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HARRY HOUDINI
1927

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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.

VOL. I.

THE SECOND EDITION, CORRECTED.

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Harry Houdini
April 1927

RATIONAL

RECREATIONS.

VOLUME THE FIRST.

CONTAINING

ARITHMETICAL AND MECHANICAL

EXPERIMENTS.

ADVERTISEMENT.

AS the deſign of this work is to render uſeful knowledge eaſy and entertaining, the author has ſelected the principal part of the experiments from the writers on recreative philoſophy of the laſt and preſent centuries; from Baptiſta Porta to Ozanam and Guyot; the laſt, eſpecially, has furniſhed a large number of Recreations that are new and pleaſing, and from him alſo are copied ſeveral figures that the authors of the experiments they explain have only deſcribed. The writers on Electricity have alſo contributed a conſiderable quantity of Recreations, and ſuch as for pleaſure and ſurprize are inferior to none. Though this work is, in general, a compilation, ſome original experiments will be here found, and the whole, perhaps, will appear to be delivered with

more perſpicuity and conciſion, and digeſted in a manner more regular than has been hitherto attempted. The principles of each ſcience are, moreover, here laid down in a few plain aphoriſms, ſuch as require no previous knowlege, and very little capacity or attention to comprehend; ſo that the reader will readily diſcover, at the ſame time he admires the phenomena, the ſource from whence they proceed, and learn, that far from being marvellous or incomprehenſible, they are the regular and neceſſary effects of the laws of nature.

INTRODUCTION.

AMONG the various productions of the preſs, thoſe that are intended for inſtructive entertainment ſeem to deſerve ſome degree of attention, and that as well from the difficulty as the utility of the enterprize; for though to offer uſeful knowlege be ſufficiently eaſy, yet to render that knowlege engaging is oftimes extremely difficult. Man, careleſs, froward, ſtubborn, vain, impetuous, diſdains the imputation of

ignorance, and loaths the authoritative dictates of aſſuming ſuperiority.

Should we not, therefore, endeavour to render uſeful learning, not dull, tedious, and diſguſtful, not rugged and perplexing, not auſtere and imperious, but facile, bland, delightful, alluring, captivating? that Philoſophy, with his ſober garb and ſolemn aſpect, when led by the hand of the ſportive nymph Imagination, decked in all the glowing ever-varying colours of the ſkies, may gain admittance to the parties of the gay and careleſs; and while his aweful eye reſtrains the exuberance of her ſallies, the beams that dart from her radiant front may play upon his countenance, and diſſipate

pate the cloud that too frequently hangs o'er his brow.

Thus will the mind of man be pleasingly enlarged and fortified; he will unavoidably acquire a knowlege of his own ignorance; and by finding the fallacy of what he thought most certain, the evidence of the senses, he will learn to determine with caution on the seeming convictions of the mind, and divest himself of those prepossessions from whence so many of the evils of life proceed.

Thus may he advance with tranquil steps through the flowery path of investigation, till arriving at some noble eminence, he beholds, with awful astonishment, the immense riches in the

boundlefs regions of fcience, and becomes animated to attain a ftill more lofty ftation; while his heart is inceffantly rapt with joys of which the groveling herd have no conception, compared with whofe ignorance, the infenfibility of the blind and deaf, to the moft brilliant harmony of colours, or enchanting melody of founds, are but trifling imperfections.

Though this work is principally intended for the rifing generation, yet they whom a criminal indulgence of their guardians, or a flavifh fubmiffion to their own tyrannic paffions, have plunged in fenfuality till inceffant fruition hath produced an unconquerable loathing, or till age hath deprived them of appetite, and nought remains of

life

life but a wretched hankering after enjoyments they can never more obtain; even they will here find an entrance to new pleafures; they will fee, with grateful admiration, that all bounteous Providence has ftill in ftore for them, joys poignant yet tranquil, perpetually increafing, yet never cloying, and that it depends on themfelves ftill to purfue, even to the utmoft verge of life, a continual round of variegated pleafures.

To each volume is prefixed, a fhort defcription of the plates contained therein, with a reference to the page where they may be found; and to the figures in each plate, is annexed the page where fuch figure is fully dedefcribed in the work.

At the end of each volume is added a table of contents, in which is given a regular abſtract of every article; ſo that the reader, after having once peruſed the whole, by looking over the contents, will readily remember how every recreation is to be performed.

DESCRIP-

DESCRIPTION of the PLATES.

PLATE I. p. 20.

Fig. 1. Neper's rods. There are eleven of theſe rods placed perpendicular and cloſe to each other: on the firſt is wrote the nine digits, and on the laſt nine cyphers: the other nine contain a multiplication table.

Fig. 2. Example of the manner of placing the rods for multiplying and dividing.

Fig. 3. The Chineſe ſwan-pan. The perpendicular lines within the ſquare A B C D repreſent bars, that divide it into ſeven diviſions. The five horizontal lines in the upper diviſions, and the ſeven horizontal lines in the lower diviſions, on which are ſmall black circles, repreſent wires;

wires; the circles are balls moveable on thoſe wires, and by bringing them up to the middle bar they expreſs the ſum required.

PLATE II. p. 148.

The myſtical dial. The inner circle ILMN turns round on its center O, within the other circle E F G H, ſo that any letter of the former may be placed againſt the firſt letter of the latter, as ſhall be agreed on. The letters of the one are then wrote for thoſe of the other, as in the example under the figure.

PLATE III. p. 152.

The muſical cypher. The inner circle ILMN, on which the notes are wrote, turns round within the other circle, as in the laſt Plate, and the notes are here wrote for the letters, as in the example under the figure.

PLATE IV. p. 166.

Fig. 1. The machine for viſual correſpondence. ABCD, Fig. 1, is a circle of wood which turns on the center G: *a*, *b*, *c*, *d*, are pins by which it turns round. Through its circumference are cut the letters of the alphabet, and between A and Z is an open ſpace.

Fig. 2, is the pole to which the circle juſt mentioned is placed by its center, near P. The board E F, at top, prevents any letter from being ſeen, except that directly oppoſite the ſpace in its middle.

Fig. 3, is the machine for auricular correſpondence. The ſtrings to the two bells A and B, which are moveable on the croſs-piece C D, are pulled one or more times, according to the letter that anſwers to the number of ſounds.

PLATE V. p. 178.

This plate contains the primary mechanic inſtruments, or mechanic powers.

Fig.

Fig. 1, 2, 3, 4, are levers of different kinds; each of the other figures have their names annexed to them.

PLATE VI. p. 186.

Fig. 1 and 2. A dial to go without wheels, ſpring, or weight. C D, Fig. 1, is the cylinder, the ends of whoſe axis, as they deſcend, point to the hours marked on the columns E F.

Fig. 2, repreſents the internal ſtructure of the cylinder, which conſiſts of five diviſions, in three of which there is water, expreſſed by the ſhade.

Fig. 3 and 4. A dial to ſhow the hour by deſcending an inclined plane. A B, Fig. 3, the external appearance of the dial: *g*, a hemiſphere, on which a figure ſits that points to the hour.

Fig. 4, the internal ſtructure of the dial.

PLATE VII. p. 194.

Fig. 1 and 2, the inſcrutable lock. AB, Fig. 1, the ſcutcheon to the lock; C the pinion by which it is fixed in any poſition.

ABCD,

ABCD, Fig. 2, the twelve wards of the key, which turn round the pipe and are fixed together by the ſcrew E.

Fig. 3, the hand-mill to grind corn, &c. inceſſantly, without any animal force. ABCD a ſmoke-jack, that turns the rope EF, by which the mill is kept in continual motion.

PLATE VIII. p. 196.

Fig. 1. a carriage to go without any external force. ABCD, the figure of the carriage, with the perſon who rides in it, and the footman who drives it.

Fig. 2, repreſents the machinery by which it is moved, and which is concealed in a box behind the carriage. C D are two treddles that are puſhed down alternately by the man behind the carriage, and by means of the ropes C A, D A, turn the wheels H, H, which being fixed on the ſame axis with the great wheels I, I, turn them alſo.

PLATE IX. p. 200.

Fig. 1. The catapulta. ABCD, the frame in which the arrows are placed; E F the ſpring by which they are forced out. G the poſt to which the rope that bends the ſpring is faſtened.

Fig. 2. The ſailing chariot; A B the body of the chariot; C D the ſails; E the rudder, guided by the man at the helm A.

PLATE X. p. 206.

Fig. 1. A carriage to ſail againſt the wind. ABCD the body of the carriage; M the maſt; GEFH the ſails; K the cog-wheel, that takes the teeth placed perpendicular to the ſides of the fore-wheels; R the rudder by which it is guided.

Fig. 2. The uninvertible carriage. AB the body of the carriage; C the weight by which it is kept always upright; FGDE are iron circles in which it moves; P the door; O the window, and Q R the ſhafts.

PLATE XI. p. 212.

Fig. 1. The caſe of the columnar dial. AC the capital, that contains the ſtriking part of this dial; G H is the ſhaft on which are marked the hours; H the index, that by its deſcent ſhows the hour. The hand in the circle on the baſe B, points to the minute.

Fig. 2, ſhows the machinery of this dial, A is the wheel that moves the minute hand, and which is turned by the weight B, to which is fixed the hour hand H. F and G are two braſs wheels fixed on the axis DE. The wheel F raiſes the end M of the lever M N O, and makes the other end, to which the hammer P is fixed, to ſtrike the bell Q.

PLATE XII. p. 222.

Fig. 1, is an air chronometer. AB is a glaſs tube; CD the frame in which it is placed; E a piſton to let out the air; F the ſtring by which the piſton is drawn up; G the handle that confines the ſtring of the piſton.

Fig.

Fig. 2, ſhows the form of the piſton in the tube.

Fig. 3, a conical roller to receive the ſtring to the index of a dial, when placed over the tube.

Fig. 4. A lamp chronometer. A is a ſmall glaſs lamp, placed in the ſtand B. C the handle that ſupports the ſtyle H, and the frame D E F G, which is covered with oiled paper, and on which are wrote the figures for the hours.

Fig. 5. A nocturnal dial. A and B are two wheels of the ſame dimenſion, and concentral; C a pinion; D and E two wheels placed on the ſame axis; F a lamp fixed on the edge of the wheel B; G the weight that gives motion to the whole machine.

Fig. 6, is a hollow cone, by which the flame of the lamp F is confined to a particular part of the wheel A.

RATIONAL

RATIONAL RECREATIONS.

ARITHMETIC.

DEFINITIONS.

WE ſhall not here define the primary principles of numbers, as our readers are ſuppoſed to underſtand the four firſt rules of arithmetic, addition, ſubtraction, multiplication, and diviſion; we ſhall therefore begin with arithmetic powers.

1. By the powers of any number, is meant the ſeveral times that number is multiplied into itſelf. Thus, if 4 be multiplied by itſelf, the product 16 will be its ſecond power, or ſquare; and if that ſum be multiplied by 4, the product 64 is the third power, or cube of 4, &c.

2. The root of any power is that number from whence it firſt ſprung, or was multiplied: ſo the ſquare root of 16 is 4; and the cube root of 27 is 3.

3. When two numbers are compared together, the firſt is called the antecedent, and the ſecond the conſequent; and the proportion theſe numbers bear to each other is called their ratio. Thus, the ratio of 27 to 9, is that of 3 to 1.

4. When three numbers are compared together, if the difference between each of them be equal, as 2, 4, 6, or 9, 6, 3, they are ſaid to be in arithmetic proportion.

5. If three numbers be compared together, and they have one common ratio, that is, the ſame multiplier or diviſor, as 3, 9, 27, or 64, 16, 4, they are in geometric proportion.

6. Whenever the conſequent is double the antecedent, they are ſaid to be in duplicate proportion; but if the antecedent be double the conſequent, they are in ſubduplicate proportion.

7. When any ſeries of numbers continually increaſes or decreaſes by an equal addition or ſubtraction, as 2, 4, 6, 8, &c. or 18, 15, 12, 9, &c. they are ſaid to be in arithmetic progreſſion.

8. When a ſeries of numbers continually increaſes or decreaſes by one common multiplier or diviſor, that is, by one common ratio, as 4, 8, 16, 32, &c. or 81, 27, 9, 3, they are in geometric progreſſion.

9. If over a ſeries of numbers in geometric progreſſion, there be placed another in arithmetic progreſſion, whoſe common difference is 1, as thus, $\left.\begin{matrix} 1, & 2, & 3, & 4, & 5, \\ 2, & 4, & 8, & 16, & 32, \end{matrix}\right\}$ &c. the latter are called the indices or exponents of the former; and if the geometric ſeries begin with 1, the other muſt begin with a cypher, thus, $\left.\begin{matrix} 0, & 1, & 2, & 3, & 4, \\ 1, & 2, & 4, & 8, & 16, \end{matrix}\right\}$ &c.

10. The ſeveral different ways that one number of quantities can be taken out of another greater number, of the ſame ſort, are

are called the combinations of the former in the latter. Thus, the different ways, that three balls can be taken out of ſix, are the combinations of 3 in 6.

11. All the different ways the whole of any number of quantities can be taken or diſpoſed, are called the permutations of that number; ſo all the different ways that ſix counters can be placed in a line, are the permutations of the number 6.

APHORISMS.

1. If two even numbers be added together, or ſubtracted from each other, their ſum or difference will be an even number.

2. If two uneven numbers be added or ſubtracted, their ſum or difference will be an even number.

3 The ſum or difference of an even and uneven number will be an uneven number.

4. The product of two even numbers will be an even number; and the product of two uneven numbers will be an uneven number.

5. The product of an even and uneven number will be an even number.

6. If two different numbers be diviſible by any one number, their ſum and their difference will be alſo diviſible by that number.

7. If ſeveral different numbers, diviſible by 3, be added or multiplied together, their ſum and their product will alſo be diviſible by 3.

8. If two numbers, diviſible by 9, be added together, the ſum of the figures in the amount will be either 9, or a number diviſible by 9.

9. If any number be multiplied by 9, or by another number diviſible by 9, the amount of the figures of the product will be either 9, or a number diviſible by 9.

10. In every arithmetic progreſſion, if double the ſum of all the terms in any ſeries be divided by the firſt and laſt term added together, the quotient will

be the number of all the terms in that ſeries*.

11. In

* This and the following aphoriſms, relating to progreſſions, may be applied to many uſeful to purpoſes beſides thoſe mentioned in the courſe of this work. For example.

1. A man is to go a journey of 1120 miles, 40 of which he propoſes to ride the firſt day, and to increaſe the number, by an equal addition, every day to the laſt, when he intends to ride 100 miles. How long will he be going his journey?

You have here the firſt term 40, the laſt term 100, and the ſum of all the terms 1200, to find the number of terms: therefore, by aphoriſm 10, if the double of 1120, that is 2240, be divided by 40 added to 100, the quotient, which is 16, will be the number of terms, or days he will be going.

But, by the 11th aphoriſm, if the difference between the firſt and laſt term, that is 60, be divided by the number of terms leſs 1, which is 15, the quotient 4 will be the common difference, or number of miles he muſt add each day.

2. A father intends to lay up 10l. toward his daughter's portion the day ſhe is a year old, and to increaſe the ſum as much every year as ſhall make her fortune, at the end of 20 years, 1000l. What will he have to lay up the laſt year?

Here the firſt term, number of terms, and ſum of the ſeries are given, to find the laſt term; therefore,

11. In every such series, if the difference between the first and last term be divided by

fore by aphorism 12, if from double the sum of the series, which is 2000, you subtract the product of the first term, multiply by the number of terms, that is 200, and divide the remainder, which will be 1800, by the number of terms, the quotient 90 is the last term, or number of pounds he must lay up the last year.

3. A gentleman proposes to plant a number of trees in his grounds, for 20 years together, in regular progression, 20 the first year, and 100 the last. How many trees will he plant?

By aphorism 13, if you multiply the first and last term by the number of terms, and divide the sum of the two products, which is 2400, by 2, the quotient 1200 is the number of trees he must plant.

4. A landlord asks 5l. a year for an acre of land, which the farmer thinking too much, the landlord offers to let him a lease of it, for 21 years, at 1d. the first year, 2d. the second year, 4d. the third, and so on, doubling the sum every year. What would the farmer pay the last year? and what would be the average rent for the whole term?

Here the 20th term (which is to be considered as the last, the first term being 1, which neither multiplies nor divides) will be found, by the 14th aphorism to be 1,048,576 pence, or 4369l. 1s. 4d. which

by the number of terms, leſs 1, the quotient will be the common difference between each term of that ſeries.

12. If the product of the number of terms multiplied by the firſt term, be ſubtracted from double the ſum of the ſeries, and the remainder be divided by the number of terms, the quotient will be the laſt term.

13. If the firſt and laſt term be each multiplied by the number of terms, and the ſum of the two products be divided by two, the quotient will be the ſum of the ſeries.

14. In every geometric progreſſion, if any two terms be multiplied together,

which is the rent he will pay the laſt year. But, by aphoriſm 15, to find the ſum of the ſeries, the laſt term muſt be multiplied by the ratio 2, which will make it 2,097,152, and from that ſum, the firſt term 1, muſt be deducted, when it will be 2,097,151, and that ſum is to be divided by the ratio 2 leſs 1, that is by 1; therefore it will remain the ſame, and conſequently be the ſum of the ſeries. Then dividing 2,097,151 by 21, the number of years, the quotient 99,864, or 416l. 2s will be the average rent for each year.

their

their product will be equal to that term which anſwers to the ſum of their two indices. Thus, in the ſeries, $\begin{matrix}1, & 2, & 3, & 4, & 5,\\ 2, & 4, & 8, & 16, & 32,\end{matrix}$ if the third and fourth terms, 8 and 16, be multiplied together, the product 128 will be the ſeventh term of that ſeries. In like manner, if the fifth term be multiplied into itſelf, the product will be the tenth term; and if that ſum be multiplied into itſelf, the product will be the twentieth term, &c. Therefore, to find the laſt, or any other term of a geometric ſeries, it is not neceſſary to continue the ſeries beyond a few of the firſt terms.

15. In any geometric ſeries, if you multiply the laſt term by the common ratio, from the product ſubtract the firſt term, and divide the remainder by the ratio, leſs 1, the quotient will be the ſum of that ſeries.

16. In all combinations, if from an arithmetic decreaſing ſeries, whoſe firſt term is the number out of which the combinations

binations are to be formed, and whose common difference is 1, there be taken as many terms as there are quantities to be combined; and those terms be multiplied into each other: and if from the series, 1, 2, 3, 4, &c. there be taken the same number of terms, and they be multiplied into each other, and the first product be divided by the second, the quotient will be the number of combinations required. Therefore, if you would know how many ways four quantities can be combined in seven, multiply the first four terms of the series, 7, 6, 5, 4, &c. together, and divide the product, which will be 840, by the product of the first four terms of the series, 1, 2, 3, 4, &c. which is 24, and the quotient 35 will be the combinations of 4 in 7.

17. In all permutations, if the series 1, 2, 3, 4, &c. be continued to as many terms as there are quantities to be changed, and those terms be multiplied into each other, the product will be the number of permutations sought. Thus, if you would

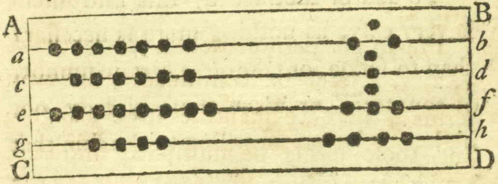
know

known how many permutations can be formed with five quantities, multiply the terms, 1, 2, 3, 4, 5, together, and the product 120 will be the number of all the permutations*.

Previous to the numerical Recreations, we ſhall here deſcribe certain mechanical methods of performing arithmetical operations, ſuch as are not only in themſelves entertaining, but will be found uſeful on ſeveral occaſions.

The ROMAN ABACUS.

ON a board about a foot long, and of the form of ABCD in the following figure, draw ſeveral lines, as *a b*, *c d*, *e f*, *g h*, &c. the number of theſe lines may be increaſed at pleaſure.



* For farther examples of combinations and permutations, ſee Recreations XVIII. XIX. &c.

On

On each of theſe lines, and on the ſpaces between them, there are to be placed a certain number of counters, according to the ſum or quantity that is to be ſet down. The counters on the loweſt line ſtand for units, thoſe on the ſecond line for tens, thoſe on the third for hundreds, &c. and the counters between the lines ſtand always for half the value of thoſe on the line next above. Therefore, if you would ſet down 7684, you place four counters on the loweſt line, eight on the next above, ſix on the next, and ſeven on the uppermoſt line. Or you may ſet down the ſame ſum by placing part of it on the lines, and the reſt between them, as you ſee in the figure.

To add or ſubtract by this inſtrument is very eaſy, as nothing more is neceſſary than to ſet on, or take off, a certain number of counters; or place thoſe already on, higher or lower, according to the ſum that is to be expreſſed.

By

By this invention a perſon who has not learned to write may ſet down any ſum of money, or other quantity whatever; for the counters on the ſeveral lines, inſtead of tens, hundreds, &c. may ſtand for hundred weights, quarters, pounds; or for years, months, days, hours, &c. and, according to the length of the board, ſeveral ſums of different denominations may be ſet down at the ſame time.

NEPER's RODS.

DIVIDE a ſquare piece of braſs, ivory, or paſteboard, as A B C D, (Pl. I. Fig. 1.) into ninety-nine equal parts, as in the figure: in the nine parts next the left hand write the nine digits; in thoſe next the rigth hand write nine cyphers, and in thoſe at top the nine digits. Separate the remaining diviſions into two parts, by a line drawn from the upper angle on the right ſide, to the lower angle on the left, and on theſe diviſions write the

the multiplication table, obſerving when there are two figures, to place the units in the right hand diviſion, and the tens in the left. Then ſeparare the eleven columns by cutting them aſunder from top to bottom, and you will have Neper's rods or bones*.

Theſe rods are to be placed in a box of the length and depth of the ſquare ABCD, and wide enough to hold ſix, nine, or as many more of each ſort as you pleaſe. The uppermoſt figure of each rod muſt ſtand out, above the box, that it may be eaſily diſtinguiſhed. The rods have ſometimes figures on each of their four ſides to anſwer different purpoſes. On the front of the box there muſt be a ledge to ſupport the rods as they are taken out and placed in order.

To multiply any ſum by theſe rods, ſuppoſe 5486 by 273, firſt, take out the

* So called from the inventor J. Neper, baron of Merchiſton in Scotland.

index rod of digits next the left hand, and place it againſt the ledge; then take each of thoſe rods that have at top one of the figures of the multiplicand, beginning with the figure 5, and place them in order as you will ſee in Pl. I. Fig. 2. You are then to ſet down the ſum that ſtands againſt each figure of the multiplier, with this caution, that when there are two figures in any ſquare, you are to add that in the left diviſion to the figure in the right diviſion of the following ſquare, beginning with the right hand column. For example, in the column that ſtands againſt 3 in the digits (Fig. 2.) you firſt ſet down the 8, and carrying the 1 to the 4 in the next diviſion, you ſet down 5; then adding the 2 on the ſecond diviſion to the 2 in the third, you ſet down 4; then adding 1 to 5, you ſet down 6, and, laſtly, the figure 1. This may be done almoſt as faſt as you can copy the figures; and ſo of the other figures in the multiplier, and the operation will ſtand as follows:

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   5486
    273
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  16458
 38402
10972
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1497678
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To divide by these rods, suppose 748524 by 2793, place the rods that contain the several figures of the divisor, with the index rod, in the same manner as in the last example, and you will have the product of that divisor by each of the nine digits. Then take the first four figures of the dividend 7485, and look for that number on the rods which is the next less to it; which you will find to be 5586, that stands against the figure 2; you therefore put 2 for the quotient, and subtracting the last number from the first, bring down another figure from the dividend. You then look again for the nearest sum to that, and so on till you have taken down all the figures of the dividend, when

when you will find the whole quotient to be 268.

The CHINESE SWAN PAN.

IN the ſquare frame of wood, ABCD, (Pl.I.Fig.3.) make four diviſions by the bars, EF and GH; and ſeparate three of theſe diviſions into two parts by the leſſer bars, *a b*. In each of the ſmaller diviſions place wires, to be taken out at pleaſure; and on each of the wires in the left-hand diviſions, ſtring a ſmall ivory ball, or large bead; and on the wires on the right hand diviſion, place four ſuch balls, or beads.

The balls in the left hand diviſions, when brought up to the middle bar, ſtand each for five; and thoſe in the right diviſions, when brought to the bar, ſtand for units.

The balls in the two lower diviſions repreſent integers, or the whole of any

quantity; thoſe on the uppermoſt wire ſtand for tens of ſuch integers, the next for hundreds, and ſo on, as is expreſſed, in the figure. The wires, in all the diviſions, may be increaſed to any number you think proper.

The balls in the four upper diviſions repreſent parts of integers; thoſe in the two diviſions next the left hand ſtand for tens; and thoſe in the two other diviſions, for units of ſuch parts*.

Now if the ſum you would ſet down be integers, begin with the balls in the two lower diviſions; for example, on the third row from the top bring two balls, of the right hand diviſion, up to the middle bar (ſee the Figure); then bring up two on the next row, and one on the ſame row in the left diviſion; next four on the

* This is not the original Swan Pan mentioned by Du Halde, in his Hiſtory of China, but an improvement on that by Mr. G. Smethurſt, of Mancheſter, publiſhed in the Gent. Mag. for 1748.

top row, and one on the other ſide of the ſame row; then in the firſt row of units, from the bottom, and in the right hand diviſion, place two balls, on the ſecond row one, and one alſo on the ſame line in the right hand diviſion of tens: laſtly, on the third row of units place three balls. The balls being thus placed, if the integers be pounds ſterling, they will expreſs 279l. 2s. 11d $\frac{3}{4}$. If the integers be hundred weights, the ſum will be 279 cwt. 2 qrs. 11lb. 3 oz or if they be years, they will denote 279 years, 2 months, 11 days, 3 hours.

A part of theſe balls may repreſent fractions, either vulgar or decimal; the balls in the firſt two diviſions of parts may ſtand for the numerators, and thoſe in the other two for denominators; or the numbers in either of theſe diviſions may be added to thoſe in the integers, as decimals*.

* There may alſo be holes made in the bars where the dots are placed, in which pegs may be occaſionally put, to ſhew that thoſe numbers ſtand for fractions.

