RATIONAL RECREATIONS.

VOLUME THE FOURTH,

CONTAINING

EXPERIMENTS

IN

PNEUMATICS, HYDROLOGY,

AND

PYROTECHNICS.

WITH AN

APPENDIX

OF

MISCELLANEOUS RECREATIONS.

NATIONAL RECREATIONS,

RATIONAL RECREATIONS,

In which the PRINCIPLES of

NUMBERS

AND

NATURAL PHILOSOPHY

Are clearly and copiously elucidated,

BY A SERIES OF

EASY, ENTERTAINING, INTERESTING

EXPERIMENTS.

Among which are

All those commonly performed with the CARDS.

By W. HOOPER, M. D.

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MDCCLXXIV.

DESCRIPTION of the PLATES.

PLATE I. p. 8.

THE common air-pump. A, A, are two braſs barrels; C, C, two piſtons, working in thoſe barrels; B the handle by which they are worked; G, G, the pillars that ſupport the frame of the pump-wheel, ſcrewed on them by the nuts F, F; HH is a braſs pipe called the ſwan's neck, through which the air paſſes, from under the receiver O O, by a ſmall hole K, in the middle of the braſs plate II, to a braſs piece in the box DD, from whence it is pumped out. L L L is a mercurial gage, that communicates with the receiver; N the ſtop-cock, by which the air is readmitted, when neceſſary.

PLATE II. p. 16.

Fig. 1. The animometer. ABCDEFGH is a frame of wood, ſupported by the poſt I; QM a horizontal axis, that moves in the croſs pieces KH and LM, by means of the four ſaifts, *a b*, *c d*, *e f*, *g b*; on this axis is fixed a cone of wood, MNO, by which the weight S is raiſed:

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IK is a ratchet wheel, whose teeth are taken by the click X.

Fig. 2. The circular hygrometer. ABCD is a square board; at the point E a catgut is fixed, that passing over several pullies, marked C, is fastened at the other end to the spring FG, which is regulated by the screw I. At H a brass indented ruler takes the teeth of the pinion K, whose axis goes through the board, and on the other side carries the index A that points to the divisions of the circle C.

Fig. 3, and 4. The perpendicular hygrometer. The circles marked C are pullies, over which passes a string, that is fastened at A, and at the other end has a weight F. A piece of brass is fixed to the string at G, and moves freely in the groove HI; to this brass piece, on the other side of the board, is fastened an index E, Fig. 4, which shows the degree of moisture, by the scale LM.

Fig. 5. AR a catgut that is fastened at S, passes over the pulley T, and has a weight at V, to the top of which is fastened an index that points to the scale Z.

PLATE III. p. 46.

Fig. 1. The air gun. ECDR the outer barrel; KA the inner barrel; SMNP the syringe, by which the air is injected through the valve NP; TL another valve, that is opened by the trigger O, and the air then gets behind the ball at K.

Fig. 2. The lock of this gun.

Fig.

Fig. 3. The machine for artificial rain and hail. A, A, &c. the boards that have holes through which ſhot paſſes. D the axis on which the wheel turns.

Fig. 4. The magical tree. A B C D the box, that contains the copper veſſel FG, into which air is forced by the ſyringe MN, Fig. 5. At I is a cock, that lets the air into the hollow ſtalk of the tree O, and from thence it paſſes, by the other branches, which are hollow likewiſe, to the fruit and flowers.

PLATE IV. p. 64.

Fig. 1. CADB a veſſel of water, in which one end of the ſyphon F is plunged, and being exhauſted of the air, the water runs out at the other end E.

Fig. 2. A ſucking pump. C D the piſton, EF two valves that open upward, MN the water in the well, H the pipe by which it runs out.

Fig. 3. The forcing pump. C a ſolid piſton, D a valve, H the pipe for conveying the water, in which is the valve E, through which the water is forced, by the piſton C, into the ciſtern F, from whence it runs out.

Fig. 4. The lifting pump. BD is an inverted piſton placed in the frame GEQHO; when this part is puſhed down the water aſcends through the piſton D, and when the frame is drawn up, it is forced through the valve C, and out of the ciſtern at H.

PLATE V. p. 78.

Fig. 1. The ſimple hydrometer. B *b* a copper ball, in which is fixed the braſs wire AB; on this wire are ſeveral marks which ſhow the different gravities of fluids, as in Fig. 2.

Fig. 3. The compound hydrometer. B is a hollow ball, to which is ſcrewed another ball *b*, filled with mercury. In the ball B is fixed a graduated wire AC. A is a ſmall weight that makes the wire deſcend to different depths, according to the gravity of the liquors.

Fig. 4. The hydroſtatic balance. From the point A is ſuſpended the bar BB, to which hangs the balance *b*, that is checked by the ſpring *z y*, ſupported by the piece M. From the bottom of each ſcale *e* and *d*, hangs a wire, that goes through the table; and to that from the ſcale *e*, is fixed another graduated wire *rs*, at the bottom of which is a weight L, and to that hangs a wire with a ſmall braſs ball *g*. T is an index, placed againſt the graduated wire *r s*. At the end of the wire that comes from the ſcale *d* hangs, by a horſe-hair, a glaſs tube R. The ſtring that goes over the point *a* paſſes down to the bottom of the ſtand, and is faſtened to the ſcrew SP, by which the balance is raiſed or lowered.

PLATE VI. p. 84.

Fig. 1. The ſcrew of Archimedes. AB a cylinder, round which runs a pipe CD, whoſe lower end

end is immerſed in the water; D is the end of the the pipe from whence the water iſſues; K the handle, ſupported by the piece IK.

Fig. 2. The hydraulic ſcoop. B the ſcoop, A the point from which the handle C is ſuſpended.

Fig. 3. The balance pumps. AB the balance, O, P, the pumps; M, N, the piſtons; HH the pipe through which the water is conveyed; F, G, are two ſprings to return the balance.

Fig. 4, ſhows the manner in which the balance moves on the points C.

Fig. 5. The hydroſtatic bellows. AB and EF two circular boards; AE and BF the ſides, which are of leather; DC a pipe ſcrewed into the board.

PLATE VII. p. 92.

Fig. 1. The water-clock. ABCD a glaſs veſſel, E a ſmall glaſs tube glued in the veſſel; GI another glaſs tube, to which hangs a weight L, F the cover of the veſſel.

Fig. 2. The hydraulic dancer. AB a figure made of cork; C a hollow cone placed under the figure.

Fig. 3. A hollow ball of copper placed on the top of a fountain.

Fig. 4. The globular fountain. A is a hollow globe of copper, fixed on the pipe B, whoſe orifice C is placed over a jet.

Fig. 5. The hemiſpherical caſcade. In a hollow inverted cone A, is fixed a pipe B, and the

water that falls from it runs over the ſide of the cone C, in form of a hemiſphere.

Fig. 6. The ſame piece reverſed, when it forms a fountain in the figure of a vaſe.

Fig. 7. The water-ſun. A is a hollow veſſel, in the middle of which are a number of holes, and the water that comes from the jet, on which it is placed, ruſhing through thoſe holes, forms the reſemblance of a ſun, as in the adjoining figure.

Fig. 8. Several pieces, of the ſame ſort with the laſt, placed over each other, in a horizontal direction, and all ſupplied by the ſame pipe.

PLATE VIII. p. 108.

Fig. 1. The revolving water-ſun. A hollow circle, in which there are ſeveral holes, is fixed on the top of a jet, and as the circle turns round the water ruſhes out of the holes, as at A.

Fig. 2. The magic bottle. A B a bottle filled with wine; CD a veſſel filled with water to the top of the bottle.

Fig. 3. The marvellous veſſel; B the mouth of the veſſel, which is filled with water and ſtopped, and at the bottom A are ſeveral holes.

Fig. 4. The magical caſcade. ABC a tin veſſel that holds the water; DE a pipe fixed to the veſſel; F, F, F, F, four ſmall tubes through which the water flows, GH the baſon to receive it.

Fig. 5. The circulating fountain. EC the box that contains the water; WBA the baſon in which

which the fountain plays; EX the leg by which the water runs into the box DX; YZ the leg through which the air is forced into the box EC.

Fig. 6. The compreſſed jet d'eau. A is a copper veſſel, in which is a pipe FE, and in that another, G, that is ſmaller; H is a cock to let out the air.

Fig. 7. The illuminated fountain. AB and CD are two cylindrical veſſels, that are connected by the tubes HL, FB, &c. and to each of theſe tubes candleſticks are fixed. At G is a cock and an aperture, by which water is poured into the veſſel CD.

Fig. 8. The ſolar fountain. GNS is a thin hollow globe of copper. Through the leg C of the table AB paſſes a pipe that goes to V. At K is a cock by which the fountain is ſtopped.

PLATE IX. p. 122.

Fig. 1. The cup of Tantalus. This cup is filled with water to S, and at A is placed an image that contains a ſyphon, which begins at one foot of the image, goes up to his breaſt, then down to the other foot, and out at the bottom of the veſſel.

Fig. 2. The ſea-gage. AB the gage bottle; F *f* the tube, the lower end of which is immerſed in mercury; GH is a pipe of braſs, that has ſeveral holes to admit the water into the bottle AB; K a weight that hangs by the ſhank L in the ſocket N; I is a large empty ball, fixed to the braſs tube H.

Fig.

Fig. 3, An inſtrument to be added to the ſea-gage, to meaſure great depths. BCDF a hollow metal globe, to the top of which is fixed the long tube AB: at the part D of the globe is joined a ſhort tube DE, that is to ſtand in the mercury and treacle.

Fig. 4. The diving-bell. AB the top of the bell; D a glaſs to admit the light; H a cock to let out the foul air; LM a circular ſeat for the divers to ſit on; C one of the barrels by which the divers are provided with freſh air; F a diver diſpatched to ſome diſtance from the bell.

Fig. 5. A diving-bell for a ſingle perſon. AB the bell, ſunk by weights at D; G, G, G, three glaſſes to admit the light, which are defended by the lids H, H, H; FFF chains that ſupport the ring E, on which the diver ſtands.

PLATE X. p. 164.

Fig. 1, and 2, are papers cut through with a piercer, and behind them a light is placed, by which they appear as illuminations.

Fig. 3, 4, 5, 6, and 8, are other papers of the ſame ſort as the laſt figures, but theſe are to revolve on a wire wheel, as Fig. 7.

Fig. 9, is an illumination where the fire appears to proceed in different directions.

Fig. 10. A double revolving wheel of fire, that at B proceeding in a different direction from that at A.

Fig. 11. The burning fountain. ABCD is a copper veſſel, in which is fixed the eolipile E, that has

has a cock at G, and a ſmall pipe F, with a very ſmall orifice.

PLATE XI. p. 168.

Fig. 1. A wheel for repreſenting illuminations in various directions; A, A, &c. are pyramids that appear to turn on their centers.

Fig. 2, and 3. The apparatus for caſcades of fire. Fig. 2, the manner of piercing the paper. AB, Fig. 3, is a paper rolled on a cylinder, and as it is unrolled by the handle D the caſcade gradually appears.

Fig. 4. The manner of repreſenting a caſcade by a ſpiral.

PLATE XII. p. 200.

Fig. 1. The machine for the luminous oracle. ABCD a tin box. At M is a door in the back of the box, where the lights are placed in it; L, the opening in front, by which the objects are viewed.

Fig. 2. O P is double glaſs, between which a compoſition is put; on the back glaſs a picture is painted, and on the front glaſs a paper, divided into 45 parts.

Fig. 3. A paſteboard divided into 15 equal parts, ſimilar to thoſe in the laſt figure.

Fig. 4. ABCD a tin box. KGHI its pedeſtal, in which, by the door at L, a chafingdiſh is placed. O a glaſs in the front of the box; R a flower placed in a tin tube.

Fig. 5. The box for the marvellous portrait. A the cover of the box, B its bottom, CD a falſe bottom, that draws out.

Fig. 6. The artificial hand. This hand is placed on a pedeſtal, covered with a thin ſtuff; at ST is an opening; and at I, a roller, by which the motion of the arm is facilitated. In the lower figure the elbow is joined to the piece F, that turns in two ſcrews C and D; the end F goes through a partition, and by that end an aſſiſtant moves the arm.

Fig. 7. The taliſman. ABC a triangular box; B a plate to be put at the bottom of the box; Q a copper triangle to be placed under the top of the box, and faſtened to the knob O.

PLATE XIII. p. 228.

Fig. 1. The box for the ſybils. AB a hollow pedeſtal; C a box that communicates with the pedeſtal. In the diviſions of the circle M are the ſigns of the zodiac, and the names of the days of the week. O is an index that turns freely on its center, and between ON is an opening into the pedeſtal, in which moves the bent index R. P is a pully whoſe axis is directly under the center of the circle M. S and T two rollers, and at the end of T is a pulley V. X is a ſmall pulley, round which goes a ſtring that communicates with P and T. D an opening in the front of the box, where the name of one of the ſybils appears.

Fig. 2. The magic urn. AB a hole, in which the cylinder C, Fig. 3, is to be placed. D the top of the cylinder.

Fig. 4. The box for the incomprehenſible writing. DE, Fig. 5, ſhows the inſide of the top of the box; L, Fig. 6, a plate of copper, to be placed in the part D of the top of the box.

Fig. 6, is a ſlip of paper GH, of the ſame ſize with the bottom of the foregoing box; at each end of this paper is wrote the name of a card.

Fig. 7. The oracular mirror. ABCD the mirror, which is moveable in the frame, and is ſeen under the glaſſes placed in the ſmall circles.

PLATE XIV. p. 274.

Fig. 1, and 2, The diſpoſition of the fingers in making the paſs.

Fig. 3, 4, 5, and 6. The cards for the fifteen thouſand livres.

Fig. 6, 7, and 8. Cards for a recreation ſimilar to the laſt.

Fig. 9. The magic ring.

Fig. 10. The card in the mirror. B the part of the glaſs where the quickſilver is ſcraped off, and the card appears. CD and EF the grooves in which the mirror moves.

Fig. 11. The marvellous vaſe. AB the ſection of the vaſe: *c d e f* the diviſions in which the cards are placed; H the point to which a ſtring is fixed, that goes down the three ſmall diviſions, under the pulley I, through the bracket L, and comes out behind the partition M.

RATIONAL

RATIONAL RECREATIONS.

PNEUMATICS.

DEFINITIONS.

1. THE atmoſphere is that body of air which every where ſurrounds the earth.

2. The air-pump is a machine contrived to produce a vacuum, by exhauſting the air out of a veſſel called a receiver.

3. The condenſer is an inſtrument, generally in form of a ſyringe, to force a greater quantity of air into any veſſel than it naturally contains.

4. The animometer is an inſtrument that meaſures the ſtrength of the wind.

5. The hygrometer is contrived to ſhow the different degrees of moiſture in the atmoſphere at different times.

6. The thermometer meaſures the degrees of heat and cold of the air, and of other bodies.

7. The barometer ſhows the different weight of the air at different times.

APHORISMS.

1. The air is an elaſtic, ponderating, compreſſible, and expanſible fluid, that is ſenſible only to the touch.

2. The elaſticity of the air is increaſed by heat and decreaſed by cold *.

* This is proved by the common experiment of tying the neck of an unflated bladder, and laying it before the fire: for the heat, by expanding the ſmall quantity of air in the bladder, will extend it to the utmoſt ſtretch, and at laſt burſt it, with a loud report. But if after the bladder becomes diſtended it be carried into the cold, it will immediately reſume its flaccid form.

3. The

3. The weight of the air is so small as not to be perceived but in large quantities *.

4. The rarefaction and condensation of the air, are indefinite †.

* A gallon of air weighs one dram, nearly. A column of the atmosphere, whose base in a square inch is equal to 15 lb. consequently, the surface of a man's body, of six feet stature, being on an average equal to 14 square feet, it must be pressed by a weight of air equal to 28000 pounds. This great weight is counteracted by the air within the human body; which, though small in quantity, is, by its spring, sufficient to balance the external air.

† Mr. Boyle found that the air near the surface of the earth is compressed, by its own weight, into a space less than $\frac{1}{13000}$ part of the space it would take up if left at liberty; and as the common air may be compressed into $\frac{1}{60}$ of its natural space, it follows, that the air may occupy a space 780,000 times greater at one time than another. Dr. Gregory has shewn, that if a globule of air of one inch diameter, had as great an expansion as it would have at the distance of a semidiameter of the earth from its surface; it would fill all the planetary regions, as far as, and even beyond the sphere of Saturn.

5. Though air is greatly condenſible by cold, it cannot be congealed.

6. Air is neceſſary to animal exiſtence *.

7. Aduſt air, that is, ſuch as has paſſed through the fire or a heated tube, will not ſupport animal life †.

8. Air is contained in almoſt all bodies, and may be produced from them ‡.

* This has been proved by many, far too many experiments, with the air-pump. It is not however univerſally true, for toads, vipers, eels, inſects of every kind, and fiſh, live in the exhauſted receiver.

† An animal put into a receiver filled with burnt air will expire immediately. Live coals and candles will likewiſe go out when put in ſuch air.

‡ Air is produced from bodies by their diſſolution, that is, by fermentation, diſtillation, and ſimilar methods. The quantity of air produced from bodies is very different. Yellow wax contains one-ſixteenth, coarſe ſugar one-tenth, oyſter-ſhells and muſtard-ſeed one-ſixth, heart of oak one-fourth, peaſe, dry tobacco, and Newcaſtle coal one-third, and the calculus humanus, or ſtone found in the human bladder, one-half, of their ſeveral weights.

9. Sound is communicated by the air *.

10. The atmoſphere is of different denſities at different heights, and is moſt denſe near the earth †.

11. The height of the atmoſphere does not exceed 50 miles ‡.

12. Wind is nothing but a current of air.

13. The velocity of the wind is from 1 to 60 miles in an hour §.

* This is proved by the bell in the receiver of the air-pump, as will be ſeen in the Recreations.

† At the height of 42 miles the air is computed to be 4096 times more rare than at the ſurface of the earth.

‡ As the air becomes continually more rare as its diſtance from the earth increaſes, it is impoſſible to determine its exact height, but by different experiments, eſpecially by obſerving the duration of the twilight, it may be reckoned from 45 to 50 miles.

§ It muſt be a very ſtrong wind that goes 60 miles in an hour. The velocity of the wind, at a medium, may be reckoned 12 or 15 miles per hour. If a perſon go the ſame way with the wind, and with an equal or greater velocity, he will not know

THE PNEUMATIC APPARATUS.

OF all the pneumatic apparatus the air-pump is doubtleſs the moſt important, and that as well from its entertainment as the elucidation it affords to this branch of ſcience.

The conſtruction of the common air-pump is as follows. A A, Plate I. repreſent two braſs barrels, in which the piſtons C C act. The braſs pipe H H is called the ſwan's neck, through which the air paſſes from under the receiver O O, by a ſmall hole K in the middle of the braſs plate I I, on the top of the pump, to

there is any wind; while another going againſt is, or with a leſs velocity, will perceive it very ſenſibly. Dr. Derham found by repeatedly obſerving the ſpace paſſed over by a feather, with a half ſecond watch, in the great ſtorm in 1705, that it was 33 feet per half ſecond, which is equal to 45 miles per hour: from whence he concluded, that the moſt vehement wind, as that in November 1703, does not exceed 50 or 60 miles per hour.

a braſs

a braſs piece in the box D D; which being perforated likewiſe to the middle point under each barrel, tranſmits the air, by a bladder valve, to be pumped out.

The mercurial gage which communicates with the receiver, is marked L L L. The ſtop-cock N, ſerves to re-admit the air, when neceſſary. B is the handle or winch for working the pump. G G are two pillars, ſupporting the frame of the pump-wheel, which is ſcrewed upon them by the two nuts E, E. The uſe of the other parts will readily appear from an inſpection of the figure.

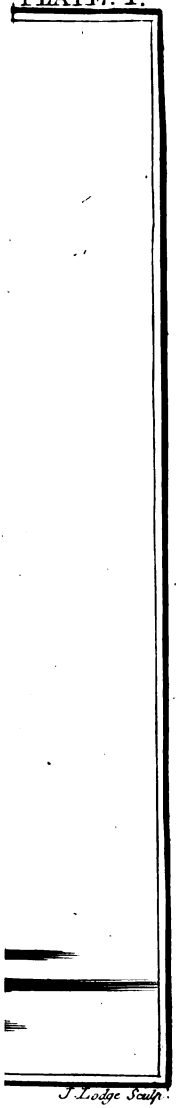
The operation of this machine depends on the elaſticity of the air; for as the pump works, the air in the receiver becomes expanded; by which mean part of it is forced into the barrels of the pump, and is carried off. By continually working the pump in this manner, the receiver is gradually exhauſted: but the air can never

be totally drawn out, ſo as to leave a perfect vacuum; for it muſt be remembered, that the air is exhauſted and puſhed out by the ſpring of that which remains behind; therefore to exhauſt every particle, the laſt muſt be expelled without an agent, which is abſurd.

Such is the conſtruction of the common air-pump; but there is another, invented by Mr. Smeaton, by which a purer vacuum is obtained, and which alſo acts as a condenſing engine. There is, moreover, what they call a portable air pump, which is placed on a table, and may be eaſily conveyed from one place to another.

THE

PLATE. I.



T. Lodge Sculp.

THE ANIMOMETER.

THE conſtruction of this inſtrument may be as follows. Let A, B, C, D, E, F, G, H, (Plate II. Fig. 1.) be an open frame of wood, firmly ſupported by the poſt I. In the croſs pieces H K, L M, is moved an horizontal axis Q M, by means of the four ſails, *a b*, *c d*, *e f*, *g h*, expoſed to the wind in a proper direction. Upon this axis is fixed a cone of wood M N O, upon which, as the ſails move round, a weight S is raiſed, by a ſtring on its ſurface, proceeding from the ſmall to the largeſt end N O. Upon the great end, or baſe of the cone, is fixed a ratchet-wheel I K, in whoſe teeth falls the click X, to prevent a retrograde motion from the depending wheel.

It is eaſy to perceive, from the conſtruction of this machine, that it is adapted to eſtimate the variable force of the wind, becauſe

becauſe the force of the weight will continually increaſe as the ſtring advances on the conical ſurface, by acting at a greater diſtance from the axis; and therefore if ſuch a weight be put on the ſmalleſt part at M, as will juſt keep the machine in equilibrium, with the weakeſt wind; as the wind becomes ſtronger, the weight will be raiſed in proportion: and the diameter of the baſe of the cone N O, may be ſo large, in compariſon of that of the ſmaller end or axis at M, that the ſtrongeſt wind ſhall but juſt raiſe the weight to the great end.

Let the diameter of the axis, for example, be to that of the baſe of the cone N O, as 1 to 28. Then if S be a weight of one pound on the axis at M, it will be equivalent to 28 pounds, or one-fourth of a hundred weight, when raiſed to the greateſt end. Therefore, if when the wind is weakeſt it ſupport one pound on the axis, it muſt be 28 times as ſtrong to raiſe the weight

weight to the baſe of the cone. It follows, that if a line of 28 equal parts be drawn on the ſide of the cone, the ſtrength of the wind will be expreſſed by the number on which the ſtring ſhall at any time hang.

The ſtring may, moreover, be of ſuch a ſize, and the cone of ſuch a length, that there may be 16 revolutions of the ſtring between each diviſion of the ſcale on the cone; by which mean the ſtrength of the wind will be expreſſed in pounds and ounces. If ſtill greater accuracy be required, let the periphery of the cone's baſe be divided into 16 equal parts: then, wherever the equilibrium happens, the ſtring will leave the conic ſurface againſt one of thoſe diviſions, and conſequently ſhow the force of the wind to a dram averdupoiſe weight.

THE

THE CIRCULAR HYGROMETER.

TAKE a board ABCD, about a foot ſquare (Plate II. Fig. 2.) and bind it round either with four pieces of iron, or dry hard wood, about half an inch thick, to prevent it from enlarging, to any ſenſible degree, by the moiſture of the air. At the ſeveral parts marked C in the figure, place pullies of about half an inch diameter, and that turn quite free on their axes. At E fix one end of a catgut, of the ſize of the ſmalleſt ſtring of a violin; let it paſs over all the pullies and be fixed, by the other end, to the ſpring G H, which is to be adjuſted by the ſcrew I, ſo as to have more or leſs force.

Near the center of the board is to be fixed to the catgut a braſs ruler H, about an inch long, and that has 20 or 25 teeth, which are to take thoſe of the pinion K, whoſe axis, which is in the center of the board, paſſes through it, and ſtands out on

on the other ſide, on which is to be fixed a very ſlight index, (ſee Fig.) and round the center deſcribe the circle C. Cover that ſide of the board on which are the pullies, with a cloth.

As the dryneſs of the air will contract the catgut, which is near ſix feet long, and the moiſture extend it, by means of the ſpring the braſs ruler will aſcend in the firſt ſtate, and deſcend in the other, and by its motion will neceſſarily turn the pinion and index.

To regulate this hygrometer, the circle C being divided into 60 equal parts, as in the figure, chooſe a time when the air is very dry, and fix the index againſt the firſt degree, and as the air becomes moiſt the index will ſhow, by the number of diviſions it paſſes over, the degree of that moiſture. If the index ſhould be found to make more than a complete revolution, the ſpring to which the catgut is faſtened, muſt be contracted.

THE

THE PERPENDICULAR HYGROMETER.

ON the board A B C D, that is a foot long and three inches wide, (Plate II. Fig. 3.) let a catgut paſs over the eight ſmall pullies marked C, and be fixed at one end to the top of the board, and at the other to the weight F. To the catgut faſten a ſmall piece of braſs at G, which moves freely in the groove H I, and to the end that is on the other ſide of the board, fix the index E, Fig. 4. which as it aſcends and deſcends, marks the degrees of dryneſs or moiſture on the ſcale L M.

This hygrometer has not ſo great an extent as the former, but is more ſenſible, as having a greater length of ſtring, and no friction of teeth, and it is more eaſily conſtructed; nothing being here neceſſary but to adjuſt a proper weight to the end of the ſtring, and to make the pullies move quite free, for which purpoſe they ſhould be frequently oiled.

But

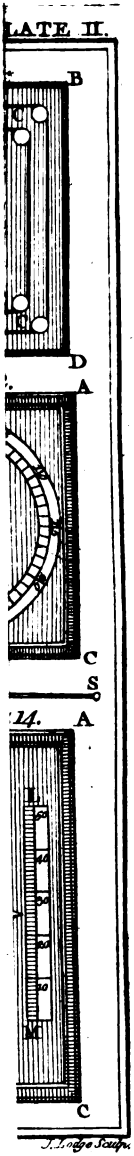
But the moſt ſimple, and at the ſame time the moſt ſenſible hygrometer, may be conſtructed as follows. Let R S, Fig. 5. be a catgut or whipcord that goes from one end of a room to the other, near the cieling, and paſſing over the pulley T, deſcends in a corner of the room to V, where it is faſtened to a weight ſufficient to keep it always ſtretched. This weight is to hang free from the wall, and there is to be faſtened to it an index X, which points to a ſcale of wood or paper Z, that is placed againſt the wall. As this hygrometer has no other friction than that of a ſingle pulley, and may have, in a ſmall room, 18 or 20 feet of ſtring, it is certainly more eligible than either of the foregoing, and perhaps, than any of the numerous and complicated hygrometers that have been invented.

THE

THE THERMOMETER.

THE figure of this inſtrument, as well as that of the barometer, is too well known to need deſcription. It will be ſufficient here to ſhow their conſtruction, and the principles on which they act.

As the thermometer is deſigned to ſhow the degrees of heat and cold by the expanſion of a fluid, different fluids have been uſed for that purpoſe. The firſt that became generally uſed was ſpirit of wine tinged with cochineal. This thermometers anſwers very well for common purpoſes, but in great degrees of heat, as that of boiling water or oil, or melting metals, the ſpirit will burſt the tube; and in a great degree of cold it will freeze. This, therefore, was ſoon rejected by philoſophers, and was ſucceeded by thoſe made with linſeed oil; which requires four times the heat to make it boil, that water does.



does. This ſort of thermometer was conſtantly uſed by Sir Iſaac Newton, and with this he meaſured the comparative heat of boiling water and ſpirit of wine, and of melting wax, tin and lead; beyond which it does not appear to have been tried.

There was ſtill wanting a thermometer that would meaſure any degree of heat, and this was invented by Farenheit of Amſterdam, whoſe name it ſtill bears. It is made with mercury, which expands itſelf uniformly from the hardeſt froſt to the greateſt heat. The common ſort of theſe thermometers have a ſcale that begins with 0, which is the freezing point, and is extended to any degree of heat at pleaſure. This thermometer is ſhort, may be put in a caſe, and carried conveniently in the pocket. It was this thermometer the great Boerhaave conſtantly uſed, in his chemical and other experiments. We forbear any further deſcription of the

manner of conſtructing this inſtrument, as it cannot be performed to a due degree of accuracy, but by an able workman.

THE BAROMETER.

THIS inſtrument, when properly conſtructed, is the moſt generally uſeful of all the pneumatic apparatus. The barometer is frequently called the Torricellian tube, from its inventor, an Italian, and diſciple of the renowned Galileo, named Torricelli; who, conſidering that a column of water of about 33 feet, was equal in weight to a column of air of the ſame baſe, concluded, that a column of mercury of about 29 inches and a half would likewiſe be equal to a column of air, for ſuch a column of mercury he knew to be equal to 33 feet of water; he accordingly made the experiment, and the apparatus he then uſed is now the common barometer.

The principal defect in the common barometer is the ſmallneſs of the bore of the tube,

tube, which occaſions the mercury to adhere to its ſide, and not riſe and fall with the neceſſary freedom. Therefore, procure a glaſs tube one-third, or at leaſt one-fourth of an inch diameter, hermetically ſealed at one end and open at the other, and 34 inches long: its inner ſurface muſt be perfectly clean, and that it may be ſo, juſt before you uſe it, rub the inſide with a piece of fine warm flannel put round a wire. Have ready a ſmall quantity of pure mercury, which you may ſqueeze through a thin leather. Then quite fill the tube with mercury, and having ready a glaſs baſon, or drinking-glaſs with a flat bottom, about an inch and a half or two inches high, in which likewiſe ſome of the ſame mercury is put, invert the tube, and put it in the baſon, ſtill holding your finger under it, till it is in the mercury of the baſon; then place it in a frame. On taking away your finger, the mercury in the tube will immediately ſubſide to about 29 or 30 inches, according to the ſtate of the air,

being very rarely lower than 28, or higher than 31 inches. Therefore if a ſcale of four inches, divided into tenths, be placed againſt the upper end of a tube, the barometer is complete.

Though the ſcale be only divided to tenths of an inch, yet if there be an index from the ſcale to the tube, as is commonly practiſed, the eye may diſtinguiſh to the 20th or 40th part of an inch, that is, to one-half or one quarter of a tenth. But for greater preciſion there is what they call, from its inventor, a Nonius diviſion, which is a ſmall plate ſo contrived as to ſlide over the graduated plate or ſcale, in ſuch manner that its index may always be ſet, in one part to the ſurface of the mercury, while another part correſponds with one of the diviſions of the ſcale. Now, this Nonius is divided into ten equal parts, which are together equal to eleven diviſions of the ſcale, that is, eleven-tenths of an inch. Conſequently, every

every diviſion of the Nonius is equal to one and one-tenth of the ſcale; two of them to two and two-tenths; three of them to three and three-tenths, &c. Whence it is eaſy to conceive, that if the Nonius index points between any two diviſions of the ſcale, you need only look back to ſee what diviſion of the Nonius coincides with a diviſion of the ſcale, and that will ſhow the number of tenths of a tenth; that is, the hundred parts of an inch.

The barometer may be applied to various uſes, as meaſuring the height of towers or mountains; for 12040 inches of air being equal to one inch of mercury, near the ſurface of the earth, 1204 inches, or 100 feet, muſt be equal to one-tenth of an inch of mercury. Conſequently if a barometer be carried up any great eminence, the mercury will deſcend one-tenth of an inch for every 100 feet the barometer aſcends.

But the great uſe of the barometer, when well conſtructed, is that of predicting the future ſtate of the weather, for ſeveral hours, and ſometimes days, preceding; though not to a certainty, yet in many inſtances to a great degree of probability: in order to obtain this deſireable end, obſerve the following rules.

Firſt, The riſing of the mercury prefages in general, fair weather; and its falling, foul weather. 2. In very hot weather, the falling of the mercury foreſhows thunder. 3. In winter, the riſing portends froſt; and in a continued froſt it foretells ſnow. 4. When foul weather happens ſoon after the falling of the mercury, expect but little of it; and ſo, on the contrary, of fair weather. 5. But when the mercury continues to riſe for ſome time before the foul weather is over, expect a continuance of fair weather to follow. 6. In fair weather, when the mercury continues to fall before rain comes, then expect a great deal

of

of it; and probably high winds. 7. The unſettled motion of the mercury denotes uncertain or changeable weather.

It appears from theſe obſervations, that it is not ſo much the height of the mercury that indicates the weather, as its motion up or down. Therefore to know whether the mercury be actually riſing or falling, obſerve the following rules. 1. If the ſurface of mercury be convex, it is then riſing. 2. If the ſurface be concave, it is then ſinking. 3. If the ſurface be plain, or rather a little convex, it may be conſidered as ſtationary. If the tube be ſmall, ſhake it, and if the air be growing heavier it will riſe about half the tenth of an inch, and if it be growing lighter it will ſink the ſame ſpace.

The great utility of the common barometer has induced many perſons to invent others, in which the riſe and fall of the mercury, and conſequently the alterations

the atmoſphere, or the height of places, may be more eaſily obſerved; ſuch as the diagonal, the rectangular, the wheel, and pendant barometers, &c. which are in general attended with ſome peculiar advantages and ſome defects. But for general uſe, the common barometer, eſpecially with a Nonius diviſion, is perhaps of all others the moſt eligible.

