that certain tribes of Foulahs were then established, as at present, along the Senegal river?

IV.

Obſervations on Metallic Money; chiefly directed to aſcertain the moſt advantageous Diſtribution and Figure of Gold, Silver, and Copper in Coins.

IF the value of ſcience be meaſured by its utility, there is no part of human knowledge that will rank higher than political economy. If we juſtly applaud the inventor, who by the conſtruction of a machine, or the improvement of a chemical proceſs, has added to the ſum of our enjoyments, in one ſmall part of the great ſcheme of ſocial life; how much more is due to thoſe, who, by inveſtigating the proceſſes upon which that ſcheme itſelf depends, have added to the facilities of mutual intercourſe, and given vigour to every department of active induſtry?

When we contemplate the ſtate of man, ſupported merely by the art of the hunter, or by the immediate products of the earth; aſſociated leſs for the purpoſe of mutual aſſiſtance in the arts than for predatory enterpriſe or direct reſiſtance againſt the oppreſſion of his neighbours; we are almoſt inclined to think him of a different ſpecies from the ſame creature in the civilized ſtate. Upon examination, however, it appears, that the inevitable neceſſity of events has produced the difference. The variety of productions, of wants and of fabrications, has given riſe to barter or exchange. Mutual ſupply has increaſed the ſubdiviſion of labour, and improved the means of conveyance. Streams, roads, ſhips and carriages, have extended this beneficial intercourſe. Confidence between man and man has advanced the moral principles of ſociety, and afforded a progreſſion, of which the paſt gradations may indeed be traced, but to the future part of which the imagination can ſcarcely afford a probable outline.

Among the impediments to commerce, the greateſt undoubtedly is the charge of conveyance from place to place. This is the great obſtacle which limits the exchange of commodities from one extremity of the world to the other. Whenever the charges of carriage ariſe to ſuch an amount as to equal the effectual return in any remote market, the motive for conveying merchandize to that place ceaſes. If goods were always exchanged for goods, it is clear that the conveyance, under the uncertainty of diſpoſal, would take place to a very ſmall diſtance indeed; and the labour required to diſcover the perſons willing to exchange would greatly enhance the charge. It would require a volume to enumerate and deſcribe the expedients, moral as well as mechanical, by which theſe difficulties are in part ſubdued, and ſtill more to deduce their origin and general effects. One of the chief of theſe expedients conſiſts in the uſe of ſome article of merchandize, as the medium of exchange, which ſhall be acceptable to every man, and will therefore be received and held by the ſeller of any commodity until he ſhall meet with another individual, who he knows will again take it for the article he wants.

In the iſland of Madagaſcar, it is ſaid, that the exchangeable value of goods is reckoned in hatchets, bullocks, and ſlaves; theſe commodities being univerſally vendible, and for that reaſon every where received. Smith affirms, that nails anſwer the ſame purpoſe in ſome parts of Great Britain. Theſe and other inſtances may ſerve to ſhew how a preferable medium of exchange becomes adopted, and it will without difficulty be ſeen that the ſcarceſt and leaſt deſtructible metals muſt have at length become the univerſal ſubſtitutes. For their value does not depend on their figure; they may be ſubdivided and joined again without lofs; they receive no injury by keeping; and the labour of conveying them from place to place forms a lefs part of their value than of almoft every other article.

The firft moneys were mere quantities of metal afcertained by weight, as the names of moft fpecies ftill indicate. The interference of governments was found neceffary to affure the weight, and more particularly the finenefs of determinate portions of metal; and this has given rife to an opinion, that a part of the value of coin muft depend on the edict of the State which iffues it. Whether ftatefmen themfelves have in reality thought this to be the cafe, is little to the purpofe; but it is certain that they have, from time to time, yielded to the temptation of diminifhing the quantity of precious metal iffued under a given denomination, either by openly deducting from the weight, or fecretly debafing the coin *. Tranfactions of this nature muft have operated to the lofs of all the creditors in the State; but they have never deceived the fellers, who have always regulated their prices by their knowledge of the real quantities of the metal, and not by the denomination or the fuppofed weight or finenefs it might denote. The imaginary coin, or money of account, to be found in the mercantile books of almoft every commercial nation, muft have arifen partly from this caufe.

I was led to the prefent examination by hearing that a committee of the Royal Academy has been appointed to take into confideration a proper defign for a new coinage; and, upon enquiry, I find that his Majefty's Privy Council have repeatedly deliberated on this fubject, and referred the ornamental part to the Royal Academy for their difcuffion and report. On fuch occafions it has always, and, I think, rightly, been confidered as a becoming tranfaction on the part of individuals to give their thoughts to the world by the medium of the prefs; and under this conviction it is that I have ventured to place the fubject in the light it appears to me to require.

The metals ufed for coinage are gold, filver and copper. According to the exchangeable value of gold, half a grain of this metal would purchafe as much bread as a man could eat at one meal. This fmall piece of gold, if as thin as paper, would not meafure above the tenth part of an inch in breadth, and would therefore be perfectly inconvenient for ufe. It has, in fact, been found, that the gold coin of the weight of 32 grains (or the quarter guinea) was too fmall to be conveniently ufed. The fame obfervations will apply to the fmaller fub-divifions of the fhilling of filver; whence upon the whole it appears, that coins of all the three metals are required to facilitate our commerce of buying and felling.

Gold, filver and copper, like every other produce of human induftry, depend for their value principally on the labour employed in producing and bringing them to market, and

* This diminution has taken place throughout Europe. With us the pound of money, which about the year 1087 contained a pound weight of filver, has continued at lefs than one-third (or $\frac{20}{62}$) of that quantity ever fince the reign of Elizabeth. Our neighbours however have univerfally exceeded us in this refpect. Thus the pound Flemifh is lefs than eleven fhillings; the French livre is ten pence, and the Italian lire is lefs than $2\frac{1}{4}$d.

The Chinefe ftill ufe fine filver, which they actually cut and weigh at every fingle payment. They are faid to have formerly poffeffed filver coin; but whether they were urged to their prefent practice by uncertain variations in its value caufed by their rulers, or by the difficulty of otherwife refifting the artifices of coiners, I know not.

in a confiderable degree upon the actual demand. As thefe articles are not employed merely in the fabrication of coins, the demand will vary in each according to circumftances, which admit of no permanent ratio of exchange between them. If the State were to coin certain pieces of known weight and finenefs out of each of thefe metals, and determine that a certain number of the filver pieces, for example, fhould in all cafes be equivalent to one piece of the gold, it would naturally follow, fuppofing the individual to pay nothing for the coinage, that a debt might be difcharged with moft facility to the debtor, and confequently lofs to the creditor, in the cheapeft of thefe two metals, whenever by the fluctuation of the market either of them fhould come to reprefent a larger portion of the other than the edict of the government had determined. This confequence of fixing the relative value of coins would fhow itfelf in a variety of ways, which need not be enumerated; becaufe it is certain that the dearer metal would occupy the greater part of the circulation, while the cheaper pieces would either be melted down or diminifhed, if their rated value were too high, or they would be fabricated by individuals if it were too low, in defiance of every public regulation which might be adopted. If we therefore admit, from confiderations of this nature, that no government does in reality poffefs the means of fixing a ratio between two articles of commerce, intended to be applied as the tickets of transfer or mediums of exchange, we fhall be naturally led to the adoption of one of the metals only, as the reprefentative fign, while the two others are applied merely as inftruments of accommodation for the convenient fub-divifions of value.

With regard to the queftion of preference in thefe three metals, experience has fhewn that fociety is difpofed to affume the deareft; namely, gold. With a fingle ftandard of value, the fluctuations of the market price of the metal, when compared with other commodities, will be nearly imperceptible, becaufe they confound themfelves with the rife and fall in the prices of all other articles to which the ftandard is thus applied. If a cheaper metal were to be adopted by the State, and gold were left to circulate at the election of individuals, the changes of price in this metal of high value would operate fo as to produce an uncertainty in the amount of large fums, and greatly difturb the general tranfactions of commerce. Merchants would therefore confider the gold coinage as mere bullion, and the community would in a great meafure be deprived of its ufe as a coin; as is actually the cafe in Holland and other countries where filver is the legal medium*. Hence it appears moft eligible, that gold in pieces of determinate weight and finenefs fhould conftitute the effective coin of the State, or legal tender of payment; that filver and copper fhould be formed into money for the purpofe of reprefenting fractions of the fmalleft gold coin; and that the creditor or feller fhould have the option to refufe all payments in thefe laft metals for any fum exceeding the fmalleft unity of the gold coin.

By this diftribution, though the coins of filver and copper would in ftrictnefs be fubject to fluctuations arifing from the ftate of the market with regard to thofe metals, yet the dif-

* A ftill more defective fcheme was propofed in the Report prefented by Prieur, de la Côte d'Or, from a Committee of the Council of Five Hundred, of which a very full abftract is given in the Moniteurs of 6 and 7 Floreal in the year VI. Nos. 216, 217. It is, that filver coin fhould be unchangeable in weight and denomination of value; but that the price of gold (alfo coined) fhould be fettled every fix months by a declaration from the National Treafury, deduced from the medium price of that metal during the preceding half-year. It was rejected by the Council of Ancients.

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ference would be diſregarded in the diſcharge of accounts, becauſe it could never amount to a ſum of any importance. The only inconvenience which offers itſelf under ſuch an arrangement is, that theſe ſubordinate coins would alſo be melted and ſold when the metal was dear, or they would be fabricated if the metal ever happened to be ſo cheap as to afford an adequate motive of profit to the illegal coiner. The State, in its deliberations on this ſubject, might determine that the coins of ſilver and copper ſhould paſs either for leſs than the medium market price of the metal, or for more, or for that value preciſely. It is evident that the firſt of theſe diſpoſitions would afford coin which would continually vaniſh in the melting-pot, and is therefore altogether unadviſable. The medium rate of intrinſic value would produce a ſimilar effect whenever the market price was low. Whence it follows, that the metal contained in ſuch auxiliary money ought to be of leſs value than the gold it repreſents; and to prevent the introduction of a ſimilar coinage from private manufacturers, it would be neceſſary that the difference between the value of the metal and that repreſented by the coin ſhould be ſomewhat leſs than the coſt of workmanſhip. Under theſe circumſtances the public would be ſupplied with an uſeful implement or ticket of exchange, which would operate as a pledge of value, very nearly to the amount of its denomination, and would be afforded cheaper from the extenſive manufactories of government than it could poſſibly be made by private workmen.

