

Description of a glass apparatus, for making mineral waters ... together with the description of some new eudiometers, or instruments for ascertaining the wholesomeness of respirable air ... in a letter to Dr. Priestley / [João Jacinto de Magalhães].

Contributors

Magalhães, João Jacinto de, 1722-1790.
Priestley, J., Dr.

Publication/Creation

London : W. Parker, etc., 1779.

Persistent URL

<https://wellcomecollection.org/works/spbcakw4>

License and attribution

This work has been identified as being free of known restrictions under copyright law, including all related and neighbouring rights and is being made available under the Creative Commons, Public Domain Mark.

You can copy, modify, distribute and perform the work, even for commercial purposes, without asking permission.

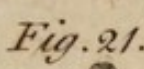
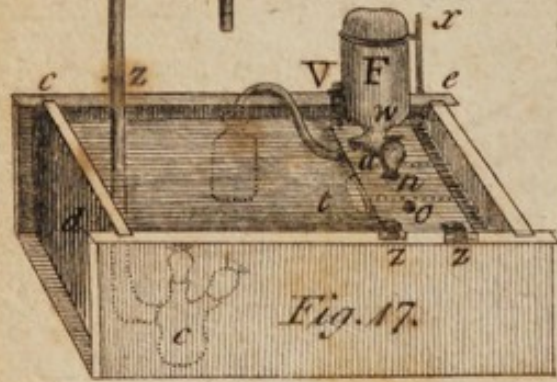
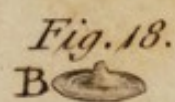
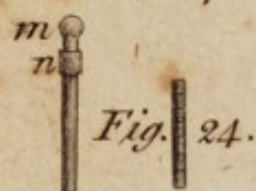
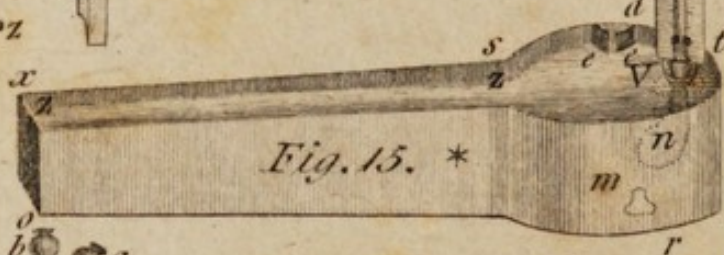
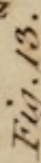
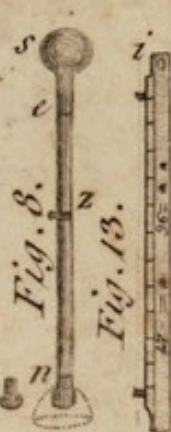
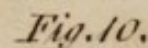
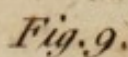
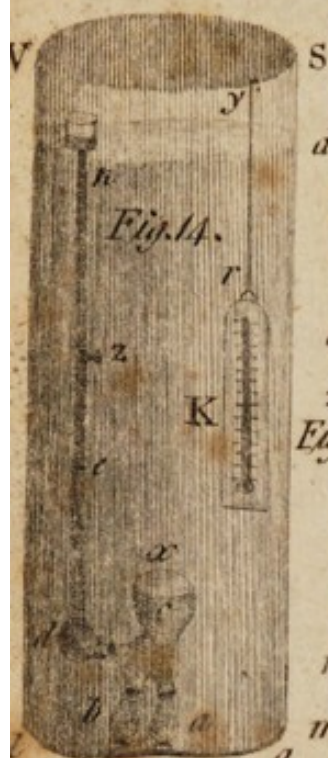
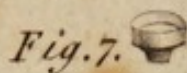
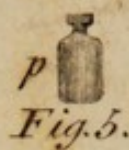
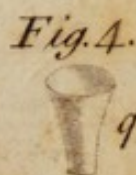
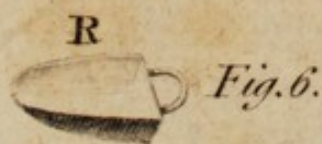


Wellcome Collection
183 Euston Road
London NW1 2BE UK
T +44 (0)20 7611 8722
E library@wellcomecollection.org
<https://wellcomecollection.org>

L. XXXIX
12/1

5/6





DESCRIPTION
OF A
GLASS APPARATUS,
FOR MAKING
MINERAL WATERS,
LIKE THOSE OF PYRMONT, SPA, SELTZER, &c.
In a few Minutes, and with a very little Expence:
TOGETHER WITH THE DESCRIPTION OF SOME
NEW EUDIOMETERS,
OR
INSTRUMENTS for ascertaining the WHOLESOMENESS of
RESPIRABLE AIR;
AND THE
METHOD OF USING THESE INSTRUMENTS:
IN A LETTER TO THE
REV. DR. PRIESTLEY, LL.D. F.R.S.
BY J. H. DE MAGELLAN, F.R.S.

The SECOND EDITION, Revised and Corrected
by the AUTHOR

L O N D O N:

Printed for W. PARKER, No. 69, FLEET-STREET,
AND SOLD BY J. JOHNSON, No. 72, ST. PAUL'S
CHURCH-YARD, AND W. BROWN, THE CORNER OF
ESSEX-STREET, IN THE STRAND.

M DCC LXXIX.

U. S. DEPARTMENT OF THE INTERIOR

BUREAU OF LAND MANAGEMENT

WATER RESOURCES DIVISION

WATER RESOURCES DIVISION

WATER RESOURCES DIVISION

WATER RESOURCES DIVISION

WATER RESOURCES DIVISION

WATER RESOURCES DIVISION

WATER RESOURCES DIVISION

WATER RESOURCES DIVISION

WATER RESOURCES DIVISION

WATER RESOURCES DIVISION

WATER RESOURCES DIVISION

WATER RESOURCES DIVISION

WATER RESOURCES DIVISION

WATER RESOURCES DIVISION

WATER RESOURCES DIVISION

WATER RESOURCES DIVISION

WATER RESOURCES DIVISION

WATER RESOURCES DIVISION

WATER RESOURCES DIVISION

WATER RESOURCES DIVISION

WATER RESOURCES DIVISION

A D V E R T I S E M E N T

O F T H E

E D I T O R,

RELATING TO THE USE OF THE SIMPLE
GLASS MACHINES FOR MAKING MINE-
RAL WATERS.

ALTHOUGH the method of using the
simple glass-machines of Mr. Parker
is minutely described in the following Letter;
nevertheless it may be more agreeable to find
here at once distinct references to those arti-
cles where it is particularly contained.

I. The description of Parker's simple machine
is comprised No. 5, 6, and 7.

II. The process to make use of the same
is described No. 8, 9, 10, and 11.

III. The manner of carrying on the pro-
duction of *fixed air* is indicated No. 12,
and note (g).

A 2

IV. The

IV. The method for reducing the process to a few minutes is described No. 14; see note (g)

V. The manner of keeping these acidulous waters is shewn No. 16.

VI. For making them sparkle like Champagne wine, No. 17.

VII. For making them ferruginous or chalybeate, No. 18.

VIII. As to the medical and oeconomic application of these waters, and *fixed air*, see No. 1, 3, 19, and 20.

N. B. *Both these* glass-machines, *and the* Eudiometers, *are made and sold at* W. Parker's Cut-glass Manufactory, No. 69, Fleet-street, London.

THE
C O N T E N T S.

ON ARTIFICIAL MINERAL WATERS.

*Advertisement concerning the simple glass
machines for making these artificial waters*
Page iii

Their discovery No. 1

*Different methods and instruments for making
artificial mineral waters* 2

*The description of the simple glass-machine for
the same* 5

The Process 9

*Diluted acid of vitriol is safer, and not liable
to those inconveniencies of strong vitriolic acid* ib.

Powdered white marble is better than chalk.
See the note (e) to No. 8

*Description of the new double glass-machine;
for making in a very short time these artificial
waters* 13

The process with these double glass-machines 14

*The simple glass-machines how to be used to
greater advantage; Note (g) to No.* 15

Qualities of these artificial waters 16

To make them sparkle No. 17

To make them chalybeate 18

*Various diseases in which these artificial
mineral waters have proved very beneficial* 19

Their advantages in æconomical purposes 20

ON EUDIOMETERS.