In ſuch of the following recreations as are performed by the air-pump, it will be ſufficient to have the receiver only in the room where the experiments are made; and to let the pipe, called the ſwan's neck, be carried through the frame of the table on which the receiver ſtands, and communicate with the other parts of the air-pump in an adjoining room, after the ſame manner as in the articles of electricity and magnetiſm. By this method the recreations will be heightened by the pleaſure of ſurprize; a pleaſure that many people find much greater than they are able to expreſs.

RECRE-

RECREATION I.

The bottles broke by air.

TAKE a bottle that is ſquare, not round or cylindrical; and if it be ſmall, the glaſs muſt not be thick. Screw this bottle on to the hole in the plate of the air-pump, and exhauſt the air. By this mean the bottle will be made to ſuſtain the weight of the external air as long as it is able, but at laſt it will be ſuddenly burſt into very ſmall parts.

The ſame effect may be produced by the ſpring of the air, in the following manner. Seal the mouth of a bottle ſo cloſe that not the leaſt air can come out, and place it in the receiver; then as the air is drawn off from its ſurface, the ſpring of the included air will act againſt the ſides of the bottle, and will con-

continually increaſe as the air in the receiver becomes more rarified, till at laſt it burſt the bottle in pieces.

A ſimilar effect is produced by laying a plate of glaſs on the top of an open receiver, and exhauſting the air; for then the weight of the external air will preſs upon the glaſs and break it in pieces. In like manner if a perſon lay his hand upon an open receiver, and the air be exhauſted, his hand will be fixed to the receiver: for if the aperture of the receiver be four ſquare inches, the weight on his hand will be equal to 60 pound. This experiment is not attended with any pain in the perſon's hand.

RECRE-

RECREATION II.

The braſs hemiſpheres.

TAKE two hemiſpheres of about four inches diameter, and whoſe circumferences exactly fit each other. Now, when they are are placed together, and the air is exhauſted from their cavities, the internal ſpring being taken away, they will be preſſed by a column of air equal to their ſurfaces, that is, twelve ſquare inches and a half, which multiplied by fifteen pounds, the weight of the air on every inch, the ſum will be 187 pounds and a half.

Therefore, give theſe hemiſpheres to any two perſons, after they have ſeen them put together, and that they are not in any manner joined to each other, and deſire them to pull the hemiſpheres aſunder; to effect which they muſt, between them, exert a force equal to the above number of pounds.

RECRE-

RECREATION III.

Water boiled by air.

TAKE water that is made as warm as you can well bear to put your hand in it, but that has not boiled, and putting it under the receiver exhauſt the air. Bubbles of air will ſoon be ſeen to riſe, at firſt very ſmall, but preſently become larger, and will be at laſt ſo great, and riſe with ſuch rapidity, as to give the water all the appearance of a violent boiling. This agitation of the water will continue till the air is again let into the receiver, when it will immediately ceaſe, and the water become quite motionleſs.

RECREATION IV.

The aerial bubbles.

TAKE a piece of iron, braſs, ſtone, or any other heavy ſubſtance, and putting it in a large glaſs with water, place it in the receiver. The air being exhauſted, the ſpring of that which is in the pores of the ſolid body, by expanding the particles, will make them riſe on its ſurface in numberleſs globules, which, reſembling the pearly drops of dew on the tops of the graſs, afford a very pleaſing appearance. On letting the air into the receiver all theſe aerial forms immediately diſappear.

RECREATION V.

The floating ſtone.

TO a piece of cork tie a ſmall ſtone, that will juſt ſink it, and putting it in a veſſel of water, place it under the receiver. Then exhauſting the receiver, the bubbles of

of air which expand from its pores, and adhering to its ſurface, will render it, together with the ſtone, lighter than water, and conſequently they will riſe to the ſurface and float.

RECREATION VI.

The withered fruit reſtored.

TAKE a ſhrivelled apple, and placing it under the receiver exhauſt the air. The apple will immediately be plumped up, and look as fair as when firſt gathered. For the preſſure of the external air being taken off, the expanſion of that contained within the ſkin of the apple will extend it to the utmoſt, ſo as ſometimes to make it burſt. This reſtoration, however, is merely apparent, for the air is no ſooner let into the receiver again, than the apple returns to its former withered ſtate.

RECRE-

RECREATION VII.

The vegetable air bubbles.

PUT a ſmall branch of a tree with its leaves, or part of a ſmall plant, in a veſſel of water, and placing the veſſel in the receiver, exhauſt the air. When the preſſure of the external air is taken off, the ſpring of that contained in the air veſſe's of the plant, by expanding the particles, will make them riſe from the orifices of all the veſſels, for a long time together, and produce a beautiful appearance. This experiment ſhows how great a quantity of air is contained in every vegetable ſubſtance.

RECREATION VIII.

The mercurial rod.

TAKE a piece of ſtick, cut it even at each end with a penknive, and immerſe it in a veſſel of mercury. When the air is pumped out of the receiver, it will at the ſame time come out of the pores of the wood, through the mercury, as will be viſible at each end of the ſtick. When the air is again let into the receiver, it falls on the ſurface of the mercury, and forces it into the pores of the wood, to poſſeſs the place of the air.

When the rod is taken out and weighed, it is found to be ſeveral times heavier than before, and has changed its colour, being now all over of a bluiſh hue. If this ſtick be cut tranſverſly, the quickſilver will be ſeen to glitter in every part of it.

RECRE-

RECREATION IX.

The myſtical bell.

FIX a ſmall bell to the wire that goes through the top of the receiver, and ſhaking it by that wire it will be diſtinctly heard, while the air is in the receiver, if it be not very thick. As the air is exhauſted, the ringing becomes gradually weaker, and at laſt, how much ſoever the bell be ſhook, the leaſt ſound cannot be heard. But when the air begins to enter again into the receiver, the ſound becomes preſently audible. This experiment proves that air is the medium of ſound.

RECREATION X.

Feathers heavier than lead.

AT one end of a fine balance hang a piece of lead, and at the other as many feathers as will keep it in equilibrium. Then

place the balance under the receiver. As ſoon as the air begins to be exhauſted, the equilibrium will begin to be deſtroyed, and when all the air is exhauſted, the feathers will deſcend and the lead mount up.

The cauſe of this phenomenon is plainly deducible from the laws of hydroſtatics; for when both bodies are weighed in air, each loſes the weight of an equal bulk of air; conſequently the feathers will loſe a greater weight than the lead: but when the air is taken away, the weight that is reſtored to the feathers being greater than that reſtored to the lead, the former will neceſſarily preponderate.

RECRE-

RECREATION XI.

The ſelf-moving wheel.

TAKE a circle of tin about ten inches diameter, or of any other dimenſion that will go into the receiver, and to its circumference fix a number of tin vanes, each about an inch ſquare. Let this wheel be placed, between two upright pieces, on an axis whoſe extremities are quite ſmall, ſo that the wheel may turn, in a vertical poſition, with the leaſt force poſſible. Place the wheel and axis in the receiver, and exhauſt the air. Let there be a ſmall pipe, with a cock; one end of this pipe is to be on the outſide of the top of the receiver, and the other end to come directly over the vanes of the wheel.

When the air is exhauſted from the receiver, open the cock juſt mentioned. A current of air will ruſh againſt the vanes

of the wheel, and put it in motion; and the velocity of its motion will increaſe till the receiver is again replete with air.

If the pump be kept continually working, after the air is exhauſted, the motion of this wheel may be regarded not only as ſpontaneous, but perpetual.

RECREATION XII.

The animated figures.

PROVIDE nine, twelve, or any number you pleaſe, of hollow cylinders, about nine inches long, and one and a half or two inches diameter. Let the bottom of each of theſe cylinders be cloſed, except a ſmall hole; and in each of them place a piſton, like that in a ſyringe. At the bottom of each piſton let there be a worm ſpring, and over it the figure of a man, woman, or what elſe you pleaſe. Theſe figures ſhould be all different, and in different attitudes,

titudes, and of ſuch a ſize that they may completely enter the cylinders.

Place all the cylinders in a circular frame of wood, and having puſhed each piſton down to the bottom of the cylinder, and ſtopped the holes at bottom, draw it up again to what height you think proper, and there will then be a vacuum under each piſton. Then place the frame in the receiver, and exhauſt the air.

When the weight of the external air begins to be taken off, the force of the ſpring that is at the bottom of each piſton being greater than its friction, and the weight of the figure placed over it, they will all gradually riſe up, and preſent themſelves in their proper attitudes. When the air is again let into the receiver, they will, in like manner, retire to their ſeparate apartments.

If the arms and legs of the figures be inflated with a due quantity of air, when the preſſure of that in the receiver is taken off, they will be extended, and may be made to aſſume any attitude required; and when the air is again let into the receiver, they will reſume their former poſitions.

RECREATION XIII.

The artificial halo.

PLACE a candle on one ſide of a receiver, and let the ſpectator place himſelf at ſome diſtance from the other ſide. As ſoon as the air begins to be exhauſted, and becomes attenuated and charged with vapours to a proper degree, the light of the candle will be refracted through that medium in circles of various colours, that lively reſemble thoſe ſeen about the moon in a hazy night.

RECREATION XIV.

The mercurial ſhower.

CEMENT a piece of wood into the lower part of the neck of an open receiver, and pour mercury over it. After a few ſtrokes of the pump, the preſſure of the air on the mercury will force it through the pores of the wood in form of a beautiful ſhower; which, if the receiver be clear and the weather be dry, will appear luminous in a dark chamber.

RECREATION XV.

The fountain in vacuo.

TAKE a tall glaſs tube, hermetically ſealed at the top and at bottom, by means of a braſs cap, ſcrewed on to a ſtop cock, and that to the plate of the pump. When all the air is exhauſted the cock is turned, the tube is taken off the plate

and immerſed in a baſon of mercury or water: then, the cock being again turned, the fluid, by the preſſure of the air, will play up in the tube, in form of a fountain, and afford a very pleaſing appearance.

There are a great number of other experiments performed by the air-pump; but theſe are quite ſufficient to explain the nature of the air's preſſure and expanſion, which is their general intention.

RECREATION XVI.

The air-gun.

THERE are two ſorts of air-guns, the common, and what is called the magazine air-gun.

The common air-gun is made of braſs, and has two barrels, Plate III. Fig. 1, and 2. The inner barrel KA, has a ſmaller bore

bore than the other ECDR. In the ſtock of the gun there is a ſyringe SM N P, by which the air is injected into the cavity, between the two barrels, through the valve N P. The ball K is put down the ſmaller barrel with a rammer, as in other guns. At T L is another valve, which being drawn open by the trigger O, makes way for the air to get behind the ball, and drive it out with great violence. By ſuddenly opening and ſhutting the valve, one charge of condenſed air will ſerve for ſeveral diſcharges, which are effected by means of the lock repreſented in Fig. II.

In the magazine air-gun there is an additional barrel of a ſerpentine form, which holds ten or twelve balls, that are brought into the ſhooting barrel ſucceſſively, by means of a lever, which is called a hammer.

RECREATION XVII.

Artificial rain and hail.

MAKE a hollow cylinder of wood (Pl. III. Fig. 3.) let it be very thin at the ſides, about eight or ten inches wide, and two or three feet in diameter *. Divide its inſide into five equal parts, by the boards A, of five or ſix inches wide; and let there be between them and the wooden circle a ſpace B, of about one-ſixth of an inch. You are to obſerve that theſe boards are to be placed obliquely, as in the figure.

In this cylinder put four or five pounds of leaden ſhot, of a ſize that will eaſily paſs through the opening you have left. Let it turn on the axis D, and be ſupported by the foot C.

* When this machine is intended for a theatre it muſt be conſtructed much larger.

The

The ſound of this machine when in motion, will ſtrongly repreſent that of rain, and will increaſe with the velocity of the motion. To produce the ſound of hail, a larger ſort of ſhot muſt be uſed.

RECREATION XVIII.

The magical flowers and fruit.

MAKE a box ABCD, (Plate III. Fig. 4.) of about ſix inches every way. In the middle of the top AB, let there be a hole, through which is to paſs the neck of the veſſel E, that is a kind of hollow copper ſphere, of three or four inches diameter, and covered at its top and bottom F and G, with two pieces of the ſame metal, that are to be well ſoldered to it. To the part next F there is to be ſoldered the tube H, about half an inch in diameter, through which is an aperture of a quarter of an inch: this tube muſt alſo be pierced horizontally, by an opening of one-

one-third of an inch at I, to admit a cock, the key of which muſt extend to the outſide of the caſe; it ſhould alſo have a ſmall aperture of about one-tenth of an inch, to let out the air that is to be compreſſed in the veſſel E, as we ſhall now explain.

To force the air into the hollow veſſel there muſt be adjuſted to one of its ſides the copper ſyringe N M, Fig. 5, which has a leather valve at M, and another at its extremity N; ſo that by the alternately thruſting in and drawing out of the piſton, the air may be ſtrongly condenſed in the veſſel E.

To the extremity of the tube H there is to be fixed the little tree O, which is compoſed of four or five fine branches of copper P, Q, R, S, that proceed from the trunk O. Theſe branches are to be hollow from one end to the other, that the air which enters at the bottom may extend itſelf to the top. To theſe branches are

to

to be adjuſted twigs, made of braſs wire, and the whole is to be decorated with orange leaves, that are made of parchment, and ſtrongly imitate thoſe of nature.

The end of each of the branches is to dilate, ſo that they may contain ſmall pieces of very fine leather, which are to take the figure of an orange, when they are extended by the air drove thro' the branches. Theſe leathers muſt be contained within the extremities of the branches, to which they are to be faſtened by a ſilk thread: and there muſt be a ſpace left at the end of the branch, to which is to be fixed the bud or flower of a blowing orange.

The trunk of the orange-tree muſt exactly fit the tube H, that none of the air may eſcape; and it is to be made to take out. The branches and the leathers that are to form the oranges, muſt be accurately painted, to favour the illuſion. There ſhould be a glaſs cover to the whole, which will

will prevent any one from touching it; and the top of the box may be covered with earth.

Previous to the performing this Recreation you take the orange-tree out of the caſe, and with a little ſtick made for that purpoſe, you put each of the oranges within the end of the branch, together with the flowers of the blowing oranges; ſo that no part of them may appear: and the better to conceal them, the greateſt number of leaves may be at the ends of the branches The tree is then to be replaced in the tube H. You are next to turn the cock at I, and with the ſyringe throw a ſufficient quantity of air into the veſſel E.

Matters being thus prepared, you introduce the box and tree, covered with the glaſs; and make the company obſerve, that in its preſent ſtate it bears neither flowers nor fruit, and tell them if it be their pleaſure it ſhall inſtantly

ATE. III.

5 p. 44.

N

M

J. Lodge Sculp.

ſtantly produce both. You then turn the cock *, when the flowers or buds will immediately appear, and will be ſucceeded by the fruit.

This Recreation may be performed by putting an eolipile in the box, inſtead of the copper veſſel; under which you place a chafing-diſh with hot coals, that is to be ſuppoſed to produce the ſudden vegetation in the tree. The air in the eolipile being rarified by the heat will produce the ſame effect as the condenſed air in the other veſſel.

* This cock ſhould be ſo concealed that you may turn it without being obſerved by the company.

HYDRO-

HYDROLOGY.

HYDROLOGY.

DEFINITIONS.

1. HYDROLOGY is that part of phiſiology which explains the properties of water. It is uſually divided into hydroſtatics and hydraulics; the former of which treats of the manner of weighing water, and fluids in general, and of aſcertaining their ſpecific gravities, that is, their particular weights; and the other ſhows the manner of conveying water from one place to another *.

2. A ſiphon is a bended tube, commonly of a form nearly reſembling half an elipſis.

3. A valve is a ſort of flap or cover, fixed to a pipe or other body, which by

* The term hydroſtatics is frequently uſed for a general treatiſe on water, but certainly with impropriety.

opening one way only, ſuffers the water to paſs, but not to return.

4. A piſton is a ſmall cylinder faſtened to the end of a rod, and fitted to the bore of a pipe or hollow cylinder, and frequently contains a valve.

5. The hydrometer is an inſtrument conſtructed to find the ſpecific gravities of fluids.

6. The hydroſtatic balance is contrived to ſhow the ſpecific gravities of fluids, and of ſolids, by weighing them in fluids.

APHORISMS.

1. Water is a ſcentleſs, tranſparent, colourleſs fluid *, which, with a certain degree of cold, turns to ice.

* Though fluidity be commonly regarded as an eſſential property of water, yet many philoſophers, particularly Boyle and Boerhaave, conſider it as an adventitious circumſtance, produced by a certain degree of heat, and aſſert its natural ſtate to be that of a cryſtalline, as when in ice.

2. Water

2. Water is one of the conſtituent parts of all bodies *.

3. All fluids, except air, are incompreſſible †.

4. Though water is leſs diaphanous than air, it is more penetrative, as it will pervade bodies that air will not ‡.

5. Water diſſolves ſome bodies, as ſalts, and conglutinates others, as bricks, ſtones, bones, &c.

6. Water, in its natural ſtate, contains

* This is proved by diſtillation, for the dryeſt woods, earths, bones, and ſtones pulverized, conſtantly yield a certain quantity of water. It has been found by experiment, that the water contained in a certain quantity of air was nearly equal to the air itſelf.

† If a globe of gold be filled with water, and preſſed with a very great weight, the water will tranſude the pores of the gold, and cover the ſurface of the globe, in the form of a fine dew. This is called the Florentine experiment.

‡ This is evident from its paſſing through the pores of a bladder.

the three other elements, fire, earth, and air *.

7. The water, in ſeveral tubes that communicate with each other, will ſtand at the ſame height in all of them, whether they be ſmall or great, perpendicular or oblique.

8. The ſurface of water contained in a veſſel will always be even, and parallel to the horizon †.

9. In a veſſel of water the preſſure of the upper parts on the lower, is in proportion to the depth; and is the ſame at the ſame depth whatever be the diameter of the veſſel.

* We have already ſaid that water owes its fluidity to heat, and it is evident from many experiments with the air-pump, that it contains no ſmall quantity of air: and the ſediment that is found in all water, except that which is diſtilled, always contains a quantity of earth. From the laſt element it is ſuppoſed that plants derive all the nouriſhment they receive by means of water.

† In large bodies of water, as the ſea, or great lakes, the ſurface will not be plain, but ſpherical, as making a part of the ſurface of the terraqueous globe.

10. The

10. The preſſure of a fluid upward is equal to its preſſure downward, at any given depth *.

11. The bottom and ſides of a veſſel are preſſed by the fluid it contains in proportion to its height, without any regard to the quantity.

12. If fluids of different gravities be contained in the ſame veſſel, the heavieſt will be at bottom, the lighteſt at top, and the

* It follows from this and the preceding aphoriſm, that the lighteſt ſolid may be ſunk in the heavieſt fluid, as cork in quickſilver, and will remain at the bottom, if it be ſo contrived that none of the fluid can get under it. On the contrary, the heavieſt ſolid may be ſuſpended in the lighteſt fluid; if the fluid be of a ſufficient depth, and be prevented from preſſing on the top of the ſolid. This is commonly proved by putting a guinea in a tube, exactly of the ſame diameter, and holding it to the bottom by means of a ſtring. Then, as gold is about nineteen times heavier than water, if you put the tube down in the water to about nineteen times the thickneſs of the guinea, and let the ſtring go, the guinea will not ſink, but be ſuſtained by the preſſure of the water under it, which is there greater than the gravity of the guinea.

reſt in proportion to their ſpecific gravities.

13. A body that is heavier than an equal quantity of any fluid will ſink in that fluid; if it be lighter, it will ſwim at the top; but if it be of the ſame gravity, it will neither ſink nor ſwim, but remain ſuſpended in any part of that fluid.

14. A ſolid immerſed in a fluid is preſſed by that fluid on all ſides, in proportion to the height of the fluid above the ſolid. Bodies very deeply immerged may be conſidered as equally preſſed on all ſides.

15. Every ſolid immerſed in a fluid, loſes ſo much of its weight, as is equal to the weight of a quantity of that fluid of the ſame dimenſion with the ſolid *.

* It is on this aphoriſm that the hydroſtatic balance is founded; for if every ſolid, on being immerſed in a fluid, loſes ſo much of its weight as is equal to the weight of an equal bulk of that fluid, it follows, that the lighter the body is, the greater proportion of its weight it will loſe: therefore, if two

16. The fluid acquires the weight the ſolid loſes.

two bodies of equal bulk be firſt weighed in air, and then in water, and it be found that one has loſt half of its weight, and the other one-fourth, it follows that the ſpecific gravity of the latter is to that of the former as 2 to 1. From hence alſo is derived the method of finding the ſpecific gravity of fluids, for if the ſame ſolid when weighed in two different fluids, loſes twice as much in one as in the other, it follows that the ſpecific gravity of the former muſt be twice as great as that of the latter.

THE

THE HYDROLOGIC APPARATUS.

AMONG the hydrologic apparatus the ſyphon claims the firſt regard, and that as well from its ſimplicity, as its utility in explaining the more complex machines.

If the ſyphon E F G (Plate Fig. 1.) be immerſed in the veſſel of water ABCD, and the air ſucked out at E *, the preſſure of the air upon the ſurface of the water in the veſſel will force it up the vacuity in the pipe from G, and paſſing through the top at F, it will deſcend the other leg, and run out at E, as long as the ſurface of the water is above the bottom of the leg C G. You muſt obſerve, however, that to make the water run out, the end E of the ſy-

* If the ſyphon or crane be filled with water, then inverted, and one end placed in a veſſel of water, it will have the ſame effect as drawing out the air; and where the ſyphon is large, will be more eaſily effected.

phon

phon muſt be below G: for if both ends be parallel, the preſſure of the air on each end will be equal, and the water will remain in the ſyphon.

It is to be remembered, that the top of the ſyphon muſt not exceed 32 feet perpendicular altitude above the ſurface of the water in the veſſel: for a column of air of the height of the atmoſphere is but juſt equal to a column of water of 32 feet. Mercury may be drawn through a ſyphon in the ſame manner as water; but then the utmoſt height of the ſyphon muſt always be leſs than 30 inches, as mercury is near 14 times heavier than water. That fluids are forced through the ſyphon by the preſſure of the atmoſphere is proved experimentally by the air-pump, for if a ſyphon immerſed in a veſſel of water be placed, when running, in the receiver, and the air extracted, the running will immediately ceaſe.

There

There is a ſort of ſyphon that will draw off water without having the air previouſly extracted from it: this conſiſts of a capillary tube, about one-tenth of an inch bore, and acts by the attraction of coheſion: for the water being attracted by the leg immerſed, is ſlowly drawn up to the top of the ſyphon, and from thence gradually deſcends by its own gravity. From the ſame cauſe it is, that if one end of a piece of the liſt of cloth be put into the water of a veſſel, and the other end hang over its ſide, the water will be ſucked up by the end of the liſt in the veſſel, which in this caſe acts as a bundle of very fine capillary tubes, and drop from the other end. This experiment with a capillary tube will ſucceed in vacuum.

THE

THE PUMP.

THE pump is at once the moſt common and moſt uſeful of all hydraulic inſtruments. Of pumps there are three ſorts, the ſucking, forcing, and lifting pump.

A B (Pl. IV. Fig. 2.) is the pipe or barrel of a common ſucking pump, C D the piſton or bucket, E F two valves that open upward. When the handle of the pump is put down it raiſes the bucket, and the valve F ſhuts. The water above the bucket being raiſed, a vacuum is left under it, and the external air preſſing on the water in the well M N, raiſes it up, through the hole B, and lifting up the valve E, enters the barrel of the pump. The handle of the pump being then raiſed, the bucket deſcends, the valve F opens, and lets the water aſcend above the bucket. The preſſure of the water at the ſame time

ſhuts

ſhuts the valve E, ſo that it cannot return through B. The handle being again preſſed down the bucket is again raiſed, and more water aſcends through B. So that at every ſtroke of the handle, the water in the barrel is increaſed, till at laſt it runs out at the pipe H.

If the bucket be more than 30 or 32 feet from the ſurface of the water in the well, it will not aſcend to the bucket, for the preſſure of the atmoſphere, as we have before obſerved, is but equal to 32 feet of water. The weight the bucket lifts at each ſtroke, is equal to a column of water whoſe diameter is that of the bore of the pump and its height MH. It is therefore of no conſequence where the bucket is placed, with regard to the weight of water. To balance that weight the handle ſhould be made heavy. The piſton or bucket muſt be ſurrounded with leather, that it may exactly fit the bore of the pump, at the ſame time it moves freely up and down. The valves alſo

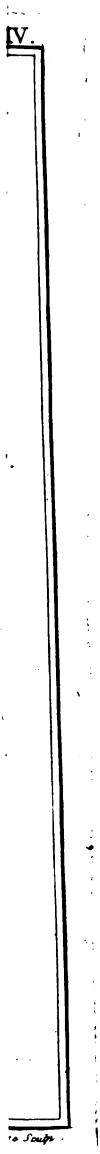
alſo ſhould move free, and ſhut quite cloſe. The ſmaller the bore of the pump, the eaſier it will work; but the wider it is, and the longer the ſtroke of the handle, the more water it will raiſe.

The forcing pump is conſtructed as follows: A B (Pl. IV. Fig. 3.) is the barrel, ſtanding in the water of the well at B. C C is the piſton: C is a ſolid piece, without any valve, as no water is to paſs thro' it: this piece ſhould be carefully leathered, and made to fit the barrel ſo exactly, that in its motion neither water nor air may paſs between them. At a diſtance below, as at D, a valve is fixed. Between this and the loweſt ſituation of the piſton C, there goes off a pipe H, in which is fixed a valve at E.

Now the piſton being drawn up from C toward A, exhauſts or rarifies the air above D, which cauſes the water to ruſh into the ſpace C D; and when the piſton

is forced down, as the water cannot repaſs at D, it is forced to aſcend into the pipe H, and through its valve E into the ciſtern F (which may be placed at any diſtance from the pump) and from thence it runs off by the ſpout.

Of lifting pumps there are ſeveral ſorts; the moſt common is thus conſtructed. AB (Pl. IV. Fig. 4.) is the barrel, fixed in the frame K I L M; which is alſo fixed immoveable, with the lower part in the water that is to be pumped up. GEQHO is a frame with two ſtrong iron rods, moveable through holes in the upper and lower parts of the pump, I K and L M. In the bottom of this frame is fixed an inverted piſton B D, with its bucket and valve uppermoſt at D. From the top of the barrel there goes off a part K H, either fixed to the barrel, or moveable by a ball and ſocket (as here repreſented at F), but in either caſe ſo very exact and tight, that no water or air can poſſibly get into the barrel, as that



that would prevent the effect of the pump. In this part, at C, is fixed a valve opening upward.

When the piſton frame is thruſt down into the water, the piſton D will deſcend, and the water beneath it ruſh up through the valve at D, and get above the piſton; where, upon the frames being lifted up, the piſton will force the water through the valve C, into the ciſtern P, there to run off by the ſpout. It is to be remembered, that this ſort of pump muſt be ſet ſo far in the water, that the piſton may play below its ſurface. It appears by the above deſcription, that this is only a different manner of conſtructing a forcing pump.

THE HYDROMETER.

THIS is the moſt eligible of all inſtruments for finding the ſpecific gravity of fluids only, as well for eaſe as expedition.

The globe of the hydrometer ſhould be made of copper, for ivory imbibes ſpiritous liquors, and thereby alters their gravity, and glaſs requires an attention that is incompatible with expedition. The moſt ſimple hydrometer conſiſts of a copper ball B *b*, (Plate V. Fig. 1.) to which is ſoldered a braſs wire A B, one quarter of an inch thick. The upper part of this wire being filed flat is marked *proof*, at *m*, Fig. 2. becauſe it ſinks exactly to that mark in proof ſpirits. There are two other marks at A and B, Fig. 1. to ſhew whether the liquor be one-tenth above or below proof, according as the hydrometer ſinks to A, or emerges to B, when a braſs

weight, as C or K, is ſcrewed to its bottom *c*. There are other weights to ſcrew on, which ſhew the ſpecific gravity of different fluids, quite down to common water.

The round part of the wire above the ball, may be marked ſo as to repreſent river water when it ſinks to R W, Fig. 2. the weight which anſwers to that water being then ſcrewed on; and when put into ſpring water, mineral water, ſea water, and water of ſalt ſprings, it will gradually riſe to the marks SP, MI, SE, SA. On the contrary, when it is put into Briſtol water, rain water, port wine, and mountain wine, it will ſucceſſively ſink to the marks *b r*, *r a*, *p o*, *m o*. Inſtruments of this kind are ſometimes called areometers.

There is another ſort of hydrometer that is calculated to aſcertain the ſpecific gravity of fluids to the greateſt preciſion poſſible, and which conſiſts of a large hol-

low ball B (Plate V. Fig. 3.) with a ſmaller ball *b* ſcrewed on to its bottom, partly filled with mercury or ſmall ſhot, in order to render it but little ſpecifically lighter than water. The larger ball has alſo a ſhort neck at C, into which is ſcrewed the graduated braſs wire AC, which by a ſmall weight at A, cauſes the body of the inſtrument to deſcend in the fluid, with part of the ſtem.

When this inſtrument is ſwiming in the liquor contained in the jar ILMK, the part of the fluid diſplaced by it, will be equal in bulk to the part of the inſtrument under water, and equal in weight to the whole inſtrument. Now, ſuppoſe the weight of the whole to be four thouſand grains, it is then evident we can by this mean compare the different dimenſions of four thouſand grains of ſeveral ſorts of fluids. For if the weight at A, be ſuch as will cauſe the ball to ſink in rain water, till its ſurface come to the middle point of

the ſtem 20, and after that if it be immerſed in common ſpring water, and the ſurface be obſerved to ſtand at one-tenth of an inch below the middle point 20, it is apparent that the ſame weight of each water differs only in bulk by the magnitude of one-tenth of an inch in the ſtem.

Now ſuppoſe the ſtem to be ten inches long, and weigh a hundred grains, then every tenth of an inch will weigh one grain; and as the ſtem is of braſs, which is about eight times heavier than water, the ſame bulk of water will be equal to one-eighth of a grain, and conſequently to the one-eighth of one-four thouſandth part, that is, one thirty-two thouſandth part of the whole bulk. This inſtrument is capable of ſtill greater preciſion, by making the ſtem or neck conſiſt of a flat thin ſlip of braſs, inſtead of one that is cylindrical: for by this mean we increaſe the ſurface, which is the moſt requiſite circumſtance, and diminiſh the ſolidity,

which neceſſarily renders the inſtrument ſtill more accurate.

To adapt this inſtrument to all purpoſes, there ſhould be two ſtems, to ſcrew on and off, in a ſmall hole at *a*. One ſtem ſhould be a ſmooth thin ſlip of braſs, or rather ſteel, like a watch-ſpring ſet ſtraight, ſimilar to that we have juſt mentioned, on one ſide of which is to be the ſeveral marks or diviſions to which it will ſink in different ſorts of water; as rain, river, ſpring, ſea, and ſalt ſpring waters, &c. and on the other ſide you may mark the diviſions to which it ſinks in various lighter fluids, as hot Bath water, Briſtol water, Lincomb water, Cheltenham water, port wine, mountain, madeira, and other ſorts of wines. But here the weight at A on the top muſt be a little leſs than before, when it was uſed for heavier waters.

But in trying the ſtrength of the ſpiritous liquors a common cylindric ſtem will

will do beſt, becauſe of its ſtrength and ſteadineſs: and this ought to be ſo contrived, that when immerſed in what is called proof ſpirit, the ſurface of the ſpirit may be upon the middle point 20: which is eaſily done by duly adjuſting the ſmall weight A, on the top, and making the ſtem of ſuch a length, that when immerſed in water, it may juſt cover the ball and riſe to *a*; but when immerſed in pure ſpirit, it may riſe to the top A. Then by dividing the upper and lower parts *a* 20 and A 20, into ten equal parts each, when the inſtrument is imerſed in any ſort of ſpiritous liquor it will immediately ſhow how much it is above or below proof.

Proof ſpirit conſiſts of half water, and half pure ſpirit, that is, ſuch as when poured on gunpowder, and ſet on fire, will burn all away; and permits the powder to take fire and flaſh, as in open air. But if the ſpirit be

not ſo highly rectified, there will remain ſome water, which will make the powder wet, and unfit to take fire. Proof ſpirit, of any kind, weighs ſeven pounds twelve ounces per gallon.

The common method of ſhaking the ſpirits in a phial, and raiſing a head of bubbles, to judge by their manner of riſing or breaking whither the ſpirit be proof, or near it, is very fallacious. There is no way ſo certain, and at the ſame time ſo eaſy and expeditious, as this by the hydrometer: which will infallibly demonſtrate the difference of bulks, and conſequently the ſpecific gravities in equal weights of ſpirits, to the thirty, forty, or fifty thouſandth part of the whole, which is a degree of accuracy no one can wiſh to exceed.

THE

THE HYDROSTATIC BALLANCE.

THOUGH the hydrometer is the moſt convenient inſtrument for meaſuring the ſpecific weights of fluids, yet for a meaſure of the ſpecific gravity of all ſubſtances, we muſt have recourſe to the hydroſtatic balance: which is conſtructed in various forms, but we ſhall content ourſelves here with deſcribing that which appears of all others the moſt accurate.

VCG, (Pl. V. Fig. 4.) is the ſtand or pillar of this hydroſtatic balance, which is to be fixed in a table. From the top A, hangs, by two ſilk ſtrings, the horizontal bar BB, from which is ſuſpended by a ring *i*, the fine beam of a ballance *b*; which is prevented from deſcending too low on either ſide by the gently ſpringing piece *lxyz*, fixed on the ſupport M. The harneſs is anulated at *o*, to ſhew diſtinctly the

the perpendicular poſition of the examen, by the ſmall pointed index fixed above it.

The ſtrings by which the ballance is ſuſpended, paſſing over two pullies, one on each ſide the piece at A, go down to the bottom on the other ſide, and are hung over the hook at *v*; which hook, by means of a ſcrew P, is moveable, about one inch and a quarter, backward and forward, and therefore the ballance may be raiſed or depreſſed ſo much. But if a greater elevation or depreſſion be required, the ſliding piece S, which carries the ſcrew P, is readily moved to any part of the ſquare braſs rod V K, and fixed by means of a ſcrew.