Coin, like every other utenſil or tool, is ſubject to wear, and will in proceſs of time be more or leſs deprived of its diſtinctive figure, and rendered leſs valuable by the loſs of weight. When new, it is the real pledge or meaſure it pretends to be; but, if it be ſuffered to circulate after its weight is conſiderably diminiſhed, it may become a deſirable object to the coiner to fabricate pieces apparently in the worn ſtate, or otherwiſe he may exerciſe his induſtry in ſpeedily reducing the new coin to that ſtate, for the ſake of the precious metal he may thus acquire.

If, on the contrary, the Legiſlature ſhould forbid the currency of pieces worn beyond a certain ſmall or moderate loſs, the conſequence will be, that all ſuch pieces will return to the Mint to be recoined; and the charge of coinage may become ſo heavy as to abſorb a conſiderable part of the value of the whole circulating medium in the courſe of a few years.

To diminiſh this laſt inconvenience as much as poſſible, it becomes neceſſary to attend to the nature of the metal as well as to the figure of the piece. Whether the Dutch ducat, of fine gold, or the Engliſh guinea, of twenty-two carats, may, under like circumſtances, be moſt diſpoſed to loſe by wear, has not I believe been determined; but it ſeems to be generally underſtood, that our ſtandard gold in watch-caſes and other trinkets is leſs durable than the coarſer and harder gold allowed to be wrought in France and Geneva. If this be true, it ſhould ſeem as if there exiſted no motive for raiſing the ſtandard of our gold, and perhaps the ſame argument may apply ſtill more to our ſilver: and the advantage, if any, in lowering the ſtandard without diminiſhing the intrinſic value, has not yet been ſhewn with ſufficient evidence to juſtify the offence againſt eſtabliſhed uſe and public prejudice which ſuch a proceeding might afford. Admitting theſe obſervations to be concluſive againſt altering the ſtandard, it would follow, that the greater durability of coin muſt be ſought for in its figure.

Let us imagine a coin to poſſeſs the figure of an equilateral triangle; let it be thin, in order

order that it may present a large surface; let its edges have the figure of a saw, and its faces that of a file. Under these conditions we should fabricate one of the worst or least durable coins that could be chosen. For the angles would be easily broken and worn, and the edges and faces would mutually operate on each other, with a degree of rapidity which, it may be concluded, would very soon take away all the sharp prominences, and greatly diminish the weight. On the other hand, let us suppose the least possible surface, and we shall obtain the spherical figure *. Against this it appears to be an objection, that if it be nearly perfect, the impressions distinctive of its purity and denomination must be indented, and will not therefore sufficiently limit its apparent magnitude; and if they be prominent it will no longer be a sphere, but a figure presenting sharp angular parts with small bearings very liable to destruction.—What then is the figure which shall partake so much of the plane, as to present surfaces of broad contact or bearing, and afford the least quantity of angular prominence? It is evidently the cylinder: and this is the figure most generally adopted for money. The edge of the cylinder affords the smallest bearing. It must therefore be very short or flat, in order that the weight of the piece may be disposed to rest on the base, and not on the edge.

If the whole surface of a piece of metal were covered with figures or impressions, it would be immediately seen whether any part had been abraded by accident or design. If the impressions were concave, they might easily be renewed by the punch or the graver; but if they were in relief, it would be almost impossible to restore them when once worn or obliterated. For this reason, the preference in coinage has mostly been given to figures in relief.

It is however a very serious inconvenience, that when the distinctive marks are thus rendered prominent, the face of the coin no longer sustains the pressure and wear of the piece; but the marks themselves are made to support the whole. Thus, in our gold money, particularly of the last recoinage, the edge is a saw, and the numerous minute prominencies on the face constitute a file, the operations of both which are severely felt in the rapid destruction of the piece †.

Hence we may observe, that neither kind of mark alone is suited to a coin intended to possess durability, and at the same time to be difficult either to imitate or diminish. A com

* The pagoda and fanam of India are the only coins I recollect which approach towards this figure.

† To place this in a more striking light, it may be observed that the amount of gold coined between the years 1762 and 177[illegible], both inclusive, was [illegible],[illegible],203 l. 15 s. 6 d. and between 1782 and 1792, both inclusive, was 19,675,666 l. 14 s. 6 d. and between 1773 and 1777, both inclusive, was 19,591,83[illegible] l. 1 s. During the middle period last mentioned the great recoinage of gold took place. I am aware that other causes may have occasioned a demand for coin besides the mere wear of the old pieces, and that the increase of commerce and manufactures has in fact produced such a demand; but as this last event (distinguishable by its gradual progress) does not appear, from the numbers in the account, to have influenced the coinage in any great proportion, I shall disregard it in the present rough statement. With this liberty, we may proceed to remark, 1st. That as most of the old pieces disappeared during the middle term of time the number of nineteen, or say twenty millions must nearly represent the whole of our gold money. 2d. That the national loss by wear in the first period, when the gold was old and smooth, reckoned at per cent. on the sum recoined, was 3708 l. per annum; and in the latter period 8943 l. per annum: and 3d. That the whole national stock of gold coin, under the regulations and figure of the last period, wears out and is recoined every eleven years. The account of coinage is to be found in the *Report of the Lords' Committee of Secrecy*, printed April 28, 1797.

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bination of both methods is necessary. If a coin be struck with indentations or parts depressed beneath the common surface, and in these there be prominent objects or designs, not more elevated than that surface, the general advantage, with regard to wear, will approach towards that of the plain surface itself, and the impression will be at least as difficult to imitate, if not more so than that of a design rising totally above the common surface *. The late copper coinage of pieces of one and of two pennies are of this kind †.

To sum up the foregoing conclusions in a few words, we may remark, that, 1. The State is unable (from the natural impracticability of the thing) to appoint two distinct articles of commerce as the circulating mediums of exchange. 2. The measure of value or legal tender ought to consist in the metal which bears the highest price, namely, gold. 3. Coin of silver and copper are required for smaller fractions than the actual subdivisions of the gold coin, but should be optional in the receipt for any larger sums. 4. These last-mentioned coins ought to represent a value in gold equal to their own quantity of metal, at the highest (or perhaps medium) market price added to the charge of fabrication. 5. No sufficient reason has yet been given, to shew that the standard of gold coin should be changed in order to render it more durable. 6. The best figure of coin is a short cylinder or flat round plate; and 7. The distinctive marks or impressions should be made neither altogether hollow nor altogether in relief, but by a combination of both forms, so as to leave a flat bearing surface on each side.

V.

An easy Method of cleaning and bleaching Copper-Plate Impressions or Prints. Extracted from a Letter of Sig. GIO. FABBRONI, *Subdirector and Superintendant of the Royal Cabinet of Philosophy and Natural History of his Royal Highness the Grand Duke of Tuscany, to Sig.* D. LUIGI TARGIONI *at Naples* ‡.

SINCE the happy invention of engraving in copper, which no doubt owes its origin to the revival of the art of chasing and ornamenting plate, collectors have availed themselves of this means to accumulate and preserve copies of the most valuable pictures and drawings. This object of research becomes every day more prevalent, and prints of the early and most celebrated masters are now sought for with the utmost avidity.

Ancient prints are valuable, not only for their own intrinsic merits, but as monuments of the

* Few coins have been made of this figure. The Chinese coin of mixed copper called the cash is the most remarkable, and perhaps the only one of extensive circulation.

† Of copper, by M. Boulton, Esq. for Government. The penny is rather more than 1.4 inch in diameter, and about 0.13 inch thick at the edge, and weighs 1 oz. avoirdupois. A circular part of the face on each side rather more than 1.1 inch in diameter is depressed by the stroke of the dye, in one of which is seen the head of the King in relief, and in the other a figure of Britannia. Upon the prominent rim on one side are the words "Georgius III. D. G. Rex," and on the other "Britannia 1797" in sunken letters. The edge or cylindrical surface is plain. The two-penny piece resembles the penny; but its diameter is 1.4 inch: sunk face 1.25 inch, and weight 2 oz. avoirdupois wanting 20 grains in the piece before me. I suppose the average weight to be 2 ounces.

‡ Translated from the Italian. Communicated by Andrew Duncan, jun. M. D. of Edinburgh, who received it from the author. The original is inserted in the Giornale Letterario di Napoli, No. 85.

the hiftory of the art. But their fcarcity renders them ftill more valuable. Moft of thofe which are ftill extant are defaced by negligence, during the time of their remaining fufpended againft walls expofed to fmoke, vapor, and the excrements of infects. Collectors of prints have not, however, fhewn the fame partiality as antiquarians for the patina; but on the contrary they have fought and practifed a method of clearing prints from thefe impurities.

This method confifts in fimple wafhing with clear water, or a ley made of the afhes of vine ftalks or reeds, and laftly by a long expofure to the dew. Aqua fortis is alfo ufed for the fame purpofe, but with a degree of rifque at leaft equal to its advantages. The ley diffolves not only the impurities but likewife the oil of the printing ink, and either difcharges it totally, or leaves a cloudy appearance. The aqua fortis acts on the vegetable fibre, of which the paper itfelf is compofed, and produces a dark colour, which cannot be removed by means of this liquid, but by an action which would confiderably injure the paper itfelf.

The difcovery of Prieftley, of the fluid erroneoufly named by him, but fince known by the name of oxygen; and the information we have obtained from Scheele, of the effects of its combination with muriatic acid, have led Berthollet to the ufeful application of its properties to the act of bleaching cloths, Chaptal to that of bleaching prints and books, and Giobert to the art of painting. But the method of making this preparation is too inconvenient for a mere amateur and collector of prints, and the oxygenated muriatic acid is not yet to be purchafed ready prepared in Italy. It may not, therefore, be unacceptable to defcribe an eafy method of effecting this purpofe without the difficulties of chemical proceffes, and within the ability of any perfon to perform.