By this inſtrument all the operations of arithmetic may be readily performed: ſuppoſe, for example, you would multiply the ſum ſet down in the diviſion of integers, that is 279 by 3. Begin with the loweſt line, and ſay 3 times 2 is 6, therefore ſet that number up; then on the next row, ſay 3 times 7 is 21, therefore inſtead of 7 ſet up 1 on that line, and carry the two tens to the line below, which will make the number there 8. Then at the upper line ſay, 3 times 9 is 27, therefore ſet 7 on that line, and carry 2 to the next line below, which will make that number 3. So that the balls on the three lines will then expreſs 837.

If you would divide 279 by 3, begin in like manner with the loweſt line; but as 3 cannot be taken in 2, you add the next number to it, and ſay, the threes in 27 are 9, therefore ſet back the 2 on the loweſt line, and place 9, inſtead of 7, on the next line above; then at the uppermoſt line

Fig. 1. p. 13.

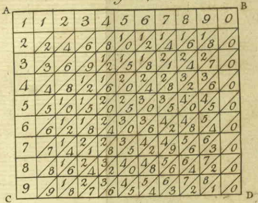


Fig. 2. p. 15.

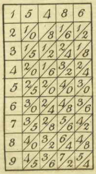
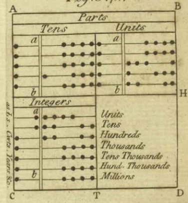


Fig. 3. p. 17.



J. Lodge sculp.

line say, the threes in 9 are 3; therefore inſtead of 9 place 3 on that line, and conſequently the quotient will be 93. When there is a remainder it may be placed with the diviſor, as a fraction, in the upper diviſions. Where there are many figures in the multiplicand and multiplier, the latter may be placed in the firſt two diviſions of parts, and the former and products in the diviſions of integers. In like manner, when there are ſeveral figures in the dividend and diviſor, the former may be placed in the diviſion of integers, the latter in the firſt two diviſions of parts, and the figures of the quotient, as they riſe, in the remaining two diviſions.

It is well worth obſerving, that by means of this inſtrument a blind man may be taught to add, ſubtract, multiply, divide, and perform all the other operations of arithmetic, with as much certainty as another perſon can by figures.

RECREATION I.

Any number being named, by adding a figure to that number to make it divisible by nine.

IF the number named be, for example, 72,857, you tell him who names it to place the number 7 between any two figures of that ſum, and it will be diviſible by 9. For by aphoriſm 9, if any number be multipled by 9, the ſum of the figures of the product will be either 9, or a number diviſible by 9. But the ſum of the fiures named is 29, therefore 7 muſt be added to make it diviſible by 9.

You may diverſify this recreation, by ſpecifying, before the ſum is named, the particular place where the figure ſhall be inſerted, to make the number diviſible by 9.

RECREATION II.

A perſon having an even number of counters in one hand, and an odd number in the other, to tell in which hand the odd or even number is.

LET the perſon multiply the number in his right hand by an odd number, and the number in his left hand by an even number, and tell you if the ſum of the products added together be odd or even. If it be even, the even number is in the right hand; but if it be odd, the even number is in the left hand: as is evident from the firſt five aporiſms.

Example.

1. Number in the right hand	18	In the left	7
Multipliers	3		2
	54		14
	14		
Their ſum	68		

 2. Num-

2. Number in the right hand	7	In the left	18
Multipliers	3		2
	21		36
	36		
Their sum	57		

RECREATION III.

A person making choice of several numbers, another shall name him the number by which the sum of those numbers is divisible.

PROVIDE a small bag, divided into two parts: in one part put several tickets, on each of which is wrote a number divisible by three, as 6, 9, 15, 36, 63, 120, 213, 309, &c. and in the other part put tickets marked with the number 3 only. From the first part draw a handful of tickets, and after shewing them, put them in again; then open the bag, and desire any one to take out as many tickets as he

thinks proper; ſhut the bag, and when you open it again offer the other part to another perſon, telling him to take out one ticket only: you then pronounce that ticket to contain the number by which the amount of the other numbers is diviſible. For each of thoſe numbers being diviſible by 3 their ſum alſo, by aphoriſm 7, muſt be diviſible by the ſame number.

RECREATION IV.

To find the difference between two numbers, the greateſt of which is unknown.

TAKE as many nines as there are figures in the ſmalleſt number, and ſubtract that ſum from the number of nines. Let another perſon add that difference to the largeſt number, and taking away the firſt figure of the amount, add it to the laſt figure, and that ſum will be the difference of the two numbers*.

* See the eight aphoriſm.

For

For example, Matthew, who is 22, tells Henry, who is older, that he can diſcover the difference of their ages; he therefore privately deducts 22 from 99, and the difference, which is 77, he tells Henry to add to his age, and to take away the firſt figure from the amount, and add it to the laſt figure, and that laſt ſum will be the difference of their ages, As thus:

The difference between Matthew's age and 99 is	77
To which Henry adding his age	35
The ſum is	112
	12
	1
Then by taking away the firſt figure 1 and adding it to the laſt figure 2, the ſum is	13
Which added to Matthew's age	22
Gives the age of Henry, which is	35

RECRE-

RECREATION V.

To tell, by the dial of a watch, at what hour any person intends to rise.

LET the person set the hand of the dial to any hour he please, and tell you what hour that is, and to the number of that hour you add, in your mind, 12. Then tell him to count privately the number of that amount upon the dial, beginning with the next hour to that on which he proposes to rise, and counting backwards, first reckoning the number of the hour at which he has placed the hand. An example will make this plain.

Suppose the hour at which he intends to rise be 8, and that he has placed the hand at 5. You add 12 to 5, and tell him to count 17 on the dial, first reckoning 5, the hour at which the index stands, and counting backwards from the hour at which he intends to rise, and the number

17 will neceſſarily end at 8, which ſhews that to be the hour he choſe.

That the hour at which the counting ends muſt be that on which he propoſed to riſe, will be evident on a little reflection; for if he had began at that hour and counted 12, he would neceſſarily have come to it again; and calling the number 17, by adding 5 to it, only ſerves to diſguiſe the matter, but can make no ſort of difference in the counting.

RECREATION VI.

A perſon chooſing any two, out of ſeveral given numbers, and after adding them together, ſtriking out one of the figures from the amount, to tell what that figure was.

SUCH numbers muſt be offered as are diviſible by 9; and when any two of them are added together there muſt be no cypher in the amount: the figures of that amount,

amount, moreover, muſt make either 9 or 18. Such are the numbers following; 36, 63, 81, 117, 126, 162, 207, 216, 252, 261, 306, 315, 360, and 432.

Theſe numbers muſt be wrote on cards; and when any two of them are added together, if a figure be ſtruck out of the ſum, it will be what would make the other figures either 9 or 18. For example; if a perſon choſe 126 and 252, their ſum will be 378, from which if he ſtrike out the 7, the remaining figures 3 and 8 will make 11, to which 7 muſt be added to make 18.

RECREATION VII.

Two perſons chooſing two numbers, and multiplying them together, by knowing the laſt figure of the product to tell the other figures.

IF the number 73 be multiplied by the numbers of the following arithmetical progreſſions, 3, 6, 9, 12, 15, 18, 21, 24, and

27, their products will terminate with the nine digits in this order, 9, 8, 7, 6, 5, 4, 3, 2, 1; the numbers being as follows, 219, 438, 657, 876, 1095, 1314, 1533, 1752, 1971; therefore put into one of the divisions of the little bag, mentioned in the third Recreation, several tickets marked with the number 73, and into the other part of the bag the numbers 3, 6, 9, 12, 15, 18, 21, 24, and 27.

Then open that part of the bag where are the numbers 73, and desire a person to take out one ticket only, then dextrously change the opening, and desire another person to take a ticket from that part; and when they have multiplied their two numbers together, by knowing the last figure of the product you will readily tell them, by the foregoing series, what the other figures are.

RECREATION VIII.

The Magical Century.

IF the number 11 be multiplied by any one of the nine digits, the two figures of the product will always be ſimilar. As follows:

11	11	11	11	11	11	11	11	11
1	2	3	4	5	6	7	8	9
11	22	33	44	55	66	77	88	99

Place a parcel of counters on a table, and propoſe to any one to add, alternately, a certain number of thoſe counters, till they amount to a hundred, but never to add more than 10 at one time. You tell him, moreover, that if you ſtake firſt he ſhall never make the even century, but you will. In order to which you muſt firſt ſtake 1, and remembering the order of the above ſeries, 11, 22, 33, &c. you conſtantly add, to what he ſtakes, as many as will make one more than the numbers of that ſeries, that is, as will make 12, 23, 34, &c.

&c. till you come to 89, after which the other party cannot make the century himſelf, or prevent you from making it.

If the other party has no knowledge of numbers, you may ſtake any other number firſt, under ten, provided you take care to ſecure ſome one of the laſt terms, as 56, 67, 78, &c.

This Recreation may be performed with other numbers; and in order to ſucceed, you muſt divide the number to be attained, by a number that has one digit more than what you can ſtake each time, and the remainder will be the number you muſt firſt ſtake. Obſerve, that to be ſure of ſucceſs, there muſt be always a remainder. Suppoſe, for example, the number to be attained is 52, making uſe of a pack of cards inſtead of counters, and that you are never to add more than 6; then divide 52 by the next number above 6, that is, by 7, and the remainder, which

is 3, will be the number you muſt ſtake firſt; and whatever the other ſtakes, you muſt add as much to it as will make it equal to the number by which you divided, that is, 7. Therefore if his firſt ſtake be 1, you muſt ſtake 6, &c. ſo that your ſecond ſtake will make the heap 10, your third ſtake will make it 17, and ſo on, till you come to 45, when as he cannot ſtake more than 6, you muſt make the number 52.

In this, as in the former caſe, if the other perſon have no knowledge of numbers, you may ſtake any number firſt under 7; or you may let him ſtake firſt, only taking care to ſecure either of the numbers 10, 17, 24, 31, &c. after which he cannot make 52, if you conſtantly add as many to his ſtake as will make it 7.

RECREATION IX.

The Confederate Counters.

PRESENT to three perſons a ring, a ſeal, and a ſnuff-box, of which deſire each perſon to chuſe one, privately. The three perſons you diſcriminate in your mind by the letters A, E, I, and by the ſame letters you diſtingniſh the ring, the ſeal, and the box. Provide 24 counters, of which give the firſt perſon A, 1, the ſecond perſon E, 2, and the third perſon I, 3. Put the 18 remaining counters on the table, and let him that has the ring take as many counters more as he already has; him that has the ſeal take twice as many as he has, and him that has the box four times as many. While they are taking the counters you retire out of ſight, and when they have done you return, and caſting your eye on the table, take notice how many counters are left.

The

The remaining counters will be either 1, 2, 3, 5, 6, or 7, which you are to refer to the vowels in the syllables of the following verse:

1	2	3	5	6	7
Par fer—	Ce sar—	ja dis—	de vint—	si grand	prince.

If there be but one counter left, the two vowels in the syllables *par fer* denote that the first person has the ring, to which you have assigned the letter A; the second person has the seal, to which you have assigned the letter E; and consequently the third person must have the box. In like manner, if there be six counters remaining, the two vowels in the syllables *si grand*, shew that the first person has the box, denoted by the letter I; the second person has the ring, to which the letter A is assigned; and consequently the third person has the seal: and so of the rest.

It appears by aphorifm 16, that the three articles can be taken only fix different ways. Now each of thefe ways neceffarily changes the number of counters to be taken by the three perfons: from whence it follows, that the counters remaining on the table will alfo be of fix different numbers; the vowels in the fyllables of the verfe ferve only to aid the memory in difcovering the manner in which the three articles are taken.

RECREATION X.

A perfon privately fixing on any number, to tell him that number.

AFTER the perfon has fixed on a number, bid him double it and add 4 to that fum, then multiply the whole by 5; to the product let him add 12, and multiply the amount by 10. From the fum of the whole let him deduct 320, and tell you the remainder, from which, if you

cut off the two laſt figures, the number that remains will be that he fixed on.

Example.

Let the number choſe be — —	7
Which doubled is — —	14
And 4 added to it makes —	18
Which multiplied by 5, gives	90
To which 12 being added, it is	102
That multiplied by 10, makes	1020
From which deducting 320, the remainder is — —	700
And by ſtriking off the two cyphers, it becomes the original number — —	7

RECREATION XI.

Three dice being thrown on a table, to tell the number of each of them, and the order in which they ſtand.

LET the perſon who has thrown the dice double the number of that next his left hand, and add 5 to that ſum; then multiply the amount by 5, and to the product add the number of the middle die; then let

the whole be multiplied by 10, and to that product add the number of the third die. From the total let there be ſubtracted 250, and the figures of the number that remains will anſwer to the points of the three dice as they ſtand on the table.

Example.

Suppoſe the points of the three dice thrown on the table to be 4, 6, and 2.

Then the double of the firſt die will be	8
To which add — —	5
	13
	5
That ſum multiplied by 5 will be	65
To which add the number of the middle die — — —	6
	71
And multiply the ſum by	10
	710
To that product add the number of the third die — —	2
	712
And from the total ſubtracting	250
The three remaining figures	462

will anſwer to the numbers on the dice, and ſhew the order in which they ſtand.

RECRE-

RECREATION XII.

To tell the number a perſon has fixed on, without aſking him any queſtions.

THE perſon having choſe any number from 1 to 15, he is to add 21 to that number, and triple the amount. Then,

1. He is to take the half of that triple, and triple that half.

2. To take the half of the laſt triple, and triple that half.

3. Take the half of the laſt triple.

4. Take the half of that half.

In this operation it appears there are four caſes or ſtages where the half is to be taken: the three firſt are denoted by one of the eight following Latin words, each word being compoſed of three ſyllables, and thoſe that contain the letter *i*, refer to thoſe caſes * where the half cannot be taken

* Theſe caſes being different in all the numbers that can be choſe, they are thereby diſtinguiſhed.

without a fraction; therefore in those cases the person who makes the deduction is to add 1 to the number to be divided. The fourth case shews which of the two numbers annexed to every word, has been chosen; for if the fourth half can be taken, without adding 1, the number chose is in the first column, but if not, it is in the second column.

The words.	The numbers they denote.	
Mi-se-ris	8	0
Ob-tin-git	1	9
Ni-mi-um	2	10
No-ta-ri	3	11
In-fer-nos	4	12
Or-di-nes	13	5
Ti-mi-di	6	14
Te-ne-ant	15	7

Example.

Example.

Suppose the number chose to be	9
To which is to be added	1
	10
Then the triple of that number is	30
The half of which is	15
The triple of that half must be	45
And the half of that*	23
The triple of that half	69
The half of that*	35
And the half of that half*	18

While the person is performing the operation, you remark, that at the second and third stage he is obliged to add 1, and consequently that the word *ob-tin-git,* in the second and third syllables of which is an *i,* denotes that the number must be either 1 or 9; and by observing that he cannot take the last half without adding 1, you know that it must be the

* At all the stages thus marked, 1 must be added in order to take the half without a fraction.

number

number in the ſecond column. If he ſhould make no addition at any one of the four ſtages, the number he choſe muſt be 15, as that is the only number that has no fraction at either of the diviſions.

RECREATION XIII.

Thirty ſoldiers having deſerted, fifteen of whom are to be puniſhed; ſo to place the whole number in a ring, that you may ſave any fifteen you pleaſe, and it ſhall ſeem to be the effect of chance.

THE men muſt be placed according to the numbers annexed to the vowels in the words of the following verſe:

Po-pu-le-am vir-gam ma-ter re-gi-na
4 5 2 1 3 1 1 2 2 3 1
fe-re-bat.
2 2 1

Therefore you place 4 of thoſe you would ſave firſt, then 5 of thoſe you would puniſh, then 2 of thoſe to be ſaved, and 1 to

to be puniſhed; and ſo on*. You then enter the ring, and beginning with the firſt of the four men you intend to ſave, you tell 9, and the ninth man is turned out to be puniſhed. You go on telling 9 more, and the ſecond 9 will fall on one you intend to puniſh; and ſo of the reſt.

RECREATION XIV.

Some perſon in company having put a ring privately on one of his fingers; to name the perſon, the hand, the finger, and the joint, on which it is placed.

LET a third perſon double the number of the order in which he ſtands who has the ring, and add 5 to that number; then multiply that ſum by 5, and to the product add 10. Let him next add 1 to the laſt number if the ring be on the right hand, and 2 if on the left, and multiply the whole by 10: to this product he muſt

* You will obſerve that each vowel denotes the number that is to be placed, as *a* 1, *e* 2, *i* 3, &c.

add

add the number of the finger (counting the thumb as the first finger) and multiply the whole again by 10. Let him then add the number of the joint; and, lastly, to the whole join 35.

He is then to tell you the amount of the whole, from which you are to subtract 3535, and the remainder will consist of four figures, the first of which will express the rank in which the person stands, the second the hand (the number 1 signifying the right hand, and 2 the left), the third number the finger, aud the fourth the joint.

Example.

Suppose the person who stands the third in order has put the ring upon the second joint of the thumb of his left hand; then

The

The double of the rank of the third person is	6
To which add	5
	11
Multiply the ſum by	5
	55
To which add	10
And the number of the left hand	2
	67
Which being multiplied by	10
	670
To which add the number of the thumb	1
	671
And multiply again by	10
	6710
Then add the number of the joint	2
And laſtly the number	35
	6747
From which deducting	3535
The remainder is	3212

Of which, as we have ſaid, the 3 denotes the third perſon, the 2 the left hand, the 1 the thnmb, and the laſt 2 the ſecond joint.

OF ARITHMETICAL MAGIC SQUARES.

A Magical ſquare of this ſort conſiſts of numbers in arithmetic progreſſion, ſo diſpoſed in parallel and equal ranks, that the ſum of each row, taken either perpendicularly, horizontally, or diagonally, is equal; as in the ſecond figure.

Fig. 1. Natural ſquare.

	A		G		B	
	1	2	3	4	5	
	6	7	8	9	10	
E	11	12	13	14	15	F
	16	17	18	19	20	
	21	22	23	24	25	
	C		H		D	

Fig. 2. Magical ſquare.

A				B
11	24	7	20	3
4	12	25	8	16
17	5	13	21	9
10	18	1	14	22
23	6	19	2	15
C				D

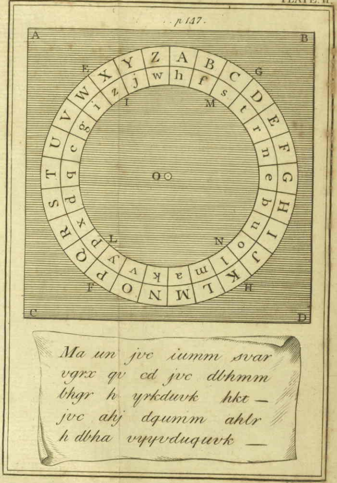
Any five of the ſums in this magic ſquare taken in a right line, make 65. You will obſerve that the five numbers in the diagonals A D and B C of the magical ſquare, anſwer to the horizontal and vertical ranks E F and G H in the natural ſquare; and that 13 is the central number of both ſquares.

To form a magical ſquare, firſt tranſpoſe the two ranks in the natural ſquare, juſt mentioned, to the diagonals of the magic ſquare; then place the number 1 under the central number 13, and the number 2, in the next diagonal downward. The number 3 ſhould be placed next in the ſame diagonal line; but as there is no room in the ſquare, you are to place it in that part it would occupy if another ſquare were placed under this. For the ſame reaſon the number 4, by following the diagonal direction, falling out of the ſquare, it is to be put in the part it would hold in another ſquare, placed by the ſide of this: you then proceed to the numbers 5 and 6, ſtill deſcending; but as the place 6 ſhould hold is already filled, you then go back to the next diagonal, and conſequently place the number 6 in the ſecond caſe under the number 5, ſo that there may remain an empty caſe between the two numbers. The ſame method is to be taken whenever you find a caſe already filled.

You

You proceed in this manner to fill all the empty cases in the angle where the number 15 is placed; and as there is no place for the number 16 in the same diagonal descending, you must place it in the part it would hold in another square, and continue the same method till all the cases are filled. This method will serve equally for all sorts of arithmetic progressions composed of odd numbers*; those composed of even numbers being too complicate and abstruse for recreations.

* M. Ozanam, who has wrote very learnedly on magical squares, observes, that the Egyptians, and the Pythagoreans, their disciples, held them in great veneration. They were dedicated by them, he says to the seven planets. Saturn had a square of nine cases assigned him; Jupiter, one of 16 cases; Mars, one of 25; Venus, 49; and Mercury, 64 cases: to the Moon they gave a square of 81 cases; and to the Deity, one of a single case, as unity can neither be multiplied nor divided, but is for ever unchangeable.



J Lodge Sculp.

RECREATION XV.

The ſeries of numbers from 1 *to* 25 *being wrote on that number of cards, after you have ſhuffled them, to deal them to five perſons, either by twos or threes, at the option of the parties, and the amount of the numbers on each one's cards to be the ſame.*

IN diſpoſing theſe cards you muſt have recourſe to the magical ſquare in the laſt Recreation, and obſerve to put the two cards that have the numbers 11 and 4 at top; thoſe cards that have 24 and 12 next, and ſo continue, by 2 and 2, to the laſt number of that rank, 16, which muſt be wrote on a card a little wider than the reſt. You muſt follow the ſame method with the next three numbers 17, 10, 23, and ſo on to the laſt three 9, 22, 15, as is fully explained in the following table.

Cards.	Numbers.	
1	11	First person.
2	4	
3	24	Second person.
4	12	
5	7	Third person.
6	25	
7	20	Fourth person.
8	8	
9	3	Fifth person.
10 wide card	16	
11	17	First person.
12	10	
13	23	
14	5	Second person.
15	18	
16	6	
17	13	Third person.
18	1	
19	19	
20	21	Fourth person.
21	14	
22	2	
23	9	Fifth person.
24	22	
25	15	

The cards being thus difpofed, or becoming fo by being fhuffled in the man-

ner

ner we ſhall explain farther on, when we treat of the combination of cards, you offer to deal them by twos or threes firſt: if it be required to deal them by twos firſt, there is no occaſion to cut them; but if they are to be dealt by threes, they muſt be cut, that he who cuts them may divide the pack exactly in that part where the wide card is, and that the fifteen cards that were at bottom may be at top. Obſerve, you muſt feel the cards before you deal, in order to know if they be cut at the wide card; if not, they muſt be cut again, or you may cut them yourſelf.

It is evident by the foregoing table, which is formed after the magic ſquare, that the numbers on each perſon's cards muſt neceſſarily amount to the ſame number, ſixty-five.

RECREATION XVI.

To deal the 32 cards of the game of piquet to four persons, after you have shuffled them, and the parties have chose whether you shall deal by twos or threes; in such manner, that all the cards in each person's hand shall be of the same suit.

FIRST, dispose the cards in the following order, and observe that the eighth card must be a little larger than the rest.

1	Ace	of Hearts.	First person.
2	Seven		
3	King	Spades.	Second person.
4	Eight		
5	Knave	Diamonds.	Third person.
6	Eight		
7	Ace	Clubs.	Fourth person.
8	Knave		
	wide card		
9	King	Hearts.	First person.
10	Eight		
11	Nine		
12	Ace	Spades.	Second person.
13	Knave		
14	Ten		

15 Ace

15	Ace		
16	Seven	Diamonds.	Third person.
17	Nine		
18	King		
19	Ten	Clubs.	Fourth person.
20	Nine		
21	Queen		
22	Knave	Hearts.	First person.
23	Ten		
24	Queen		
25	Nine	Spades.	Second person.
26	Seven		
27	King		
28	Queen	Diamonds.	Third person.
29	Ten		
30	Queen		
31	Eight	Clubs.	Fourth person.
32	Seven		

You then follow the same method as in the preceding Recreation: if the cards are required to be dealt by twos first, they are not to be cut, but you deal, once two and twice three. If they are to be dealt by threes first, they must be cut at the place of the wide card, and then dealt by twice three and once two.

OF GEOMETRICAL MAGIC SQUARES.

THE ſame method we have given for filling up the caſes or diviſions of an arithmetic magic ſquare, is to be followed in theſe. We ſhall confine ourſelves here to examples of the three following geometric ſquares, containing nine diviſions each which are filled up with three different progreſſions, applicable to the following Recreation.

Fig. 1.

16	512	4
8	32	128
256	2	64

Fig. 2.

24	768	6
12	48	192
384	3	96

Fig. 3.

56	179	214
28	112	448
896	7	224

You will obſerve, that in every geometric ſquare the product of the numbers in each row, whether taken vertically, horizontally, or diagonally, is conſtantly the ſame.

RECRE-

RECREATION XVII.

Several different numbers being wrote upon cards, to ſhuffle them, and deal the whole, or part of them, to three perſons, in ſuch manner that each one multiplying the numbers on his cards together, the product of each perſon's cards ſhall be the ſame; and to repeat the recreation after having ſhuffled the cards a ſecond time.

WRITE upon ſeven-and-twenty cards the numbers that are in the foregoing ſquares, and diſpoſe them in the following order:

1	16	Firſt perſon.
2	512	Second perſon.
3	4	Third perſon.
4	8	1ſt perſon.
5	32	2d perſon.
6	128	3d perſon.
7	256	1ſt perſon.
8	2	2d perſon.
9 wide card	64	3d perſon.
10	24	1ſt perſon.
11	768	2d perſon.
12	6	3d perſon.

13	12	Firſt perſon.
14	48	Second perſon.
15	192	Third perſon.
16	384	1ſt perſon.
17	3	2d perſon.
18 wide card	96	3d perſon.
19	56	1ſt perſon.
20	179	2d perſon.
21	14	3d perſon.
22	28	1ſt perſon.
23	112	2d perſon.
24	448	3d perſon.
25	896	1ſt perſon.
26	7	2d perſon.
27 wide card	224	3d perſon.

You obſerve that the 9th, 18th, and 27th cards are to be wider than the reſt, that the cards being cut in thoſe parts the numbers may not be diſarranged. It is plain likewiſe, from this diſpoſition of the cards, that if they are dealt to three perſons, one by one, or three together, they muſt each have one of the ranks of numbers in the magic ſquare.