The motion of the ballance being thus adjuſted, the reſt of the apparatus is as follows. H H is a ſmall board, fixed upon the piece D, under the ſcales *d* and *e*, and is moveable up and down in a long

ſlit

ſlit in the pillar, above C, and faſtened at any part by a ſcrew behind. From the point in the middle of the bottom of each ſcale hangs, by a fine hook, a braſs wire *a d*, and *a c*. Theſe paſs through two holes *m m*, in the table. To the wire *a d* is ſuſpended a curious cylindric wire *r s*, perforated at each end for that purpoſe: this wire *r s* is covered with paper, graduated by equal diviſions, and is about five inches long.

In the corner of the board at E, is fixed a braſs tube, on which a round wire *h l* is ſo adapted as to move neither too tight nor too free, by its flat head I. Upon the lower part of this moves another tube Q, which has ſufficient friction to make it remain in any poſition required: to this is fixed an index T, moving horizontally when the wire *h l* is turned about, and therefore may be eaſily ſet to the graduated wire *r s*. To the lower end of the wire *r s* hangs a weight L, and to that a wire

wire *p n*, with a ſmall braſs ball *g*, about one-fourth of an inch diameter. On the other ſide, to the wire *a c*, hangs a large glaſs bubble R, by a horſe hair.

Let us firſt ſuppoſe the weight L taken away, and the wire *p n* ſuſpended from S: and on the other ſide, let the bubble R be taken away, and the weight F ſuſpended at *c*, in its room. This weight F we ſuppoſe to be ſufficient to keep the ſeveral parts hanging to the other ſcale in equilibrium; at the ſame time that the middle point of the wire *p n* is at the ſurface of the water in the veſſel N. The wire *p n* is to be of ſuch a ſize that the length of one inch ſhall weigh four grains.

Now it is evident, ſince braſs is eight times heavier than water, that for every inch the wire ſinks in the water it will become half a grain lighter, and half a grain heavier for every inch it riſes out of

of the water: conſequently, by ſinking two inches below the middle point, or raiſing two inches above it, the wire will become one grain lighter or heavier. Therefore, if when the middle point is at the ſurface of the water in equilibrium, the index T, be ſet to the middle point *a*, of the graduated wire *r s*, and the diſtance on each ſide *a r* and *a s* contains a hundred equal parts, then, if in weighing bodies the weight is required to the hundreth part of a grain, it may be eaſily had by proceeding in the following manner.

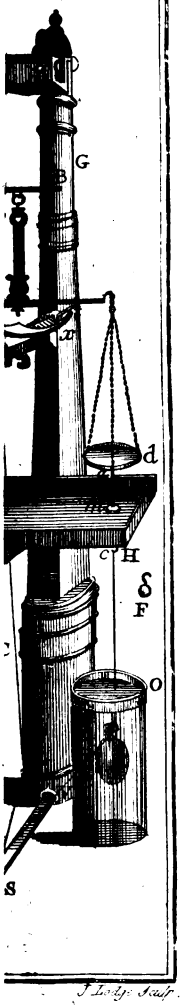
Let the body to be weighed be placed in the ſcale *d*. Put the weight X in the ſcale *e*, and let this be ſo determined, that one grain more ſhall be too much, and one grain leſs, too little. Then the ballance being moved gently up or down, by the ſcrew P, till the equilibrium be nicely ſhewn at *o*; if the index T be at the middle point *a* of the wire *r s*, it ſhews that the weights put into the ſcale *e*, are juſt equal

equal to the weight of the body. By this method we find the abſolute weight of the body: the relative weight is found by weighing it hydroſtatically in water, as follows.

Inſtead of putting the body into the ſcale *e*, as before, let it hang with the weight F, at the hook *c*, by a horſe hair, as at R, ſuppoſing the veſſel O of water were away. The equilibrium being then made, the index T ſtanding between *a* and *r*, at the thirty-ſixth diviſion, ſhews the weight of the body put in to be 1095,36 grains. As it thus hangs, let it be immerſed in the water of the veſſel O, and it will become much lighter: the ſcale *e* will deſcend till the beam of the ballance reſt on the ſupport *z*. Then ſuppoſe a hundred grains put into the ſcale *d* reſtore the equilibrium preciſely, ſo that the index T ſtand at the thirty-ſixth diviſion above *a*; it is evident that the weight of an equal bulk of water would, in this caſe, be exactly a hundred grains.

After

PLATE V.



After a like a manner this ballance may be applied to find the ſpecific gravity of liquids, as is eaſy to conceive from what has been ſaid.

THE SCREW OF ARCHIMEDES.

THIS is a ſort of ſpherical pump, and receives its name from its inventor. It conſiſts of a long cylinder AB (Pl. VI. Fig. 1.) with a hollow pipe CD round it; and is placed in an oblique poſition, with the lower end in the water, the other end being joined to the lower end of the winch IK, ſupported by the upright piece IR.

When this ſcrew is immerſed in the water, it immediately riſes in the pipe, by the orifice C, to a level with the ſurface of the water EF, and if the point in the ſpiral, which in the beginning of the motion is coincident with the ſurface of the water, happen not to be on the lower ſide of the cylinder, the water, upon the motion of the ſcrew, will move on in the ſpiral, till it

it come to the point on the other ſide that is coincident with the water. When it arrives at that point, which we will ſuppoſe to be O, it cannot afterwards poſſeſs any other part of the ſpiral than that on the loweſt part of the cylinder: for it cannot move from O toward H or G, becauſe they are higher above the horizon: and as this will be conſtantly the caſe, after the water in the ſpiral has attained the point O, it is plain it muſt always be on the under ſide of the cylinder.

But becauſe the cylinder is in conſtant motion, every part of the ſpiral ſcrew, from O to D, will by degrees ſucceed to the under part of the cylinder. The water therefore muſt ſucceed to every part of it, from O to D, as it comes on the lower ſide, that is, it muſt aſcend on the lower part of the cylinder, through all the length of the pipe, till it come to the orifice at D, where it muſt run out, having nothing further to ſupport it.

THE

THE BALLANCE PUMPS.

THIS is a ſimple and eaſy method of working two pumps at once, by means of the ballance A B, (Plate VI. Fig. 3 and 4.) having a large iron ball at each end, and placed in equilibrium on the two ſpindles C, as repreſented in the 4th figure. On the right and left are two boards I, nailed to two croſs-pieces, faſtened to the axis of the machine. On theſe boards the perſon who is to work the pump ſtands, and ſupports himſelf by a croſs piece nailed to the two poſts E D, Fig 3. At the diſtance of ten inches on each ſide the axis, are faſtened the piſtons M, N.

The man, by leaning alternately on his right and left foot, puts the ballance in motion, by which the pumps O, P are worked, and the water thrown into the pipe H, and carried to a height proportional to the diameter of the valves,

and the force of the ballance. There muſt be placed on each ſide an iron ſpring, as F and G, to return the ballance, and prevent its acquiring too great velocity.

THE HYDRAULIC SCOOP.

THIS machine conſiſts of five pieces of board, forming a ſort of ſcoop as B, (Pl. VI. Fig. 2.) The handle C is ſuſpended by a rope, faſtened to three poles, placed in a triangle, and tied together at A.

The working of this machine conſiſts entirely in ballancing the ſcoop that contains the water, and directing it in ſuch manner that the water may be thrown in any given direction. It is evident that the operation of both this and the laſt machine is ſo very eaſy, that it may rather be conſidered as an agreeable and ſalutary recreation, than hard labour.

With

With this machine a man of moderate ſtrength, by two ſtrokes in four ſeconds, can draw half a cubic foot of water, that is, more than four hundred cubic feet in an hour.

This machine is frequently uſed by the Dutch in emptying the water from their dykes.

RECREATION XIX.

The hydroſtatic bellows.

LET AB and EF, (Pl. VI. Fig. 5.) be two circular boards of oak: the ſides AE and BF are to be of leather, and joined very cloſe to the top and bottom by ſtrong nails. CD is a pipe, ſcrewed into a piece of braſs on the top board, at C.

Now if a man blow into the pipe DC, he may raiſe a very heavy weight placed on the top of the bellows. Or if he ſtand on the top AB, he will, by blowing ſtrongly into the pipe, ſoon blow himſelf up.

If water be poured in at D, till the bellows and pipe be full, the preſſure againſt AB, on the inſide, will lift as much weight on the top, as is equal to a cylinder of water, whoſe baſe is AB, and its height CD.

RECRE-

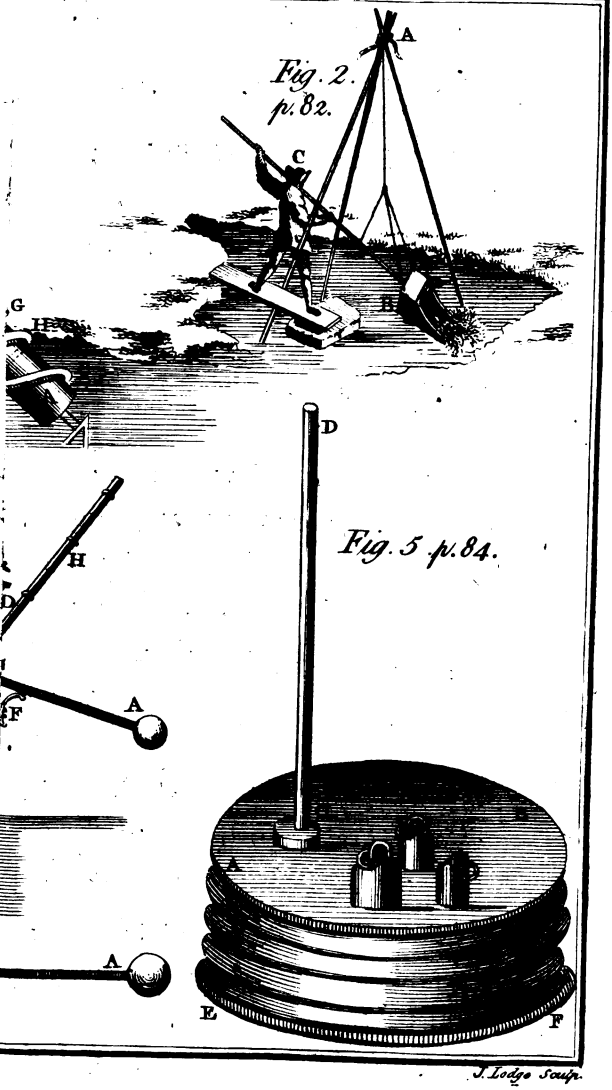


Fig. 2. p. 82.

Fig. 5 p. 84.

J. Lodge Sculp.

RECREATON XX.

The water clock.

PROVIDE a cylindric veſſel of glaſs, or china, ABCD (Pl. VII. Fig. 1.) about a foot high, and four inches diameter. Make a hole in its bottom, in which glue a ſmall glaſs tube E, of about one-third of an inch diameter, and whoſe end has been partly cloſed in the flame of a lamp, ſo that it will not ſuffer the water to paſs out but by drops, and that very ſlowly. Cover the top of the veſſel with a circle of wood F, in the center of which make a round hole about half an inch diameter.

Have a glaſs tube GH, a foot high, and a quarter of an inch diameter, and at one end let it have a ſmall glaſs globe I, to which you may hang a weight L, by which it is kept in equilibrium, on or near the ſurface of the water; or you may pour a

ſmall quantity of mercury into the tube, for the ſame purpoſe. Fill the veſſel with water; put the tube in it, and over it place the cover F, through the hole of which the tube muſt paſs freely up and down. Now, as the water drops gradually out of the veſſel, the tube will continue to deſcend till it come to the bottom.

Therefore, paſte on the tube a graduated paper, and put it in the veſſel when nearly full of water. Hang a watch by it, ſet to a certain hour, and as the tube deſcends, mark the hours, with the half and quarter hours. If the veſſel be ſufficiently large, with regard to the hole at the bottom, it will go for twelve hours, a day, or as much longer as you pleaſe, and requires no other trouble than that of pouring in water to a certain height. Care muſt be had however that the water be clean, for if there be any ſediment it will in time ſtop the

ſmall

ſmall hole at bottom, or at leaſt render the motion of the water irregular.

The veſſel may be of tin, but the pipe at bottom ſhould be glaſs, that its ſmall aperture may not alter by uſe. It is to be obſerved, that the tube of one of theſe clocks is not to be graduated by another, for though the veſſel be of the ſame diameter at top, it may not be perfectly cylindrical throughout; nor is it eaſy to make the hole at the bottom of one veſſel exactly of the ſame dimenſion with that of another.

RECREATION XXI.

The globular fountain.

MAKE a hollow globe A, (Pl. VII. Fig. 4.) of copper or lead, and of a ſize adapted to the quantity of water that comes from the pipe to which it is to be placed. Pierce a number of ſmall holes through this globe, that all tend toward its center *. Annex to it a pipe B, of ſuch height as you think convenient, and let it be ſcrewed at C, to the pipe from whence the jet flows.

The water that comes from the jet ruſhing with violence into the globe, will be forced out at the holes, with the direction in which they are made, and will produce a very pleaſing ſphere of water.

* The diameters of all theſe holes, taken together, muſt not exceed that of the pipe at the part from whence the water flows.

RECRE-

RECREATION XXII.

The hydraulic dancer.

PROCURE a little figure, made of cork, as AB, (Plate VII. Fig. 2.) which you may paint, or dreſs in a light ſtuff, after your own fancy. In this figure you are to place the ſmall hollow cone C, made of thin leaf braſs.

When the figure is placed on the jet-d'eau that plays in a perpendicular direction, it will remain ſuſpended on the top of the water, and perform a great variety of motions.

If a hollow ball of copper, of an inch diameter, and very light, be placed on a ſimilar jet, it will, in like manner, remain ſuſpended, revolving on its center, and ſpreading the water all round it, in the manner repreſented by Fig. 3.

RECRE-

RECREATION XXIII.

The hemiſpherial caſcade.

MAKE a hollow leaden cone A, (Pl. VII. Fig. 5.) whoſe axis is one-third of the diameter of its baſe. The circle C, that forms its baſe, muſt be in proportion to the ſurface of water that flows from the jet on which it is to be placed, that it may flow from it equally on all ſides. To the cone join the pipe B, which ſerves not only as a ſupport, but is to be pierced with a number of holes, that it may ſupply the cone with a ſufficient quantity of water. Screw the tube juſt mentioned to the top of that from whence the jet proceeds.

The water that ruſhes into the cone from the pipe, will run over its circumference, and form a hemiſpherial caſcade. If this piece be ſo conſtructed that it may be

be placed in a reverſed poſition, it will produce a fountain in the form of a vaſe, (ſee Fig. 6.) and if there be a ſufficient quantity of water, both theſe pieces may be placed on the ſame pipe. The fountain at top and the caſcade underneath; which, by their variety, will produce a very pleaſing appearance.

RECREATION XXIV.

The water ſun.

LET there be two portions of a hollow ſphere, (Plate VII. Fig. 7.) that are very ſhallow: and let them be ſo joined together, that the circular ſpace between them may be very narrow. Fix them vertically to a pipe from whence a jet proceeds. In that part by which the portions of the ſphere are joined, there muſt be made a number of holes; then the water ruſhing into the narrow cavity will be forced out from the holes, and produce a regular

regular figure of the ſun, as in the plate. This piece requires a large quantity and force of water, to make it appear to advantage.

Several pieces of this ſort may be placed over each other, in a horizontal direction, and ſo that the ſame pipe may ſupply them all with water (ſee Fig. 8.) It is proper to obſerve, that the diameter of theſe pieces muſt continually diminiſh, in proportion to their diſtance from the bottom.

RECREATION XXV.

The revolving water ſun.

MAKE a hollow circle A, (Pl. VIII. Fig. 1.) the ſides of which are to be pierced with twelve or fifteen holes, made in an inclined direction: or you may place the like number of ſmall tables round the

the circle. Fix this circle on the top of a jet, in ſuch manner that it may turn freely round.

The water ruſhing violently into the hollow circle will keep it in continual motion; and at the ſame time forcing out of the holes or ſmall tubes, will form a revolving figure with rays in different directions, as in the plate.

RECREATION XXVI.

The phial of the four elements.

TAKE a phial ſix or ſeven inches long, and about three quarters of an inch diameter. In this phial firſt put glaſs, groſsly powdered: ſecondly, oil of tartar per deliquum; thirdly, tincture of ſalt of tartar; and fourthly, diſtilled rock oil.

The glaſs and the different liquors being of different denſities, if you ſhake the phial,

phial, and then let it reſt for a few moments, the three liquors will intirely ſeparate, and each one aſſume its proper place, according to its ſpecific gravity. The powdered glaſs at the bottom of the phial may be ſuppoſed to repreſent earth; the oil of tartar, which occupies the ſecond place, repreſents water: the tincture that floats above it may be compared to the air; and the rock oil which ſwims at the top, is ſuppoſed to repreſent the element of fire.

RECREATION XXVII.

The magic bottle.

TAKE a ſmall bottle AB, (Pl. VIII. Fig. 2.) the neck of which muſt be very narrow *; and have a glaſs veſſel CD, whoſe height exceeds that of the bottle about two inches.

With a ſmall funnel fill the bottle quite full of red wine, and place it in the veſſel

* The mouth of this bottle ſhould not be more than one-ſixth of an inch wide.

CD,

CD, which is to be full of water. The wine will preſently come out of the bottle, and riſe, in form of a ſmall column, to the ſurface of the water; and at the ſame time the water entering the bottle, will ſupply the place of the wine; for water being ſpecifically heavier than wine, muſt hold the loweſt place, while the other naturally riſes to the top.

A ſimilar effect will be produced if the bottle be filled with water, and the veſſel with wine. For the bottle being placed in the veſſel, in an inverted poſition, the water will deſcend to the bottom of the veſſel, and the wine will mount into the bottle. The ſame effect may be produced by many other liquors, whoſe ſpecific gravities are conſiderably different.

RECRE-

RECREATION XXVIII.

The compreſſed jet d'eau.

PROVIDE a ſtrong copper veſſel A, (Plate VIII. Fig. 6.) of ſuch figure as you think convenient; in which ſolder a pipe B E, of the ſame metal. Let there be a cock at H, which muſt be made ſo tight that no air can paſs by it. The pipe B E muſt go very near the bottom of the veſſel, but not touch it. There muſt be another pipe F, at whoſe extremity G there is a very ſmall hole: this pipe muſt be ſcrewed into the former.

The veſſel being thus diſpoſed, take a good ſyringe, and placing the end of it in the hole at G, open the cock, and force the air into the veſſel; then turn the cock and take out the ſyringe. Repeat this operation ſeveral times, till the air in the veſſel be ſtrongly condenſed. Then fill the ſyringe

ſyringe with water, and force it into the veſſel, in the ſame manner as you did the air; and repeat this operation till you can force no more water into the veſſel; then ſhut the cock.

This veſſel will be always ready to perform an extempore jet d'eau: for on turning the cock the ſpring of the compreſſed air will force out the water with great violence, and the jet will continue, tho' continually decreaſing in force, till the water is all exhauſted, or the air within the veſſel is come to the ſame denſity with that without.

RECREATION XXIX.

The marvellous veſſel.

LET there be made a tin veſſel, about ſix inches high, and three inches in diameter, (Pl. VIII. Fig. 3.) The mouth of this veſſel muſt be only one quarter of an inch wide; and in its bottom make a great number of ſmall holes, about the ſize of a common ſewing needle.

Plunge this veſſel in water, with its mouth open, and when it is full, cork it up, and take it out of the water. So long as the veſſel remains corked, no water whatever will come out, but as ſoon as it is uncorked, the water will iſſue from the ſmall holes at its bottom.

You muſt obſerve, that if the holes at the bottom of the veſſel be more than one-ſixth of an inch diameter, or if they be in

in too great number, the water will run out though the veſſel be corked; for then the preſſure of the air againſt the bottom of the veſſel will not be ſufficient to confine the water.

A Recreation ſimilar to this is made with a glaſs filled with water, over which a piece of paper is placed. The glaſs is then inverted, and the paper drawn dextrouſly away, when the water, by the preſſure of the air under it, will remain in the glaſs.

RECREATION XXX.

The circulating fountain.

IN this fountain the boxes CE and DYX (Pl. VIII. Fig. 5.) being cloſe, you ſee only the baſon ABW, with a hole at W, through which the water that ſpouts out at B falls, and runs down, through the pipe WX, into the box DYX, from whence

it drives out the air, through the aſcending pipe Y Z, into the cavity of the box C E, where preſſing upon the water contained in that box, it forces it out, thro' the ſpouting pipe O B, as long as there is any water in C E; ſo that the continuance of the play is while the water in C E ſpouts out and falls down through the pipe W X, into the cavity D Y X.

The force of the jet is in proportion to the height of the pipe W X, or of the diſtance between the boxes C E and D Y. The height of the water, meaſured from he baſon A B W to the ſurface of the water in the lower box D Y X, is always equal to the height, meaſured from the top of the jet to the ſurface of the water in the middle cavity C E. Now, ſince the ſurface C E is always falling, and the water D Y is always riſing, the height of the jet muſt continually decreaſe, till it is ſhorter by the depth of the cavity C E, which is emptying, added to the depth of the

the cavity DY, which is always filling; and when the jet is fallen ſo low, it immediately ceaſes.

The method of preparing this fountain is as follows. Firſt, pour water in at W, till you have filled the cavity D X Y: then turn the fountain over, and the water will run from the cavity D X Y, into the cavity C E, which you will know to be full by the water's running out at B, when it is held down. Set the fountain up again, and pour about a pint of water into the baſon ABW, and as ſoon as it has filled the pipe W X, the fountain will play, and continue as long as there is any water in C E. You may then empty the water left in the baſon into any other veſſel, and invert the fountain; which, upon being placed again erect, will begin to play, when the water poured out of the baſon is put into it again. There are fountains of this ſort that have four pipes, inſtead of two, and by that mean

the water is forced up to twice the height it is in this.

RECREATION XXXI.

The magical caſcade.

PROCURE a tin veſſel A B C, (Pl. Fig. 4.) five inches high and four in diameter; and let it be cloſed at top. To the bottom of this veſſel let there be ſoldered the pipe D E, of ten inches length and half an inch in diameter: this pipe muſt be open at each end, and the upper end muſt be above the water in the veſſel. To the bottom alſo fix five or ſix ſmall tubes F, about one-eighth of an inch diameter. By theſe pipes the water contained in the veſſel is to run ſlowly out.

Place this machine on a ſort of tin baſon G H, in the middle of which is a hole of one quarter of an inch diameter. To the tube DE fix ſome pieces that may ſupport the veſſel over the baſon, and obſerve

ſerve that the end D, of the tube D E, muſt be little more than one quarter of an inch from the baſon. There muſt be alſo another veſſel placed under the baſon, to receive the water that runs from it.

Now, the ſmall pipes diſcharging more water into the baſon than can run out at the hole in its center, the water will riſe in the baſon, above the lower end of the pipe D E, and prevent the air from getting into the veſſel A B, and conſequently the water will ceaſe to flow from the ſmall pipes. But the water continuing to flow from the baſon, the air will have liberty again to enter the veſſel A B, by the tube D E, and the water will again flow from the ſmall pipes. Thus they will alternately ſtop and flow, as long as any water remains in the veſſel A B.

As you will eaſily know, by obſerving the riſe of the water, when the pipes will ceaſe to flow, and by the fall of it, when they will begin to run again, you may

ſafely predict the change; or you may command them to run or ſtop, and they will ſeem to obey your orders.

RECREATION XXXII.

The illuminated fountain.

THIS fountain begins to play when certain candles placed round it are lighted, and ſtops when thoſe candles are extinguiſhed. It is conſtructed as follows. Provide two cylindrical veſſels, A B and C D (Pl. VIII. Fig. 7.) Connect them by tubes open at both ends, as H L, F B, &c. ſo that the air may deſcend out of the higher into the lower veſſel. To theſe tubes fix candleſticks H, &c. and to the hollow cover C F, of the lower veſſel, fit a ſmall tube E F, furniſhed with a cock G, and reaching almoſt to the bottom of the veſſel. In G let there be an aperture with a ſcrew, whereby water may be poured into C D.

Now,

Now, the candles at H, &c. being lighted, the air in the contiguous pipes will be thereby rarified, and the jet from the ſmall tube EF will begin to play: as the air becomes more rarified, the force of the jet will increaſe, and it will continue to play till the water in the lower veſſel is exhauſted. It is evident, that as the motion of the jet is cauſed by the heat of the candles, if they be extinguiſhed, the fountain muſt preſently ſtop.

RECREATION XXXIII.

The ſolar fountain.

THE motion of the water in this fountain is produced by the heat of the ſun, in the following manner. GNS (Pl. VIII. Fig. 8.) is a thin hollow globe of copper, of eighteen inches diameter, ſupported by a ſmall inverted baſon, placed on a frame with four legs ABCD, which have between them, at the bottom, a baſon of two feet diameter. Through the leg

C paſſes a concealed pipe, which comes from G, the bottom of the inſide of the globe: this pipe goes by H V, and joins the upright pipe *u* I, to make a jet at I. The ſhort pipe *u* I, which goes to the bottom of the baſon, has a valve at V, under the horizontal pipe H *u*, and another valve at V, above that horizontal pipe, under the cock at K. The uſe of this cock is to keep the fountain from playing in the day, till you think proper. The north pole N of the globe has a ſcrew that opens a hole, whereby water is poured into the globe.

The machine being thus prepared, and the globe half filled with water, let it be ſet in an open place, when the heat of the ſun, rarifying the air as it heats the copper, the air will preſs ſtrongly againſt the water, which coming down the pipe GCHVI, will lift up the valve V, and ſhut the valve *u*. The cock being opened the water will ſpout out at I, and continue

tinue to play a long time, if the ſun ſhine.

At night, when the air is condenſed, that which is on the outſide of the veſſel will preſs on the adjutage I, and ſhut the valve V; and at the ſame time preſſing on the water in the baſon D *u* H, which has been played in the day, will puſh it up, through the valve *u*, and pipe *u* H G, into the globe, ſo as to fill it again, to the ſame height as at firſt. When the ſun ſhines again on the globe, the fountain will play again, &c. A ſmall jet will play ſix or eight hours.

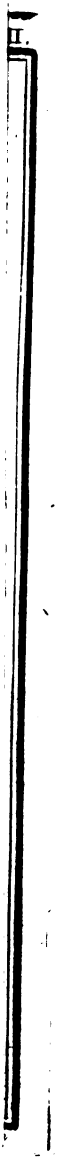
If the globe be ſet to the latitude of the place, and rectified before it be fixed, with the hour lines or meridians drawn upon it, the hours marked, and the countries painted, as on the common globe, it will form a good dial; the ſun then ſhining upon the ſame places in this globe, as it does

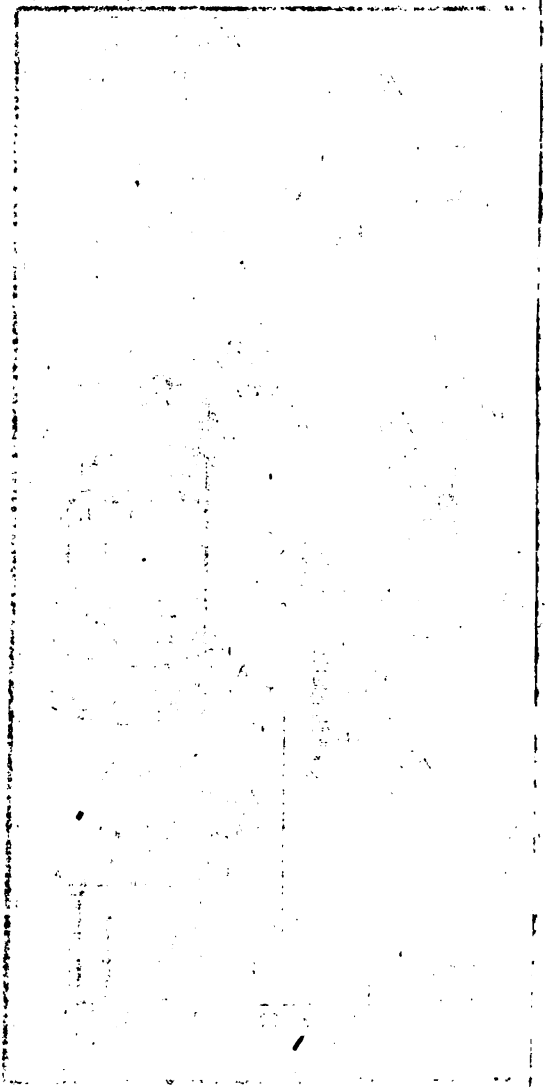
does on the earth itſelf. This fountain was invented by Dr. Deſaguliers.

RECREATON XXXIV.

The cup of Tantalus.

IN this cup is placed a ſyphon, the ſhorteſt leg of which is near the bottom of the cup, and the longeſt is concealed in the handle. If water be poured into this cup it will not run out till it come above the top of the bended part of the ſyphon, and then, by the preſſure of the air, it will be forced up the ſhort leg, and run out by that in the handle, till the water in the cup be lower than the ſhort leg of the ſyphon, which may be placed very near the bottom of the veſſel. If the cup be filled juſt to the top of the ſyphon, and an apple or orange thrown in, it will, by raiſing the water, have





have the ſame effect as pouring in more.

This is called the cup of Tantalus, from the reſemblance of an experiment ſometimes made with an image placed upright in the cup, (Pl. IX. Fig. 1.) to the fable of Tantalus. For a ſyphon being placed in the body of the image, one end of which beginning at the bottom of one foot, riſes to the upper part of his breaſt, from thence deſcends through the other leg, on which he ſtands, and from thence through the bottom of the cup. As ſoon as the water riſes to the chin of the image, above S, it will begin to run out, in the ſame manner as from the cup above mentioned.

RECREATION XXXV.

The ſea gage.

THIS inſtrument is conſtructed as follows. AB (Pl. IX. Fig. 2.) is the gage bottle, in which is cemented the gage tube F *f*, in the braſs cap at G. The upper end of the tube F is hermetically ſealed, and the lower, open end *f*, is immerſed in mercury, marked C, on which ſwims a ſmall ſurface of treacle. On the top of the bottle is ſcrewed a pipe of braſs GH, pierced with ſeveral holes, to admit the water into the bottle AB. K is a weight, hanging by its ſhank L, in a ſocket N, with a notch on one ſide at *m*, in which is fixed the catch *l*, of the ſpring S, which paſſing through the hole L, in the ſhank of the weight K, prevents its falling out, when once hung on. On the top, in the upper part of the braſs tube, at H, is fixed a large empty ball, or full blown bladder

I,

I, which muſt be of ſuch a ſize that the weight K may be able to ſink the whole under water.

This inſtrument is uſed in the following manner. The weight K is hung on, and the gage being let fall into deep water, ſinks to the bottom: the ſocket N is ſomething longer than the ſhank L, and therefore, after the weight K comes to the bottom, the gage will continue to deſcend, till the lower part of the ſocket ſtrike againſt the weight: this gives liberty to the catch to fly off the hole L, and let go the weight K. When this is done, the ball or bladder I, inſtantly buoys up the gage to the top of the water.

While the gage is ſinking, the water having free acceſs to the treacle and mercury in the bottle, will, by its preſſure, force it up into the tube F *f*; and the height to which it has been forced by the greateſt preſſure, which is that at the bottom,

tom, will be ſhown by the mark in the tube which the treacle leaves behind it; and which is here its only uſe. This ſhows into what ſpace the whole air in the tube F*f* is compreſſed, and conſequently the depth of the water, which by its weight produced that compreſſion.

If the gage tube F*f* be of glaſs, a ſcale may be drawn on it with the point of a diamond, which will ſhew by inſpection, at what height the water ſtands above the bottom. But the length of ten inches is not ſufficient to fathom depths at ſea; for when all the air in ſuch a length of the tube is compreſſed into half an inch, the depth of water is not more than 634 feet, which is not half a quarter of a mile.

If to remedy this, we uſe a tube 50 inches long, which, for ſtrength, may be a muſket barrel, and if the air be compreſſed into the hundredth part of half an inch, even then the depth will be but 3300 feet, that

is 660 feet more than half a mile. But it is reaſonable to ſuppoſe the cavities of the ſea bear a near proportion to the mountainous parts of the land, ſome of which are more than three miles high. Therefore, to inveſtigate the greateſt depths of the ſea, the following improvement was made to the foregoing apparatus.

Let B C D F, Fig. 3. be a hollow metal globe, on the top of which is fixed the long tube A B, whoſe capacity is one-ninth part of the globe. At the lower part D, it has a ſhort tube D E, which is to ſtand in the mercury and treacle. The air contained in this compound gage-tube is compreſſed by the water, as before; but the degree of compreſſion, or height to which the treacle has been forced, cannot here be ſeen through the tube: therefore, to anſwer the ſame end, a ſlender rod of metal or wood, with a knob at the top of the tube AB, will receive the mark of the treacle, and ſhow it when taken out.

If the tube be 50 inches long, and of ſuch a bore that every inch in length be equal to a cubic inch of air, and the content of the globe and tube together be 500 cubic inches; then, if the air be compreſſed within a hundredth part of the whole, it is evident that the treacle will not approach the top of the tube nearer than five inches, which will anſwer to the depth of 3300 feet of water, as above. Twice that depth will compreſs the air into half that ſpace, nearly, that is, two inches and a half, which correſponds to 6600 feet, or a mile and a quarter. Laſtly, half that ſpace, or an inch and a quarter, will anſwer to double the laſt depth, that is, 13,200 feet, or two miles and a half; which is, probably, very near the greateſt depth of the ſea. This ſea-gage was invented by the Drs. Hales and Deſaguliers.

RECREATION XXXVI.

The diving bell.

THERE have been many machines invented to explore the hidden chambers of the deep; as may be eaſily imagined: for when curioſity is joined by avarice they ſtrongly excite the inventive faculty. Of all theſe machines the moſt complete is that invented by Dr. Halley, who does not appear, however, to have been excited by any other motive than curioſity; nor is it wonderful: for to a man of his exalted faculties one motive only is equal to many, when acting conjointly, on a vulgar mind.