It is known that oxygen is abundantly contained in the combinations called metallic calces, though in a ftate of inactivity; and it is equally well afcertained, that thefe fubftances have a very ftrong attraction for it. On the other hand it is a fact, that fome of the metallic calces of very moderate price are capable of eafily yielding the whole or the greateft proportion of this conftituent part. Manganefe is not very well adapted for this purpofe; but minium is much better. Nothing more is required to be done, but to provide a certain quantity of the common muriatic acid, for example, three ounces, in a glafs bottle, with a ground ftopper, of fuch a capacity that it may be only half full. Half an ounce of minium muft then be added; immediately after which the ftopper is to be put in, and the bottle fet in a cold and dark place. The heat, which foon becomes perceptible, fhews the beginning of the new combination. The minium abandons the greateft part of its oxygen with which the fluid remains impregnated, at the fame time that it acquires a fine golden yellow, and emits the deteftable fmell of oxygenated muriatic acid. It contains a fmall portion of muriate of lead; but this is not at all noxious in the fubfequent procefs. It is alfo neceffary to be obferved, that the bottle muft be ftrong, and the ftopper not too firmly fixed, otherwife the active elaftic vapor might burft it. The method of ufing this prepared acid is as follows:

Provide a fufficiently large plate of glafs, upon which one or more prints may be feparately fpread out. Near the edges let there be raifed a border of foft white wax half an inch high, adhering well to the glafs and flat at top. In this kind of trough the print is to be placed in a bath of frefh urine, or water containing a fmall quantity of ox gall, and kept in this fituation for three or four hours. The fluid is then to be decanted off, and pure warm water poured on, which muft be changed every three or four hours until it paffes limpid and clear.

clear. The impurities are sometimes of a resinous nature, and resist the action of pure water. When this is the case the washed print must be left to dry, and alcohol is then to be poured on and left for a time. After the print is thus cleaned, and all the moisture drained off, the muriatic acid prepared with minium * is to be poured on in sufficient quantity to cover the print; immediately after which another plate of glass is to be laid in contact with the rim of wax, in order to prevent the inconvenient exhalation of the oxygenated acid. In this situation the yellowest print will be seen to recover its original whiteness in a very short time. One or two hours are sufficient to produce the desired effect; but the print will receive no injury if it be left in the acid for a whole night. Nothing more is necessary to complete the work, than to decant off the remaining acid, and wash away every trace of acidity by repeated affusions of pure water. The print being then left to dry (in the sun if possible) will be found white, clear, firm, and in no respect damaged either in the texture of the paper or the tone and appearance of the impression.

VI.

On the Propagation of the Zebra with the Ass †.

AN experiment was made in the year 1773 with a zebra, in the collection of the late Lord Clive, the result of which, though of considerable interest to the natural historian, is no where upon record in any public journal or printed work. A set of questions were proposed at the time of the event to Mr. Parker ‡ by Sir Joseph Banks; which, together with the answers, he has at my request permitted me to make use of.

The zebra was first covered by an Arabian horse. For this purpose it was found necessary to bind her, and she shewed great disgust. As she did not conceive, an English ass was procured; to which she shewed a degree of aversion, scarcely if at all less than to the horse, and was subjected to him by the same means. The result of this trial not being more favourable than the other, recourse was had to the extraordinary expedient of painting another ass so as to resemble the zebra. Complete success attended this deception. When the animals were put together, the zebra at first appeared shy; but she received the embraces of the painted ass, and conceived. The offspring was a fine large male foal, which was just turned of six months old at the time of enquiry, namely, December 1773. It resembled both parents; the father as to make, and the mother as to colour; but the colour was not so strong, and the stripes on the shoulders were more conspicuous than on any other part. In answer to a question directed to that object, the relator states it as his opinion, that it would very probably propagate its species, as it did not appear at all like a mule.

In the course of the year after this information was received, his lordship died suddenly, and the

* As I have not repeated this process, I cannot estimate how far the presence of the lead may weaken the corrosive action of the acid on the paper; but I should be disposed to recommend a previous dilution of the acid with water. Whoever uses this process will of course make himself master of the proportion of water required to dilute the acid, by making his first trials with an old print of no value. N.

† Communicated by the Right Hon. Sir Joseph Banks, Bart. K. B. P. R. S. &c. &c.

‡ He was either Steward or in some other confidential employ to Lord Clive.

the collection of animals was disposed of. Sir Joseph Banks was then absent from town; and upon his return he was prevented, by this circumstance, either from purchasing the animals or acquiring any further information respecting the foal. I have lately endeavoured to obtain some intelligence on this behalf among the dealers in animals, but hitherto without success.

VII.

On the Process of Bleaching with the Oxygenated Muriatic Acid; and a Description of a new Apparatus for Bleaching Cloths with that Acid dissolved in Water without the Addition of Alkali. By THEOPHILUS LEWIS RUPP*.

THE arts which supply the luxuries, conveniences and necessaries of life have derived but little advantage from philosophers. A view of the history of arts will evince the justice of this observation. In mechanics, for instance, we find that the most important inventions and improvements have been made, not through the reasonings of philosophers, but through the ingenuity of artists, and not unfrequently by common workmen. The chemist in particular, if we except the pharmaceutical laboratory, has but little claim on the arts: on the contrary, he is indebted to them for the greatest discoveries, and a prodigious number of facts, which form the basis of his science. In the discovery of the art of making bread, of the vinous and acetous fermentations, of tanning, of working ores and metals, of making glass and soap, of the action and applications of manures, and in numberless other discoveries of the highest importance, though they are all chemical processes, the chemist has no share. But no branch of the useful arts is less indebted to him than that of changing the colours of substances. The art of dyeing has attained a high degree of perfection without the aid of the chemist, who is totally ignorant of the rationale of many of its processes, and the little he knows of this subject is of a late date. The process of dyeing the Turkey red has been known and practised from time immemorial by the most uncultivated nations, but its theory is not yet understood by philosophers. The manufacture of indigo and its application have been long known to the planter and the dyer; but it is not more than ten years since a true theory of them has been formed. The art of printing or topical dyeing is of the greatest antiquity; but the theory of this process, and of adjective colours in plain dyeing, was unknown till Mr. Henry developed it in the Memoirs of this Society †. The bleaching or whitening of vegetable substances has been long practised; but the knowledge of its theory could not be antecedent to the æra of pneumatic chemistry. We might even at this moment have been unacquainted with the cause of the destruction of the colouring matter of vegetable substances, if the discovery of the oxygenated muriatic acid, and its effects on colouring matter, had not pointed it out to us. For this discovery, and its inestimable advantages, the arts are indebted to the justly celebrated Scheele; and I am happy to pay this tribute to chemistry after the mortifying truths which I have stated above.

M. Berthollet lost no time in applying the properties of this curious and highly interesting substance to the most important practical uses. His experiments on bleaching with the oxygenated muriatic acid proved completely successful, and he did not delay to communi-

* Manchester Memoirs, vol. v. part i.

† Manchester Memoirs, vol. iii.

cate

cate his valuable labours to the public. The new method of bleaching was quickly and succefsfully introduced into the manufactures of Manchefter, Glafgow, Rouen, Valenciennes, and Courtray; and it has fince been generally adopted in Great Britain, Ireland, France, and Germany. The advantages which refult from this method, which accelerates the procefs of whitening cottons, linens, paper, &c. to a really furprifing degree in every feafon of the year, can be juftly appreciated by commercial people only, who experience its beneficial effects in many ways, but particularly in the quick circulation of their capitals.

Great difficulties for a time impeded its progrefs, arifing chiefly from prejudice and the ignorance of bleachers in chemical proceffes. Thefe obftacles were, however, foon removed by Mr. Watt at Glafgow, and by Mr. Henry and Mr. Cooper at Manchefter. Another difficulty prefented itfelf, which had nearly proved fatal to the fuccefs of the operation. This was the want of a proper apparatus, not for making the acid and combining it with water (for this had been fupplied in a very ingenious manner by Mr. Watt and Mr. Berthollet *), but for the purpofe of immerfing and bleaching goods in the liquor. The volatility of this acid, and its fuffocating vapours, prevented its application in the way commonly ufed in dye-houfes. Large cifterns were therefore conftructed, in which pieces of ftuff were ftratified; and the liquor being poured on them, the cifterns were clofed with lids. But this method was foon found to be defective, as the liquor could not be equally diffufed; the pieces were therefore only partially bleached, being white in fome parts and more or lefs coloured in others. Various other contrivances were tried without fuccefs, till it was difcovered that an addition of alkali to the liquor deprived it of its fuffocating effects without deftroying its bleaching powers. The procefs began then to be carried on in open veffels, and has been continued in this manner to the prefent period. The bleacher is now able to work his pieces in the liquor, and to expofe every part of them to its action without inconvenience. This advantage is unqueftionably great; but it is diminifhed by the heavy expence of the alkali, which is entirely loft. It is moreover to be feared, that the alkali which is added to the liquor, though it does not deftroy its power of bleaching, may diminifh it; becaufe a folution of the oxygenated muriat of potafh, which differs from the alkaline bleaching liquor in nothing but in the proportion of alkali, will not bleach at all. This is a well-known fact; from which we might infer, that the oxygenated muriatic acid will lofe its power of deftroying the colouring matter of vegetable fubftances in proportion as it becomes neutralized by an alkali.

* M. Berthollet's apparatus, however, is too complex for the ufe of a manufactory; Mr. Watt's is better; but a range of four, five or fix hogfheads or rum puncheons connected with one another in the manner of Woulfe's diftilling apparatus is preferable to either of them. Agitators on M. Berthollet's principle may be applied. The retort or matrafs fhould be of lead, ftanding in a water bath; its neck fhould be of fufficient length to condenfe the common muriatic acid, which always comes over; and it fhould form an inclination towards the body of the retort, fo that the condenfed acid may return into it. I beg leave to obferve here, that I always found the liquor to be ftrongeft when the diftillation was carried on very flowly. I have alfo found that the ftrength of the liquor is much increafed by diluting the vitriolic acid more than is ufually done. The following proportions afforded the ftrongeft liquor:

Three parts manganefe.
Eight parts common falt.
Six parts oil of vitriol.
Twelve parts water.