In

In order to repeat this recreation, it is only neceſſary to put the cards that have been dealt on the top of the pack, and in ſhuffling the cards take care not to ſhuffle the nine bottom cards. The pack being then cut at the wide card that is at the top of the loweſt range of cards, they are then placed at top, and ſerve for the ſecond recreation, which will appear the more extraordinary, as the product then will not be the ſame as before.

A Recreation of the ſame kind may be performed with numbers in arithmetic progreſſion, taken, in like manner, from a magical ſquare; and that will be the more agreeable, as the numbers on the cards will then require to be added only, not multiplied.

RECREATION XVIII.

To find the number of changes that may be rung on twelve bells.

IT apears by the 17th aphorism, that nothing is more necessary here, than to multiply the numbers from 1 to 12 continually into each other, in the following manner, and the last product will be the number sought.

1
2
2
3
6
4
24
5
120
6
720
7
5040
8
40320
9
362880
10
3628800
11
39916800
12
479,001,600

RECREATION XIX.

Suppose the letters of the alphabet to be wrote so small that no one of them shall take up more space than the hundredth part of a square inch: to find how many square yards it would require to write all the permutations of the 24 letters in that size.

BY following the same method as in the last Recreation, the number of permutations of the 24 letters will be found to be

62,044,840,173,323,943,936,000

Now the inches in a square yard being 1296, that number multiplied by 100 gives 129600, which is the number of letters each square yard will contain; therefore if we divide 62,044,840,173,323,943,936,000 by 129600, the quotient, which is 478,741,050,720,092,160, will be the number of yards required, to contain the above mentioned number of permutations.

But

But as all the 24 letters are contained in every permutation, it will require a ſpace 24 times as large, that is

11,489,785,217,282,211,840.

Now the number of ſquare yards contained on the ſurface of the whole earth is but 617,197,435,008,000, therefore it would require a ſurface 18620 times as large as that of the earth to write all the permutations of the 24 letters in the ſize above mentioned.

RECREATION XX.

To find how many different ways the eldeſt hand at piquet may take in his five cards.

THE eldeſt hand having twelve cards dealt him, there remain twenty cards, any five of which may be in thoſe he takes in; conſequently we are here to find how many ways five cards may be taken out of 20: therefore by, aphoriſm 16, if we multiply 20, 19, 18, 17, 16, into each other, which will make 1860480,

and

and that number be divided by 1, 2, 3, 4, 5, multiplied into each other, which make 120, the quotient, which is 15504, will be the number of ways five cards may be taken out of 20. From hence it follows, that it is 15503 to 1, that the eldest hand does not take in any five certain cards.

RECREATION XXI.

To find the nnmber of deals a person may play at the game of whist without ever holding the same cards twice.

THE number of cards played with at whist being 52, and the number dealt to each person being 13, it follows, that by taking the same method as in the last Recreation, that is, by multiplying 52 by 51, 50, &c. so on to 41, which will make 3,954,242,643,911,239,680,000, and then dividing that sum by 1, 2, 3, &c. to 13, which will make 6,227,020,800, the quotient, which is 635,013,559,600, will be the number of different ways thirteen

cards

cards may be taken out of 52, and consequently the number sought.

The ARITHMETIC TRIANGLE.

Rank	
1 Rank	A 1
2	2. 1 B
3	3. 3. 1
4	4. 6. 4. 1
5	5. 10. 10. 5. 1
6	6. 15. 20. 15. 6. 1
7	7. 21. 35. 35. 21. 7. 1
8	8. 28. 56. 70. 56. 28. 8. 1
9	9. 36. 84. 126. 126. 84. 36. 9. 1
10	10. 45. 120. 210. 252. 210. 120. 45. 10. 1
11	11. 55. 165. 330. 462. 462. 330. 165. 55. 11. 1
12	*a* 12. 66. 220. 495. 792. 924. 792. 495. 220. 66. 12. 1 *b*
	c

The construction of this table is very simple. The line A *a* consists of the first twelve numbers. The line A *b* consists every where of units; and second term 3,

 of

of the line B *c*, is compoſed of the two terms 1 and 2 in the preceding rank: the third term 6, in that line, is formed of the two terms 3 and 3 in the preceding rank: and ſo of the reſt; every term, after the firſt, being compoſed of the two next terms in the preceding rank: and by the ſame method it may be continued to any number of ranks. To find by this table how often any number of things can be combined in another number, under 13, as ſuppoſe 5 cards out of 8; in the eighth rank look for the fifth term, which is 56, and that is the number required.

Though we have ſhewn in the foregoing Recreations the manner of finding the combination of all numbers whatever, yet as this table anſwers the ſame purpoſe, for ſmall numbers, by inſpection only, it will be found uſeful on many occaſions; as will appear by the following Recreations.

RECREATION XXII.

To find how many different sounds may be produced by striking on a harpsichord two or more of the seven natural notes at the same time.

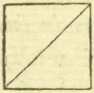
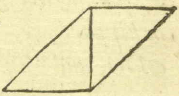
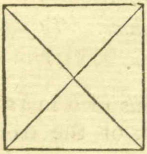
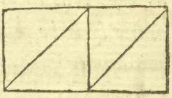
1. THE combinations of two in seven, by the foregoing triangle are	21
2. The combinations of 3 in 7, are	35
3. The combinations of 4 in 7, are	35
4. The combinations of 5, are	21
5. The combinations of 6, are	7
6. The seven notes all together once	1
Therefore the number of all the sounds will be	120

RECREATION XXIII.

Take four square pieces of pasteboard, of the same dimension, and divide them diagonally, that is by drawing a line from two opposite angles, as in the figures, into 8 *triangles; paint*

paint 7 of theſe triangles with the primitive colours, red, orange, yellow, green, blue, indigo, violet, and let the eighth be white. To find how many chequers or regular four-ſided figures, different either in form or colour, may be made out of thoſe eight triangles.

FIRST by combining two of theſe triangles there may be formed either the triangular ſquare A, or the inclined ſquare B, called a rhomb. Secondly, by combining four of the triangles, the large ſquare C, may be formed; or the long ſquare D, called a parallelogram.

A

B

C

D


Now the firſt two ſquares, conſiſting of two parts out of 8, they may each of them,

by the eighth rank of the triangle be taken 28 different ways, which makes 56. And the last two squares, consisting of four parts, may each be taken by the same rank of the triangle 70 times, which makes 140

To which add the foregoing number 56

and the number of the different squares that may be formed of the eight triangles, will be } 196

RECREATION XXIV.

A man has 12 different sorts of flowers, and a large number of each sort. He is desirous of setting them in beds or flourishes, in his parterre. Six flowers in some, 7 in others, and 8 in others; so as to have the greatest variety possible; the flowers in no two beds to be the same. To find how many beds he must have.

1. THE combinations of 6 in 12 by the last rank of the triangles, are } 924
2. The combinations of 7 in 12, are 792
3. The combinations of 8 in 12, are 495

Therefore the number of beds must be } 2211

RECREATION XXV.

To find the number of chances that may be thrown on two dice.

AS each die has 6 faces, and as every face of one die may be combined with all the faces of the other, it follows, that 6 multiplied by 6, that is 36, will be the number of all the chances: as is alſo evident from the following table.

Points.							Numb. of chances.	Numb. of points.
2	1.1						1	2
3	2.1	1.2					2	6
4	3.2	3.1	1.3				3	12
5	4.1	1.4	3.2	2.3			4	20
6	3.3	5.1	1.5	4.[illegible]	2.4		5	30
7	6.1	1.6	5.2	2.5	4.3	3.4	6	42
8	4.4	6.2	2.6	5.3	3.5		5	40
9	6.3	3.6	5.4	4.5			4	36
10	5.5	6.4	4.6				3	30
11	6.5	5.6					2	22
12	6.6						1	12
							36	252

It appears by this table, 1. That the number of chances for each point continually encreaſes to the point of ſeven,

and then continually decreaſes till 12: therefore if two points are propoſed to be thrown, the equality, or the advantage of one over the other, is clearly viſible *. 2. The whole number of chances on the dice being 252, if that number be divided by 36, the number of different throws on the dice, the quotient is 7: it follows therefore, that at every throw there is an equal chance of bringing ſeven points. 3. As there are 36 chances on the dice, and only 6 of them doublets, it is 5 to 1, at any one throw, againſt throwing a doublet.

By the ſame method the number of chances upon any number of dice may be found: for if 36 be multiplied by 6, that

* It is eaſy from hence to determine whether a bet propoſed at hazard, or any other game with the dice, be advantageous or not; if the dice be true: which, by the way, is rarely the caſe for any long time together, as it is ſo eaſy for thoſe that are poſſeſſed of a dexterity of hand to change the true dice for falſe.

product

product, which is 216, will be the chances on 3 dice; and if that number be multiplied by 6, the product will be the chances on 4 dice, &c.

RECREATION XXVI.

To discover the number of points on 3 cards, placed under three different parcels of cards.

YOU are first to agree that the ace shall tell eleven, the pictured cards ten each, and the others according to their number of points; as at the game of piquet. Then propose to any one to choose 3 cards, and over each of them to put as many cards as will make the number of the points of that card 15. Suppose, for example, he choose a 7, a 10, and an ace: then over the 7 he must place eight cards: over the 10, five cards, and over the ace, four. Take the remainder of the cards, and seeming to look for some card among them, tell how many there are,

and adding 16 to that number, you will have the number of points on the three cards. As in this inſtance, where there will remain 12 cards, if you add 16 to that number it will make 28, which is the number of points on the three cards *.

RECREATION XXVII.

The ten duplicates.

TAKE twenty cards, and after any one has ſhuffled them, lay them down by pairs on the board, without looking at them. Then deſire ſeveral perſons to look each of them at different pairs, and remember what cards compoſe them. You then take up all the cards, in the order they lay, and place them again on the table, according to the order of the letters in the following words.

* If this Recreation be performed with a pack of quadrille cards, the number added to the remaining cards muſt be eight.

M	U	T	U	S
1	2	3	4	5
D	E	D	I	T
6	7	8	9	10
N	O	M	E	N
11	12	13	14	15
C	O	C	I	S*
16	17	18	19	20

Now you will obſerve that theſe words contain ten letters repeated, or ten pair of letters. Therefore you aſk each perſon which row, or rows, the cards he looked at are in; if he ſay they are in the firſt row, you know that they muſt be the ſecond and fourth: if in the ſecond and fourth rows, they muſt be the ninth and nineteenth, and ſo of the reſt.

* Theſe words convey no meaning. The laſt word is ſometimes wrote Cœcis; but that being no Latin word, can make no ſenſe with the others. If, indeed, it was Cæcis, a ſort of ſenſe might be made out: but then the *æ* would by no means anſwer the *o* in Nomen, as it muſt do to perform the Recreation.

RECREATION XXVIII.

To name the number of cards that a perſon ſhall take out of the pack.

TO perform this Recreation you muſt ſo diſpoſe a piquet pack of cards, that you can eaſily remember the order in which they are placed. Suppoſe, for example, that they are placed according to the words in the following line;

Seven aces, eight kings, nine queens, and ten knaves.

And that every card be of a different ſuit, following each other in this order; ſpades, clubs, hearts, and diamonds. Then the eight firſt cards will be the ſeven of ſpades, ace of clubs, eight of hearts, king of diamonds, nine of ſpades, queen of clubs, ten of hearts, and knave of diamonds; and ſo of the reſt*.

* This Recreation may be farther diverſified, by placing the cards in ſuch manner, by the table for thirty-two numbers, that after they have been ſhuffled once or twice, they may come into the above order.

You

You ſhow that the cards are placed promiſcuouſly, and then offer them with the backs upward, to any one, that he may draw what quantity he pleaſe: which when he has done, you dexterouſly look at the card that precedes, and that which follows thoſe he has taken. After he has well regarded the cards, you take them from him, and putting them into different parts of the pack, ſhuffle them, or give them to him to ſhuffle. During which you recollect, by the foregoing line, all the cards he took out: and as you lay them down, one by one, you name each card.

This is a pleaſing Recreation for thoſe that have a good memory; they that have not, ſhould never attempt it.

RECREATION XXIX.

A century of different names being wrote on the cards, to tell the particular name which any perſon has thought on.*

ON ten cards write a hundred different names, obſerving only, that the laſt name on each card begin with one of the letters of the word, INDROMACUS, which letters, in the order they ſtand anſwer to the numbers 1, 2, 3, &c. to 10. On ten other cards write the ſame names, with this reſtriction, that the firſt name on every card muſt be taken from the firſt of the other cards, whoſe laſt name begins with I: the ſecond name muſt be taken from that whoſe laſt name begins with N: and ſo of the reſt. Then let any one choſe a card out of the firſt ten, and after he has fixed on a name

* This is called the Impenetrable Secret; though it is one of the moſt eaſy Recreations with the cards.

give it you again, when you carefully note the laſt name, by which you know the number of that card. You then take the other ten cards, and after ſhuffling them, ſhow them to the perſon one by one, and aſk if he ſee the name he choſe, and when he ſays he does, you look to that name which is the ſame in number from the top, with the number of the card he took from the other parcel, and that will be the name he fixed on. As for example, ſuppoſe he took out the card that had the word Daphnis at the bottom, which is the third card, and that he fixed on the name Galatea, then that word will neceſſarily be the third on the other card.

Order of the words on the first ten cards.

First Card	*Second*	*Third*	*Fourth*
Celadon	Pomona	Deucalion	Licas
Andromeda	Omphalus	Hesiona	Calypso
Silenus	Ariadne	Galatea	Medea
Acis	Lisis	Thetis	Adonis
Eglea	Flora	Atys	Ceres
Sirincus	Danae	Palamedes	Cassandra
Thyrsis	Alcander	Melibæus	Pales
Polyphemus	Tiresias	Orion	Menelaus
Proteus	Issoria	Nisus	Glaucus
Jason	Narcissus	Daphnis	Rophelina
Fifth	*Sixth*	*Seventh*	*Eighth*
Latona	Icarus	Ganymede	Leander
Hilas	Clitander	Aristea	Peleus
Thisbe	Alcinous	Hyacinthus	Calista
Diana	Endimion	Circe	Cadmus
Palæmon	Alcidon	Mopsa	Psyche
Hebe	Iphis	Piramus	Semele
Sappho	Achelous	Philemon	Iphigenia
Acteon	Philomela	Astrea	Silvia
Medusa	Cephalus	Pelias	Alpheus
Orpheus	Mirtilus	Adrianus	Coridon
Ninth		*Tenth*	
Hipolitus	Eson	Dryope	Isander
Corilas	Calistus	Nessus	Isidora
Procris	Arachne	Philoctetes	Melicerte
Caparissa	Pirus	Marsias	Riblis
Arethusus	Vertumnus	Licas	Silvander

Order of the words on the last ten cards.

First card	*Second*	*Third*	*Fourth*
Celadon	Andromeda	Silenus	Acis
Pomona	Omphalus	Ariadne	Lisis
Deucalion	Hesiona	Galatea	Thetis
Licas	Calypso	Medea	Adonis
Latona	Hilas	Thisbe	Diana
Icarus	Clitander	Alcinous	Endimion
Ganymede	Aristea	Hiacinthus	Circe
Leander	Peleus	Calista	Cadmus
Hypolitus	Corilas	Procris	Caparissa
Dryope	Nessus	Philoctetes	Marsias
Fifth	*Sixth*	*Seventh*	*Eighth*
Eglea	Sirineus	Thyrsis	Polyphemus
Flora	Danae	Alcander	Tiresias
Atys	Palamedes	Melibæus	Orion
Ceres	Cassandra	Pales	Menelaus
Palæmon	Hebe	Sappho	Acteon
Alcidon	Iphis	Archelous	Philomela
Mopsa	Piramus	Philemon	Astrea
Psyche	Semele	Iphigenia	Silvia
Arethusus	Eson	Calistus	Arachne
Licas	Isander	Isidora	Melicerte
Ninth		*Tenth*	
Proteus	Cephalus	Jason	Myrtilus
Issoria	Pelias	Narcissus	Adrianus
Nisus	Alpheus	Daphnis	Corydon
Glaucus	Pirus	Rophelina	Vertumnus
Medusa	Riblis	Orpheus	Silvander

Instead

Inſtead of ten cards, there may be twenty to each parcel, by adding duplicates to each card, which will make the Recreation appear the more myſterious, and will not at all embarraſs it, as you have nothing to remember but the laſt name on each card. Or inſtead of names, you may write queſtions on one of the parcels, and anſwers on the other.

OF THE COMBINATIONS OF THE CARDS.

THE tables we here give are the baſis of many recreations, as well on numbers, letters, and other ſubjects, as on the cards; and the effect here produced by them is the more ſurpriſing, as that which ſhould ſeem to prevent any colluſion, that is, the ſhuffling of the cards, is, on the contrary, the cauſe from whence it proceeds.

It is a matter of indifference what numbers are made uſe of in forming theſe tables. We ſhall here confine ourſelves to ſuch as are applicable to the ſubſequent Recre-

Recreations. Any one may conſtruct them in ſuch manner as is agreeable to the purpoſes he intends they ſhall anſwer.

To make them, for example, correſpond to the nine digits and a cypher, there muſt be ten cards, and at the top of nine of them muſt be wrote one of the digits, and on the tenth a cypher. Theſe cards muſt be placed upon each other in the regular order, the number 1 being on the firſt, and the cypher at bottom. You then take the cards in your left hand, as is commonly done in ſhuffling, and taking off the two top cards, 1 and 2, you place the two following, 3 and 4, upon them; and under thoſe four cards the three following 5, 6, and 7: at the top you put the cards 8 and 9, and at the bottom the card marked 0. Conſtantly placing in ſucceſſion 2 at top and 3 at bottom, and they will then be in the following order:

8.9..3.4..1.2...5.6.7..0

If you ſhuffle them a ſecond time, in the ſame manner, they will then ſtand in this order:

6.7..3.4..8.9..1.2.5..0

Thus, at every new ſhuffle, they will have a different order, as is expreſſed in the following lines:

1 ſhuffle	8.9.3.4.1.2.5.6.7.0
2	6.7.3.4.8.9.1.2.5.0
3	2.5.3.4.6.7.8.9.1.0
4	9.1.3.4.2.5.6.7.8.0
5	7.8.3.4.9.1.2.5.6.0
6	5.6.3.4.7.8.9.1.2.0
7	1.2.3.4.5.6.7.8.9.0

It is a remarkable property of this number, that the cards return to the order in which they were firſt placed, after a number of ſhuffles, which added to the number of columns that never change the order, is equal to the number of cards. Thus the number of ſhuffles is 7, and the number of columns in which the cards marked 3, 4, &c. never change their places is 3, which are equal to 10, the number of the cards.

cards. This property is not common to all numbers; the cards ſometimes returning to the firſt order in leſs number, and ſometimes in a greater number of ſhuffles than that of the cards.

Though the cards are here directed to be ſhuffled by twos or threes only, yet tables may be conſtructed with equal facility for ſhuffling them by 2 and 1, 3 and 4, or any other number whatever; obſerving that the fewer cards are taken together the leſs liable you will be to err.

Note, Before you venture to perform theſe Recreations, you ſhould accuſtom yourſelf to ſhuffle the cards exactly and readily; which will be eaſily attained by practice.

TABLES OF COMBINATIONS,

Constructed on the foregoing principles.

TABLE I.*

FOR TEN NUMBERS.

Order before shuffling.	After 1st shuffle.	After the 2d.	After the 3d.
1	8	6	2
2	9	7	5
3	3	3	3
4	4	4	4
5	1	8	6
6	2	9	7
7	5	1	8
8	6	2	9
9	7	5	1
0	0	0	0

* These tables and the following Recreations at piquet, except the 36th, appear to have been composed by Mr. Guyot.

TABLE

TABLE II.

FOR TWENTY FOUR NUMBERS.

Order before ſhuffling.	After 1ſt ſhuffle.	After the 2d.	After the 3d.
1	23	21	17
2	24	22	20
3	18	12	2
4	19	15	7
5	13	5	13
6	14	6	14
7	8	9	3
8	9	3	18
9	3	18	12
10	4	19	15
11	1	23	21
12	2	24	22
13	5	13	5
14	6	14	6
15	7	8	9
16	10	4	19
17	11	1	23
18	12	2	24
19	15	7	8
20	16	10	4
21	17	11	1
22	20	16	10
23	21	17	11
24	22	20	16

TABLE III.

FOR TWENTY SEVEN NUMBERS.

Order before ſhuffling.	After 1ſt ſhuffle.	After the 2d.	After the 3d.
1	23	21	17
2	24	22	20
3	18	12	2
4	19	15	7
5	13	5	13
6	14	6	14
7	8	9	3
8	9	3	18
9	3	18	12
10	4	19	16
11	1	23	21
12	2	24	22
13	5	13	5
14	6	14	6
15	7	8	9
16	10	4	19
17	11	1	23
18	12	2	24
19	15	7	8
20	16	10	4
21	17	11	1
22	20	16	10
23	21	17	11
24	22	20	16
25	25	25	25
26	26	26	26
27	27	27	27

TABLE IV.

FOR THIRTY TWO NUMBERS.

Order before ſhuffling.	After 1ſt ſhuffle.	After the 2d.	After the 3d.
1	28	26	22
2	29	27	25
3	23	17	7
4	24	20	12
5	18	10	9
6	19	11	3
7	13	1	28
8	14	2	29
9	8	14	2
10	9	8	14
11	3	23	17
12	4	24	20
13	1	28	26
14	2	29	27
15	5	18	10
16	6	19	11
17	7	13	1
18	10	9	8
19	11	3	23
20	12	4	24
21	15	5	18
22	16	6	19
23	17	7	13
24	20	12	4
25	21	15	5
26	22	16	6
27	25	21	15
28	26	22	16
29	27	25	21
30	30	30	30
31	31	31	31
32	32	32	32

RECREATION XXX.

Several letters that contain no meaning, being wrote upon cards, to make them, after they have been twice ſhuffled, give an anſwer to a queſtion that ſhall be propoſed; as for example, What is love ?

LET 24 letters be wrote on as many cards, which, after they have been twice ſhuffled, ſhall give the following anſwer :

A dream of joy that ſoon is over.

Firſt, write one of the letters in that line on each of the cards†. Then write the anſwer on a paper, and aſſign one of the 24 firſt numbers to each card, in the following order :

A	D	R	E	A	M	O	F	J	O	Y	T	H	A	T
1	2	3	4	5	6	7	8	9	10	11	12	13	14	15

S	O	O	N	I	S	O'	E	R.
16	17	18	19	20	21	22	23	24

† Theſe letters ſhould be wrote in capitals on one of the corners of each card, that the words may be eaſily legible when the cards are ſpread open.

Next,

Next, write on another paper a line of numbers, from 1 to 24, and looking in the table for 24 combinations you will ſee that the firſt number after the ſecond ſhuffle is 21, therefore the card that has the firſt letter of the anſwer, which is A, muſt be placed againſt that number in the line of numbers you have juſt made* In like manner the number 22 being the ſecond of the ſame column, indicates, that the card which anſwers to the ſecond letter, D, of the anſwer, muſt be placed againſt that number: and ſo of the reſt. The cards will then ſtand in the following order:

1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17
O	O	F	S	A	M	N	T	O	I	S	R	H	A	E	O'	E

18	19	20	21	22	23	24
J	O	R	A	D	Y	T

From whence it follows that after theſe cards have been twice ſhuffled, they muſt

* For the ſame reaſon if you would have the anſwer after one ſhuffle, the cards muſt be placed according to the firſt column of the table: or if after three ſhuffles, according to the third column.

infallibly ſtand in the order of the letters in the anſwer.

Obſerve 1. You ſhould have ſeveral queſtions, with their anſwers, conſiſting of 24 letters, wrote on cards: theſe cards ſhould be put in caſes, and numbered, that you may know to which queſtion each anſwer belongs. You then preſent the queſtions; and when any one of them is choſe, you pull out the caſe that contains the anſwer, and ſhewing that the letters wrote on them make no ſenſe, you then ſhuffle them, and the anſwer becomes obvious.

2. To make this Recreation the more extraordinary, you may have three cards, on each of which an anſwer is wrote; one of which cards muſt be a little wider, and another a little longer, than the others. You give theſe three cards to any one, and when he was privately choſe one of them he gives you the other two, which you put into your pocket without looking at them,

them, having diſcovered by feeling which he has choſe. You then pull out the caſe that contains the cards that anſwer to his queſtion, and perform as before.

3. You may alſo contrive to have a long card at the bottom, after the ſecond ſhuffle. The cards may be then cut ſeveral times, till you perceive by the touch that the long card is at bottom, and then give the anſwer; for the repeated cuttings, however often, will make no alteration in the order of the cards.

The ſecond of theſe obſervations is applicable to ſome of the ſubſequent Recreations, and the third may be practiſed in almoſt all experiments with the cards. You ſhould take care to put up the cards as ſoon as the anſwer has been ſhewn: ſo that if any one ſhould deſire the Recreation to be repeated, you may offer another queſtion, and pull out thoſe cards that contain the anſwer.

Though

Though this Recreation cannot fail of exciting at all times pleaſure and ſurprize, yet it muſt be owned that a great part of the applauſe it receives ariſes from the addreſs with which it is performed.

RECREATION XXXI.

The twenty-four letters of the alphabet being wrote upon ſo many cards, to ſhuffle them, and pronounce the letters ſhall then be in their natural order; but that not ſucceeding, to ſhuffle them a ſecond time, and then ſhew them in proper order.

WRITE the 24 letters on the cards in the following order:

1	2	3	4	5	6	7	8	9	10	11	12
R	S	H	Q	E	F	T	P	G	U	X	C

13	14	15	16	17	18	19	20	21	22	23	24
N	O	D	Y	Z	I	K	&	A	B	L	M

The cards being diſpoſed in this manner, ſhew them upon the table, that it may appear they are promiſcuouſly mark-

ed.

ed. Then ſhuffle and lay them again on the table, pronouncing that they will be then in alphabetical order. Appear to be ſurpriſed that you have failed; take them up again and give them a ſecond ſhuffle, and then counting them down on the table they will all be in their natural order.

RECREATION XXXII.

Several letters being wrote promiſcuouſly upon 32 cards, after they have been once ſhuffled, to find in a part of them a queſtion; and then ſhuffling the remainder a ſecond time, to ſhew the anſwer.

SUPPOSE the queſtion to be, *What is each Briton's boaſt?* and the anſwer, *His liberty*; which taken together contain 32 letters.