This machine was in the form of a bell (Pl. IX. Fig. 4.) It was three feet wide at top, five at bottom, and eight feet high, and contained about forty-three cubic feet, or near eight hogſheads.

The machine was coated with lead, and ſo heavy that it would ſink empty. The weight was diſtributed about the bottom IK, ſo that it would go down in a perpendicular direction only. In the top was fixed a ſtrong clear glaſs D, to let in the light from above. There was likewiſe a cock at B, to let out the hot, foul air. Below was fixed a circular ſeat LM, for the divers to ſet on; and laſtly, from the bottom hung, by three ropes, a ſtage for them to ſtand on, while they were performing their operations *.

To ſupply the bell with air under water, were made two barrels, ſuch as C, of about 63 gallons each, and caſed with lead, ſo that they would ſink empty; each of them

* This machine was ſuſpended from the maſt of a ſhip by a ſprit, which was ſufficiently ſecured to the maſt-head by ſtays, and was directed by braces, to carry it over board, clear of the ſide of the ſhip, and to bring it in again.

had

had a hole in the lower part, to let in the water, as the air in them was condenſed in their deſcent, and to let it out again, when they were drawn up full from below.

To a hole in the top of the barrel was fixed a hollow pipe, well prepared with bees-wax and oil; this pipe was long enough to fall below the hole at the bottom, being ſunk with a weight hanging to it, ſo that the air in the upper part could not eſcape, unleſs the lower end of the pipes were firſt lifted up.

Theſe air barrels were fitted with tackle, adapted to make them riſe and fall alternately, like two buckets in a well. In their deſcent they were directed by lines, faſtened at the under edge of the bell to the man ſtanding on the ſtage to receive them, who, by taking up the ends of the pipes above the ſurface of the water in the

bell, gave liberty to the water in the barrels to force all the air in the upper parts into the bell, while it entered below and filled the barrels; and as ſoon as one was diſcharged, at a ſignal given, it was drawn up, and the other deſcended to be ready for uſe.

As the cold air ruſhed into the bell from the barrel below, it expelled the hot air through the cock B, at the top of the bell, which was then opened for that purpoſe. By this method air was communicated ſo quick, and in ſuch plenty, that the Doctor tells us, he himſelf was one of five, who was at the bottom in nine or ten fathom water, for more than an hour and a half together, without any ſort of ill conſequence; and for any thing that appeared to the contrary, he might have continued there as long as he pleaſed.

In going down, it is neceſſary the deſcent ſhould be at firſt very gentle, that the

the denſe air may be inſpired, to keep up by its ſpring, a balance to the preſſure of the air in the bell. At each twelve feet of deſcent the bell was ſtopped, and the water that entered was driven out, by letting in three or four barrels of freſh air.

By the glaſs on the top of the bell ſo much light entered, when the ſun ſhined, that Dr. Halley could ſee diſtinctly to write and read. By the return of the air-barrels he ſent up orders, wrote with an iron pen on ſmall pieces of lead, directing where the bell was to be moved. But in dark weather, when the ſea was rough, the bell would be as dark as night: but then, the Doctor obſerved, he could keep a candle burning in the bell as long as he pleaſed; for it is found by experiment, that a candle conſumes as much air in a minute as a man, that is, about one gallon.

The only inconvenience attending this bell was, that upon firſt going down, they

felt a ſmall pain in their ears, as if the end of a quill was forcibly thruſt into the hole of the ear. This pain preſently ceaſed; but on deſcending lower returned again, and again ceaſed; and ſo alternately, till the machine got to the bottom, where the air is always of the ſame denſity.

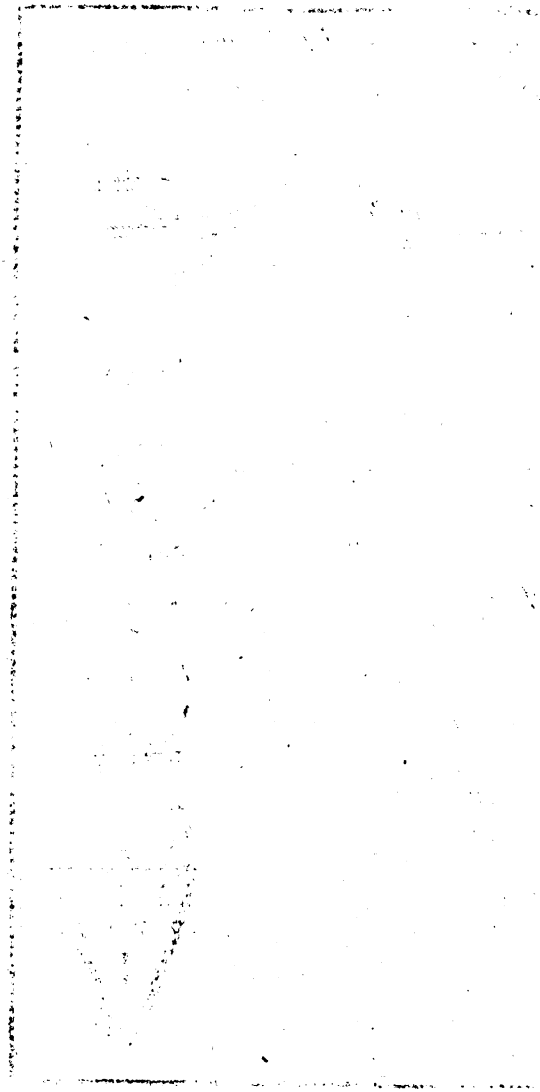
This bell was ſo improved by the inventor, that he could detach one of his divers to the diſtance of a hundred yards from it. For this purpoſe he contrived a cap, or head-piece, ſomething like an inverted hand-baſket, as F, with a glaſs in the fore part, for the diver to ſee his way.

This cap was of lead, and made to fit quite cloſe about his ſhoulders: in the top of it was fixed a flexible pipe, communicating with the bell, and by turning a ſtop cock near his head-piece, he received

ceived air whenever he pleaſed. There was alſo another cock at the end of the pipe in the bell, to prevent any accident happening from the perſon without. This perſon was always well cloathed with thick flannels, which were warmed upon him before he left the bell, and would not ſuffer the cold water to penetrate. His cap contained air enough to ſerve him a minute or two; then by raiſing himſelf above the bell, and turning the cock F, he could repleniſh it with freſh air. The pipe he coiled round his arm, which ſerved him as a clue to find his way back to the bell.

Since the invention of the above diving machine, there has been one contrived by M. Triewald, F. R. S. and military architect to the King of Sweden, which, for a ſingle perſon, is in ſome reſpects more eligible, and is conſtructed as follows.

lows. AB (Pl. IX. Fig. 5.) is the bell, which is ſunk by lead weights D D, hung to its bottom. This bell is of copper, and tinned all over on the inſide, which is illuminated by three ſtrong convex lenſes G, G, G, with copper lids H, H, H, to defend them. The iron ring or plate E, ſerves the diver to ſtand on when he is at work, and is ſuſpended at ſuch a diſtance from the bottom of the bell, by the chains F, F, F, that when the diver ſtands upright, his head is juſt above the water in the bell, where the air is much better than higher up, becauſe it is colder, and conſequently more fit for reſpiration. But as the diver muſt be always within the bell, and his head of courſe in the upper part, the inventor has contrived that even there, when he has breathed the hot air as long as he well can, he may, by means of a ſpiral copper tube *b c* placed cloſe to the inſide of



of the bell, draw the cooler and freſher air from the lowermoſt parts; for which purpoſe a flexible leather tube, about two feet long, is fixed to the upper end of the copper tube at *b*; and to the other end of this tube is fixed an ivory mouth-piece, by which the diver draws in the air.

PYRO-

PYROTECHNICS.

PYROTECHNICS.

DEFINITIONS.

1. PYROTECHNICS is that branch of physiology which explains the nature of fire, and the manner of employing it in offices of use or pleasure.

2. Fire is said to be of six degrees.

3. The first degree of fire is that measured by Farenheit's thermometer between its first and 80th degree; and is the limit necessary to vegetation.

4. The second degree of fire, is that contained between the 40th and 94th degrees of the same thermometer; and is that necessary to animal life.

5. The third degree of heat extends from the 94th to the 212th degree of that thermo-

thermometer; the laſt of which is commonly that of boiling water.

6. The fourth degree of heat is extended to the 600th degree of the ſame thermometer; which is very near the boiling point of mercury: within this degree lead and tin melt *.

7. The fifth degree of heat is that in which all metals and fixed ſalts melt, and moſt other bodies vitrify or become volatile. This is the extreme heat of a chemical furnace.

8. The ſixth degree of heat is that of the focus of a large lens or mirror, which no ſubſtance can ſuſtain unaltered.

9. Heat is divided into abſolute and relative: abſolute heat is that which exiſts in any ſubſtance; and relative or comparative heat is that which is perceived by an animal body.

* Theſe diviſions of heat by the thermometer, were firſt fixed by the illuſtrious Boerhaave.

APHO-

APHORISMS.

1. Abſolute heat proceeds from an inteſtine motion in the parts of any body *.

2. Relative heat ariſes from the degree of inteſtine motion in any ſubſtance being greater than that of the animal body to which it is applied.

3. There is the ſame affinity between abſolute and relative heat, as between motion and velocity: abſolute heat being the whole motion of all the parts of the heated body, and relative heat only the comparative velocity of the parts †.

* This is the doctrine of fire maintained by the Engliſh philoſophers: thoſe of other nations aſſert, in general, that fire is an element, like air and water, that it is contained in all bodies, and obtainable from them by attrition or pulſation.

† This is exemplified by placing equal quantities of mercury and water over a ſand heat, where the fire being uniformly communicated to each of them, they will acquire, in the ſame time, the ſame degree of abſolute heat: but the relative heat, or that which is ſenſible to an animal body, will be near

4. When the motion of the parts of an inflammable body is increaſed to a certain degree, it will throw off a quantity of particles, in form of ſmoke. If the velocity be further increaſed, thoſe particles will become ſparks of fire: and if the velocity be ſtill further increaſed, thoſe particles will make a body of fire, in the form of a flame.

5. The effect of fire in burning proceeds from the velocity of its particles, which ſo far increaſe the velocity of thoſe of the body to which it is applied, as to ſeparate them from the body, and drive them beyond the ſphere of its attraction. By which mean the body is diſſolved, ſuch of its particles as are volatile fly off in ſmoke or flame, and the reſt remain in the form of a calx or aſhes.

6. The force or burning power of the

fourteen times greater in the water than the mercury; for the water having fourteen times leſs matter, will have acquired a velocity, in proportion as much greater.

parti-

particles of fire when condenſed, as in the focus of a lens or mirror, are increaſed in proportion to the area of the glaſs, directly, and the ſquare of the focal diſtance, inverſly *.

7. The force of heat increaſes in proportion to the ſquares of the diſtances, inverſly; that is, at the diſtance of one foot the fire is four times as ſtrong as at two feet, and nine times as ſtrong as at three feet; and ſo in proportion.

8. The dimenſions of bodies, in general, are increaſed by heat †.

* For example: ſuppoſe the area of one glaſs to be twelve ſquare inches, and its focal diſtance nine inches; and the area of another to be ten inches, and its focal diſtance five inches. Then the burning power of the former will be to the latter as 12 multiplied by 25, is to 10 multiplied by 81; that is, as 300 to 810, or as 30 to 81.

† Dr. Halley found that water has no perceptible expanſion when gently heated, but when boiled, expands one-twenty-ſixth part. Mercury with a very gentle heat expands one-ſeventy-fourth part; and ſpirit of wine, with a heat much leſs than that of boiling water, expands one-twelfth.

9. Fire pervades, and is found in all bodies.

10. The immediate inflammable matter of every body is oil, or an unctuous ſubſtance.

11. No ſubſtance will continue to burn without the admiſſion of freſh air.

12. Fire acts in all directions from the ignited body, as from a center.

M. Muſchenbroek found the expanſions of the following metals in the ſame heat, to be in the proportions here ſet down. Silver 78; iron 80; ſteel 85; copper 89; braſs 110; tin 153; lead 155.

RECREATION XXXVII.

The inflammable phosphorus *.

TAKE the meal or flour of any vegetable, put it into an iron pan over a moderate fire, and keep it ſtirring with an iron ſpatula, till it be converted into a black powder: to one part of this add four parts of crude alum. Make the whole into a fine powder, which being put into an iron pan over the fire, is to be kept conſtantly ſtirring with a ſpatula till almoſt ignited, to prevent its cohering in lumps, as it is apt to do upon the melting of the alum, in which caſe it muſt be broke again, ſtirred about, and accurately mixed with the flour, till it emit no more fumes, and the whole appear a fine, dry, black, fixed powder.

* For a more eaſy method of preparing a lucid phoſphorus, ſee Vol. III. p. 91.

Put this powder in a clear, dry phial, with a narrow neck, filling to about one-third from the top. Then ſtop the mouth of the phial with looſe paper, ſo as to let the air paſs freely through it, and leave room for fumes to come through the neck. Place the phial in a crucible, encompaſſed on all ſides with ſand, but ſo that it may not touch any part either of the bottom or ſides of the crucible, but a conſiderable ſpace be every where left between them. The phial muſt be covered up with ſand, ſo as only to leave a part of it bare, through which you may perceive whether the matter be ignited. In this ſtate the crucible is to be ſurrounded with coals kindled ſlowly, till it be well heated on all ſides, when the fire is to be raiſed, till the crucible, ſand, glaſs, and matter in it, be all red hot; in which ſtate they are to be kept for an hour; after this, the fire being ſtill kept up, the orifice of the phial is to be well cloſed with wax, to prevent any air from entering. Thus the

the whole being left to cool undiſturbed, you will at laſt find in the phial a black duſty coal, formed of the flour and alum.

A ſmall quantity of the matter contained in this phial being ſhook out, into the cold air, immediately takes fire and burns; but having once felt the air, loſes all power of kindling thereby. This manner of producing fire appears the moſt extraordinary of all that have hitherto been diſcovered, ſince the matter thus prepared will preſerve its virtue three months, provided the air be kept from it: but if the ſmalleſt quantity of moiſture, even of that little which is lodged in the air, come to touch this powder, the experiment will not ſucceed.

RECREATION XXXVIII.

The liquid phoſphorus.

TAKE a piece of Engliſh phoſphorus, about the ſize of a pea, and cutting it very ſmall, put it into half a glaſs of quite clear water. Boil it in a little earthen veſſel over a moderate fire. Have a phial with a narrow neck and a glaſs ſtopper; take out the ſtopper and plunge the phial in boiling water: then take it out, and pouring out the water, put the boiling mixture immediately into it: inſtantly ſtop the phial, and cover it with a cement, that the air may not in any degree enter it.

This mixture will ſhine in the dark for ſeveral months, though the phial be not touched: if it be ſhook, eſpecially in warm dry weather, very ſtrong lightnings will dart from the middle of the water.

Some pleaſing amuſements may be produced by putting this phoſphorus in a long or broad phial, and paſting a paper over it, in which letters or figures are cut.

RECREATION XXXIX.

The fulminating gold.

PLACE a ſmall mattraſs, on a ſand heat, and in it put one part of filings of pure gold, and three parts of aqua regia. When the liquor has entirely diſſolved the gold, put the mixture in a phial, and add five or ſix times as much common water.

Then take ſpirit of ſal ammoniac, or oil of tartar, and pour it, drop by drop, on the diſſolution, till the ebulition ceaſe. Let this mixture reſt, till the gold be entirely precipitated to the bottom of the phial. Pour the water that ſwims at the top gently off, and after waſhing this

gold

gold duſt ſeveral times in common water, dry it by a very moderate heat, by putting it on a paper that will abſorbe all its moiſture.

If a grain of this powder be put in a copper ſpoon, over the flame of a candle, as ſoon as it is well heated, it will go off, with a report like that of a piſtol. If the ſpoon be not ſufficiently ſtrong, the matter will run through it, and make an explo-ſion underneath, with great violence.

RECREATION XL.

The burning fountain.

MAKE a veſſel of tin or copper, as ABCD, (Pl X. Fig. 11.) or of what other form you pleaſe. Let there be an eolipile E, of the ſame metal, and of the ſize and figure of a pear, and let its neck paſs through the top of the veſſel, where it ſhould not be of more than one quarter of an inch diameter: to this neck join

join the pipe F, whoſe bore at the extremity ſhould be extremely ſmall, and there muſt be a ſmall cock, that goes croſs it. Pour ſome ſpirit of wine into the eolipile, and having filled the veſſel with boiling water, cover it over.

The heat of the boiling water rarifying the air contained in the eolipile, it will preſs on the ſurface of the ſpirit of wine, and force it through the ſmall hole at the end of the pipe. Therefore, if the flame of a candle be placed cloſe to the orifice of the pipe, the ſpirit will take fire, and it will form a flaming fountain, that will have a pleaſing effect; and if the orifice of the pipe be quite ſmall, will continue for ſome time.

This piece may be executed on a larger plan, and many of the jets deſcribed under the article of Hydraulics, may be annexed to the eolipile; taking care always that the orifice by which the ſpirit is to paſs be

be extremely ſmall. If filings of iron be ſifted over theſe jets, through a very fine ſieve, they will take fire, and imitate exactly the appearance of fireworks.

RECREATION XLI.

Prince Rupert's drop.

TAKE up a ſmall quantity of the melted matter of glaſs, with a tube, and let it drop, red hot, into a pail of water, by which it will receive its form, and be ſolid throughout; except that ſometimes it contain a few air bubbles. This drop or tear will have a ſmall tail, which being broke the whole ſubſtance of the drop will burſt, with great violence, into a fine powder, and give conſiderable pain to the hand that breaks it.

It is remarkable, that the bulb or body will bear the ſtroke of a hammer without breaking, but if the leaſt part of the tail be broke the above-mentioned effect is pro-

produced. If the tear be cooled in the air, it will not produce the effect; and if it be ground away on a ſtone, nothing extraordinary appears. But if it be put into the receiver of an air-pump, and there broke, the effect will be ſo violent as to produce light.

This phenomenon is ſuppoſed to proceed from the particles of the glaſs being in a ſtate of repulſion, while melted, but by being dropped into cold water, the external particles are condenſed, and hold the internal, which are ſtill in a ſtate of repulſion, as in a caſe, but when an opening is made in that caſe, by breaking off the tail, the confined particles ruſh forth, and burſt the drop with the greateſt violence.

RECREATION XLII.

The revivified roſe.

TAKE a roſe that is quite faded, and throwing ſome common ſulphur on a chafingdiſh of hot coals, hold the roſe over the fumes, and it will become quite white. Then dip it in a baſon of water, and giving it to any one, tell him to put it in his box or drawer, and after locking it, to give you the key. When you return him the key, five or ſix hours after, and he unlocks his drawer, inſtead of the white roſe he put in it, he will find one that is perfectly red.

RECREATION XLIII.

Writing on glaſs by the rays of the ſun.

DISSOLVE chalk in aqua fortis, to the conſiſtence of milk, and add to that a ſtrong diſſolution of ſilver. Keep this liquor in a glaſs decanter well ſtopped. Then cut out from a paper the letters you would have appear, and paſte the paper on the decanter, which you are to place in the ſun, in ſuch a manner that its rays may paſs through the ſpaces cut out of the paper, and fall on the ſurface of the liquor. The part of the glaſs through which the rays paſs will turn black, and that under the paper will remain white. You muſt obſerve not to move the bottle during the time of the operation.

RECREATION XLIV.

The magic picture.

TAKE two pieces of glaſs about three inches long and four wide: they muſt be quite level, and exactly of the ſame ſize. Place them one over the other, and let there be about one-twentieth part of an inch between them, which you may effect by paſting papers on their four corners. Join theſe two glaſſes together by a luting compoſed of lime ſlacked by lying in the air and reduced to very fine powder, mixed with the white of an egg. Cover all the borders of theſe glaſſes with parchment or bladder, except a ſmall opening left on one ſide, in order to introduce the following compoſition.

Diſſolve by a ſlow fire ſix ounces of fine hogs-lard, and put to it half an ounce of white wax, and if you find it neceſſary to render it more ſenſible to the heat, add

an

an ounce, or more, of the cleareſt linſeed oil. This, when liquid, is to be poured between the glaſſes by the ſpace left in their ſides, and which you are then to ſtop cloſe up. Wipe the glaſſes clean, and hold them before the fire, to ſee that the compoſition will not run out at any part. Then paſte a picture, painted on any thin ſubſtance, or a coloured print, with its face to one of the glaſſes, and fix the whole in a frame.

The mixture between the glaſſes, while it is cold, will quite conceal the picture, but becoming perfectly tranſparent by heat, the painting will appear as if there was only a ſingle glaſs before it. As the compoſition cools, the picture will gradually diſappear, and at laſt be quite inviſible.

RECREATION XLV.

The luminous oracle.

PROCURE a tin box ABCD, (Pl. XII. Fig. 1.) about eight inches high, four wide, and two deep, and let it be fixed on the wooden ſtand E. On two of the inſides let there be a groove F G, and in the front an opening I, three inches wide and one high.

At the back of the box let there be a little tin door, that opens outward, by which two wax candles M, may be put in. Let the top of the box have a cover of the ſame metal, in which there are ſeveral holes, and which may be taken off at pleaſure.

Provide a double glaſs O P, Fig. 2. conſtructed in the ſame manner as that in the laſt Recreation. On one of its ſides you are to paſte a black paper, the length of which

which is to be divided into three parts, and the breadth into fifteen: in every two of these fifteen divisions you cut out letters, which will make in the whole three answers, to three questions that may be proposed. On the other side of the glass paste a very thin paper and to the top fasten a small cord, by which they may be made to rise or descend in the groove F G.

Then take a slip of pasteboard F S, Fig. 3. one inch and a half wide and three inches long, which is to be divided into fifteen equal parts, similar to those of the paper O P, and cut out spaces, as in the figure, so that this paper sliding horizontally before O P, will either cover or conceal the letters cut in that.

This pasteboard is to slide between two brass wires, and is to be fastened to one side of the box, by a string that communicates with a small brass spring, and to

the other ſide, by a ſtring faſtened to the box by a ſmall piece of wax, ſo ſituate that the ſtring may be eaſily ſet at liberty by the heat of the candles placed in the box.

Take a parcel of cards, and write on on them different queſtions, three of which are to correſpond with the anſwers on the glaſs. Shuffle theſe cards, and let a perſon draw any one of the three queſtions. Then by raiſing the glaſs you bring the anſwer againſt the hole in the front of the box. You next place the candles in the box, the heat of which will melt the wax that holds the paper R S, which being then drawn by the ſpring the anſwer will be viſible, and in proportion as the compoſition between the glaſſes becomes diluted, by the increaſe of the heat, the letters will become more ſtrongly illuminated.

The

The letters cut in the paper may be made to anſwer ſeveral different queſtions, as has been explained in other Recreations; and the whole parcel of cards may conſiſt of queſtions that may be anſwered by one or other of the three diviſions in the paper.

RECREATION XLVI.

To produce the appearance of a flower from its aſhes.

MAKE a tin box ABCD, (Plate XII. Fig. 4.) with a cover M, that takes off. Let this box be ſupported by the pedeſtal F G H I, of the ſame metal, and on which there is a little door L. In the front of this box is to be a glaſs, O.

In a groove, at a ſmall diſtance from O, place a double glaſs of the ſame ſort with that in the laſt Recreation. Between the front and back glaſſes place a ſmall upright

tin tube, ſupported by the croſs-piece R. Let there be alſo a ſmall chafingdiſh placed in the pedeſtal F G H I. The box is to be open behind. You privately place a flower in the tin tube R *, and preſenting one that reſembles it to any perſon †, deſire him to burn it on the coals in the chafing diſh.

You then ſtrew ſome powder over the coals, which may be ſuppoſed to aid the aſhes in producing the flower; and then put the chafingdiſh in the pedeſtal, under the box. As the heat by degrees melts the compoſition between the glaſſes, the

* This flower muſt not be placed ſo near the front glaſs, as to make it in the leaſt degree viſible.

† You may preſent ſeveral flowers, and let the perſon chooſe any one of them. In this caſe, while he is burning the flower, you fetch the box from another apartment, and at the ſame time put in a correſponding flower, which will make the experiment ſtill more ſurpriſing.

flower

flower will gradually appear, but when the chafingdiſh is taken away, and the power of the aſhes is ſuppoſed to be removed, the flower ſoon diſappears.

RECREATION XLVII.

To produce fire by the mixture of two cold liquors.

TAKE half a pound of pure dry nitre, reduced to powder, put it in a retort that is quite dry, add to it an equal quantity of oil of vitriol highly rectified, and diſtilling the mixture in a moderate ſand heat, it will yield a liquor in form of a yellowiſh fume, which being caught in a clean dry receiver, is the *Spiritus nitri Glauberianus.* Now if to a dram of diſtilled oil of cloves, ſaſſafras, turpentine, or caraways, contained in a glaſs veſſel, there be added an equal quantity, or half as much more, of the above ſpirit, though both the bodies are perfectly cold before

the mixture, a violent flame will inſtantly ariſe, and entirely deſtroy them, leaving only a little reſinous matter, inſtead of aſhes, at the bottom.

RECREATION XLVIII.

Artificial lightning.

PROVIDE a tin tube that is much larger on one ſide than the other, and in which there are ſeveral holes. Fill this tube with reſin in powder, and when it is ſhook over the flame of a torch, it will produce a ſudden coruſcation, that ſtrongly repreſents a flaſh of lightning. You are to obſerve that it is not the flame itſelf that is to be ſeen, but its reflection, as is practiſed at the theatres, and as happens, for the moſt part, in nature *.

* It is after this manner that the flambeaux of the furies on the ſtage are conſtructed, except that at the end of each of them there is a match, dipped in ſpirit of wine, by means of which it is only neceſſary to ſhake them, and they will produce a ſudden and very conſiderable flame.

RECRE-

RECREATION XLIX.

Artificial thunder.

TAKE a ſtrong bottle that holds about a quarter of a pint, in which put one ounce of concentered ſpirit of vitriol, and adding to that two drachms of the filings of iron, ſtop the bottle cloſe. After a ſhort time ſhake the bottle, and taking out the cork, put a lighted candle near the mouth of it, which ſhould be a little inclined, and there will preſently ariſe an inflammation, attended with a loud noiſe.

If you are apprehenſive of any miſchievous effects from the burſting of the bottle, you may ſurround it with a ſtrong cloth: or you may put it on the ground and light the vapour by a bougie fixed to the end of a long ſtick.

Another way of imitating thunder is, by mixing three parts of ſaltpetre, two parts

parts of ſalt of tartar, and two parts of ſulphur, and putting the quantity of a ſmall nut in an iron ladle or ſhovel, place it over a coal fire. The exploſion of this mixture will much reſemble a moderate clap of thunder.

If you would produce a more violent exploſion, put an ounce or two of this mixture in the ſhovel, but then you muſt have a chafingdiſh of hot coals, and placing it out of the houſe, ſtand at a conſiderable diſtance from it, and not go near it, till the matter be completely exploded, or, what is better, till the fire be out. Experiments of this nature ſhould, in general, be conducted with great caution, for an amuſement of this kind would be dearly bought with a wound in the face, or the loſs of ſight.

RECRE-

RECREATION L.

The predicted earthquake and volcano.

GRIND freſh iron filings, free from ruſt, with an equal quantity of pure ſulphur, for a long time, till the whole be formed into a fine powder. This mixture kept in a dry air will continue cold for any time, but if it be wrought up with only as much fair water as will form it into a ſtiff paſte, the maſs will ſoon grow warm, ſwell, heave, emit a thick ſmoke, and at laſt a ſulphureous fire and flame. Therefore take about fifty pounds of the above powder, and burying it privately about a foot deep under the earth, you may ſafely predict that in about eight hours time the ground will begin to heave and ſwell, that it will ſend forth hot ſulphureous ſteams, and at laſt, burſting into live flames, will form a true volcano.

The

The pretended miracles of Mahomet and Haly, were, as Boerhaave obſerves on a ſimilar inſtance, mere trifles to this. If any leader of a ſect, a very few centuries paſt, had been in poſſeſſion of this ſecret, and had performed this miracle in confirmation of his doctrine, the man who had dared to diſbelieve it would have been regarded as a very hardened infidel indeed!

We ſhall here add the deſcription of a new method of imitating artificial fire-works, which appears to be the invention of the ingenious M. Guyot.

To perform theſe recreations to the greateſt advantage, there are three circumſtances to be carefully obſerved: the firſt is, the different colours of the fire: the ſecond, is the manner of cutting out the ſeveral figures, and the third, the direction of the motion of each piece, whether it be ſwift or ſlow, ſtrait or circular.

Arti-

Artificial fireworks may be reduced to four principal colours. The firſt is that of jets of fire, which is of a clear white: the ſecond is that of ſuch jets as are of a yellow or gold colour: the third is that of ſerpents or rockets, which is very bright, and of a light blue caſt *: and the fourth is that of a colour inclining to red, and is commonly uſed in caſcades of fire.

The vivacity of the fire being imitated, by the rays of light that fall upon tranſparent paper †, as we ſhall ſhow hereafter, the paper is to be ſtained with different colours. For the firſt ſort of fire it is left of its natural colour: for the ſecond an infuſion of ſaffron may be uſed, made more or leſs ſtrong: for the third a light tincture of Pruſſian blue: and for the

* There is another ſort of fire of a ſtronger blue, of which cyphers and emblems are formed, and which is placed on the centers of ſuns.

† The paper ſhould be quite thin, and after it is coloured, may be made more tranſparent by being dipped in, or rubbed over with clear oil.

fourth

fourth, a ſmall quantity of carmine may be put in the ſaffron water juſt mentioned.

If among theſe fireworks you would have ſome parts that are tranſparent, and thro' which other parts are to be ſeen, you muſt uſe for the tranſparent parts a paper that is thicker than the other, that the latter may appear with a due degree of ſuperior luſtre: for in theſe exhibitions it is from a juſt mixture of light and ſhade that the moſt pleaſing effects are produced.

RECREATION LI.

To imitate a jet de feu, column, globe, or pyramid of fire.

TAKE a paper that is blacked on both ſides *, and of a proper ſize for the figure you intend to exhibit, for example,

* Inſtead of black, the paper may be coloured on each ſide with a deep blue, which will be ſtill better for ſuch as are to be ſeen through tranſparent papers.

that

that of Fig. 1, or 2. Plate X. In this paper cut out with a penknife ſeveral ſpaces B, beginning from the point A; and with a piercer make a great number of holes, rather long than round, and at no regular diſtance from each other; obſerving, however, that they muſt form right lines from the point A, as is clearly expreſſed in the figures, the parts engraved being thoſe that are to be cut out.

To repreſent revolving pyramids and globes, ſuch as Fig. 3, and 4. the paper muſt be cut through with a penknife, and the ſpace cut out between each ſpiral ſhould be three or four times as wide as the ſpirals themſelves. You muſt obſerve to cut them in the ſame form repreſented in the figures, that the pyramid or globe may appear to turn on its axis. The columns that are repreſented in pieces of architecture, or in jets of fire, muſt be cut in the ſame manner, if they are to be repreſented as turning on their axes.

In like manner may be exhibited a great variety of ornaments, cyphers, and medallions, which when properly coloured cannot fail of producing a moſt pleaſing effect *.

When theſe pieces are drawn on a large ſcale, the architecture or ornaments may be ſhaded; and to repreſent the different ſhades pieces of coloured paper muſt be paſted over each other, which will produce an effect that would not be expected from tranſparent paintings. Five or ſix pieces of paper paſted over each other will be ſufficient to repreſent the ſtrongeſt ſhades.

To give theſe pieces the different motions they require, you muſt firſt conſider the nature of each piece: if, for example, you have cut out the figure of the ſun, as Pl. X. Fig. 5. or of a ſtar as Fig. 6.

* There ſhould not be a very great diverſity of colours, as that would not produce the moſt agreeable appearance.

you muſt conſtruct a wire wheel of the ſame diameter with thoſe pieces, in the manner repreſented in Fig. 7. * over this wheel you paſte a very thin paper, on which is drawn, with thick black ink, the ſpiral figure repreſented by Fig. 8. The wheel thus prepared is to be placed behind the ſun or ſtar, in ſuch manner that its axis may be exactly oppoſite the center of either of thoſe figures. This wheel may be turned by any method you think proper.

Now, the wheel being placed directly behind the ſun, for example, and very near to it, is to be turned regularly round, and ſtrongly illuminated by candles placed behind it. The lines that form the ſpiral will then appear, through the ſpaces cut out from the ſun, to proceed from its center to its circumference, and will re-

* This wheel is made of wire, that its radii, by being ſmall, may not intercept the light that is to be placed behind it.

ſemble ſparks of fire that inceſſantly ſucceed each other. The ſame effect will be produced by the ſtar, or by any other figure where the fire is not to appear as proceeding from the circumference to the center.

Theſe two pieces, as well as thoſe that follow, may be of any ſize, provided you obſerve the proportion between the parts of the figure and the ſpiral, which muſt be wider in large figures than in ſmall. If the ſun, for example, have from ſix to twelve inches diameter, the width of the ſtrokes that form the ſpiral need not be more than one-twentieth part of an inch, and the ſpaces between them, that form the tranſparent parts, about two-tenths of an inch. If the ſun be two feet diameter, the ſtrokes ſhould be one-eighth of an inch, and the ſpace between one quarter of an inch; and if the figure be ſix feet diameter, the ſtrokes ſhould be one quarter of an inch, and the ſpaces five-twelfths of an

an inch. Theſe pieces have a pleaſing effect when repreſented of a ſmall ſize, but the deception is more ſtriking when they are of large dimenſions.

It will be proper to place theſe pieces, when of a ſmall ſize, in a box, quite cloſe on every ſide, that none of the light may be diffuſed in the chamber: for which purpoſe it will be convenient to have a tin door behind the box, to which the candle-ſticks may be ſoldered, and the candles more eaſily lighted.

The ſeveral figures cut out ſhould be placed in frames, that they may be put, alternately, in a groove in the fore part of the box: or there may be two grooves, that the ſecond piece may be put in before the firſt is taken out. The wheel muſt be carefully concealed from the eye of the ſpectator.