The proportion of manganefe is fubject to variation according to its quality.

alkali. But as we should not content ourselves with inferences, however plausible, when the truth may be established by experiment, and as I thought the matter of sufficient importance, I made the following experiments on the subject:

I beg leave to premise, that in all these experiments I made use of one and the same acid, which was kept in a bottle with a ground glass stopper, and secured from the influence of light. The manner in which I made the experiments was simply this: I weighed first of all a bottle filled with the colouring substance which I meant to employ: I then weighed in a large and perfectly colourless bottle half an ounce of the acid, to which I immediately, but very gradually, added of the colouring substance contained in the former bottle till the acid ceased to destroy any more of its colour. The bottle with the colouring substance was then weighed again, and the difference between its present and original weight was noted. The same method was observed in all the experiments.

Experiment I. To half an ounce of oxygenated muriatic acid I added a solution of indigo in acetous acid *, drop by drop, till the oxygenated acid ceased to destroy any more colour. It destroyed the colour of 160 grains of the acetite of indigo.

Experiment II. A repetition of Experiment I. The colour of 165 grains of acetite of indigo was destroyed in this experiment.

Experiment III. A repetition of Experiments I and II. The colour of 160 grains of the acetite was destroyed.

Experiment IV. To half an ounce of the oxygenated muriatic acid were added 8 drops of pure potash in a liquid state. This quantity of alkali was about sufficient to deprive the acid of its noxious odour. This mixture destroyed the colour of 150 grains of the acetite of indigo.

Experiment V. A repetition of Experiment IV. The colour of 145 grains of the acetite was destroyed.

Experiment VI. To half an ounce of the oxygenated muriatic acid, 10 drops of the same alkali were added. It destroyed the colour of 135 grains of the acetite of indigo.

Experiment VII. A mixture of half an ounce of the oxygenated acid, and 15 drops of the alkali, destroyed the colour of 120 grains of the acetite of indigo.

Though I had taken the precaution of avoiding the sulphuric acid for the reason stated in the foregoing note, I was not quite satisfied with these experiments, on account of errors which might have taken place through a double affinity. I therefore made the following experiments, in which I employed a decoction of cochineal in water instead of the acetite of indigo.

Experiment VIII. To half an ounce of the oxygenated muriatic acid, a decoction of cochineal was added till the acid ceased to act on its colour. It destroyed the colour of 390 grains of the decoction.

* It has been usual to estimate the strength of the oxygenated muriatic acid by a solution of indigo in sulphuric acid. This method was inadmissible in these experiments on the comparative strength of the bleaching liquor with and without alkali; because the sulphuric acid would have decomposed the muriat of potash, and thereby produced errors. I therefore added to a solution of indigo in sulphuric acid after it had been diluted in water, acetite of lead, till the sulphuric acid was precipitated with the lead. The indigo remained dissolved in the acetous acid.

Experiment IX.

Experiment IX. A repetition of Experiment VIII. The colour of 385 grains of the decoction was destroyed in this experiment.

Experiment X. To half an ounce of the acid six drops of the liquid alkali were added. This mixture destroyed the colour of 315 grains of the decoction.

Experiment XI. Eight drops of the alkali were mixed with half an ounce of the acid. This mixture destroyed the colour of 305 grains of the decoction.

On a comparative view of the results of these experiments, it will appear that an addition of potash to the bleaching liquor impairs its strength considerably. This diminution of power and the expence of potash are a serious loss in an extensive manufacture. It would therefore be desirable to have an apparatus for the use of the pure oxygenated muriatic acid simply dissolved in water, which is at once the cheapest and best vehicle for it. This apparatus must be simple in its construction, and obtained at a moderate expence; it must confine the liquor in such a manner as to prevent the escape of the oxygenated muriatic acid gas, which is not only a loss of power, but also an inconvenience to the workmen and dangerous to their health; and it must at the same time be so contrived, that every part of the stuff which is confined in it shall certainly and necessarily be exposed to the action of the liquor in regular succession. Having invented an apparatus capable of fulfilling all these conditions, I have the pleasure of submitting a description of it to the Society by means of the annexed drawing.

Explanation of Plate XI.

Fig. 1, is a section of the apparatus. It consists of an oblong deal cistern, A B C D, made water-tight. A rib, E E, of ash or beech wood, is firmly fixed to the middle of the bottom C D, being mortised into the ends of the cistern. This rib is provided with holes at F F, in which two perpendicular axes are to turn. The lid, A B, has a rim G G which sinks and fits into the cistern. Two tubes H H are fixed in the lid, their centres being perpendicular over the centres of the sockets F, F, when the lid is upon the cistern. At I, is a tube by which the liquor is introduced into the apparatus. As it is necessary that the space within the rim G G be air-tight, its joints to the lid and the joints of the tubes must be very close, and, if necessary, secured with pitch. Two perpendicular axes, K, L, made of ash or beech wood, pass through the tubes H, H, and rest in the sockets, F, F. A piece of strong canvas, M, is sewed very tight round the axis K, one end of it projecting from the axis. The other axis is provided with a similar piece of canvas. N, are pieces of cloth rolled upon the axis L. Two plain pulleys, O, O, are fixed to the axes in order to prevent the cloth from slipping down. The shafts are turned by a moveable handle P. Q, a moveable pulley, round which passes the cord R. This cord, which is fastened on the opposite side of the lid (see fig. 2) and passes over the small pulley S, produces friction by means of the weight T. By the spigot and fausset V, the liquor is let off when exhausted.

Fig. 2. A plan of the apparatus with the lid taken off.

The Manner of using the Apparatus.

The dimensions of this apparatus are calculated for the purpose of bleaching twelve or fifteen pieces of 4-4 calicoes, or any other stuffs of equal breadth and substance. When the goods are ready for bleaching, the axis L is placed on a frame in a horizontal position, and one of the pieces N being fastened to the canvas M, by means of wooden skewers in the manner represented in fig. 1, it is rolled upon the axis by turning it with the handle P. This operation

operation muſt be performed by two perſons; the one turning the axis, and the other directing the piece, which muſt be rolled on very tight and very even. When the firſt piece is on the axis, the next piece is faſtened to the end of it by ſkewers, and wound on in the ſame manner as the firſt. The ſame method is purſued till all the pieces are wound upon the axis. The end of the laſt piece is then faſtened to the canvas of the axis K. Both axes are afterwards placed into the ciſtern with their ends in the ſockets F, F, and the lid is put on the ciſtern by paſſing the axes through the tubes H, H. The handle P is put upon the empty axis, and the pulley Q upon the axis on which the cloth is rolled; and the cord R with the weight T is put round it, and over the pulley S. The uſe of the friction produced by this weight is to make the cloth wind tight upon the other axis. But as the effect of the weight will increaſe as one cylinder increaſes and the other leſſens, I recommend that three or four weights be ſuſpended on the cord, which may be taken off gradually as the perſon who works the machine may find it convenient. As the weights hang in open hooks which are faſtened to the cord, it will be little or no trouble to put them on and to remove them.

Things being thus diſpoſed, the bleaching liquor is to be transferred from the veſſels in which it has been prepared into the apparatus, by a moveable tube paſſing through the tube I, and deſcending to the bottom of the ciſtern. This tube being connected with the veſſels by means of leaden or wooden pipes provided with cocks, hardly any vapours will eſcape in the transfer. When the apparatus is filled up to the line *a*, the moveable tube is to be withdrawn, and the tube I cloſed. As the liquor riſes above the edge of the rim G, and above the tubes H, H, it is evident that no evaporation can take place except where the rim does not apply cloſely to the ſides of the box: which will, however, form a very trifling ſurface if the carpenter's work be decently done. The cloth is now to be wound from the axis L upon the axis K, by turning this; and when this is accompliſhed, the handle P and pulley Q are to be changed, and the cloth is to be wound back upon the axis L. This operation is of courſe to be repeated as often as neceſſary. It is plain, that by this proceſs of winding the cloth from one axis upon the other, every part of it is expoſed in the moſt complete manner to the action of the liquor in which it is immerſed. It will be neceſſary to turn at firſt very briſkly, not only becauſe the liquor is then the ſtrongeſt, but alſo, becauſe it requires a number of revolutions, when the axis is bare, to move a certain length of cloth in a given time, though this may be performed by a ſingle revolution when the axis is filled. Experience muſt teach how long the goods are to be worked; nor can any rule be given reſpecting the quantity and ſtrength of the liquor in order to bleach a certain number of pieces. An intelligent workman will ſoon attain ſufficient knowledge of theſe points. It is hardly neceſſary to obſerve, that if the liquor ſhould retain any ſtrength after a ſet of pieces are bleached with it, it may again be employed for another ſet.

With a few alterations, this apparatus might be made applicable to the bleaching of yarn. If, for inſtance, the pulley O were removed from the end of the axis K, and fixed immediately under the tube H; if it were perforated in all directions, and tapes or ſtrings paſſed through the holes, ſkains of yarn might be tied to theſe tapes underneath the pulley, ſo as to hang down towards the bottom of the box. The apparatus being afterwards filled with bleaching liquor, and the axis turned, the motion would cauſe every thread to be acted upon by the liquor. Several axes might thus be turned in the ſame box, and, being connected with each other by pulleys, they might all be worked by one perſon at the ſame time; and as all would turn

turn the ſame way, and with the ſame ſpeed, the ſkains could not poſſibly entangle each other.

In order to ſhew the uſefulneſs of this apparatus ſtill more clearly, I requeſt the ſociety to attend to the following ſtatement of the expence of a given quantity of bleaching liquor, with and without alkali, but of equal ſtrength.

With ALKALI*.	£.	s.	d.
80 lb. of ſalt, at $1\frac{1}{2}$d. per lb. — — —	0	10	0
60 lb. of oil of vitriol, at $6\frac{1}{2}$d. per lb. — — —	1	12	6
30 lb. of mangaueſe — — — — —	0	2	6
20 lb. of pearl-aſhes, at 6d. per lb. — — — —	0	10	0
	2	15	0
But it appears by the foregoing experiments, that the liquor loſes ſtrength by an addition of alkali. The value of this loſs, which on an average amounts to 15 per cent. muſt be added to the expence — — —	0	8	3
	3	3	3
Without ALKALI.			
80 lb. of ſalt — — — — —	0	10	0
60 lb. of oil of vitriol — — — — —	1	12	6
36 lb. of manganeſe — — — —	0	2	6
	£. 2	5	0

It appears from this calculation, that a certain quantity of the liquor for the uſe of any apparatus coſts only 2 *l.* 5 *s.*; but, that the ſame quantity of the alkaline liquor coſts 3 *l.* 3 *s.* 3 *d.* which is 40 *per cent.* more than the other. The aggregate of ſo conſiderable a ſaving muſt form a large ſum in the extenſive manufactures of this country.

