Recreations for gentlemen and ladies: being, ingenious sports and pastimes. Containing, many curious inventions: pleasant tricks on the cards and dice ... and other curiosities, affording variety of entertainment / Translated from the French of Mons. Ozanam.

Contributors

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RECREATIONS

FOR

GENTLEMEN and LADIES:

Being, ingenious

Sports and *Pastimes.*

CONTAINING,

Many curious Inventions:
Pleasant Tricks on the Cards and Dice:
Arithmetical Sports:
Diverting Experiments, natural and artificial:
Recreative Fire-Works:

AND

Other Curiosities, affording variety of Entertainment.

Translated from the French of Monf. OZANAM.

The FOURTH EDITION.

DUBLIN:

Printed by JAMES HOEY, Junior,
MDCCLIX.

TO THE
READER.

THE author of the following treatise, Monsieur Ozanam, is a person so well known and deservedly esteemed, amongst the learned who understand him in his native language, that if all others were alike acquainted with his worth, his name would be a sufficient recommendation.

This book is such a collection of the most curious, most surprizing, most useful, and most agreeable performances of the arts and sciences as may prove a spring of invention to the ingenious, furnishing them with hints of innumerable other discoveries and contrivances, serviceable to the necessity, or the conveniency, or the pleasure of human life. [Thus far the translator.]

The Author's Account of the Work.

IT has been an opinion of long standing, that there was some secret art amongst the most learned of the Jews, of the Arabians, and of the disciples of that antient academy, which was in Egypt when Moses was there educated, and still flourished in the time of Solomon; insomuch that it hath excited the curiosity of the finest wits to endeavour the discovery of it: but is it possible

to learn an art without a mafter, and without books?
The learned of that time committed nothing to
writing ; or if they did, it was enigmatical, and fo
remote from what a reader did expect, that of them
it may be faid, their filence was more inftructive
than their difcourfes.

Father Schott faith there are three forts of Cabala,
(fo is that fecret art of the Orientals called ;) that
of the Rabbies, that of Raimond Lully, and that
of the Algebrifts. The firft he knows not what it is;
the two laft are Recreations in numbers and figures:
and no doubt is to be made, but the firft is of the
fame fort. Jofephus, who was a Levite, writes
with confidence, that by right of his birth he had
been inftructed in all the myfteries of the Jews,
and had been taught all the fecrets of their art.
He boafted, from a courtly principle which fwayed
him more than his confcience, that, by his art he
had foretold the elevation of Titus to the Imperial
dignity. He concealed his game as men of cunning
fhould, and as our mafters teach us. He gives out
himfelf for a miraculous perfon ; and when he re-
lates the adventure where he fhould have loft his
life by the defpair of the foldiers, refolved to cut
one another's throat rather than furrender to the
Romans, he attributes his deliverance to chance
and a miracle. Notwithftanding Hegefippus, who
wrote the fame hiftory, fays, that Jofephus did
that miracle by the knowledge of numbers and
figures: for he made thofe difperadoes to be ranged
in fuch an order, that the lot feil upon thofe, whom
the commander defired to have deftroyed : he fav'd
his own life, not by reafon of being a Levite, but
becaufe he was a mathematician. Monfieur Bachet,
in his 23d. probl. defcribes this fecret ; who, had he
then lived, would have been accounted as great a
magician as Jofephus. Hence it appears, that the

moſt abſtracted knowledge may be reduced to prac-
tice, and what ſeems moſt remote may become of
uſe.

'Tis moſt aſtoniſhing to find, that in the time
of the emperours Dioclefian and Conſtantine, the
mathematicks were prohibited by the laws, as a
dangerous ſcience, under the ſame penalties as for-
cery or magick, being reputed equally criminal and
pernicious to civil ſociety; as appears from the
17th title of the 9th book of Juſtinian's Code. No
doubt this was an effect of the ignorance which at
that time reigned; and becauſe of the great num-
ber of impoſtors who uſed the mathematicks to
cheat and deceive the credulity of the illiterate.
Neverthelefs, the ſtupidity of thoſe is to be blamed,
who ſuffered themſelves to be gull'd; and their
negligence is not to be allowed, who will not ſuffi-
ciently improve their underſtanding, ſo as to be in
a condition not to be abuſed. There have been
ſtates wherein tricks and little thefts, cleverly per-
formed, were permitted, that all might be on their
guard, and accuſtomed to a requiſite precaution.

Ignorance keeps the world in perpetual admira-
tion, and in a diffidence, which ever produces an
invincible inclination to blame and perſecute thoſe
that know any thing above the vulgar; who, being
unaccuſtomed to raiſe their thoughts beyond things
ſenſible, and unable to imagine that nature employ-
eth agents that are inviſible and impalpable, aſcribe
moſt an end to forceries and demons, all effects
whereof they know not the cauſe. To remedy
theſe inconveniencies is the deſign of theſe Recrea-
tions, and to teach all to perform theſe forceries
which were dreaded by the councel of Juſtinian:
and hereby will be vindicated the fame of Thomas
Aquinas, Albertus Magnus, Solomon, and many

A 3   other

other great men, who had never been accufed for magicians, but becaufe they knew fomething more than others; more effectually than has been done by the learned, who have been fatisfied by dint of argument only, to plead their caufe.

It will, perhaps, be here objected, that by the paftimes of mind, prefented to the world in the enfuing book, the reader is diverted' from that ftudy and application, to which he might have been engaged by treatifes of a ferious nature, which fix the thoughts, rendering them penetrating and inquifitive. To this it might fuffice to alledge the example of men famous for learning, whofe like practice in this matter, may feem a juftification beyond any other could be brought. The learned Bachet, Sieur de Meziriac, famous for his excellent works, began to make himfelf known to the learned world, by a collection which he intitled *pleafant problems performed by numbers*; by which he defigned to make trial of his own ability, and the opinion of the world, before he publifhed his commentaries on the arithmetick of Diophantus of Alexandria, and his other works by which he hath purchafed to himfelf immortal glory. Many other authors of this age, as the famous father Kircher, the fathers Schott and Bettin, have gained no lefs renown by the diverting problems in their works, than by their reafonings, and more ferious obfervations.

But left thefe illuftrious men, adduced as precedents, fhould themfelves be expofed to the cenfure of thofe who would accufe them of novelty; inftances much more ancient, grounded on folid reafon, fhall be here produced, whereby it will appear that in all times this has been done by the greateft men, being perfuaded, that the fame fource of reafon that makes men take pleafure in admiration,

caufes

caufes them in like manner, to find delight in things which are the object of that paffion.

The enigmatical fentences and propofitions, fo much admired and promoted by the kings of Syria, which occafioned the continuance of the parabolical ftile fo long after, were nothing elfe but paftimes of mind, and entertainments equally fitted to excite pleafure, and to give enlargement of underftanding. Perfons of higher birth and rank were of the fame make at that time, as thofe of our own are now: what was painful and laborious did difcourage them: to engage them to ftudioufnefs and reflection, by pleafure and curiofity, was a piece of extraordinary fkill and dexterity. Doubtlefs, the education Nathan, by this means, gave to Solomon, did mightily conduce to that grandeur of foul, and to that admirable wifdom which conftitutes the character, and is the glory of that prince.

It was alfo by way of diverfion the Chaldeans and Egyptians, the inventers of aftronomy, did foretell to their friends the time, and other circumftances of eclipfes, and erected fyftems which fhewed the length of the days, demonftrated the courfe of the ftars, and reprefented all the varieties of the celeftial motions; being perfuaded no lefs than the Grecians, that the firft intellectual pleafures are thofe which proceed from mathematical fciences, in which they educated their children. They were convinced, that childrens reafon, though not yet in action, was not without its ftrength, and wanted only to be put in motion, in order to its progrefs towards perfection; which might be effected by exciting in them a curiofity, that would do the fame with them which a long train of neceffities does with thofe of more advanced years. Herein lay the fecret of Socrates, who taught children to

A 4 refolve

refolve the greateft difficulties of geometry and arithmetick : this was the key with which he laid open their underftanding, knew its ftrength and predicted their deftiny : this was inftead of that Demon or Genius he is faid to have confulted, and which is reported ever to have accompanied him.

Though thefe plays of the intellect, here fpoken of, feem only amufements to pafs away the time ; yet are they poffibly of no lefs advantage than thofe exercifes in which the youths of quality are bred up at academies, which fashion as well as invigorate their bodies, and give them a graceful air in their deportment : for to be accuftomed to difcern the proportions, and the force of mixtures ; to find out an unknown point required, amongft a confufed infinity of others ; to take a right method in re-folving the moft intricate and perplexing propofiti-ons ; is to have the mind fitted for bufinefs, to be armed againft furprizes, and prepared to overcome unexpected difficulties : things of no lefs confe-quence, one would think, than adjufting the moti-ons of the body by the inftructions of a dancing mafter, or the tone of a voice by that of a mu-fician.

Befides, are not diverfions fometimes neceffary? And can any one be diverted by what he defpifes, or is afhamed of? Would a ftatefman choofe to be performing at dancing matches, in the intervals of conncils, and of important bufinefs? Or were it becoming for him to be found in thofe exercifes wherein he fpent the time of his youth? Decency, bufinefs, and health would in no wife allow it. But paftimes of mind are for all feafons and all ages : they inftruct the youth and divert the old : they are not beneath the rich nor above the ability of the poor : they may be ufed by either fex without tranf-

greffing

greffing the bounds of modefty. Thofe diverfions have this further and peculiar advantage, that there can be no excefs in them : for feeing there is a regular conduct of reafon therein, through all the fteps it fhould take, it cannot be conceived how it fhould touch upon any extreme, its exercife being within the due medium, where the folution of the propofed fport is to be found.

Thofe who have had the curiofity to obferve the conduct of great men in their private actions, have found that they are diftinguifhed as well in their recreations as in their bufinefs. Auguftus ufed to exercife himfelf in the evenings with his family at thefe diverfions, not judging it beneath him ; and recorded with no lefs exactnefs the particulars of his recreations than thofe of his important affairs. That learned lawyer Mutius Scevola, after his confultations were over, diverted himfelf by playing at Chefs, and became one of the beft players of his time. Pope Leo X. one of the greateft men of his age, played fometimes at Chefs, if we may believe Paulus Jovius, to recreate himfelf after the fatigues of bufinefs.

It is certain the game of Chefs was invented for inftruction as well as diverfion. The attacks and defences, the divers fteps and advantages of the different pieces, may furnifh the confiderate with political and moral reflections. By the difafter of of the king, we may learn, that a prince muft infallibly fall under his enemies power when deprived of his foldiers ; and that he cannot neglect the prefervation of them without expofing himfelf and his dominions.

All games that are, or may be invented, may be reduced to three ranks. The firft is of thofe that depend altogether on numbers and figures; as the Chefs, the Draughts, and fome others : the fecond
of

of thofe that are governed by chance ; as the dice, and fuch like: the third fort is of thofe that are fubjected to the laws of motion, and require an exactnefs and regularity thereof; fuch as fhooting with guns, and with bows, the Tennis and Billiards. There are fome plays of a mixed nature, depending partly on fkill, partly on chance ; as the Tables, the Cards and moft others. But it is certain, there is none of them which might not be fo far fubjected to the rules of the mathematicks, that one might be affured of the victory, had he but all the underftanding requifite. Games of dexterity depend fo much upon principles of ftaticks and mechanicks, that it is only the want of a due knowledge of their rules, or of the way of reducing them to practice, that makes a man fall fhort of conqueft.

In all plays of chance whatever, the victory depends upon the coming up of a certain number, upon weight, or upon the dimenfions of a figure. The gamefter that gives the motion, might at pleafure determine the end of it, were his fkill and dexterity perfect; and though this does not feem to be poffible, there being none to be found mafter of fo much cunning; yet it is true that this might be done, and that an infallible method of winning, at Chefs for inftance, is not abfolutely impoffible : but no body has hitherto found it out ; nor perhaps ever will, feeing it depends on two great a number of combinations. It is enough that the point of perfection is poffible, to encourage the labour of the curious. " *A perfect orator,* faid Tully, *never* " *was, and yet is poffible.*" His picture drawn by that famous mafter, may be a pattern for the imitation of thofe who ftudy to excell in eloquence. The like may be faid of a poet, a painter, an architect, a phyfician, and all others. In like manner,
                                                                though

though it is true that no one has attained an infallible method in all plays, nor perhaps in any one; this ought to hinder none from endeavouring to become as skilful as he can, and to come up as near as may be to the idea of that method, which, because founded upon principles of mathematicks, must participate of a mathematical certainty.

It may possibly be thought an extraordinary attempt to endeavour to proselyte gamesters to this opinion, and to engage statesmen and great commanders in the study of arithmetical recreations: notwithstanding there can be no harm in carrying the light, let who will follow after it : yea, is it possible to hinder mankind from learning what is built on the most natural principles, and on truths flowing from the essence of things? should they be deprived of pleasure so inviting by their utility; and which are so familiar, so easy, and so suited to all endowed with reason, that to bereave men of them, were to rob them of what is most agreeable in life.

Table of Contents.

ARITHMETICAL SPORTS.

PART III.

MISCELLANEOUS SPORTS.

Juft publifhed by the Printer hereof.

Humbly infcribed to the Lady Amelia Fitzgerald, eldeft daughter to the Rt. hon. James Earl of Kildare.

THE POLITE TUTORESS, or

Young Lady's Instructor : Being a feries of Dialogues between Mrs. Affable, a fenfible Governefs, and feveral of her pupils of the firft rank : in which the Young Ladies are made to think, fpeak, and act in a manner fuitable to their refpective tempers difpofitions, and capacities. No lefs care being taken to form their hearts to virtue, than to cultivate their underftandings with ufeful knowledge. In this work are included leffons in Geography ; and a clear abridgment of Sacred and Profane Hiftory : interfperfed with ufeful Reflections, Fables, Moral Tales, Songs, &c. for their amufement. By Madam La Princeffe de Beaumont ; tranflated from the French. To which is added, Margaretta, the Perfidious Orphan ; and Sophia, or the Double Efcape ; two new NOVELS, never before printed.—With an addrefs to the Mafters and Governeffes of Boarding Schools.—In two Vols. price neatly bound together, in red leather and gilt 2s. 2d.

S P O R T S

A N D

P A S T I M E S.

Arithmetical Sports.

SPORT I.

Three jealous husbands with their wives being ready to pass by night over a river, do find at the river side a boat which can carry but two persons at once, and for want of a waterman they are necessitated to row themselves over the river at several times: The question is, how those six persons shall pass 2 by 2, so that none of the 3 wives may be found in the company of 1 or 2 men, unless her husband be present.

THEY must pass in this manner, *viz.* first two women pass, then one of them brings back the boat and repasses with the third woman; that done, one of the three women brings back the boat, and sitting down upon the ground with her husband, permits the other two men to pass over to find their

B · wives

wives : then one of the said men with his wife brings back the boat, and placing her upon the ground, he takes the other man, and repasses with him : Lastly, the woman who is found with the three men enters the boat, and at twice goes to fetch over the other two women.

S P O R T II.