*Inattention of philosophers to so important an
object* 21

*First attempts for constructing these instru-
ments* 22

Their usefulness; Note (i) to No. 22

*Why marshy grounds are unfit for being inha-
bited* ibid.

Description

<i>Description of the first new Eudiometer</i>	24
<i>Water is preferable to mercury in these experiments</i>	25
<i>The Process</i>	26
<i>Description of a commodious trough for these experiments, Note K, to No.</i>	26
<i>How to send atmospherical air to be examined elsewhere; Note (l) to the same No.</i>	26
<i>Niceties to be observed in these Experiments; Note (m) to the same No.</i>	26
<i>A desideratum to bring them to perfection; Note (n) to No.</i>	27
<i>How to extract the utmost nitrous air</i>	ibid.
<i>Usefulness of nitrous air for preserving from corruption</i>	ibid.
<i>Phenomenon of the contraction and expansion of the air, independent from heat and cold; Note (o) to No.</i>	28
<i>How to estimate the comparative salubrity of air</i>	31
<i>Attention required to the temperature of the atmosphere</i>	35
<i>Description</i>	

<i>Description of the second Eudiometer</i>	36
<i>The Process</i>	37
<i>Relative advantages of the three Eudiometers</i>	40
<i>Description of the third Eudiometer No. 41</i>	
<i>The Process</i>	43
<i>Usefulness of these instruments in many other cases</i>	45
<i>How to try dephlogisticated air, with great accuracy.</i>	46
<i>Wonderful phenomenon of its diminution by nitrous air</i>	49
<i>The circumstances relating to the same</i>	51
<i>Conclusion</i>	52

TO THE
 REVEREND DR. PRIESTLEY.

DEAR SIR,

I Do not know how better to employ the leisure of these holy-days I enjoy in your neighbourhood, than in describing, according to my promise (*a*), the two contrivances I have mentioned in my last letter; which, I hope, will be useful to the public. It is with pleasure I have observed a great agreement in almost all our philosophical ideas: but I am very happy to find that we agree still more, in looking with the greatest indifference on any discovery, even the most ingenious, if no real

(*a*) This refers to a former letter to Dr. Priestley, printed in the Appendix to his third volume of *Experiments and Observations on Air*, No. III. p. 376. of the London edition.

advantage may accrue from it to mankind. Amongst the many that you have made, and which are scattered in your Philosophical Works, that of producing by art, at any time or place, with very little expence and trouble, Mineral Waters, like those of Pyrmont, Spa, Saltzer, &c. whose virtues depend on their being impregnated with *fixed air*; and that of finding out a general standard, or test, for ascertaining the greater, or less salubrity of respirable air, in any place whatsoever, are, undoubtedly, the most beneficial. The success with which the first of these two discoveries is employed, wherever it is known, and the very interesting observations relating to the second, made almost all over Italy by the Chevalier Landriani, with his Eudiometer, clearly evince the truth of my assertion (*b*).

2. As soon as your pamphlet, containing the method of making Pyrmont Water, fell into my hands, in the year 1772, I sent abroad a great many copies of it, to different parts of Europe, where I have a literary correspon-

(*b*) Dr. William White of York, has made in England many valuable observations of this kind, part of which were communicated to the Royal Society: and a very able physician of Florence, Dr. Alexander Bicchierai, has undertaken, with other friends, to make daily observations with the eudiometer, in different parts of Italy; considering this, as a branch of the utmost importance in the meteorological register of the weather.

dence;

dence; this having long been my custom, whenever any useful discovery comes to my knowledge. I made then some change or improvement in your method, which rendered the manner of conveying the fixed air to water somewhat easier. This was added in a note to the French translation of it, made soon after at Paris, from a copy that I had sent to that great promoter of Natural Philosophy, the late Monsieur Trudaine de Montigny, mentioned page 261 of your second vol. on *Different Kinds of Air*. Some time after, Mr. Blunt invented a machine, which rendered this operation still more easy. One of this kind, made by himself at Mr. Nairne's, I sent to a very judicious lover of philosophical experiments at Turin, the Marquis de Rosignan, lately ambassador of the King of Sardinia to the Court of Berlin.

3. Another construction of a glass machine for the same purpose, was published by Dr. Nooth, in the 65th vol. of Philosophical Transactions. But this being very imperfect, was afterwards improved by Mr. Parker; and you have given an account of it in the second volume of your work, above mentioned, page 302, and following. A very great number, [about 1660] of these machines have been sent to different parts, even to the East Indies:

and it is known that many persons have been greatly benefited by the use of these artificial acidulous waters. (c)

4. I found, however, not long ago, that the manner of conducting the process, as described in the printed directions sent with these machines, was very inconvenient, on account of its slow operation; it requiring four, and even six or seven hours to get the water fully impregnated with fixed air. This I felt the more in November last (1776) on my being at his Serene Highness's the Duke of Arenberg, whom I have a right to call my Mæcenas, on account of the many favours I have received from him. (d)

(c) See Dr. Withers's Observations on Chronic weakness, in 8vo, p. 164. printed at York, 1777.

(d) Alas! this truly great Prince is no more! He fell a sacrifice to the small pox, that evil so vastly destructive to the human species. Thinking himself secured on account of some few of the discreet kind, which he had in his infancy, he did not avail himself of the great blessing of our times, inoculation, through which so many thousands, or rather millions, have been rescued from death. This great Prince died the 17th of August, 1778, in the 57th of a glorious life, generally employed for the good of his subjects, and the happiness of every one, who had any dependence upon, or acquaintance with, this true friend to mankind. He was the patron of all sciences, a lover of all Polite Arts, and the promoter, as well as the warm protector of all useful knowledge.

Knowing this generous Prince to be endowed with the best dispositions that any of his rank ever had, for encouraging and giving his protection to all improvements and discoveries beneficial to mankind, this consideration prompted me to send, from London, one of these improved machines to Brussels, for the use of his Highness; and, on my trying it, on my arrival there, I felt, for the first time, how disagreeable it was to wait so long for the desired effect; which could be soon compleated, if the first method already mentioned (No. 2) was employed: for which reason I always had made use of this last, in preference to any other; as it requires but few minutes to compleat the operation.

I then considered what could be done to avoid this. At last I contrived the following apparatus, consisting of some additional pieces, by which means the whole operation is so shortened, as to take but few minutes; and, at the same time, the quantity of the artificial water is increased to double of that, which is impregnated, at one process, in the simple glass-machine, improved by Mr. Parker.

DESCRIPTION of the SIMPLE GLASS-
MACHINE.

5. A B C (fig. 1,) represents one of the improved machines of Mr. Parker, standing upon a wooden dish *d e*, in order to avoid any water, if spilled, from falling on the table. The middle vessel B has a neck, which is inserted into the mouth of the vessel A, being nicely ground air-tight to it. This lower neck of the middle vessel B, has a stopple V of glass, composed of two parts, both having holes, sufficient to let a good quantity of air pass through them: between these two parts is left a small space, containing a plano-convex lens, which acts like a valve, in letting the air pass from below upwards, and hindering the fall of the water into the vessel A.

6. The upper vessel C terminates below in a tube, marked 2, 1, (fig. 1,) which being crooked, hinders the immediate passage of the bubbles of fixed air into the upper vessel C, before they reach the surface of the water in the vessel B. The vessel C is also ground air-tight to the upper neck of the middle vessel B; and has a stopple *w*, fitted to its upper mouth, which either is perforated through the middle, as *w* and *i* (fig. 1 and 2); or is of a
conical

conical form, without any hole. But it will be better to have that kind of stopple, which will be hereafter described, No. 17. This upper vessel C contains just half the water that can be contained in the under one B; and the end (1,) of its crooked tube (2, 1,) goes no lower than the middle of the same vessel B. Each of the vessels, A and B, have an opening, *m* and *n*, with ground stopples, which are only open when occasion requires, as will be mentioned hereafter.

7. Figure the 2nd represents the two vessels B and C upon a wooden stand F, whilst separated from the vessel A.

Figure the 4th represents a wide glass-funnel *q*, which may enter into the upper mouth of the vessel A.

Figure the 5th represents a small phial *p*, which serves to measure the quantity of the vitriolic acid to be made use of.

Fig. the 6th represents a little trough of tin R, to measure the pounded chalk or marble, that is to be employed in every process:

And fig. the 7th represents a particular kind of stopples, the use of which will be explained hereafter.