VIII.

Experimental Reſearches concerning the Principle of the lateral Communication of Motion in Fluids applied to the Explanation of various Hydraulic Phenomena. By Citizen J. B. VENTURI, *Profeſſor of Experimental Philoſophy at Modena, Member of the Italian Society of the Inſtitute of Bologna, the Agrarian Society of Turin, &c.*

(Continued from Page 179 of the preſent Volume.)

Propoſition V.

IN an additional conical tube, the preſſure of the atmoſphere increaſes the expenditure in the proportion of the exterior ſection of the tube to the ſection of the contracted vein, whatever may be the poſition of the tube, provided its internal figure be adapted throughout to the lateral communication of motion.

We have ſeen (Propoſition III.) that the preſſure of the atmoſphere increaſes the expen-

* I make no mention of the expence attending the preparation of the liquor, it being the ſame in both caſes.

diture through additional tubes, whatever may be their poſition. We ſhall in the next place examine the mode of action by which the atmoſphere produces this augmentation, and determine the reſult from its cauſe. I ſhall begin with the caſe beſt adapted to favour the action of the atmoſphere, which is, that of conical diverging tubes of a certain form, which we have not yet conſidered.

Let the extremity AB, fig. 10, Plate VIII. of the tube A B E F be applied to an orifice formed in a thin plate. The part A B C D is nearly of the figure of the contracted vein, which form has been ſhewn to make no perceptible alteration in the expenditure (Experiment IV.) The fluid which iſſues through C D is diſpoſed to continue its courſe in the cylindrical form C D H G. But if the lateral parts of the diverging conical tube C E G, D F H, contain a maſs of the fluid at reſt, the cylindrical ſtream C D H G will communicate its motion to the lateral parts (by Prop. I.) ſucceſſively from part to part. And provided the divergence of the ſides C E, D F, be ſuch as is beſt adapted to the ſpeedy and complete lateral communication of motion, all the fluid contained in the truncated cone C D E F will at length acquire the ſame velocity as that of the ſtream which continues to iſſue through C D. On this ſuppoſition, while the fluid ſtratum C D Q R, preſerving its velocity and thickneſs, would paſs into R Q T S, a vacuum would be formed in the ſolid zone R m r S Q n o T. Or otherwiſe, if it be ſuppoſed that the ſtratum C D Q R, preſerving its progreſſive velocity, ſhould enlarge in R Q T S, this cannot happen without its becoming thinner, and detaching itſelf from the ſtratum which follows, and by that means leaving a vacuum equal in magnitude to the zone laſt mentioned. A ſimilar effect would take place through the whole of the tube C E; and if the quantity C m be ſuppoſed to be invariable, the ſum of all theſe void ſpaces will be equal to the ſolid zone V E x G z Y F H.

From this conſideration, we ſee that the lateral communication of motion cauſes the ſame effect in a conical tube, whether horizontal or vertical, as gravity produces in the deſcending tube of Propoſition IV. The atmoſphere in this caſe alſo renders part of its preſſure active on the reſervoir, and at E F. If the action of the atmoſphere upon the reſervoir increaſes the velocity of the ſection C D, this velocity will communicate itſelf likewiſe to the whole fluid C D F E, and the tendency to a vacuum will take place as before; but ſince the action of the atmoſphere is exerted equally at E F, it will take away at E F all the velocity which it added at C D; ſo that, being deducted from the ſame maſs, and in the ſame time, at E F, the fluid will not ceaſe to be continuous in the pipe. It is found by computation, that this will happen when the velocity of C D is increaſed in the ratio of CD^2 to EF^2.

By applying the general laws of motion to the lateral fluid filaments of the ſtream which iſſues through A B, it is found that they tend to deſcribe a curve which commences within the reſervoir, for example, at A, and continues towards C S E. To determine the nature of this curve, it is requiſite to know, and to combine together by calculation, the mutual convergency of the fluid filaments in A B, the law of the lateral communication of motion between the filaments themſelves and their divergent progreſſion from C to E. Theſe combinations and calculations are perhaps beyond the utmoſt efforts of analyſis. While the tube A B F E poſſeſſes a different figure from this natural curve, the reſults of experiment will always differ more or leſs from the theory.

Experiment XIII. The compound tube A B F E of the ſame fig. 10, having the following dimenſions

dimenſions in lines AB = EF = 18; AC = 11; CD = 15,5; CG = 49; and this tube being applied to the orifice P, fig. 1, under a charge of 32,5 inches, the four cubical feet of water were emitted in 27″,5.

We have ſeen that, in the third experiment, under like circumſtances, the orifice through a thin plate afforded four cubic feet of water in 41″. The contracted vein was 0,64 of the orifice. Conſequently, by following the enunciation of the theorem, the expence through the pipe ABF ought to be made in 26″,24. The experiment falls ſhort in the quantity 1″,26.

Experiment XIV. Between the two conical tubes of the preceding experiment is interpoſed a cylindrical tube three inches long and 15,5 lines in diameter. The interpoſition of the cylinder between the two cones was as in fig. 13. This addition retarded the expenditure 1″, the time now being 28″,5.

Experiment XV. The charge of the reſervoir being conſtantly 32,5 inches, the portion of the tube ABCD, fig. 11, had the ſame dimenſions as before; the tube CDFE was 78 lines in length, and its diameter 23 lines. To this horizontal tube I added three glaſs tubes; the firſt DX at CD; the ſecond NY at the diſtance of 26 lines from the firſt; and the third OZ at 26 lines diſtance from the ſecond. The lower extremities of theſe three tubes were plunged in the mercury of the veſſel Q. When the water was ſuffered to flow through the tube AEFB the mercury roſe 53 lines in the tube DX; 20,5 in NY, and 7 in OZ. Theſe quantities correſpond with 62 inches height of water in DX; 24 inches in NY; and 8,1 in OZ. The expenditure of four cubic feet was effected in 25″.

I cut off the portion PNFE of the tube, and the remaining pipe ABNP emitted the ſame quantity in 31″.

In the truncated conical tube ACPBDN, the ſection PN is to the ſection of the contracted vein (namely 0,64 of the ſection AB) as 41″ to 30″. In the experiment with this laſt truncated tube the retardation is conſequently no more than 1″ leſs than the theory.

In the entire tube CDFE we have $\sqrt{62 + 32,5} : \sqrt{32,5} = 41'' : 24''$. The difference of 38 inches elevation of water in the two tubes DX, NY, muſt ariſe from the motion of the fluid from C to P; it is 1-13th leſs than by the theory. The loſs is ſucceſſively greater in the two portions PQ, QE. The reaſon of this is, that the ſtream deſcends as it moves from CD, ſo that the lateral communication not being made uniformly through the whole of any one ſection, the different parts of the current acquire irregular motions, and even eddies within the tube; whence the jet comes forth by leaps and irregular ſcattering.—Theſe uncertain motions cannot be reduced to the theory, and manifeſt themſelves the more, the longer or the more diverging the ſides of the tube. The effects conſequently remain to be aſcertained by experiment.

Experiment XVI. I conſtructed a tube CDFE as before, (fig. 11) 148 lines long, and 23 lines in diameter at EF, the reſt of the apparatus being the ſame as in the foregoing experiment. The expenditure of four cubical feet was effected in 21″; the inequality and irregularity of motion in the ſtream were greater in this experiment than in the foregoing.

It was uſeleſs to prolong the tube CDFE beyond 148 lines; for the ſtream did not in that caſe fill the portion of tube added beyond that length, and the expenditure remained conſtantly at 21″. This expenditure is nearly double what took place through the ſimple aperture in a thin plate; and it is the greateſt I have been able to obtain by additional tubes, the axis of which had an horizontal poſition under a charge of 32,5 inches.

 It

It is true, that by prolonging the tube C D F E to the length of 204 lines in the horizontal position, the four cubic feet flowed out in 19″. But to obtain this effect, I found it necessary to fix a prominence within the tube at O, which forced the fluid to fly upwards, and by that means to fill the whole tube.

Experiment XVII. In this experiment the horizontal tube C D F E, fig. 11, was more divergent than in the foregoing trials. It was 117 lines long, and 36 lines in diameter at E F. The rest of the apparatus was the same as before. The expenditure was made in 28″; the stream did not fill the whole section E F. The result was the same when successive portions of the pipe were cut off, until C E was no longer than 20 lines, and the external diameter 18 lines. In this case the stream filled the pipe, and the expenditure was also made in 28″.

When the length C E was 20 lines, its external diameter E F was increased to 20 lines. In this case the stream was detached from the sides of the tube, and the expence of four feet took place in 42 seconds, as in the VIth experiment.

These experiments teach us, that by varying the divergence of the sides of tubes, the lateral communication of motion has a minimum and a maximum of effect. The minimum is seen in the last experiment. It appears that the lateral communication ceases to produce its effect when the angle made by the sides of the tube with each other exceeds 16 degrees. The XIIIth experiment nearly determines the maximum of the effect when the same angle is about 3 degrees. These limits may also, perhaps, in a small degree depend upon some function of the velocity.

[*To be continued.*]

IX.

An Account of the Means employed to obtain an overflowing Well. By Mr. Benjamin Vulliamy.*

SIR,

PERMIT me, in compliance with your request, to give you a short account of the well at Norland house, belonging to Mr. L. Vulliamy; a work of great labour and expence, executed entirely under my direction, and finished in November 1794.

Before I began the work, I considered that it would be of infinite advantage should a spring be found strong enough to rise over the surface of the well; and though I thought it very improbable, yet I resolved to take from the beginning the same precautions in doing the work as if I had been assured that such a spring would be found. But although this very laborious undertaking has succeeded beyond my expectation, yet, from the knowledge I have acquired in the progress of the work, I am of opinion, that it will very seldom happen that the water will rise so high; nor will people, I believe, in general, be so indefatigable as I have been in overcoming the various difficulties that did and ever will occur in bringing such a work to perfection.