A Country-man having a fox, a goose, and a peck of corn, in his journey came to a river, where it so happened that he could carry but one over at a time. Now, as no two were to be together that might destroy each other; so he was at his wit's end how to dispose of them; for, says he, tho' the corn can't eat the goose, nor the goose eat the fox, yet the fox can eat the goose, and the goose eat the corn: The question is, how he must carry them over ?

FIRST he must carry over the goose, leaving the fox and corn, (for the fox will not eat the corn) then, returning back, he may carry over the fox, bringing the goose back again ; then leaving the goose, he may carry over the corn ; lastly, he must return to fetch the goose.

S P O R T III.

Two merry companions are to have equal shares of eight gallons of wine, which are in a vessel containing axactly eight gallons: now to make this equal partition they have only two other empty vessels, of which one contains five gallons, and the other three ; the question is, how they shall exactly divide the wine by the help of those three vessels ?

TO answer this question ; let us call the vessel of 8 gallons A, the 5 gallon vessel B, and the 3 gallon vessel C. We suppose there are 8 gallons

lons of wine in the veſſel A, and
the other two, B and C, are
empty, as you ſee in D. Hav-
ing filled the veſſel B with wine
out of the veſſel A, in which
there will then remain but 3
gallons, as you ſee at E; fill
the veſſel C with wine out of
the veſſel B, in which, by con-
ſequence, there will then remain
but 2 gallons, as you ſee at F.

	8	5	3
	A	B	C
D	8	0	0
E	3	5	0
F	3	2	3
G	6	2	0
H	6	0	2
I	1	5	2
K	1	4	3

This done, pour the wine of the veſſel C into the
veſſel A, where there will then be 6 gallons, as you
ſee in G; and pour the 2 gallons of the veſſel B
into the veſſel C, which will then have 2 gallons,
as you ſee at H; then fill the veſſel B with wine
out of the veſſel A, by which means there will re-
main but 1 gallon in it, as you ſee at I; and con-
clude the operation by filling the veſſel C with wine
out of the veſſel B, in which there will then re-
main juſt 4 gallons, as you ſee at K; and ſo the
queſtion is ſolved.

If, inſtead of the veſſel B, you would have the
4 gallons to remain in A, which we ſuppoſed to be
filled with 8 gallons; fill the veſſel C with wine
out of the veſſel A, and ſo there
will remain but 5 gallons in it, as
you ſee at D; pour the 3 gallons
of the veſſel C into the veſſel B.
which will then have 3 gallons of
wine, as you ſee at E; and hav-
ing again filled the veſſel C with
wine out of the veſſel A, where
there will then remain but 2
gallons, as you ſee at F; fill up
the veſſel B with wine out of C,
where there will then remain but

	8.	5.	3.
	A	B	C
	8.	0.	0.
D	5	0	3
E	5	3	0
F	2	3	3
G	2	5	1
H	7	0	1
I	7	1	0
K	4	1	3

1 gallon

ɪ gallon, as you see at G: at laſt, having poured the wine of the veſſel B into the veſſel A, where there will then be 7 gallons, as you ſee at H; pour the gallon of wine that is in C into the veſſel B, which by conſequence will have only ɪ gallon, as you ſee at I ; fill the veſſel C with wine out of the veſſel A, where there will then remain juſt 4 gallons, purſuant to the demand of the queſtion, as you ſee at K.

SPORT IV.

A blind Abbeſs, viſiting her Nuns, who were equally diſtributed in eight cells built at the four corners of a ſquare, and in the middle of each ſide; finds an equal number of perſons in each row or ſide containing three cells: At a ſecond viſit, ſhe finds the ſame number of perſons in each row, tho' their number was enlarged by the acceſſion of four men: And coming a third time, ſhe ſtill finds the ſame number of perſons in each row, tho' the four men were then gone, and had carried each of them a nun with them.

T O reſolve the firſt caſe, when the 4 men were got into the cells, we muſt conceive it ſo, that there was a man in each corner-cell, and that two nuns removed from thence to each of the middle cells: At this rate, each corner cell contained one perſon leſs than before, and each middle cell 2 more than before, ſuppoſe then that at the firſt viſitation, each cell contained 3 nuns, and ſo that there were 9 in each row, and 24 in all ; at the ſecond viſit which is the firſt caſe in queſtion there muſt have been 5 nuns in each

middle

3	3	3
3		3
3	3	3

2	5	2
5		5
2	5	2

middle cell, and 2 perſons, *viz.* I man and I nun in each corner cell; which ſtill makes 9 perſons in each row.

To account for the ſecond caſe, when the 4 men were gone, and 4 nuns with them; each corner cell muſt have contained I nun more than at the firſt viſit, and each middle cell 2 fewer: And thus, according to the ſuppoſition laid down, each corner cell contained 4 nuns, and there was only I in each middle cell; which ſtill make 9 in a row, though the whole number was but 20.

4	I	4
I		I
4	I	4

Note. Though at firſt ſight it may be thought by ſome that the four foregoing Sports cannot be reſolved by any certain rule, but only by many trials; yet by infallible argumentation and diſcourſe, the ſolution of thoſe queſtions may be found out, or elſe the impoſſibility of them, if by chance they ſhould be propounded impoſſible.

SPORT V.

Fifteen Chriſtians and fifteen Turks being at ſea in one and the ſame ſhip in a terrible ſtorm, and the pilot declaring the neceſſity of caſting the one half of thoſe perſons into the ſea, that the reſt might be ſaved; they all agreed, that the perſons to be caſt away ſhould be ſet out by lot after this manner, viz. *the thirty perſons ſhould be placed in a round form like a ring, and then beginning to count at one of the paſſengers, and proceeding circularly, every ninth perſon ſhould be caſt into the ſea, until of the thirty perſons there remained only fifteen. The queſtion is, how thoſe thirty perſons ought to be placed, that the*

B 3

lot

lot might infallibly fall upon the fifteen Turks
and not upon any of the fifteen Christians?

FOR the more easy remembring of the rule to
resolve this question, I shall presuppose the five
vowels, *a*, *e*, *i*, *o*, *u*, to signify five numbers, to
wit, (*a*) one, (*e*) two, (*i*) three, (*o*) four, and (*u*)
five; then will the rule itself be briefly compre-
hended in these two following verses:

> *From numbers, Aid, and Art,*
> *Never will fame depart.*

In which verses you are principally to observe
the vowels, with their correspondent numbers before
assigned; and then beginning with the Christians,
the vowel *o* (in *from*) signifies that four Christians
are to be placed together; next unto them the
vowel *u* (in *Num.*) imports that five Turks are to
be placed together; in like manner *e* (in *bers*) de-
notes two Christians; *a* (in *Aid*) one Turk; *i* (in
Aid) three Christians; *a* (in *and*) one Turk; *a*
(in *Art*) one Christian; *e* (in *ne*) two Turks; *e* (in
ver) two Christians; *i* (in *will*) three Turks; *a* (in
Fame) one Christian; *e* (in *Fame*) two Turks; *e*
(in *de*) two Christians; *a* (in *part*) one Turk.

The invention of the said rule, and such like,
depends upon the subsequent process, *viz.* If the
number of persons be thirty, let thirty figures or
cyphers be placed circularly, or else in a right line
as you see,

ooooooooooooooooooooooooooooooo

That done, begin to count from the first, and
mark the ninth (or what other shall be assigned) by
putting a point or cross over it; then count forward
from that which you have marked, and place ano-
ther point over the next ninth; and continue to
do

do the fame, beginning again when you fhall be at the end (if the cyphers are placed in a right line,) and paffing over thofe which you had already marked, until you have marked the number requir- ed, as in the example propounded, until you have marked fifteen; for then all the cyphers marked fhall be thofe which muft be caft away, and the others thofe that are to remain. Hence it is evident, that if you obferve how thofe cyphers marked, are difpofed among thofe which are not marked, you will eafily make a rule for any number whatfoever.

By this invention (as fome conjecture) the famous hiftorian, *Jofephus* the *Jew*, preferved his life very fubtilly in the cave, to which himfelf and forty of his countrymen had fled from the furious and conquering *Romans* at the fiege of *Jotapata:* For his faid coun- trymen having moft wickedly refolved to kill one another, rather than yield to their enemies, he at length (when no arguments that he could ufe would diffuade them from fo horrid an act) prevailed with them to execute their tragical defign by lot; and fo by the help of the aforefaid artifice, as we may fuppofe, himfelf, with one other perfon only re- mained alive, after the reft were inhumanly mur- dered, they agreed to put an end to the lot, and thereby fave their lives. This ftory you may fee at large in the fourteenth chapter of the third book of the Hiftory of *Jofephus*, of the wars of the Jews.

SPORT VI,

To fubftract, with one fingle operation, feveral fums, from feveral other fums given.

TO fubftract all the fums that are under the line at B, from all the fums above the line at A; begin by adding the numbers of figures of

the

56243
84564 A
3252
26848
———————

2942
3654 B
2708
———————

162003

the right hand column under the line saying, 8 and 4 is 12, and 2 makes 14 ; which taken from the neareſt tens, *viz.* 20, there remains 6 ; which we add to the correſponding column above, ſaying 6 and 8 make 14, and 2 is 16, and 4 make 20, and 3 make 23 : here we write 3 underneath ; and in regard there are juſt two tens, as before, we retain or carry nothing. This done, we add after the ſame manner, the numbers of the next lower column, ſaying, 0 and 5 is 5, and 4 make 9 ; which taken from the neareſt ten, leaves 1 ; which we add, as above, to the ſuperior correſpondent column, ſaying, one and 4 make 5, and 5 make 10, and 6 make 16, and 4 make 20 : here we ſet 0 underneath, and there being here two tens, whereas in the inferior correſponding column there was but one, we keep or carry the difference 1 to be taken from the next inferior column, becauſe we found more tens in A than in B : For had we found fewer in A than in B, we muſt have added the difference : and if it ſhould ſo fall out, that this difference can not be taken from the inferior column, for want of ſignificant figures, as it happens here in the fifth column ; we muſt add it to the ſuperior column, and write the whole ſum under the line. Thus in the example propoſed, we have 162003, for the remainder of the ſubſtraction.

SPORT VII.

Compendious ways of Multiplication.

TO multiply any number, 128 for inſtance by a number that's the product of the multiplication of two other numbers ; 24 for inſtance, the product of the multiplication of 4 and 6, or of 3
and

and 8 : we multiply the number propofed 128 by 4, and the product 512 by 6, (or elfe 128 by 3, and the product by 8) and have 3072 for the required multiplication.

Hence it follows, that to multiply a number propofed by a fquare number, we muft multiply the number propofed by the fide or the root of the fquare, and then the product by the fame fide again. Thus to multiply 128 by 25, we multiply it by 5, and the product by 5 again.

To multiply any number, 128 for inftance, by a number that's the product of the multiplication of *three* other numbers, as 108 the product of 2, 6, and 9, or of 2, 6, and 6 : we multiply 128 by 2, the product by 6, and the fecond product by 9; or elfe 128 by 3, the product by 6, and the fecond product by 6.

The confequence of this is, that to multiply any number propofed, by a cube-number, we muft multiply it firft by the fide or root of the cube; then the product of that multiplication by the fame root, and the fecond product by the fide again. As, to multiply 128 by 125, the cube-root of which is 5, we multiply 128 by 5, and the product 640 by five again, and the fecond product 3200 by five again. Thus to find how many cubical feet are in 32 cubical toifes, we multiply 32 by 6, the product of that by 6, and the fecond product by 6.

To multiply any number by what power you will of five, add to the number propofed, on the right-hand, as many cyphers as the exponent of the power contains unites, as, one cypher for 5, two for its fquare 25, three for its cube 125, and fo on : and divide the numbers thus augmented by the like power from 2, that is, 2 for 5, 4 for its fquare 25, 8 for its cube 125, and fo on.

Thus to multiply 128 by 5, we divide 1280 by 2, and the quotient 640 is the product of the mul-
tipli-

tiplication : but to multiply 128 by 25 the square
of 5, we divide 12800 by 4 the square of 2, and
the quotient is the product demanded ; and to mul-
tiply the same number 128 by 125 the cube of 5,
we divide 128000 by 8 the cube of 2. And so
on.

To know how many inches are in 53 foot, we
multiply 53 by 12; or it might be done by multi-
plying 53 by 2, and the product by 6 ; or
53 by 3, and the product by 4. But there's
a way of doing it without any multiplication ;
viz. by setting down 53 under 53, and then
53 again under both, advancing it a column
to the left, so as to make 3 stand under 5 ;
for the sum of these three is 636, the num-
ber of inches contained in 53 foot, or of pence in
53 shillings.

$$
\begin{array}{r}
53 \\
53 \\
53 \\
\hline
636
\end{array}
$$

To multiply together two numbers composed of
several figures, 12, for instance, and 18 ; we re-
duce the first number 12, into these three parts,
each of which consists only of one figure, 2, 4, and
6 , and in like manner the second number, 18, into
4, 6, 8 ; each of which last must be multiplied by
2, the first part of the first number; and then by
4, the 2d figure of the same first number ; and at
last by 6, the third part : and the sum of all these
products answers the demand.

SPORT VIII.

Division shortened.

TO divide a large number by a smaller, by
only addition and subtraction, as 1492992
by 432 ; we commonly put the divisor to the left,
under 1492, to know how many times 'tis contain-
ed in that number. But yet we may save ourselves
that labour by making a tariff of the divisor ; for
which end we place it on the right over-against 1 ;

then

then add it to itself, or double it, and place that
over-againſt 2 : Then we add it to the double, and
place the ſum oppoſite to 3 ; adding it to the
triple, we have its quadruple oppoſite to 4 ; as the
additional of itſelf to the quadruple, gives the
quintuple oppoſite to five; and ſo of the other
multiples oppoſite to 6, 7, 8, 9, 10 : The laſt of
which, *viz.* the multiple correſponding to 10,
ought, if the table is right done, to be the ſingle
diviſor with a cypher on the right-hand.

1	432	1492992	(3456
2	864	1296...	
3	1296	──────────	
4	1728	1969	
5	2160	1728	
6	2592	────	
7	3024	2419	
8	3456	2160	
9	3888	────	
10	4320	2592	
		2592	
		────	
		900	

Having thus prepared your table, proceed in the
common way of diviſion; and every time you have
occaſion to know how often your diviſor is con-
tained in the correſponding number, **look** in your
table for the neareſt number that does not exceed ;
and the number to which that is oppoſite gives you
at one view the figure you are to put in your quo-
tient. As, in the beginning of the diviſion here
exemplified, you want to know how often 432 is
to be found in 1492; in your table, you find 1296
(the neareſt number to 1492 and not exceeding it)
oppoſite to 3, and accordingly 3 is the firſt figure
of your quotient; and ſo of all the reſt.

This

This way is very convenient, when we have occasion to divide large numbers by a smaller number; for the tariff of our divisor keeps us from being at a stand, by resolving us readily upon all our divisions. This is frequently the case of surveyors of land, who have occasion to divide large numbers by 144, when they want to reduce square inches into square feet: or by 1728, when they want to reduce cubical inches into cubical feet.

To divide any number by what power you will of 5, multiply it by the like power of 2, and cut off from the right hand of the product as many figures as there are unites in the degree of the power; the remaining figures on the left will represent the quotient of the division, and those struck off will be the numerator of a fraction, the denominator of which will be the like power of 10.