THE PROCESS, with the SIMPLE MACHINE.

8. Let some dry chalk, as it comes out of the earth, that is to say, raw, without being burned in the fire; or rather white marble, which is much better for the purpose (*e*), be reduced to powder; and let some oil of vitriol be at hand. The vessel *B*, together with *C*, (fig. 1.) must be taken off from *A*, and put on the wooden stand *F* (fig. 2). Let the vessel *B* be filled with spring, or any other drinking water, or even with distilled water; and let it be joined again with the upper vessel *C*.

(*e*) White marble being first granulated, or pounded like coarse sand, is much better for this purpose, than the pounded chalk: because the action of the diluted acid upon the marble, lasts a very considerable time; and the supply of the *fixed air*, which is disengaged by this effervescence, is much more regular than otherwise. In general it continues to furnish *fixed air* more than twenty-four hours. When no more air is produced, if I decant out of the vessel *A*, all the acid fluid, already saturated, and wash off the thin, white sediment: I may employ again the remaining granulated marble, by adding to it fresh water, and a new quantity of vitriolic acid; which will then furnish a further supply of *fixed air*: and this may be repeated over again, until all the marble is dissolved; which will not be very soon.

9. Let

9. Let some water be poured on the lower vessel A, so as to cover the rising part of its bottom: but if this appears too vague a direction, pour in fourteen or sixteen measures of water, with the glass *p* (fig. 5.): then fill the same phial *p* with oil of vitriol, and pour it into the same vessel A, along with the water.

It will be, however, much easier to have made beforehand the mixture of oil of vitriol and water, in the above proportion. In this case it will not be liable to such bad consequences, as sometimes happen with strong oil of vitriol, which, if spilt, burns and destroys almost every thing it meets with. But when weakened by the mixture of about fourteen or sixteen times of water, as its own bulk (or twenty times its bulk, if the oil of vitriol is well concentrated) hardly will it then be able to do any mischief, no more than the juice of lemons, or any other such acid, as vinegar, &c. It is true that it's bulk becomes greatly increased: but it's carriage will be safer, and it's value very considerably cheaper to the purchaser.

10. After the acid is poured into the vessel A, let the glass-funnel *q* (fig. 4.) be put into the same vessel: and filling the trough *R* (fig. 6.) with the pounded chalk or marble,

C

let

let it be thrown into it. Take off the funnel *q*, which is used only to prevent the chalk from touching the inside of the mouth of this vessel; since otherwise it will stick so strongly to the neck of the vessel *B*, as not to allow the taking it off again without breaking. Then immediately place the two vessels *B* and *C*, as they are, over the mouth of the vessel *A*; and all the fixed air which is disengaged from the chalk or marble, by the force of the diluted acid, will pass up, through the valve *V*, into the vessel *B*. When this fixed air comes to the top of the vessel *B*, it will dislodge from thence as much water as its bulk: and this water, so dislodged, will go up, by the crooked tube 2, 1, into the vessel *C*.

II. Care must be taken not to shake the vessel *A*, when the powdered chalk is poured in; for otherwise a great and sudden effervescence will ensue, which will, perhaps, expel part of the contents. In such a case, it will be necessary to open the stopple *m*, in order to give vent to the effervescence for a moment; otherwise the vessel *A* may happen to burst. Perhaps it will be necessary to throw away the contents, to wash the vessel with water (because the boiling matter will stick between the necks of these vessels, and will cement them together) and to begin the operation afresh. But
if

if the powdered chalk is thrown in, without any considerable shake of the machine, there will be but a small effervescence at the beginning. When this operates well, the vessel *C* will soon be filled with water, and the vessel *B* half filled with air; which when done will be easily perceived, by the air going up in large bubbles by the crooked tube 1, 2; this will take place in about two or three minutes.

12. Whenever the effervescence nearly ceases in the vessel *A*, it will be revived again by giving it a gentle shake, so that some part of the powdered chalk which is in a heap at the bottom of *A*, may be mixed with the diluted vitriolic acid, and disengage more fixed air. However, when it happens that the whole is exhausted, and no more air rushes up to the middle vessel from the lower one, either more powdered chalk must be put in, or more oil of vitriol; or at last more water, if neither of the two first produced the desired effect. These additions may be performed by letting them in, either through the opening *m*, or through the mouth of the vessel *A*. In this case use must always be made of the funnel *q*, in order to avoid the sticking of the junctures above-mentioned. If these vessels be suffered to stand six or seven hours, the water will be sufficiently impregnated, without any further trouble, provided

vided the supply of fixed air be copious: and still more so, if it is there compressed any way (*f*). It will be of some advantage to shake the whole apparatus very gently, once or twice in every hour: In this case the water may be impregnated by the *fixed air*, in four hours, and perhaps less. It was, however, to avoid even this delay, that I invented the following additional vessels, by means of which the whole operation is considerably shorter.

DESCRIPTION of the NEW DOUBLE MACHINE.

13. Besides the two vessels B and C (fig. 1.), I have added two others perfectly alike, represented by G and H (fig. 2.). The vessel H is furnished with a stopple *i*, either of a conical form, or equally perforated as the other *w*: this vessel contains half as much as the vessel G. Both these vessels are set upon the wooden stand F; and the lower neck of the vessel G is, not only furnished with a valve and stopple, as already described, No. 5, speaking of the vessel B; but it is fitted, and ground air tight, to the neck of the same vessel A; and has an opening *l*, with a ground stopple, which is

(*f*) When the stopple *w* is solid, of a conical form, and well ground to the upper neck of the vessel C, it then greatly contributes to forward the impregnation by it's pressure; as will be seen by-the-by, No. 17.

only

only opened when occasion requires, as will be mentioned hereafter.

The wooden stand *K* (fig. 3.) is so contrived, that a thick piece of glass *x*, like a small tumbler, must be cemented in the top, after it has been ground air-tight to the under neck of the vessels *B* and *G*. The form of this stand is easily conceived by fig. 3, it being plane at the bottom, turns up in a kind of convexity *zz* towards it's edge, and has a round moulding *oo*, which hinders its tumbling, when moderately pushed sideways.

The PROCESS, *with the* DOUBLE GLASS-MACHINE.

14. The two middle vessels *B* and *G* (fig. 1. and 2.), are to be filled with pure water, and put on the stands *K* and *F*, with their upper ones *C* and *H*, as in the figure. The mixture of oil of vitriol, water, and powdered chalk, or rather marble, must be done in the same manner, as was said in No. 9 : and finally the vessels *B* and *C* are to be put on the vessel *A*, as was said No. 10. and following. But as soon as the vessel *C* is filled with the water, thrown up by the air, which dislodges it from the vessel *B*, through the crooked tube 1. 2. Both these vessels *B* and *C* are to be removed together

ther as they are, from the vessel A, to the stand K (fig. 3.), and the other vessels G H, which are in the stand F, are to be put in their stead, upon the vessel A. Whilst the operation is going-on in these last, you must hold the vessels B C, which are in the stand K, by the neck and stopple *w* with your right hand, and the under neck V with your left: incline them a little sideways, and shake them very briskly, so that the water within B, be very much agitated, presenting many fresh surfaces in contact with the *fixed air*; the greatest part of which will be absorbed into the water: as it will soon appear, by the end of the crooked tube being considerably under the surface of the water in the vessel B.

15. It will suffice to shake the water in this manner during two or three minutes; which done, loosen the upper vessel C, so that the remaining water may fall into the vessel B; and the unabsorbed air may go out (*g*). Then taking off these vessels from the stand K, put them, joined together as they are, on the stand F. By this time the vessel G will be half filled with *fixed air*; and the upper vessel H will be

(*g*) By this method, even the simple glass-machine, above-mentioned, may be worked so, as to have the water fully impregnated with the *fixed air*, in a few minutes, though with less advantage.

filled

filled with the water thrown up by it. Take then these vessels to the stand K, and replace the others B C, on the mouth of the vessel A, after letting out the unmixed air, as aforesaid; so that these vessels may be half filled again with fixed air, whilst the water in the vessels G H is briskly shaken in the same manner, as the others have been.

When this operation has been repeated three, or at most four times alternately, with each set of vessels, throwing out the remaining air which does not incorporate with the water, after it has been briskly shaken: and adding fresh quantities of *fixed air*, with which it be well agitated; in this case, the water contained in both the vessels B and C, will be fully saturated in a few minutes.