Where there is an opportunity of repreſenting theſe artificial fires by a hole made in a partition, they will doubtleſs have a much more ſtriking effect, as the ſpectator cannot then conjecture by what means they are produced.

To repreſent fires that flow from the circumference to the center, as B, B, &c. (Pl. X. Fig. 9.) and at the ſame time others that flow from the center to the circumference, as A, A, &c. you muſt conſtruct the double ſpiral repreſented by the 10th figure of the ſame plate.

When this wheel is placed behind Fig. 9, the concentric ſpirals A, A, Fig. 10. being oppoſite the part A A, Fig. 9. the fire will appear to iſſue from the center, as before: but the parts againſt the excentric ſpiral of the wheel B B, which are thoſe marked B, B, in Fig. 9. will appear

p160.

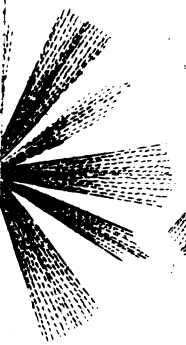


Fig. 6. p 160.

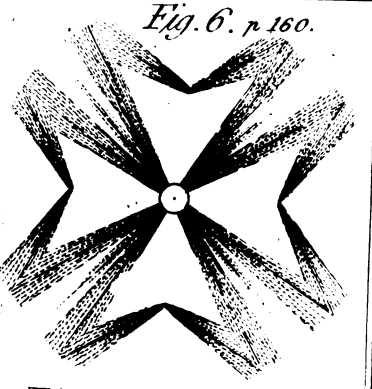


Fig. 9. p 164.

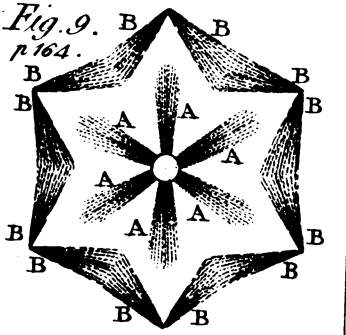


Fig. 7. p161.

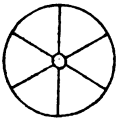


Fig. 10. p 164.

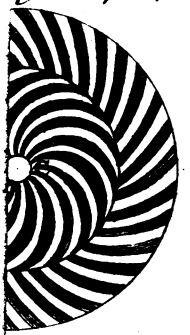
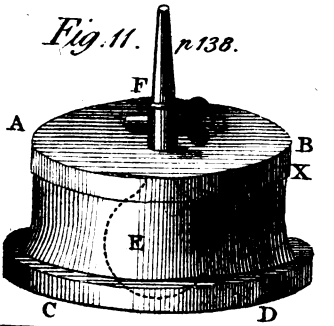


Fig. 11. p 138.



J. Ledge Sculp.

pear to move from the circumference to the center.

It is eaſy to conceive that by extending this method, wheels may be conſtructed with three or four ſpirals, to which may be given different directions, as in Plate XI. Fig. 1. where is drawn, on the tranſparent piece, the ſpirals that are proper to produce, not only jets de feu, but alſo ſmall pyramids, as A, A, &c. which will appear to turn on their centers. It is manifeſt alſo, that on the ſame principle, a great variety of tranſparent figures may be contrived, and which may be all placed before the ſame ſpiral lines.

RECREATION LII.

To repreſent caſcades of fire.

IN cutting out caſcades you muſt take care to preſerve a natural inequality in the parts cut out, as is expreſſed in Plate XI. Fig. 3. for if, to ſave time, you ſhould make all the holes with the ſame pointed tool, the uniformity of the parts will not fail to produce a diſagreeable effect. As theſe caſcades are very pleaſing when well executed, ſo they are highly diſguſtful when imperfect. Theſe are the moſt difficult pieces to cut out.

To produce the apparent motion of theſe caſcades, inſtead of drawing a ſpiral, you muſt have a ſlip of ſtrong paper as ABCD, (Pl. XI. Fig. 2.) of ſuch length as you judge convenient. In this paper there muſt be a great number of holes, near each other, and made with pointed tools of different dimenſions.

At

At each end of the paper a part, of the ſame ſize with the caſcade, muſt be left uncut: and toward thoſe parts the holes muſt be made at a greater diſtance from each other, as is expreſſed in the figure. This paper is to be fixed, by its two extremities, to the two rollers A and B, Fig. 3.

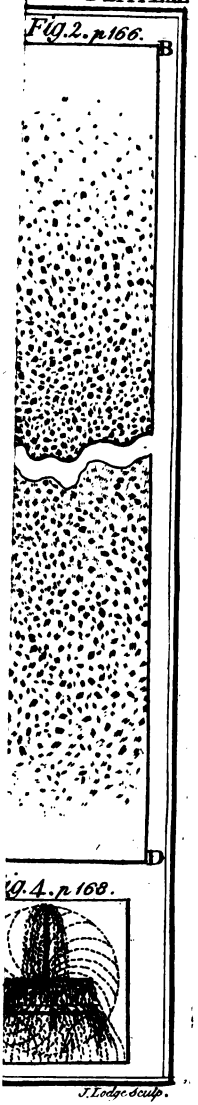
When the caſcade that is cut out is placed before the ſcroll of paper juſt mentioned, and it is entirely wound upon the roller A, the part of the paper that is then between A and B, being quite opaque, no part of the caſcade will be viſible. But as the winch D is turned gently and regularly round, the tranſparent part of the paper proceeding from A to B, will give to the caſcade the appearance of fire that deſcends in the ſame direction; and the illuſion will be ſo ſtrong that the ſpectators will think they ſee a caſcade of fire; eſpecially if the figure be judiciouſly cut out.

A caſcade may be alſo tolerably well executed by a ſpiral, in the manner expreſſed in Fig. 4; but the roller is more eligible. The paper being totally rolled on B, the part between A and B will be quite opaque; therefore the caſcade may be then taken away, and another piece, which repreſents fire that aſcends, as a jet, may be placed in its room: and thus the pieces may be alternately, and continually changed.

RECREATION LIII.

Imitative illuminations.

ON a very ſtrong double paper, whoſe backſide is blacked with ſoot, diſſolved in brandy, and to which a little gum arabic is added, you muſt firſt paint the draught of the illumination you intend to repreſent in miniature, and mark the exact place of the ſeveral lamps and other parts that compoſe it. Then take piercers of different ſizes, with which make holes in



in the papers, in ſuch form as ſhall repreſent the flame of a lamp or other body, If the lamps are ſuppoſed to be all in a line, you muſt uſe the fineſt piercers for the ſmalleſt lamps, and the larger for the greateſt: but if the parts of the illumination be ſuppoſed at different diſtances, then the fine piercers are to be uſed for thoſe parts that are moſt diſtant, and the holes muſt be nearer together, in proportion to the diſtance. If there be objects in front perpendicular to the point of view, you muſt uſe piercers whoſe diameters decreaſe inſenſibly, and make the holes continually cloſer, in proportion as the extremities of the front are more diſtant. It is not material, in this caſe, whether the points be cloſe together: provided the perſpective be obſerved.

When the piece is completely cut out, you place behind this double paper one that is very thin; obſerving to colour the parts that are to appear the moſt diſtant with

with a little carmine diluted in water *. It is then to be placed in a box, and ſtrongly illuminated behind by ſeveral candles or lamps, placed at equal diſtances from each other, that all the parts may be equally illuminated †; for otherwiſe the illuſion will not be complete. The front of the paper ſhould be alſo illuminated with a faint light, ſuch as is juſt ſufficient to ſhow the pieces of architecture that may be painted on it.

After the manner above deſcribed, prints alſo, of every kind, may be cut out, and placed in any optical machine, except ſuch as have an inclined mirror, for there the print being naturally placed in a ho-

* This circumſtance is neceſſary, for the more diſtant natural illuminations are, the more red they appear.

† The candles ſhould be placed not cloſe to the paper, but at five or ſix inches diſtance, and if they do not produce a light ſufficiently ſtrong, you may place more. It will be proper to line the box with tin, as that will reflect the light on the piece.

rizontal

rizontal direction, it will be difficult to illuminate it ſufficiently to produce any remarkable effect. If you are deſirous, however, of making an experiment with a print in a horizontal poſition, inſtead of placing a tranſparent paper behind it, you muſt put one that is gilt, which is to appear through the parts cut out. A print thus prepared, when a ſtrong light is thrown upon it, will repreſent an illumination tolerably well.

APPEN-

APPENDIX.

Several of the Recreations in this Appendix have, in fact, but little relation to experimental philoſophy, eſpecially thoſe that depend on a dexterous manœuvre; but as experiments of this kind are commonly found in books of mathematical recreations, it ſeemed requiſite to inſert ſome of the moſt entertaining among them at the end of this treatiſe.

CHYMICAL TRANSMUTATIONS.

AMONG the moſt pleaſing as well as ſurpriſing phenomena of nature, may be juſtly ranked the tranſmutations produced by chymiſtry, eſpecially thoſe of colours; and recreations of this kind are the more pleaſing, as they are, for the moſt part, eaſily executed.

RECREATION LIV.

Tranſcolourations.

TAKE antimony and grind it to a powder, and it will become black. Let it be calcined with aqua regia, and it will be of a greeniſh yellow; white, red, yellow, greeniſh, and black, when ſublimed with ſal ammoniac; of an uniform red, when freed from its ſalt by water; but white when fixed with thrice its weight of nitre. Thus you have almoſt all the colours in one ſolid body. Mercury diſſolved

ſolved by aqua fortis, and diſtilled in a glaſs retort, affords likewiſe, in different parts of the glaſs, a variety of colours.

To make a gold colour by mixing a limpid liquor with a grey powder: pour hot alcohol on ſulphur melted with fixed alkali, then ground and heated. To change this gold coloured liquor into one of the colour of milk, by pouring it into a clean glaſs; let the glaſs be previouſly rinced with oil of vitriol.

To turn an almoſt limpid liquor blue: pour ſpirit of ſal ammoniac to a ſolution of verdigreaſe in vinegar, and dilute it with water till it be almoſt limpid. To turn that blue liquor pellucid, add acid to it, till the acid predominate.

To turn a very green liquor of a beautiful violet colour: to a high green ſolution of copper in vinegar, drop ſpirit of

of ſal ammoniac, till the alkali predominate.

To turn a blue into a beautiful green. To a rich ſolution of copper in ſpirit of ſal ammoniac, add vinegar, or any other acid, till the acid preponderate.

To produce numerous blues and greens, between a deep blue and a deep green: put a ſtrong and hot ſolution of copper in ſal ammoniac, into a clean cylindrical glaſs, and add thereto, ſlowly, ſpirit of nitre, drop by drop. A different colour, between the two degrees, will appear upon the addition of each drop.

RECREATION LV.

To make a colourleſs liquor black, by pouring it into a clean glaſs.

RINSE a clean hot glaſs in a ſtrong ſolution of the vitriol of iron; then pour into it a warm infuſion of bruiſed white galls in fair water, made ſo weak as ſcarce to afford any colour. This black mixture is inſtantly made. Inſtead of galls you may uſe red roſes, pomegranate bark, or tea, ſage or oak leaves.

RECREATION LVI.

To turn a pellucid liquor black, by adding to it a white powder.

PUT a hot weak pellucid infuſion of galls into a glaſs, throw into it a grain of the vitriol of iron calcined to whiteneſs, and heated: this, as it falls, makes a black cloud, that diffuſes itſelf through

through the tranſparent liquor in a pleaſing manner, and gradually turns it black all round.

The ſame may be done with a pellucid drop: by putting a ſingle drop of the aqueous ſolution of the vitriol of iron into the hot ſolution of galls.

The ſame effect may alſo be produced by the addition of a little yellow or red powder; in the firſt inſtance by uſing vitriol calcined to a yellow colour; and in the other, by the colcothar of vitriol calcined to redneſs. To produce the ſame effect by a drop of gold coloured liquor, uſe the golden tincture made with the red calx of the vitriol of iron, and the dulcified ſpirit of ſalt.

In all theſe experiments, while the liquor is changing from limpid to deep black, there ariſe almoſt innumerable

ſhades, or intermediate degrees of darkneſs, which at laſt all terminate in black.

The black liquor produced in all the preceding caſes, may be rendered pellucid again, by pouring the liquor hot into a glaſs rinſed with the pure oil of vitriol, which attracts the iron. But the black liquor made with the calx of iron remains ſomewhat reddiſh, while it tends to tranſparency.

To make this tranſparent liquor black again, pour to it as much hot oil of tartar per deliquium, as will ſaturate the acid that has attracted the metallic matter. This is attended with an effervescence, which at the ſame time reduces, deſtroys, and regenerates, viciſſitudes of colours, which is beſt perceived by letting the alkaline liquor fall in at ſeveral times, but with a quick motion.

Laſtly,

Laſtly, if a ſufficient quantity of acid be added to the black liquor thus regenerated, ſo as to aboliſh the alkali, the whole will become pellucid again; and thus blackneſs may be reciprocally deſtroyed or reſtored. Hence alſo appears the ſurpriſing power of a metal to produce blackneſs, and how little matter is required to the production of colours.

RECREATION LVII.

To produce different colours by pouring a limpid liquor in a clean glaſs.

TAKE a ſtrong ſolution of mercury made with ſpirit of nitre; dilute it with water, and pour it into a hot glaſs rinſed in a ſtrong ſpirit of ſea ſalt, and it will become coloured. A very dilute ſolution of ſilver, made in ſpirit of nitre poured into a glaſs prepared in the manner juſt mentioned, or the oil of antimony poured into a glaſs rinſed in hot water, will have the ſame effect.

To produce an orange colour, pour hot water upon new made crocus metallorum, and put it into a clean glaſs rinſed with any acid.

RECREATION LVIII.

The colour that appears and diſappears by the influence of the air.

PUT into a decanter volatile ſpirit in which you have diſſolved copper filings, and you will have a fine blue tincture. If the bottle be ſtopped the colour will preſently diſappear, but when it is unſtopped the colour will ſoon return: and this experiment may be repeated a great number of times.

SYMPA-

SYMPATHETIC INKS.

BY ſympathetic inks is meant thoſe ſorts of liquors with which any characters being wrote they remain inviſible, till ſome method is uſed to give them a colour. Theſe liquors are divided into five claſſes, and that with reſpect to the means uſed to make them viſible.

The firſt claſs of theſe inks are ſuch as become viſible by paſſing another liquor over them, or by expoſing them to the vapour of that liquor.

The ſecond are thoſe that do not appear ſo long as they are kept cloſe, but become ſoon viſible on being expoſed to the air.

The third are ſuch as are made apparent by ſtrewing or ſifting ſome very fine powder, of any colour, over them.

The fourth are thoſe that will not be viſible till they have been expoſed to the fire, or heated.

The fifth, like the fourth, appear by heat, but diſappear again when the paper becomes cold, or has had a ſufficient time to imbibe the moiſture of the air.

The compoſitions of the firſt claſs of theſe inks.

Impregnation of Saturn.

Put litharge of lead into ſtrong diſtilled vinegar, and let it ſtand for twenty-four hours. Then ſtrain it off, and let it remain till quite ſettled. Preſerve this liquor in a bottle.

Diſſolve orpiment in water of quick lime *, either by a ſand heat, or by ſetting

* Put in a pint bottle two ounces of quick lime, one ounce of orpiment in powder, and as much water as will riſe two or three fingers above them. When the diſſolution is made, pour the liquor gently off.

the

the bottle in the ſun for two or three days, obſerving to turn it five or ſix times each day *.

In preparing theſe liquors you muſt take care that they have no communication; for the vapour of the latter is ſufficient to deſtroy the limpidity of the other, and thereby render it unfit for uſe.

When the letters wrote by the firſt liquor are expoſed to the vapour of the ſecond, they become preſently viſible. If you would have them diſappear again, you muſt draw a ſponge, or pencil, dipped in aqua fortis, or ſpirit of nitre, over them. If after this you would have them appear again, let the paper be quite dry by the air, and then paſs the vivifying liquor, that is, the diſſolution of orpiment, over them again.

* The vapour of this liquor ſhould be kept from the mouth, as it is highly pernicious.

Another

Another ink of this claſs.

Diſſolve biſmuth in the nitrous acid. The letters wrote with this ink will become quite black by being expoſed to the vapour of the liver of ſulphur, which is of ſo penetrating a nature that it will act upon the ink through a quire of paper, or even the ſlight partition of a room.

Sympathetic gold ink.

Put as much gold into a ſmall quantity of aqua regia as it will diſſolve, and then dilute it with two or three times as much diſtilled water.

Diſſolve, in a ſeparate veſſel, fine pewter in aqua regia, and when it is well ſaturated, add to it an equal quantity of diſtilled water.

Let the characters you write with the diſſolution of gold become quite dry, in the ſhade,

ſhade, and they will not appear for the firſt ſeven or eight hours. Dip a pencil, or ſmall fine ſponge, in the diſſolution of pewter, and drawing it lightly over the inviſible characters, they will preſently appear of a purple colour.

The extraordinary effect of this ſympathetic ink is an exception to the general chymical principles, for we here ſee two metallic ſubſtances change their colour by mixture, without any apparent fermentation.

The purple colour of the letters may be effaced, by wetting them with aqua regia; and it may be produced a ſecond time by paſſing the diſſolution of pewter over them again. This diſſolution of gold in aqua regia, as well as that of ſilver in the nitrous acid, being diluted by a ſufficient quantity of water, will likewiſe ſerve to write letters that will diſappear when they become dry, if they be carefully kept from

from the open air; but will be viſible after being expoſed an hour or two to the ſun or the fire.

Another ſympathetic ink.

Diſſolve green vitriol in common water, and add a ſmall quantity of nitrous acid, to prevent that yellowiſh precipitation that will otherwiſe be formed. The characters wrote in this diſſolution with a new pen will be inviſible.

Infuſe in water, or white wine, ſmall Aleppo galls, lightly bruiſed *. At the end of two or three days pour the infuſion cleanly off. By drawing a pencil dipped in this infuſion over the letters wrote with the laſt diſſolution, they will appear of a beautiful black, eſpecially if the infuſion be ſtrong.

* You may put three-fourths of a pint of water or wine to two ounces of galls.

The

The letters wrote with the laſt diſſolution will become a fine blue, if they be wetted with water ſaturated with Pruſſian blue: and letters wrote with this water, which will be inviſible, will likewiſe turn to a fine blue, by being wetted with the above diſſolution.

RECREATION LIX.

The book of fate.

MAKE a book of ſeventy or eighty leaves, and in the cover at the end of it let there be a caſe, which opens next the binding, that it may not be perceived.

At the top of each right hand page write any queſtion you pleaſe, and at the beginning of the book let there be a table of all thoſe queſtions, with the number of the page where each is contained. Then write with common ink, on ſeparate papers, each about half the ſize of the pages in the

the book, the ſame queſtions that are in the book, and under each of them write, with the ink made of the impregnation of ſaturn, or the diſſolution of biſmuth, the anſwer.

Soak a double paper in the vivifying ink made of quick lime and orpiment, or the phlogiſton of the liver of ſulphur, and place it, juſt before you make the experiment, in the caſe that is in the cover of the book.

Then deliver ſome of the papers on which the queſtions are wrote to the company, and after they have choſe ſuch as they would have anſwered, they put them in thoſe leaves where the ſame queſtions are contained, and ſhutting the book for a few minutes, the ſulphureous ſpirit with which the paper in the cover of the book is imbibed, will penetrate the leaves, and make the anſwers viſible, which will be of a brown colour, and more or leſs deep in

in proportion to the time the book has been closed *.

RECREATION LX.

The marvellous portrait.

MAKE a box about four inches long, and three wide, as A B C D, (Plate XII. Fig. 5.) and quite shallow. Let it shut with hinges and fasten with a hook; and let it have two bottoms, the lowest of wood, that draws out by a groove, and the uppermost of pasteboard. Between these two bottoms is to be placed a paper dipped in the vivifying ink mentioned in the last Recreation. Let there be also a board of the same size with the inside of the box, which being placed in it may press a paper against the pasteboard bottom.

Then take several pieces of paper, of the same size with the inside of the box,

* If a weight be placed upon the book the effect will be the sooner produced. Or you may put the book in a box that will press it close down.

and

and draw on them the figures of men and women, in different attitudes and employments, as walking, riding, reading, writing, &c. Theſe figures muſt be drawn with a new pen or pencil, dipped in the impregnation of ſaturn.

Being thus provided, and having privately placed the paper dipped in the vivifying ink between the two bottoms, you tell a perſon you will ſhow him what an abſent friend of his is doing at the preſent hour. You then give him the paper adapted to the employment you intend, and tell him to write his friend's name at the bottom, that you may not change the paper. Then placing that paper next the paſteboard bottom, and putting the piece of wood over it, you ſhut the box. After amuſing him with diſcourſe for three or four minutes, you take out the paper, when he will ſee his friend in the employment you have aſſigned him.

RECRE-

RECREATION LXI.

The artificial hand.

LET a workman make a hand of wood, as in Plate XII. Fig. 6. fixed at the end next the elbow to the piece E, the ends of which go through the ſcrews C D and E F. The fore and middle fingers, and the thumb, are to be moveable at their joints. There muſt go a wire through the arm, that is fixed at one end to the fore finger, and at the other to the piece E, round which it is to move: under the two joints of the two fingers are alſo placed two ſmall ſprings, which are to raiſe it up.

To the fore finger and thumb fix two ſmall rings, through which a pen may be put, ſo as not to impede their motion. Under the arm, at the point I, place a ſmall braſs roller, which ſerves to ſuſtain the arm.

The pedeſtal on which this hand is placed muſt be at leaſt a foot long, if the hand be of the natural ſize, and about eight inches wide. This pedeſtal muſt be hollow, and at the part ST there muſt be an opening about three inches long and two inches wide; the whole pedeſtal may be covered with a thin ſtuff, by which the hole will be concealed. There is to be a valve, or ſort of trap-door, on the inſide of the pedeſtal, which is to faſten againſt the opening.

Over the hand and pedeſtal place a glaſs frame, as in the figure: cover the hand with fine leather of fleſh colour, and decorate the arm with a ruffle and cuff, which will entirely conceal the machinery.

Then take a number of cards and write on them different queſtions, and on the ſame number of papers write, with the impregnation of ſaturn, the anſwers. Give the cards to any one, and let him chooſe a queſtion, and you place the paper with the

the anſwer under the pen in the hand, letting him firſt ſee there is no writing on it *. Now the pedeſtal being placed againſt a partition, the end F is to go thro' it. Therefore an aſſiſtant, upon a ſignal given, turns a handle fixed to F, and as piece E turns round the wires that move the fingers and thumb are alternately lengthened and ſhortened, by which their joints are kept in continual motion; and the ſcrew at the ſame time turning gently from F towards G, gives the whole arm a motion which very much reſembles that of nature †.

* The paper dipped in the vivifying liquor is to be previouſly placed againſt the opening in the table, and ſupported by the trap door.

† This might be performed without an aſſiſtant, by means of a trigger placed in the leg of the table, and communicating with the handles, which the operator might thruſt down with his foot. Where expence is not regarded, there may be a complete figure of a man in wood, or plaiſter of Paris, ſeated by the table.

The hand and pen ſerve here merely to aſſiſt the illuſion: but if a bit of ſponge, dipped in the vivifying ink, be placed at the end of the pen, as it goes over the writing on the paper, it will make it become gradually viſible, and in this caſe the trap door and dipped paper may be omitted *.

Sympathetic inks of the ſecond claſs.

The ſympathetic ink of gold, of which we have already given the compoſition, is alſo of this claſs; for without paſſing the diſſolution of copper over it, when it is only expoſed to the air an hour or two it becomes by degrees of a deep violet colour, that nearly approaches black.

* You may alſo have a glaſs ink-ſtand, with ſome of the vivifying liquor, into which the pen may be dipped, and it will then appear to write with common ink. The ſpectators ſhould not be permitted to come very near this machine, which may be applied to ſeveral other purpoſes.

But

But if instead of exposing it to the air, you keep the paper on which it is wrote in a box shut close, or wrapt up in another paper, it will remain invisible for three or four months, but after that time it will become of a deep violet colour *.

Sympathetic silver ink.

Dissolve fine silver in aqua fortis, and after the dissolution add some distilled water, in the same manner as in the gold ink. What is wrote with this ink will remain invisible for three or four months, if it be kept quite close from the air, but will appear in an hour if exposed to the sun, and will be of a grey colour, like that of a slate.

Under this second class of sympathetics, may be also included several other dissolutions of metals, such as lead by vinegar,

* If in writing it make yellow spots on the paper, you must add to it a little common water.

copper by aqua fortis, which gives the colour of tan on the paper; pewter by aqua regia; emery and certain pyrites, in ſpirit of ſalt; mercury in aqua fortis; or iron by vinegar. Each of theſe diſſolutions expoſed to the air have a particular colour; but they have the diſagreeable quality of rotting the paper, ſo that after a certain time the characters appear like holes, in the ſame manner as if they had been cut out; they are therefore fit only for extempore recreations.

RECREATION LXII.

The writing againſt the wall.

TAKE ſeveral pieces of paper, of a ſize that you can put in any book that will go into your pocket, and write at the top of each of them a queſtion, with common ink, and under it write the anſwer with the gold or ſilver ink juſt mentioned. Give any one of theſe papers, cloſely wrapt up,

up, to a perſon, and tell him to place it againſt the wall of his chamber, and keeping the door locked he will next day find the anſwer wrote on it.

As the gold ink will ſometimes give a yellow caſt to the paper, you may previouſly give a ſlight tincture of that kind to the papers you uſe for this purpoſe.

RECREATION LXIII.

The taliſman.

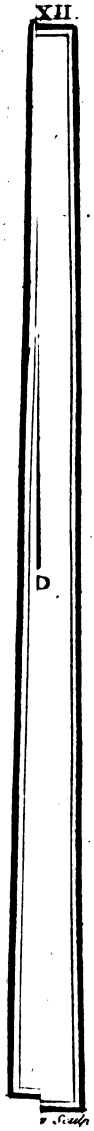
MAKE a little triangular box, (Plate XII. Fig. 7.) each ſide of which is to be about five inches, and let its inſide be divided into three parts. The firſt part A, which makes the bottom of the box, is to be covered by the ſecond part B, in form of a caſe, and let the top C, exactly cover the part B; as is expreſſed in the figure and the profiles.

Upon the bottom of the box let there be a plate of copper, about one twentieth of an inch thick, on which let there be a number of hieroglyphic characters, contiguous to each other, and cut in different ſorts of metal.

On the top of the cover place a knob O, that goes through it, and to which the copper triangle Q is to be fixed occaſionally, in ſuch manner as it may go into the caſe B. There muſt be a ſpace of one quarter of an inch between the triangle Q, and the bottom of the caſe B; into which another plate of copper, of that thickneſs, may be placed.

The outſide of this taliſman may be decorated with uncommon figures or characters, to give it the appearance of greater myſtery.

On ſeveral pieces of paper, of the ſame ſize with the inſide of the taliſman, write dif-



different queſtions, in common ink, and write the anſwers in thoſe different ſorts of ſympathetic ink, that appear when heated, obſerving that each word of the anſwer is to be wrote in a different ink *.

Having properly heated the triangle, and placed it under the cover, you introduce the taliſman, and tell any one of the company to chooſe one of the papers on which the queſtions are wrote, and place it in the taliſman, and he will immediately have an anſwer wrote on that paper, the words of which will be of different colours, according to the different metals of which the taliſman is compoſed. The paper being placed in the taliſman, and the cover placed over it, the heat of the triangle will make the anſwer viſible in a few moments. This Recreation may be repeated if the triangle be made ſuffici-

* The inks proper for this purpoſe will be deſcribed further on.

ently

ently hot; and two papers may be placed in the taliſman at the ſame time.

This Recreation, when well executed, occaſions a ſurpriſe that cannot be conceived by a mere deſcription.

RECREATION LXIV.

The ſibyls.

MAKE a wooden pedeſtal AB, (Pl. XIII. Fig. 1.) about ten inches long, eight wide, and one deep: and at one end erect a box C, about ten inches high, eight broad, and two and a half deep.

The top of the pedeſtal muſt ſlide in a groove, on which inſcribe a dial M, of ſix inches diameter; and which is to be divided into nineteen equal parts in; twelve of which write the names of the months, and mark the reſpective ſigns of the zodiac, and in the ſeven other diviſions, which

muſt be next the end B, write the days of the week, and mark the figures of the planets. Next the inner circle NO, make an opening into the box of about one-tenth of an inch. On the center of the dial place an index that turns freely on its center.

Within the pedeſtal place a pulley P, about four inches diameter, which is to turn on an axis that is directly under the center of the dial, and on the upper part of that axis fix a bent index R, which comes out at the opening made by the inner circle *, and paſſes over thoſe ſeven diviſions only, on which are wrote the days of the week.

Within the box C, let there be two rollers S and T, as in the figure: let that of S contain a ſpring, and at the end of T let there be a pulley V of three quarters of an inch diameter, round which goes a ſtring

* If the axis be made to paſs through the top of the pedeſtal, this opening will not be neceſſary.

or

or thread that paſſes under the ſmall pulley X, and is faſtened to that of P: ſo that when the laſt pulley makes about one-third of a turn, that of V may make three or four turns.

There muſt alſo be a ſcroll of paper, about two feet long, and each end of which muſt be paſted to one of the rollers. In the front of the box, between the two rollers, make an aperture D, about four inches long, and one inch and a half wide: to this opening let there be a little flap or ſlider, by which it may be cloſed at pleaſure.

The apparatus being thus diſpoſed, place the index R ſucceſſively againſt each of the diviſions marked with one of the planets, and as the paper is gradually wound up the roller, mark againſt that part which is at the aperture D, the name of one of the following ſibyls.

The

The Helleſpontian
Cumean
Artemiſian
Phrygian
Albunean
Perſian
Lybian
} ſibyl.

On each of the ſeven cards write a different queſtion, and draw one of the ſeven planets. Next, take a memorandum-book, that contains ſeven leaves, and on each of them write the name of one of the foregoing ſibyls; in each of the leaves place ſeveral pieces of paper, and on each of them write, with the ſympathetic ink that does not appear till the paper is heated, different anſwers to the ſame queſtion.

Then give a perſon the ſeven cards on which the queſtions are wrote, and tell him to chooſe one of them privately, and conceal the reſt, ſo that it cannot poſſibly be known which of them he has choſe. Next,

Next, tell him to place the index that points to the month againſt that in which he was born *, and to place the index of the planets againſt that which is on the card he has choſe, and which is to preſide over the anſwer: you tell him to do this privately, that no one may ſee him, and after that to cover the dial with his handkerchief. Then let him open the door that is before the aperture in the box, and tell you the name of the ſibyl there viſible.

You then open the memorandum-book, and taking out the papers that are in the leaf where the name of the ſibyl juſt mentioned is wrote, you deſire him to chooſe any one of them he thinks proper. The taliſman uſed in the laſt Recreation being properly heated, is then to be introduced, when you direct the perſon to put the

* Theſe months and the index are of no other uſe than to give the experiment an air of greater myſtery.

blank

blank paper into it, and taking it out a few moments after, he will find the anſwer to his queſtion.

To make this operation appear the more extraordinary, it will be proper to have a ſmall preſs or cupboard, at the back of which there is a door that opens into an adjoining room, by which mean an aſſiſtant having prepared the taliſman may place it in the cupboard the moment before it is wanted. This contrivance will be uſeful on many other occaſions.

RECREATION LXV.

The magic urn.

PROVIDE an urn of wood or metal, about ſix inches high and two and a half diameter in the wideſt part, and of ſuch figure in other reſpects as you think proper (ſee Pl. XIII. Fig. 2). Let there be a cylinder of copper C, Fig. 3. of about one-eighth of an inch diameter, which is

to

to fill a hole AB, made in the urn. The top of this cylinder is to be in the top of the urn, ſo that it may be eaſily taken out. To this urn there muſt be a cover D, which fits it exactly.

On a ſmall ſquare piece of paper draw the figure of a flower or leaf, with that ſort of ſympathetic ink whoſe colour moſt reſembles it. You then preſent ſeveral ſorts of flowers or leaves to a perſon, and deſire him to chooſe any one of them. Then put that flower on a chafingdiſh of hot coals, and taking the paper on which it is ſecretly drawn, you give it to the perſon to examine, and then put it in the urn, having previouſly heated the cylinder *. Then taking ſome of the aſhes of the burnt flower, you ſtrew them over the paper, after which you take it out and ſhew the company the figure of that flower. While the flower is burning you

* There are ſome ſorts of ſympathetic inks that require much more heat than others.

may

may ſprinkle ſome powder over it, ſuppoſe that of ſaltpetre, and by that, mixed with the aſhes of the flower, the company may imagine the effect is produced.

The preſs or cupboard mentioned in the laſt Recreation will be here very convenient for heating the cylinder and placing it in the urn. A ſimilar Recreation may be performed by putting the paper in a copper veſſel, that may be placed on an iron plate over the chafingdiſh in which the flower is burnt. But this method has not ſo myſterious an appearance as the other, and in ſome perſons may cauſe a ſuſpicion that the effect is produced by heat.

Other ſympathetic inks.

Beſide thoſe mentioned in the beginning of this article there are ſeveral other inks which appear very lively when a

coloured liquor is paſſed lightly over them, of which the following are the moſt material.

A yellow ſympathetic ink is made by ſteeping the flowers of the marygolds ſeven or eight days, or more, in clear diſtilled vinegar, and then preſſing them out. The liquor is to be kept in a bottle well corked. If you would have it ſtill more limpid, add, at the time of uſing it, ſome clear water.

For a red inviſible ink; to the pure ſpirit of vitriol or that of nitre, add eight or ten times as much water, as you would have it more or leſs red.

For a green ink of this ſort, diſſolve ſalt of tartar, the cleareſt and drieſt you can procure, in a ſufficient quantity of river water.

For

For a violet ſympathetic ink, expreſs the juice of lemons, and keep it in a bottle well corked.