In beginning to sink this well, which has a diameter of four feet, the land springs were stopped out in the usual manner, and the well was sunk and steined to the bottom. When the workmen had got to the depth of 235 feet, the water was judged not to be very far off,

* In a letter to the Right Honourable Sir Joseph Banks, Bart. K. B. P. R. S. Phil. Transf. 1797.

and

and it was not thought safe to sink any deeper. A double thickness of steining was made about six feet from the bottom upwards, and a borer of $5\frac{1}{4}$ inches diameter was made use of. A copper pipe of the same diameter with the borer was driven down the bore hole to the depth of 24, at which depth the borer pierced through the rock into the water; and by the manner of its going through it must probably have broken into a stratum containing water and sand. At the time the borer burst through, the top of the copper pipe was about three feet above the bottom of the well: a mixture of sand and water instantly rushed in through the aperture of the pipe. This happened about two o'clock in the afternoon, and by twenty minutes past three o'clock the water of the well stood within 17 feet of the surface. The water rose the first 124 feet in eleven minutes, and the remaining 119 feet in one hour and nine minutes. The next day several buckets of water were drawn out, so as to lower the water four or five feet; and in a short time the water again rose within 17 feet of the surface. A sound line was then let down into the well in order to try its depth. To our great surprise, the well was not found by 96 feet so deep as it had been measured before the water was in it; and the lead brought up a sufficient quantity of sand to explain the reason of this difference, by shewing that the water had brought along with it 96 feet of sand into the well. Whether the copper pipe remained full of sand or not, is not easy to be determined; but I should rather be inclined to think it did not.

After the well had continued in the same state several days, the water was drawn out so as to lower it eight or ten feet; and it did not rise again by about a foot so high as it had risen before. At some days interval, water was again drawn out, so as to lower the water as before; which at each time of drawing rose less and less, until after some considerable time it would rise no more; and the water being then all drawn out, the sand remained perfectly dry and hard. I now began to think the water lost; and consequently that all the labour and expence of sinking this well, which by this time were pretty considerable, had been in vain. There remained no alternative but to endeavour to recover it by getting out the sand, or all that had been done would be useless; and although it became a more difficult task than sinking a new well might have been, yet I determined to undertake it, because I knew another well might also be liable to be filled with sand in the same manner that this was. The operation of digging was again necessarily resorted to, and the sand was drawn up in buckets until about 60 feet of it were drawn out; consequently there remained only 36 feet of sand in the well: that being too light to keep the water down, in an instant it forced again into the well with the same violence it had done before; and the man who was at the bottom getting out the sand was drawn up almost suffocated, having been covered all over by a mixture of sand and water. In a short time the water rose again within 17 feet of the surface, and then ceased to rise as before. When the water had ceased rising the sounding line was again let down, and the well was found to contain full as much sand as it did the first time of the water's coming into it.

Any further attempt towards recovering the water appeared now in vain; and most people would, I believe, have abandoned the undertaking. I again considered, that the labour and the expence would be all lost by so doing; and I determined without delay to set about drawing the sand out through the water by means of an iron box made for that purpose, without giving it time to harden as before. The labour attending on this operation was very great, as it was necessary continually to draw out the sand, and thereby to prevent the

sand

ſand from hardening. What rendered this operation the more diſcouraging was, that frequently after having drawn out 6 or 7 feet of ſand in the courſe of the day, upon ſounding the next morning the ſand was found lowered only one foot in the well, ſo that more ſand muſt have come in again. This, however, did not prevent me from proceeding in the ſame manner during ſeveral days, though with little or no appearance of any advantage ariſing from the great exertions we were making. After perſevering however for ſome conſiderable time, we perceived that the water roſe a little nearer the ſurface, and I began to entertain ſome hopes, that it might perhaps riſe high enough to come above the level of the ground; but when the water had riſen a few feet higher in the well ſome difficulties occurred, occaſioned by accidental circumſtances, which very much delayed the progreſs of the work; and it remained for a conſiderable time very uncertain whether the water would run over the top of the well or not.

Theſe difficulties being at length ſurmounted, we continued during ſeveral days the proceſs before mentioned of drawing out the ſand and water alternately; and I had the ſatiſfaction of ſeeing the water riſe higher and higher, until at laſt it ran over the top of the well into a temporary channel that conveyed it into the road. I then flattered myſelf, that every difficulty was overcome; but a few days afterwards, I diſcovered, that the upper part of the well had not been properly conſtructed, and it became neceſſary to take down about ten feet of brick work. The water, which was now a continued ſtream, rendered this extremely difficult to execute. I began by conſtructing a wooden cylinder 12 feet long, which was let down into the well, and ſuſpended to a ſtrong wooden ſtage above, upon which I had fixed two very large pumps of ſufficient power to take off all the water that the ſpring could furniſh at 11 feet below the ſurface. The ſtage and cylinder were ſo contrived as to prevent the poſſibility of any thing falling into the well; and I contrived a gage by which the men upon the ſtage could always aſcertain to the greateſt exactneſs the height of the water within the cylinder. This precaution was eſſentially neceſſary, in order to keep the water a foot below the work which was doing on the outſide of the cylinder to prevent the new work from being wetted too ſoon. After every thing was prepared, we were employed eight days in taking down 10 feet of the wall of the well, remedying the defects, and building it up again; during which time ten men were employed, five relieving the other five, and the two pumps were kept conſtantly at work during one hundred and ninety-two hours. By the aſſiſtance of the gage, the water was never ſuffered to riſe upon the new work until it was made fit to receive it. When the cylinder was taken out, the water again ran over into the temporary channel that conveyed it into the road.

The top of the well was afterwards raiſed 18 inches, and conſtructed in ſuch a manner as to be able to convey the water five different ways at pleaſure, with the power of being able to ſet any of theſe pipes dry at will, in order to repair them whenever occaſion ſhould require. The water being now entirely at command, I again reſolved upon taking out more ſand, in order to try what additional quantity of water could be obtained thereby. I cannot exactly aſcertain the quantity of ſand taken out, but the increaſe of water obtained was very great; as inſtead of the well diſcharging thirty gallons of water in a minute, the water was now increaſed to forty-ſix gallons in the ſame time.

If you think, Sir, that the above account of an overflowing well, the joint production of nature and art, is deſerving your attention, I feel myſelf much gratified in the pleaſure I have in giving you this defcription of it; and have the honour of being with the greateft regard, &c. &c. B. VULLIAMY.

Explanation of Plate XII.

Fig. I.

a Top of the well, with the water running over.

bb Ground line.

c Sand lying in the well.

d Copper pipe.

ffffff Steining of the well.

gg Double fteining fix feet from the bottom upwards.

h Stratum which the end of the copper pipe was driven into.

Fig. II and III

Iron box for drawing fand out of the well, weighing about 60lbs. one foot fquare, and two feet nine inches long.

a Handle of the box.

b A flap or door which opens inwards by a joint at c. There is another door like this on the other fide.

c The joint.

d The centre or pin of the joint.

SCIENTIFIC NEWS, AND ACCOUNTS OF BOOKS.

IN a Letter from Sig. Fabbroni to Sig. D. Luigi Targioni of Naples, inferted in the 85th No. of the Giornale Letterario di Napoli, I find an account of a very effectual compofition for extinguifhing fire, invented by M. Von Aken. The compofition is,

Burnt alum	pounds	30
Green vitriol powdered		40
Cinabrefe or red ochre in powder		20
Potters' clay, or other clay, alfo powdered		200
Water		630

With 40 meafures of this mixture an artificial fire was extinguifhed under the direction of the inventor by three perfons, which would have required the labour of 20 men and 1500 meafures of common water. Sig. Fabbroni was commiffioned to examine the value of this invention, and found in his comparative trials with engines of equal power, worked by the fame number of men, that the mixture extinguifhed the materials in combuftion in one fixth part lefs time, and three eighths lefs of fluid than when common water was ufed. He obferved, as might indeed have been imagined from the nature of the material, that the flame difappeared wherever the mixture fell, and that the faline, metallic and earthy matters formed an impenetrable lute round the hot combuftible matter, which prevented the accefs of the air, and confequently the renewal of the deftructive procefs.

Sig. Fabbroni eftimates the price of this compofition at about one foldo (or halfpenny) per pound, but remarks, that it requires fewer hands, and affords the incalculable advantage of a fpeedier extinction of the fire. Whence he concludes, that it might be adviseable to keep the ingredients ready powdered to mix with water.

I have

I have given this abridged account, becauſe it is evident that ſuch inventions are worthy the attention of philoſophers and economiſts, even though in the firſt applications they may prove leſs advantageous than their inventors may be diſpoſed to think. It is ſcarcely probable that this practice in the large way, with an engine throwing upwards of 200 gallons (value about 3l. 10s.) each minute, would be thought of or adopted, or that a ſufficient ſtore of the materials would be kept in readineſs; ſince at this rate the expenditure for an hour would demand a proviſion to the amount of 210l. ſterling. But in country places the proceſs, or ſome variation of it, might be applied with ſufficient profit in the reſult; more eſpecially if it be conſidered that common ſalt or alum, or ſuch ſaline matter as can be had and mixed with the water, together with clay, chalk, or lime, ochreous earth or common mud, or even theſe laſt without any ſalt, may anſwer the purpoſe of the lute with more or leſs effect, and extinguiſh an accidental fire with much greater ſpeed and certainty than clear water would do.

Mr. Park has circulated Propoſals for publiſhing by Subſcription (under the Patronage of the African Aſſociation) his "Travels in the interior Parts of Africa, by Way of the River Gambia, performed in the Years 1795, 1796, and 1797, by the Direction and at the Expence of that Aſſociation." The Work will form One handſome Volume Quarto, and is expected to be ready for delivery early in the enſuing Seaſon. One Guinea is to be paid at the time of ſubſcribing, which it is expected will be the price of the Book; but as the charges are not at preſent aſcertained, it is underſtood that a further payment of Half-a-Guinea will be expected, provided the Committee of the African Aſſociation ſhall certify that ſuch demand is reaſonable. Subſcriptions are taken by G. Nicol, Bookſeller, Pall-Mall.