To divide any number by a smaller, that is the product of the multiplication of two yet smaller numbers, divide the number proposed, by one of the two smaller, and the quoient by the other; and the second quotient arising from the last division, is what you want.

Thus to divide 20736 by 24, the product of 3, and 8, or of 4 and 6, we take the 8th part of its 3d, or the 6th part of its 4th, or, (which is the same thing) we take the 3d of its 8th part, or the 4th of its 6th, and our quotient proves 1728.

Hence to reduce square feet to square toises, (a toise is 6 foot) we must take the 6th part of the 6th part of the number proposed of square feet, because a square toise is 36 square foot, and 6 times 6 is 36. Thus to reduce 542 square feet to square toises, we must take the 6th part of $90\frac{2}{6}$ (the 6th part of 542) and so have 15 square toises and 2 square feet, as the value of 542 square feet.

SPORT

SPORT IX.

Curious properties of Numbers.

I. NUMBER 9 has this property; that when it multiplies any number of integers whatfoever, the fum of the figures in the product is divifible by 9: thus 53, multiplied by 9, makes the product 477; the figures of which, added together, *viz.* 7 and 7 and 4 make 18, which is exactly divifible by 9.

II. Take any two numbers whatfoever, either one of the two, or their fum, or their difference is divifible by 3: thus, of the two numbers 6 and 5, 6 is divifible by 3; of 11 and 5 the difference 6 is divifible by 3; of 7 and 5 the fum 12 is divifible by 3.

III. The product arifing from the multiplication of two numbers, the fquares of which make a joint fquare number, is divifible by 6: thus 12 the product of 3 and 4, the fquares of which, *viz.* 9 and 16, make together the fquare number 25; this 12, I fay, is divifible by 6.

- *To find two numbers, the fquares of which make together a fquare number,* multiply any two numbers, the one by the other, and the double of the product will be one of the two numbers demanded, and the difference of their fquares will be the other. Thus in 2 and 3, the double of their product 12, and 5 the difference of their fquares (4 and 9) are two numbers of that quality, that their fquares 144 and 25 make together the fquare number 169, the root of which is 13. *See* Sport X *and* XI.

IV. The fum and the difference of any two numbers, the fquares of which differ by a fquare number, are each of them, either a fquare number, or the half of one; thus, take the number 6 and 10, their fquares 36 and 100 differ by the fquare number

number 64; their fum is 16, and their difference 4, each of which is a fquare number: then take 8 and 10 for the two numbers, their fquares 64 and 100, differ by the fquare number 36; and the fum 18, and the difference 2, are the halfs of the two fquare numbers 36 and 4.—

To find two numbers, the fum and difference of which, are, each of them, a fquare number, In which cafe, the fquares of thefe two numbers will likewife differ by a fquare number ; pitch upon any two numbers, as 2, and 3, the product of their multiplication is 6, their fquares are 4 and 9 ; 13 the fum of the two fquares, and 12 the double of the product of their multiplications, are the numbers we look for ; for their fum 25, and their difference 1 are both fquare numbers ; and further, their fquares 169 and 144 differ by the fquare number 25.

To find two numbers, the fum and difference of which are each of them the half or the double of a fquare number; in which cafe their fquares will likewife differ by a fquare number; take any two numbers, as 2 and 3, the fquares of which are 4 and 9 ; 13 the fum of thefe two fquares, and 5 the difference, are the two numbers demanded ; for their fum 18 and their difference 8, are the halfs of the two fquare numbers 36 and 16, and the doubles of the two fquares numbers 9 and 4 ; and farther, their fquares 169 and 25, differ by the fquare number 144 the root of which is 12.

V. Every fquare number ends either with two cyphers, or with one of the 5 figures 1, 4, 5, 6, 9, which ferves for a rule, *to diftinguifh when a number propofed is not fquare, viz.* when it does not end as above ; nay, if it does end with two noughts, and thefe are not preceded by any of the
foregoing

foregoing five figures, we may reft affured it is not fquare.

VI. Every fquare fraction, that is, every fraction that has its fquare root, is fuch, that the product of the multiplication of the numerator by the denominator is fquare. Thus *we know a fraction is not fquare*, when that does not happen. Take the fraction $\frac{28}{63}$, we know it to be fquare, becaufe 1764, the product of 28, multiplied by 63, is a fquare number, having 42 for its root; and fo the fquare root of the propofed fraction is $\frac{42}{63}$, retaining the fame denominator; or $\frac{28}{42}$, retaining the fame numerator, for either of thefe is equivalent to $\frac{2}{3}$, for the fquare root of the propofed fraction $\frac{28}{63}$ or $\frac{4}{9}$.

VII. Any cubical fraction, *i. e.* any that has its cube-root, is fuch, that if you multiply the numerator by the fquare of the denominator, or the denominator by the fquare of the numerator, the product has its cube-root; and it is by this rule that *we know when a fraction is a cube fraction, fuch* is $\frac{24}{375}$ for 3375000, and 216000, the two products of the two ways of multiplication juft mentioned, have 150 and 60 for their cube roots, and fo the cube root of the fraction $\frac{24}{375}$ is $\frac{150}{375}$ retaining the fame denominator, or $\frac{24}{60}$ retaining the fame numerator, for each of thefe fractions is equal to $\frac{2}{5}$ as the cube root of the propofed fraction $\frac{24}{375}$.

VIII. Though it is not poffible to find two homogeneous powers, the fum and difference of which are each of them a power of the fame degree, that is, fquare numbers if the two firft are fquares, and cube-numbers if they are cubical, &c. yet it is poffible, and very eafy, *to find two triangular numbers, the fum and difference of which, are each of them a triangular number.*

Thus 15 and 21 are two triangular numbers, the fides of which are five and 6, and their fum 36;

and

and the difference 6 are likewife triangular numbers, having 8 and 3 for their fides. Again 780 and 990 are triangular numbers, the fides of which are 39 and 44, and their fum 1770 and the difference 210 are likewife triangular numbers, having 59 and 20 for their fides. Once more, 1747515 and 2185095 are triangular numbers, having 1869 and 2090 for their fides; and their fum 3932610 and the difference 437580 are likewife triangular numbers, the fides of which are 2804 and 935.

By a *Triangular Number* we underftand the fum of the natural numbers, 1, 2, 3, 4, 5, 6; beginning with unit, and rifing to what number you will, the laft and the greateft of which is called the fide. Thus we know that 10 is a triangular number, the fide of which is four, by reafon that it is equal to the fum of the firft four natural numbers, 1, 2, 3, 4, the laft and greateft of which is 4. It was called *Triangular*, becaufe you may difpofe 10 points in the form of an equilateral triangle, each fide of which contains 4, and hence it was that 4 got the name of the fide of the triangular number 10.

To know if a number propofed is triangular, you muft multiply it by 8, and add 1 to the product; for if the fum be fquare, the propofed number is triangular. Thus we know that 10 is triangular, becaufe 81 (the fum of its multiplication by 8, with with the addition of 1) is a fquare number, having 9 for its root.

IX The difference of two homogeneous powers, as of two fquare numbers, of two cube numbers, &c. is divifible by the difference of their fides. Accordingly we find that 21, the difference of the two fquare numbers 25 and 4, the fides of which are 5 and 2, is divifible by 3, the difference of the fides or roots, the quotient 7 being always equal

equal to the fum of the fame fides or roots; and that 117, the difference of the cubes 125 and 8, the roots of which are 5 and 2, is divifible by 3 the difference of the roots, the quotient 39 being equal to the product of the faid roots multiplied one into another, *viz.* 10, added to 29 the fum of their fquares 25 and 4.

X. The difference of the two homogeneal powers, the common exponent of which is an even number, is divifible by the fum of their roots. Thus, 21 the difference of the two fquare numbers 25 and 4, the roots of which are 5 and 2, is divifible by 7, the fum of the faid roots, the quotient 3 being equal to the difference of the roots, and 609 the difference of the bi-quadrats 625 and 16, the roots of which are 5 and 2, is divifible by 7, the fum of the roots, the quotient 87 being equal to the product arifing from 3, the difference of the roots, multiplied with 29 the fum of their fquares 25 and 4.

XI. The fum of two homogeneal powers, the common exponent of which is an odd number, is divifible by the fum of their roots. Thus we know that 133 the fum of the two cubes 125 and 8, the roots of which are 5 and 2, is divifible by 7 the fum of thefe roots, the quotient 19 being equal to the excefs of the fum of the fquares of the roots (29) above the product of the roots (10). And that 3157 the fum of the two fur-folids 3125 and 32, the roots of which are 5 and 2, is divifible by 7 the fum of the roots; the quotient 451 being equal to the excefs of 741 the fum of the bi-quadrat powers of the roots 5 and 2 (625, 16) and of the fquare of the product of the roots (100) its excefs, I fay, above 290 the product of the fum of the fquares of the fame roots (29) multiplied by 10 the product of the roots themfelves.

C

XII.

XII. All the powers of the natural numbers 1, 2, 3, 4, 5, 6, &c. have as many differences as their exponents contain units, the laſt differences being always equal among themſelves in each power, that is, the ſecond differences, or the differences of the differences, in the ſquares 1, 4, 9, 16, 25, 36. &c. for theſe ſecond differences make 2, the firſt being the uneven numbers 3, 5, 7, 9, 11, &c. The third differences, or the differences of the differences of the firſt differences in the cubes 1, 8, 27, 64, 125, 216. &c. for theſe third differences make 6, the firſt being 7, 19, 37, 61, 91, &c. and the ſecond differences, i, e, the differences of theſe differences being 12, 18, 24, 30, &c. which riſe by 6 for the third difference, and ſo of the reſt.

The ſame thing happens to Pollygon numbers formed by the continual addition of numbers in continual arithmetical progreſſion, which are called Gnomons, and of which the firſt is always an unite, which is virtually any Polygon number. The ſame is the caſe with Pyramidal numbers, which are formed by the continual addition of Polygon numbers conſidered as Gnomons, the firſt of which is always unit : and in like manner with the Pyrami-do-Pyramidal numbers, which are produced by the continual addition of Pyramidal numbers, conſidered as Gnomons, the firſt of which is always unity.

When the Gnomons riſe, or exceed one another by one, as 1, 2, 3, 4, 5, 6, &c, the Polygon numbers 1, 3, 6, 10, 15, 21, &c. which are formed from them are called Triangular, the property of which is ſuch, that each of them being multiplied by 8, and the product inlarged by unity, the ſum is a ſquare number, as we intimated above. And farther, 9 the ſum of the ſecond and the third,

omitting

omitting the firſt, is a ſquare number, and 36 the ſum of the fifth and the ſixth, omitting the fourth, is likewiſe ſquare, and ſo on.

When the Gnomons riſe, or exceed one another by two unites, as the odd numbers 1, 3, 5, 7, 9, 11, &c. the Polygon numbers formed from them, 1, 4, 9, 16, 25, 36, &c. are ſquare numbers; and when the Gnomons increaſe by three unites, as 1, 4, 7, 10, 13, 16, &c. the numbers formed from them, 1, 5, 12, 22, 35, 51, &c. are called Pentagons, and have this peculiar quality that each of them being multiplied by 24, and 1 added to the product, the ſum is a ſquare number, by which rule *we know when a propoſed number is Pentagon,* and ſo of the others.

To find the ſum of as many triangular numbers as you will, commencing from unit, of theſe eight for inſtance, 1, 3, 6, 10, 15, 21, 28, 36, multiply the given number 8 by the next follower 9, and the product 72, by the next after that 10, and divide the ſecond product 720 by 6, the quotient gives you 120 the ſum demanded.

The ſum of all theſe infinite fractions $\frac{1}{3}, \frac{1}{6}, \frac{1}{10}, \frac{1}{15}, \frac{1}{21}$, &c. the common numerator of which is 1, and the denominators of which are triangular numbers, their ſum, I ſay, is juſt 1.

To find the ſum of as many ſquare numbers from an unit as you will, of theſe eight, for example, 1, 4, 9, 16, 25, 36, 49, 64, take 36, the laſt of as many triangular numbers, *viz.* 1, 3, 6, 10, 15, 21, 28, 36, from 240 the double of this ſum 120, and the remainder 204 is the ſum you want.

XIII. The cubes, 1, 8, 27, 64, 125, 216, &c. of the natural numbers, 1, 2, 3, 4, 5, 6, &c. are ſuch, that the firſt 1 is a ſquare number, the root of which 1 is the firſt triangular number; the ſum of the two firſt, 1 and 8, *viz.* 9, is a ſquare number,

the

the root of which 3 is the fecond triangular numbers 36 the fum of the three firft, 1, 8, 27 is a fquare number, the root of which 6 is the third triangular number, and fo on. And therefore if you want *to find the fum of any number of cubic numbers from an unit*, of thefe fix for example, 1, 8, 27, 64, 125, 216,) the fquare of the fixth triangular number 21, (441) is the fum you defire.

XIV. Among whole numbers, there is only 2 that being added to itfelf, makes as much as when multiplied by itfelf, *viz.* 4. for all other numbers make more by multiplication than by addition.

Though we cannot find two whole numbers, the fum of which is equal to the product of their multiplication, yet we can eafily *find two fractional numbers, and even in a given Ratio, the fum of which is equal to their product, viz,* by dividing the fum of the two terms of the given Ratio by each of the two terms; thus, if you give them the Ratio of the two numbers, 2, 3, divide their fum 5 feparately by 2 and by 3, and you will have the two numbers $2\frac{1}{2}$, $1\frac{2}{3}$, which make as much when added together as when multiplied together, *viz.* $4\frac{1}{6}$.

XV. Any number is the half of the fum of two others equally remote, the one in the way of defect, and the other in excefs. For example, 6 is the half of 12, the fum of the two numbers equally remote, 5 and 7, or 4 and 8.

XVI. The number 37 has this property, that being multiplied by any of thefe numbers, 3, 6, 9, 12, 15, 18, 21, 24, 27, which are in continual arithmetical progreffion, all the products are compofed of one figure thrice repeated.

37	37	37	37	37	37	37	37	37
3	6	9	12	15	18	21	24	27
111	222	333	444	555	666	777	888	999

XVII.

XVII. The two numbers 5 and 6 are called Spherical, becaufe their powers terminate in thefe very numbers. The powers of 5, *viz.* 25. 125, 625, *&c.* terminate in 5; and in like manner the powers of 6, *viz.* 36, 216, 1296, *&c.* end with 6.

5 has that peculiar quality, that when multiplied by an odd number (as 7) its product terminates in 5, (as 35) and when multiplied by an even number (as 8) its product ends in a cypher, (as 40)

The other number, 6, has likewife this fingular quality, that it is the firft of the numbers which we call *perfect*, as being equal to the fum of their aliquot parts, for 6 is equal to the fum of its aliquot parts 1, 2, 3 ; 28 is likewife a *perfect* number, in regard it is equal to the fum of its aliqout parts 1, 2, 4, 7, 14 : and one may find an infinity of other perfect number, as 496, which is equal to the fum of its aliquot parts 1, 2, 4, 8, 16, 31, 62, 124, 248.