All that is wrote on paper, or any white body, ſuch as ſilk, cloth, &c. when dipped in one of theſe inks will appear of the colour above expreſſed, after it has been dipped in the following liquor. Take a ſufficient quantity of the flowers of pancy, or of the common violet, and bruiſe them in a mortar, adding ſome water to them; and ſtraining the liquor through a cloth, keep it in a bottle, or take water in which turnſole has been ſteeped.

RECREATION LXVI.

The revivified bouquets.

PROVIDE a number of artificial flowers, ſuch as roſes, jonquils, pinks, or any other you find convenient. Theſe flowers muſt be made of white thread or ſilk, and their leaves of parchment. Dip the roſes in the red ſympathetic ink, the jonquils in the yellow, the pinks in the violet, and their leaves in the green ink. When they are all dry form them into ſmall bouquets, which will all appear white, and may be uſed in this Recreation, either the day they are dipped, or ſeveral days after.

You take one of theſe bouquets, and after ſhowing the company that every part of it is white, you dip it in the vivifying liquor made of violets, juſt deſcribed, and

and drawing it preſently out, all the flowers and leaves will appear in their natural colours *.

RECREATION LXVII.

The tranſcolorated writing.

WRITE on a paper, with the violet liquor, as many letters or words as you pleaſe; and aſk any perſon whether he will have that writing turn to yellow, green, or red.

Have a ſponge with three ſides that you can readily diſtinguiſh, and dip each of its ſides in one of the three ſympathetic inks. Draw the ſide of the ſponge that correſponds to the colour the perſon has

* The vivifying liquor ſhould be put in a ſort of jar, with a narrow neck, that it may not be ſeen by the company; and you ſhould draw the flowers gently out, that the liquor may drop, if thin, and they may have time to acquire their colours.

choſe, over the writing once only; and it will directly change to the colour required *.

Sympathetic inks of the third claſs.

Theſe, as we have ſaid, are ſuch as become viſible by having any fine powder ſtrewed over them, and may be compoſed of the glutinous and colourleſs juice of any vegetable, the milk of animals, and many other ſubſtances.

RECREATION LXVIII.

Magical vegetations.

ON different papers draw the figures of ſeveral leaves or flowers with one of the colourleſs juices above mentioned: then take one of the correſponding leaves or flowers, and laying it on an iron plate, over a chafingdiſh of hot coals, let it burn

* The ſponge ſhould be well cleaned immediately after the experiment.

to

to aſhes. Put theſe aſhes into a ſieve, in which there is ſome very fine ſteel filings, and ſift them over the paper on which the flower is drawn, when they will adhere to the glutinous liquor, and form an exact repreſentation of the figure of the leaf or flower.

Sympathetic inks of the fourth claſs.

This claſs, comprehending all thoſe that become viſible by being expoſed to the fire; is very extenſive, as it contains all thoſe infuſions and diſſolutions, in which the matter diſſolved is capable of being reduced into a ſort of charcoal by a ſmall heat. A few examples of theſe inks will here ſuffice, and the rather, as moſt of thoſe of the firſt claſs which appear on being expoſed to the air, are of this claſs likewiſe.

Theſe inks may be made by a ſtrong diſſolution of vitriol in common water, or

of the juice of lemons or onions; the two latter requiring leſs heating than the firſt, but they will not keep ſo long.

RECREATION LXIX.

The tranſmutable cards.

IN a common pack of cards, let the ace of hearts and nine of ſpades be ſomething larger than the reſt. With the juice of lemon draw over the ace of hearts a ſpade, large enough to cover it entirely, and on each ſide draw four other ſpades.

Preſent the pack to two perſons, ſo adroitly, that one of them ſhall draw the ace of hearts and the other the nine of ſpades, and tell him who draws the latter, to burn it on a chafingdiſh. You then take the aſhes of that card, and put them into a ſmall metal box, and give it to him who has the ace of hearts, that he may himſelf put that card into the box and faſten it. Then put the box for a ſhort time

time on the chafingdiſh, and let the perſon who put the card in it, take it off and take out the card, which he will ſee is turned to the nine of ſpades *.

RECREATION LXX.

The convertible cards.

TO perform this Recreation you muſt obſerve that there are ſeveral letters which may be changed into others, without any appearance of the alteration; as the *a* into *d*, the *c* into *a*, *e*, *d*, *g*, *o*, or *q*, the *i* into *b*, *d*, or *l*, the *l* into *t*, the *o* into *a*, *d*, *g*, or *q*, the *v* into *y*, &c.

Take a parcel of cards, ſuppoſe 20, and on one of them write, with the ink of the fourth claſs the word *law* †, and on

* In making this experiment the chafingdiſh ſhould not be brought into the room till the two cards are drawn, that if the parties ſhould not draw thoſe cards you may exhibit ſome other recreation.

† Theſe letters ſhould not be joined.

the

the other, with the ſame ink, the words *old woman*; then holding them to the fire they will both become viſible. Now you will obſerve that by altering the *a* in the word *law* into *d*, and adding *o* before the *l*, and *oman* after the *w*, it becomes *old woman*. Therefore you make thoſe alterations with the inviſible ink, and let it remain ſo. On the reſt of the cards you write any words you think fit.

Preſent the cards in ſuch manner to two perſons, that one of them ſhall draw the word *law*, and the other the words *old woman*. You then tell the perſon who drew the word *law*, that it ſhall diſappear, and and the words on the other card ſhall be wrote in its place: and that you may not change the cards, deſire each of the parties to write his name on his card. Then putting the cards together, and holding them before the fire, as if to dry the names juſt wrote, the word *law* will preſently change into *old woman*.

This

This Recreation may be varied by fixing on a word that may be changed into three other words, and making four perſons draw the cards on which thoſe words are wrote; and it may be further diverſified by chooſing three ſuch words, as that the firſt can be changed into the ſecond, and the ſecond into the third. You then tell him who drew the firſt word, that it ſhall be changed into that drawn by the ſecond perſon; and him you tell, that his word ſhall be changed into that of the third perſon.

RECREATION LXXI.

The oracular letters.

WRITE on ſeveral ſlips of paper different queſtions, and ſuch as may be anſwered by the name of ſome perſon; for example, Who is the merrieſt man in the company? Anſwer, Mr. ***. To whom will Miſs *** be married? Anſwer,

ſwer, To Mr. * * *. Theſe queſtions are to be wrote in the ſympathetic ink of this claſs, and expoſed to the fire, and the anſwers wrote in the ſame ink, and left inviſible. The papers are to be folded in form of letters, and in ſuch manner that the part where the name is wrote ſhall be directly under the ſeal, and the heat of the wax will make it viſible. Then give the letter to the perſon who requires the anſwer, and he will find it plainly wrote,

A recreation ſimilar to this may be made with a number of blank cards, on each of which an ace of ſpades is drawn with the inviſible ink; then let a perſon chooſe any one of them, and encloſe it in a letter caſe, prepared in ſuch manner that the figure of the ace ſhall be directly under the ſeal, and on opening the letter it will be immediately viſible.

Sympa-

Sympathetic inks of the fifth claſs.

The green ink.

Take zaffre in powder, and let it remain for diſſolution in aqua regia during twenty-four hours. Pour the liquor off clear, and add to it as much or more common water, and keep it in a bottle well corked.

This ink will not be viſible till it has been expoſed to the fire, or to the ſtrong rays of the ſun. The characters will then be of a lively green. It is the peculiar property of this ink, that as ſoon as the paper becomes cold again the letters diſappear, and this alternate appearance and diſappearance may be repeated a great number of times, provided that by too great heat the letters never acquire the colour

lour of fillemot, for after that they will never diſappear *.

RECREATION LXXII.

The incomprehenſible writing.

HAVE a box that is divided into three parts, after the ſame manner as the taliſman in the 63d Recreation, except that inſtead of being triangular, it muſt be of a long ſquare (ſee Pl. XIII. Fig. 4.) Divide its top B into two equal parts D and E, as in Fig. 5. and to the part D adjuſt a plate of copper L, about one quarter of an inch thick, and under both the plate L and the opening E, place a cloth. The upper part C muſt have a button by which it may be fixed on the

* This ink may be alſo made of cobalt, in the manner deſcribed by M. Hellot, in the Memoires de l'Academie des Sciences for 1737; but that method is far more embarraſſing to ſuch as are not uſed to chemical operations.

cover

cover B, ſo as to appear of one piece with it.

At the bottom of the box place a piece of cloth, or other ſtuff, on which you may ſtamp certain myſterious characters, and obſerve that the bottom of the cover muſt reſt upon this cloth.

Then provide a ſlip of paper G H, Fig. 6. of the ſame ſize with the bottom of the box, and at each end of it write, with the green ſympathetic ink, the name of a different card, and make ſome private mark, by which you can tell at which end each name is wrote *.

Take a parcel of cards, and offer thoſe two of them whoſe names are wrote on the paper to the two perſons, that they

* That there may be no ſuſpicion of the papers being prepared, you may cut it from a whole ſheet, before the company, having previouſly wrote the names.

may

may draw them. You tell the parties to keep their cards to themſelves, and you propoſe to make the names of thoſe cards appear upon a ſlip of paper, which you put into the box. You then aſk which name of the two cards ſhall appear firſt. The copper plate being previouſly heated and placed in the cover, you put it over that end of the paper on which is the name required, and it will preſently appear. Then taking the paper out and ſhowing the name wrote, you put it in again, turning the other end to the ſide of the box where the plate is, and it will in like manner become viſible.

The firſt name may be made to diſappear at the ſame time that the ſecond appears, if the cloth at the end oppoſite to that where the plate is, be made damp.

RECRE-

RECREATION LXXIII.

Winter changed to ſpring.

TAKE a print that repreſents winter, and trace over the proper parts of the trees, plants, and ground with the green ſympathetic ink; obſerving to make ſome parts deeper than others, according to their diſtance. When thoſe parts are dry, paint the other objects with their natural colours. Then put the print in a frame with a glaſs, and cover the back of it with a paper that is paſted over its border only.

When this print is expoſed to the heat of a moderate fire, or to the warm rays of the ſun, all the graſs and foliage will turn to a pleaſing green, and if a yellow tint be given to ſome parts of the print, before the ſympathetic ink be drawn over it, this green will be of different ſhades; and the ſcene that a minute before repre-

ſented winter, will now be changed to ſpring. When this print is placed in the cold, winter will again appear, and will again be driven away by the warm rays of the ſun. This alternate change of ſeaſons may be repeated as often as you pleaſe; remembering, however, as was before obſerved, not to make the print at any time too hot, for then a faded autumn will for ever remain.

Sympathetic ink that appears by being wetted with water.

Mix alum with a ſufficient quantity of lemon juice. The letters wrote with this mixture will be inviſible till they are wetted with water, and then will appear of a greyiſh colour and tranſparent.

Or you may write with a ſtrong diſſolution of rock alum only, and when the writing is dry, pour a ſmall quantity of water over it, and it will appear of a white,

white, like that of the paper before it was wetted.

All ſaline liquors, ſuch as vitriolic, nitreous, and marine acids, diluted with water; the liquor of fixed vegetable alkalis, and even vinegar, will produce the ſame effect.

When the paper is ſtrong and contains a ſufficient quantity of ſize, and the ſaline liquors are properly diluted, as, for example, when one ounce of aqua fortis is mixed with three or four ounces of water, the writing will dry well, become abſolutely inviſible, and not run out of its form when the paper is wetted. As the paper dries it will become again inviſible, and may be made to appear and diſappear many times.

This ſort of ink is very convenient, as it may be eaſily prepared with many ſubſtances that are readily procured, and

as it does not require heating, nor the assistance of any other liquor, except common water *.

RECREATION LXXIV.

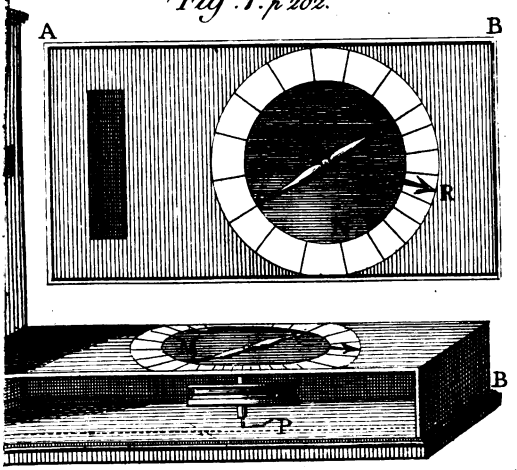
The oracular mirror.

PROVIDE a square or round mirror, of about three inches diameter, and whose frame is an inch wide, as in Plate XIII, Fig. 7. Line the under part of the frame, in which holes are to be cut, with very thin glass: behind this glass let the mirror ABCD, of about two inches diameter, be placed, which is to be moveable, so that by inclining the frame to either side, part of the mirror will be visible, behind the glass, on that side.

* They who would amuse themselves further with these matters, may consult a treatise wrote expressly on the subject, by that bright luminary in the British hemisphere of science, the sagacious Boyle.

Then

Fig. 1. p 202.



p 207.

Fig. 3. p 207.

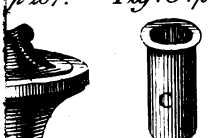


Fig. 7. p 228.

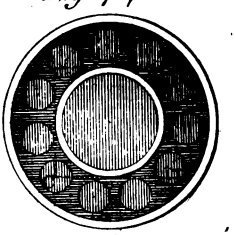


Fig. 6. p 223.

5. p 222.

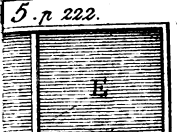
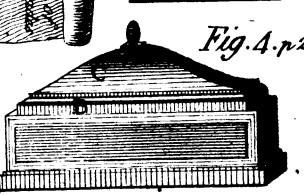


Fig. 4. p 222.



Then take Spaniſh chalk, or Cyprus vitriol, of which you make a pencil, and with this you may write on a glaſs and rub it off with a cloth, and by breathing on the glaſs the writing will appear and diſappear ſeveral times. With this pencil write on one ſide of the mirror, before it is put in the frame, the word *yes*, and on the other ſide, *no*; and wipe them off with a cloth.

You propoſe to a perſon to aſk any queſtion of this mirror that can be anſwered by the words *yes* or *no*. Then turning the glaſs to one ſide, and putting your mouth cloſe to it, as if to repeat the queſtion ſoftly, you breathe on it, and the word *yes* or *no* will immediately appear. This mirror will ſerve for many other agreeable amuſements.

RECREATION LXXV.

The tree of Diana.

TAKE half an ounce of fine silver, either in filings or cut small, and two drams of mercury, and dissolve them in three or four ounces of aqua fortis. When the dissolution is perfectly made, pour it into a pint of common water, and stir it about, that the whole may be well mixed. Keep this preparation in a bottle well corked.

In a small phial put the quantity of a pea, of the amalgam of silver with mercury, and pour an ounce of the above liquor over it. There will presently rise from that little globular amalgam small branches, that by increasing will form a kind of shrub or bushy tree, of a silver colour.

Another

Another way of producing this appearance is by diſſolving an ounce of fine ſilver in three ounces of ſtrong aqua fortis, in a glaſs or earthen veſſel. When the ſilver is quite diſſolved, pour the aqua fortis into another glaſs veſſel, wide at the bottom, with ſeven or eight ounces of mercury, and add one quart of common water: to the whole add your diſſolved ſilver, and let it remain untouched.

In a few days the mercury will appear to be covered with a multitude of little branches, reſembling ſlender ſhrubs, and of a ſilver colour. This appearance will continually increaſe for a month or two, and will remain after the mercury is entirely diſſolved *.

* It was, very likely, ſome experiment like this, together with a deception ſimilar to that uſed in a foregoing Recreation, that gave riſe to the pretended experiment of producing a tree or flower from its aſhes, which many have thought poſſible, and for the performing of which Paracelſus and Kircher have each of them given a regular proceſs, which ſerves only to ſhow what low arts and effrontery, have been practiſed by men of letters in ignorant ages.

RECREATIONS

OF

ADDRESS

AND

DEXTERITY.

RECREATIONS WITH THE CARDS *.

Previous to these recreations with the cards, it will be necessary to explain the method of *making the pass*; that is, bringing a certain number of cards from the bottom of the pack to the top; as many of these recreations depend on that manœuvre.

HOLD the pack of cards in your right hand, so that the palm of your hand may be under the cards: place the thumb of that hand on one side of the pack, the first, second, and third fingers on the other side, and your little finger between those cards that are to be brought to the top, and the rest of the pack. Then place your left hand over the cards, in such manner, that the thumb may be at C, (Pl. XIV. Fig. 1, and 2.) the fore finger at A, and the other fingers at B.

* Several of these recreations were invented by M. Guyot.

The hands and the two parts of the cards being thus diſpoſed, you draw off the lower cards, confined by the little finger and the other parts of the right hand, and place them, with an imperceptible motion, on the top of the pack.

It is quite neceſſary, before you attempt any of the recreations that depend on making the paſs, that you can perform it ſo dexterouſly that the eye cannot diſtinguiſh the motion of your hand; otherwiſe, inſtead of deceiving others you will expoſe yourſelf. It is alſo proper that the cards make no noiſe, as that will occaſion ſuſpicion. This dexterity is not to be attained without ſome practice.

We have mentioned in the firſt volume the method of preparing a pack of cards, by inſerting one or more that are a ſmall matter longer or wider than the reſt, and that preparation will be neceſſary in ſeveral of the following recreations.

RECRE-

RECREATION LXXVI.

The card of divination.

HAVE a pack in which there is a long card; open the pack at that part where the long card is, and preſent the pack to a perſon in ſuch manner that he will naturally draw that card *. He is then to put it into any part of the pack, and ſhuffle the cards. You take the pack and offer the ſame card in like manner to a ſecond or third perſon; obſerving, however, that they do not ſtand near enough to ſee the card each other draws. You then draw ſeveral cards yourſelf, among which is the long card, and aſk each of the parties if his card be among thoſe cards, and he will naturally ſay yes, as they have all drawn the ſame card. You then ſhuffle all the cards together, and cutting them at the long card, you hold

* See Vol. I. p. 78.

it

it before the first person, so that the others may not see it, and tell him that is his card. You then put it again in the pack, and shuffling them a second time, you cut again at the same card, and hold it in like manner to the second person, and so of the rest *.

If the first person should not draw the long card, each of the parties must draw different cards; when cutting the pack at the long card, you put those they have drawn over it, and seeming to shuffle the cards indiscriminately, you cut them again at the long card, and show one of them his card. You then shuffle and cut again,

* There is frequently exhibited another experiment, similar to this, which is by making a person draw the long card, then giving him the pack, you tell him to place his card where he pleases, and shuffle them, and you will then name his card, or cut the pack where it is. You may also tell him to put the pack in his pocket, and you will draw the card, which you may easily do by the touch.

in

in the ſame manner, and ſhow another perſon his card, and ſo on: remembering that the card drawn by the laſt perſon is the firſt next the long card; and ſo of the others.

This Recreation may be performed without the long card, in the following manner. Let a perſon draw any card whatever, and replace it in the pack: you then make the paſs, and bring that card to the top of the pack, and ſhuffle them without loſing ſight of that card. You then offer that card to a ſecond perſon, that he may draw it, and put it in the middle of the pack. You make the paſs and ſhuffle the cards a ſecond time, in the ſame manner, and offer the card to a third perſon, and ſo again to a fourth or fifth, as is more fully explained further on.

RECREATION LXVII.

The four confederate cards.

YOU let a perſon draw any four cards from the pack, and tell him to think on one of them. When he returns you the four cards you dextrouſly place two of them under the pack and two on the top. Under thoſe at the bottom you place four cards of any ſort, and then taking eight or ten from the bottom cards, you ſpread them on the table, and aſk the perſon if the card he fixed on be among them. If he ſay *no*, you are ſure it is one of the two cards on the top. You then paſs thoſe two cards to the bottom, and drawing off the loweſt of them, you aſk if that is not his card. If he again ſay *no*, you take that card up, and bid him draw his card from the bottom of the pack.

If the perſon ſay his card is among thoſe you firſt drew from the bottom, you muſt

muſt dextrouſly take up the four cards that you put under them, and placing thoſe on the top, let the other two be the bottom cards of the pack, which you are to draw in the manner before deſcribed.

RECREATION LXXVIII.

The numerical card.

LET the long card be the ſixteenth in a pack of piquet cards. Take ten or twelve cards from the top of the pack, and ſpreading them on the table deſire a perſon to think of any one of them, and to obſerve the number it is from the firſt card. Make the paſs at the long card, which will then be at the bottom. Then aſk the party the number his card was at, and counting to yourſelf from that number to 16, turning the cards up one by one, from the bottom. Then ſtop, at the ſeventeenth card, and aſk the perſon if he has ſeen his card, when he will ſay *no*. You then aſk him how many more cards

you ſhall draw before his card appears; and when he has named the number, you draw the card aſide with your finger, and turn up the number of cards he propoſed, and then throw down the card he fixed on.

RECREATION LXXIX.

Divination by the ſword.

AFTER a card has been drawn you place it under the long card, and by ſhuffling them dextrouſly you bring it to top of the pack. Then lay, or throw, the pack on the ground, obſerving where the top card lays. A handkerchief is then bound over your eyes, in ſuch manner however that you can ſee the ground, which may be eaſily done. A ſword is then put into your hand, with which you touch ſeveral of the cards, ſeemingly in great doubt, but never loſing ſight of the top card, in which at laſt you fix the point of

of the ſword, and preſent it to him who drew it. Two or three cards may be diſcovered in the ſame manner, that is, by placing them under the long card, and then bringing them to the top of the pack.

RECREATION LXXX.

The card thought on per force.

YOU ſpread part of a pack of cards before a perſon, in ſuch manner that one of the picture cards only is completely viſible. You then tell him to think on one of thoſe cards, obſerving attentively if he fix his eye on the picture card. When he ſays he has determined, you ſhuffle the cards, and turning them up, one by one, you tell him that is his card.

If he does not appear to fix his eye on the pictured card, or if he ſpread the cards in order to fix on another, you tell him to draw the card he chooſes, and then by

placing it under the long card you perform ſome other recreation. It is eaſy to conceive that this recreation may fail, and that it ſhould not be attempted with thoſe who are converſant with deceptions of this ſort.

RECREATION LXXXI.

The tranſmutable cards.

YOU muſt have in the pack two cards of the ſame ſort, ſuppoſe the king of ſpades. One of theſe is to be placed next the bottom card, which may be the ſeven of hearts, or any other card. The other is to be placed at top. You then ſhuffle the cards, without diſplacing thoſe three cards, and ſhow a perſon that the bottom card is the ſeven of hearts. Then drawing that card privately aſide with your finger, which you have wetted for that purpoſe, you take the king of ſpades from the bottom, which the perſon ſuppoſes to be the ſeven of hearts, and lay it on the table,

table, telling him to cover it with his hand. You then ſhuffle the cards again, without diſplacing the firſt and laſt card, and paſſing the other king of ſpades at the top to the bottom, you ſhow it to another perſon. You then draw that privately away, and taking the bottom card, which will then be the ſeven of hearts, you lay that on the table, and tell the ſecond perſon, who believes it to be the king of ſpades, to cover it with his hand.

You then command the ſeven of hearts, which is ſuppoſed to be under the hand of the firſt perſon, to change into the king of ſpades; and the king of ſpades, which is ſuppoſed to be under the hand of the ſecond perſon, to change into the ſeven of hearts; and when the two parties take their hands off, and turn up the cards, they will ſee, to their no ſmall aſtoniſhment, after having ſo carefully obſerved the bottom cards, that your commands are punctually obeyed.

RECREATION LXXXII.

The three magical parties.

YOU are to offer the long card to any one, that he may draw it, and place it again in any part of the pack he thinks proper. You then make the pass, and bring that card to the top of the pack. You next divide the pack into three heaps, observing to put the long card in the middle heap, as that is most commonly chose. You then demand of the person which of the heaps the card he drew shall be in. If he reply in the middle parcel, you immediately show him the card. But if he say in either of the others, you take all the cards in your hand, placing the parcel he has named over the other two, observing to put your little finger between that and the middle heap, at the top of which is the card he drew. You then ask at what number in that heap he will have his card appear.

appear. If he ſay, for example, the ſixth card, you tell down five cards from the top of the pack, and then dextrouſly making the paſs, you bring the long card to the top, and tell it down as the ſixth.

RECREATION LXXXIII.

The inverted cards.

PREPARE a pack of cards, by cutting one end of them about one-tenth of an inch narrower than the other: then offer the pack to any one that he may draw a card; place the pack on the table, and obſerve carefully if he turn the card while he is looking at it; if he do not, when you take the pack from the table, you offer the other end of it for him to inſert that card; but if he turn the card, you then offer him the ſame end of the pack. You afterwards offer the cards to a ſecond or third perſon, for them to

draw and replace a card in the ſame manner. You then let any one ſhuffle the cards, and taking them again in your own hand, as you turn them up one by one, you eaſily perceive by the touch which thoſe cards are that have been inverted, and laying the firſt of them down on the table, you aſk the firſt perſon if that card be his, if he ſay *no*, you aſk the ſame of the ſecond perſon, and if he ſay *no*, you tell the third perſon it is his card; and ſo of the ſecond and third cards. You ſhould lay the pack on the table after each perſon has drawn his card, and turn it dextrouſly in taking it up, when it is to be turned, that the experiment may not appear to depend on the cards being inverted.

RECREATION LXXXIV.

The card discovered by the touch or smell.

YOU offer the long card, or any other that you know, and as the person who has drawn it holds it in his hand, you you pretend to feel the pips or figure on the under side by your fore finger; or you sagaciously smell to it, and then pronounce what card it is.

If it be the long card, you may give the pack to the person who drew it, and leave him at liberty either to replace it or not. Then taking the pack, you feel immediately whether it be there or not, and shuffling the cards in a careless manner, without looking at them, you pronounce accordingly.

RECREATION LXXXV.

The incomprehenſible tranſpoſition.

TAKE a card, the ſame as your long card, and rolling it up very cloſe, put it in an egg, by making a hole as ſmall as poſſible, and which you are to fill up carefully with white wax. You then offer the long card to be drawn, and when it is replaced in the pack you ſhuffle the cards ſeveral times, giving the egg to the perſon who drew the card, and while he is breaking it, you privately withdraw the long card, that it may appear, upon examining the cards, to have gone from the pack into the egg. This Recreation may be rendered more ſurpriſing by having ſeveral eggs, in each of which is placed a card of the ſame ſort, and then giving the perſon the liberty to chooſe which egg he thinks fit.

This

This deception may be ſtill further diverſified, by having, as moſt public performers have, a confederate, who is previouſly to know the egg in which the card is placed; for you may then break the other eggs, and ſhow that the only one that contains a card is that in which you directed it to be.

RECREATON LXXXVI.

The card in the pocket-book.

THIS Recreation is to be performed by a confederate, who is previouſly to know the card you have taken from the pack and put in your pocket-book. You then preſent the pack to your confederate, and deſire him to fix on a card, (which we will ſuppoſe to be the queen of diamonds) and then place the pack on the table. You then aſk him the name of the card, and when he ſays the queen of diamonds, you aſk him if he be not miſtaken, and if he be

be ſure that card is in the pack: when he replies in the affirmative, you ſay, it might be there when you looked over the cards, but I believe it is now in my pocket: then deſire a third perſon to put his hand in your pocket, and take out your book, and when it is opened the card will appear.

Experiments of this kind appear as wonderful to thoſe who have no idea of a confederacy, as they do ſimple and trifling to thoſe that are in the ſecret.

RECREATION LXXXVII.

To tell the card that a perſon has only once touched with his finger.

THIS Recreation alſo is to be performed by confederacy. You previouſly agree with your confederate on certain ſigns, by which he is to denote the ſuit, and the particular card of any ſuit: as thus;

thus; if he touch the firſt button of his coat, it ſignifies an ace; if the ſecond, a king, &c. and then again if he take out his handkerchief, it denotes the ſuite to be hearts; if he take ſnuff, diamonds, &c. Theſe preliminaries being ſettled, you give the pack to a perſon who is near your confederate, and tell him to ſeparate any one card from the reſt, while you are abſent, and draw his finger once over it. He is then to return you the pack, and while you are ſhuffling the cards, you carefully note the ſignals made by your confederate. Then turning the cards over one by one, you directly fix on the card he touched.

RECREATION LXXXVIII.

To name ſeveral cards that two perſons have drawn from the pack.

DIVIDE a piquet pack of cards into two parts by a long card. Let the firſt part contain a quint to a king in clubs and ſpades, the four eights, the ten of diamonds and ten of hearts; and let the other part contain the two quart majors in hearts and diamonds, the four ſevens and the four nines *.

Then ſhuffle the cards, but obſerve not to diſplace any of thoſe cards of the laſt part which are under the long card. You then cut at that card, and leave the pack in two parts. Next, preſent the firſt of thoſe parts to a perſon, and tell him to draw two or three cards, and place the

* The cards may be divided in any other manner that is eaſy to be remembered.

remainder

remainder on the table. You preſent the ſecond parcel in like manner to another. Then having dextrouſly placed the cards drawn by the firſt perſon in the ſecond parcel, and thoſe drawn by the ſecond perſon in the firſt parcel, you ſhuffle the cards, obſerving to diſplace none but the upper cards. Then ſpreading the cards on the table, you name thoſe that each perſon drew; which you will very eaſily do, by obſerving the cards that are changed in each parcel.

RECREATION LXXXIX.

The two convertible aces.

ON the ace of ſpades fix, with ſoap, a heart, and on the ace of hearts, a ſpade, in ſuch manner that they will eaſily ſlip off.

Show theſe two aces to the company; then taking the ace of ſpades you deſire a perſon

perſon to put his foot upon it, and as you place it on the ground, draw away the ſpade. In like manner you place the ſeeming ace of hearts under the foot of another perſon. You then command the two cards to change their places; and that they obey your command, the two perſons, on taking up their cards, will have ocular demonſtration *.

* A deception ſimilar to this is ſometimes practiſed with one card, ſuppoſe the ace of ſpades, over which a heart is paſted ſlightly. After ſhowing a perſon the card you let him hold one end of it, and you hold the other, and while you amuſe him with diſcourſe, you ſlide off the heart. Then laying the card on the table you bid him cover it with his hand. You then knock under the table, and command the heart to turn into the ace of ſpades. By deceptions like theſe people of little experience and much conceit are frequently deprived of their money and rendered ridiculous.

RECRE-

RECREATION XC.

The fifteen thouſand livres.

YOU muſt be prepared with two cards, like thoſe repreſented by Plate XIV. Fig. 3. and with a common ace and five of diamonds.

The five of diamonds and the two prepared cards are to be diſpoſed as in Fig. 4. and holding them in your hand, you ſay, "A certain Frenchman left fifteen thouſand livres, which are repreſented by theſe three cards, to his three ſons. The two youngeſt agreed to leave their 5000, each of them, in the hands of the elder, that he might improve it." While you are telling this ſtory you lay the 5 on the table, and put the ace in its place, and at the ſame time artfully change the poſition of the other two cards, that the three cards may appear, as in Fig. 5. You then reſume your diſcourſe. "The eldeſt brother, inſtead

of improving the money, loſt it all by gaming, except three thouſand livres, as you here ſee." You then lay the ace on the table, and taking up the 5, continue your ſtory: "The eldeſt, ſorry for having loſt the money, went to the Eaſt-Indies with theſe 3000, and brought back 15000." You then ſhow the cards in the ſame poſition as at firſt, in Fig. 3.

To render this deception agreeable, it muſt be performed with dexterity, and ſhould not be repeated, but the cards immediately put in the pocket; and you ſhould have five common cards in your pocket, ready to ſhow, if any one ſhould deſire to ſee them.

Another recreation of this ſort may be performed with fives and threes, as in Fig. 6, 7, and 8.

RECRE-

RECREATION XCI.

The card discovered under the handkerchief.

LET a person draw any card from the rest, and put it in the middle of the pack. You make the pass at that place, and the card will consequently be at top. Then placing the pack on the table, cover it with a handkerchief, and putting your hand under it, take off the top card, and after seeming to search among the cards for some time, draw it out.

This Recreation may be performed by putting the cards in another person's pocket, after the pass is made. Several cards may also be drawn and placed together in the middle of the pack, and the pass then made.

RECREATION XCII.

To change the cards that ſeveral perſons have drawn from the pack.

ON the top of the pack put any card you pleaſe, ſuppoſe the queen of clubs. Make the paſs, and bring that card to the middle of the pack, and offer it a perſon to draw. Then, by cutting the cards, bring the queen again to the middle of the pack. Make the paſs a ſecond time, and bring it to the top, and ſhuffle the cards without diſplacing thoſe on the top. Make the paſs a third time, and bring it to the middle of the pack, and offer it to a ſecond perſon to draw; who muſt be at a proper diſtance from the firſt perſon, that he may not perceive it is the ſame card. After the like manner let five perſons draw the ſame card.

Shuffle the pack, without loſing ſight of the queen of clubs, and laying down four

four other cards with the queen, aſk each perſon if he ſee his card there. They will all reply *yes*, as they all drew the queen of clubs. Place four of thoſe cards to the pack, and drawing the queen privately away; you approach the firſt perſon, and ſhowing him that card, ſo that the others cannot ſee it, and aſk if that be his card. Then putting it on the top of the pack, blow on it, or give it a ſtroke with your hand, and ſhow it in the ſame manner to the ſecond perſon; and ſo of the reſt.

RECREATION XCIII.

The four inſeparable kings.

TAKE the four kings, and behind the laſt of them place two other cards, ſo that they may not be ſeen. Then ſpread open the four kings to the company, and put the ſix cards at the bottom of the pack. Draw one of the kings, and put him at the top of the pack. Draw

one of the two cards at the bottom, and put it towards the middle. Draw the other, and put it at ſome diſtance from the laſt, and then ſhow that there remains a king at bottom. Then let any one cut the cards, and as there remained three kings at bottom, they will then be altogether in the middle of the pack.

RECREATION XCIV.

To tell the number of cards by their weight.