After you have wrote thoſe letters on 32 cards, write on a paper the words *his liberty*,

liberty, and annex to the letters the firſt ten numbers thus:

HIS LIBERTY
1 2 3 4 5 6 7 8 9 10

Then have recourſe to the table of combinations for ten numbers, and apply the reſpective numbers to them in the ſame manner as in the 30th Recreation, taking the firſt column, as theſe are to be ſhuffled only once, according to that order.

1 2 3 4 5 6 7 8 9 10
IBS LERTHIY

This is the order in which theſe cards muſt ſtand after the whole number 32 has been once ſhuffled, ſo that after a ſecond ſhuffle they may ſtand in their proper order. Next diſpoſe the whole number of letters according to the firſt column for 32 letters: the laſt ten are to be here placed in the order above; as follows,

WHAT IS EACH BRITON'S
1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17
BOAST?
18 19 20 21 22
IBSLERTHIY
23 24 25 26 27 28 29 30 31 32

Therefore, by the firſt column of the table, they will next ſtand thus:

1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	
I	T	B	R	O	N	S	C	H	B	O	A	E	A	S	T	long card
17	18	19	20	21	22	23	24	25	26	27	28	29	30	31	32	
I	I	S	B	S	L	I	B	E	R	T	W	H	H	I	Y	

You muſt obſerve that the card here placed the 16th in order, being the laſt of the queſtion, is a long card; that you may cut them, or have them cut, after the firſt ſhuffle, at that part, and by that means ſeparate them from the other ten cards that contain the anſwer.

Your cards being thus diſpoſed, you ſhow that they make no meaning; then ſhuffle them once, and cutting them at the long card, you give the firſt part to any one, who reads the queſtion, but can find no anſwer in the others, which you open before him; you then ſhuffle them a ſecond time, and ſhow the anſwer as above.

RECRE-

RECREATION XXXIII.

To write 32 letters on ſo many cards, then ſhuffle and deal them by twos to two perſons, in ſuch manner, that the cards of one ſhall contain a queſtion, and thoſe of the other, an anſwer.

SUPPOSE the queſtion to be, *Is nothing certain?* and the anſwer, *Yes, diſapointment.*

Over the letters of this queſtion and anſwer write the following numbers, which correſpond to the order in which the cards are to be dealt by two and two.

I S N O T H I N G C E R T A I N
31 32 27 28 23 24 19 20 15 16 11 12 7 8 3 4
Y E S, D I S A P O I N T M E N T
29 30 25 26 21 22 17 18 13 14 9 10 5 6 1 2

Then have recourſe to the firſt column of the table for 32 numbers, and diſ-

pose these 32 cards in the following order, by that column.

1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16
O	I	E	R	G	C	A	N	T	P	I	N	T	A	I	S

17	18	19	20	21	22	23	24	25	26	27	28	29	30	31	32
T	M	E	H	S	D	I	N	N	O	Y	N	T	E	I	S

The cards being thus disposed, shuffle them once, and deal them 2 and 2; when one of the parties will necessarily have the question, and the other the answer.

Instead of letters you may write words upon the 32 cards, 16 of which may contain a question, and the remainder the answer; or what other matter you please. If there be found difficulty in accommodating the words to the number of cards, there may be two or more letters or syllables wrote upon one card.

RECRE-

RECREATION XXXIV.

The Five Beatitudes

THE five bleſſings we will ſuppoſe to be, 1. Science, 2. Courage, 3. Health, 4. Riches, and 5. Virtue. Theſe are to be found upon cards that you deal, one by one, to five perſons. Firſt write the letters of theſe words ſucceſſively, in the order they ſtand, and then add the numbers here annexed to them.

S	C	I	E	N	C	E
31	26	21	16	11	6	1

C	O	U	R	A	G	E
32	27	22	17	12	7	2

H	E	A	L	T	H
28	23	18	13	8	3

R	I	C	H	E	S
29	24	19	14	9	4

V	I	R	T	U	E
30	25	20	15	10	5

Then range them in order agreeable to the firſt column of the table for 32 numbers, as in the laſt Recreation. Thus.

1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16
L	H	N	A	T	E	R	E	U	A	C	R	G	T	I	U

17	18	19	20	21	22	23	24	25	26	27	28	29	30	31	32
E	E	C	I	I	C	H	S	O	H	R	E	E	V	S	C

Next,

Next, take a pack of cards, and write on the four firſt the word Science; on the four next the word Courage; and ſo of the reſt.

Matters being thus prepared, you ſhow that the cards on which the letters are wrote convey no meaning. Then take the pack on which the words are wrote, and ſpreading open the firſt four cards, with their backs upward, you deſire the firſt perſon to chooſe one. Then cloſe thoſe cards and ſpread the next four to the ſecond perſon; and ſo to all the five: telling them to hold up their cards leſt you ſhould have a confederate in the room.

You then ſhuffle the cards and deal them one by one, in the common order, beginning with the perſon who choſe the firſt card, and each one will find in his hand the ſame word as is wrote on his card. You will obſerve, that after the ſixth round of dealing, there will be two cards left, which

 you

you give to the firſt and ſecond perſons, as their words contain a letter more than the others.

RECREATION XXXV.

The cards of the game of piquet being mixed together, after ſhuffling them, to bring, by cutting them, all the cards of each ſuit together.

THE order in which the cards muſt be placed to produce the effect deſired, being eſtabliſhed on the ſame principle as that explained in the 31ſt Recreation, except that the ſhuffling is here to be repeated three times, we think it will be ſufficient to give the order in which they are to be placed before the firſt ſhuffle.

Order of the Cards.

1 Ace	clubs	17 King clubs	
2 Knave		18 Ten	hearts
3 Eight	diamonds	19 Nine	
4 Seven		20 Seven clubs	
wide card			
5 Ten clubs		21 Ace diamonds	
6 Eight	ſpades	22 Knave ſpades	
7 Seven		23 Queen hearts	
wide card			
8 Ten	diamonds	24 Knave hearts	
9 Nine		25 Ace ſpades	
10 Queen		26 King diamonds	
11 Knave		27 Nine clubs	
12 Queen clubs		28 Ace	hearts
13 Eight	hearts	29 King	
14 Seven		30 Eight clubs	
wide card			
15 Ten	ſpades	31 King	ſpades
16 Nine		32 Queen	

You then ſhuffle the cards, and cutting at the wide card, which will be the ſeven of hearts, you lay the eight cards that are cut, which will be the ſuit of hearts, down on the table. Then ſhuffling the remaining cards a ſecond time, you cut at the

ſecond wide card, which will be the ſeven of ſpades, and lay, in like manner, the eight ſpades down on the table. You ſhuffle the cards a third time, and offering them to any one to cut, he will naturally cut them at the wide card*, which is the ſeven of diamonds, and conſequently divide the remaining cards into two equal parts, one of which will be diamonds and the other clubs.

RECREATION XXXVI.

The cards at piquet being all mixed together, to divide the pack into two unequal parts, and name the number of points contained in each part.

YOU are firſt to agree that each king, queen, and knave ſhall count, as uſual, 10, the ace 1, and the other cards ac-

* You muſt take particular notice whether they be cut at the wide card, and if they are not, you muſt have them cut, or cut them again yourſelf.

cording

cording to the number of the points. Then diſpoſe the cards, by the table for 32 numbers, in the following order, and obſerve that the laſt card of the firſt diviſion muſt be a wide card.

Order of the cards before ſhuffling.

1	Seven hearts		17	Nine diamonds	
2	Nine clubs		18	Ace ſpades	
3	Eight hearts		19	Ten clubs	
4	Eight		20	Knave	
5	Knave	ſpades	21	Eight	diamonds
6	Ten		22	King	
7	Queen	clubs	23	Seven ſpades	
8	Ace		24	Seven	diamonds
9	Ace hearts wide card		25	Queen	
10	Nine hearts		26	Knave hearts	
11	Queen ſpades		27	King clubs	
12	Knave clubs		28	Nine	ſpades
13	Ten diamonds		29	King	
14	Ten		30	Ace diamonds	
15	King	hearts	31	Seven	clubs
16	Queen		32	Eight	

You then ſhuffle them carefully, according to the method before deſcribed, and they will ſtand in the following order.

Cards.	Numbers.	Cards.	Numbers.
		Brought up	34
1 Nine } Spades	9	6 Ten clubs	10
2 King } Spades	10	7 Ten diamonds	10
3 Seven } Spades	7	8 Ten hearts	10
4 Seven diamonds	7	9 Ace clubs	1
5 Ace ſpades	1	10 Ace hearts (wide card)	1
Carried up	34	Total	66

		Brought up	101
11 Eight hearts	8	22 Queen hearts	10
12 Eight ſpades	8	23 Nine } Diamonds	9
13 Seven hearts	7	24 Knave } Diamonds	10
14 Nine clubs	9	25 Eight } Diamonds	8
15 Knave } Spades	10	26 King } Diamonds	10
16 Ten } Spades	10	27 Queen } Diamonds	10
17 Queen clubs	10	28 Knave hearts	10
18 Nine hearts	9	29 King clubs	10
19 Queen ſpades	10	30 Ace Diamonds	1
20 Knave clubs	10	31 Seven } Clubs	7
21 King hearts	10	32 Eight } Clubs	8
Carried up	101	Total	194

When the cards are by ſhuffling diſpoſed in this order, you cut them at the wide card, and pronounce that the cards you have cut off contain 66 points, and conſequently the remaining part 194. This Recreation excites a good degree of admiration, but the applying of theſe cards to the next Recreation produces a much greater.

RECREATION XXXVII.

*The inconceivable repique**.

WHEN you would perform this Recreation with the cards uſed in the laſt, you muſt obſerve not to diſorder the firſt ten cards in laying them down on the table. Putting thoſe cards together, in their proper order, therefore, you ſhuffle them a ſecond time in the ſame manner, and offer them to any one to cut, obſerving carefully if he cut them at the wide card, which will be the ace of hearts, and will then be at top; if not, you muſt make him, under ſome pretence or other, cut them till it is; and the cards will then be ranged in ſuch order that you will repique the perſon againſt whom you play, though you let him chooſe (even after he has cut) in what ſuit you ſhall make the repique.

* This manœuvre of piquet was invented by the the Counteſs of L—— (a French lady) and communicated by her to M. Guyot.

Order of the cards after they have been ſhuffled and cut.

1 Eight hearts	17 Nine } diamonds
2 Eight } ſpades	18 Knave } diamonds
3 Knave } ſpades	19 Nine hearts
4 Ten } ſpades	20 Queen ſpades
5 Queen } clubs	21 Seven hearts
6 Knave } clubs	22 Nine clubs
7 King } hearts	23 Ten hearts
8 Queen } hearts	24 Ace clubs
9 Eight } diamonds	25 Seven ſpades
10 King } diamonds	26 Seven diamonds
11 Queen } diamonds	27 Nine } ſpades
12 Ace } diamonds	28 King } ſpades
13 Seven } clubs	29 Ace } ſpades
14 Eight } clubs	30 Ten clubs
15 Knave hearts	31 Ten diamonds
16 King clubs	32 Ace hearts (wide card)

The cards being thus diſpoſed, you aſk your adverſary in what ſuit you ſhall repique him. If he ſay in clubs or diamonds, you muſt deal the cards by threes, and the hands will be as follows,

Elder

Elder.	Younger.
Hearts, king	Clubs, ace
——— queen	——— king
——— knave	——— queen
——— nine	——— knave
——— eight	——— nine
——— ſeven	Diamonds, ace
Spades, queen	——— king
——— knave	——— queen
——— eight	——— knave
Diamonds, eight	——— nine
Clubs, eight	Spades, ten
——— ſeven	Hearts, ten

Rentrée, or take in, of the elder.	Rentrée of the younger.
Seven ſpades	Ten clubs
Seven diamonds	Ten diamonds
Nine, King, Ace } ſpades	Ace hearts

If he againſt whom you play, who is ſuppoſed to be elder hand, has named clubs for the repique, and has taken in five cards, you muſt then lay out the queen, knave, and nine of diamonds, and you

you will have, with the three cards you take in, a ſixiem major in clubs, and quatorze tens. If he leave one or two cards, you muſt diſcard all the diamonds.

If he require to be repiqued in diamonds, then diſcard the queen, knave, and nine of clubs ; or all the clubs if he leave two cards; and you will then have a hand of the ſame ſtrength as before.

Note, If the adverſary ſhould diſcard five of his hearts, you will not repique him, as he will then have a ſeptiem in ſpades : or if he only take one card : but neither of theſe any one can do, who has the leaſt knowlege of the game. If the perſon againſt whom you play would be repiqued in hearts or ſpades, you muſt deal the cards by twos, and the game will ſtand thus :

Elder

Elder hand		Younger hand.	
King, Knave, Nine, Eight	diamonds	Ace, King	clubs
Queen, Knave, Nine, Eight, Seven	clubs	Ace, Queen	diamonds
Eight, Seven	hearts	Queen, Knave, Ten	ſpades
Eight	ſpades	King, Queen, Knave, Ten, Nine	hearts

Rentrée.	Rentrée.
Seven ſpades	Ten clubs
Seven diamonds	Ten diamonds
Nine, King, Ace ſpades	Ace hearts

If he require to be repiqued in hearts, you keep the quint to a king in hearts, and the ten of ſpades, and lay out which of the reſt you pleaſe: then, even if he ſhould leave two cards, you will have a ſixiem major in hearts, and quatorze tens, which will make a repique.

But

But if he demand to be repiqued in ſpades; at the end of the deal you muſt dexterouſly paſs the three cards that are at the bottom of the ſtock (that is, the ten of clubs, ten of diamonds, and ace of hearts) to the top*, and by that means you reſerve the nine, king, and ace of ſpades for yourſelf: ſo that by keeping the quint in hearts, though you ſhould be obliged to lay out four cards, you will have a ſixiem to a king in ſpades, with which, and the quint in hearts, you muſt make a repique.

Obſerve here likewiſe, that if the adverſary lay out only three cards, you will not make the repique: but that he will never do unleſs he be quite ignorant of the game, or has ſome knowlege of your intention.

This laſt ſtroke of piquet has gained great applauſe, when thoſe that have

* The manner of doing this you will find in the Appendix, among the Recreations of Dexterity.

publicly

publicly performed it, have known how to conduct it dexterously. Many persons who understand the nature of combining the cards, have gone as far as the passing the three cards from the bottom of the stock, and have then been forced to confess their ignorance of the manner in which it was performed.

RECREATION XXXVIII.

The metamorphosed Cards.

PROVIDE thirty-two cards that are differently coloured; on which several different words are wrote, and different objects painted. These cards are to be dealt two and two, to four persons, and at three different times, shuffling them each time. After the first deal every one's cards are to be of the same colour: after the second deal, they are all to have objects that are similar; and after the third, words that convey a sentiment.

Diſpoſe of the cards in the following order.

Order of the cards.	Colours.	Objects.	Words.
1	Yellow	Bird	I find
2	Yellow	Bird	In you
3	Green	Flower	Charming
4	Green	Flower	Flowers
5	White	Bird	To hear
6	White	Orange	Beauty
7	Red	Butterfly	My
8	Red	Flower	Notes
9	Red	Flower	In
10	Red	Butterfly	Shepherdeſs
11	Green	Butterfly	Lover
12	Green	Butterfly	Your
13	White	Flower	Of
14	White	Flower	an inconſtant
15	Yellow	Orange	Image
16	Yellow	Flower	Enchanting
17	White	Orange	Ardour
18	Yellow	Butterfly	My
19	Yellow	Butterfly	Phyllis
20	White	Bird	Birds
21	Red	Orange	Sing
22	Red	Orange	Dear
23	Green	Orange	and Sweetneſs
24	Green	Orange	The
25	Green	Bird	Of

Order of the cards.	Colours.	Objects.	Words.
26	Green	Bird	Prefent
27	Yellow	Flower	As
28	Red	Bird	Changes
29	Red	Bird	Bofom
30	Yellow	Orange	Me
31	White	Butterfly	Your
32	White	Butterfly	I long

The cards thus coloured, figured, and tranfcribed, are to be put in a cafe, in the order they here ftand.

When you would perform this Recreation you take the cards out of the cafe, and fhow, without changing the order in which they were put, that the colours, objects, and words are all placed promifcuoufly. You then fhuffle them in the fame manner as before, and deal them, two and two, to four perfons, obferving that they do not take up their cards till all are dealt, nor mix them together: and the eight cards dealt to each perfon will be found all of one colour. You then take

each perſon's cards, and put thoſe of the ſecond perſon under thoſe of the firſt, and thoſe of the fourth perſon under thoſe of the third. After which you ſhuffle them a ſecond time, and having dealt them in the ſame manner, on the firſt perſon's cards will be painted all the birds; on the ſecond perſon's cards, all the butterflies; on thoſe of the third, the oranges; and on thoſe of the fourth, the flowers. You take the cards a ſecond time, and obſerving the ſame precautions, ſhuffle and deal them as before, and then the firſt perſon, who had the laſt time the birds in his hands, will have the words in his hand that compoſe this ſentence.

Sing dear birds, I long to hear your enchanting notes.

The ſecond perſon, who the laſt deal had the butterflies, will now have theſe words,

Of an inconſtant lover your changes preſent me the image.

The third, who had the oranges, will have this ſentence.

As in my Phylis, I find in you, beauty and ſweetneſs.

The fourth, who had the flowers, will have theſe words,

Charming flowers, adorn the boſom of my ſhepherdeſs.

It ſeems quite unneceſſary to give any farther detail, as they who underſtand the foregoing Recreations will eaſily perform this.

RECREATION XXXIX.

The repique with carte blanch.

IN the following Recreations relating to piquet, we ſhall confine ourſelves to the order in which the cards muſt ſtand after they are cut, and ready to be dealt. They who chooſe to ſhuffle them firſt (in order to make the performance appear the more extraordinary) may eaſily diſpoſe them in a proper order for that purpoſe. by having recourſe to the table of combinations for 32 numbers.

Order of the cards.

Elder	1 Ace 2 Seven	} ſpades
Younger	3 Seven clubs 4 Ten hearts	
E.	5 Ace hearts. 6 Knave ſpades	
Y.	7 Nine hearts 8 Eight clubs	
E.	9 Queen ſpades 10 Ace diamonds	
Y.	11 Eight hearts 12 Eight ſpades	
E.	13 Queen diamonds 14 Ace clubs	
Y.	15 Nine diamonds 16 Nine clubs	
E.	17 King 18 Ten	} Diamonds
Y.	19 Seven hearts 20 Seven diamonds	
E.	21 Nine ſpades 22 Knave diamonds	
Y.	23 Ten clubs 24 Eight diamonds	

25 King hearts 26 King clubs 27 Queen hearts 28 King ſpades 29 Ten ſpades	Elder's rentrée
30 Queen clubs 31 Knave clubs 32 Knave hearts	Younger's rentrée

The cards being thus diſpoſed, the hands of the players, after they have been dealt two and two, will be as follows.

Elder.		Younger.	
Ace Queen Knave Nine Seven	ſpades	Ten Nine Eight Seven	clubs
Ace King Queen Knave Ten	diamonds	Ten Nine Eight Seven	hearts
Ace hearts Ace clubs		Nine Eight Seven	Diamonds
		Eight ſpades	

The rentrée.

King Queen	hearts	Queen Knave	clubs
King clubs		Knave hearts	
King Ten	ſpades		

The cards being thus dealt, you desire the other player to cast his eye over the two hands, and take which he please, on condition, that if he keep the hand dealt him he shall be eldest; but if he take the other he shall be youngest.

If he keep the hand dealt him, which in appearance is much preferable to the other, he will naturally lay out the four lowest spades, and leave a card, by carrying the quint in diamonds and four aces. You then tell down your carte blanch, and keeping the two quarts in clubs and hearts, lay out the others, and with your rentrée you will have a sixiem in clubs and a quint in hearts, with which you will make a repique, counting 107 points, though if the cards were played you would be capoted.

If the opposite player choose the youngest hand, you then discard the quart to a king in diamonds with the seven of spades,

ſpades, and with your rentrée you will have a ſixiem major in ſpades, and quatorze of aces : by which you make repique and capot.

Here alſo you may miſs the repique, if the other player keep the hand dealt him, and diſcard his diamonds ; but this as in the other caſes, no one will do, who has any knowledge of the game.

RECREATION XL.

Caſe at piquet, where you repique the elder hand, though he have the choice of the cards after they are dealt.

THE cards muſt here ſtand, after they have been cut, in the following order.

Elder 1 Ace, 2 Eight } ſpades

Younger 3 Knave, 4 Ten } clubs

E. 5 Ace clubs, 6 Nine hearts

Y. 7 Eight clubs
8 Nine diamonds

E. 9 Queen clubs
10 Eight diamonds

Y. 11 Seven clubs.
12 Ten diamonds

E. 13 Ten ſpades
14 Eight hearts

Y. 15 Nine }
16 King } clubs

E. 17 King }
18 Queen } ſpades

Y. 19 Knave diamonds
20 Seven ſpades

E. 21 Seven diamonds
22 Knave ſpades

Y. 23 Ace diamonds
24 Nine ſpades

25 King }
26 Knave }
RentréE. 27 Queen } hearts
28 Seven }
29 Ten }

30 Ace hearts
RentréY. 31 Queen }
32 King } diamonds

The

The cards being thus diſpoſed * when they are dealt, the hands of the two players will be as follows.

Elder.	Younger.
Spades, ace	Diamonds, ace
——— king	——— knave
——— queen	——— ten
——— knave	——— nine
——— ten	Clubs, king
——— eight	—— knave
Clubs, ace	—— ten
—— queen	—— nine
Hearts, nine	—— eight
——— eight	—— ſeven
Diamonds, eight	Spades, nine
——— ſeven	——— ſeven

Rentrée.	Rentrée.
King, Queen, Knave, Ten, Seven } hearts	Ace, hearts; King, Queen } diamonds

You then give the other player the liberty of chooſing either hand, but without

* In all theſe Recreations with piquet, there ſhould be a wide card laſt, that they may be properly cut.

ſeeing them. If he choſe the elder hand, you diſcard the king of clubs, with the nine and ſeven of ſpades, and by your rentrée you will have a ſixiem in diamonds and the point which will make 22, and that added to the quint in clubs will make 97, and you will neceſſarily win, as the adverſary will not fail to lay out his two ſmall hearts.

If, on the contrary, he chooſe the younger hand, you diſcard the knave, ten, and eight of ſpades, with the ſeven and eight of diamonds: then by taking in the quint to a king in hearts, you will have a ſeptiem in hearts, a tierce major in ſpades, and three queens, which will tell 90, though the adverſary ſhould diſcard to the moſt advantage poſſible.

RECREATION XLI.

Caſe at piquet, where you give the other player not only the choice of the ſuite in which he will be repiqued, but that of dealing the cards by twos or by threes, and of taking either hand after they are dealt, you being to tell and play firſt.

THE cards muſt be diſpoſed as follows:

No.	Card	Suit
1	Queen	clubs
2	Nine	clubs
3	Eight	clubs
4	Seven	clubs
	wide card	
5	Ace	hearts
6	King	hearts
7	Knave	hearts
8	Ten	hearts
9	Queen	hearts
10	Nine	hearts
11	Eight	hearts
12	Seven	hearts
	wide card	
13	Ace	ſpades
14	King	ſpades
15	Knave	ſpades
16	Ten	ſpades
17	Queen	ſpades
18	Nine	ſpades
19	Eight	ſpades
20	Seven	ſpades
	wide card	
21	Ace	diamonds
22	King	diamonds
23	Knave	diamonds
24	Ten	diamonds
25	Queen	diamonds
26	Nine	diamonds
27	Eight	diamonds
28	Seven	diamonds
	wide card	
29	Ace	clubs
30	King	clubs
31	Knave	clubs
32	Ten	clubs

It is evident by this diſpoſition of the cards, that if they are cut at any one of the wide cards, which are the laſt of each ſuite, there will be always a ſtock of eight cards of the ſame ſuite. Conſequently, if he with whom you play require to be repiqued in clubs, by cutting at the firſt wide card, which is the ſeven of clubs, the eight clubs will neceſſarily be at the bottom of the pack, and you will have for your rentrée a quint major in clubs. The ſame will happen in all the other ſuites, by cutting at the 7 of each. If he deal the cards by twos, the hands will be as follows*.

Elder		Younger	
Ace King Queen Nine	hearts	Knave Ten Eight Seven	hearts
Ace King Queen Nine	ſpades	Knave Ten Eight Seven	ſpades
Ace King Queen Nine	diamonds	Knave Ten Eight Seven	diamonds

* The hands will be always the ſame, though in different ſuites.

Rentrée

Ace	clubs	Nine	clubs
King		Eight	
Knave		Seven	
Ten			
Queen			

But if he deal the cards by threes, the hands will ſtand thus:

Elder		Younger	
Ace	hearts	Ten	hearts
King		Queen	
Knave		Nine	
Seven		King	ſpades
Ace	ſpades	Knave	
Queen		Ten	
Nine		Seven	
Eight		Ace	diamonds
Knave	diamonds	King	
Ten		Nine	
Queen		Eight	
		Seven	

Rentrée.

Ace	clubs	Nine	clubs
King		Eight	
Knave		Seven	
Ten			
Queen			

If

If the other player require to be repiqued in ſpades, you cut them at the 7 of that ſuite, and tell him he is at liberty to deal them by twos or threes*. If he deal them by twos, he is to chooſe which hand he will have, without ſeeing them; you being ſtill eldeſt.

If he keep his own hand, you diſcard the nine of hearts, ſpades, and diamonds, and either of the two queens; and by your rentrée you will have a quint major in clubs, quatorze aces, and quatorze kings, with which you make a repique. But if he chooſe the cards dealt for the elder, you diſcard the ſeven of hearts, ſpades, and diamonds, and any two of the eights; and you will have by your rentreé the ſame quint in clubs, qua-

* You are to take care he does not ſhuffle the cards; and the better to prevent it, you may ſo diſpoſe them as to ſhuffle them before him, after the manner explained in ſome of the foregoing Recreations.

torze

torze queens, and quatorze knaves; which will alſo make a repique.