To find all the perfect numbers in order, make ufe of the powers of 2, *viz.* 2, 4, 8, 16, 32, *&c*, and fee which of thefe powers, when an unit is taken from them, makes a prime number, and you will find in 4, 8, 32, *&c.* that if you fubftract 1 from each of them, the remainders 3, 7, 31, *&c.* are prime numbers, each of which ought to be multiplied by the half of the correfponding power, that is, 3 by 2, 7 by 4, 31 by 16, *&c.* in order to obtain the perfect numbers 6, 28, 496, *&c.*

2	4	8	16		32
1	1				1
—	—				—
3	7				31
2	4				16
—	—				—
6	28				496

To find all the Aliquot Parts, or all the divifors of a propofed number, of which an unit is always one. If the number be 8128 (for example) which

is

is likewife a perfect number, divide it by the leaft number that offers, *viz.* 2, which is eafily done, becaufe 8128 is an even number, fo the quotient will be 4064, which fet down over againft 2 for your fecond divifor, which may ftill be divided by the firft divifor 2, and fo its fquare 4 may likewife be a divifor, which fet down under 2, over againft the fecond quotient 2032 for another divifor, which may ftill be divided by the firft divifor 2, and therefore its cube 8 will likewife be a divifor, which you are to write under the fquare 4, and oppofite to the third quotient 1016 for another divifor: thus you go on, till you come to the laft divifor that cannot be divided by 2, *viz.* the fixth quotient 127 which being a prime number, that is, a number that can be divided by nothing but an unit, gives us to know that we have traced all the divifors of the number propofed 8128, and here you fee the fum of the divifors is equal to the number propofed, and by confequence it is a perfect number.

1	
2	4064
4	2032
8	1016
16	508
32	254
64	127
—	——
127	8001
	127
	——
	8128

By the fame method did we find out all the divifors of the other number 2096128, which is likewife perfect, for as you fee it is equal to the fum of its aliquot parts. You fee likewife that the laft quotient 2047 which anfwers to 1024 the tenth power of the firft divifor 2 is alfo a prime number, for if it could have been divided by any other number beyond 2, as by 3, it behoved us to have mul-

1	
2	1048064
4	524032
8	262016
16	131008
32	65504
64	32752
128	16376
256	8188
512	4094
1024	2047
——	————
2047	2094081

tiplied

tiplied all the power of the firſt diviſor 2 by this new diviſor 3, and to have divided the number propoſed and all the quotient by this new diviſor 3, in order to have their diviſors, as you will ſee in the following example.

XVIII. The number 120 is equal to the half of 240, the ſum of its aliquot parts 1, 2, 3, 4, 5, 6, 8, 10, 12, 15, 20, 24, 30, 40, 60. The number 672 is likewiſe equal to the half of 1344 the ſum of its aliquot parts, as will appear by obſerving the method above preſcribed, which we ſhall not now repeat. We may find a great many other numbers, that have the ſame quality; nay, ſome may be found to be the third, or any other part of the ſum of their aliquot parts, which we ſhall not now inſiſt upon.

XIX. The two numbers 220 and 284 are called *Amiable*, becauſe the firſt 220 is equal to the ſum of the aliquot parts of the latter, 1, 2, 4, 71, 142; and reciprocally the latter 284 is equal to the ſum of the aliquot parts of the former, 1, 2, 4, 5, 10, 11, 22, 44, 55, 110. Theſe aliquot parts are eaſily found by what we have ſaid before, eſpecially if we conſider that all numbers that end in 5 or in 0, are diviſible by 5.

To find all the *Amiable Numbers in order*, make uſe of the number 2, which is of ſuch a quality, that if you take 1 from its tripple 6, from its ſextuple 12, from the octodecuple of its ſquare, 72, the remainders are the three prime numbers 5, 11, and 71, of which 5 and 11 being multiplied together, and the product 55 being multiplied by 4 the double of the number 2, this ſecond product 220 will be the firſt of the two numbers we look for; and to find the other 284, we need only to multiply the third prime number 71, by 4, the ſame double of 2, that we uſed before.

To

To find two other amiable numbers, instead of 2 we make use of two of its powers that possesses the same quality, such as its cube 8 ; for you subtract an unit from its tripple 24, from its sextuple 48, and from 1152 the octodecuple of its square 64, the remainders are the three prime numbers, *viz.* 23, 47, 1151, of which the two first, 23, 47, ought to be multiplied together, and their product 1081 ought to be multiplied by 16 the double of the cube 8 in order to have 17296 for the first of the two numbers demanded. And for the other amiable number, which is 18416, we must multiply the third prime number 1151 by 16 the same double of the cube 8.

If you still want other amiable numbers, instead of 2, or its cube 8, make use of its square cube 64, for it has the same quality, and will answer as above.

In regard, it is difficult to know whether a number is prime if it be a large number, we shall at the end of this Sport subjoin a table of all the prime numbers between 1 and a 10000.

XX. The squares of the two numbers 31, 34, *viz.* 961, 1156, are such, that the first 961, with its aliquot parts, 1, 31, makes a sum (993) equal to 1, 2, 4, 17, 34, 68, 289, 578, the aliquot parts of the second 1156.

XXI. The two numbers 26, 20, make each of them with their aliquot parts, the same sum ; the first 26 with its aliquot parts, 1, 2, 13, makes 42, and the second (20) with its aliquot parts 1, 2, 4, 5, 10, makes likewise 42.

The same is the case of 488 and 464, each of them with their aliquot parts making 930: of 11 and 6, each of them with their aliquot parts making 12 ; and in fine of 17 and 10, which with their aliquot parts make 18 a piece.

Nay,

Nay, we may find three numbers, each of which with its aliquot parts makes the same sum, as 20, 26 and 41, as also 23, 14, 15, and 46, 51, 71.

We may find two square numbers of the same quality, particularly 16 and 25 the squares of 4 and 5; which are the lowest that can be, and by virtue of which we come at as many more as we will of the same quality, *viz.* by multiplying them by some odd square number, that is not divisible by five. For example, if we multiply each of them by the square number 9, we obtain two other square numbers 144, and 225, each of which with its aliquot parts makes just 403.

XXII. 81 the square of 9, with its aliquot parts, 1, 3, 9, 27, makes a square number (121) the root of which is 11, 400 the square of 20, with its aliquot parts, make the square of 31 (961.)

XXIII. 666 the sum of these three triangular numbers 15, 21, 630, the sides of which are 5, 6, 35, is likewise a triangular number, the sides of which is 36. The same is the case of these three triangular numbers 210, 780, 1711, and likewise of these 666, 2628, 5886.

XXIV. 49 the square of 7 has this quality that 8 the sum of its aliquot parts, 1, 7, is the cube of 2, and 343 the cube of the same number 7, does with its aliquot parts 1, 7, 49, make the square number 400, the root of which is 20. I do not here pretend to direct you how to find out others of the same quality, for unless you light upon them by chance, it is very difficult to trace them without Algebra, which I propose not to mention in this performance.

XXV. 9 the square of 3 has this quality, that 4 the sum of its aliquot parts 1, 3, is the square of 2, 2401 the square of 49 has the same quality,

for

for 400, the fum of its aliquot parts 1, 7, 49, 343 is the fquare of 20.

XXVI. The two numbers 99, 63, have this quality, that (57) the fum of the aliquot parts of the firft, 1, 3, 9, 11, 33, furpaffes (41) the fum of the aliquot parts of the fecond, 1, 3, 7, 9, 21. by the fquare number 16, the root of which is 4. The fame is the condition of 325 and 175 ; for the fum of the aliquot parts of the firft exceeds that of the aliquot parts of the other, by the fquare number 36.

XXVII. The fum of two numbers that differ by unity, is equal to the difference of their fquares, and the fum of the fquares of their triangular numbers is likewife a triangular number. Thus 5 and 6 make the fum 11 equal to the difference of their fquares 25, 36, and their triangular numbers 15, 21, are fuch, that 666, the fum of their fquares 225, 441, is likewife a triangular number, the fide of which is 36.

XXVIII. The two triangular numbers, 6, 10, of the two numbers 3, 4, the difference of which is likewife an unity, have this quality, that their fum 16, and their difference 4, are fquare numbers, having 4 and 2 for roots ; and 136 the fum of their fquares (36, 100) is a triangular number, the fide of which 16 is likewife a fquare number, the root of which is at the fame time a fquare number, having 2 for its fide or root.

The fame is the quality of the two other triangular numbers, 36, 47 the fides of which, 8, 9, differ only by unity, for their fum 81, and their difference 9, are fquare numbers, the roots of which are 9 and 3, and 3321 the fum of their fquares (1296, 2025) is a triangular number, the fide of which is 81, and that has its fquare root 9, which again is the fquare of 3.

There

There are many other triangular numbers of this quality, that may be found out by subtracting and adding any square number to its square, the halves of the remainder and of the sum being the two triangular numbers demanded. For example, if you subtract 8 the square number 16 from and add it to its square 256, half the remainder 240, and half the sum 272, present us with 120, and 136, for the two triangular numbers thought for, the sides of which are 15, 16, the difference consisting still in unity.

These two triangular numbers thus found, have this farther quality, that the greatest of their sides is always a square number, and the difference of their squares is likewise a square number; and withal their sum is a bi-quadrate, equal to the square of their difference, and at the same time to the side of the triangular number that composes the sum of their squares.

XXIX. The difference of the squares of the two numbers in a duplicate Ratio, is equal to the sum of their cubes divided by the sum of their two numbers, and that very sum of their cubes is the third of a cube.

Accordingly, 4 and 8 being in a duplicate Ratio, the difference 48 of their squares, 16, 64, is equal to the quotient resulting from the division of 576 (the sum of their cubes, 64, 512) by 12 the sum of the two numbers, and the very sum of their cubes 576 is the third part of the cube 1728, the root of which 12 is always equal to the sum of the two numbers.

I should never have done, if I pretended here to fetch in all the properties of numbers, which indeed are infinite, and upon that consideration I shall now conclude this Sport with the table of the prime numbers that I promised above.

Table of the Prime Numbers between 1 and 10000.

1								
2	149	337	547	757	997	1223	1471	1699
3	151	347	557	761	——	1229	1481	——
5	157	349	563	769	1009	1231	1483	1709
7	163	353	569	773	1013	1237	1487	1721
11	167	359	571	787	1019	1249	1489	1723
13	173	367	577	797	1021	1259	1493	1733
17	179	373	587	——	1031	1277	1499	1741
19	181	379	593	811	1033	1279	——	1747
23	191	383	599	821	1039	1283	1511	1753
29	193	389	——	823	1049	1289	1523	1759
31	197	397	601	827	1051	1291	1531	1777
37	199	——	607	829	1061	1297	1543	1783
41	——	401	613	839	1063	——	1549	1787
43	211	409	617	853	1069	1301	1553	1789
47	223	419	619	857	1087	1303	1559	——
53	227	421	631	859	1091	1307	1567	1801
59	229	431	641	863	1093	1319	1571	1811
61	233	433	643	877	1097	1321	1579	1823
67	239	439	647	881	——	1327	1583	1831
71	241	443	653	883	1103	1361	1597	1847
73	251	449	659	887	1109	1367	——	1861
79	257	457	661	——	1117	1373	1601	1867
83	263	461	673	907	1123	1381	1670	1871
89	269	463	677	911	1129	1399	1609	1873
97	271	467	683	919	1151	——	1613	1877
——	277	479	691	929	1153	1409	1619	1879
101	281	487	——	937	1163	1423	1621	1889
103	283	491	701	941	1171	1427	1627	——
107	293	499	709	947	1181	1429	1637	1901
109	——	——	719	953	1187	1433	1657	1907
113	307	503	727	967	1193	1439	1663	1913
127	311	509	733	971	——	1447	1667	1931
131	313	521	739	977	1201	1451	1669	1933
137	317	523	743	983	1213	1453	1693	1949
139	331	541	751	991	1217	1459	1697	1951

1973	2237	2477	2749	3037	3329	3607	3889
1979	2239	——	2753	3041	3331	3613	——
1987	2243	2503	2767	3049	3343	3617	3907
1993	2251	2521	2777	3061	3347	3623	3911
1997	2267	2531	2789	3067	3359	3631	3917
1999	2269	2539	2791	3079	3361	3637	3919
——	2274	2543	2797	3083	3371	3643	3923
2003	2281	2549	——	3089	3373	3659	3929
2011	2287	2551	2801	——	3389	3671	3931
2017	2293	2557	2803	3109	3391	3673	3943
2027	2297	2579	2819	3119	——	3677	3947
2029	——	2591	2833	3121	3407	3691	3967
2039	2309	2593	2837	3137	3413	3697	3989
2053	2311	——	2843	3163	3443	——	——
2063	2333	2609	2851	3167	3449	3701	4001
2069	2339	2617	2857	3169	3457	3709	4003
2081	2341	2621	2861	3181	3461	3719	4007
2083	2347	2633	2879	3187	3463	3727	4013
2087	2351	2647	2887	3191	3467	3733	4019
2089	2357	2657	2897	——	3469	3739	4021
2099	2371	2659	——	3203	3491	3761	4027
——	2377	2663	2903	3209	3499	3767	4049
2111	2381	2671	2909	3217	——	3769	4051
2113	2383	2677	2917	3221	3511	3779	4057
2129	2389	2683	2927	3229	3517	3793	4073
2131	2393	2687	2939	3251	3527	3797	5079
2137	2399	2689	2953	3253	3529	——	4091
2141	——	2693	2957	3257	3533	3803	4093
2143	2411	2699	2963	3259	3539	3821	4069
2153	2417	——	2969	3271	3541	3823	——
2161	2423	2707	2971	3299	3547	3833	4111
2179	2437	2711	2999	——	3557	3847	4127
——	2441	2713	——	3301	3559	3851	4129
2203	2447	2719	3001	3307	3571	3853	4133
2207	2459	2729	3011	3313	3581	3863	4139
2213	2467	2731	3019	3319	3583	3877	4153
2221	2473	2741	3023	3323	3593	3881	4157

4159	4463	4759	5039	5381	5651	5903	6229
4177	4481	4783	5051	5385	5653	5923	6247
——	4483	4787	5059	5393	5657	5927	7257
4201	4493	4789	5077	5399	5659	5939	6261
4211	——	4793	5081	——	5669	5953	6269
4217	4507	4799	5087	5407	5683	5981	6271
4219	4513	——	5099	5413	5689	5987	6277
4229	4517	4801	——	5417	5693	——	6287
4231	4519	4813	5101	5419	——	6007	6299
4241	4523	4817	5107	5431	5701	6011	——
4243	4547	4831	5113	5437	5711	6029	6301
4253	4549	4861	5119	5441	5717	6037	6307
4259	4561	4871	5147	5443	5737	6043	6313
4261	4567	4877	5153	5449	5741	6047	6323
4271	4583	4889	5167	5471	5743	6053	6329
4273	4591	——	5171	5477	5749	6067	6337
4283	4597	4903	5179	5479	5779	6073	6343
4289	——	4909	5189	5483	5783	6079	6353
4297	4603	4919	5197	——	5791	6089	6355
——	4621	4931	——	5501	——	6091	6359
4327	4637	4933	5209	5503	5801	——	6361
4337	4639	4937	5227	5507	5807	6101	6367
4339	4643	4943	5231	5519	5813	6113	6373
4349	4649	4951	5233	5521	5821	6121	6379
4357	4651	4957	5237	5527	7827	6131	6389
4363	4657	4967	5261	5531	5839	6133	6397
4373	4663	4969	5273	5557	5843	6143	——
4391	4673	4973	5279	5563	5849	6151	6421
4397	4679	4987	5281	5569	5851	6163	6427
——	4691	4993	5297	5573	5857	6173	6449
4409	——	4999	——	5581	5861	6197	6451
4421	4703	——	5303	5591	5867	6199	6469
4423	4721	5003	5309	——	5869	——	6473
4441	4723	5009	5323	5623	5879	6203	6481
4447	4729	5011	5333	5639	5881	6211	6491
4451	4733	5021	5347	5641	5897	6217	——
4457	4751	5023	5351	5647	——	6221	6421