Proceedings of the Aſſociation for promoting the Diſcovery of the interior Parts of Africa, containing an Abſtract of Mr. Park's Account of his Travels and Diſcoveries, abridged from his own Minutes by Bryan Edwards, Eſq. Alſo Geographical Illuſtrations of Mr. Park's Journey, and of North Africa at large. By Major Rennell. London: Printed for the Aſſociation. Quarto, 162 pages, with the following Maps by Major Rennell. 1. The Route of Mr. Mungo Park upon a large Scale. 2. The Lines of Magnetic Variation in the Seas round Africa; and 3. A Map ſhowing the Progreſs of Diſcovery and Improvement in the Geography of North Africa. The Scale of this intereſting Map, which comprehends the whole of Africa, from the Mediterranean Sea to the Equator, affords five Equatorial Degrees in two Inches. The Work has no Bookſeller's name, and is not vendible.

The title-page renders it needleſs to repeat, that this book conſiſts of two diſtinct works. Of the latter, which adds no ſmall portion to the well-acquired fame of its author, I have not yet been able to ſatisfy myſelf that any abridgment can be offered to the Public without mutilations, which ſuch a ſubject cannot endure. The reader has already been preſented with the concluding chapter in our preſent number. The whole will be re-printed, together with the Maps, in Mr. Park's own work. Mr. Edwards's abſtract of Mr. Park's Travels contains the following particulars:

From the houſe of Dr. Laidley at Piſania, on the banks of the river Gambia, but three degrees

degrees more westerly than the mouth of that river, Mr. Park departed to the eastward for the kingdom of Woolli with two Negro servants, himself on horseback and his servants each on an ass. He carried a small assortment of beads, amber, and tobacco, a few changes of linen and apparel, a pocket sextant, a magnetic compass, and a thermometer, together with two fowling-pieces, two pair of pistols, and some other small articles. At Medina, the capital of Woolli, he was hospitably received, and proceeded to the kingdom of Bondou, where the sovereign compelled him to surrender his coat, but nevertheless gave him five drams of gold dust and plenty of provisions. From the capital of Bondou he travelled through Kajaaga, which is bounded on the North by the Senegal river, where the French formerly had a small factory. The king commanded that he should be brought before him; but Mr. Park, who had been cautioned to avoid him, declined the interview, and escaped with the loss of about half his goods and apparel. Hence he was conducted to Kasson, under the protection of the nephew of the king of that district, where he was treated with great kindness and hospitality, but detained some weeks an account of the extreme curiosity of the natives to behold an European. Hence he proceeded still further eastward to Kemmoo, a large and populous town, since destroyed, but at that time the metropolis of an extensive kingdom called Kaarta. The king of this place, who received our traveller with great kindness, was at that time at war with the neighbouring nation of Bambarra, to the eastward, through which the Joliba or Niger river flows. Unfortunately for Mr. Park, it was the opinion of the sovereign of Kaarta, that he could not with safety pass into Bambarra immediately from his dominions; in consequence of which he advised him to shape his course to the northward into the territory of the Moors, called Ludamar, on the border of the Great Desert; through which territory he might continue his route easterly, and enter Bambarra on the northern side. By complying with these instructions, Mr. Park entered the frontier town of the Moors, called Jarra, about a degree to the northward of Kemmoo, near which he passed through the village of Simbing, whence the last dispatch of Major Houghton written with pencil was received.

Thus far our traveller had continued his journey to the eastward declining to the north, through six degrees of longitude with about a degree and a half of northing, the town of Jarra being placed in the map in about 15° 5′ north latitude. The territory through which he passed was very generally clothed with native woods, and presented to the eye an appearance of great uniformity. In his progress eastward the country rose into hills, and the soil became various, but was every where fertile in such places as had been cleared. Bondou in particular is a land abounding with black cattle, sheep, goats, and poultry, with an excellent breed of horses, though the usual beast of burthen in all the Negro territories is the ass. Animal labour is no where applied to agricultural purposes. The land is cultivated by slaves, and affords plenty of rice and Indian corn. The Pagans make an intoxicating liquor from honey. The woods furnish a small species of antelope, of which the venison is highly esteemed. Among wild animals in these countries, the most common are the hyena, the panther, and the elephant. The latter is often destroyed for the sake of its teeth, but they have not yet tamed it for the service of man.

Besides the grains proper to tropical climates, the inhabitants cultivate in considerable quantities, ground nuts, yams, and pompions. They likewise raise cotton and indigo, and have sufficient skill to convert these materials into tolerably fine cloth of a rich blue colour, and they make good soap from a mixture of ground nuts and a ley of wood ashes.

Their trade with the Whites is composed of slaves, gold-dust, ivory, and bees-wax. Their inland traffic consists chiefly of salt procured from the Moors, and warlike stores obtained from the European traders on the Gambia river. These articles are sold again to itinerant merchants called Slatees, who come down annually from distant countries, some of which are unknown even by name to the natives of the coast, with slaves and a commodity called shea-toulou, or tree-butter. This butter, in Mr. Park's opinion, besides the advantage of its keeping without salt the whole year, is whiter, firmer, and of a richer flavour than the best butter he ever tasted made from cow's milk. The tree which affords it very much resembles the American oak; and the nut, from the kernel of which the butter is prepared by boiling it in water, has somewhat the appearance of a Spanish olive, and is enveloped in a sweet pulp under a thin green rind. The growth and preparation of this commodity are among the first objects of African industry in the Eastern States, to which Mr. Park had acces. The natives of the Gambia countries are also supplied, in considerable quantities, with sweet-smelling gums and frankincense from Bondou.

The government in all these petty States, though monarchical, is no where absolute. The chiefs form an aristocracy, which greatly restrains the powers of the Sovereign, and prevent him from declaring war or concluding peace without their consent. Every considerable town is governed by a magistrate, whose office is hereditary, and who collects the duties and customs from traders, which are paid in kind. The lower orders or bulk of the people are in a state of slavery or vassalage to individual proprietors; but the power of the master, as well with regard to treatment, as the disposal of the slave to a stranger, is limited with regard to natives. These indulgencies are not however extended to captives taken in war, or obtained in traffic.

To return to Mr. Park, whom we left at Jarra in the power of the Moors, a set of the worst fanatics, who consider it as a meritorious act to destroy a Christian. After a fortnight's waiting, permission arrived from Ali, the Moorish chieftain or king of the country, for him to proceed in his journey to the eastward. With much difficulty, danger and insult, he succeeded in passing through a district of near two degrees in length, and was within two days journey of the frontier town of Bambarra, when he was carried back to the Moorish camp by order of the chief. On his arrival he was thrown into confinement, in which he remained for eight or ten weeks exposed to daily insult, robbed of all his effects, in danger of perishing from the frequent want of food and every other necessary of life, with no other probable consequence to expect than ultimately to perish by the caprice or fanaticism of the barbarians around him. Here it was that he learned some particulars of the death of Major Houghton, who was seduced into the Desert by the Moors, robbed of all his property, and died either for want of sustenance, or by the violence of those who refused to supply that want. For the particulars of Mr. Park's adventures we must wait till his work appears. He succeeded in July 1796 in escaping from his oppressors. He was fortunate enough to procure his own horse, saddle and bridle, a few articles of his apparel, and his pocket compass, which he had concealed in the sand. The joy he experienced at his escape soon subsided into more anxious emotions. Alone in the woods of Africa, exposed to the ferocity of wild beasts, and the dread of meeting again with men more ferocious than thoſe animals ; ſinking under the rage of hunger, and the ſtill more intolerable torture of thirſt, it was in vain that he chewed the bitter leaves of the trees, or climbed to look around him for a watering-place. A ſeaſonable ſhower however ſaved him from periſhing during the firſt night ; and after a weary courſe without food or water for the greateſt part of the day following, he had the good fortune to meet with relief among a few huts of Negro ſhepherds. In this manner, and with no better dependance for ſupport than the kindneſs of the moſt wretched of human beings, he proceeded on the object of his miſſion for fifteen days ; when, on the morning of the 16th, having been joined by ſome Negroes who were travelling to the town of Sego, he had the inexpreſſible ſatisfaction of beholding the object of his wiſhes, the long ſought Niger glittering to the morning ſun as broad as the Thames at Weſtminſter, and flowing ſlowly from weſt to eaſt through the middle of a very extenſive town, which his fellow travellers told him was Sego, the capital of the great kingdom of Bambarra, which Major Rennell places in 14° 10′ North latitude, and 2° 26′ Weſt longitude from Greenwich.

[*The remainder of this Abſtract in our next.*]

A TABLE for reducing the Unities of the English Inch, Gallon, and Grain into Metres, Litres, and Grammes.