16. These artificial mineral waters, are much more pleasant to taste, than the natural Pyrmont or Seltzer's waters, which, besides their *fixed air* (the only part perhaps which affords their renewed virtues, and which is hardly half of what this artificial water may absorb) contain some disagreeable saline taste: and it is known that this alone, does not contribute at all to their medicinal virtues; but on the contrary, it may be hurtful in some complicated cases.

The

The artificial waters will remain as limpid and as transparent as before, although there has been absorbed above as much air as their own bulk. The whole process will hardly take above a quarter of an hour, by this method; and the quantity will be double of that which could be made in the simple glass-machine.

The water may be taken out by the opening *l* or *n*, to be drank immediately; if not, it will be better to let it remain in the machine, where it has no communication with the external air; otherwise, the fixed air goes off by degrees, and it becomes vapid and flat; as it happens also to the natural acidulous waters. These artificial waters may, however, be kept a very long time, in bottles well corked, placed with their mouths downwards.

17. In general they are so similar to the natural acidulous waters, that they may be even made to sparkle like Champaign wine. Mr. Warltire has actually brought these waters to this state, by keeping the fixed air compressed upon the surface of the water in the middle vessel; as appears by his letter printed in the Appendix to your third volume of *Experiments and Observations on Air*, page 366. The same end will be obtained, if, instead of
the

the stopples *w* and *i*, use is made of the solid one represented (fig. 7.) which has a kind of a basin at the top, in order to hold some additional weight. This stopple must be of a conical figure, and very loose; but so well ground and smooth in its contact, as to be air-tight by its pressure, which may be increased by some additional weights in its basin. If the vessels are stout enough, there is no danger of their bursting in the operation.

18. These waters may also be rendered fenugineous (or chalybeate) very easily, by putting, in the middle vessel, two or more slender phials, filled with cuttings of fine iron-binding wire; otherwise with small iron nails: because the impregnated water will dissolve the iron so fast, as to become well saturated with it in a few hours, according to the experiment of Mr. Lane. If the iron nails, or the cuttings of wire, were not confined in the small phials, but set loose in the middle vessel; their rust or sediment would soon stop the passages of the *fixed air* from the under vessel: in such a case the vessel A must burst; and the whole machine be broken into pieces.

19. According to Sir John Pringle, there may be added to each pint of these waters,
D from

from eight to ten drops of *tinctura martis cum spiritu salis*, in order to resemble more nearly to the genuine Pyrmont water. But the method of rendering Chalybeate these artificial waters, used by Dr. Hulme, is to add one grain of salt of steel to each pint (16 ounces) of water already impregnated with fixed air. There is no doubt but these artificial waters may be advantageously employed in many medical purposes; not only by dissolving in them the very salts, which are found to be contained in many natural springs, renowned for their different virtues; but by applying them simply without any other mixture. The same able physician Dr. Hulme, has lately published, after the first edition of this pamphlet, one *Account of different Cases and Experiments*, by which it clearly appears, that *fixed air*, administered internally, has a powerful action for dissolving the stone in the bladder, and against nephritic complaints. Its efficacy is equally beneficial against the scurvy, the gout, the fevers, even the hectic ones with consumption, the dysentery, and the worms (*b*). These artificial waters may be

(*b*) Dr. Hulme's method is to give fifteen grains of salt of tartar, diluted with three ounces of pure, or distilled, water, four times a day: drinking immediately after, at every time, the same quantity of water impregnated with twenty drops of weak spirit of vitriol. See his treatise, intituled, *Safe and easy Remedy*, &c. in 4to. London, 1771, G. Robinson and P. Elmsly.

even

even applied as a vehicle to many draughts, and internal medicines, which will be then less nauseous to the patients, and perhaps more agreeable to the stomach, giving to it a tonical strength.

20. The advantages derived from *fixed air* in œconomical purposes, deserve to be taken notice of in this place. Mr. William Lee and his neighbours, at Hartwell, did preserve flesh meat perfectly sweet for ten days, which was as long as they had occasion for, in the last hot weather of this summer (1778), one of the hottest we ever had in this country; and this was obtained by washing the meat two or three times a day with water impregnated with *fixed air*; even meat that had begun to change was totally recovered by the same process, as the said gentleman asserted in a letter I have seen, directed to a friend of mine.

I shall conclude this subject by observing with you, that fixed air may be given to wine, beer, cyder, and to almost any liquor whatsoever. Even when beer has become flat, or dead as it is called, it may be revived by employing the same method: but the delicate, though brisk, and agreeable flavour, or acidulous taste, communicated by the fixed air, and

which is so manifest in water, will hardly be perceived in wine, or other liquors, which have much taste of their own. I shall now proceed to the second object of this letter.

ON EUDIOMETERS.

21. The happy discovery you have made for the general benefit to mankind, and perhaps of almost the whole animal creation of this globe, by finding that *nitrous air is a true test of the purity of respirable air*, which is absolutely necessary to life, and without which it is presently extinct, gives a most striking instance of the blameable slowness of mankind to pay a proper attention to those objects, the importance of which is infinitely superior to that of the numerous trifling novelties which so often spread with prodigious rapidity through remote provinces, and even to the most distant countries of the earth. Since the beginning of the year 1772, in which you announced this most interesting and valuable discovery, in the 62d vol. of the *Philosophical Transactions*, no more than three or four philosophers, that I know of, have given any considerable degree of attention to so important a subject: I must acknowledge, however, that since the first edition of this pamphlet their number is very considerably increased.

22. The

22. The Abbé Fontana and the Chevalier Landriani, both of Italy, and already known to the public by their several valuable productions, were the first, as it seems, who availed themselves of this discovery (*i*), Both proposed

(*i*) Mr. Volta, Professor of Natural Philosophy at Como in Italy, has made a discovery, mentioned No. V. of the Appendix to your third volume *On different Kinds of Air*, which seems closely connected with the present subject. He discovered that *inflammable air* is contained in the mud of almost all lakes, marshes, and wet grounds of Italy. He published different Letters on this subject, of which he was so kind as to send me a printed copy, after part of this letter was printed. The experiments you have made afterwards with me at Calne on this matter, show that this air is less inflammable than what proceeds from the solution of metals, with vitriolic acid: it burns with a lambent slow flame, like the air produced by heat from charcoal: but the inflammable principle of this air seems to be much denser; as it bears a larger mixture of common air, without destroying the power of being inflamed. This discovery of professor Volta accounts very well for the unhealthy habitations such marshy grounds generally afford to the human species: and shows the necessity of examining, with care, by means of the Eudiometer, what places are fit for being inhabited. This is a new and a very interesting requisite, never to be over-looked, before any building is erected, or the place for any country seat is fixed upon. Such grounds or places, whose atmosphere is loaded with phlogistic miasms, are the most dangerous to animal life: because the air of such an atmosphere cannot be a good conductor or discharger of the superabundant phlogiston, of which the animal œconomy requires to be unloaded: this being the aim intended

posed to the public one of the most useful kinds of instruments, that we can boast of among the numberless ones already employed in philosophical researches and experiments. They gave to these instruments different forms, as appears by the printed descriptions that each of them has separately published: and the Chevalier Landriani has transmitted to England, as a present to you, the very instrument he had made use of, to estimate the respective salubrity of the air in different parts of Italy, as mentioned page 23 of the Preface to your third volume *On different Kinds of Air*. This Eudiometer is smaller than that described by him, and published in the 6th volume of Rosier's Journal for the year 1775, though nearly of the same form. It consists of a glass tube, ground to a cylindrical vessel, with two glass cocks, and a small basin, all fitted in a wooden frame. Quicksilver is there used instead of water; and that part of it which replaces the bulk lost by the diminution of the two mixed airs, is conducted either

intended by Nature in the function of respiration, as you have at last discovered, and incontrovertibly demonstrated, by the most decisive experiments, to be the case; after so many ineffectual attempts of the greatest philosophers of all ages. This appears by section V. page 55, and following, of your third volume *On different Kinds of Air*, London edit. 1777; and by *Phil. Transact.* vol. 66. p. 226.

through

through a kind of glass siphon, or through the capillary holes of a glass funnel: so that by its fall, the whole mixture of the two kinds of air is more readily made.