TAKE a parcel of cards, ſuppoſe 40, among which inſert two long cards; let the firſt be, for example, the 15th, and the other the 26th from the top. Seem to ſhuffle the cards, and then cutting them at the firſt long card, poiſe thoſe you have cut off in your hand, and ſay, "there ſhould be here fifteen cards." Cut them again at the ſecond long card, and ſay, "there are here only eleven cards." Then poiſing the remainder, you ſay, "here are fourteen cards."

RE-

RECREATION XCV.

To discover the card that is drawn by the throw of a die.

PREPARE a pack of cards, in which six different cards are contained six times; that is, in which there are only six sorts of cards. Dispose these cards in such manner that each of the six different cards shall follow each other, and let the last of each suit be a long card. The cards being thus disposed, it follows, that if you divide them into six parcels, by cutting at each of the long cards, those parcels will all consist of similar cards.

Let a person draw a card from the pack, and let him replace it in the parcel from whence it was drawn, by dextrously offering that part. Cut the cards several times, so that a long card may be always at bottom. Divide the cards in this manner into six heaps, and giving a die to the

perſon who drew the card, tell him that the point he throws ſhall indicate the parcel in which is the card he drew; then take up that parcel and ſhow him the card.

You ſhould put the cards in your pocket immediately after performing this Recreation, and have another pack, ready to ſhow, if any one ſhould aſk to ſee the cards.

RECREATION XCVI.

To ſeparate the two colours of a pack of cards by one cut.

THE pack muſt be prepared in the ſame manner as in the 83d Recreation; that is, all the cards of one colour muſt be cut ſomething narrower at one end than the other. You ſhow the cards, and give them to any one that he may ſhuffle them, then holding them between

your hands, one hand being at each extremity, with one motion you ſeparate the hearts and diamonds from the ſpades and clubs.

This Recreation is eaſy and pleaſant to perform, but ſhould not be repeated; unleſs you have another pack of cards which you can adroitly ſubſtitute in the place of the former, and with them you may ſeparate the pictured cards from the others, they being prepared for that purpoſe; which will afford a freſh ſurprize. You may alſo write on a number of blank cards certain letters or words that form a queſtion, and on others the anſwer. Several other recreations may likewiſe be performed by the ſame method.

RECREATION XCVII.

The metamorphoſed cards.

IN the middle of a pack place a card that is ſomething wider than the reſt, which we will ſuppoſe to be the knave of ſpades, under which place the ſeven of diamonds, and under that the ten of clubs. On the top of the pack put cards ſimilar to theſe, and others on which are painted different objects, in the manner following:

Firſt card	A bird
2	A ſeven of diamonds
3	A flower
4	Another ſeven of diamonds
5	A bird
6	Ten of clubs
7	A flower
8	Another ten of clubs.

Then

Then ſeven or eight indifferent cards; the knave of ſpades, which is the wide card; the ſeven of diamonds; the ten of clubs; and the reſt any indifferent cards.

Two perſons are then to draw the two cards that are under the wide card, which are the ſeven of diamonds and the ten of clubs. You then take the pack in your left hand, and open it at the wide card, as you open a book, and tell him who drew the ſeven of diamonds to place it in that opening. You then blow on the cards, and without cloſing them you inſtantly bring the card which is at top, and on which a bird is painted, over that ſeven of diamonds *. You then bid the perſon look at his card, and when he has remarked the change, to place it where it was before. Then blow on the cards a ſecond time, and bringing the ſeven of diamonds,

* To do this dexterouſly you muſt wet the middle finger of your left hand, with which you are to bring the card to the middle of the pack.

which is at the top of the pack, to the opening, you bid him look at his card again, when he will ſee it is that he drew. You may do the ſame with all the other painted cards, either with the ſame perſon, or with him who drew the ten of clubs.

The whole artifice in this Recreation conſiſts in bringing the card at the top of the pack to the opening in the middle, by the wet finger, which requires no great practice. You muſt obſerve not to let the pack go out of your hands while you are performing this Recreation.

RECREATION XCVIII.

The cards in the opera glaſs.

PROVIDE an opera glaſs about two inches and a half long, the tube of which is to be ivory, and ſo thin that the light may paſs through it. In this tube place a lens of two inches and a quarter focus,

focus, ſo that a card of about three quarters of an inch long may appear of the ſize of a common card. At the bottom of the tube there is to be a circle of black paſteboard, to which muſt be faſtened a ſmall card with figures on both ſides, by two threads of ſilk, in ſuch manner that by turning the tube either ſide of the card may be viſible.

You then offer two cards in a pack to two perſons, which they are to draw, and that are the ſame as thoſe in the glaſs. After which you ſhow each of them the card he has drawn, in the glaſs, by turning it to the proper poſition.

The better to induce the parties to draw the two cards, place them firſt on the top of the pack, and then, by making the paſs, bring them to the middle. When you can make the paſs in a dexterous manner, it is preferable, on many occaſions to the long card, which obliges you to change the

the pack frequently; for otherwiſe it would be obſerved that the ſame card is always drawn, and doubtleſs occaſions ſuſpicion.

RECREATION XCIX.

The magic ring.

MAKE a ring large enough to go on the ſecond or third finger, (Pl. XIV. Fig. 9.) in which let there be ſet a large tranſparent ſtone, to the bottom of which muſt be fixed a ſmall piece of black ſilk, that may be either drawn aſide or expanded by turning the ſtone round. Under the ſilk is to be the figure of a ſmall card.

Then make a perſon draw the ſame ſort of card as that at the bottom of the ring, and tell him to burn it in the candle. Having firſt ſhown him the ring, you take part of the burnt card, and reducing it to pow-

powder, you rub the ſtone with it, and at the ſame time turn it artfully about, ſo that the ſmall card at bottom may come in view.

RECREATION C.

The card in the mirror.

PROVIDE a mirror, either round, as A, (Plate XIV. Fig. 10.) or oval, the frame of which muſt be at leaſt as wide as a card. The glaſs in the middle muſt be made to move in the two grooves CD and EF, and ſo much of the quickſilver muſt be ſcraped off, as is equal to the ſize of a common card. You will obſerve that the glaſs muſt likewiſe be wider than the diſtance between the frame, by at leaſt the width of a card.

Then paſte over the part where the quickſilver is rubbed off, a piece of paſte-board, on which is a card, that muſt exactly

actly fit the ſpace, which muſt at firſt be placed behind the frame.

This mirror muſt be placed againſt a partition, through which is to go two ſtrings, by which an aſſiſtant in the adjoining room can eaſily move the glaſs in the grooves, and conſequently make the card appear or diſappear at pleaſure *.

Matters being thus prepared, you contrive to make a perſon draw the ſame ſort of card with that fixed to the mirror, and place it in the middle of the pack: you

* This Recreation may be performed without an aſſiſtant, if a table be placed againſt the partition, and the ſtring from the glaſs be made to paſs through a leg of it, and communicate with a ſmall trigger, which you may eaſily puſh down with your foot, and at the ſame time be wiping the glaſs with your handkerchief, that the card may appear the more conſpicuous. It may alſo be diverſified, by having the figure of a head, ſuppoſe that of ſome abſent friend, in the place of the card.

then

then make the paſs, and bring it to the bottom; you then direct the perſon to look for his card in the mirror, when the confederate behind the partition is to draw it ſlowly forward, and it will appear as if placed between the glaſs and the quickſilver. While the glaſs is drawing forward you ſlide off the card from the bottom of the pack, and convey it away.

The card fixed to the mirror may eaſily be changed each time the experiment is performed. This Recreation may be alſo made with a print that has a glaſs before it, and a frame of ſufficient width; by making a ſlit in the frame through which the card is to paſs; but the effect will not be ſo ſtriking as in the mirror.

RECREATION CI.

The marvellous vase.

PLACE a vase of wood or pasteboard AB (Pl. XIV. Fig. 11.) on a bracket L, fixed to the partition M. Let the inside of this vase be divided into five parts, *c*, *d*, *e*, *f*, *g*; and let the divisions *c* and *d* be wide enough to admit a pack of cards, and those of *e*, *f*, *g*, one card only.

Fix a thread of silk at the point H, the other end of which passing down the division *d*, and over the pulley I, runs along the bracket L, and goes out behind the partition M.

Take three cards from a piquet pack, and place one of them in each of the divisions *e*, *f*, *g*, making the silk thread or line go under each of them. In the division *c*, put the pack of cards from which you

p 235.

ttom

Thumb

finger

Fig. 2. p 235.

B

Top

C

Fig. 3. p 257.

Fig. 4. p 257.

B

Fig. 5. p 257.

Fig. 8. p 258.

p 258.

Fig. 7. p 258.

Fig. 10. p 270.

A

C

D

B

E

F

p 270.

Fig. 11. p 274.

c d e f g

H

A

B

M

L

I

J. Ledge Sculp.

you have taken the three cards that are in the other diviſions.

Then take another pack of cards, at the top of which are to be three cards of the ſame ſort with thoſe in the three ſmall diviſions, and making the paſs, bring them to the middle of the pack, and let them be drawn by three different perſons. Then give them all the cards to ſhuffle, after which place the pack in the diviſion *d*, and tell the parties they ſhall ſee the three cards they drew come, at their command, ſeparately out of the vaſe.

An aſſiſtant behind the partition then drawing the line, with a gentle and equal motion, the three cards will gradually riſe out of the vaſe. Then take the cards out of the diviſion *c*, and ſhow that thoſe three cards are gone from the pack.

The vaſe muſt be placed ſo high that the inſide cannot be ſeen by the company.

You may perform this Recreation alſo without an aſſiſtant, by fixing a weight to the end of the ſilk line, which is to be placed on a ſupport, and let down at pleaſure, by means of a ſpring in the partition.

RECREATION CII.

The divinating perſpective glaſs.

LET a ſmall perſpective glaſs be made, that is wide enough at the end where the object-glaſs is placed, to hold a table ſimilar to the following Fig.

Fig. 4.

1.131	10..132	19.133
2.231	11..232	20.233
3.331	12..332	21.333
4.121	13..122	22.123
5.221	14..222	23.223
6.321	15..322	24.323
7.111	16..112	25.113
8.211	17..212	26.213
9.311	18..312	27.313

Take a pack of cards that consists of 27 only, and giving them to a person, desire him to fix on any one, then shuffle them and give the pack to you. Place the twenty-seven cards in three heaps, by laying down one alternately on each heap, but before you lay each card down show it to the person, without seeing it yourself; and when the three heaps are finished, ask him at what number, from 1 to 27, he will have his card appear, and in which heap it then is. Then look at the heap through the glass, and if the first of the three numbers which stands against that number it is to appear at be 1, put that heap at top; if the number be 2, put it in the middle; and if it be 3, put it at bottom. Then divide the cards into three heaps, in the same manner, a second and third time, and his card will then be at the number he chose.

For example. Suppose he desire that his card shall be the 20th from the top, and the first time of making the heaps he

ſay it is in the third heap; yon then look at the table in the perſpective, holding it at the ſame time over that heap, and you ſee that the firſt figure is 2, you therefore put that heap in the middle of the pack. The ſecond and third times you in like manner put the heap in which he ſays it is, at the bottom, the number each time being 3. Then looking at the pack with your glaſs, as if to diſcover which the card was, you lay the cards down one by one, and the twentieth card will be that he fixed on.

You may ſhow the perſon his card in the ſame manner, without aſking him at what number it ſhall appear, by fixing on any number yourſelf. You may alſo perform this Recreation with the magnetical dial deſcribed in the third volume, by making the hand point to any number, from 1 to 27, at which you intend the card ſhall be found.

The

The foregoing recreations with the cards will be found ſufficient to explain all others of a ſimilar nature, that have or may be made, the number of which is very great. To perform theſe we have deſcribed requires no great practice; the two principal points are, the making the paſs in a dexterous manner, and a certain addreſs by which you influence a perſon to draw the card you preſent.

Thoſe recreations that are performed by the long card are, in general, the moſt eaſy, but they are confined to a pack of cards that is ready prepared; whereas, thoſe that depend on making the paſs, may be performed with any pack that is offered.

RECREATION CIII.

The burnt writing reſtored.

COVER the outſide of a ſmall memorandum-book with black paper, and in one of its inſide covers make a flap, to open ſecretly, and obſerve there muſt be nothing over the flap but the black paper that covers the book.

Mix ſoot with black or brown ſoap, with which rub the ſide of the black paper next the flap: then wipe it quite clean, ſo that a white paper preſſed againſt it will not receive any mark.

Provide a black lead pencil that will not mark without preſſing hard on the paper. Have likewiſe a ſmall box, about the ſize of the memorandum-book, and that opens on both ſides, but on one of them by a private method. Give a perſon the pencil, and a ſlip of thin paper, on which he is to write

write what he thinks proper: you preſent him the memorandum-book at the ſame time, that he may not write on the bare board. You tell him to keep what he writes to himſelf, and direct him to burn it on an iron plate laid on a chafingdiſh of coals, and give you the aſhes. You then go into another room to fetch your magic box, before deſcribed, and take with you the memorandum-book.

Having previouſly placed a paper under the flap in the cover of the book, when he preſſes hard with the pencil, to write on his paper, every ſtroke, by means of the ſtuff rubbed on the black paper, will appear on that under the flap. You therefore take it out, and put it into one ſide of the box.

You then return to the other room, and taking a ſlip of blank paper, you put it into the other ſide of the box, ſtrewing the aſhes of the burnt paper over it. Then ſhaking

ſhaking the box for a few moments, and at the ſame time turning it dextrouſly over, you open the other ſide, and ſhew the perſon the paper you firſt put in, the writing on which he will readily acknowledge to be his.

If there be a preſs or cupboard that communicates with the next room, as in the 64th Recreation, you need only put the book in the preſs, and your aſſiſtant will open it and put the paper in the box, which you preſently after take out, and perform the reſt of the recreation as before.

There may likewiſe be a flap in the other cover of the book, and you may rub the paper againſt that with red lead. In this caſe you give the perſon the choice of writing either with a red or black pencil; and preſent him the proper ſide of the book accordingly.

RECREATION CIV.

The opaque box rendered tranſparent.

MAKE a box of three or four inches long, and two or three wide, and have a ſort of perſpective glaſs, the bottom of which is of the ſame ſize with the box, and ſlides out, that you may privately place a paper on it. The ſides of this perſpective are to be of glaſs, covered on the inſide with fine paper.

Let a perſon write on a ſlip of paper, putting your memorandum-book under it, as in the laſt Recreation. Then give him the little box, and let him put what he has wrote into it. In the mean time you put the memorandum-book into the preſs, where the perſpective is already placed. Your aſſiſtant then takes the paper out of the book, and puts it at the bottom of the perſpective; which you preſently take out of the preſs, and direct the perſon

perſon to put the little box, that contains his paper, under it. You then look in at the top of the perſpective; and feigning to ſee through the top of the box, you read what is wrote on the paper at the bottom of the perſpective.

With this perſpective-box you may perform another recreation, which is, by having in a bag twelve or more ivory counters, numbered, which you ſhow to the company, that they may ſee all the numbers are different. You tell a perſon to draw any one of them, and keep it cloſe in his hand. You then put the bag in the preſs, when your aſſiſtant examines the counters, and ſees which is wanting, and puts another of the ſame number at the bottom of the perſpective, which you then take out; and placing the perſon's hand cloſe to it, look in at the top, and pretending to ſee through his hand, you name the number on the counter in it.

RECRE-

RECREATION CV.

The tranſpoſable pieces.

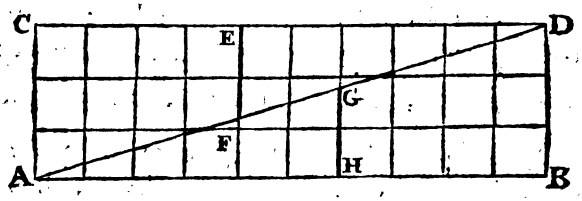
TAKE two guineas and two ſhillings, and grind part of them away, on one ſide only, ſo that they may be but of half the common thickneſs; and obſerve that they muſt be quite thin at the edge: then rivet a guinea and a ſhilling together. Lay one of theſe double pieces, with the ſhilling upwards, on the palm of your hand, at the bottom of your three firſt fingers; and lay the other piece, with the guinea upward, in like manner, in the other hand. Let the company take notice in which hand is the guinea, and in which the ſhilling. Then as you ſhut your hands, you naturally turn the pieces over, and when you open them again, the ſhilling and the guinea will appear to have changed their places.

RECRE-

RECREATION CVI.

The geometric money.

DRAW on paſteboard the following rectangle A B C D, whoſe ſide A C is three inches, and A B ten inches.

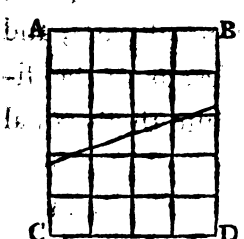


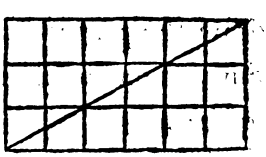
Divide the longeſt ſide into ten equal parts, and the ſhorteſt into three equal parts, and draw the perpendicular lines, as in the figure, which will divide it into thirty equal ſquares.

From A to D draw the diagonal A D, and cut the figure, by that line, into two equal triangles, and cut thoſe triangles into two parts, in the direction of the lines E F and G H. You will then have two trian-

triangles, and two four-ſided irregular figures, which you are to place together, in the manner they ſtood at firſt, and in each ſquare you are to draw the figure of a piece of money; obſerving to make thoſe in the ſquares at A and D ſomething imperfect.

As the pieces ſtand together in the foregoing figure, you will count thirty pieces of money only, but if the two triangles and the two irregular figures be joined together, as in the following figures, there will be thirty-eight pieces.





RECREATION CVII.

The penetrative guinea.

PROVIDE a round tin box, of the ſize of a large ſnuff-box, and in this place eight other boxes, which will go eaſily into each other, and let the leaſt of them be of a ſize to hold a guinea. Each of theſe boxes ſhould ſhut with a hinge, and to the leaſt of them there muſt be a ſmall lock, that is faſtened with a ſpring, but cannot be opened without a key: and obſerve that all theſe boxes muſt ſhut ſo freely, that they may be all cloſed at once. Place theſe boxes in each other, with their tops open, in the drawer of the table on which you make your experiments; or if you pleaſe, in your pocket, in ſuch manner that they cannot be diſplaced.

Then aſk a perſon to lend you a new guinea, and deſire him to mark it, that it may not be changed. You take this piece in

in one hand, and in the other you have another of the ſame appearance, and putting your hand in the drawer you ſlip the piece that is marked into the leaſt box, and ſhutting them all at once, you take them out. Then ſhowing the piece you have in your hand, and which the company ſuppoſe to be the ſame that was marked, you pretend to make it paſs through the box, and dextrouſly convey it away.

You then preſent the box, for the ſpectators do not yet know there are more than one, to any perſon in company, who, when he opens it, finds another, and another, till he comes to the laſt, but that he cannot open without the key, which you then give him, and retiring to a diſtant part of the room, you tell him to take out the guinea himſelf, and ſee if it be that he marked.

This recreation may be made more ſurpriſing, by putting the key into the ſnuff-box of one of the company, which you may do by aſking him for a pinch of his

ſnuff, and at the ſame time conceal the key, which muſt be very ſmall, among the ſnuff: and when the perſon who is to open the box aſks for the key, you tell him that one of the company has it in his ſnuff-box. This part of the recreation may likewiſe be performed by means of a confederate.

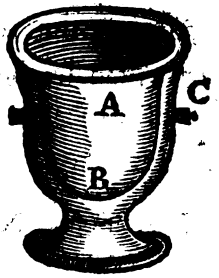
RECREATION CVIII.

The reſuſcitated flower.

PROVIDE a ſmall tin mortar, that is double as A, in the following Fig. whoſe bottom B turns round on an axis, by means of a ſpring which communicates with the piece C. There muſt be a hollow ſpace under the falſe bottom. To the underſide of the bottom faſten, by a thread of fine ſilk, a flower, with its ſtalk and leaves.

Then take a flower that exactly reſembles the other, and plucking it from the ſtalk, and all the leaves from each other, put

put them into the mortar, and pound them with a ſmall peſtle; after which you ſhow the mortar to the company, that they may ſee the parts are all bruiſed.



Then taking the mortar up in your hands, you hold it over the flame of a lamp or candle, by whoſe warmth the flower is ſuppoſed to be reſtored; and at the ſame preſſing the piece at C, the bottom will turn round, the bruiſed parts deſcend into the ſpace under the bottom, and the whole flower will be at top: you then put your hand into the mortar, and eaſily breaking the ſilk thread, which may be very ſhort as well as fine, you take the flower out and preſent it to the company.

There is an experiment similar to this, in which a live bird is concealed at the bottom of the mortar, and one that is dead is pounded in it; after which, by the motion of the bottom, the live bird is set at liberty. But surely the pounding a bird in a mortar, though it be dead, must produce, in persons of any delicacy, more disgust than recreation.

AN ARTIFICIAL MEMORY.

THE reader must have observed, that to perform several of the recreations in this book, it is necessary to have a good memory; but as that is a gift every one has not from nature, many methods have been contrived to supply that defect by art; the most material of which we shall here describe.

An artificial memory respects either figures or words: for the former let the five vowels *a*, *e*, *i*, *o*, *u*, represent the first five digits; the dipthongs that begin with the first four vowels, as *au*, *ea*, *ie*, *ou*, represent

ſent the remaining four digits, and let *y* ſtand for an o, or cypher. Let the ten firſt conſonants alſo ſtand for the nine digits and the cypher; as in the following table.

a	*e*	*i*	*o*	*u*	*au*	*ea*	*ie*	*ou*	*y*
1	2	3	4	5	6	7	8	9	o
b	*c*	*d*	*f*	*g*	*h*	*k*	*l*	*m*	*n*

Then to repreſent any number let the firſt letter be a vowel or dipthong, the ſecond a conſonant, the third a vowel, the fourth a conſonant, &c. Thus for the number 1763, you write or remember the word *akaud*. If there are ſeveral ſums to be retained, you place the words in forms of verſes, which will make them more pleaſing to repeat and more eaſy to remember: for example, if you would remember the dates of the acceſſion of the family of Stuart to the crown of England; the powder plot; the decapitation of Charles I. the Reſtoration; the Revolution; the Union of England and Scotland; the acceſſion of the Houſe of Hanover; and the laſt rebellion, which were in 1603, 1605, 1649,

1660, 1689, 1707, 1714, and 1746, you write as follows, for you are to obſerve that in this, and in ſimilar caſes, where the firſt figure is always the ſame, it is unneceſſary to write it after the firſt time.

Ahyd hyg hom haun
hiem kyk kaf koh.

This method is rendered in ſome inſtances ſtill more eaſy by adding parts of words to dates: thus to remember the date of the acceſſion of the monarchs from James I. to the preſent king, you may write as follows, omitting the letter that would ſtand for one thouſand.

Jam*hyd* Char*heg* Char*hom* Jam*hieg*
Will*hiem* An*kyc* Geor*kaf* Sec*kek* Thi*kaun*

When ſeveral cyphers come together, inſtead of repeating *y* or *n*, you may write *y* or *n* 2, 3, &c. Thus for 3400 write *ify*2, and for 256000 write *ehun*3.

To remember any number of words, ſelect the initial letters of thoſe words, and to

to the first add *a* if it begin with a consonant, or *b* if it begin with a vowel. In like manner add *e* or *c* to the second initial letter; to the third add *i* or *d*; to the fourth *o* or *f*; and to the fifth *u* or *g*. So that of the five initials you make five syllables, which are joined together in one word. Then of the next five initials you make, in the same manner, another word, and of every two words you may make a verse. For example, suppose you would remember the names of all the kings since the Conquest, in the order in which they reigned, you then write as follows.

*W*a*weh*i*ſoh*u *R*a*jeh*ie*ſeg*
*E*b*reh*i*hoh*u *E*b*ecr*i*hoh*u
*E*b*meedjccu* *Caje*w*ia*ſ*gu Gage*

Or if you would remember the letters that begin any number of verses, suppose the twenty-first lines of Pope's Essay on Man, you write as follows.

*A*b*telitoeg* *A*b*acodtotu*
*T*a*ocedaf*l*u* *B*a*ſewioffu.*

THE

CONTENTS.

PNEUMATICS.

DEFINITIONS page 1
APHORISMS 2
Properties of air, aph. 1 to 9.—Of the atmosphere, aph. 10 and 11.—Of the wind, aph. 12 and 13.

PNEUMATIC APPARATUS.

Conſtruction of the common air-pump 6
The animometer 9
The circular hygrometer 12
The perpendicular hygrometer 14
The thermometer 16

The

The barometer p. 18
Rules for predicting the weather by the barometer 22

RECREATION I. p. 25

The bottles broke by air.

A bottle is ſcrewed on to the mouth of the receiver, and the internal air being exhauſted the bottle is broke by the weight of the external air. The ſame effect is produced by the ſpring of the air in the bottle, when the weight of the external air is taken off. A perſon's hand, when laid on the mouth of the receiver, is preſſed by a great weight p. 26

RECREATION II. p. 27

The braſs hemiſpheres.

Theſe hemiſpheres being placed cloſe together, and the air exhauſted from them, a force equal to one hundred and eighty-ſeven pounds is required to ſeparate them.

RECRE-

RECREATION III. p. 28

Water boiled by air.

A veſſel with hot water is placed in the receiver, and the air being exhauſted the water boils with great rapidity.

RECREATION IV. p. 29

The aerial bubbles.

A piece of ſtone or iron being put in a veſſel of water placed in the receiver, and the air exhauſted, a great number of bubbles, reſembling drops of dews, riſe on the ſurface of the body in the water.

RECREATION V. p. 29

The floating ſtone.

A piece of cork is tied to a ſtone that will juſt ſink it, in a veſſel of water placed in

the receiver, and the air is exhauſted, when the ſtone and cork float on the ſurface of the water.

RECREATION VI. p. 30

The withered fruit reſtored.

A ſhrivelled apple being placed in the receiver, and the air exhauſted, it is plumped up, and looks as fair as when firſt gathered.

RECREATION VII. p. 31

The vegetable air bubbles.

Part of a plant is put in a veſſel of water, placed in the receiver: when the air is exhauſted that in the plant ariſes from the extremities of all its veſſels, and preſents a beautiful appearance.

RE-

RECREATION VIII. p. 32

The mercurial rod.

A piece of ſtick is put in a veſſel of mercury, in the receiver, and the air exhauſted; when it is let in again it forces the mercury into the ſtick, which is then ſeveral times heavier than before, and when cut the mercury glitters in every part.

RECREATION IX. p. 33

The myſtical bell.

A wire that is faſtened to a bell in the receiver goes through the top of it; when the air is exhauſted and the bell ſhook by the wire, no ſound is heard; but as the air is let in again the ſound becomes continually more audible.

RECREATION X. p. 33

Feathers heavier than air.

A piece of lead is hung to one end of a balance, and as many feathers to the other end as will keep the balance in equilibrium; but when it is put in the receiver, and the air exhausted, the feathers will preponderate.

RECREATION XI. p. 35

The self-moving wheel.

A wheel with small vanes is placed in the receiver, and the air exhausted; when it is let in again, by a small cock, it rushes against the vanes and puts the wheel in motion. If the pump be continually worked the motion of the wheel will be perpetual, without any apparent mover.

RECRE-

RECREATION XII. p. 36

The animated figures.

Several perpendicular cylinders are fixed in a circular frame; in each cylinder is placed the figure of an animal, under which is a piston, and under that a spring; and at the bottom of the cylinder is a small hole. When this machine is placed in the receiver and the air exhausted, the figures all rise up out of the cylinders; and when the air is let in again they all retire to several apartments.

RECREATION XIII. p. 38.

The artificial halo.

A candle is placed on one side of a receiver, and a spectator on the other; as the air is exhausted the light of the candle is refracted into circles of various colours, like those of a halo.

RECRE-

RECREATION XIV. p. 39

The mercurial ſhower.

A piece of wood is cemented to the top of the receiver, and mercury poured over it. The preſſure of the air, as the receiver is exhauſted, forces the mercury through the wood in the form of a ſhower, that is ſometimes luminous in the dark.

RECREATION XV. p. 39

The fountain in vacuo.

A tube that is hermetically ſealed at one end, and cloſed by a ſtop-cock at the other, is placed on the receiver, and when the air is exhauſted from the tube it is immerſed in water, which will then play up in the tube, in the form of a fountain.

RECRE-

RECREATION XVI. p. 40

The air-gun.

The air gun conſiſts of two barrels (Plate III. Fig. 1.) and a ſyringe that condenſes the air between the barrels. Near the ſtock of the gun is a valve and a trigger, by which the air is admitted behind the ball and forces it out. Some air-guns contain ſeveral balls, which they diſcharge ſucceſſively.

RECREATION XVII. p. 42

Artificial rain and hail.

In a hollow cylinder (Pl. III. Fig. 3.) that has five oblique partitions, and a ſmall hole in each of them, is placed a quantity of lead ſhot, and when the cylinder is turned round, the ſound of the ſhot, in paſſing through the partitions, reſembles that of rain or hail, according to the ſize of the ſhot.

RECREATION XVIII. p. 43

The magical flowers and fruit.

The ſtem of an artificial orange-tree, that is hollow, (Pl. III. Fig. 4.) is placed in a copper veſſel, in which there is a quantity of condenſed air, and when a cock is turned, the air ruſhing up the tree, forces out the artificial fruit concealed in the end of the branches.

HYDROLOGY.

DEFINITIONS p. 51
APHORISMS 52

The properties of water, aph. 1 to 6.—The laws of fluids in general, aph. 7 to 12.—Properties of ſolid bodies immerſed in fluids, aph. 13 to 16.

THE HYDROLOGIC APPARATUS.

Properties of the ſyphon 58
The ſeveral ſorts of pumps 61

The

The hydrometer p. 66
The hydroſtatic balance 73
The ſcrew of Archimedes 79
The balance pumps 81
The hydraulic ſcoop 82

RECREATION XIX. p. 84

The hydroſtatic bellows.

Two circular horizontal boards (Pl. VI. Fig. 5.) are joined by leathers, and in the upper board is fixed a perpendicular braſs pipe. If a man, ſtanding on the board, blow into the tube, he will raiſe himſelf up, or if water be poured in, a large weight will be raiſed.

RECREATION XX. p. 85

The water-clock.

A glaſs cylinder (Pl. VII. Fig. 1.) has a ſmall hole at the bottom, by which water drops out. On the ſurface of the

water floats a glaſs tube, whoſe neck is confined by the cover of the cylinder, and as it deſcends ſhows the hour, by a ſcale marked on it.

RECREATION XXI. p. 88

The globular fountain.

Over the jet of a fountain is placed a pipe, and at the end of that a hollow globe, in which a number of ſmall holes are made: the water of the fountain ruſhing up the pipe enters the globe, and being forced out of its holes forms a ſphere of water.

RECREATION XXII. p. 89

The hydraulic dancer.

A ſmall figure of a man (Pl. VII. Fig. 2.) is made of cork, and within it is placed a cone of leaf braſs: this figure being placed on the top of a jet will remain ſuſpended, and perform a variety of motions.

motions. A ſimilar experiment is made with a light ball of copper, Fig. 3.

RECREATION XXIII. p. 90

The hemiſpherial caſcade.

To the top of a jet is ſcrewed a pipe that enters the bottom of an inverted cone (Plate VII. Fig. 5.) The water from the pipe falling into the cone runs over it in form of a hemiſpherial caſcade. If this fountain be reverſed, it will have the form of a vaſe, Fig. 6.

RECREATION XXIV. p. 91

The water-ſun.

Two ſmall portions of a ſphere (Pl. VII. Fig. 7.) are joined together, and fixed to a pipe from whence a jet flows: near that part where the portions of the ſpheres join are a number of holes; and the water ruſhing violently into the

cavity is forced out of the holes, in the figure of the ſun. Several pieces of this ſort may be placed over each other, and the ſame pipe may ſupply them all, as in Fig. 8.

RECREATION XXV. p. 92

The revolving water-ſun.

A number of ſmall tubes are fixed in the ſide of a hollow circle, (Plate VIII. Fig. 1.) which is placed over a jet, in ſuch manner that it will turn freely round. The water ruſhing into the hollow circle keeps it in continual motion, and at the ſame time forcing out of the tubes, forms the figure of a revolving ſun.

RECREATION XXVI. p. 93

The phial of the four elements.

Glaſs, finely powdered, oil of tartar, tincture of ſalt of tartar, and diſtilled rock oil,

oil, are put into a phial, and ſhook together; after a ſhort time they ſeparate, and each aſſumes its place, according to its ſpecific gravity; the glaſs at bottom repreſenting the earth, the oil of tartar the water, the tincture the air, and the rock oil, which mounts to the top, the element of fire.

RECREATION XXVII. p. 94

The magic bottle.

A bottle, with a very ſmall neck, being filled with wine, and placed in a veſſel of water, (Plate VIII. Fig. 2.) the wine will come out of the bottle and float on the ſurface of the water, which will deſcend and fill the bottle. A ſimilar effect is produced by filling the bottle with water, and placing it, with the mouth downward, in a veſſel of wine.

RECREATION XXVIII. p. 96

The compound jet d'eau.

A tube with a very ſmall orifice is inſerted in the neck of a copper veſſel, (Pl VIII. Fig. 6.) in which there is a cock. Air is firſt injected by a ſyringe, and then water, and the cock is turned. This veſſel contains an extempore jet d'eau; for whenever the cock is opened, the water ruſhes out with great violence.

RECREATION XXIX. p. 98

The marvellous veſſel.

At the bottom of a tin veſſel, that has a narrow mouth, there are a great number of very ſmall holes. This veſſel is plunged in water, and corked when it is full, and as long as it remains ſo no water will come out, but when it is uncorked the water will run out of the holes

holes at the bottom of the veſſel. An experiment on the ſame principle, by placing a paper over a glaſs filled with water, then inverting the glaſs and drawing the paper away; when the water will remain ſuſpended in the glaſs.

RECREATION XXX. p. 99

The circulating fountain.