If the adverſary deal the cards by threes, and keep his hand, you diſcard the king, eight, and ſeven of hearts, with the nine and eight of ſpades; and by your rentrée you will have the quint major in clubs, a tierce to a queen in diamonds, three aces, three queens, and three knaves, with which you make a repique. But if he chooſe the cards dealt for the elder, you diſcard the queen and nine of hearts, the knave and ſeven of ſpades, and the ace of diamonds, and you will then have the ſame quint in clubs, a tierce to a nine in diamonds, three kings, and three tens, with which you will tell 29 points, therefore by playing one, you can in this caſe make a pique only.

RECREATION XLII.

An exemplary caſe at piquet, where you re-pique your adverſary, after giving him the choice of having the cards dealt either by twos or threes.

TO diſpoſe the cards in the order neceſſary to produce the effect here required, and in all others where you give the choice of having the cards dealt either by twos or threes, you muſt have recourſe to the following table.

Cards that will go to the eldest.	Numb. of the Cards.	Cards that will come to the youngest.	Variable cards.
1	1		
2	2		
	3	- - -	3
	4	4	
	5	- - -	5
	6	- - -	6
	7	- - -	7
	8	- - -	8
9	9		
	10	- - -	10
	11	11	
	12	12	
13	13		
14	14		
	15	- - -	15
	16	16	
	17	- - -	17
	18	- - -	18
	19	- - -	19
	20	- - -	20
21	21		
	22	- - -	22
	23	23	
	24	24	

This table ſhews the different hands that reſult from the two different methods of dealing the cards; that the eldeſt hand has always, in ſome order or other, the ſix cards placed againſt the numbers 1, 2, 9, 13, 14, and 21: and the younger, the ſix cards placed againſt 4, 11, 12, 16, 23, and 24. It ſhows, likewiſe, that the 12 cards marked 3, 5, 6, 7, 8, 10, 15, 17, 18, 19, 20, and 22, may be in either hand, ſo far as concerns the manner of dealing the cards.

Being therefore certain when you deal that the cards marked 1, 2, 9, 13, 14, and 21 will always be in the adverſary's hand, and thoſe marked 4, 11, 12, 16, 23, and 24 will be in your own hand, you muſt apply your ſix numbers to ſuch cards, as with the three of the rentrée, (which you may chooſe as you pleaſe) will always make a great hand, and ſuperior to the adverſary. The great cards which you are forced to leave, you muſt diſtribute among

the variable cards, in ſuch manner that they can have no remarkable effect, when dealt either way.

This method we have obſerved in the following example, which we here give for the ſatisfaction of thoſe who would compoſe theſe ſorts of games themſelves. To the numbers 4, 11, 12, 16, 23, and 24, annex a ſixiem major in hearts, which joined to the three tens of the rentrée are ſufficient to make a repique, youngeſt hand. But as you muſt prevent the elder hand from defeating your point, by having ſeven cards in any of the other ſuits, you are ſo to diſpoſe ſome part of each ſuit, by the column of variable cards, that he may never have, whether the cards are dealt by twos or threes, any large ſequence *: as you will

* If you cannot effect this by the cards that are to be dealt the adverſary, you muſt ſo diſpoſe his rentrée, that he may lay out his game, as in the thirty-eight Recreation.

ſee by the following diſpoſition of the cards.

1 King
2 Ace } diamonds
3 Nine
4 Ace hearts
5 Queen ſpades
6 Eight diamonds
7 Queen clubs
8 Eight ſpades
9 King clubs
10 Seven
11 King } hearts
12 Nine
13 Queen } diamonds
14 Seven
15 Seven clubs
16 Knave hearts

17 Ace clubs
18 Seven
19 King } ſpades
20 Ace
21 Knave diamonds
22 Eight clubs
23 Ten } hearts
24 Queen
25 Knave } ſpades
26 Nine
27 Knave clubs
28 Eight hearts
29 Nine clubs
30 Ten diamonds
31 Ten ſpades
32 Ten clubs

By this arangement of the cards you will be ſure to ſucceed, whether you deal the cards by twos or threes: even though the adverſary, thinking to fruſtrate your intention, ſhould leave three cards.

Remark:

Remark: there is no danger that any of these Recreations at piquet ſhould be applied to a bad purpoſe, for after the cards have been once ſhuffled by both players, it will be impoſſible to ſucceed in any one of them. There are, however, tricks to be played at this, as at all other games, with the cards; ſuch as changing the whole pack, or ſome particular cards, or taking in part, or all the diſcard, or making the paſs, that is, bringing part of the cards at bottom to the top, as will be more fully explained in the fourth vol. all of which many perſons can perform ſo dextrouſly, that it is impoſſible for the eye to diſcover them. We ſay nothing of the practice of marking the cards, for of that almoſt every one's experience will afford ſufficient proof. To aggravate the misfortune, it is indubitably certain, that many perſons who are ſtrictly honeſt in all other reſpects, are diſhoneſt at cards; and that no rank or condition of men, no, nor women neither, is entirely free from this vice.

They who make a trade of dexterity frequently exhibit other recreations with the cards; but as thofe have no relation to numbers, they will be found among the mifcellaneous articles in the Appendix to the laft volume.

RECREATION XLIII.

Several different cards being fhown to different perfons, that each of them may fix on one of thofe cards, to name that on which each perfon has fixed.

THERE muft be as many different cards fhown to each perfon, as there are perfons to choofe; therefore, fuppofe there are three perfons, then to each of them you muft fhow three cards, and telling the firft perfon to retain one in his memory, you lay thofe three cards down, and fhow three others to the fecond perfon, and fo to the third. You then take up the firft perfon's cards, and lay them down, one by one, feparately, with their

 faces

faces upward. You next place the second person's card over the firſt, and in like manner the third perſon's card over the ſecond's; ſo that in each parcel there will be one card belonging to each perſon. You then aſk each of them in which parcel his card is, and when you know that, you immediately know which card it is; for the firſt perſon's card will always be the firſt, the ſecond perſon's the ſecond, and the third perſon's the third, in that parcel where they each ſay his card is.

This Recreation may be performed with a ſingle perſon, by letting him fix on three, four, or more cards. In this caſe you muſt ſhow him as many parcels as he is to chooſe cards, and every parcel muſt conſiſt of that number, out of which he muſt fix on one; and you then proceed as before, he telling you the parcel that contains each of his cards.

RECREATION XLIV.

To name the rank of the card that a perſon has drawn from a piquet pack.

BY the rank of the card we mean whether it be ace, king, queen, &c. You are therefore firſt to fix a certain number to each card, thus, you call the king 4, the queen 3, the knave 2, the ace 1, and the others according to the number of their pips.

You then ſhuffle the cards, and let the perſon draw any one of them: then turning up the remaining cards, you add the number of the firſt to that of the ſecond, that to the third, and ſo on, till it amount to ten, which you then reject and begin again; or if it be more, you reject the ten, and carry the remainder to the next card; and ſo continue till you come to the laſt card; and to the laſt amount you muſt add 4, and ſubtract that ſum from 10 if it be

leſs

lefs, or from 20 if it be more than 10, and the remainder will be the number of the card that was drawn: as for example, if the remainder be 2, the card drawn was a knave; if 3, a queen, &c.

RECREATION XLV.

*To tell the amount of the numbers of two cards that a perfon has drawn from a common pack of cards**.

THE fmall cards here tell, as before, according to the number of their pips, but each pictured card tells for 10. Let the perfon add as many more cards to each of thofe he has drawn, as will make each of their numbers 25. Then take the remaining cards in your hand, and feeming to fearch for fome card among them, tell them over to yourfelf, and their

* This Recreation may be made with two perfons, by letting each of them draw, and adding, their numbers together.

number will be the amount of the two cards drawn. An example will make this plain. Suppose the person has drawn a 10 and a 7, then he must add 15 cards to the first, to make the number 25, and 18 cards to the last, for the same reason; now 15 and 18 make 33, and the two cards themselves make 35, which deducted from 52 leaves 17, which must be the number of the remaining cards, and also of the two cards drawn.

This Recreation may be performed without your touching the cards, thus: let the person who has drawn the two cards deduct the numbers of each of them from 26, which is half the number of the pack, and after adding the remainders together, let him tell you the amount, which you privately deduct from 52, the number of all the cards, and the remainder will be the amount of the two cards. For example, suppose the two cards to be, as before, 10 and 7; then the person deduct-

ing 10 from 26 there remains 16; and deducting 7 from 26 there remains 19; thoſe two remainders added together will make 35, which you ſubtract from 52, and there muſt remain 17, for the amount of the two cards, as before.

As the number 26 may be thought to lead to a diſcovery of the principle on which the Recreation is founded, it being manifeſtly the half of the pack, to render it more myſterious you may take any other number leſs than 26, but greater than 10, as for example 24, and let the party ſubtract the number of each of his cards from that; therefore, ſuppoſing the numbers to be as before 10 and 7, the remainders will be 14 and 17, which make 31, to which you muſt add 4, for the double of the 2 you took from 26, and the amount will be 35, which is to be deducted from 52, as before. By this alteration the performance will not only be rendered more abſtruſe

ſtruſe, but alſo more diverſified, as you may change the number, from which thoſe of the two cards are to be deducted, every time you repeat the experiment.

This Recreation may be performed, equally well, with a pack of piquet cards, and then the numbers of the two cards muſt be deducted from 16, which is the half of the pack; or if you choſe to make it more myſterious, from any other number leſs than 16 and more than 10; afterwards adding, as in the laſt caſe, the double of what that number wants to make it 16.

RECREATION XLVI.

To tell the amount of the numbers of any three cards that a perſon ſhall draw from the pack.*

AFTER the party has drawn his three cards, you are to draw one yourſelf, and lay it aſide; for it is neceſſary that the number of the remaining cards be diviſible by 3, which they will not be, in a pack of 52 cards, if only 3 be drawn. The card you draw you may call the confederate, and pretend it is by the aid of that card you diſcover the amount of the others. Then tell the party to add as many more to each of his cards, as will make its number 16, which is the third part of the remaining 48 cards; therefore, ſuppoſe he has drawn a 10, a 7, and a 6:

* This Recreation may alſo be performed with three perſons, but much more readily with one, as the ſeparate additions and ſubtractions will be very like to occaſion confuſion.

then

then to the first he must add 6 cards, to the second 9, and to the third 10, which together make 25, and the 4 cards drawn being added to them make 29. You then take the remaining cards, and telling them over, as in the last Recreation, you find their number to be 23, which must be the amount of the three cards the person drew.

You may perform this Recreation likewise without touching the cards, as thus: after the party has drawn his three cards, and you have drawn one, let him deduct the number of each of the cards he has drawn from 17, which is one-third of the pack, after you have drawn your card: and let him tell you the amount of the several remainders, to which you privately add one for the card you drew, and deducting that amount from 52, the whole number of cards, the remainder will be the amount of the three cards drawn. For example, suppose the three cards to

be 10, 7, and 6, as before; then each of those numbers being subtracted from 17, the remainders will be respectively 7, 10, and 11, which, added together, make 28, to which the single card you drew being added makes 29, and that number deducted from 52 leaves 23, which is the amount of the three cards the party drew.

There is little reason to imagine any one will discover why you here make choice of the number 17; but if you are desirous of rendering the Recreation still more abstruse, and at the same time susceptible of greater variety, you may fix on any other number less than 17, but more than 10; and afterwards add to the amount of the remainders the double of what that number is less than 17; in the same mannner as in the last Recreation.

This Recreation also may be performed with a pack of piquet cards; but then you must draw, or, what will answer to

same

the ſame purpoſe, deduct 2, in your own mind, from the whole number 32, that the remainder may be diviſible by 3; and let him deduct the number of each of his cards from that ſum, which is 10, and add the remainders together, as before; thus, if his three cards be 16, 7, and 6, he is to deduct each of them from 10, which is the third part of 30; therefore the remainders will be 0, 3, and 4, which, added together, make 7, and that added to the 2 you deducted from the whole number, makes 9, which taken from 32, leaves 23, and that muſt be the amount of his three cards.

Among the different purpoſes to which the doctrine of combinations may be applied, thoſe of writing in cypher, and decyphering, hold a principal place, as will appear by the following Recreations.

DIFFERENT METHODS OF WRITING IN CYPHER.

The Lacedæmonians are ſaid to be the inventors of cyphers, or at leaſt they were not, to our knowledge, uſed by any people before them. Their method was by a wooden cylinder or roller, called a Scytala Laconica, round which they rolled a thin parchment, and wrote their diſpatches. It was then taken off and ſent to the confederate, who had another roller, exactly of the ſame ſize, round which he wrapped the parchment, and read its contents.

RECREATION XLVII.

To communicate intelligence by a pack of piquet cards.

THE parties muſt previouſly agree in what manner the cards ſhall be firſt placed, and then how they ſhall be ſhuffled. Thus, ſuppoſe the cards are to be firſt placed in the order as hereafter follows,

and

and then ſhuffled by taking off 3 from the top, putting the next 2 over them, and the following 3 under them*, and ſo alternately. Therefore the party who ſends the cypher firſt writes the contents of it on a ſeparate paper, and then copies the firſt 32 letters on the cards, by writing one letter on every card; he then ſhuffles them in the manner deſcribed, and writes the ſecond 32 letters: he ſhuffles them a ſecond time and writes the third 32 letters, and ſo of the reſt. An example will make this plain. Suppoſe the letter to be as follows:

I am in full march to relieve you; within|
three days I ſhall be with you. If the ene|my
in the mean time ſhould make an aſſau|lt, remember what you owe to your countr|y, to
your family and yourſelf. Live with ho|nour
or die with glory.

* By ſhuffling the cards in this manner, there will remain only 2 to put under at laſt.

Order of the cards
before the 1ſt ſhuffle.

Ace ſpades	*i a d u y i*
Ten diamonds	*a l e u l*
Eight hearts	*m l m o i u*
King ſpades	*i s u m l*
Nine clubs	*n h l e o*
Seven diamonds	*f b m r i*
Nine diamonds	*u e a c t n*
Ace clubs	*l w k r y i*
Knave hearts	*l s e e a e*
Seven ſpades	*m i a r m w*
Ten clubs	*a i t h e r*
Ten hearts	*r r h o f*
Queen ſpades	*c h e e i*
Eight diamonds	*h a h y w*
Eight clubs	*t y o o o l*
Seven hearts	*o y a o h o*
Queen clubs	*r o n u y h*
Nine ſpades	*e u i y f y*
King hearts	*l e t e u o*
Queen diamonds	*e d s o e*
Eight ſpades	*i i n w s o*
Knave clubs	*v f a n t g*

Seven clubs	*e t s l y*
Ace hearts	*y r e b r*
Nine hearts	*o l n w o t*
Ace diamonds	*u h s t & d*
Knave ſpades	*w l m a l*
Ten ſpades	*i e y t r r*
King diamonds	*t t i b u r*
Queen hearts	*b h m m u*
King clubs	*i n a t h*
Knave diamonds	*n e u r o*

The perſon that receives theſe cards firſt places them in the order agreed on, and tranſcribes the firſt letter on every card. He then ſhuffles them, according to order, and tranſcribes the ſecond letter on each card. He ſhuffles them a ſecond time and tranſcribes the third letters; and ſo of the reſt.

If the cards were to be ſhuffled the ſecond time by threes and fours, the third time by twos and fours, &c. it would make

5 the

the cypher ſtill more difficult to diſcover: though as all cyphers depend on the combination of letters, there are ſcarce any that may not be decyphered with time and pains; as we ſhall ſhow farther on. Thoſe cyphers are the beſt, that are by their nature moſt free from ſuſpicion of being cyphers; as for example; if the letters were here wrote with one of the ſympathetic inks, deſcribed in the fourth volume of this work, the cards might then paſs for a common pack.

RECREATION XLVIII.

The myſtical dial.

ON a piece of ſquare paſteboard ABCD (Plate II.) draw the circle EFGH, and divide it into twenty-ſix equal parts, in each of which muſt be wrote one of the letters of the alphabet.

On the inſide of this there muſt be another circle of paſteboard, ILMN, move-

able round the center O, and the extremity of this muſt be divided into the ſame number of equal parts as the other. On this alſo muſt be wrote the letters of the alphabet, which, however, need not be diſpoſed in the ſame order. The perſon with whom you correſpond muſt have a ſimilar dial, and at the beginning of your letter you muſt put any two letters that anſwer to each other when you have fixed the dial.

Example.

Suppoſe you would write as follows:

If you will come over to us you ſhall have a penſion, and you may ſtill make a ſham oppoſition.

You begin with the letters *Ma,* which ſhow how the dial is fixed; then for *If you*, you write *un juc,* and ſo for the reſt, as you will ſee at the bottom of the plate.

The ſame intention may be anſwered by a ruler, the upper part of which is fixed and

and the lower part made to ſlide: but in this caſe the upper part muſt contain two alphabets in ſucceſſion, that ſome letter of that part may conſtantly correſpond to one in the lower part. The diviſions ſtanding directly over each other in a ſtraight line will be much more obvious than in the circumference of a circle. Or two ſtraight pieces of paſteboard regularly divided, the one containing a ſingle and the other a double alphabet, would anſwer exactly the ſame purpoſe. In this caſe a blank ſpace may be left at each end of the ſingle alphabet, and one or two weights being placed on both the pieces will keep them ſteady.

RECREATION XLIX.

The correſponding ſpaces.

TAKE two pieces of paſteboard or ſtiff paper, through which you muſt cut long ſquares, at different diſtances, as you will ſee in the following example. One of theſe pieces you keep yourſelf, and the

other you give to your correſpondent. When you would ſend him any ſecret intelligence, you lay the paſteboard upon a paper of the ſame ſize, and in the ſpaces cut out, you write what you would have underſtood by him only, and then fill up the intermediate ſpaces with ſomewhat that makes with thoſe words a different ſenſe.

|I ſhall be| much obliged to you, as reading |alone| engages my attention |at| preſent, if you will lend me any one of the |eight| volumes of the Spectator. I hope you will excuſe |this| freedom, but for a winter's |evening| I |don't| know a better entertainment. If I |fail| to return it ſoon, never truſt me for the time |to come.|

A paper of this ſort may be placed four different ways, either by putting the bottom at top, or by turning it over, and by thoſe means the ſuperfluous words may be the

the more eaſily adapted to the ſenſe of the others.

This is a very eligible cypher, as it is free from ſuſpicion, but it will do only for ſhort meſſages: for if the ſpaces be frequent it will be very difficult to make the concealed and obvious meanings agree together: and if the ſenſe be not clear, the writing will be liable to ſuſpicion.

RECREATION L.

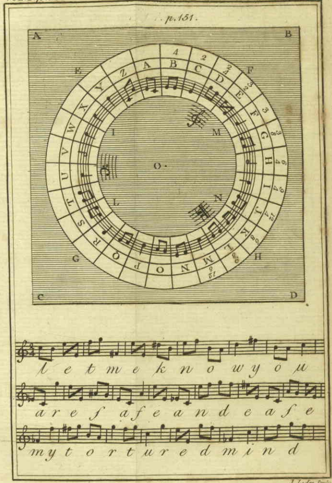
The muſical cypher.

THE conſtruction of this cypher, is ſimilar to that of the forty-eighth Recreation. The circle EFGH (Pl. III.) is to be divided into twenty-ſix equal parts, in each part there muſt be wrote one of the letters of the alphabet: and on the interior circle ILMN, moveable round the center O, there is to be the ſame number of diviſions: the circumference of the inner circle muſt be ruled in the manner of

a muſic paper, and in each diviſion there is to be placed a note, differing either in figure or poſition. Laſtly, within the muſical lines place the three keys, and on the outer circle, the figures that are commonly uſed to denote the time.

Then provide yourſelf with a ruled paper, and place one of the keys, as ſuppoſe that of *ge re ſol*, againſt the time two-fourths at the beginning of the paper, which will inform your correſpondent how to fix his circle. You then copy the notes that anſwer to the ſeveral letters of the words you intend to write, in the manner expreſſed at the bottom of the plate.

A cypher of this ſort may be made more difficult to diſcover by frequently changing the key, and that will not in the leaſt embarraſs the reader. You may likewiſe add the mark ♯ or ♮ to the note that begins a word, which will make it more eaſy to read, and at the ſame time give the



J. Lodge Sculp.

the muſic a more natural aſpect. This cypher is preferable to that of the 48th Recreation, as it may be encloſed in a letter about common affairs, and paſs unſuſpected: unleſs it ſhould fall into the hands of any one who underſtands compoſition, for he would very likely ſurmiſe, from the odd diſpoſition of the notes, "that more is meant that meets the ear."

OF DECYPHERING.

The rules of decyphering are different in different languages: by obſerving the following, you will ſoon make out any common cypher wrote in Engliſh.

1. Obſerve the letters or characters that moſt frequently occur, and ſet them down for the ſix vowels, including *y*; and of theſe the moſt frequent will generally be *e*, and the leaſt frequent *u*.

2. The vowels that moſt frequently come together are *e a* and *o u*.

3. The

3. The consonant most common at the ends of words is *s*, and the next frequent *r* and *t*.

4. When two similar characters come together, they are most likely to be the consonants *f*, *l*, or *s*, or the vowels *e* or *o*.

5. The letter that precedes or follows two similar characters is either a vowel, or *l*, *m*, *n*, or *r*.

6. In decyphering, begin with the words that consist of a single letter, which will be either *a*, *I*, *o*, or *&*.

7. Then take the words of two letters, one of which will be a vowel. Of these words the most frequent are, *an*, *to*, *be*, *by*, *of*, *on*, *or*, *no*, *so*, *as*, *at*, *if*, *in*, *is*, *it*, *he*, *me*, *my*, *us*, *we*, *am*.

8. In words of three letters there are most commonly two consonants. Of these words the most frequent are, *the*, *and*, *not*, *but*, *yet*, *for*, *tho'*, *how*, *why*, *all*, *you*, *she*, *his*, *her*, *our*, *who*, *may*, *can*, *did*, *was*, *are*, *has*, *had*, *let*, *one*, *two*, *six*, *ten*, &c *.

* Some of these, or those of two letters, will be found in every sentence.

9. The

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10. The most usual words of five letters are, there, these, those, which, where, while, since, their, shall, might, could, would, ought, three, seven, eight, and so forth.

11.

Words of two or more syllables frequently beginn with double consonants, or with a preposition;

that is a vowel joined with one or two consonants.

The most common double consonants are, BL, BR, DR, FL, FR, GL, GR, PH, PL, PR, SH, SP, ST, TH, TR, WH, WR, and so forth, and the most common prepositions are, COM, CON, DE, DIS, EX, IM, IN, INT, MIS, PAR, PRE, PRO, RE, SUB, SUP, UN, and Etc.

12.§ The double consonants most frequent at the end of long words are, CK, LD, LF, MN, ND, NG, RL, RM, RN, RP, RT, SM, ST, XT, &c.and the most commontermanitions are, ED, EN, ET, ES, ER, ING, LY, SON, SION, TION, ABLE, ENCE, ENT, MENT, FULL LESS, NESS, &c.

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⊏ΛXOO ЄΛ+IO λ+Γ⊏ΛΔ
SΓƆ. Γ+⊏ +ΓO I.CΓO +
LXЄOI SΓƆ. ΘOX⊔CƆC+ЄΔ
∇+Є ЄCII. ⊏SIΠ +⊔
ΘXЄƆOΓLO ◇. LSЄ⊏C+Γ
Γ+ ⊏XSC⊏+X C⊏ CΔ
CΓƆC⊔⊔OXOΓLO ◇
ΓOTIOL⊏ OC⊏ΛOX ⊔CΓƆ.
Δ+λO λOSΓΔ Γ+ ΔOΓƆ.
λO S IO⊏⊏OX ΔΛ+X⊏I∇
◇ IO⊏ λO ΔOO ⊏ΛS⊏ C⊏
L+λOΔ ⊔X+λ ⊏ΛO ΛOSX⊏
+X ΓONOX ƆSXO ⊏+ ΔOO
λ∇ ⊔SLO λ+XO.

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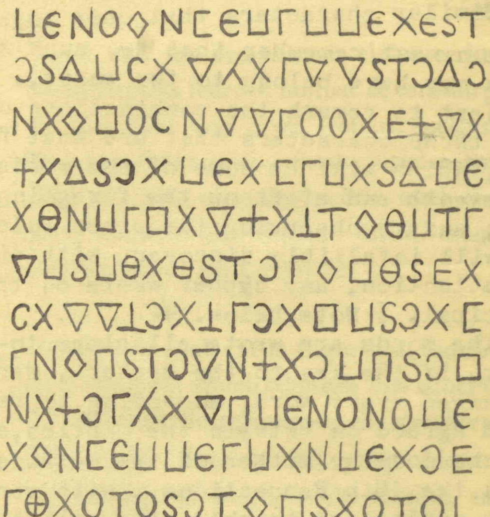
9. The most common words of four letters are, *this*, *that*, *then*, *thus*, *with*, *when*, *from*, *here*, *some*, *most*, *none*, *they*, *them*, *whom*, *mine*, *your*, *self*, *must*, *will*, *have*, *been*, *were*, *four*, *five*, *nine*, &c.

difficult.



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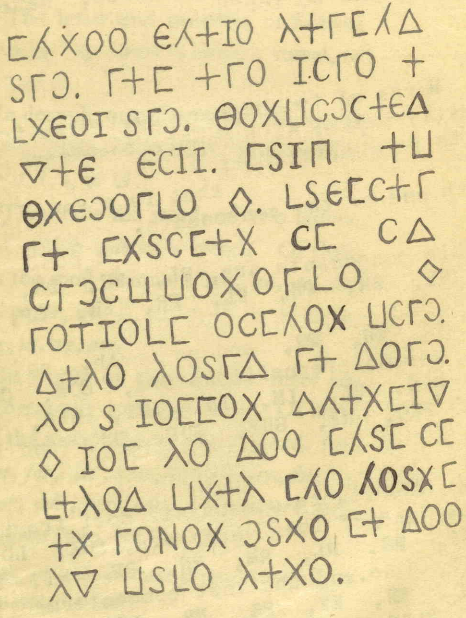
ſion, tion, able, ence, ent, ment, full, leſs, neſs, &c.

We ſhall here give an example of a cypher wrote in arbitrary characters, as is commonly practiſed.