6429	6827	7121	7477	7723	8069	8369	8689
6547	6829	7127	7481	7727	8081	8377	8693
6551	6833	7129	7487	7741	8087	8387	8699
6553	6841	7151	7489	7753	8089	8389	——
6563	6857	7159	7499	7757	8093	——	8707
6569	6863	7177	——	7759	——	8419	8713
6571	6869	7187	7507	7789	8101	8423	8719
6577	6871	7193	7517	7793	8111	8429	8731
6581	6883	——	7523	——	2117	8431	8737
6599	6899	7207	7529	7817	8123	8443	8741
——	——	7211	7537	7823	8147	8447	8747
6607	6907	7213	7541	7829	8161	8461	8753
6619	6911	7219	7547	7841	8167	8467	8761
6637	6917	7229	7549	7853	8171	——	8779
6653	6947	7237	7559	7867	8179	8501	8783
6659	6949	7253	7561	7873	8191	8513	——
6661	6959	7243	7573	7877	——	8521	8803
6673	6961	7247	7577	7879	8209	8527	8807
6679	6967	7283	7583	7883	8219	8537	8819
6689	6971	7297	7589	——	8221	8539	8821
6691	6977	——	7591	7901	8231	8543	8831
——	6983	7307	——	7907	8233	8563	8837
6701	6991	7309	7603	7917	8237	8573	8839
6703	6997	7321	7607	7927	8243	8581	8849
6709	——	7331	7621	7933	8263	8597	8861
6719	7001	7333	7639	7937	8269	8599	8863
6733	7013	7349	7643	7949	8273	——	8867
6737	7019	7351	7649	7951	8287	8609	8087
6761	7027	7369	7669	7963	8291	8623	8893
6763	7039	7393	7673	7993	8293	8627	——
6779	7043	——	7681	——	8297	8629	8923
6781	7057	7411	7687	8009	——	8641	8929
6791	7069	7417	7691	8011	8311	8647	8933
6793	7079	7433	7699	8017	8317	8663	8941
——	——	7451	——	8039	8329	8669	8951
6803	7103	7457	7703	8053	8353	8677	8963
6823	7109	7459	7717	8059	8363	8681	8969

8971	9109	9239	9377	9479	9629	9767	8971
8999	9127	9241	9393	9491	9631	9769	9883
——	9133	9257	9397	9497	9643	9781	9887
9001	9137	9277	——	——	9649	9787	——
6007	9151	9281	9403	9511	9661	9791	9901
9011	9157	9283	9413	9521	9677	9793	9907
9013	9161	9293	9419	9533	9679	——	9923
9029	9173	——	9421	9539	9689	9803	9929
9041	9181	9311	9431	9547	9697	9811	9931
9043	9187	9319	6433	9551	——	9817	9941
9049	9199	9323	9437	9587	9719	9829	9949
9059	——	9337	9439	——	9721	9833	9967
9067	9203	9341	9461	9601	9733	9839	9973
9091	9209	9343	9463	9613	6739	9851	——
——	9221	9349	9467	9619	9743	9857	
9103	9227	9371	9473	9623	9749	9859	

SPORT XI.

Of Right-angled Triangles in numbers.

BY a Rectangular Triangle in numbers, we mean three unequal numbers, the greateft of which is fuch that its fquare is equal to the fquare of the other two, fuch are 3, 4, 5, for 25 the fquare of 5 the greateft, which we call the Hypothenufe, is equal to the fum of 9 and 16, the fquares of the other two numbers, 3, 4, which we call the fides, taking one for the Bafe of the right-angled triangle, and the other for the Altitude or Height. Half the product of the Bafe, and the Altitude, is called the Area, and is always divifible by 3. The reader will obferve all along that by the product of two numbers, we underftand the number arifing from their mutual multiplication.

There is an infinite number of right-angled triangles of divers forts, both in whole and in broken or fractional numbers, but we generally conceive them in integers, among which the firft and the

leaft

least of all is that now mentioned, 3, 4, 5, which
has an infinity of fine properties, but it would be
tedious to enumerate them, and therefore I shall
content myself with observing, that the sum (216)
of the cubes (27, 64, 125) of the two sides 3, 5,
and of the Hypothenuse (5) is a cube, the root or
side of which (6) is equal to its Area.

*To find in numbers as many Right-angled Trian-
gles as you will:* Take any two numbers, for ex-
ample 2 and 3, which we call Generating Numbers,
multiply them the one by the other, and (12) the
double of their product (6) is the side of a right-
lined triangle, the other side being equal to (5) the
difference of the squares (4, 9) of the generating
numbers, 2, 3, and the Hypothenuse being equal to
(13) the sum of the same squares, 4, 9. And thus
you have this right-angled triangle 5, 12, 13, for
169, the square of the Hypothenuse 13 is equal to the
sum of 25, 144, the squares of the two sides 5, 12.

The first right-angled triangle, having 1, 2, for
its generating numbers is such, that the difference
of the two sides 3, 4, is 1 ; and if you want to *find
another of the same quality,* take 2 the greatest of
these generating numbers for the least of the two in
the triangle demanded ; and in order to find the
greatest for this second triangle, add 1, the least of
the first, to 4 the double of the greatest of the
first, and so you have 5 for your greatest generating
number of the second right-angled triangle, which
consequently is 20, 21, 29, where the difference
of the two sides 20, 21, is again 1.

If you desire a third right-angled triangle of the
same quality, make use of the last 20, 21, 29,
after the same manner as you did the first, taking
its greatest generating number for the least of the
third, and adding its least to the double of the
greatest, for the greatest of this your third triangle ;

and

and so observing the same method you may find a
fourth, fifth, &c. as appears by this table.

Sides		Hypoth.	Generat. numb.	
3	4	5	1	2
20	21	29	2	5
119	120	169	5	12
696	697	1025	12	29
4059	4060	5741	29	70
23660.	23661	33461.	70.	169.

The first right-angled triangle 3, 4, 5, has like-
wise this quality, that the excess of the Hypothe-
nuse 5 above the side 4, is also 1, forasmuch as the
difference of the two generating numbers is 1, and
for this reason you may *find an infinite number of
other right-angled triangles of this quality,* if for
their generating you take two that differ only by
unity, as you see in this table,

Bases.	Altitude.	Hypoth.	Generat. numb.	
3	4	5	1	2
5	12	13	2	3
7	24	25	3	4
9	40	41	4	5
11	60	61	5	6
14	84	85	6	7

Here you see the first differences of the bases, 3, 5,
7, 9, &c. are equal, and the second differences of
the altitudes, 4, 12, 24, 40, &c. are likewise
equal; and the same is the case of the Hypothenuses,
5, 13, 25, &c.

Here the Bases are odd numbers, and if you *would
have them the squares of these odd numbers,* only
take the altitudes and Hypothenuses for the gene-
rating numbers of the triangles you propose, which
by consequence will run thus

Bases.	Heights,	Hypoth.	Gen. numb.	
9	40	41	4	5
25	312	113	12	13
49	1200	1201	24	25
81	3280	3281	40	41
121	7320	7321	60	61
169	14280.	14281.	84.	85.

If Inſtead of one ſide you would have the *Hypo-thenuſe to be the ſquare number,* then your gene-rating numbers muſt be the ſides of a right-angled triangle, as in the following ſcheme, where you ſee the Hypothenuſe is the ſquare of the greateſt generating number, with the addition of 1.

Sides.		Hypoth.	Gen. uumb.	
7	24	25	3	4
119	120	169	5	12
336	527	625	7	24
720	1519	1681	9	40
1320	3479	3721	11	60
2184	6887	7225	13	84

The right-angled triangle, 21, 28, 35, has this quality, that the two ſides 21, 28, are triangular numbers, the ſides of which, 6 and 7, differ only by unity, and the ſquare (1225) of the Hypothe-nuſe (35) is likewiſe a triangular number, the ſide of which is 49.

The ſame is the quality of the triangle 820, 861, 1189, as alſo of the triangle 28441, 28680, 40391, and of others.

The following right-angled triangles, which may be continued *in infinitum,* are ſuch that their baſes and hypothenuſes are triangular numbers, and their heights cubic numbers.

Baſes.

Bafes,	Heights.	Hypoth.	Gen. numb.	
6	8	10	1	3
36	27	43	3	6
120	64	136	6	10
300	125	135	10	15
630	216	666	15	21
1176	343	1225	21	28

You may *find as many fuch triangles as you will*, by adding and fubtracting a fquare number from its fquare, for in the addition half the fum is the hypothenufe, and in fubftracting half the remainder is the bafe, the height being equal to the cube of the root of the firft fquare number : or, which is the fame thing, by taking for the generating numbers the triangular numbers in order, as you fee in the fcheme before us, where the leaft generating numbers of one right-angled triangle is the greateft of the preceding triangle.

SPORT XII.

Of Arithmetical Progreffion.

BY Arithmetical Progreffion, we mean a feries of quantities called Terms, that rife continually by an equal excefs, as 1, 3, 5, 7, 9, 11, &c. where the excefs is 2; or 1, 4, 7, 10, 13, 16, &c. where the excefs is 3 ; or 2, 6, 10, 14, 18, 22, &c. where they rife by four at a time. And fo of the reft.

The principal property of arithmetical progreffion, is this. Take three continual terms, as 6, 10, 14, the fum (20) of the two extremes (6, 14,) is equal to the double of the middle term (10.) Take four continual terms, as 6, 10, 14, 18, the fum (24) of the two extremes (6, 18) is equal to that of the two middle terms, (10, 14) In fine, in a larger number of continual terms, fix for inftance, as 2,

6, 10,

6, 10, 14, 18, 22, the sum (24) of the two ex-
tremes (2, 22) is equal to that of any two terms
that lie at an equal diftance from them, as 6, 18,
and 10, 14. From whence it is eafy to conclude,
that when a multitude of progreffive terms is an odd
number, the fum of the extremes, or of thofe
equally remote, is the double of the middle term, as
in thefe five terms, 2, 6, 10, 14, 18 ; for the fum
(20) of the extremes 2, 10, 18, or of the two equal-
ly remote, 6, 14, is the double of the middle
term, 10.

You may readily find fuch numbers as have this
quality, that the fum of their fquares make a fquare
number, or, which is the fame thing, the fides of
a right-angled triangle in numbers ; and that by
virtue of this double arithmetical progreffion, $1\frac{1}{2}$,
$2\frac{2}{5}$, $3\frac{3}{7}$, $4\frac{4}{9}$, where the excefs is 2 in fractions, and
1 in whole numbers ; for if you reduce the integer
with its fraction to a fraction only, as $1\frac{1}{3}$ to $4\frac{4}{3}$, the
numerator 4 and the denominator 3 will be the fides
of the right-angled triangle 3, 4, 5 ; and in like
manner if you reduce $2\frac{2}{5}$, to $\frac{12}{5}$ (which is done by
multiplying the whole number 2 by the denominator
5, and adding to the product 10 the numerator 2)
the denominator 5 and the numerator 12, will be
the fides of the right-angled triangle 5, 12, 13 ; and
fo of the reft. Here you may fee any odd number
may be one of the fides of a right-angled triangle
in whole numbers.

Inftead of the double arithmetical progreffion,
you may make ufe of this, $1\frac{7}{8}$, $2\frac{11}{12}$, $3\frac{15}{16}$, $4\frac{19}{18}$, $5\frac{23}{24}$,
&c. where the excefs is 4 in fractions, and 1 in
whole numbers, for if you reduce $1\frac{7}{8}$ to $\frac{15}{8}$, the
denominator 8, and the numerator 15, will be the
two fides of the right-angled triangle 8, 15, 17 ;
and in like manner if you reduce $2\frac{11}{12}$ to $\frac{35}{12}$, the de-
nominator 12 and the numerator 35 will be the

two

two fides of another triangle 12, 35, 37; and fo on. Here you fee any odd number may be one of the fides of a right-angled triangle in whole numbers.

In an arithmetical progreffion, the fum of the terms is equal to the fum of the two extremes, multiplied by half the number of all the terms. And for this reafon, in order *to find the fum of any number of terms in Arithmetical Progreffion,* for example, the fum of thefe eight, 3, 5, 7 9, 11, 13, 15, 17, you muft multiply the fum (20) of the two extremes (3, 17) by the number of the multitude of the terms (8) for then half the product (80 the half of 160) is the fum you inquire for.

If on the other hand you know the fum of the terms, the firft term itfelf, and the number or multitude of the terms, you may find out what the terms are, by tracing the excefs in this manner. Suppofe the given fum of the terms to be 80, the number of them 8, and the firft term given 3, divide (160) the double of the fum given (80) by the number given (8) then fubtract from 20 the quotient, 6 the double of the firft term given 3, and at laft divide the remainder 14 by the given number wanting 1, that is 7, and the quotient 2 is the excefs you look for, which added to the firft term gives you five for the fecond, and added to the fecond 7 for the third and fo on.

If the fum of the terms, their number, and the excefs be given, we find out the firft term, and by confequence all the reft after the manner of the third queftion enfuing.

Queftion I. *A gentleman bargains with a bricklayer to have a well funk upon thefe terms ; he is to allow him three livres for the firft toife (a toife is 6 foot) of depth, 5 for the fecond, 7 for the third, and fo on, rifing two livres every toife till the*

the well is twenty toifes deep. Query, how much will be due to the bricklayer, when he has digged twenty toifes deep?

To refolve this queftion, multiply the 2 livres augmentation money at every toife, by the number of the toifes, bating 1, that is by 19, to the product 38 add 6 the double of 3 the number of livres promifed for the firft toife, then multiply the fum 44 by half the number of all the toifes, *viz.* 10, and the product fhews you 444 livres due to the bricklayer for finking the well 20 toifes deep.

Queft. II. *A gentleman travelled* 100 *leagues in eight days, and every day travelled equally farther than the preceding day. Now it being difcovered that the firft day he travelled two leagues, the queftion is how many leagues he travelled on each of the other days.*

To refolve this queftion, divide 200, the double of the leagues given 100, by 8 the number of days given, and from the quotient 15, fubftract 4, the double of 2 the given number of leagues that he travelled the firft day. Divide the remainder 21 by 7, the given number of days wanting one, and the quotient 3 fhews that he travelled every day three leagues more than the day before, from whence it is eafy to conclude, that fince he traveled 2 leagues the firft day, he travelled 5 the fecond, 8 the third, and fo on.