Eng. Measures	Inches in Metres.	Cubic Inches in Litres.	Ale Gallons of 282 Inches in Litres.	Wine Gallons of 231 Inches in Litres.	Grains in Grammes.	Eng. Measures	Inches in Metres.	Cubic Inches in Litres.	Ale Gallons of 282 Inches in Litres.	Wine Gallons of 231 Inches in Litres.	Grains in Grammes.
1	0.0254	0.0164	4.6168	3.7821	0.0435	51	1.2950	0.8349	235.46	192.89	2.2207
2	0.0508	0.0327	9.2336	7.5643	0.0871	52	1.3204	0.8513	240.07	196.67	2.2642
3	0.0762	0.0491	13·850	11.346	0.1306	53	1.3458	0.8677	244.69	200.45	2.3078
4	0.1016	0.0655	18.467	15.128	0.1742	54	1.3711	0.8840	249.31	204.24	2.3513
5	0·1270	0.0819	23.084	18.911	0.2177	55	1.3965	0.9004	253.92	208.02	2.3948
6	0.1523	0.0982	27·701	22.693	0.2613	56	1.4219	0.9168	258.54	211.80	2.4384
7	0.1777	0.1146	32.318	26.475	0.3048	57	1.4473	0.9332	263.16	215.58	2.4819
8	0.2031	0.1310	36.934	30.257	0.3483	58	1.4727	0.9495	267.77	219.36	2.5255
9	0.2285	0.1473	41.551	34.039	0.3919	59	1.4981	0.9659	272.39	223.15	2.5690
10	0.2539	0.1637	46.168	37.821	0.4354	60	1.5235	0.9823	277.01	226.93	2.6126
11	0.2793	0.1801	50.785	41.604	0.4790	61	1.5489	0.9986	281.63	230.71	2.6561
12	0.3047	0.1965	55.402	45.386	0.5225	62	1.5743	1.0150	286.24	234.49	2.6996
13	0.3301	0.2128	60.018	49.168	0.5661	63	1.5997	1.0314	290.86	238.28	2.7432
14	0.3555	0.2292	64.635	52.950	0·6096	64	1.6251	1.0478	295.48	242.06	2.7867
15	0.3809	0.2456	69.252	56·732	0.6531	65	1.6505	1.0641	300.09	245.84	2.8303
16	0.4063	0.2619	73.869	60.514	0.6967	66	1.6758	1.0805	304.71	249.62	2.8738
17	0.4317	0.2783	78.486	64.297	0.7402	67	1.7012	1.0969	309.33	253.40	2.9174
18	0.4570	0.2947	83.102	68.079	0.7838	68	1.7266	1.1132	313.94	357.19	2.9609
19	0.4824	0.3111	87.719	71.861	0.8273	69	1.7520	1.1296	318.56	260.97	3.0044
20	0.5078	0.3274	92.336	75.643	0.8709	70	1.7774	1.1460	323.18	264.75	3.0480
21	0.5332	0.3438	96.953	79.425	0·9144	71	1.8028	1.1623	327.79	268.53	3.0915
22	0.5586	0.3602	101.57	83.207	0.9579	72	1.8282	1.1787	332.41	272.31	3.1351
23	0.5840	0.3765	106.19	86.989	1.0015	73	1.8536	1.1951	337.03	276.10	3.1786
24	0.6094	0.3929	110.80	90.772	1.0450	74	1.8790	1.2115	341.64	279.88	3.2222
25	0.6348	0.4093	115.42	94.554	1.0886	75	1.9044	1.2278	346.26	283.66	3 2657
26	0.6602	0.4256	120.04	98.336	1.1321	76	1.9298	1.2442	350.88	287.44	3.3092
27	0.6856	0.4420	124.65	102.12	1.1757	77	1.9552	1.2606	355.49	291.23	3.3528
28	0.7110	0.4584	129.27	105.90	1.2192	78	1.9805	1.2769	360.11	295.01	3.3963
29	0.7364	9.4748	133.89	109.68	1.2627	79	2.0059	1.2933	364.73	298.79	3.4399
30	0.7617	0.4911	138.50	113.46	1.3063	80	2.0313	1.3097	369.34	302.57	3.4834
31	0.7871	0.5075	143.12	117.25	1.3498	81	2.0567	1.3261	273.96	306.35	3.5270
32	0.8125	0.5239	147.74	121.03	1.3934	82	2.0821	1.3424	378.58	310.14	3.5705
33	0.8379	0.5402	152 35	124.81	1.4369	83	2.1075	1.3588	383.19	313.92	3.6140
34	0.8633	0.5566	156.97	128.59	1.4804	84	2.1329	1.3752	387.81	317.70	3.6576
35	0.8887	0·5730	161.59	132.38	1.5240	85	2.1583	1.3915	392.43	321.48	3.7011
36	0.9141	0.5894	166.20	136.16	1.5675	86	2.1837	1.4079	397.05	325.26	3.7447
37	0.9395	0.6057	170.82	139.94	1.6111	87	2.2091	1.4243	401.66	329.05	3.7882
38	0.9649	0.6221	175.44	143.72	1.6546	88	2.2345	1.4407	406.28	332.83	3.8317
39	0.9903	0.6385	180.06	147.50	1.6982	89	2.2599	1.4570	410.90	336.61	3.8753
40	1.0157	0.6548	184.67	151.28	1.7417	90	2.2852	1.4734	415.51	340.39	3·9188
41	1.0411	0.6712	189.29	155.07	1.7852	91	2.3106	1.4898	420.13	344.18	3.9624
42	1.0664	0.6876	193.91	158.85	1.8288	92	2.3360	1.5061	424.75	347.96	4.0059
43	1.0918	0.7040	198.52	162·63	1.8723	93	2.3614	1.5225	429.36	351.74	4.0495
44	1.1172	0.7203	203.14	166.41	1.9159	94	2.3868	1.5389	433.98	355.52	4.0930
45	1.1426	0.7367	207.76	170.20	1.9594	95	2.4122	1.5553	438.60	359.30	4.1365
46	1.1680	0.7531	212.37	173.98	2.0030	96	2.4376	1.5716	443.21	363.09	4.1801
47	1.1934	0.7694	216.99	177.76	2.0465	97	2.4630	1.5880	447.83	366.87	4.2236
48	1.2188	0.7858	221.61	181.54	2.0900	98	2.4884	1.6044	452.45	370.65	4.2672
49	1.2442	0.8022	226.22	185.33	2.1336	99	2.5138	1.6207	457.06	374.43	4.3107
50	1.2696	0.8186	230.84	189.11	2.1771	100	2.5392	1.6371	461.68	378.21	4.3543

A TABLE exhibiting the Prices of various Neceſſaries of Life, together with that of Day Labour, in Sterling Money, and alſo in Decimals, at different Periods from the Conqueſt to the preſent Time, derived from reſpectable Authorities; with the Depreciation of the Value of Money inferred therefrom. To which is added, the mean Appreciation of Money, according to a Series of Intervals of 50 Years, for the firſt 600 Years; and, during the preſent Century, at ſhorter Periods, deduced by Interpolation. By SIR GEORGE SHUCKBURGH EVELYN, Bart. F. R. S. and A. S.

THE PRICES OF VARIOUS ARTICLES AT DIFFERENT TIMES, (in Money reduced to the preſent Standard and Value.)

Year of our Lord.	Wheat per Buſhel. s. d.	MISCELLANEOUS ARTICLES. Cattle in Huſbandry. Horſe. £. s. d.	Ox. £. s. d.	Cow. £. s. d.	Sheep. £. s. d.	Hog. £. s. d.	Poultry. Gooſe. s. d.	Hen. s. d.	Cock. s. d.	Butter per lb. d.	Cheeſe per lb. d.	Ale per Gallon. s. d.	Small Beer per Gallon. d.	Mean depreciation from theſe 12 articles.	Beef and Mutton per lb. d. qr.	Labour in Huſbandry per day. s. d.	Depreciation of Money, according to the Price of Wheat.	Twelve Miſcellaneous Articles.	Meat.	Day Labour.	Mean of all.
1050	0 2¼	1 17 6 * 89	0 7 6 20	0 6 0 37	0 1 3 29	0 2 0 36								42			10	42			26
1150	0 4½	0 12 5	0 4 8¼		0 1 8	0 3 0		0 3								0 2					
1250	1 7¾	1 11 0	1 0 7	0 17 0	0 1 7		1 0	0 3	0 4½												
1350	1 10½	0 18 4 43	1 4 6 66	0 17 2 106	0 2 7 61	0 2 6 45	0 9 75	0 2 24	0 3¾ 31					56		0 3	100	56		75	77
1450	1 5		1 15 8	0 15 6	0 4 11½	0 5 1	0 6¼									0 3¾					
1550	1 10½	2 2 0 100	1 16 7 100	0 16 0 100	0 4 3¾ 100	0 5 6 100	1 0 100	0 8¼ 100	1 0 100	5 100	2 100	0 1½ 100	1 100	100	1 0½	0 4	100	100	100	100	100
1600	4 0½											0 4	2		1 2	0 6					
1625	4 11						2 0		1 6							0 6½					
1650	5 6											0 4	2								
1675	4 6	5 10 0 250	3 6 0 184	2 17 0 345	0 11 0 256	0 14 0 254	3 0 300	1 3 182	1 3 125	4½ 90	2 100	0 8 530	2½ 250	239	1 3½	0 7½	246	239	166	188	210
1700	4 9½											0 10	3								
1720	4 4½											1 0	3		2 2	0 8					
1740	3 8	10 0 0 476	8 0 0 437	7 7 0 784	1 6 0 602	1 15 0 634	3 6 350	1 6 218	1 6 150	9 180	3½ 175	1 0 800	3 300	434	3 0	0 10	197	434	266	250	287
1760	3 9¾	14 0 0 667	8 10 0 465	7 0 0 874	1 7 0 626	1 15 0 634	5 0 500	1 10 266	1 10 183	10 200	5½ 262	1 2 930	3 300	492	4 2	0 11	203	492	400	275	342
1780	4 5½															1 2					
1795	7 10	19 0 0 904	16 8 0 890	16 8 0 2000	1 18 0 882	5 8 0 1960	3 0 300	1 6 218	1 6 150	11½ 230	5 250	1 2½ 969	2¾ 275	752	5 3	1 5¼	426	752	511	436	531

Mean Appreciation by Interpolation. A. D.	
1050	26
1100	34
1150	43
1200	51
1250	60
1300	68
1350	77
1400	83
1450	88
1500	94
1550	100
1600	144
1650	188
1675	210
1700	238
1720	257
1740	287
1750	314
1760	342
1770	384
1780	427
1790	496
1795	531
1800 nearly	562

* The ſmall Figures denote the Price in Decimals, whereof thoſe for the year 1550 may be taken for the Integer, viz. 100.

Beſides moſt of the old Chronicles and Hiſtorians, the following Books were conſulted, in conſtructing the above Table; viz. Biſhop Fleetwood's *Chronicon Pretioſum*, 1ſt and 2d edit. *Liber Garderobæ*, in 1299. The Sketch of the Eſtabliſhments of this Kingdom, *temp.* Ed. III. *et ſeqq.* by J. Bree, 1791. Collection of Ordinances and Regulations of the Royal Houſehold, in divers Reigns, from Edw. III. to King William and Queen Mary, Lond. 1790, 4to. The 11th Volume of the *Archæologia*. An Enquiry into the Prices of Wheat and other Proviſions in England, from the Year 1000 to 1765, by Mr. Combrune, fol. Lond. by T. Longman, 1768. Dr. Smith's Wealth of Nations. Sir James Steuart's Political Œconomy; and Dr. Henry's Hiſtory. (I have copied this Article from the Philoſophical Tranſactions, M.D.CC.XC.VIII. p. 176. W. N.)