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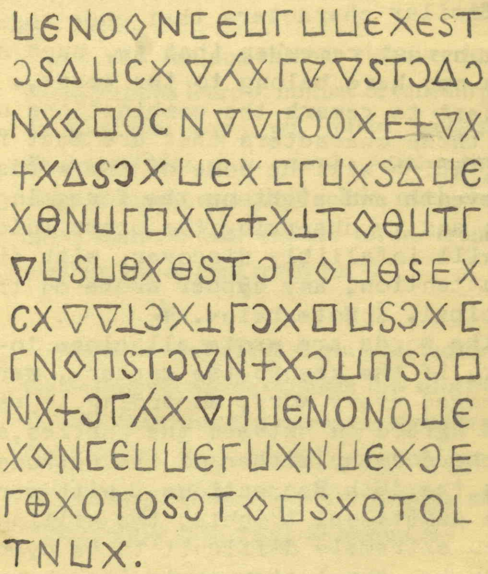
The foregoing will be easily decyphered by observing the rules; but when the characters are all placed close together, as in the following example, and as they always should be, the decyphering is much more difficult.



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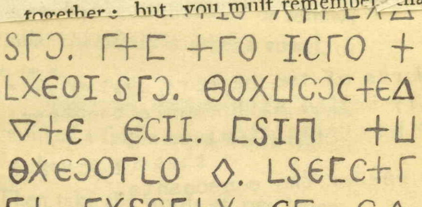
To decypher a writing of this ſort, you muſt firſt look for thoſe characters that moſt frequently occur, and ſet them down for the vowels, as before. Then obſerve the ſimilar characters that come together; but you muſt remember that



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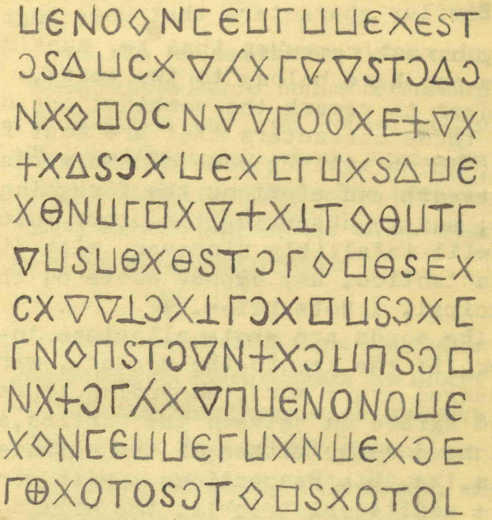

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To decipher a writing of this sort, you m must first look for those characters that most frequently occur, and set them down for the vowels, as before. Then observe the Similar characters that come together; but you must remember that two such characters may here belong to two words,. You are next to remark the combinations of twoor three characters that are most frequent, which will be some of the words in the seventh and eight og the foregoing rules; and by observing the other rules, you will infallibly discover, with time and attention, any cypher wrote on these principal. § Note.below. *

* When the words are wrote all close together, if the key to the cypher , were to be changed every word, according to regular method agreed on between the parties,as might be done by either of the methods menti ed. in the 48th Recreations , with very little additional trouble, the writing would be then extremely difficult to be cyphered. The longer any letter wrote incypher is, the more easy it is to decypher, as then the xepitionx repetitions of the characters and combinations are the most frequent.

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The following are the contents of the two foregoing cyphers; in which we have inverted the order of the words and letters, that they who are desirous of trying their talent at decyphering, may not, inadvertently, read the explanation before the cypher.

enil eno ton dna shtnom elohw eerht, suoidifrep dna leurc o. noituac & ecnedurp fo klat lliw uoy : on, rotiart, tcelgen & ecnereffidni si ti. yltrohs rettel a em dnes ot snaem emos dnif rehtie, traeh eht morf semoc ti taht ees em tel &, erom ecaf ym ees ot erad reven ro.

evlewt fo ruoh eht ta thgin siht, ledatic eht fo etag eht erofeb elbmessa lliw sdneirf ruo lla. ruoh eht ot lautcnup eb : deraperp llew emoc dna, ytrebil ruoy niager ot, ylevarb eid ro. thgin eht si siht, su sekam rehtie taht, etiuq su seodnu ro.

The

The method of correſponding by ſignals being nearly related to that of cyphers, we ſhall here give two inſtances of the manner in which it may be performed.

RECREATION LI.

Viſual Correſpondence.

PROVIDE a circle of wood ABCD (Plate IV. Fig. 1.) of about four feet in diameter, and divide its circumference, which will be about 12 feet, into 25 equal parts. In one of theſe ſpaces cut an open ſquare, and through each of the others cut one of the 25 letters of the alphabet. *(I* ſerving for *J.)* Over the ſpaces that are cut out paſte a thin oiled paper.

On the top of a pole P (Fig. 2.) fixed to the ground or floor, place a frame of wood EF, in which there is to be an opening of the ſame ſize with one of the diviſions on the wheel. On the outſide of this opening

ing let there be a door, by which it may be occaſionally cloſed. To the pole let the wheel be fixed, at its center G, round which it muſt turn, and be placed at ſuch a height that the letters on its circumference may anſwer to the hole in the frame. Behind that part of the wheel which is oppoſite the board, let there be fixed, on a ſtand, a ſtrong light.

When you would communicate your intelligence, open the door on the outſide of the frame; then put that diviſion of the wheel in which the ſquare is cut, againſt the opening, and place the light behind it; that ſerves for a ſignal to your correſpondent, which he anſwers by putting his wheel in the ſame poſition*. What you intend to communicate being wrote on a paper and placed before you in a

* Where there is a frequent correſpondence required, certain hours of the day ſhould be fixed for obſerving the ſignal.

 pro-

proper poſition, you turn the wheel round, till that diviſion which contains the firſt letter of the firſt word come before the opening, and keep it there while you tell 4; you then turn the wheel, either backward or forward*, to the ſecond letter and keep that before the opening the ſame time; and ſo of all the letters of that word; and between every word you place the vacant diviſion before the opening, while you, in like manner, tell 4. When you have finiſhed the whole of your intelligence, you ſhut the door of the frame, or withdraw the light.

If your correſpondent be far off, as ſuppoſe two or three miles, or farther, you muſt be each provided with a teleſcope, of a ſize adapted to the diſtance between you.

* There may be placed handles on different parts of the wheel as at *a*, *b*, *c*, *d*, by which it will be the more readily turned about.

Your

Your apparatus ſhould be placed ſome way within the room, that it may not be obvious to paſſengers. It is evident, from the conſtruction of this inſtrument, that it is full as well adapted for a correſpondence by night as by day.

A machine of this ſort may be conſtructed at a trifling expence, and will be found highly uſeful in many inſtances, as where two perſons live on the oppoſite ſides of a large river, or in a country where the roads are for a great part of the year impaſſable, &c. If you are fearful any perſon, beſide your correſpondent, ſhould know what paſſes, inſtead of letters, you may uſe 24 characters, like thoſe we have given in the laſt example of cyphers.

This invention may alſo be applied to public uſe, as to convey intelligence to the garriſon of a town beſieged; or where great diſpatch is required; and in that

caſe ſeveral machines may be placed at different diſtances, that may convey the intelligence to each other; and here the wheel may be of a much larger dimenſion. There is one circumſtance, however, that will render this contrivance entirely uſeleſs, and that is a thick miſt or fog; for in that caſe, let the light be as ſtrong, and the letters as large as they may, it will be impoſſible to diſcern them at any conſiderable diſtance. How to maintain a correſpondence in that ſituation, will be ſhown in the next Recreation.

RECREATION LII.

Auricular Correſpondence.

ON the top of a houſe, or any other building, fix two bells A and B, (Pl. IV. Fig. 3.) by the iron rod CD, that paſſes thro' their handles, from which there muſt hang two ropes that go to the room beneath. The

weight of the handles ſhould be nearly equal to that of the bells, ſo that a ſmall additional force applied to the ropes may draw them up. One of the bells muſt be much larger than the other, that there may be no difficulty in diſtinguiſhing their ſounds.

The letters of the alphabet are to be expreſſed by pulling of theſe bells, according to the following order; in which you are to obſerve, that the ſmall figures denote the number of pulls of the leſſer, and the numeral letters, thoſe of the greater bell.

A 1	G 1 I	N 1 III	T II 1
B 2	H 2 I	O 2 III	V II 2
C 3	I 3 I	P 3 III	U II 3
D I	K 1 II	Q I 1	W III 1
E II	L 2 II	R I 2	X III 2
F III	M 3 II	S I 3	Y III 3
			Z IIII

After each letter you muſt ſtop while you tell 4, and at the end of each word you may, for greater diſtinction, pull both bells twice together.

The above combinations may be continued to what number you pleaſe; ſo as to take in the moſt common words, ſuch as *and*, *the*, *you*, *he*, *ſhe*, *they*, *them*, *this*, *that*, *may*, *can*, *do*, &c.

PLATE IV.

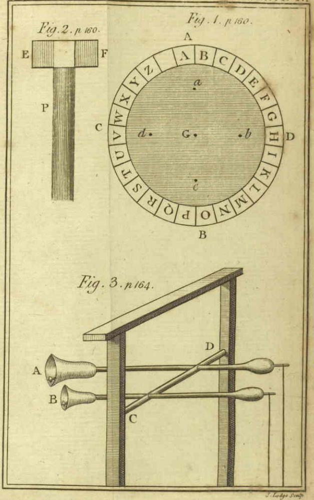


Fig. 2. p. 160.
E
F
P
Fig. 1. p. 160.
A
B
C
D
a
b
d
G
c
Fig. 3. p. 164.
A
B
C
D
J. Lodge Sculp.

MECHANICS.

MECHANICS.

DEFINITIONS.

1. MECHANICS is that ſcience which explains the properties of moving bodies, and of thoſe machines from which they frequently receive their motion.

2. Gravity is that power by which every body naturally deſcends toward the center of the earth.

3. The center of gravity, in a ſingle body, is that point round which the ſeveral parts of the body, in every ſituation, exactly balance each other, and conſequently if that point be ſuſpended the body will remain at reſt.

4. The center of gravity, in two or more bodies, is that point between them, from which the diſtance of each is in proportion to the quantity of matter it contains. The leſs the matter the greater the diſtance.

5. The Vis Inertiæ, or Inert Force, is that property in bodies, by which they resiſt the power that endeavours to put them in motion.

6. The denſity of bodies is the quantity of matter they contain, compared with their magnitude or dimenſions.

7. Elaſticity is that property in bodies by which, when their parts are forced out of their natural ſtate, they return to it again; and by which two moving bodies, after ſtriking, recoil from each other.

8. Power, in mechanics, is the force by which any body is put in motion.

9. Weight, is the body to be moved.

10. Motion, is either ſimple or compound: ſimple motion is that which proceeds from one power only; and compound motion is that which proceeds from two or more powers, either at the ſame time or in ſucceſſion.

11. The center of motion is that point round which one or more bodies move.

12. Ve-

12. Velocity of motion, is the ſpace paſſed over by a body in a given time.

13. Accelerated motion, is that which continually increaſes, and retarded motion is that which continually decreaſes.

14. The quantity of motion, or momentum of a moving body, ariſes from its velocity multiplied into the quantity of matter it contains.

15. There are ſix primary mechanic inſtruments, commonly called mechanic powers, which are (1.) the lever*, (2.) the balance, (3.) the pulley, (4.) the wheel and axis, (5.) the ſcrew †, and (6.) the wedge: to which is ſometimes added the inclined

* Levers are ſaid to be of the firſt, ſecond, or third ſort, according to the ſituation of the fulcrum F, as in Pl. V. Fig. 1, 2, 3; to which is added the bended lever, Fig. 4.

† There are ſeveral ſorts of ſcrews uſed in machines, of which thoſe of Fig. 8, and 9, Pl. V. are moſt common. In Fig. 8, the part A B is called the male ſcrew, and C D the nut, or female ſcrew. The part A B (Fig. 9.) which is turned by the wheel C D, is called an endleſs ſcrew, becauſe, while the wheel goes, it turns inceſſantly.

plane

plane: and of ſome or all of theſe every compound machine is compoſed. See Plate V.

16. A pendulum is any body ſuſpended from a point, from which it oſcillates or vibrates, as from a center; but is generally underſtood to be a ball ſuſpended at the end of a ſtring or wire.

17. That reſiſtance which ariſes from the rubbing of the parts of a machine againſt each other, is called their friction.

APHORISMS.

1. Every body, whether at reſt or in motion, will conſtantly continue in its preſent ſtate, unleſs compelled to alter it by ſome external power.

2. All motion, whether changed or generated, is in proportion to the force impreſſed, and is made in the direction that force acts.

3. Action and re-action, that is, the impulſes of two bodies on each other, are always

always equal, and in contrary directions.

4. In bodies not elaſtic, if one in motion ſtrike againſt another at reſt, they will both move in the direction of the firſt moving body; and the quantity of motion in both bodies will be the ſame as it was in the firſt before the ſtroke.

5. If one ſuch body in motion, ſtrike againſt another moving in the ſame direction, but with leſs velocity, they will both continue in that direction, and the quantity of motion in both bodies will continue the ſame.

6. When two ſuch bodies, with equal quantities of motion, and moving in oppoſite directions, ſtrike againſt each other, their whole motion will be deſtroyed, and they will remain at reſt.

7. If two ſuch bodies, with different quantities of motion, and moving in oppoſite directions, ſtrike againſt each other, they will continue to move in the direction of that body which had the greateſt

momen-

momentum, and the quantity of motion in both bodies, after the ſtroke, will be equal to the difference of their motions before it.

8. The force of action in elaſtic bodies is twice as great as that of non-elaſtic bodies; for the former ſtrike each other not only by impulſe, but by repulſe; recoiling from each other after the ſtroke*.

9. The inert force of every body is in proportion to its denſity.

10. All bodies near the ſurface of the earth deſcend equal ſpaces in equal times†.

11. The velocity of falling bodies, in unreſiſting mediums, is 16 feet the firſt

* In theſe aphoriſms bodies are ſuppoſed to be perfectly elaſtic or non-elaſtic: in all other bodies they will hold true only in proportion to the degrees of their elaſticity.

† This muſt be underſtood of ſuch as are called heavy bodies; for in thoſe that are light the reſiſtance of the air makes a conſiderable difference. A bullet and a feather fall with very different velocities in the air, though in the exhauſted receiver they deſcend together.

ſecond,

ſecond, nearly, and becomes continually accelerated in a regular progreſſion.

12. In every pendulum all its vibrations in ſmall arches, or parts of circles, are made in the ſame time.

13. The times of vibrations in different pendulums, are as the ſquare roots of their lengths*: therefore a pendulum of four feet will vibrate twice while one of 16 feet vibrates once.

14. The length of a pendulum that vibrates every ſecond, will be 39 inches, nearly†, and one that vibrates twice in a ſecond will be $9\frac{4}{5}$ inches.

15. Any body, in the form a rod or ſtaff, that is every where of equal denſity, as an iron rod, and that is one third longer than a pendulum, will vibrate in the ſame time as that pendulum.

16. In the lever, where the power P

* See page 2. definition 2.

† A pendulum of this ſort is therefore a regular meaſure of time, and may be of uſe on many occaſions.

(Pl. V. Fig. ..) and weight W are to each other reciprocally as their diſtances from the fulcrum F, they will be in equilibrio*.

17. The balance being a lever of the firſt kind, where the fulcrum is placed exactly between its two extremities, if two weights E, F, (Pl. V. Fig. 5.) be placed any where, at equal diſtances from the fulcrum, and the balance remain in equilibrio, thoſe weights muſt be equal.

18. When a power ſuſtains a weight, by a rope going over a fixed pulley, the weight and power will be equal: but if one end of the rope be fixed, and the pulley be moveable with the weight, then the power will be but half the weight.

19. In a combination of pullies, as A, B, C, D, (Pl. V. Fig. 6.) called a tackle of pullies, the power will be to the weight,

* The lever is to be regarded as the origin of the other powers, ſeeing they all act in a ſimilar manner, though in different directions.

as 1 to the number of ropes applied to the moveable pullies C D, that is, in this caſe, as 1 to 4.

20. In the wheel and axis, the power will be to the weight, as the diameter of the axis is to the diameter of the wheel.

21. When there is a combination of wheels and axles, the power will be to the weight, as the diameters of the axles multiplied into each other, is to the diameters of the wheels multiplied into each other.

22. In the ſcrew, the power is to the weight, as the perpendicular diſtance between any two threads of the ſcrew A B, (Pl. V. Fig. 8.) is to the circumference of the circle deſcribed by the power at C or D*.

23. In the wedge, the power is to the weight or reſiſtance, as half the length of the baſe C E (Fig. 10.) to its height E F.

24. In the inclined plane, the power is

* The ſcrew has the peculiar advantage of ſuſtaining a conſiderable weight, when once raiſed, though the power be taken away.

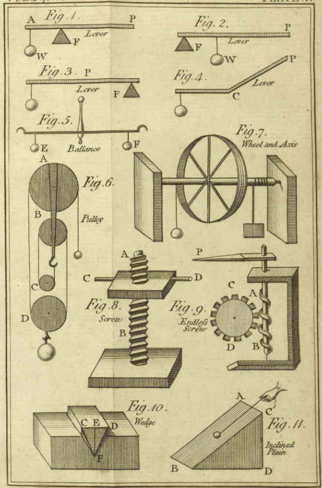
to the weight, as the height of the plane CD (Fig. 11.) is to its length A B.

25. A body acquires the ſame velocity by rolling down an inclined plane A B (Fig. 11.) as it would by falling through its perpendicular height C D.

26. It is evident from the foregoing aphoriſms, that whatever is gained in time is loſt in power; and that no machine can of itſelf give any freſh power, but by diminiſhing the velocity of the weight, and increaſing that of the power, bring them to an equality.

27. When a fly is added to any machine, as to a common jack, it does not increaſe, but diminiſh, the ſtrength of the power; its only uſe being to regulate the motion of the machine, and keep it conſtantly equal*.

* Though the fly does not in reality add any freſh power, yet by regulating the motion, it will in ſome caſes, as when a man is employed to turn a large wheel, render the operation of the power more eaſy and efficacious.



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28. In every machine, when the weight and power are in equilibrio, the leaſt additional power ſhould put it and keep it in motion; but from the friction of the ſeveral parts of the machine, it is found that, on a medium, near one-third of the firſt power muſt be added to keep the machine in motion.

29. The friction of a machine does not ariſe merely from the number of the rubbing parts, but from the weight with which they are charged, multiplied into the velocity of the motion.

30. In all machines, ſimplicity is their primary excellence, as they are thereby leſs liable to friction and impediment; the diſorder of any one part of a machine frequently obſtructing the operation of the whole.

RECREATION LIII.

To construct a mechanical dial without wheels, spring, or weight.

THIS dial consists of a tin or copper barrel or cylinder C D, (Plate VI. Fig. 1.) which is supported by two strings of catgut that are fastened to the points A and B. This cylinder, for common use, may be about a foot long, and nine inches diameter.

The principal mechanism of this dial is in the internal structure of the cylinder which is represented by Fig. 2. and consists of five divisions*, that are formed by the five pieces *a f*, *b g*, *c h*, *d i*, and *e l*, placed perpendicular to the ends of the cylinder: all these divisions must be precisely equal; and in each of the partitions

* There are sometimes six or more divisions, and the machine is commonly esteemed the more accurate for having a greater number.

almost

almoſt cloſe to the circumference of the cylinder, there is to be a ſmall hole, ſuch as is made with a large needle.

In the diviſions muſt be placed a quantity of water, equal to about one-fourth of the content of the cylinder; but the exact proportion can be determined by trial only. This water ſhould be diſtilled, or at leaſt well filtered, that it may not, by growing foul, impede the motion of the machine; and if there be a due quantity of ſpirits mixed with the water, it will be thereby prevented from freezing. At one end of the cylinder is a ſmall hole, by which it may at any time be emptied: this hole is to be ſtopped with wax.

The barrel being brought up to the points A and B, by winding the ſtring round its axis, it would there reſt, but the water oozing through the ſmall holes in the upper partitions deſtroys its equilibrium; and as it ſlowly and gradually de-

ſcends, the ſmall points at the end of its axis ſhow the hours, and parts of an hour, according to the number of diviſions on the ſcales E or F.

If this dial go too faſt or ſlow, it may be eaſily regulated, either by diminiſhing or increaſing the ſize of the catcut, or the quantity of water in the cylinder.

Machines of this kind are moſt common in monaſteries, and are frequently made by the monks themſelves, for their own private uſe; the purchaſe of a watch requiring a ſum of money which is very rarely poſſeſſed by any of that claſs of men; if they can be called men who diſclaim the principal characteriſtic of manhood.

RECRE-

RECREATION LIV.

A dial to ſhow the hour by gradually deſcending an inclined plane.

THE external ſtructure of this dial conſiſts of two parallel plates, connected by a hoop A B (Pl. VI. Fig. 3.) which is placed about one-eighth of an inch beneath the circumference of the plates. Theſe plates are indented, to prevent their ſliding down the plane. On the front plate are inſcribed the 24 hours; and at its center is a ſmall hollow hemiſphere *g*, moving freely on a pin: the lower part of this hemiſphere is filled with lead, that keeps the little gentleman who ſits upon it, and points with his finger to the hour, conſtantly in an erect poſition. The deep ſhades in the plate repreſent its concavity, which is about half an inch.

Fig. 4. In the ſame plate, repreſents the internal ſtructure of this dial. L E T Q

is the circumference of the hoop: *f* a frame-plate, on which is placed the train of wheels 1, 2, 3, 4, which are nearly ſimilar to thoſe in another dial, and are, in like manner, governed by a balance and regulator. There is here no ſpring, nor fuſee, their effects being otherwiſe ſupplied, as will appear hereafter. The great wheel of the train is placed upon the axis of the movement, at the center, and the other wheels on one ſide, which would give the machine a movement, for a ſhort time, on a horizontal plane: it is therefore neceſſary to fix a thin plate of lead, C, on the oppoſite ſide, to preſerve the equilibrium. The machine will then reſt in any poſition on the horizontal plane H H; but if it be placed on the inclined plane D G D, it will touch it in the point G, but cannot reſt there; for the center of gravity at M, acting in the direction M T, and having nothing to ſupport it, muſt neceſſarily deſcend, and carry the body down the plane.

But

But if on the other ſide ſuch a weight P, be fixed, as ſhall remove the center of gravity from M to V, in the line L G, which paſſes through the point G, then it will naturally reſt on the inclined plane.

Now if the weight P be not fixed, but ſuſpended at the end of an arm or lever, which is faſtened to the center-wheel 1, moving on the axis of the machine at M, and which communicates, by its teeth, with the other wheels; in that caſe, if the weight P be juſt equal to the reſiſtance ariſing from the friction of the train, the dial will remain at reſt, as on a horizontal plane.

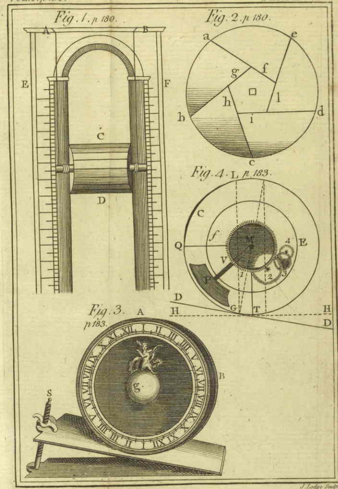
But if the weight P be ſuperior to the reſiſtance of the train, it will neceſſarily put it in motion, and the dial will then gradually deſcend the inclined plane; while the weight P, its arm P M, and the wheel 1, conſtantly preſerve the ſame

poſition they were in when the dial began to move.

From what has been ſaid it is eaſy to conceive that the weight P may have ſuch a determinate gravity as ſhall act upon the train with any required force, and conſequently produce a motion in the machine of any required velocity, ſuch, for example, as ſhall carry it round once in 24 hours. Therefore, if the diameter of the dial plate be four inches, it will deſcribe the length of its circumference, that is, 12 inches five-tenths, nearly, in the 24 hours. From whence it follows, that this movement may be made to continue any number of days, by a proportional increaſe of the length of the plane; and if that were infinite, the motion of the dial would be perpetual.

The motion of this dial is eaſily accelerated or retarded by raiſing or depreſſing the inclined plane, by means of the ſcrew

PLATE. VI.



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S (Fig. 3.) The angle to which the plane is firſt raiſed is about 10 degrees, that is, the ninth part of a quadrant, or quarter of a circle.

RECREATION LV.

A clock to go perpetually by the influence of the celeſtial bodies.

THE conſtruction of the movements in this clock is the ſame with thoſe in common uſe: it differs from thoſe only in its ſituation, and the manner in which it is wound up.

This clock is to be placed near a wall, by, or againſt, which the tide conſtantly flows. To each of the barrels, round which the ſtring that carries the weight is wound, there muſt hang a bucket, and into that, when the tide riſes to a certain height, the water runs, by means of a pipe fixed in the wall. The bucket then overbalanceing the weight, deſcends, and winds up the clock;

clock; but when it comes to a certain depth, it is taken by a catch fixed in the wall, which, by turning it over, difcharges the water. The weights of the clock then defcend in the ufual manner, and the buckets are drawn up.

Now as this clock is kept in motion by the tide, and as the tide proceeds from the influence of the fun and moon, it neceffarily follows, that the motion of the clock proceeds from the fame caufe; and that as long as the parts of the machine remain, motion will be perpetual.

This, according to the common acceptation of the term, is certainly a perpetual motion; and fo is every mill that is driven by a conftant ftream; but that is not the fenfe in which the term was ufed by the advocates for a perpetual motion in the laft century. They meant a machine, which, being once put in motion, fhould, by its peculia: conftruction, move perpetually,

tually, without any fresh force impressed. This they attempted by various means; as the attraction of a loadstone, the descent of heavy bodies, the difference of the momentum in revolving weights, &c. all of which, though ingenious enough, discover a want of due attention to the principles of mechanics. Besides, if a perpetual movement could be effected by either of those means it would be of very little, or no use: for the unavoidable wear of the several parts of the machine, arising from the incessant friction, must necessarily destroy that equality of motion, which alone could render its perpetuity of any consequence.

RECREATION LVI.

The inſcrutable lock.

THE difficulty a ſtranger would find in opening this lock, when in poſſeſſion of the key, ariſes partly from the ſcutcheon that is placed before it, and partly from the peculiar form of the key.