Queft. III. *A traveller went* 100 *leagues in* 8 *days, and every day* 3 *leagues more than the preceding day. 'Tis asked how many ieagues he travelled a day?*

Divide 200, the double of the leagues given 100, by 8 the number of days given, and from the quotient 25 fubtract 21, the product of 3 the number of the daily increafe multiplied by 7 the given number

of

of days bating 1. The remainder being 4 half it, and that shews you he travelled 2 leagues the first day; from whence it is easy to gather that he travelled 5 the second, 8 the third, and so on.

Quest. IV. *A robber being pursued travelled 8 leagues a day; an Archer, who was the pursuer, made but 3 leagues the first day, 5 the second, 7 the third, and so on, increasing two leagues every day. The question is in how many days the archer will come up with the robber, and how many leagues they will have travelled.*

To resolve this and such like questions, add 2 the number of the daily increase of leagues by the archer, to 16 the double of 8 the number of leagues made every day by the robber: from the sum 18 subtract 6 the duplicate of 3 the number of leagues that the archer travelled the first day. The remainder 12, divide by 2 the number of the archer's daily increase; and the quotient 6 will shew you, that the archer will come up with the robber at the end of 6 days, and consequently both of them must by that time have travelled 48 leagues, for 6 times 8 is 48, and the same is the sum of these six terms of Arithmetical Progression, 3, 5, 7, 9, 11, 13.

Quest. V. *We will suppose, it is 100 leagues from Paris to Lions, and that two couriers set out at the same time, and took the same road; one to go from Paris to Lions, making every day 2 leagues more than the day before, and the other from Lions to Paris, travelling every day 3 leagues farther than the preceding day; and that they met exactly half way, the first at the end of 5 days, and the other at the end of 4 days. Query, how how many leagues these two couriers travelled each day?*

To find how many leagues the courier travelled every day that was 5 days upon the road before he met the other; subtract 5 the number of days from

25 the fquare of it, and having multiplied the re-
mainder 20 by 2 the number of the daily increafe of
leagues for this courier; fubtract the ptoduct 40
from 100, the number of leagues between Paris
and Lions; and divide the remainder 60 by 10 the
double of 5 the number of days; and the quotient
6 will fhew you, that the courier travelled 6 leagues
the firft day, and confequently 8 the fecond, 10 the
third, 12 the fourth and 14 the fifth.

In like manner with reference to the other courier,
that arrived halfway in 4 days, fubtract 4 the num-
ber of days from 16 its own fquare, and having
multiplied the remainder 12 by 3 the number of his
daily increafe of leagues, fubtract the product 36
from 100, the diftance of leagues from Paris to
Lions; and divide the remainder 64 by 8 the dou-
ble of 4 the number of days, and the quotient 8
will fhew you that this courier travelled 8 leagues
the firft day, and confequently 11 the fecond, 14
the third, and 17 the fourth.

Queft. VI. *There is a hundred apples and one
basket ranged in a ftrait line at the diftance of a
pace one from another; the queftion is, how many
paces muft he walk that pretends to gather the ap-
ples one after another, and fo put them into the baf-
ket, which is not to be moved from its place?*

It is certain, that for the firft apple he muft
make 2 paces, one to go, and another to return;
for the fecond 4, two to go and two to return; for
the third 6, three to go, and fo on in this arithme-
tical progreffion, 2, 4, 6, 8, 10, &c. of which the
laft and greateft term will be 200, that is, double
the number of apples. To 200 the laft term, add
2 the firft term, and multiply the fum 202 by 50,
which is half the number of apples, or the number
of the multitude of the terms; and the product
10100 will be the fum of all the terms, to the
number of paces demanded.

SPORT

SPORT XIII.

Of Geometrical Progreſſion.

BY Geometrical Progreſſion we underſtand a
ſeries of ſeveral quantities that grow or riſe
continually through the multiplication of one and
the ſame number, as 3, 6, 12, 24, 48, 96, &c.
where each term is the double of the precedent
term ; or, as 2, 6, 18, 54, 192, 486, &c. where
each term is the triple of its antecedent. And
ſo of others.

The principal property of Geometrical Progreſ-
ſion, is, that in three terms continually proportio-
nal, as 3, 6, 12, the product 36 of the two ex-
tremes, 3, 12, is equal to the ſquare of the middle
term 6 : and that in four terms in continual pro-
portion, as 3, 6, 12, 24, the product 72 of the
two extremes 3, 24, is the ſame with the product
of the two means 6, 12 : and in fine, that in a
greater number of terms in continual proportion,
as in theſe ſix, 3, 6, 12, 24, 48, 96, the product
288 of the two extremes 3, 96, is the ſame with
that of 12, 24, two equally remote from it. From
hence it is eaſy to conclude that when the number
of the terms is odd, this product is equal to the
ſquare of the mean, as in theſe five terms, 3, 6, 12,
24, 48 ; for 144 the product of the two extremes
3, 48, or of the two equally remote, 6, 24, is the
ſquare of the mean 12.

Thus you ſee that what arithmetical progreſſion
has by addition, geometrical progreſſion has it by
multiplication. But there is another conſiderable
difference between theſe two progreſſions, conſiſting
in this ; that in arithmetical progreſſion the diffe-
rences of the terms are equal, and in geometrical
progreſſion they are always unequal, and keep up
among themſelves the ſame geometrical progreſſion,

by

by continuing *in infinitum*, the differences of differences, without ever coming to equal differences. Accordingly we fee in this geometrical progreſſion 2, 6, 18, 54, 162, 486, the differences of the terms make juſt ſuch another geometrical progreſſion 4, 12, 36, 108, 324; and in this laſt progreſſion the differences of the terms make again the like geometrical progreſſion, 8, 24, 72, 216, and ſo on.

In three proportional terms, ſuch as 2, 6, 18, the cube 216 of the mean 6, is equal to the ſolid product of the three terms multiplied together: and in four numbers in continued proportion, ſuch as 2, 6, 18, 54, the cube 216 of the ſecond 6, is equal to the ſolid product ariſing from the multiplication of 54, the fourth term, by the ſquare of the firſt 2; and in like manner 5832 the cube of the third term 18, is equal to the ſolid product of the firſt term 2 multiplied by 2916 the ſquare of the fourth 54.

From what has been ſaid it is eaſy *to find a geometrical mean proportional between two numbers given*, by multiplying the one number by the other, and extracting the ſquare root for the mean proportional: and it is equally eaſy *to find two means in continued geometrical proportion to two numbers given*, as 2 and 54; by multiplying the laſt 54 by the ſquare of the firſt, and extracting the cube root (6) of the product (216) for the firſt mean proportional, which multiplied by the ſecond number 54, makes 324, and 18 the ſquare root of that product is the ſecond mean proportional.

But *to find an arithmetical mean proportional to two numbers given*, take half the ſum of the two numbers for the mean required; as in 2, 8 given, 5 the half of 10 is the mean: and *to find two arithmetical means in continued proportion* as between 2 and 11, we ſubtract the leaſt number 2 from the greateſt

greateſt 11, and add 3 a third part of the remainder 9, to the leaſt number 2, which gives us 5 for the firſt mean; as the addition of 6, the double of that third part, to the ſame leaſt number 2, does 8 for the ſecond. Or, if you will, you may add 4, the double of the leaſt 2, to 11 the greateſt, and reciprocally 22, the double of 11 the greateſt, to 2 the leaſt, and the thirds of the two ſums make 5 and 8 for the two means demanded.

It is evident that all the powers of the ſame number, as 2, riſing in order, make a geometrical progreſſion, ſuch as this, where you ſee the exponents of the powers

$$(1) \quad (2) \quad (4) \quad (8)$$
$$2, \quad 4, \quad 8, \quad 16, \quad 32, \quad 64, \quad 128, \quad 256, \quad \&c.$$
$$\frac{1}{3} \quad \frac{1}{5} \qquad \frac{1}{17} \qquad\qquad \frac{1}{257}$$

(1) (2) (4) (8) are the terms of a geometrical proportion, viz. 2, 4, 16, 256, &c. and all the powers are ſuch that if you add an unite to each of them, the ſums 3, 5, 17, 257, &c. are prime number: and ſo it is eaſy to find a prime number greater than any number given.

If you continue a geometrical progreſſion upon the decreaſe in infinitum as 6, 2, $\frac{2}{3}$, $\frac{2}{9}$, $\frac{2}{27}$, &c. the difference 4 of the two firſt terms 6, and 2 is to the firſt 6, as the ſame number 6 is to the ſum of all the infinite terms. And therefore, *to find the ſum of all the infinite terms of a decreaſing geometrical proportion*, as that above, you muſt divide 36 the ſquare of the firſt term 6, by 4 the difference of the two firſt terms, and the quotient 9 is the ſum you want. If you take from this quotient, 8 the ſum of the two firſt terms 6 and 2, the remainder 1 is the ſum of the infinite fractions continually proportional, $\frac{2}{3}$, $\frac{2}{9}$, $\frac{2}{27}$, &c. And by the ſame means we

are

are taught that the fum of other infinite fractions in continued proportion, amounts likewife to 1. This rule gives tne folution to the following quefti- on: but before I propofe it, I muft acquaint you, that,

When we fpeak of quantities in proportion, with- out fpecifying, we always mean geometrical pro- portion. Here I muft obferve by the by, that taking an unit for numerator, and the natural num- bers, 1, 2, 3. 4, 5, &c. for denominators, if you make the following feries of fractions, $\frac{1}{1} \frac{1}{2} \frac{1}{3} \frac{1}{4} \frac{1}{5}$, &c. which ftill decreafe, thefe three taken confecutively from three to three at pleafure, will be in harmonic proportion; that is, the firft of the three will be to the third, as the difference of the two firft is to the difference of the two laft; as will better appear by reducing thefe fractions to the fame de- nomination, or to integers, by multiplying them by the number 60, which is divifible by all the denominators 2, 3, 4, 5, for inftead of the five fractions you have the five whole numbers, 60, 30, 20, 15, 12; of which the three firft 60, 20, 20, are fairly in harmonic proportion for the firft 60 is to the third 20 which is its third part, as 30 the difference of the two firft is to 10 the difference of the two laft, which is likewife the third part of 30. By the fame confideration you will perceive that thefe three, 20, 20, 15 are in harmonic pro- proportion as well as the other three 20, 15, 12.

Queft. *A great ſhip purſues a little one, ſteer- ing the ſame way, at the diſtance of four leagues from it, and ſails twice as faſt as the ſmall ſhip. It is asked how far the great ſhip muſt ſail before it overtakes the leſſer.*

The diftance of the two fhips being 4, and their celerities being in a double Ratio, continue *in infi- nitum,* the double geometrical progreffion, 4, 2, 1,

1, $\frac{1}{2}$ $\frac{1}{4}$ $\frac{1}{8}$, &c. the firft and the greateft term of which is 4; and find the fum of all the infinite terms, by dividing 16 the fquare of the firft 4, by 2 the difference of the two firft, and the quotient 8 directs that the great fhip muft make 8 leagues before fhe can come up with the other.

SPORT XIV.

Of Magical Squares.

BY a Magical Square we underftand a fquare divided into feveral other fmall equal fquares, filled with terms of an arithmetical progreffion, fo tranfpofed, that all of the fame line or rank, whether londitudinal, tranfverfe, or diagonal, make the fame fum.

This is the fquare here annexed, divided into 25 little boxes or fquares in which the firft 25 natural numbers are fo tranfpofed, that the fum of each rank from above downward, or from the right to the left, or along the diagonals or diameters of the fquares, is every way 65; which fum 65 is in all an odd fquare number, that is, it contains an odd fquare number of places, viz.

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

25, and is equal to the product arifing from 5, the root of the fquare number 25; multiplied by 13 the middle term of the arithmetical progreffion, 1, 2, 3, 4, &c.

This

This sum is likewise found, by difpofing the given terms of the arithmetical progreffion, according to their natural feries, 1, 2, 3, 4, &c. in the fquare places, as you fee here; for then the fum of each diagonal rank, that is the rank extending from one corner of the fquare to the other, is the fum demanded. This will likewife hold in even fquares, or thofe which contain an even fquare number of boxes.

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

In order to difpofe magically in the boxes of an odd fquare: for inftance, that of 25 boxes, having 5 for its fide; to difpofe, I fay, as many given numbers in arithmetical progreffion, as 1, 2, 3, 4, 5, and fo on till you come to the laft, and greateft 25; write the firft and the leaft immediately under the middle box, or that which poffeffes the center of the fquare; and moving diagonal wife to the right, write the fecond term 2 in the adjacent box, the lowermoft of the next right hand rank. Here proceeding in the courfe of the diagonal from left to right you find no place for number 3, and fo are to place it in the oppofite or uppermoft box of the rank into which it fhould have fallen. In like mannner, finding no place for 4, you are to place it in the oppofite box of the rank that it falls to on the outfide

Thus

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

. Thus you continue proceeding ſtill diagonal-wiſe to the right; but in regard 6 falls to a place that is already filled with 1, you muſt there take a re-trogade diagonal courſe from the right to the left, and write 6 in the lowermoſt ſtation of the rank in which the foregoing term 5 was placed, and ſo there will remain an empty place between 5 and 6. This retrogade courſe muſt always be obſerved when you fall in with a ſtation already poſſeſſed. Con-tinue to place the reſt in order, according to theſe rules till you come to the angle of the ſquare, where in this example ſtands 15 : then, foraſmuch as you can no longer move diagonal-wiſe to the right, you muſt place the term 16 in the ſecond place (from the top) of the ſame rank ; this done, the reſt may be placed as the former, without any difficulty.

There are ſeveral magical diſpoſitions both for odd and even ſquares; but theſe being difficult to underſtand, we reckon them improper for Arithme-tical Recreations.

This ſquare was called Magical, from its being in great veneration among the Egyptians, and the

Pythagoreans

Pythagoreans their difciples, who to add more effi-
cacy and virtue to this fquare, dedicated it! to the
feven planets divers ways, and engraved it upon a
plate of the metal that fympathized with the pla-
net. The fquare thus dedicated, was inclofed with
a regular Polygon, infcribed in a circle divided
into as many equal parts as there were units in the
fide of the fquare ; with the names of the angels of
the planet, and the figns of the zodiac written upon
the void fpaces between the Polygon and the cir-
cumference of the circle-circumfcribed. Through
vain fuperftition they believed that fuch a medal or
Talifman would befriend the perfon that carried it
about him upon occafion.

They attributed to Saturn the fquare of 9 places
or boxes, 3 being the fide, and 15 the fum of
numbers in each row or column ; to Jupiter the
fquare of 16 places, 4 being the fide, and 34 the
fum of the numbers in each row ; to Mars the
fquare with 25, 5 being the fide, and 65 the fum
of numbers in each rank ; to the Sun the fquare
with 36, 6 being the fide, and 111 the fum of each
row ; to Venus that of 49, 7 being the fide, and
175 the fum of numbers in each rank or column ;
to Mercury that of 64, 8 being the fide, and 260
the fum of each column ; to the Moon the fquare
with 81 lodges, having 9 for its fide, and 369 for
the fum of each column.

In fine, they attributed to imperfect matter, the
fquare with 4 divifions, having 2 for the fide ; and
to God the fquare of only 1 lodge, the fide of
which is an unit, which multiplied by itfelf, un-
dergoes no change. By virtue of this Sport, we
are taught to refolve the following Queftion.