This fountain has two boxes, the uppermoſt of which is ſupported by two hollow pillars (Plate VIII. Fig. 5.) And on that box is placed a baſon, into which water being poured, it runs down one of the pillars, into the lower box, and driving the air up the other pillar, into the upper box, forces the water up a pipe, and forms a fountain. The water falling into the baſon, deſcends by the pillar, in the ſame manner as before, and making a freſh impulſe on the water in the upper baſon, by forcing the air up the other

other pillar, the fountain is kept continually playing, as long as any water remains in the upper box.

RECREATION XXXI. p. 102

The magical caſcade.

In a tin veſſel, (Plate VIII. Fig. 4.) water is poured, and in the center of it is fixed a pipe, whoſe upper end is above the water in the veſſel: to this pipe are joined four arms, by which it is ſupported over a baſon, at the center of which is a ſmall hole. At the bottom of the veſſel are ſeveral ſmall tubes, by which the water runs into the baſon; but when it riſes above the lower end of the pipe, in the center of the veſſel, the circulation of the air being ſtopped, the tubes ceaſe to flow. When ſo much of the water is run out of the baſon as to admit the air to enter the pipe, the tubes flow again; and thus they alternately

nately flow and ſtop, as long as any water remains in the veſſel.

RECREATION XXXII. p. 104

The illuminated fountain.

This fountain is formed by two cylindrical veſſels that are connected by four pipes, (Plate VIII. Fig. 7.) On the lower veſſel is placed a baſon, from which goes a tube, that reaches almoſt to the bottom of the veſſel, and by which water is poured into it. To each of the pipes a candleſtick is joined, and when the candles are lighted, the air in the pipes being rarified, that in the upper veſſel ruſhes down the pipes, and preſſing on the water in the lower veſſel, makes it riſe out of the tube, in form of a fountain: but when the candles are extinguiſhed, and the circulation of the air ſtopped, the fountain no longer plays.

RE-

RECREATION XXXIII. p. 105

The ſolar fountain.

A globe of thin copper, half filled with water, is placed on a frame (Plate VIII. Fig. 8.) There is a communication between the lower part of the globe, and a pipe placed in a baſon at the bottom of the frame, by one of the legs, which is hollow. Near the pipe in the baſon is a cock, by which the communication may be ſtopped. When the ſun ſhines on the globe the air within it being rarified, preſſes on the water, and forcing it down the leg of the frame, opens a valve at the bottom, and the water riſes out of the pipe in the baſon, in form of a fountain. At night the cold air preſſing on the adjutage ſhuts the valve, and ſtops the fountain; and at the ſame time preſſing on the water in the baſon, forces it back into the

the globe, ſo as to fill it to the ſame height as before.

RECREATION XXXIV. p. 108

The cup of Tantalus.

In a tall narrow cup (Plate IX. Fig. 1.) is placed an image, in which is concealed a ſyphon, that beginning at one foot riſes to the upper part of the breaſt, and from thence deſcending thro' the other foot, on which the image ſtands, goes out at the bottom of the cup. Therefore, when the liquor poured into this cup riſes to the chin of the image, it begins to run out.

RECREATION XXXV. p. 110

The ſea gage.

This inſtrument conſiſts of a hollow globe, (Plate IX. Fig. 2, and 3.) to which is fixed

fixed a tube, that is immerſed in a veſſel of mercury, on which floats a ſurface of treacle; and to the bottom is hung a weight, ſufficient to ſink the whole machine. While this inſtrument is ſinking the water will force the mercury and treacle up the tube, according to the depth it has deſcended, and the mark of the treacle on the tube ſhows to what height it has been forced. When the machine comes to the bottom, the weight ſtriking againſt the ground is diſengaged, by means of a catch and a ſpring, and the other parts of the machine riſe to the ſurface of the water. By the addition of the ball and tube, Fig. 3, the ſea may be ſounded to the depth of 13200 feet, that is, two miles and a half, p. 114

RECRE-

RECREATION XXXVI. p. 115.

The diving bell.

This machine is in form of a bell, (Plate IX. Fig. 4.) and is coated with lead. In the top is fixed a glaſs, to let in the light, and a cock to let out the foul air. Near the bottom is a circular ſeat for the divers to ſit on. This bell is ſupplied with air by two barrels, that are let down and drawn up alternately; and it is ſo light, in fair weather, that the divers can ſee to read diſtinctly. This machine is let down from the ſhip by a ſprit faſtened to the maſt-head. There is a contrivance to diſpatch a diver to the diſtance of a hundred yards, p. 120. Conſtruction of a different machine for a ſingle perſon, Fig. 5. p. 121.

PYRO-

PYROTECHNICS.

DEFINITIONS p. 127
APHORISMS 129

Abſolute and relative heat, aph. 1 to 3.—The effects of fire on other bodies, aph. 4 to 9.—Other properties of fire, aph. 10 to 12.

RECREATION XXXVII. p. 133

The inflammable phoſphorus.

The meal of any vegetable is put into an iron pan, where it is heated till it becomes a black powder. To one part of this powder are added four parts of alum, and the whole put into a phial, and placed in a ſand heat, and gradually raiſed till the glaſs and matter is red hot; the neck of the phial is then cloſed with wax. A ſmall quantity of this powder being ſhook out, immediately takes fire and burns. This phoſphorus will

will retain its virtue, if it be kept from the air, for three months.

RECREATION XXXVIII. p. 136

The liquid phosphorus.

A small piece of common phosphorus is boiled in water, and the mixture is put in a phial, which is sealed up. This mixture shines in the dark for several months, when the phial is shook. Pleasing recreations to be made with this phosphorus, p. 137.

RECREATION XXXIX. p. 137

The fulminating gold.

To a dissolution of gold in aqua regia common water is added, and to that mixture, the spirit of sal ammoniac: the gold that precipitates is taken out and dried. A grain of this powder put in a spoon, over a candle, will go off with a loud report.

RECREATION XL. p. 138

The burning fountain.

An eolipile, containing ſpirit of wine, is placed in a veſſel of boiling water (Plate X. Fig. 11.) To the eolipile is joined a pipe, whoſe orifice is extremely ſmall. The ſpirit is forced out of the eolipile by the heat of the water, and when a candle is brought near the veſſel, the ſpirit takes fire, and continues to burn, for ſome time. This phenomenon improved by ſifting over it the filings of iron, p. 140

RECREATION XLI. p. 140

Prince Rupert's drop.

A ſmall quantity of melted glaſs is dropped into water, where it aſſumes the form of a round body, with a ſmall tail; and when that tail is broke the whole drop burſts

bursts into a fine powder, and gives pain to the hand that breaks it. Conjecture on the cause of this phenomenon, p. 141.

RECREATION XLII. p. 142

The revivified rose.

A faded rose is held over the fumes of sulphur, when it becomes quite white: it is then dipped in water, and after five or six hours it becomes quite red.

RECREATION XLIII. p. 143

Writing on glass by the rays of the sun.

In a glass decanter, well stopped, that contains a dissolution of chalk in aqua fortis, is put a dissolution of silver. On the decanter is pasted a paper, from which letters are cut out; and when it is set in the sun the parts on the glass that form the letters turn black.

RECREATION XLIV. p. 144

The magic picture.

Between two pieces of glaſs placed at one-twentieth of an inch from each other, a diſtillation of hog's lard and white wax is poured. A coloured print is paſted with its face to one of the glaſſes, and the whole is put in a frame. When the mixture is cold the print is inviſible, but when the glaſſes are heated the print appears as if there was only one glaſs before it.

RECREATION XLV. p. 146

The luminous oracle.

In the front of an upright tin box (Pl. XII. Fig. 1.) is a ſmall ſquare hole, and in the back is a door, by which candles are put in. In the two ſides are grooves, in which ſlide a double glaſs, prepared as

as in the laſt recreation: behind this glaſs is paſted a black paper, from which letters are cut out, that anſwer queſtions wrote on cards. When a part of the glaſs that contains a particular anſwer is drawn up, before the hole, the heat of the candles makes the letters become viſible.

RECREATION XLVI. p. 149

To produce the appearance of a flower from its aſhes.

In the front of a tin box (Pl. XII. Fig. 4.) is a glaſs; behind it is a ſmall tin tube, in which a flower is placed, and behind that a double glaſs, prepared as in the 44th Recreation. You preſent a flower, ſimilar to that in the tube, to a perſon, which he throws on a chafingdiſh of hot coals; you then place the chafingdiſh under the box, and the heat makes the flower in the tube gradually viſible.

RECREATION XLVII. p. 151

To produce fire by the mixture of two cold liquors.

An equal quantity of the diſtilled oil of cloves or turpentine, and of Glauber's ſpirit of nitre, made as here deſcribed, are put together in a glaſs veſſel, and the mixture immediately takes fire and burns away.

RECREATION XLVIII. p. 152

Artificial lightning.

Powder of reſin is put in a tin tube that has holes on one ſide, by which the powder is ſhook over the flame of a torch, when it produces a corruſcation that ſtrongly reſembles lightning.

RECREATION XLIX. p. 153

Artificial thunder.

An ounce of oil of vitriol and two drams of iron filings are ſhook in a ſtrong bottle, and when a lighted candle is brought near the mouth of the bottle, an inflammation and a loud noiſe preſently enſue. A ſimilar exploſion produced by putting a certain quantity of the mixture of three parts of nitre, two of ſalt of tartar, and two of ſulphur, in an iron ſhovel over a coal fire.

RECREATION L. p. 155

The predicted earthquake and volcano.

Equal quantities of iron filings and ſulphur are ground together: about fifty pounds of this powder is wrought up with water into a ſtiff paſte, and buried a foot under the earth. In about eight

hours the ground will heave, emit ſulphureous ſteams, and at laſt, burſting into flames, form a true volcano.

RECREATION LI. p. 158

To imitate a jet de feu, column, globe, or pyramid of fire.

In a black or deep blue paper are made a number of cuts with the end of a penknife, and holes with a piercer, that all run in ſtraight lines, as in Plate X. Fig. 1, and 2: behind the paper is placed a ſtrong light, by which the figures appear as bright illuminations. To give theſe pieces motion, they muſt be placed on a wheel of thin wire, adapted to their figures, as that of Fig. 7. to the pieces 5 and 6; to theſe wheels any degree of velocity may be given. To repreſent pieces that flow from the circumference to the center, and at the ſame time others that flow from the center to the circumference, as in Fig. 9, a double ſpiral wheel

wheel, as Fig. 10, muſt be placed behind the other. When theſe pieces are of a ſmall ſize they ſhould be placed in a box, that no light may appear, but what comes through the paper p. 163

RECREATION LII. p. 166

To repreſent caſcades of fire.

The paper to repreſent a caſcade is wound upon a roller, as Plate XI. Fig. 3, and as the handle is turned, and the paper gradually deſcends, it livelily repreſents a caſcade of fire. A caſcade may be alſo repreſented by a ſpiral, as in Fig. 4.

RECREATION LIII. p. 169

Imitative illuminations.

Theſe illuminations differ from the preceding, in having figures of architecture, &c. drawn on the fore part of the paper, and thoſe parts only where the lamps are to appear, cut or pierced. They

They are placed in a box, with a very ſtrong light behind; and a faint light before them, to make the drawing on the front of the paper viſible. The light of all theſe illuminations ſhould be of different colours, according to the pieces they are to repreſent, and which is to be effected by paſting a very thin paper, tinged with a particular colour, over the parts cut out.

APPENDIX.

RECREATION LIV. p. 175

Chymical tranſcolorations.

Antimony and mercury, by different preparations, produce almoſt all the colours of nature. A gold colour is made by mixing a limpid liquor with a grey powder, and then changed to the colour of milk by being poured into a clean glaſs, p. 176. An almoſt limpid liquor turned blue, and that made pellucid.

lucid. Method of producing various blues and greens, p. 177.

RECREATION LV. p. 178

A colourleſs liquor is made black, by pouring it into a clean glaſs.

An infuſion of white galls is poured into a glaſs dipped in a ſolution of vitriol.

RECREATION LVI. p. 178

A pellucid liquor is turned black, by adding to it a white powder.

The ſame done by a pellucid drop, or by the addition of yellow or red powder, or by a drop of gold coloured liquor, p. 179.—Method of making any of theſe black liquors pellucid again, p. 180, and then again black, &c.

RECRE-

RECREATION LVII. p. 181

Different colours are produced by pouring a limpid liquor into a clean glaſs.

A ſolution of mercury or ſilver, in ſpirit of nitre, is poured into a glaſs dipped in ſpirit of ſea ſalt.

RECREATION LVIII. p. 182

The colour that appears and diſappears by the influence of the air.

A blue tincture made of copper filing diſſolved in volatile ſpirit, diſappears when the bottle is ſtopped, but when it is unſtopped, the colour preſently returns.

SYMPATHETIC INKS. p. 183

Theſe inks are of five ſorts; the firſt of which are thoſe that are inviſible till expoſed to the fumes of another liquor.

Diſ-

Different methods of making theſe inks, p. 184. Method of preparing the vivifying liquor to make this ink apparent.

RECREATION LIX. p. 189

The book of fate.

On ſeventy or eighty papers queſtions are wrote, and under them anſwers in theſe ſympathetic inks. Several of theſe papers are choſe by different perſons, who put them in a book that has the ſame number of leaves, and on which the ſame queſtions are wrote. In the cover of this book is concealed a double paper, dipped in the vivifying liquor, and the book is cloſed; when the vapour of the liquor, penetrating the leaves, makes the anſwers on the papers become viſible.

RECRE-

RECREATION LX. p. 191

The marvellous portrait.

At the bottom of a box (Plate XII. Fig. 5.) is placed a paper dipped in the vivifying liquor, and over it is put a pafteboard. Several papers, on which figures are drawn with the fympathetic ink, are given to a perfon, and he making choice of one of them, you tell him it fhall fhow him the portrait, and prefent the employment of an abfent friend: then putting the paper in the box, and preffing it down by a board over it, after a few moments you take it out, and fhow him a figure in the employment you intended.

RECREATION LXI. p. 193

The artificial hand.

A hand and arm of wood, conftructed mechanically, are placed on a pedeftal, covered

vered with green cloth (Pl. XII. Fig. 6.) Between the thumb and fore fingers, which are moveable, is placed a pen, and under that part of the cloth is put a paper dipped in the vivifying liquor. Several cards, on which queſtions are wrote, are given to a perſon, and he chooſing one of them, you place a paper, on which the anſwer is wrote in the ſympathetic ink, under the pen, and giving the arm a motion, by means of an aſſiſtant in an adjoining room, to the partition of which the arm joins, by the time the pen has paſſed over the paper the anſwer will be viſible.

Sympathetic inks of the ſecond claſs, which are thoſe that become viſible by being expoſed to the air. Inks of this kind made by the diſſolution of ſilver and other metals, p. 197.

RECRE-

RECREATION LXII. p. 198

The writing againſt the wall.

A queſtion is wrote with common ink, and under it the anſwer in this ſympathetic ink. This paper being placed againſt a wall, the anſwer will be viſible after twenty-four hours.

RECREATION LXIII. p. 199

The taliſman.

This taliſman conſiſts of a triangular metal box, (Plate XII. Fig. 7.) in the top of which is concealed a heated plate of of iron. A paper, on which a queſtion is wrote in common ink, and an anſwer in that ſort of ſympathetic ink which does not appear till it is heated, is put in the box, and after a few moments the anſwer appears; each word of which is of a different colour.

RECRE-

RECREATION LXIV. p. 202

The ſibyls.

On the top of a hollow pedeſtal (Plate XIII. Fig. 1.) is a dial, that has nineteen diviſions, in twelve of which are drawn the ſigns of the zodiac, and on the others the ſeven planets. To this dial is fixed an index, that is moved by a pulley underneath: this pulley communicates with two rollers in a box at the end of the pedeſtal, and on theſe rollers are wound a paper, on which is wrote the names of the ſeven ſibyls, one of which appears at an opening in the front of the box. On ſeven cards queſtions are wrote, and the ſigns of the planets drawn, and on the ſeven leaves of a book are wrote, in the ſympathetic ink that does not appear till heated, the the names of the ſibyls, and in each leaf, on pieces of paper, different an-

ſwers to each queſtion on the cards. A perſon chooſes one of the cards, and conceals the reſt; then ſets the index to the ſame planet on the circle as on his card, and covers the circle. He next opens the door in the front of the box, and tells you the name of the ſibyl. You then take out the papers in that leaf of your book where the name of that ſibyl is wrote, and the perſon chooſing one of them, puts it into the taliſman, and in a few moments it ſhows the anſwer.

RECREATION LXV. p. 207

The magic urn.

You draw on a paper the figure of a flower, with that ink which reſembles it in colour, and does not appear till heated. You then burn a flower of that ſort on a chafingdiſh of coals, and ſtrewing ſome of the aſhes over the paper, you put it in an urn, (Plate XIII. Fig. 5.) in which

which a ſmall heated cylinder is concealed, and taking it out preſently after, you ſhow the figure of the flower on the paper.

Methods of making yellow, red, green, and violet ſympathetic inks, of the ſecond claſs, that is, ſuch as are not viſible till another liquor is paſſed lightly over them, p. 209.—Preparation of the liquor to make theſe inks viſible, p. 211.

RECREATION LXVI. p. 212

The revivified bouquets.

A bouquet is made of artificial flowers, each of which is put in one of theſe ſympathetic inks. The bouquet is then dipped in the vivifying liquor, when each of the flowers preſently appears of its natural colour.

RECREATION LXVII. p. 213

The tranſcolorated writing.

You write ſeveral words on a paper with the violet ink, and aſk a perſon whether he will have them appear yellow, green or red. You then take a ſponge that has three diſtinct ſides, each of which is wetted with one of thoſe three ſympathetic inks, and draw one of the ſides of the ſponge over the writing, according to the colour required.

Sympathetic inks of the third claſs, that is, ſuch as become viſible by having a fine powder ſtrewed over them, p. 214.

RECREATION LXVIII. p. 214

Magical vegetation.

A leaf or flower being drawn with this ink, you burn a ſimilar leaf or flower, and ſtrew

its aſhes on the drawing, when the figure becomes immediately viſible.

Sympathetic inks of the fourth claſs, which are ſuch as become viſible by being expoſed to the fire, p. 215.

RECREATION LXIX. p. 216

The tranſmutable cards.

Over an ace of hearts draw, with this ſympathetic ink, a ſpade and four other ſpades on each ſide of it. Let a perſon draw this card, and another perſon the nine of ſpades, and let the laſt perſon burn his card. You give the aſhes to him who drew the heart, that he may put them, with that card, in a metal box, over a chafingdiſh, for a ſhort time, and when he takes it out, he finds it turned to the nine of ſpades.

RECREATION LXX. p. 217

The convertible cards.

You write on a card the word *law*, with this ink, and hold it before the fire till it is visible. You then add to and alter the letters of that word, with this ink, so as to make it *old woman*, and leave the alteration invisible. A person draws this card and writes his name on it, which you hold to the fire to dry, when the alteration you made becomes visible.

RECREATION LXXI p. 219

The oracular letters.

Several questions are wrote on different papers, in this ink, and held before the fire. The answers are wrote and left invisible. These papers are folded up in form of letters, with the answers under

der the part where they are ſealed, and the heat of the wax makes them viſible. A ſimilar experiment with a card enclоſed in a letter.

Method of making the ſympathetic ink of the fifth claſs, which does not appear till heated, and diſappears when cold, p. 221.

RECREATION LXXII. p. 222

The incomprehenſible writing.

The names of two cards are wrote with this ink, at the two ends of a paper (Pl. XIII. Fig. 6.) Two perſons draw the ſame cards privately, and you propoſe to make the names of thoſe cards appear on the paper, without knowing what they are. You then put the paper in a metal box, Fig. 4, under one end of whoſe cover is a heated plate of metal, and the names become, alternately, viſible.

RECREATION LXXIII. p. 225

Winter changed to ſpring.

In a print that repreſents winter, the trees, plants, &c. are traced over with this ink, and when the print is ſet in the ſun they become preſently green. If it be placed again in the cold, winter again appears: and thus the two ſeaſons may be changed, alternately, a great number of times.

Methods of making ſympathetic inks that appear by being wetted with water, p. 226.

RECREATION LXXIV. p. 228

The oracular mirror.

A mirror is moveable in a frame; (Plate XIII. Fig. 7.) on one ſide of this mirror is wrote, with Spaniſh chalk, the word *yes*;

yes; on the other ſide is wrote *no*: theſe words are wiped off, but when breathed on become viſible. A perſon aſking a queſtion, you put your mouth to the mirror, as if to whiſper to it, and the word *yes* or *no* appears immediately.

RECREATION LXXV. p. 230

The tree of Diana.

This tree is made by a globule of the amalgam of ſilver with mercury, put in a diſſolution of ſilver filings and mercury in aqua fortis. From this globule ariſe branches, that, by ſpreading, form a ſhrub or buſhy tree, of a ſilver hue. Another method of producing this tree, p. 231

RECRE-

RECREATIONS OF ADDRESS AND DEXTERITY.

Recreations with the cards—Method of making the paſs, p. 235.

RECREATION LXXVI. p. 237

The card of divination.

You make ſeveral perſons, who do not ſtand very near each other, draw the long card; and each perſon ſhuffles the pack. You then lay down ſeveral cards, among which is the long card, and aſk each perſon if he ſee his card. You ſhuffle the pack, and cutting at the long card, go up to one of the parties, and ſhow him his card; and repeat the ſame operation for all the others. Method of performing this Recreation by making the paſs, p. 239.

RECREATION LXXVII. p. 240

The four confederate cards.

You ſhow a perſon four cards that he may think on one of them: then dextrouſly place

place two of them at top and two at bottom. You take ſeveral cards from the bottom, and aſk the perſon if his card be among them: if not, you paſs the two cards from the top to the bottom, and ſhow one of them; and if that be not his card, you bid him draw it from the bottom. If his card be among thoſe you firſt drew, you ſeparate them dextrouſly from the reſt, place them at the bottom, and then do as before directed.

RECREATION LXXVIII. p. 241

The numerical card.

The ſixteenth card, in a piquet pack, is a long card. You take ſeveral from the top, and a perſon thinks of one of them. You make the paſs, and he telling you what number from the top his card was at, you count from that number to 16, and draw aſide the 17th, which is the card. You then aſk how many more you ſhall draw before the card appear,

which being done you throw down the card.

RECREATION LXXIX. p. 242

Divination by the ſword.

Place a card drawn under the long card, and then bring it to the top. Throw the pack on the ground, and obſerve where the top card falls. A handkerchief being bound over your eyes, in ſuch manner that you can ſee the ground, you touch ſeveral cards with a ſword, and at laſt fix it in the top card.

RECREATION LXXX. p. 243

The card thought on per force.

Several cards are ſpread before a perſon, in ſuch manner that only one is completely viſible, and you obſerve, carefully, whether the perſon fix his eye on that card: if not, you make him draw

draw a card, and perform ſome other Recreation.

RECREATION LXXXI. p. 244

The tranſmutable cards.

There are two cards of the ſame ſort, one of which is put at top, and the other next the bottom card. You ſhow a a perſon the bottom card, and convey it dextrouſly away; then drawing off the ſuppoſed bottom card, you direct the perſon to put it under his hand. You next ſhuffle the pack, and bringing the top card to the bottom, you ſhow it to another perſon, and convey it privately away; then drawing off the next card you direct the laſt perſon to put it under his hand, and command the cards under the two perſons hands to change places, which they will appear to do.

RE-

RECREATION LXXXII. p. 246

The three magical parties.

A perſon draws the long card, and puts it in any part of the pack. You make the paſs, and bring it to the top: then divide the pack into three heaps, and aſk him in which heap his card ſhall be, and at what number it ſhall appear. You place the heap he names over that at the top of where the card is, and after telling down the number of cards named, you make the paſs, bring the card to the top, and turn it up.

RECREATION LXXXIII. p. 247

The inverted cards.

One end of all the cards of a pack are cut a ſmall matter narrower than the other. A perſon draws a card, and when he puts it in again you offer the other end of

of the pack: the cards are then ſhuffled, and as you turn them up, one by one, you diſtinguiſh, by the touch, the card he drew.

RECREATION LXXXIV. p. 249

The card diſcovered by the touch or ſmell.

A perſon draws the long card, puts it in again, and ſhuffles the cards. You pretend to feel the figures on the cards, or ſmell to them, and when you come to the long card you turn it up.

RECREATION LXXXV. p. 250

The incomprehenſible tranſpoſition.

A card of the ſame ſort as the long card is put in an egg: you make a perſon draw the long card, and while he is breaking the egg, you conceal that card. This Recreation diverſified by offering ſeveral eggs that each contain the ſame card;

card; and by a confederate, who knows the egg in which the card is put.

RECREATION LXXXVI. p. 251

The card in the pocket-book.

This is performed by the aid of a confederate, who knows the card you have taken from the pack, and concealed in your pocket-book.

RECREATION LXXXVII. p. 252

To tell the card that a perſon has only once touched with his finger.

You agree with your confederate on certain ſigns, by which to expreſs the ſuit and particular card; and you fix on a perſon to touch the card who ſtands near your confederate.

RE-

RECREATION LXXXVIII. p. 254

To name ſeveral cards that two perſons have drawn from the pack.

You divide a piquet pack into two parts by a long card, and ſo diſpoſe the cards of each part that you can eaſily recollect them. You let a perſon draw two or more cards from the firſt part, and put them into the ſecond; and in like manner, another perſon draws from the ſecond part and puts them into the firſt, and by ſpreading the cards on the table, you eaſily diſtinguiſh which cards were drawn.

RECREATION LXXXIX. p. 255

The two convertible cards.

On the ace of ſpades a heart is ſlightly paſted, and on the ace of hearts a ſpade. You lay theſe two cards on the ground, at the ſame time ſlipping off the figures

paſted on them, and deſire two perſons to put each of them his foot on one of the cards, and you then command the two cards to change places; which they appear to do. Method of performing a ſimilar experiment with a ſingle card, p. 256.

RECREATION XC. p. 257

The fifteen thouſand livres.

You take two cards like Pl. XIV. Fig. 3. with an ace and five of diamonds; and by placing theſe cards in different poſitions, you make them appear to be either 3 or 15.

RECREATION XCI. p. 259

The card diſcovered under the handkerchief.

A perſon draws a card and puts it in the middle of the pack: you make the paſs, and bring it to the top. Then throwing

ing a handkerchief over the pack, you take off the top card, ſeeming at the ſame time to ſearch among the cards.

RECREATION XCII. p. 260

To change the cards that ſeveral perſons have drawn from the pack.

You make the paſs, bring the top card to the middle, and let a perſon draw it: then make the paſs again, and bring it to the middle, and let a ſecond perſon draw it; and ſo for three or four more. You after ſhow the card to the ſeveral parties, ſeparately, and they all acknowledge it to be the card they drew.

RECREATION XCIII. p. 261

The four inſeparable kings.

The four kings and two other cards are put at the bottom: one of the kings is

drawn and put at top; then the two other cards are drawn and put in different parts, and when the cards are cut all the kings will be together in the middle.

RECREATION XCIV. p. 262

To tell the number of cards by their weight.

There are two long cards, whose number from the top you know, and by cutting at these cards you tell the number over them.

RECREATION XCV. p. 263

To discover the card that is drawn, by the throw of a die.

The pack consists of only six sorts of cards repeated six times, and at the bottom of each parcel is a long card. A person draws one of these cards and puts it into the same parcel again. You cut the pack,

pack, by the long cards, into ſix heaps, and giving the perſon a die, tell him his card ſhall be in that heap which anſwers to the number he throws on the die.

RECREATION XCVI. p. 264

To ſeparate the two colours of a pack of cards by one cut.

The cards are prepared by cutting thoſe of one colour ſomething narrower than the others, as in a former Recreation, and then you ſeparate the two colours by one motion of your hands.

RECREATION XCVII. p. 266

The metamorphoſed cards.

Under a wide card in the middle of the pack is placed two particular cards, and two others of the ſame ſort at the top: and between them two cards on which figures are painted. You open the pack

at the wide card, and let a perſon draw one of the two cards and replace it: you then dextrouſly bring one of the painted cards at top to the middle, and ſhow him the change: you perform in the like manner with another perſon and the two other cards.

RECREATION XCVIII. p. 268

The cards in the opera glaſs.

At the end of an opera-glaſs is a ſmall card, but which appears there of the common ſize: this card has figures on both ſides, either of which is viſible by turning the glaſs differently. You make a perſon draw one of thoſe cards from the pack, and then ſhow it him in the glaſs.

RECREATION XCIX. p. 270

The magic ring.

Under a large tranſparent ſtone in a ring (Plate XIV. Fig. 9.) is the figure of a ſmall

ſmall card, and over it a piece of ſilk that may be drawn aſide, by turning the ſtone round. A perſon draws a ſimilar card from the pack, and burns it. You rub the ſtone with the aſhes, and turning it about, ſhow the perſon the card he burnt.

RECREATION C. p. 271

The card in the mirror.

A mirror is moveable in its frame, which is of the width of a card (Pl. XIV. Fig. 10.) A part of the quickſilver is ſcraped off the mirror, and a card fixed over that part, which is to be behind the frame. This mirror moves in a groove, and there are two ſtrings that go from the back of it, through the partition of the room. You make a perſon draw the ſame ſort of card as that in the mirror, and put it in the middle of the pack: you make the paſs, and bring it to the bottom; then tell him to look in the mir-

ror for his card, and while the confederate is bringing it forward you ſecrete the card he drew.

RECREATION CI. p. 274.

The marvellous vaſe.

A vaſe that is placed on a bracket (Plate XIV. Fig. 11.) has five diviſions, in three of which a ſingle card is placed, and in another a pack of cards. There is a ſtring that goes through the three ſmall diviſions down the bracket, and through the partition. Three perſons draw from a pack three cards of the ſame ſort with thoſe in the vaſe, and putting them in again, ſhuffle the pack, which you put in the fifth diviſion. Your aſſiſtant then makes the three cards riſe gently out of the vaſe, by drawing the ſtring. You take out the other pack, that you had previouſly placed in the fourth diviſion, and ſhow that the three cards are gone from it.

RE-

RECREATION CII. p. 276

The divinating perſpective glaſs.

A ſmall table of numbers is placed at the end of a perſpective glaſs. You give a perſon a pack of twenty-ſeven cards, that he may think on one of them. You then lay the cards down, ſingly, in three heaps; aſk the perſon in which heap his card is, and at what number it ſhall appear. Then look at that heap thro' the glaſs, and according to the number that ſtands in the perſpective againſt that he mentioned, you put that heap either at top, in the middle, or at bottom: this operation you perform three times, and then telling the cards down, one by one, the card he fixed on will be at the number he named.

RECRE-

RECREATION CIII. p. 280

The burnt writing reſtored.

The inſide of the cover of a memorandum-book is rubbed over with ſoot mixed with brown ſoap; under this cover you place a piece of paper, and give a perſon another paper, which he lays on the outſide of the book, and writes what he thinks proper, with a pencil you give him, and that will not mark without preſſing hard on it; therefore as he writes on the cover, the ſame letters will be impreſſed on the paper under it. You direct the perſon to burn what he has wrote, without ſhowing it; and going into another room to fetch a box, you take the paper from the memorandum-book, and put it in one ſide of the box. You return to the room, put a blank paper in the other ſide of the box, and preſently after turning it dextrouſly over, you take out the paper on which

the impreſſion is made, which the perſon will acknowledge to be his writing.

RECREATION CIV. p. 283

The opaque box rendered tranſparent.

A perſon writes what he thinks proper on a ſlip of paper, the memorandum-book deſcribed in the laſt Recreation being placed under it, and puts the paper in a box, which he keeps. You put the memorandum-book in the preſs mentioned in the 64th Recreation, and your confederate takes it out and puts it at the bottom of a perſpective, which you take out, and holding it over the box ſee what is wrote on the paper, pretending at the ſame time to ſee through the top of the box. A ſimilar experiment with a counter that is taken out of a bag, and another counter of the ſame ſort put at the bottom of a perſpective, p. 284.

RECREATION CV. p. 285

The tranſpoſable pieces.

Two guineas and two ſhillings are ground to half their common thickneſs, and then one of each ſort joined together. One of theſe double pieces is placed in one hand, with the guinea upward, and the other in the other hand with the ſhilling upward: then by cloſing your hands you turn the pieces over, when the ſhilling and guinea appear to have changed places.

RECREATION CVI. p. 286

The geometric money.

A piece of paſteboard, in form of a parallelogram, (ſee the Fig. p. 286.) is divided into thirty equal parts, in each of which is drawn the figure of a piece of money. This parallelogram is cut into four parts, and thoſe parts, when formed into two figures,

figures, as in p. 287, contain the figures of thirty-eight pieces of money.

RECREATION CVII. p. 288

The penetrative guinea.

In a tin box, of the ſize of a ſnuff-box, there are eight more, which go into each other; they all ſhut with a hinge, and the laſt is locked. Theſe boxes are placed in a drawer, and open. You deſire a perſon to lend you a new guinea, and mark it: this guinea you ſlip into the leaſt box, and cloſe them all at once in taking them out of the drawer; then having another new guinea in your other hand, and which is ſuppoſed to be the ſame, you pretend to make it paſs through the box, and convey it away. You then give the boxes to any one, and he opens them all to the laſt, of which you give him the key, and on opening that box he finds the guinea he had

had marked. This Recreation improved by ſlipping the key into a ſtranger's ſnuff-box, or by a confederate, p. 290.

RECREATION CVIII. p. 290

The reſuſcitated flower.

There is a double tin mortar, and between its two bottoms is a vacuity (ſee the Fig. p. 291.) At the ſide of this mortar is a ſpring, by which the bottom is turned round. Having placed a flower between the two bottoms, you take another of the ſame ſort, and pulling it to pieces, pound it in the mortar, which you then hold over a lamp, that the flower may be reſtored; and at the ſame time preſſing the ſpring with your finger, the bruiſed parts deſcend and the whole flower turns up, which you take out and preſent to the company.

AN

AN ARTIFICIAL MEMORY.

Methods of remembering numbers or dates by the vowels and conſonants, p. 293.—Words are to be remembered by joining their initials to vowels and conſonants, and forming thoſe combinations into verſes, p. 294.

THE END.