The ſcutcheon AB (Pl. VII. Fig. 1.) conſiſts of a circular plate of braſs or iron, on whoſe rim are 24 teeth, that take the leaves of the pinion C: this ſcutcheon may therefore be placed in 24 different poſitions; in ſeveral, or all of which, the key may be inſerted, but the lock opened in one of them only: D, is the aperture for the key, and *a*, *b*, *c*, *d*, are four knobs by which it is turned about.

The key ABCD (Fig. 2.) conſiſts of two ſets of wards, which are divided into twelve

twelve parts, as is expreſſed by the parallel lines in the figure, and which ſhould be made to join ſo exactly, that when they are preſſed together, their diviſions may not be viſible. At the middle of the key is a ſcrew E, which, when turned in, faſtens all the parts together, and when ſcrewed out, ſets them at liberty, that they may be turned round the barrel of the key, at the center of each part. When you have locked the door, you turn the ſcutcheon about by one of the knobs; then unſcrewing the wards of the key, you turn part of them half round, that is, you bring ſome of thoſe parts that were next AB to CD, and then make them faſt again, by the ſcrew at the end.

Now if the perſon, into whoſe hands this key ſhall fall, be ignorant of the ſcrew, it will be abſolutely impoſſible for him to open the lock; and if he ſhould know the uſe of it, the trials he muſt make before he can have any proſpect of ſucceſs,

cefs, will render the attempt highly abfurd; for there being 12 divifions in the key, it appears by the 18th Recreation of this volume, they may be placed in 479,001,600 different pofitions, and as each of thefe pofitions may be applied to the feveral ways in which the fcutcheon may be placed, it follows, that if the foregoing number be multiplied by 24, the product, which is 11,496,038,400, will be the number of all the trials that can be made: therefore, it is eleven thoufand four hundred and ninety-fix millions, thirty-eight thoufand, three hundred and ninety-nine, to one, at each trial, that he does not open the lock.

For common purpofes a much lefs number may fuffice: fuppofe, for example, there are only feven divifions in the key, the number of trials will be then 120,960. Now fuppofing 60 trials to be made in an hour, it would require 2016 hours to make all thofe trials, that is, to be fure of fuc-

ceeding; that is, ſuppoſing again, a regular account to be kept of each trial as it is made, for otherwiſe the ſame trial might, and naturally would, be made ſeveral times.

RECREATION LVII.

So to diſpoſe a hand-mill, to grind corn, &c. that being once put in motion, it ſhall work inceſſantly, from morning to night, without the aſſiſtance of any animal power.

THE form of this mill may be ſimilar to thoſe in common uſe: its motion is to be maintained by means of a ſmoke-jack: the uſe of this ſort of jack is common enough; but its conſtruction and manner of acting being clearly underſtood by few, we ſhall here deſcribe them.

The horizontal wheel AB (Plate VII. Fig. 3.) is placed in the narroweſt part of the chimney that is next the fire: its wings, which are made of tin, are inclin-

ed to the horizon, that is, placed in a ſloping direction. To the ſame axis on which AB turns, is likewiſe placed the cog-wheel C, that takes the teeth of the perpendicular wheel D. On the ſame axis with D, is placed the wooden wheel E, round which runs the rope F, on whoſe lower part is placed the wheel of the ſpit.

Now, the air, being rarefied by the fire, forces up the chimney, and meeting with the wings of the horizontal wheel in the narroweſt part, neceſſarily turns it round, and at the ſame time turns the cog-wheel C, which turns D and E, together with the rope, which by its friction againſt the wheel of the ſpit, keeps that likewiſe conſtantly turning; and its velocity will be always in proportion to its weight, and the ſtrength of the fire.

Therefore, if inſtead of the iron ſpit, the handle of the mill, be fixed in the center of the lower wooden wheel, it muſt, in like manner, turn that round: and the motion

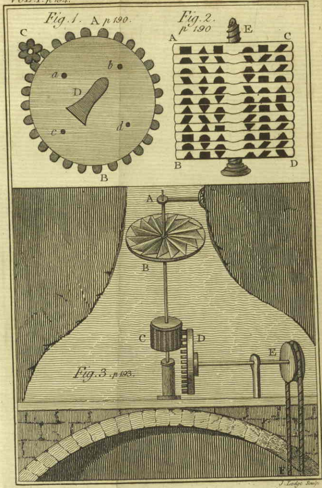
Fig. 1. A p 190.
C
a
b
D
c
d
B
Fig. 2. p 190
E
A
C
B
D
A
B
C
D
E
Fig. 3. p 193.
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motion will continue not only while the fire lafts, but a confiderable time after; for there will be a continual circulation of the air up the chimney, till that in the room becomes equally cold with the external air.

This machine may in like manner be applied to the reeling of yarn; to the making a hammer ftrike perpetually on an anvil; and many other domeftic purpofes.

RECREATION LVIII.

A carriage to go without any other force than what it receives from the paffengers.

THIS machine is reprefented by AB CD, (Pl.VIII. Fig. 1.) It is moved by the footman behind it; and the fore wheels, which act as a rudder, are guided by the perfon who fits in the carriage*.

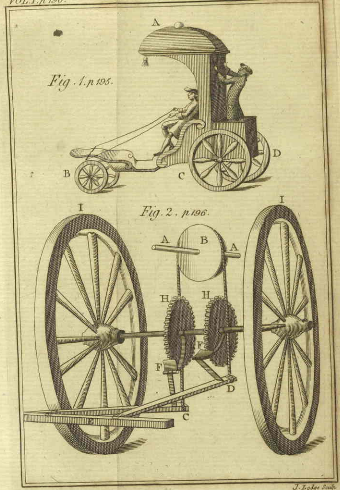
* This machine was invented by M Richard, a phyfician of Rochelle, and was exhibited at at Paris in the laft century. It is defcribed by M. Ozanam in his Recreations Mathematiques.

Between the hind wheels is placed a box, in which is concealed the machinery that moves the Carriage. AA, Fig. 2. is a ſmall axis, fixed into the box. B is a pulley, over which runs a rope, whoſe two ends are faſtened to the ends of the two leavers or treddles CD, whoſe other ends are fixed in ſuch manner in the piece E, which is joined to the box, that they can eaſily move up and down. F, F, are two flat pieces of iron, that are joined to the treddles, and take the teeth of the two wheels H H, which are fixed on the ſame axis with the hind wheels of the carriage, I, I.

It is evident that when the footman behind preſſes down one of the treddles, ſuppoſe C, with his foot, he muſt bring down one of the pieces of iron F, and conſequently turn the wheel H that is next to it; and at the ſame time, by means of the rope that goes over the pulley, he muſt raiſe the other treddle D, together with its piece F, which being thruſt down, will turn the other wheel H; and ſo alternately:

Fig. 1. p. 195.

Fig. 2. p. 196.



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ly: and as the great wheels are fixed on the ſame axis, they muſt neceſſarily move at the ſame time.

It is eaſy to conceive that if the ends of the treddles next E, inſtead of being placed behind the carriage were turned the oppoſite way, ſo as to come under the feet of the perſon who ſits in it, he might move it with equal, or even greater facility, than the footman, as it would then be charged with the weight of one perſon only.

A machine of this kind will afford a ſalutary recreation in a garden, or park, or on any plain ground, but in a rough or deep road muſt be attended with more pain than pleaſure.

RECREATION LIX.

The catapulta.

THIS engine was in great repute among the ancients, and uſed by them in throwing darts or ſpears againſt their enemies, from whence it had its name. Some of the ſpears or darts thrown by theſe engines are ſaid to have been eighteen feet long, and to have been thrown with ſuch velocity as to take fire in their courſe*.

* It will not be improper to inſert here, what is related by writers of the laſt century concerning the force of darts or arrows. Greaves, in his Pyromodographia, ſays, "Some Turkiſh bows "are of that ſtrength as to pierce a plank ſix "inches thick." He adds, "I ſpeak what I "have ſeen." And Barclay, a writer of ſufficient credit, in his Icon Animorum, ſpeaking of the Turkiſh bow, which differed very little in form from the long bow, anciently in uſe among us, being drawn by the hand, without the help of the rack that is uſed to ſome other bows. He ſays, "I was an eye witneſs, how one of theſe bows, "with a little arrow, did pierce through a piece "of ſteel three fingers thick." Of facts like theſe a man

ABCD, (Pl. IX. Fig. 1.) is the frame that holds the darts or arrows, which may be of different numbers, and placed in different directions. EF, is a large and ſtrong iron ſpring, which is bent by a rope, that goes over the three pullies I, K, L, and is drawn by one or ſeveral men; this rope may be faſtened to a pin at M. The rope therefore being ſet at liberty, the ſpring muſt ſtrike the darts with great violence, and ſend them, with ſurpriſing velocity, to a great diſtance. This inſtrument differs in ſome particulars from the deſcription we have of that of the ancients; principally in throwing of ſeveral darts at the ſame time, one only being thrown by their's. A machine of this ſort would be of uſe in thoſe countries where there are frequently large flights of birds, for a great

a man may be very well allowed to doubt, or to ſuppoſe they were attended with ſome deception: yet totally to diſbelieve them, when related by ſuch witneſſes, merely becauſe they are to us impracticable, favours rather of ignorance and temerity than a rational caution.

number of arrows being thus difcharged at the fame inftant, could not fail of doing remarkable execution.

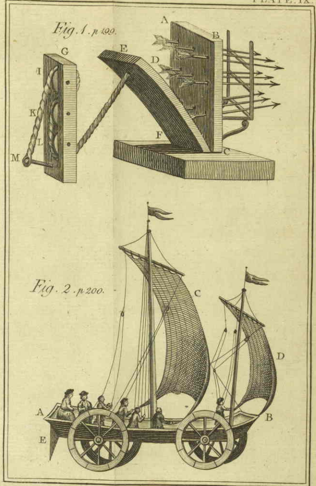
RECREATION LX.

To fail as faft, with a fair wind, by land as by water.

THIS is to be effected by means of a failing chariot, or boat fixed on four wheels; as AB (Plate IX. Fig. 2.) which is driven before the wind by the fails C D, and guided by the rudder E. In a chariot of this kind the wheels fhould be farther afunder, and the axle-trees longer, than in other carriages, to prevent overturning.

A machine of this fort was conftructed in the laft century by Stephinus, at Scheveling in Holland, and is celebrated by many writers. Its velocity with a ftrong wind is faid to be fo great, that it would carry eight or ten perfons from Scheveling to Putten, which are forty-two Englifh miles diftant, in two hours.

Carriages



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Carriages of this kind are ſaid to be frequent in China; and in any wide, level country, muſt be ſometimes both pleaſant and profitable. The great inconvenience attending this machine is, that it can only go in the direction the wind blows: and even not then unleſs it blow ſtrong; ſo that, after you have got ſome way on your journey, if the wind ſhould fail, or change you muſt either proceed on foot, or go back Some remedy for this inconvenience will be found in the next recreation. The Hollanders have, or had, ſmall veſſels, ſomething of this kind, that carry one or two perſons on the ice, having a ſledge at bottom inſtead of wheels; and being made in the form of a boat, if the ice break the paſſengers are ſecured from drowning.

RECRE-

RECREATION LXI.

To sale by land against the wind.

LET A B C D (Plate X. Fig. 1.) be the body of a sailing chariot: M the mast, to which are fixed the wings or sails E F G H; the two first of which E F, are here supposed to be expanded by the wind. R is the rudder by which it is guided. Therefore, the wind driving the sails round, with the mast M, and the cog wheel K, take the teeth, placed perpendicular to the sides of the two fore-wheels of the carriage, and consequently keep it in continual motion.

The body of this machine should not be large, nor placed very high, not only to prevent overturning, but that its motion may not be thereby impeded; for the velocity will be in proportion to the force of the wind on the sails to that on the body of the machine. Therefore if they be

be both equal it will ſtand ſtill; or if the force on the body be the greateſt, it will go backwards; unleſs there be a contrivance to lock the wheels. The upper part of the machine next A, may be made to take off, when the wind is contrary, and there may be another ſet of ſails placed between the two hind wheels, which will conſiderably increaſe its velocity. But after all, for general uſe, a common carriage muſt be preferable: for this cannot be expected to go up a moderate aſcent without great difficulty, nor down a declivity, when there is a ſtrong wind, without danger; and even on level ground, if the road be in any degree rough, its progreſs muſt be very ſlow; attended both with difficulty and danger. In an open country, however, where there is a large tract of level and ſmooth ground, and frequent ſtrong winds, a machine of this ſort will certainly be very convenient; and in moſt countries, when made of a ſmall ſize, may be uſeful to young people, by affording them a pleaſant and healthful exerciſe.

RECREATION LXII.

The uninvertible carriage.

THE body of this carriage muſt conſiſt of a regular hollow globe, as A B (Plate X. Fig. 2.) at the bottom of which is to be an immoveable weight, and which muſt be proportioned to the number of perſons, or the load the machine is intended to carry. Round the globe muſt go two horizontal iron circles D, E, and two others F, G, that are perpendicular to the former. All theſe circles muſt be made exactly to fit the globe, that it may move freely in every direction. The two horrizontal circles are to be joined on each ſide by a perpendicular bar, one of which is expreſſed in the figure by H I. All theſe irons ſhould be lined with leather, to prevent unneceſſary friction. The body of the carriage may be either of leather or hard wood, but the latter will be moſt elegible, as leaſt liable to wear. The wheel

on

on each ſide is to be faſtened to the perpendicular bar by means of a handle K, that keeps it ſteady.

Now, the body of this machine moveing freely in the iron circles, every way, the center of gravity will always lie at C; therefore in whatever poſition the wheels are, or even if they overturn, the body of the carriage will conſtantly remain in the ſame perpendicular direction.

At L is placed a pin, round which is a hollow moveable cylinder: this pin moves up and down in the groove M N, that it may not impede the perpendicular motion of the circles, at the ſame time that it prevents the body of the machine from turning round in a horizontal direction. O, is one of the windows, P the door, and Q R the ſhafts to this machine,

When a carriage of this ſort is intended for a ſingle perſon, or a light weight,

it

it may be hung on ſwivels, in the ſame manner as the rolling lamp or the ſea compaſs, which will make its horizontal motion ſtill more regular: and when it is deſigned to carry ſeveral perſons, by adding another perpendicular bar, on each ſide, between the two horizontal circles, it may be placed on four wheels. The body of this machine ſhould be frequently oiled or greaſed, not only to prevent any diſagreeable noiſe that may ariſe from its rubbing againſt the circles, but to prevent unneceſſary wear in the ſeveral parts.

This carriage is not intended for ſmooth roads, or a regular pavement; there, certainly, thoſe of the common conſtruction are much preferable; nor ſhould a carriage totally free from irregular motion be ſought after by thoſe who are in perfect health: but there are many perſons, ſubject to different diſorders, who by being obliged to travel over rough roads in the common carriages, ſuffer tortures of which the

PLATE. X.

Fig. 1. p 202.

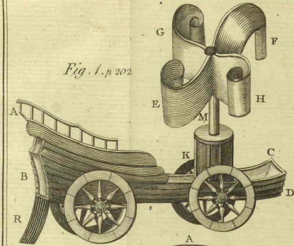
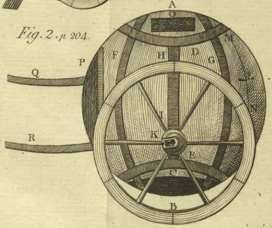


Fig. 2. p 204.



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the healthful have no idea, to all these, therefore, and to every one who is forced to travel through dangerous roads, a carriage of this sort must doubtless be highly desirable.

As this design may appear to some persons, on a superficial view, impracticable, we shall here insert an account of a similar carriage, which we have taken from the first volume of the Abridgement of the Philosophical Transactions, by Lowthorp, p. 592. There is not, however, any description of the manner in which that machine was constructed. The account is as follows: "A new sort of calesh described "by Sir R. B. This calesh goes on "two wheels; carries one person: is light "enough. Though it hangs not on braces "yet it is easier than the common coach. "A common coach will overturn if one "wheel go on a superficies a foot and a "half higher than the other, but this "will admit of the difference of three "foot

" foot and one third in height of the su-
" perficies, without danger of overturn-
" ing. We chose all the irregular banks,
" and sides of ditches, to run over; and I
" have this day seen it, at five several
" times, turn over and over, and the horse
" not at all disordered. If the horse should
" be in the least unruly, with the help
" of one pin, you disengage him from
" the calesh without any inconvenience
" *(a contrivance of this sort may be easily*
" *added to the foregoing design.)* I myself
" have been once overturned, and knew
" it not till I lookt up, and saw the
" wheel flat over my head: and if a man
" went with his eyes shut, he would
" imagine himself in the most smooth
" way, though at the same time there be
" three foot difference in the height of
" the ground of each wheel."

RECREATION LXIII.

The columnar dial.

PLATE XI. Fig. 1. repreſents a column or obeliſk AB, whoſe ſhaft GH is fluted, and divided by horizontal lines, that appear as joints, and ſerve to mark the hours: the inſide of this column is hollow, and is repreſented by Fig. 2: in the baſe is placed the hollow cylinder A, conſtructed exactly in the ſame manner with that of the 53d Recreation of this volume, but here it is kept in motion by the weight B, faſtened to a ſtring that goes over the pulley C, and to this ſtring is likewiſe faſtened the index H, that, as the weight deſcends, points to the hours marked on the outſide of the column, as is expreſſed in Fig. 1, at H. The axis of the cylinder comes through the front of the column, and to the end of it is fixed an index that points to the minutes of each hour, mark-

ed on a circle in the front of the baſe, as in Fig. 1. at B.

The ſtriking part of this dial is contained in the capital of the column, (ſee Fig 2.) where DE is an axis, on which are placed the two braſs wheels F and G, that are of an equal diameter. On the circumference of the wheel G are ſix teeth, placed at equal diſtances from each other; theſe teeth are taken by the detent or lever IKL. The wheel F is likewiſe divided into ſix equal parts, in each of which is placed a different number of teeth from one to ſix. The ſhort end of the detent or lever MNO takes the teeth of this wheel, and to the other end of it is fixed the hammer P, that ſtrikes the bell Q.

The wheel A making a complete revolution every hour, when it comes to X, its tooth raiſes the end *a* of the lever *a*, *b*, *c*, conſequently depreſſes the oppoſite end *c*, which by means of the ſtring *cd*, raiſes

the end I of the lever IKL, and the wheel G is turned by the weight W from G to Z, but can go no farther; for the end I, of that lever, being heavier than the other end, descends again immediately after it has quitted the tooth. Now the wheel F being of the same dimension as G, and fixed on the same axis, must necessarily move the same space, in order to which it must push up the end of the lever MNO, that presses against one of its teeth, and that end descending again immediately, being heavier than the other, the hammer O will strike the bell; it will, in like manner, be forced over and fall between each tooth, till it come to the end of the division, and consequently give as many strokes on the bell as there are teeth in that division. As the end NO of the lever MNO is three times as long as M N, while the short end is pushed over one of the teeth, the other will be pushed three times as far from the bell.

Due care muſt be had in adjuſting the weight to the effect it is to produce : for if it be too light, it will not overcome the friction of the lever with the teeth; and if it be too heavy, the wheel will move with too great velocity, and not give the lever ſufficient time to fall in between the teeth. To the axis of each of the wheels A and F is fixed a racket-wheel and a ketch, by which they were wound up. The time of this dial's going may be conſiderably increaſed by adding one or more pullies to thoſe at C and W.

It is evident from the conſtruction of this dial that it ſtrikes from one to ſix only : it may, however, be made to ſtrike all the twelve hours, but then the number of teeth on the wheel F muſt be increaſed from 21 to 78, and conſequently the wheels muſt be larger or the teeth ſmaller, either of which would be inconvenient ; and, as we have obſerved elſewhere, ſimplicity is a capital excellence in the

Vol. I. p. 212. PLATE XI.

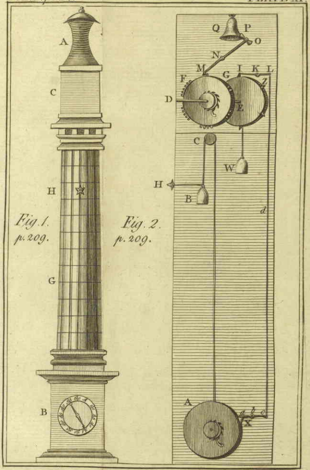

Fig. 1. p. 209.

Fig. 2. p. 209.

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the conſtruction of every machine. It would certainly be more eligible for clocks in general to ſound no more hours than 6, as they would be leſs complex in their conſtruction, the hours would be more readily told and leſs liable to be miſtook; nor could it be attended with any inconvenience, as it is impoſſible for any one, to whom time is of the leaſt importance, not to diſtinguiſh morning, noon, and night from each other,

A clock of this ſort may be conſtructed at a ſmall expence, and will make an elegant piece of furniture; or if elegance be not regarded, the machinery may be placed in the corner of a room, with a plain board before, and it will anſwer the intention equally well. It is eaſy to conceive, that with a ſmall alteration this machine may ſerve as a reveilleur or alarum.

RECREATION LXIV.

An air chronometer.

PROVIDE a glaſs tube (Plate XII. Fig. 1.) of about an inch diameter, and three or four feet long: the diameter of the inſide of this tube muſt be preciſely equal in every part: at the bottom is to be a ſmall hole, that is cloſely covered with a valve. In the tube place a piſton E, (Fig. 2.) which is made to fit it exactly, and muſt be oiled, that it may move in the tube with the greateſt freedom: in this piſton there is a cock, that ſhuts quite cloſe, and from the top of it there goes a cord F, that paſſes through the handle G.

Now the cock of the piſton being cloſed, it is to be let down to the bottom of the tube, and being then drawn up to the top, the air will ruſh in by the valve at

at the bottom of the tube, and ſupport the piſton. You are then to turn the cock, ſo as to make a very ſmall vent, and the air paſſing ſlowly through that vent, the piſton will gradually deſcend and ſhow the hour, either by lines cut in the tube with a diamond, or marked with paint, or by ſmall ſlips of paper paſted on the glaſs. If this chronometer ſhould go too faſt or ſlow, it may be eaſily regulated by altering the poſition of the cock in the piſton, as it is on that the whole depends.

If, inſtead of marking the tube, you would have the time ſhown by a dial, it may be eaſily effected by placing an axis, to which the hand of the dial is fixed, directly over the tube, and winding the ſtring, to which the piſton is joined, round that axis: for then as the piſton deſcends the axis will gradually turn the hand, and ſhow the hour: but you are

to obſerve, that as the deſcent of the piſton is not conſtantly regular, occaſioned by the decreaſe of reſiſtance from the quantity of ſubjacent air as the piſton deſcends, the axis therefore muſt not be a regular cylinder, but conical, like the fuſee of a watch, as in Fig. 3. by which means the motion of the hand of the dial will be conſtantly uniform.

RECRE-

RECREATION LXV.

The lamp chronometer.

PLATE XII. Fig. 4. represents a chamber-lamp A, consisting of a cylindrical vessel about three inches high and one inch diameter, placed in the stand B. The inside of this vessel must be every where exactly of the same diameter. To the stand B is fixed the handle C, which supports the frame DEFG, about twelve inches high and four inches wide. This frame is to be covered with oiled paper, and divided into twelve equal parts, by horizontal lines; at the end of which are wrote the numbers for the hours, from 1 to 12, and between the horizontal lines are diagonals, that are divided into halves, quarters, &c. On the handle B, and close to the glass, is fixed the style or gnomon H.

Now

Now as the diſtance of the ſtyle from the flame of the lamp is only half an inch, if the diſtance of the frame from the ſtyle be ſix inches, then while the float that contains the light deſcends, by the decreaſe of the oil, one inch, the ſhadow of the ſtyle on the frame will aſcend twelve inches, that is, its whole length, and ſhow by its progreſſion, the regular increaſe of the hours, with their ſeveral diviſions.

It is quite neceſſary that the oil uſed in this lamp be always of the ſame ſort, and quite pure, and that the wick alſo be conſtantly of the ſame ſize and ſubſtance, as it is on theſe circumſtances and the uniform figure of the veſſel, that the regular progreſs of the ſhadow depends.

To make this machine ornamental as well as uſeful, there may be drawn in the middle of the frame, yet ſo as to leave the diviſions of the hours quite viſible, the

figures

figures of trees, flowers, animals, or whatever else the owner's imagination shall suggest; and if they be properly painted, in lively colours, they will have a very pleasing effect.

RECREATION LXVI.

The nocturnal dial.

THE two wheels A and B (Plate XII. Fig. 5.) are of the same diameter, and have each fifty four teeth: their axes are parallel, but have no connection with each other. The pinion C and the wheel D have each six teeth, and the wheel E eighteen teeth; the two last wheels, D and E, are placed on the same axis: all these wheels must be of brass or copper, and as light as possible. Near the circumference of the wheel A are the figures for the hours and their divisions, which are cut through the plate, and covered with oiled paper.

paper. On the wheel B, at F, is fixed a lamp, the oil of which muſt be of the pureſt ſort, and the wick conſtantly of the ſame ſize and matter; and round the axis of this wheel is wound a rope, to which hangs the weight G.

Now the quantity of oil in the lamp is ſo adjuſted, as to exactly counterbalance the weight G; but as the oil is continually decreaſing, the weight muſt deſcend, though very gradually, and conſequently turn the wheel B, and that muſt turn the pinion C and wheel D, which being fixed on the ſame axis as E, turns that alſo, and conſequently the wheel A. But as each of the great wheels A and B have fifty-four teeth, the pinion C and wheel D only ſix teeth, and the wheel E eighteen teeth, it neceſſarily follows, that while the wheel B moves from F to H, that is, one-third of its circumference, the wheel A muſt make a complete revolution; and as

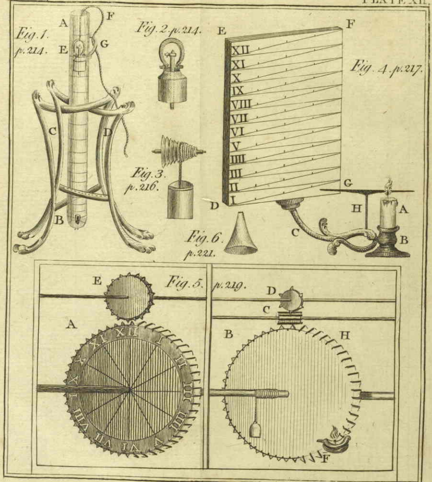
ſome

ſome parts of its circumference will be continually oppoſite the lamp, the number of the hour will be always viſible.