Queftion. *To draw up in three ranks the nine
firft cards, from an ace to a nine, in fuch a manner
that all the points of each rank, taken either length-
wife or breadthwife, or diagonal wife, may make
the fame fum.* E. Difpofe

Difpofe the nine firft natural numbers, 1, 2, 3, 4, 5, 6, 7, 8, 9, magically according to the directions laid down above, and as you fee it done here, and place the cards according to their number, anfwerable to thefe figures.

Inftead of an arithmetical progreffion, you may take a geometrical; for inftance, this double progreffion, 1, 2, 4, 8, 16, 32, 64, 128, 256, &c. and placing them magically, as above, you will find the product of each rank will be equal, viz. 4096, which is juft the cube of the middle term 16.

Here we fhall add by the by, one fquare more of 9 ftations, in which the numbers of each rank taken any way, as above, are in harmonical proportion; and you may find as many other numbers of the fame quality, as you will, if inftead of the foregoing numbers you put letters, as you fee it done underneath, where the literal magnitudes of each rank are harmonically proportional; and fo by giving different value to the three undetermined letters, a, b, c, you will have inftead of literal quantities, numbers that will always preferve an harmonic proportion in each rank.

$$a \qquad \frac{2ac}{a+c} \qquad c$$

$$\frac{2ab}{a+b} \qquad \frac{2bc}{b+c} \qquad \frac{2abc}{2ab+ab-ba}$$

$$b \qquad \frac{2abc}{2ac+ab-bc} \qquad \frac{abc}{ab+ac-bc}$$

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

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

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

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

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

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

SPORT

SPORT XIV.

Of an Arithmetical Triangle.

BY an Arithmetical Trangle we mean the half of a square like a magical square, divided into several small and equal stations or points, which contain the natural numbers 1, 2, 3, 4, &c. the triangular numbers 1, 3, 6, 10, &c. which are formed by the continual addition of the foregoing numbers: the Pyramidal numbers 1, 4, 10, 20, &c. formed by the contitual addition of the triangular; the Pyramido-Pyramidals 1, 5, 15, 35, &c. formed by the continual addition of the Pyramidal; and so on, as you see in the following cut.

1	1	1	1	1	1	1	1	1
1	2	3	4	5	6	7	8	
1	3	6	10	15	21	28		
1	4	10	20	35	56			
1	5	15	35	70				
1	6	21	56					
1	7	28						
1	8							
1								

Among

Among the different ufes of the arithmetical tri-
angle, I fhall only fingle out thofe relating to Cmo-
binations, Permutations, and the Rules of Game;
the reft being too fpeculative for Arithmetical Re-
creations.

By Combinations we underftand all the different
choices that can be made of feveral things; the
multitude of which is known, by taking them di-
vers ways, one by one, and two, three and three,
&c. without ever taking the fame twice.

For Example, If you have four things exprefs'd
by thefe four letters, *a*, *b*, *c*, *d*; all the different
ways of joining two of them, as *ab*, *ac*, *ad*, *bc*, *bd*,
cd; or three of them, as *abc*, *abd*, *acd*, *bcd*; thefe
I fay, are called Combinations. And from hence
it is eafy to apprehend, that when four things are
propofed, you may take them one by one four ways;
two and two fix ways; three and three four ways:
and by fours only one way; fo that 1 in 4 combines
four times; 2 fix times; 3 four times; and 4 only
once.

To find in a greater number of different things,
fuch as feven; the divers combinations that may be
made by taking them divers ways, whether by
Addition or Multiplication: as, if you would
know all the poffible conjunctions of the feven pla-
nets, taking them two by two; that is to fay, if
you would know how often 2 combines in 7; add
an unite to each of the two numbers given, 2, 7,
and fo you have 3, 8, which gives us to know, that
in the third ftation (reckoning from below upwards,
or from above downwards) of the eighth diagonal
of the arithmetical triangle, you'll have the num-
ber of combinations demanded, *viz.* 21.

Or elfe, the two numbers given being 2 and 7,
add together all the numbers of the fecond rank,

till

till you come at the feventh diagonal, *viz.* 1, 2, 3, 4, 5, 6, and the fum 21 is what you want.

When the number of things propofed goes beyond 9, the triangle here delineated can't ferve you; and therefore we fhall give this general rule for any number whatfoever.

The two numbers given being 2 and 7, to know how often 2 the leaft will combine in 7 the greateft; make of them thefe two arithmetical progreffions 2, 1, and 7, 6, which decreafe by an unit, and ought to have but two terms, that is, as many as the leaft number 2 has units. Then multiply together all the terms of each progreffion, that is, 7 by 6, and 2 by 1 ; and divide the firft product 42 by the fecond 2, and the quotient 21 fatisfies the demand.

By this, or the foregoing method, you'll difcover that three combines in 7, 35 times ; 4 likewife 35 times ; 5, 22 times; and 6 only 7 times. Whence it follows, that the number of all the combinations poffible of feven different things, taken 1 by one, by two's, by threes, by fours, by fives, by fixes, and fevens, amounts to 127, as appears by the addition of all the particular combinations, 7, 21, 35, 35, 21, 7, 1, which anfwer the numbers, 1, 2, 3, 4, 5, 6, 7. But you may find this total yet eafier, by forming this double geomitrical progreffion, 1, 2, 4, 8, 16, 32, 64, confifting of feven terms, anfwerable to the number of things combined, *viz.* 7; for the fum of thefe terms, 127, is the number you look for; which may ftill be found yet an eafier way, *viz.* Subtract 1 from the propofed number of things 7, and the remainder, 6, directs you to take the fixth power (64) of the number 2; and the double of that power, bating an unit, 127, is the number defired.

Before I difmifs this fubject, I fhall here fet down two methods peculiar to two and 3, for finding out how

how often thefe two numbers may be combined in any number of things. Suppofe the number of things given is 7, you'll find how often 2 will combine in it, by fubtracting the given number 7 from its fquare 49; and taking (21) the half of the remainder, 42, for the number defired. You'll find how often 3 may combine in 7, by adding 14, the double of 7 to 343, the cube of the fame giving number 7, and fubtracting from the fum (357) the triple (147) of the fquare (49) of the fame number (7) for then the fixth part (35) of the remaininder (210) fhews you, that three will combine in 7 35 times.

There is another fort of combinations, that may be called Permutation, in which we take the fame thing twice; as if you would combine thefe three numbers by two's, 2, 5, 6, in order to know what different quantities they can produce, if you confider the two firft thus, 25, you'll call them twenty five; if thus, 52, you will call them fifty two; in like manner, the firft and third taken thus, 26, is a quite different quantity from the fame two taken thus, 62; and fo of all others. From whence it appears, that the multitude or number of permuta- tions is the double of that of combinations.

Permutations are of very good ufe in making ana- grams, and fometimes give very lucky hints; as in the word *R O MA*, the letters of which being tranf- pofed make this other word *A M O R*; but it is a much luckier hit that we meet with in thefe two Latin verfes;

Signa te, figna, temere me tangis & angis,
Roma tibi fubito motibus ibit amor.

the letters of which being read backwards, form the fame verfes.

We likewife make ufe of Permutations in playing at dice, to know the number of chances that attend

the

the engaging to throw with two dice, 9 for inftance ; it being certain that the perfon who engages has four chances for it ; for 9 may come up four ways, by *quatre cinque*, by *cinque quatre*, by *tres fix*, and again by *fix tres* (according as the firft or fecond dye happens to appear.)

To give the joynt combinations of feveral letters; for example thefe four *A M O R*, that is to find the number of their fimple permutations, by tranfpofing them all poffible ways ; make this arithmetical progreffion, confifting of as many terms as there are letters to combine together, which in this example are four ; fo that the firft term is always an unit, and the laft denotes the number of letters; then multiply together all the terms, and the product 24 is the number of permutations or different changes that thefe four letters *A M O R* can undergo, as you fee here;

A M O R	M A R O	O A M R	R O M A
A M R O	M A O R	O A R M	R O A M
A O M R	M O A R	O M A R	R M A O
A O R M	M O R A	O M R A	R M O A
A R M O	M R A O	O R A M	R A M O
A R O M	M R O A	O R M A	R A O M

By the fame way do we find the number of Permutations of any other number of letters, *viz.* By making a progreffion of as many natural numbers as there are letters to combine, and multiplying together all the terms of the progreffion. Thus you'll find that five letters may be tranfpofed 120 ways; fix 720 ; and fo on as in the following table, where you fee the 23 letters of the alphabet may be combined 25852016738884976640000 ways,

1 | 1. A.

1	1. A.
2	2. B.
3	6. C.
4	24. D.
5	120. E.
6	720. F.
7	5040. G.
8	40320. H.
9	362880. I.
10	3628800. K.
11	39916800. L.
12	479001600. M.
13	6227020800. N.
14	87178291200. O.
15	1307674368000. P.
16	20922789888000. Q.
17	355687428096000. R.
18	6402373705728000. S.
19	121645100408832000. T.
20	2432902008176640000. V.
21	51090942171709440000. X.
22	1124000727777607680000. Y.
23	25852016738884976640000. Z.
24	620448401733239439360000.
25	15511210043330985984000000.

This table is eafily calculated ; for having dif-
covered that four letters, for example, may be
combined or tranfposed 24 ways ; for if you mul-
tiply 24, the number of combinations, by 5 the
next number, you have 120 for the combinations
of five letters ; and that multiplied by the next
number 6, makes 720 for the combinations of fix
letters ; and fo on through all the fucceeding let-
ters.

By Parti, in the way of gaming, we underftand
the juft diftribution or adjuftment of what money

out

out of the ſtakes belonging to ſeveral players, who
play for it ſo many games, or a certain number of
parts or ſets, in proportion to what every one has
ground to hope from fortune, upon the ſets he
wants to be up.

For example, If two gameſters have ſtaked down
forty piſtols, which is then no longer their pro-
perty only by way of retalliation, they have a right
to what chance may bring them, upon the condi-
tions ſtipulated at the firſt agreement ; ſuppoſe they
were to play for theſe 80 piſtols three ſets, that
the firſt had gained one ſet, and the ſecond none ;
that is, the firſt wants two ſets to be out and the ſe-
cond three ; theſe ſuppoſitions being laid down,
and the gameſters having a mind to draw their
ſtakes, without ſtanding to their chances, the juſt
Quota appertaining to each, is what is called Parti,
and is found out by the arithmetical triangle, after
this manner :

Since the ſuppoſition runs, that the firſt gameſter
wants 2 ſets, and the other 3, and the ſum of the
two numbers 2 and 3 is 5 ; we muſt turn to the
fifth diagonal of the arithmetical triangle, and there
take five the ſum of the two firſt numbers 1, 4, by
reaſon of the two ſets that the firſt gameſter is
ſhort ; and 11 the ſum of the other three, 6, 4, 1,
by reaſon of the three ſets that the ſecond game-
ſter is ſhort : and theſe two ſums 5 and 11 give
the reciprocal Ratio of the two Parti's inquired for ;
ſo that the Parti or Quota of the one or firſt is to
that of the ſecond, as 11 to 5.

But to adjuſt theſe Quota's, that is, to aſſign each
gameſter his poſſitive ſhare of the 80 piſtoles at
ſtake, this number 80 muſt be divided into two
parts proportional to the two terms 11, 5 ; and this
is done by multiplying 80 by the two ſums 11, 5,

ſeparately

separately, and dividing each of the two products, (880, 400.) by 16, the sum of the two terms 11, 5 ; by which means you have 55 for the number of piftoles due to the firft gamefter that gained a fet ; and 25 for the other that gained none.

In like manner, if the firft wants but 1 fet to be out, and the fecond 2, we add together thefe two numbers 1, 2, and their fum being 3, turn to the third diagonal of the arithmetical triangle, and there take the firft number 1, and the fum 3 of the two others 2, 1 ; from thefe two numbers 1, 3, we learn that the firft his Quota is to that of the fecond as 3 to 1 ; and fince the fum of thefe two terms is 4, the confequence is, that the firft game-fter ought to have $\frac{3}{4}$ of the 80 piftoles ftaked, and the fecond only $\frac{1}{4}$, that is, the firft 60 piftoles, and the other 20.

Hence it appears, that when the game is at this pafs, the firft may lay upon the fquare 3 to 1 : and this we can likewife make out without the arith-metical triangle, after the following manner.

Since the firft wants one fet to be out, and the fecond two, we muft confider, that if they went on with the game, and the fecond gained a fet, then the two gamefters would have equal chances, and fo their quota's or dividends would be equal, it being a conftant and a general rule, that the one fhare of the firft is to that of the fecond, as the chances of the one are to thofe of the other. And fo in this fuppofition, each of them has a title to an equal half of the money. 'Tis therefore certain, that if the firft gains the fet that is to be played, he fweeps all ; but if he lofes it, he has a title to an equal half : and therefore if they have a mind to draw without playing the fet, the firft ought to have half the money at ftake, and the half of the remain-

ing

ing half, that is $\frac{3}{4}$ of the whole; so that $\frac{1}{4}$ remains
to the second, for 'tis evident, that if a gamester has
a right to a certain sum, in case he gains, and to a
lesser in case he loses, he has a right to the half of
those two taken together, if the game is thrown
up.

This first case directs us to the solution of the
second, which supposes the first to want one set to
be out, and the second three; for if the first gains
the set, he sweeps all the 80 pistoles; if he loses, i
turns to the first case, as above, that is, he has a
right only to $\frac{3}{4}$; and therefore, if the stakes are
drawn without playing that set, his right is half of
these two sums taken together, i. e. $\frac{7}{8}$ or 70 pistols
$\frac{1}{8}$ or 10 pistoles remaining to the second.

This leads us to a resolution of a third case. Sup
posing the first to be too sets short, and the second
three; for if the first gains the next set, he has a
right to $\frac{7}{8}$ of the money, by the second case; if he
loses it, so that the second wants only two to be
out, as well as he, the money is to be equally di
vided between them. Upon the whole, the game
stands thus; if the first wins, he claims $\frac{7}{8}$, if he
loses, he claims $\frac{1}{2}$; and therefore, if the game i
thrown up without playing this set, he claims the
half of these two sums put together, i. e. $\frac{11}{16}$ or 5
pistoles, leaving $\frac{5}{16}$ or 25 to the second.

The second case leads us likewise to the solution o
a fourth case, in which the first is supposed to be
one set short of the whole, and the second four
for if the first gains a set, he carries the 80 pistoles
if he loses it, so that the second lacks only three
to be out, he claims $\frac{7}{8}$ by the second case. Now
since, in case of winning, he takes 80 pistoles
and in case of losing $\frac{7}{8}$ of them, his dividend, upon
throwing up, is the half these two sums put toge
ther

her, that is, $\frac{15}{16}$, or 75 piftoles, and fo he leaves
$\frac{1}{16}$, or 5 piftoles for the fecond.