23. Dr. Falconer of Bath sent, some time ago, to the Royal Society of London, a glass tube, neatly divided; by means of which one may be enabled to know the quantity of diminution produced in a certain bulk of the mixture of *nitrous air* with another air, in order to judge of its salubrity, which you have shewn to be in proportion to the *diminution suffered in the sum of their original bulk, after they are mixed together*. This method is the nearest to your original one, or, rather, is the very same you have used in the pursuit of this discovery; as appears by your printed work on this subject: and I think it to be the readiest of all, whenever no great nicety is required in observations of this kind. There are, however, so many circumstances necessary in a good instrument for fully answering so great an object to its utmost extent, that I should be deterred from offering to the public what I have as yet done on this subject, was I not aware, that some advantages always accrue to public good by any new steps towards perfection, how distant soever we may still happen to be from its compleat attainment.

DESCRIP-

DESCRIPTION OF THE FIRST NEW EUDIOMETER.

24. Of the three Eudiometers I have contrived, which are represented fig. 8, 15, and 16, in the annexed plate, I think the last is the easiest in its application, and the most exact in its results. The figures 12, 14, 16, and 17, represent it in different positions, for the better understanding of its application: and it consists of the following parts, *viz.* a glass tube *m n e d* fig. 16, about twelve or fifteen inches long, and of an equal diameter, with a ground glass stopple, *m*: a vessel, *c*, the neck of which is ground air-tight to the lower end *d* of the tube: and two equal phials *a* and *b*, whose necks are also ground air-tight to the respective mouths of the vessel *c*. Both these vessels contain nearly as much as the whole tube *m n e d*. There is, moreover, a sliding brass ring, marked *z*, which slides in the tube *n d*, and may be made tight at pleasure by a finger-screw: and, lastly, a ruler, either of brass or of wood, represented fig. 11, which is divided into equal parts, and indicates the contents of both the phials *a* and *b*, when thrown into the tube, by the number of parts which is engraved or stamped about the middle of it. The two bent pieces of brass *z t* serve to hold

it easily in the side of the tube *nd* fig. 14 and 17, keeping it close to its neck *n* by the notch *i*.

25. Experiments with these Eudiometers, which are easily constructed, may be made either with water or with quicksilver; with this difference, that when the last is made use of, the Eudiometers (particularly the third, represented fig. 8, which seems the fittest for being used with quicksilver) will be more convenient, if made of a still smaller size. Mercury, however, is a fluid that, I think, never ought to be used preferably to water in the inside of Eudiometers; because it suffers a sensible action from the contact with nitrous air, as yourself have observed: and this must have an influence on the result of the experiments. Water, on the contrary, seems less liable to mistakes, although it imbibes some part of the *nitrous air*. In fact, this effect only takes place in a long time, or with much agitation: and, after duly weighing the question on both sides, I should think water may be generally used, without the fear of any sensible error. The weight and the dearth of quicksilver are, likewise, two other considerations to give the preference to water in these experiments.

THE PROCESS.

26. In the first place there must be either a trough, as represented fig. 17 (*k*); or at least a common tub, nearly filled up with water; unless the tall glass receiver, of which I shall speak No. 34, be at hand. I take out the stopple *m* (fig. 16,) and fill the Eudiometer entirely with water, keeping it in the position represented fig. 16 and 17. I then shut it with the stopple *m*, without leaving any bubble of air in the inside; and put the lower part *c*, under the surface of the water in the tub (fig. 17) in an erect position, as it is therein seen. I take the phial *a*, filled with water; and, keeping its mouth downwards under the surface of the water, I fill it with that air, the salubrity of which I want to ascertain.

This

(*k*) This figure 17 represents the most commodious shape, a trough must have for any experiments on different kinds of air. It is made with strait boards of elm-wood *one inch* thick. The inside dimensions are 25 inches long, $13\frac{1}{2}$ wide, and 11 deep, English measure. The two end-boards, *cd* and *ef*, are fitted into a groove, cut in the other three boards; this is daubed with thick white painting, as a cement, to keep well the water in: and the whole is fastened with screws from the outside. The shelf *wano* is eight inches wide, and two inches thick. It has three holes of three tenths of an inch diameter, with as many separate cavities under-
neath

This is done either by putting the phial *a* on the shelf *no* of the tub fig. 17, and throwing the air into the glass funnel *t*, which is there cemented to the shelf; or by holding in the left hand the same phial *a*, together with the glass funnel *B* (which is represented fig. 18, and has no pipe at all) applied to the mouth of the phial, whilst I throw up the air, with my right hand, into it (*l*). But lest the heat
of

neath, so as to serve like so many funnels. The figure, however, represents a glass funnel *t* cemented to the middle hole *n*: which is equally convenient. This shelf is supported by four metallic hooks *z z V w*, which may be raised or lowered at pleasure, by the wooden wedges there represented: and it is white painted with oil colour, as well as the whole trough, both in the inside and outside.

(*l*) The case I am speaking of, is when I have a bottle of air, which has been taken at any distant place, and sent for trial. If a glass bottle, with a ground glass stopple, is filled with water or with mercury, and emptied in the place whose atmospherical air is intended for being examined, it will, of course, be filled with that air: and, being closely shut with the glass stopple, may be carried to any distant place for trial. By this means the atmospherical air of any part of a country may be sent to any distant one, in order to ascertain its comparative salubrity: and many useful inquiries and discoveries may be made hereafter on this subject, with great ease, and at very small expence.

But if I only want to try the air of the room, where I have the Eudiometer, I then only pour out, of the phial *a*, the water it contains. I find, however, that

of my hand should produce any considerable expansion in this air, I generally use in hot weather the wooden tongs, represented fig. 21, with two bent wires xx , in order to hold the glass funnel z close to the mouth of the phials; unless these are made with a solid lump at their bottoms, as represented in the plate. See note (*m*).

27. The

after some trials with *nitrous air*, the atmosphere about me is loaded with phlogistic miasma: and for that reason I always empty the phial *a* out of the window of the room, in order to have nearly the same kind of air in all the experiments.

(*m*) There are some niceties to be observed in order to fill up, exactly, any phial intended to serve as a measure of air; of which I must give an account in this place. The easiest method to succeed is the following: Let a glass funnel *t* (fig. 17.) be cemented under the hole *n* of the shelf *no* in the trough. In this case I hold the phial *a* filled with water, with its mouth downwards over the hole *n* of the funnel *t*: I throw the air into the funnel; and, when the phial is filled with air, I take it sideways, rubbing its mouth along the surface of the shelf, so that the redundant air, adhering to the mouth of the phial, be got off: and I put it into the mouth of the Eudiometer it belongs to. But as the heat of the hand must expand the air contained in the phial, which of course will then contain less air than its real measure in the temperature of the surrounding water, I handle the phial with a kind of pliers or tongs of wood, represented fig. 21, till the neck enters into the proper place of the vessel *c*, where I secure it with the other hand; and, laying aside the wooden tongs, I make it properly tight. But if the phials have a solid knob or basis at their bottoms, as represented in the plate,

27. The phial *a* being filled with that air, the salubrity of which I am to examine; I put it into the mouth of the vessel *c*, making it rather tight, which must be done with some care; for if the phials *a* and *b* are not tight enough to the respective mouths of the vessel *c*, they will slip out, when turned downwards, and of course will be broken: and, if they are too tight, the vessel *c* will be easily cracked, and become unfit for use. The better to avoid these accidents, and to judge of the

plate, it will then be enough to handle them by it only: since the heat of the hand cannot be then communicated, in so short a time, to the air in the inside, through such a solid basis.

If I have not the convenience of a trough, prepared with a shelf, and its fixed funnel, as above mentioned: an assistant holds the funnel under the water in a common tub, whilst I fill up the phial with air: and I take care to hold the phial in such a manner that the end of the funnel be out of the inside of the phial at the last moment, that the air may rush out, after it is totally filled: otherwise that part of the phial, occupied by the end of the funnel, will not be totally filled with the air.

Even without any assistant, but with a little care, a person may hold both the phial and the funnel in the left hand, whilst he throws the air into it with the other hand; as I have myself frequently done in experiments of this kind: and when I make use of the wooden tongs, I add to it the two bent pieces of wire *xx* (fig. 21.) by means of which the funnel is kept close to the mouth of the phial.

proper

proper degree of tightness; the necks of the phials *a b*, and of the vessel *c*, as well as the glass stopple *m*, must be always rubbed with tallow, previously to every experiment. When I have done with the phial *a*, I take the other phial *b*, filled with water: by the same method I throw into it as much *nitrous air*, as to be perfectly filled up with it: and I then replace this phial *b* in the other mouth of the vessel, *c* (*n*).