A hollow cone or funnel, as Fig. 6, is to be placed to that ſide of the lamp oppoſite the wheel A, the ſmall end of this cone ſhould be ſquare, and which will confine the light of the lamp to a determinate part of the wheel A: if a moveable lens be adjuſted to this ſmall end, the quantity of light may be extended or contracted at pleaſure.

This dial may be made to ſound the hours, by adding the apparatus deſcribed in the 63d Recreation, and fixing a tooth on the rim of the wheel A, againſt each hour, which will take the end of the lower lever, in the ſtriking part of that machine, and it may like that ſerve as an alarum.

To thoſe who are troubled with an inſomny, or inability to ſleep, whether from conſtitution or diſeaſe, a dial of this ſort will prove an agreeable companion, as it will continually ſhow how the tireſome hours wear away; and to make it more amuſing, over each hour ſome motto may be cut out; for if the diameter of the wheel be one foot, its circumference will be ſomething more than three feet, and conſequently there will be a ſpace of three inches to every hour. In the twelve compartments under the hours there may be likewiſe figures of hiſtory, either religious or profane; or emblems of devotion, love, morality, or whatever elſe the temper and diſpoſition of the owner may require; and if theſe figures be covered with tranſparent paper, properly coloured, this machine, at the ſame time that it anſwers the common purpoſes of a dial and lamp, will afford a pleaſing repreſentation; and as the wheels are in continual motion, and the



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the light confined to a certain ſpace, one that is continually varying.

We might here give a much greater variety of mechanical conſtructions, but we chooſe to confine ourſelves to ſuch as are moſt remarkable, and which, when duly conſidered, will be quite ſufficient to exemplify the foregoing aphoriſms. They who are deſirous of more variety, will readily find a great number of experiments that are conſtantly repeated by every writer on mechanics.

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THE ROMAN ABACUS. p. 11

An inſtrument by which any ſum may be ſet down, added to, or ſubtracted from, another, by counters, and without the uſe of figures.

NEPER'S RODS. p. 13

A method of multiplying and dividing by a table of figures, engraved on moveable rods (ſee Plate I. Fig. 1 and 2.)

THE CHINESE SWAN-PAN. p. 17

An inſtrument that performs all the operations of arithmetic, by moveable balls ſtrung on wires (Plate I. Fig. 3.) and without the aid of figures. A blind perſon, with this inſtrument, may make any calculation with certainty.

RECRE-

RECREATION I. p. 22

Any number being named, by adding a figure to it, to make it divisible by nine.

By adding as much to the amount of the figures that compose the number, as will make it divisible by nine.

RECREATION II. p. 23

A person having an even number of counters in one hand, and an odd number in the other, to tell in which hand the odd or even number is.

By directing him to multiply the number in one hand by an odd number, and that in the other by an even number, and to tell you whether the amount of the two products be even or odd.

RECREATION III. p. 24

A person making choice of several numbers, another is to name him the number by which the sum of those numbers is divisible.

By putting a parcel of tickets, marked with numbers divisible by 3, into one division of a bag, and into another division tickets marked with the number 3 only, and letting two persons draw one from each division.

RECREATION IV. p. 25

To find the difference between two numbers, the greatest of which is unknown.

By subtracting the least number from an equal number of nines, and directing another person to add to, and subtract from, the amount, in a determinate manner.

RECREATION V. p. 27

To tell, by the dial of a watch, at what hour any perſon intends to riſe.

You tell him to place the hand of the dial at what hour he pleaſe, and you privately add 12 to that number; you then tell him to count ſo many hours on the dial as are equal to the amount, and the laſt will be the hour required.

RECREATION VI. p. 28

A perſon chooſing any two out of ſeveral given numbers, and after adding them together, ſtriking out one of the figures of the amount, to tell what that figure was.

By offering ſuch numbers only as are diviſible by 9, and the ſum of any two of them is either 9 or 18, and contains no cypher.

RECREATION VII. p. 29

Two persons choosing two numbers, and multiplying them together, by knowing the last figure of the product to tell the other figures.

By putting into one division of a bag tickets marked 73, and into another division such numbers, as when multiplied by 73, will end with the nine digits.

RECREATION VIII. p. 31

The magical century.

If two person stake a number of counters alternately, but never more than ten at once, he that stakes first must make the century, provided he make the other's stake each time, equal to one more than the sum of one of the nine digits multiplied by 11—the same Recreation with a pack of cards, p. 32.

RECREATION IX. p. 34

The confederate counters.

A ring, a ſeal, and a ſnuff-box being choſe by three perſons, to tell, by means of twenty four counters, and a verſe of fourteen ſyllables, which of them each perſon has choſe.

RECREATION X. p. 36

A perſon privately fixing on any number, to tell him that number.

By directing him to double, add to, and multiply that number, and ſubtract another number from it, in a determinate order.

RECREATION XI. p. 37

Three dice being thrown on a table, to tell the number of each die, and the order in which they ſtand.

The perſon who threw the dice is to double and multiply each number, and ſubtract another number from the amount, as in the laſt Recreation.

RECREATION XII. p. 39

To tell the number a perſon has fixed on, without aſking him any queſtion.

By directing him to halve and triple his number four times, and by obſerving when he is obliged to add one to the ſum, before he can halve it, and applying thoſe caſes to the ſyllables of eight Latin words.

RECREATION XIII. p. 42

Thirty ſoldiers having deſerted, fifteen of them are to be puniſhed; ſo to place the

whole number in a ring, that you may ſave any 15 you pleaſe, and it ſhall ſeem the effect of chance.

By placing them according to numbers annexed to the vowels of a Latin verſe.

RECREATION XIV. p. 43

Some perſon in company putting a ring, privately, on one of his fingers, to name the perſon, the hand, the finger, and the joint, on which it is placed.

Another perſon is to double, add to, and multiply the number of the rank in which the firſt perſon ſtands, and tell you the amount, from which you deduct a certain ſum, and the remainder will anſwer the queſtion.

OF ARITHMETICAL MAGIC SQUARES. p. 46

They conſiſt of numbers in arithmetic progreſſion, placed in equal rows, and

in ſuch manner that the ſum of each row, taken either perpendicularly, horizontally, or diagonally, is the ſame—method of conſtructing theſe ſquares.

RECREATION XV. p. 49

The ſeries of numbers, from 1 to 25, being wrote on that number of cards, after they have been ſhuffled, to deal them to five perſons, either by twos or threes, at the option of the parties, and the amount of the numbers on each one's cards to be the ſame.

There is to be a wide card—table for diſpoſing the cards, before they are ſhuffled, according to the magic ſquare, p. 50—manner of dealing them, p. 51.

RECREATION XVI. p. 52

To deal the thirty-two cards of the game of piquet to four perſons, after you have ſhuffled them, and the parties have choſe whether

whether you ſhall deal them by twos or threes, in ſuch manner, that all the cards in each perſon's hand ſhall be of the ſame ſuit.

Order of diſpoſing the cards—manner of dealing them, p. 53.

OF GEOMETRIC MAGIC SQUARES. p. 54

To be filled after the ſame manner as the arithmetic ſquares—the product of each line, taken in any direction, is the ſame.

RECREATION XVII. p. 55

Several numbers being wrote upon cards, to ſhuffle them, and deal the whole, or part of them, to three perſons, in ſuch manner, that each one multiplying the numbers on his cards together, the product of each perſon's cards ſhall be the ſame; and to repeat the recreation after having ſhuffled the cards a ſecond time.

The numbers wrote on the cards are to be thoſe of the geometric magic ſquare—there

there muſt be three wide cards, p. 56—method of repeating the experiment, p. 57—may be performed with the numbers of the arithmetic magic ſquare.

RECREATION XVIII. p. 58

To find the number of changes that may be rung on twelve bells.

By multiplying the numbers from 1 to 12 into each other.

RECREATION XIX. p. 59

Suppoſing the letters of the alphabet to be wrote ſo ſmall that no one of them ſhall take up more ſpace than the hundredth part of an inch; to find how many ſquare yards it would require to write all the permutations of the twenty-four letters in that ſize.

The permutations of the twenty-four let-letters are found as in the laſt recreation—the number of ſquare yards re-

quired

quired to contain thoſe permutations is 18620 times as large as the ſurface of the earth, p. 60.

RECREATION XX. p. 60

To find how many different ways the eldeſt hand at piquet may take in his five cards.

This number found by the ſixteenth aphoriſm—it is 15503 to 1 that he does not take in any five certain cards, p. 61.

RECREATION XXI. p. 61

To find the number of deals a perſon may play at the game of whiſt, without ever holding the ſame cards twice.

This number alſo is found by the ſixteenth aphoriſm.

THE ARITMETIC TRIANGLE, p. 62

Its conſtruction—its uſe in finding the combination of ſmall numbers, p. 63.

RECREATION XXII. p. 64

To find how many different sounds may be produced by striking on a harpsichord two or more of the seven natural notes at the same time.

This number, which is 120, found by the foregoing table.

RECREATION XXIII. p. 64

Take four pieces of pasteboard, of the same dimension, and divide them diagonally, as in the figures, into eight triangles: paint seven of these triangles with the primitive colours, red, orange, yellow, green, blue, indigo, and violet, and let the eighth be white. To find how many chequers or four-sided figures, differing either in form or colour, may be made out of those eight triangles.

This number, which is 196, found in the same manner as in the last recreation, p. 66

RECRE-

RECREATION XXIV. p. 66

A man has 12 different ſorts of flowers, and a large number of each ſort. He is deſirous of ſetting them in beds or flouriſhes, in his parterre. Six flowers in ſome, 7 in others, and 8 in others; ſo as to have the greateſt variety poſſible; the flowers in no two beds to be the ſame. To find how many beds he muſt have.

This number, which is 2211, is alſo found by the foregoing table.

RECREATION XXV. p. 67

To find the number of chances that may be thrown by two dice.

This number is 36—the whole number of points is 252—it is an equal chance, at every throw, to bring ſeven points, p. 68—method of finding the number of chances on any number of dice.

RECREATION XXVI. p. 69

To discover the number of points on 3 cards, placed under three different heaps of cards.

As many cards are to be put over each of them as with the number of its points will make 15, then telling the number of the remaining cards, privately, and adding 16 to that number, the amount will be the number of points on the three cards.

RECREATION XXVII. p. 70

The ten duplicates.

Twenty cards being laid in pairs, and in four rows, several persons are to look at different pairs, and tell you in which rows they are, when you tell them, by the aid of four Latin words, which cards they looked at.

RECRE-

RECREATION XXVIII. p. 72

To name the number of cards that a perſon ſhall take out of the pack.

This is done by previouſly diſpoſing the cards in a certain order, and by an Engliſh verſe to aid the memory.

RECREATION XXIX. p. 74

A century of different names being wrote on the cards, to tell the particular name that any perſon has thought on.

A hundred names are wrote on 10 cards, and the laſt name of each card begins with one of the letters of a word that has ten letters; and on ten other cards, the ſame hundred names are wrote, in different diſpoſitions. A perſon is to draw a card from the firſt ten, and after fixing on a name, give it you

again: you then ſhow him the other ten cards, and when he tells you the card that has the name, you tell him, by means of the laſt name on the card he drew, which it is. This recreation may be performed with twenty cards, inſtead of ten; and queſtions and anſwers may be uſed inſtead of names 78

OF THE COMBINATIONS OF THE CARDS. p. 78.

The tables formed by theſe combinations are applicable to many other ſubjects beſide cards—manner of ſhuffling the cards, ſo as to make them correſpond to the tables, p. 79.

Table of combinations for ten numbers, and for one, two, and three ſhuffles, p. 82

Table for twenty-four numbers 83

Table for twenty-ſeven numbers 84

Table for thirty-two numbers 85

RE-

RECREATION XXX. p. 86

Several letters that contain no meaning, being wrote upon cards, to make them, after they have been twice ſhuffled, give an anſwer to a queſtion that ſhall be propoſed; as for example, What is love?

The twenty-four letters of the anſwer are to be wrote on that number of cards, and the anſwer itſelf to be wrote on a paper; the numbers from 1 to 24 are to be affixed to the letters, and the cards to be diſpoſed according to the third column in the table for twenty-four numbers—neceſſary obſervations for conducting this and ſimilar experiments, p. 88.

RECREATION XXXI. p. 90

The twenty-four letters of the alphabet being wrote on ſo many cards, to ſhuffle them and pronounce the letters ſhall then be in their natural order, but that not ſucceed-

ing, to ſhuffle them a ſecond time, and then ſhow them in proper order.

The cards are here to be diſpoſed after the ſame method as in the laſt recreation—the experiment is to fail at firſt, that it may appear the more extraordinary after the ſecond ſhuffle.

RECREATION XXXII. p. 91

Several letters being wrote promiſcuouſly upon 32 cards, after they have been once ſhuffled, to find on a part of them a queſtion; and then ſhuffling the remainder a ſecond time, to ſhew the anſwer.

The letters of the queſtion and anſwer, which are 32, are to be wrote on the cards; the letters of the anſwer, which are ten, are to be wrote on a paper, and the numbers from 1 to 10 affixed to them. They are then to be ranged by the ſecond column of the table for ten numbers, and the whole thirty-two cards

are next to be difpofed by the fecond column of the table for that number—there is to be a long card, by which they are to be cut, and then fhuffled, p. 93

RECREATION XXXIII. p. 94

To write 32 letters on fo many cards, then fhuffle and deal them by twos to two perfons, in fuch manner, that the cards of one fhall contain a queftion, and thofe of the other, the anfwer.

The numbers from 1 to 32 are to be wrote over the letters of the queftion and anfwer; they are then to be ranged according to the firft column of the table for thirty-two numbers, fhuffled and dealt.

RECREATION XXXIV. p. 96

The five beatitudes.

Thefe five bleffings, which are fcience, courage, health, riches, virtue, are to

be found on thirty-two cards that are dealt to five perſons—the numbers from 1 to 32 are to be wrote over the letters of thoſe words, in a determinate order: the cards are then to be ranged according to the firſt column for thirty-two numbers. The five beatitudes being wrote, each of them, on four cards, each perſon is to draw one from one of the fours, and when the other cards are dealt, one by one, each perſon will have the ſame word on the cards dealt him as on that he drew.

RECREATION XXXV. p. 98

The cards of the game of piquet being mixed together, after ſhuffling them, to bring, by cutting them, all the cards of each ſuit together.

The order in which the cards are to be ranged before the firſt ſhuffle, p. 99—they are then to be cut at a wide card, and the part cut off laid aſide: the remaining

cards are to be ſhuffled a ſecond time, and cut at another wide card; the ſame operation is to be repeated a third time; and the four ſuits will then be all ſeparate.

RECREATION XXXVI. p. 100

The cards at piquet being all mixed together, to divide the pack into two unequal parts, and name the number of points contained in each part.

The cards are to be diſpoſed by the table for thirty-two numbers; they are then to be ſhuffled, according to order, and cut at a wide card, when each parcel will have a determinate number.

RECREATION XXXVII. p. 103

The inconceivable repique.

This recreation is to be performed with the cards ranged in the order deſcribed

in the laſt: they are to be ſhuffled a ſecond time, and cut at the wide card, and they will be then ranged in ſuch order, that you will repique your adverſary, though you let him choſe, after the cards are cut, in what ſuit you ſhall make the repique—in a particular circumſtance you muſt paſs the three bottom cards to the top, p. 108.

RECREATION XXXVIII. p. 109

The metamorphoſed Cards.

Thirty-two different words being promiſcuouſly wrote, and four different colours and objects painted on thirty-two cards, they are to be ſhuffled, as before, and dealt to four perſons, and after the firſt deal every one's cards are to be all of the ſame colour: after the ſecond deal they are all to have the ſame object; and after the third deal each perſon's cards are to contain a different ſentiment.

RECREATION XXXIX. p. 113

The repique with carte blanch.

The order in which the cards are to be disposed before the deal, p. 114—the hands of the two players, p. 115—one of them is to have the choice of the two hands, on condition of his being eldeſt or youngeſt, p. 116—method of the other's diſcarding accordingly.

RECREATION XL. p. 117

Caſe at piquet, where you repique the elder hand, though he have the choice of the cards after they are dealt.

The order in which the cards muſt ſtand after they have been cut—the hands of the two players, p. 119—one of the players is then to chooſe either hand, but without ſeeing them—manner in which the other muſt diſcard, p. 120.

RECREATION XLI. p. 121

Caſe at piquet, where you give the other player not only the choice of the ſuite in which he will be repiqued, but that of dealing the cards by twos or threes, and of taking either hand after they are dealt, you being to tell and play firſt.

Previous diſpoſition of the cards: there are to be four wide cards—if they are cut at any one of the wide cards, the ſtock will be all of one ſuit, p. 122—the hands and rentrées of the two players, when the cards are dealt by twos and when they are dealt by threes, p. 123—method of diſcarding according to the hand the adverſary chooſes, and as the deal is by twos or threes, p. 124

RECREATION XLII. p. 126

An exemplary caſe at piquet, where you repique your adverſary, after giving him the

the choice of having the cards dealt either by twos or threes.

Table for diſpoſing the cards in this and like caſes, p. 127—remark on the foregoing manœuvres at piquet, p. 131.

RECREATION XLIII. p. 132

Several different cards being ſhown to different perſons, that each of them may fix on one of thoſe cards, to name that on which each perſon has fixed.

As many cards are to be ſhown each perſon as there are perſons to chooſe; each one's cards to be laid down ſeparately, and the firſt perſon's card will be the firſt in the heap where it is; the ſecond perſon's card the ſecond, &c.—The ſame recreation may be performed with a ſingle perſon, p. 133.

RECREATION XLIV. p. 134

To name the rank of a card a perſon has drawn from a piquet pack.

By aſſigning a certain number to each card, and adding the number of the firſt to that of the ſecond, &c. rejecting the tens and carrying the remainder, and ſubtracting 4 from 10 or 20, for the number of the card drawn.

RECREATION XLV. p. 135

To tell the amount of the numbers of two cards that a perſon has drawn from a common pack of cards.

He is to add as many cards to each of thoſe he has drawn as will make its number 25. You then tell the remaining cards, ſilently, and their number will be the amount of the cards drawn. This recreation may be performed without tell-

ing

ing the cards, p. 136—or with a pack of piquet cards, p. 138.

RECREATION XLVI. p. 139

To tell the amount of the numbers of any three cards that a perſon has drawn from the pack.

You are to draw a ſingle card yourſelf, to make the remaining number diviſible by 3; the perſon is then to add as many more to each of his cards as will make its number 16, and the number of the remaining cards will be the amount of the cards he drew. This recreation alſo may be performed without telling the remaining cards, p. 140—and with a pack of piquet cards, p. 141.

DIFFE-

DIFFERENT METHODS OF WRITING IN CYPHER.

RECREATION XLVII. p. 143

To communicate intelligence by a pack of piquet cards.

The parties are previoufly to agree how the cards are to be difpofed and fhuffled—he who fends the cypher copies the letters on thirty-two cards, alternately, and fhuffles them as agreed, p. 144—example of a cypher of this kind—methods of making it more difficult to decypher, and lefs liable to fufpicion, p. 146.

RECREATION XLVIII. p. 147

The myftical dial.

A moveable circle of pafteboard is placed within another circle, and on each of them are wrote the letters of the alphabet

bet (Plate II.) The moveable circle is placed as agreed on between the parties, and the letters of the one wrote for the other—the ſame intention may be anſwered by a ruler, p. 148.

RECREATION XLIX. p. 149

The correſponding ſpaces.

Similar ſpaces to be cut in two pieces of paſteboard, and one of them kept by each party. The ſecret intelligence to be wrote in theſe ſpaces, when laid on a paper, and the diſtances between them to be filled up by words that make a different ſenſe.

RECREATION L. p. 151

The muſical cypher.

The conſtruction of this inſtrument is ſimilar to that of the 48th Recreation. The notes of muſic anſwer to the letters of the alphabet (Pl. III.) The cypher

pher to be wrote on ruled paper, as a piece of music, p. 152—is liable to very little suspicion, p. 153.

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Manner of decyphering a writing of this sort 158

Method of rendering a similar writing extremely difficult to decypher 158 (note)

The contents of the two foregoing cyphers 159

RECREATION LI. p. 160

Visual Correspondence.

The letters of the alphabet are cut through a circle of wood, near its circumference, and the circle being made to turn on a pole, the letter wanted is brought before

fore an opening at the top of it, and a light placed behind the letter (Plate IV. Fig. 1 and 2.)—method of uſing this machine, p. 161—a teleſcope is neceſſary when the diſtance is conſiderable, p. 162—particular purpoſes to which this machine may be applied, p. 163.

RECREATION LII. p. 164.

Auricular correſpondence.

Two bells are placed at the top of a building, and the letters of the alphabet are expreſſed by the number of ſtrokes on one or both bells — a correſpondence may be carried on by this contrivance, where that of the laſt recreation can have no effect.

MECHANICS.

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Properties of moving bodies, aph. 1 to 12.—Properties of pendulums, aph. 12 to 16.—Of the mechanic powers, aph. 16 to 26.—Of compound machines, aph. 26, to the end.

RECREATION LIII. p. 180

To conſtruct a mechanical dial without wheels, ſpring, or weight.

This dial conſiſts of a hollow cylinder, (Pl. VI. Fig. 1 and 2.) on the ends of whoſe axis are wound two ſtrings, the other ends of which are faſtened to the top of the wainſcot. Within the cylinder are five partitions, and between them water is placed, which paſſing,

by a ſmall hole, from one partition to the other, cauſes the cylinder to deſcend ſlowly and ſhow the hour, by the ends of the axis pointing to a table of numbers on the wainſcot.

RECREATION LIV. p. 183

A dial to ſhow the hour by gradually deſcending an inclined plane.

It conſiſts of two parallel plates connected by a hoop (Plate VI. Fig. 3 and 4:) Between the plates are a train of wheels, and on the outſide is a weight, which is faſtened to the center wheel, and therefore cauſes the dial to deſcend in a regular progreſſion—this dial will go for any time, according to the length of the inclined plane, p. 186.

RECREATION LV. p. 187

A clock to go perpetually by the influence of the celeſtial bodies.

This clock is of the common conſtruction, but is placed againſt a wall by which the tide flows, and is moved by that, as that is by the moon, &c.

RECREATION LVI. p. 190

The inſcrutable lock.

The inſcrutability of this lock ariſes from the combinations of the moveable parts of the ward of the key, with the different poſitions in which the ſcutcheon before the lock may be placed, (Plate VII. Fig. 1. and 2.) which make it more than eleven thouſand four hundred and ninety-ſix millions to one, at every trial, that a ſtranger does not

open the lock; which however is opened inſtantly by the owner.

RECREATION LVII. p. 193

So to diſpoſe a hand-mill, to grind corn, &c. that being once put in motion, it ſhall work inceſſantly without the aſſiſtance of any animal power.

This mill is to be moved by a ſmoke jack —a deſcription of that machine (Plate VII. Fig. 3.)—as the motion of the jack is inceſſant while there is ſmoke in the chimney, the motion of the mill connected with it muſt be inceſſant alſo—this machine may be applied to other uſeful purpoſes.

RECREATION LVIII. p. 195

A carriage to go without any force but what it receives from the paſſengers.

This carriage is moved by machinery (Plate VIII. Fig. 1 and 2.) contained in a box that is placed behind it, and is worked by the footman—might be moved, with equal or greater facility, by the perſon who ſits in it, p. 197—the uſe or convenience of this carriage.

RECREATION LIX. p. 198

The catapulta.

This machine (Plate IX. Fig. 1.) uſed by the ancients to throw darts againſt their enemies—amazing force of ſome darts (note)—uſe to which this machine may be applied, p. 199.

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RECREATION LX. p. 200

To ſail as faſt, with a fair wind, by land as by water.

By a ſailing chariot, or boat fixed on four wheels, (Plate IX. Fig. 2.) — its ſurpriſing velocity—ſimilar machine to go on the ice, p. 201.

RECREATION LXI. p. 202

To ſale by land againſt the wind.

The body of this machine is ſimilar to that in the laſt recreation, (Plate X. Fig. 1.) but on the inſide there are wheels that are worked by the maſt, which is turned round by the force of the wind againſt its wings; and the wheels within the machine communicating with thoſe on which it runs, drive it forward—the advan-

advantages and inconveniencies attending this machine, p. 203.

RECREATION LXII. p. 204

The uninvertible carriage.

This carriage consists of a hollow globe, surrounded by two perpendicular and two horizontal brass or iron circles, in which its moves freely every way: its two wheels are fixed to two perpendicular pieces; and at the bottom of the globe is a weight that keeps it constantly upright—the great utility of this carriage in certain circumstances, p. 206—account of the trial of a similar machine, p. 207.

RECRE-

RECREATION LXIII. p. 209

The columnar dial.

The caſe of this dial is a hollow column, in the baſe of which is the wheel that guides the hour and minute hands; and in the capital is the machinery that ſtrikes the hours. On the ſhaft of the column the hours are marked by horizontal lines, to which an index points as it deſcends from the top of the ſhaft to the bottom; and on the baſe is a circle of minutes, marked by a hand fixed on the end of the wheel within.

RECREATION LXIV. p. 214

An air chronometer.

This chronometer conſiſts of a glaſs tube, wherein a piſton is placed, that has a cock by which the ſubjacent air is ſuffered

fered to paſs very ſlowly : as this piſton deſcends it ſhows the hours, by diviſions marked on the tube—a dial may be added to this chronometer, the hand of which may be moved by the ſtring that is joined to the piſton.

RECREATION LXV. p. 217

The lamp chronometer.

The ſhadow of a ſtyle placed before a lamp is thrown upon a frame covered with oiled paper, on which the hours and their diviſions are marked. This inſtrument may be made ornamental as well as uſeful.

RECREATION LXVI. p. 219

The nocturnal dial.

This dial conſiſts of two large and three ſmall wheels, a weight, a lamp, and a hollow

hollow cone. Through one of the large wheels, which is placed in the front of the machine, the figures for the hours are cut, on each of which the light of the lamp is directed to fall, by the hollow cone, in a regular progression—this dial may be made to sound the hours, or serve as an alarum, p. 221—method of making this machine exhibit a pleasing representation, p. 222.

THE END OF THE FIRST VOLUME.