28. I

(*n*) No pains or trouble ought to be spared, in order to obtain, at any rate, a *nitrous air* perfectly alike in its contractive power, when mixed with common air.

In order to come the nearest to this, I take a phial *D* (fig. 19.) like those you have described in the second volume of your work *On different Kinds of Air*: to the mouth of which is ground air-tight the crooked tube *n z* in the shape of an S. I fill the half of this phial with thin brass wire, the thickness of which is equal to $\frac{1}{40}$ of an English inch, nicely cut by a pin-maker to this length. I fill the three quarters of the phial with common water; and the remainder with *nitrous acid*, which I have always taken of the best sort, at the Apothecary's Hall in London. I put the crooked tube *n z* to the phial: and, as soon as the effervescence causes the liquor to rise to the end *z* of the tube, I pass it under water into the mouth of the bottle *E* (fig. 20.) which is filled with water, and inverted with its mouth downwards, marked by *F*, fig. 17. upon the hole of the shelf *no*, covered with water within the trough, or pan, as seen fig. 17.

When

28. I take afterwards the Eudiometer with my left hand, holding it by the part *d*, over the
the

When the bottle *F* is entirely filled by the *nitrous air*, I shut it up with its stopple *x* (fig. 20,) which I pass under the surface of the water, to avoid any communication with the external air: and I push this bottle under the shelf, where I let it remain for a quarter of an hour, to acquire the same temperature of the surrounding water: and the same I always observe with the bottle, containing that atmospherical air, which I desire to try, before I put it into the phial *b*.

I must acknowledge, however, that, notwithstanding these precautions, I cannot say that all the results of my experiments, even when made upon the same atmospherical air, have as yet agreed so exactly as I flattered myself they would. Perhaps there was some difference in the strength of the *nitrous air*, the density of which I thought might be proportionable to its strength; if so, it may be brought to a settled standard easily, and be determined by means of a glass hydrometer. Perhaps there was some other little variety in the circumstances of the experiments, the influence of which I was not aware of. But let it be as it may: I very willingly leave this problem to be resolved by abler chemists than I can pretend to be: and I heartily wish they may succeed better than I have done: for, without being assured of getting every where a certain *standard nitrous air*, by which the same atmospherical air be equally affected, we cannot draw with certainty any general decisive conclusions, from Eudiometrical experiments made in distant times or places.

Before I leave this subject, I cannot help mentioning two striking circumstances relating to *nitrous air*. The first is the great quantity of it, produced by the action of
nitrous

the surface of the water in the trough, to avoid breaking any of the phials, if it chances to fall; and, with my right hand, I turn the vessel *c* upwards, so that the two phials may be downwards, as represented fig. 14. By this operation the two kinds of air come up to *x*, from the phials *a b*; and there they mix together in the best possible manner; the particles

nitrous acid on many metals; which may still be carried to a greater extent, if helped by bringing the flame of a candle to the bottom of the phial, which contains the solution, when it seems to be nearly done with: if the bottom of this glass phial, fig. 19, be round and very thin, it will not crack by the heat of the flame. The second circumstance is the antiseptic power of *nitrous air* to preserve animal matters from corruption. A beef-stake, almost entirely putrid, and with an insupportable stench, being put into a jar of *nitrous air*, in less than two days was perfectly restored, and very eatable when dressed. A pigeon was very well preserved above six weeks by the same treatment; and, when roasted, was found so good as to be eaten without any dislike. Two other pigeons were kept in it full six months without corruption: they were still very firm, and of a good colour; but the flesh had lost all its flavour, and was far from being eatable when dressed. But the *nitrous air* for these æconomical purposes, which may be of a great resource at sea, as well as at home, must be made out of *nitrous acid* with iron, or other metal less exceptionable, than brass or copper, the effluvia of which are pernicious to animals: and for this reason the method already mentioned, No. 20, seems to deserve some particular regard, whenever the circumstances allow it to be made use of,

The

particles of each having a large room to come into contact with each other; since the foremost ones do not detain those which are behind, as it happens when this mixture is made in a narrow vessel. This being done, I immediately dip the Eudiometer in the water of the trough (fig. 17), leaving the mouth of the instrument above its surface; so that no more water may enter in than what it had at first. I then observe with attention the moment when the mixture x (fig. 14) of the two kinds of air comes to its greatest diminution, after which its bulk will begin to increase again. In order to catch this moment with certainty, I slide down the brass ring z of the instrument, as the surface of the water in the tube falls. This point of the greatest diminution will be easily perceived, by observing when that inside surface is stationary: which will happen in a few minutes, if the *nitrous air* has a proper strength (o).

(o) The bulk of the mixed air will decrease to a certain degree, within a few minutes, according to the strength of *nitrous air*. Afterwards it will begin to expand again: but this it will do to a very short limit, much below its former bulk. This is a phenomenon which, I think, I have observed the first on these experiments; having made a very great number of them with nice Eudiometers, of the kind I am now describing. It certainly deserves the attention of Philosophers: and, although I have communicated it to some of my acquaintance, none have as yet, in my humble opinion, given a satisfactory solution of this phenomenon.

29. As soon as the diminution of the two kinds of air appears to be stationary, I fill up the whole tube of the Eudiometer with water: I shut it up with the stopple *m*; and incline the top of the instrument forwards, till the air comes from *x* (fig. 14) up to the top *n* of the tube. I then keep the lower part of the instrument dipped in the water; take off the glass vessel *c* with the two phials *a b*: and raise or lower the tube of the Eudiometer, so as to see the surface of the water, in the inside, even with that in the outside; which I mark by sliding to it the brass ring *z*. Otherwise I apply the ruler (fig. 11, without making any use now of the brass ring) to the side of the Eudiometer, whilst it is immersed in the water of the trough: and there I see the true dimension of the remaining bulk of the two kinds of air, already diminished. Perhaps the best method for this observation would be to allow time enough that the mixed air may take its settled bulk; but this requires sometimes twenty-four hours time. I leave, however, the choice of these two methods to the observer, who may use both if he pleases, provided he keeps distinctly the result of each method, in his account of these experiments.

30. The number marked about the middle of this ruler (fig. 11), as for instance, * * = 96,
means,

means, that the contents of both phials, *a* and *b*, are equal to ninety-six divisions of the ruler, when put into the tube of that Eudiometer: that is to say, they are equal to a solid cylinder, as thick as the inside of the glass tube, and whose length is ninety-six divisions of the ruler, which has been divided into tenths of an English inch.

31. Now if, for instance, this remaining bulk of mixed air corresponds to the 56th division of the ruler, it shews that, out of 96 parts, only 40 ($=96-56$) have been lost or contracted: and, in this case, the wholesomeness of that air, which I call *A*, will be $\frac{40}{96}$. If another equal quantity of different air, which I shall call *B*, had also been tried by the same Eudiometer, and its residuum was equal to 60 parts of the same ruler, the respective salubrity of the air *B* will then be to that of the air *A*, as 36 ($=96-60$) to 40.

32. But if the air *B* had been tried by another Eudiometer, whose proportional dimensions, marked about the middle of the ruler, were $** = 108$, then the respective salubrity of these two kinds of air *A* and *B*, would be in the compound ratio of $\frac{36}{108}$ to $\frac{40}{96}$

$$= \frac{36 \times 96 \text{ to } 40 \times 108}{108 \times 96} = 3456 \text{ to } 4320 = 54 \text{ to } 67, 5:$$

that is to say, the wholesomeness of the
F 2
air

air *B* would be to that of the air *A*, as 54 to $67\frac{1}{2}$ (*p*).

33. Nearly the same results would be found, if the ruler (fig. 11) was applied to the side of the Eudiometer as soon as the inclosed mixture of air came to its utmost diminution, as mentioned No. 28 : because as much water must fall into the tube *nd*, as corresponds to the diminution suffered by the two mixed airs in *x* (fig. 14), as it is longer

(*p*) It is supposed that the inside of the tube is of an uniform diameter; but it often happens, that there are some varieties in different parts of its whole length. When they are not very considerable, we may neglect their influence in the result of these Eudiometrical experiments; but, when the contrary happens, it will be very easy to make a proper allowance for them in the calculation. It is for this reason that I have always ordered that the contents of one single phial be marked also upon the scale of each Eudiometer, as well as the contents of both phials; for instance as in this manner:

$$* * = 96$$

$$* = 47$$

which means, first, that the contents of both phials *a* and *b* are equal to a cylinder, whose diameter is the same as that of the inside bore of the tube *nd* (fig. 16), and whose height is equal to 96 equal divisions of the ruler: secondly, that the contents of a single phial are equal to 47 divisions in the upper part of the same tube *mnd*, and of course to 49 divisions ($=96-47$) of its lower part. By this difference it appears, that the tube of such Eudiometer is wider in the top than at the bottom, by $\frac{2}{96}$ of the whole.

or shorter: and these varieties ought not to be overlooked in nice experiments: they are avoided by the process already described, No. 29; and may otherwise be prevented by the method, of which I will speak at the end of No. 39.

34. Whenever I have at hand a tall glass receiver, like that represented fig. 14, the whole process is then more easily performed; for in this case I dip the Eudiometer, inverted as it appears fig. 12, into the water contained in the vessel *V S q l*: I then put the two kinds of air into the phials *a* and *b* as above said, No. 26 and 27: I turn the instrument upright, as represented fig. 14; and finish the process, as I have already described.

35. I must, however, warn the operator that, unless every trial, and even almost every part of the process, be made in the same temperature; or, at least, unless the varieties arising from this cause be accounted for; no reliance can be had on the result of such experiments: it being well known, that air is apt to increase or diminish very considerably in its bulk by the influence of heat and cold. It is for this reason that I constantly keep a good thermometer *K*, which hangs by the wire

yr, and is immersed in the water of the glass vessel fig. 14, or in the trough fig. 17, whenever I make any of these experiments. For the same reason I take care to leave the Eudiometer and the vessels of air immersed in water time enough, as above-mentioned, to get the same temperature: and I make use of the wooden tongs mentioned in note (g), whenever I handle the phials *ab* filled with air, unless I feel the heat of my hands to be the same as that of the water, in the trough, I make use of. But if the phials are made with a flat basis or bottom to each, as represented in the plate; in that case the wooden tongs are quite unnecessary,

DESCRIPTION OF THE SECOND NEW EUDIOMETER.

36. The Eudiometer, represented fig. 15, consists of a glass tube *tc*, two or three feet long, and of an uniform diameter: the end *c* is bent forwards; and the other end *t* is wide open, as a funnel, unless a separate one is made use of: this tube is fastened, by two loops, to the brass scale *cwtV*. There is a glass phial *n*, the neck *V* of which is ground air-tight to the end *t* of the tube; and contains only half of the whole inside capacity of the divided tube

tube *ct*. It has, at the other end *c*, a large round phial *abc*, containing three or four times the bulk of the phial *n*: its neck is also ground air-tight to the mouth *c* of the tube. The brass scale *cwtV* is divided into 128 equal parts, this being a number that can be divided to unity in a subduplicate ratio without fraction, by continual bisections; on which account it is one of the numbers the late famous Mr. Bird had adopted for his dividing mathematical instruments with the utmost accuracy. These numbers are set out in the scale from *t* towards *c*. The contents or capacity of the tube till the number 128 is the double of the capacity of the phial *n*. Besides this there is a tin vessel *xsdtro* (fig. 15*), which may serve as a packing case for the whole instrument, and its necessary appendages; and also as a trough, when experiments are made, it being then filled with water. Both the glass tube *K*, represented fig. 22, and the glass stopple *m* (fig. 15*), belong to this Eudiometer; and both are fitted in, air-tight, to its mouth *V*.

THE PROCESS.

37. Let the instrument be immersed under the water *zz* of the tin vessel fig. 15*: and
let

let the phial *n*, filled with water, be put in the inside socket *e e d* of the tin vessel. Let it be filled with *nitrous air*, as above directed at the end of No. 27: and let this quantity of air be thrown into the phial *a b c* (as directed No. 26 and No. 27), which I fix a little tight to the mouth *c* of the Eudiometer. I afterwards fill the same phial *n* with the air I want to try: and, raising the end *c* of the instrument, I put it into its mouth *V*: when this is done, I set the instrument upright, as represented fig. 15, hanging it on the hook *w*; and, as soon as this last air goes up to the phial *a b c*, I take off the phial *n*, that the diminution of the two mixed airs may be supplied from the water in the tin vessel; which must be the case, as the mouth *V* of the Eudiometer is then under the surface of the water.

38. I then put, to the lower end *V* of the Eudiometer, the bent tube (fig. 22), to which is fitted the brass ring *K*, and which is filled with water. It is by observing the surface of the water in this small tube (which then forms a true siphon with the tube of the instrument), and by means of the brass ring *K*, that I can distinguish the stationary state of the diminishing bulk of the two mixed airs above-mentioned at the end of No. 28: which being perceived, I take off the small tube *g b* from the Eudiometer,
and

and lay down, for some minutes, the whole instrument, in an horizontal position, under the water of the tin vessel: I shut up the mouth *V* with the glass stopple *m*; and, reversing the instrument, I hang it up by the end *V*, on the hook *w*. By this position the whole diminished air of the vessel *a b c* goes up to the top, where its real bulk is shewn by the number of the scale, facing the inside surface of water. This number being deducted from 128, gives the comparative wholesomeness of the air already tried, without any further calculation.

39. But this process will be still easier, when the last diminution of the two mixed kinds of air, mentioned No. 29, is only required in the observation: because no use will be then made of the syphon (fig. 22). In such a case the instrument is left hanging on the hook *w* for 48 hours: after which it is laid down under the water of the trough (fig. 15*), in an horizontal position, for 20 or 30 minutes, in order to acquire the same temperature of the water. The mouth *V* is then shut up with the stopple *m*; the instrument is hung by the end *V* in a contrary position, and the last real bulk of the two mixed airs will be then shown by the number of the brass scale, answering to the inside surface of the water. This number being subtracted from 128, will give the com-

parative salubrity of the air employed in the trial, without any further calculation.

I need not say that all the circumstances already mentioned, for the better obtaining exact results in these experiments, are to be carefully observed, when this second, or the third Eudiometers are used: but chiefly that circumstance, mentioned No. 35, ought never to be omitted. The thermometer is to be kept dipped in the water of the tin vessel; and the Eudiometer must be kept there immersed some minutes, as I have said just now, before it is raised for the last time, to read off the quantity of the total diminution of the mixed air. As to the other circumstance, mentioned No. 33, it has been rendered unnecessary by laying this Eudiometer in an horizontal position before the glass stopple was put in. The same method must be applied to the third new Eudiometer I am going to describe; and even the first Eudiometer, already described, may be treated in the same manner: for if it be laid down in an horizontal position under the water in the tub, before it be shut up with the stopple, as directed No. 29, there will be no variation produced by the contraction or expansion of the air in the inside; because the proper quantity of water is then shut up within the glass vessel c
of

of the instrument: so that raising it up, as it is, together with the vessel *c*, and its phials *a b* (fig. 14), the weight of the column of water will press totally upon them, without expanding the inclosed air, or causing any variation, beyond the trifling one, which may proceed from the natural elasticity of the sides of the glass tube and vessels.

40. I must, however, acknowledge, that the long way through which the air passes, in going at first to the large phial *a b c* in this second Eudiometer, must leave some doubt whether it has not then suffered some sensible change in its quality, before it is mixed with the *nitrous air*; since, as you have observed, the air, that has been long agitated in water, changes for the better from its bad qualities: and this objection must be still greater in the use of the third Eudiometer. It is on this account that I have mentioned the first Eudiometer, as the least exceptionable of all that we know till the present; and perhaps the nature of the thing is not capable of a further perfection. Indeed that instrument, I mean my first Eudiometer, has not only the advantage of offering a very small way through the water to the two kinds of air, on their going to mix at *x* in the vessel *c* (fig. 14); but they are kept separated till that moment, in

the two respective phials *a* and *b*, without any other contact with the water, but only in the narrow diameter of the necks of these phials.

DESCRIPTION OF THE THRD NEW EUDIOMETER.

41. This third Eudiometer is the nearest to your original one: and, was it not for the consideration I have mentioned in the preceding number (which, perhaps, will not weigh too much with some philosophers) and a few other circumstances which are obvious, I should not doubt to pronounce this third instrument to be the best of all the three, as I have advanced in my last letter to you of the 30th of November last (1776). This, however, I gladly submit to your superior judgement.

42. This Eudiometer consists of a strait glass tube *en* (fig. 8), of an uniform diameter, about one or two feet long, with a large ball *s*, and a glass stopple *m*, fitted air-tight to the mouth *n*, which ought to be wide open, as a funnel, unless a separate one is made use of. There is also a small siphon *K* (fig. 23) with a brass ring *x*: a small phial *z* (fig. 9),
the

the contents of which may be received in the third part of the ball *s*; and, when put into the glass tube *ns*, must take there no more than the half of its length. Lastly, this instrument has a ruler (fig. 13), which is divided and stamped like that other already described at the end of No. 24; and a glass funnel, fig. 10. which is ground to the mouth *n* of the instrument, when this is not wide open, as already said.

THE PROCESS.

43. The use of this instrument is easily understood by what I have already said of the two preceding ones.

First, it is filled with water, and set in a vertical position, with the mouth *n* under the surface of the water in a tub, or in the trough, (fig. 17.)

Secondly, the phial *z* (fig. 9.) is filled, as above, with *nitrous air*; and thrown into the tube by means of the glass funnel *y* (fig. 10), which is ground to the mouth *n* of the Eudiometer; unless it be wide enough, not to be in need of any funnel.

Thirdly,

Thirdly, the same phial z is again filled with the air to be tried; and thrown into the same.

Fourthly, the siphon (fig. 23) is added immediately to the mouth n of the Eudiometer, under the surface of the water; some of which is to be poured into it.

Fifthly, the stationary moment of the greatest diminution of the mixed air at s , is watched by means of the ring x , of the siphon, fig. 23, as mentioned No. 28 and 38.

Sixthly, when that moment arrives, the siphon KI (fig. 23) is taken off; the Eudiometer is laid for some minutes under the water, in an horizontal position, or nearly so, but in such a manner that no part of the inclosed air may get out; the mouth n is shut up with the glass stopple m , and the instrument is inverted with the mouth n upwards.

Lastly, the space occupied by the residuum of the diminished air is measured by applying to its side the divided ruler, or scale (fig. 13): and the result is estimated after the manner already explained No. 31 and 32.

44. Whenever I want only to know the last diminution of the mixed air, mentioned

No. 39, the process then becomes easier, as no use is made of the siphon (fig. 23). The method of conducting the process in such a case being respectively the same as that already described No. 39, it is unnecessary to describe it here again. The same precautions I have spoken of, No. 35 and 39, must be observed when this Eudiometer is made use of, in order to form a true judgement concerning those places, where people will be able to live without danger of hurting their constitutions, by breathing and being continually surrounded by noxious air; which they have not yet been able to distinguish from the most wholesome, except by a long and too late experience.

45. The Eudiometers already described are the fittest instruments for philosophical experiments on the bulk of air and other fluids, when mixed together; and even when mixed with some solid substance, which can be introduced into the lower vessel *c* of the first of the three Eudiometers. It will be better, however, to have them made purposely for such objects, with a tube two or three times longer than I have indicated above.

Whenever dephlogisticated air is to be tried by these instruments, proper care is to be taken to observe the precise point of its full saturation,

saturation, which is that of its greatest diminution by the addition of *nitrous air*.

46. In order to make this experiment with great accuracy, let a narrow glass tube of an uniform diameter (fig. 24) be provided: let one of the two phials *a* or *b* (fig. 16), filled with quicksilver, be thrown into it, and the tube cut exactly to that size, so as to contain neither more nor less. Let its whole length be divided into some number of equal parts, by which number the value marked on the ruler (fig. 11), of this Eudiometer, can be divided without any fraction: for instance, when the number $\ast \ast = 108$ is marked in the ruler, it means, that the contents of the two phials *a* and *b*, of which I spoke No. 32, are equal to a cylinder of 108 divisions long, as those of the ruler: and, of course, it shews that a single phial *a* or *b* contains but 54 of these parts. In this case this tube (fig. 24) may be divided either into 27 parts, each containing two of the ruler; or into 54, into 108, &c.

N. B. If the top of the tube is not very flat in the inside, it will be more exact to divide the weight of the quicksilver in two parts; to put one of them into the tube; to mark the space occupied by it; to divide the
part

part of it, which was empty, into half the number intended for this tube; and afterwards to divide the other half into similar equal parts, as the first half, carrying them towards the closed end.

47. If the dephlogisticated air is very pure, it will require almost double the quantity of *nitrous air*, to be completely saturated. In order to do this without exceeding the necessary quantity, I throw into the tube *nd* (fig. 17) a second measure *b* or *a* of *nitrous air*, after I have brought the process to the moment mentioned No. 29: in this case the whole volume or bulk of the dephlogisticated and nitrous air will be 162 [= 108 + 54 :] I observe where the surface of the inside water in the tube stops, and I mark it by the sliding brass ring *z*. I then fill up the divided tube (fig. 24) with *nitrous air*: I throw a small quantity into the Eudiometer's tube *nd*; and, if it becomes of a reddish colour, the inclosed air will diminish: I then push up the ring *z*, and, by this means, I go on throwing in the nitrous air, by little and little, till I see that the whole diminishes no more; which shews me that it is fully saturated.

48. Let us suppose, for example, that the tube (fig. 24) was divided only into 27 equal
H parts,

parts; and that the saturation of the dephlogisticated air was compleated at the eighth division of it: this shews that 19 parts $[27 - 8 = 19]$, equal to 38 of those marked in the ruler, have been thrown into the Eudiometer; that is to say, that the whole bulk of both kinds of air is equal to 200 $[= 162 + 38]$ measures, as those marked by the ruler (fig. 11) already explained No. 30. Now if the remaining quantity of air within the Eudiometrical tube is only equal to two measures or numbers of the ruler, it is clear that such dephlogisticated air is ninety-nine times of an hundred $\left[\frac{200 - 2}{200} = \frac{198}{200} = \frac{99}{100} \right]$ pure air; since its bulk is reduced, by the combination of *nitrous air*, to the $\frac{1}{100}$ of the whole.

49. It is but three days ago (1), that you shewed me such a wonderful kind of air, as I have exemplified in the preceding number. This air you have produced before my eyes, from a solution of *quicksilver* and *nitrous acid*, made many months before, and then distilled

(q) This additional article to the present letter was wrote on the 16th of September, 1777; although the greatest part of it had been written many months before, and the first twenty numbers were already printed: but some circumstances, the knowledge of which cannot interest the public, have hindered the publication of the whole till this present time.

in a long but narrow glass retort, with a sand-heat. This is, indeed! an extraordinary phenomenon, and seems to bring us, perhaps, a little nearer to the door of the secret laboratory of Nature in the formation of air.

50. I cannot say, but so pure a *dephlogisticated* air may still be produced by this process; that its whole bulk may be reduced to nothing by a proper combination with *nitrous air*. If so, what shall we then be able to think of a fluid substance, which is coercible in a glass vessel, to which above the double quantity of another substance
$$\left[\frac{54 + 54 + 38}{54} = \frac{146}{54} = 2, 7 \right],$$

likewise coercible in a glass vessel, being added; both these substances to appearance wholly vanish!

51. This phenomenon certainly deserves the attention of philosophers: and I gladly leave to them the examination of it. I must only add, for their information, that the *nitrous acid* is the thing chiefly concerned in its production: when this admirable substance acts on certain kinds of bodies, as *quicksilver* in the present case, its solution produces that *elastic*, but *coercible* fluid, which we call *nitrous air*: the residuum, kept a long while, being properly urged by fire, gives at last the other *elastic*, but likewise *coercible* fluid, which we

call *dephlogisticated air*: and the combination of both, nearly in the above proportion, produces the wonderful phenomenon I have spoken of.

52. I shall say no more on this matter; and leave it very willingly to be considered and unravelled by abler philosophers than I can pretend to be: and conclude the subject of this letter by assuring you, that I shall be very happy, if the things here treated of should deserve your approbation: and still more so, if they produce the desired effect I aim at,—the general good of mankind. I am, with the utmost regard and sincere friendship,

My dear Sir,

Your most obedient

and

Affectionate servant,

Bowood Park,
January 3, 1777.

J. H. de MAGELLAN.