The fourth and third cafes lead us after the fame manner, to the folution of a fifth, which fuppofes that the firft gamefter is two fets fhort, and the fecond four ; for if the firft gains a fet, and fo lacks but one to be out, he claims $\frac{15}{16}$, by the fourth cafe ; and if he lofes it, fo that the feconds wants but three, he claims $\frac{11}{16 2}$ by the third ; and confequenily, in cafe of drawing, his due is the half of hefe two fums put together, that is, $\frac{13}{16}$, or 65 piftoles, $\frac{3}{16}$, or 15 piftoles being left for the fecond. And fo of the other cafes.

All thefe, and an infinite number of other cafes hat may happen, are folvable without the arithnetical triangle, after a different and an eafy manner, as follows ;

Take the fifth cafe for inftance, which fuppofes he firft to be two fets fhort, and the fecond four ; in this fuppofition the two gamefters want between them fix fets to be out : Take 1 off the 6, and fince the remainder is 5, fuppofe thefe five letters of the fame form *a a a a a*, to favour the firft gamefter; and thefe five *b b b b b*, to favour the fecond; make combinations of thefe ten letters, as you fee it here done; where of 32 combinations, the firft 26 to the left, having at leaft two *a*, are taken for the number of chances that can make the firft to win ; becaufe he lacks two fets ; and the remaining 6 to the right, or where there are at leaft four *b*, are taken for the number of chances upon which the fecond may win ; becaufe he wants four to be out,

aaaaa

aaaaa	*aaabb*	*aabbb*	*abbbb*
aaaab	*aabba*	*abbba*	*bbbba*
aaaba	*abbaa*	*bbbaa*	*babbb*
aabaa	*bbaaa*	*ababb*	*bbabb*
abaaa	*aabab*	*abbab*	*bbbab*
baaaa	*abaab*	*ababb*	*bbbbb*
	baaab	*baabb*	
	baaba	*babba*	
	babaa	*bbaba*	
	ababa	*babab*	

Thus it is plain, that the firſt his due is to that of the ſecond as 26 to 6, or, as 13 to 3.

In like manner to ſolve the third caſe, which ſuppoſes the firſt to want two ſets to be up, and the ſecond three, ſo that they want five between them; take 1 from the ſaid ſum 5, and ſince the remainder is 4, ſuppoſe theſe ſimilar letters *a a a a* to be favourable to the firſt, and theſe four *b b b b* to the ſecond, and combine theſe eight letters together, as you ſee it here done; where, of the 16 combinations, the firſt 11 to the left having at leaſt two *a*'s, muſt repreſent the number of chances that the firſt has for game, two ſets being what he wants; and

aaaa	*aabb*	*abbb*
aaab	*abba*	*bbba*
aaba	*bbaa*	*bbab*
abaa	*baab*	*babb*
baaa	*baba*	*bbbb*
	abab	

the remaining 5 to the right having at leaſt three *b*'s, muſt be taken for the number of chances that can make the ſecond up, he being three ſets ſhort. Thus the claim of the firſt is to that of the ſecond as 11 to 5, &c.

The ſame 16 combinations will ſerve for the ſolution of the fourth caſe, in which the firſt was ſuppoſed to be one ſet ſhort, and the ſecond four; ſo that five is the number of ſets wanted between them

hem, as in the third cafe. For among thefe 16
ou will find 15 that have at leaft one *a*, (anfwer-
ble to the one fet that the firft wants) for the chan-
es upon which the firft will win ; and only one
hat has four *b*'s, the fecond being four fets fhort,
vhich fhews there is but one chance that can fave
he fecond. Thus the firft fhare is to that of the
fecond, as 15 to 1. And fo of all other cafes.

To know, when two are at play, what advan-
tage one has, that engages to throw 6, for exam-
ple, with one dye at a certain nnmber of throws,
and firft of all, at the firft throw ; we muft
confider that his cafe is 1 to five ; for he has but
one chance to win, and 5 to lofe upon ; and con-
fequently if he lays upon one throw, he ought to
lay but one to 5.

To engage to throw 6 with one dye at two
throws, is the fame thing, as to throw two dyes
at a time, one of which is to be a 6 ; and in that
cafe, he who throws has but 11 chances to win
upon, fince he may throw the firft 6, and the fecond
1, 2, 3, 4, or 5 ; or the fecond 6, and the firft 1,
2, 3, 4, or 5 ; or elfe both dyes fixes ; whereas he
has 25 to lofe

upon, as you fee

here. Where it										
1.	1	2.	1	3.	1	4.	1	5.	1
1.	2	2.	2	3.	2	4.	2	5.	2
1.	3	2.	3	3.	3	4.	3	5.	3
1.	4	2.	4	3.	4	4.	4	5.	4
1.	5	2.	5	3.	5	4.	5	5.	5

upon, as you fee
here. Where it
is eafy to con-
clude, that he
who offers to
throw with one
dye at two throws, ought to fet but 11 to 25.

When you lay upon 6 at two throws, take no-
tice that 36, the fum of all the chances, 11, 25, is
the fquare of the given number 6 ; and that 25, the
number of chances againft him who throws, is the
fquare of the fame number, wanting 1, that is, 5.
And therefore to find the number of chances that

favour

favour him who is to throw, you need only take
1 from 12, the double of the number given, and
the remainder 11 is the number required; which
being subtracted from 36, the square of the former
number 6, leaves 25 the remainder, which will al-
ways be a square number, and denote the chances
against him.

To lay upon 6 at three throws with one dye, is
the same as to lay upon 6 at one throw with three
dice; and in that case, he who throws has 91
favourable chances, and 125 against him, and so
ought to set but 91 to 125; thus you see he is at a
loss who lays upon the square for 6 at three throws
of one dye.

Take notice that the sum 216 of all the chances
91, 125, is the cube of the given number 6, when
you engage to throw 6 at three throws with one
dye; and that 125, the number of the chances
against you is the cube of the same number given,
less 1, i. e. 5. And therefore, to find the number
of chances that favour the person that throws, you
need only to subtract 125, the cube of the given
number 6, wanting 1 (i. e. 5) from 216 the cube of
the same number given.

By the same method we find out what advantage
he has who proffers to throw 6 with one dye at
four throws; for if we subtract from the fourth
power or biquadrate 1296 of the given number 6,
if we subtract, I say, from that, 625 the biquadrate
of the same number, less one, or of 5, the remainder
shews us 671 favourable chances for him that throws;
the biquadrate 625 being the number of the chances
against him: So that he who lays upon 6 at four
throws has the odds on his side.

But he has a much greater advantage upon 6 at
five throws with one dye, as appears by subtracting
3125, the fifth power of 5 (the given number,

bating

bating 1) from 7776, the fifth power of the given number 6; for the remainder 4651, is the number of the favourable chances, and 3125, the fifth power subtracted, is the number of thofe againft him who throws.

If you want to know what advantage he has, who offers with two or feveral dice, to throw at one throw a determined raffle; for example two *tres*; you muft confider, that with two dice he has but one chance to fave him, and 35 to loofe upon, fince two dice can combine 36 different ways, that is, their 6 faces may have 36 different poftures, as you fee by this fcheme;

I	I	2	I	3	I	4	I	5	I	6	I
I	2	2	2	3	2	4	2	5	2	6	2
I	3	2	3	3	3	4	3	5	3	6	3
I	4	2	4	3	4	4	4	5	4	6	4
I	5	2	5	3	5	4	5	5	5	6	5
I	6	2	6	3	6	4	6	5	6	6	6

This number 36, is the fquare of 6, the number of faces, there being but two dice; but if there were three, the cube of 6, 216, would be the number of combinations: and if there were four, the biquadrate of 6, 1296 would be the number. And fo on.

From what has been faid it is evident, that in engaging a determined raffle at one throw with two dice, one ought to lay but 1 to 35; and by a parity of reafon, that he ought to lay 3 to 213 upon a determined raffle or pair-royal with three dice; and 6 to 1290 with four; for of the 216 chances of three dice, there's only three that can favour him, fince three things can combine by two's only 3 ways; and of 1296 chances of four dice, only 6 can favour the thrower, fince four things combine by two's 6 ways.

F

But

But if you want to know what odds he lies under who proffers to throw a raffle of one fort or t'other at the firft throw of two or more dice; you may find without difficulty, that he ought to fet but 6 to 30, or 1 to 5 upon two dice, fince of the 36 chances of two dice, there is only 6 that can make a raffle; and that upon three dice, his cafe is 18 to 198, or 1 to 11, fince of the 216 chances, that three dice can fall upon only 18 can produce a raffle.

SPORT XV.

Several dice being thrown, to find the number of points that arife from them, after fome operations.

SUPPOSE three dice thrown upon a table, which we fhall call A, B, C, bid the perfon that threw them add together all the uppermoft points, and likewife thofe underneath of any two of the three: for inftance, B and C, A being fet apart, without altering its face. Then bid him throw again the fame two dice, B and C, and make him add to the foregoing fum all the points of the upper faces, and withal the lowermoft points, or thofe underneath of one of them, C for inftance, B being fet apart near A without changing its face, for giving a fecond fum. In fine, order him once more to throw the laft dye C, and bid him add to the foregoing fecond fum the upper points, for a third fum, which is thus to be difcovered. After the third dye C is fet by the other two, without changing its pofture, do you come up, and compute all the points upon the faces of the three dice, and add to their fum as many 7's as there are dice, that is, in this example 21, and the fum of thefe is what you look for; for when a dye is well made 7 is rhe number of the points of the oppofite faces.

To

To exemplify the matter: Suppose the firft thrown of the three dice, A, B, C, brought up 1, 4, 5; fetting the firft 1 apart, we add to thefe three points 1, 4, 5, the points 3 and 2 that are found under or oppofite to the upper points 4 and 5 of the other two dice; and this gives me the firft fum 15. Now fuppofe again that the two laft dice are thrown, and fhew uppermoft the two points 3 and 6, we fet that with the three points apart, near the die that had 1 before, and add to the foregoing fum (15) thefe two points 3 and 6, and withal 1 the point that is found lowermoft in the die that is ftill kept in fervice, and had 6 for its face at this throw; thus we have 25 for the fecond fum. We fuppofe at laft, that this third and laft die being thrown a third time, it comes up 6, which we add to the fecond fum 25, and fo make the third fum 31. And this fum is to be found out by adding 21 to 10 the fum of the points 1, 3, 6, that appear upon the faces or uppermoft fides of the three dice then fet by.

SPORT XVI.

Two dice being thrown, to find the upper points of each die without feeing them.

MAKE any one throw two dice upon a table, and add 5 to the double of the upper points of one of them, and add to the fum multiplied by 5, the number of the uppermoft points of the other or the fecond die; after that, having afked him the joint fum, throw out of it 25, the fquare of the number 5 that you gave to him, and the remainder will be a number confifting of two figures; the firft of which to the left reprefenting the tens, is the number of the upper points of the firft dye, and

the fecond figure to the right reprefenting units, is the number of the upper points of the fecond die.

We will fuppofe that the number of the points of the firft die that comes up is 2, and that of the fecond 3 ; we add 5 to 4, the double of the points of the firft, and multiply the fum 9 by the fame number 5, the product of which opperation is 45, to which we add 3, the number of the upper points of the fecond die, and fo make it 48, then we throw out of it 25, the fquare of the fame number 5, and the remainder is 23, the firft figure of which 2 reprefents the number of points of the firft die, and the fecond 3 the number of points of the fecond die.

Another way of anfwering this Sport is this ; afk him who threw the dice, what the points underneath make together, and how much the under points of one furpafs thofe of the other ; and if this excefs is, for example, 1, and the fum of all the lower points is 9, add thefe two numbers 1 and 9, and fubtract the fum 10 from 14 ; then take 2, the half of the remainder 4, for the number of the upper points of one of the dice ; and as for the other die, inftead of adding the excefs 1, to the fum 9, fubtract it out of 9, and take the remainder 8 out of 14, 6 is the remainder, the half of which, 3, is the number of the upper points of the fecond die.

A third way is this : bid the perfon who threw the dice, add together the upper points, and tell you their fum, which we here fuppofe to be 5 ; then give him orders to multiply the number of the upper points of one die by the number of upper points of the other die, and to acquaint you in like manner with their product, which we here fuppofe to be 6 : now having this product 6, and the preceding fum 5, fquare 5, and from its fquare 25 fubtract 24, the quadruple of the product 6, and the remainder is 1 : then take the fquare root of

the

the remainder, which in its cafe is 1, and by ad-
ding it to, and fubftracting it from the foregoing
fum 5, you have thefe two numbers 6, 4, the halfs
of which, 3, 2, are the numbers of the upper points
of each die.

SPORT XVII.

*Upon the throw of three dice, to find the upper
points of each die, without feeing them.*

ORDER the perfon that has thrown the dice,
to place them near one another in a ftraight
line, and afk him the fum of the lowermoft points
of the firft and fecond die, which we here fuppofe
to be 9 ; then afk him the fum of the points under-
neath of the fecond and third, which we here fup-
pofe to be 5 ; and at laft the under points of the
firft and third, which we put 6. Now, having
thefe numbers given you, 9, 5, 6, fubtract the
fecond number 5 from 15, the fum of the firft and
third, 9 and 6 ; and the remainder 10 from 14 ;
fo there remains 4, the half of which 2 is the num-
ber of the upper points of the firft die. To find the
number of the upper points of the fecond, fubtract
the third number 6 from 14, the fum of the two
firft 9 and 5 ; and the remainder 8 from 14 again ;
fo you have a fecond remainder 6, the half of
which, 3, is the number demanded. At laft for
the third die, fubtract the firft number 9 from 11,
the fum of the fecond and third 5, 6, and the re-
mainder 2 from 14 ; fo you have a fecond remain-
der 12, the half of which, 6, is the number of the
upper points of the third die.

SPORT XVIII.

To find a number thought of by another.

ORDER the perfon to take 1 from the num-
ber thought upon, and after doubling the

remain-

remainder, to take 1 from it, and to add to the laſt remainder, the number thought upon. Then aſk him what that ſum is, and after adding 3 to it, take the third part of it for the number thought of. For example, let 5 be the number, take 1 from it, there remains 4; then take 1 from 8, the double of that 4, and the remainder is 7, which becomes 12, by the addition of 5, the number thought of; and that 12, by the addition of 3, makes 15, the third part of which, 5, is the number thought of.

Another way is this: After taking 1 from the number thought of, let the remainder be tripled; then let him take 1 from that triple, and add to the remainder the number thought of. At laſt, aſk him the number ariſing from that addition, and if you add 4 to it, you will find the fourth part of the ſum to be the number thought of. Thus 5, bating 1, makes 4, that tripled makes 12, which loſing 1 ſinks to 11, and enlarged by the acceſſion of 5, comes to 16, which, by the addition of 4, is 20, and the fourth part of that, *viz.* 5, is the number thought of.

3*d way*. Add 1 to the number thought of, double the ſum, and add 1 more to it, and then add to the whole ſum the number thought of. Having learned the ſum total, take 3 from it, and the third part of the remainder is what you look for. Thus, 5 and 1 is 6, and the double of that, enlarged by 1 is 13, which by the addition of 5, comes to 18; take 3 from that, the remainder is 15, the third part of which, 5, is the number thought of.

4*th*. Or elſe after adding 1 to the number thought of, bid the perſon triple the ſame, and add firſt 1 to it, and then the number thought of. At laſt aſk the ſum of this laſt addition, and after robbing it of 4, take the fourth part of the remainder for the number

number thought of. Thus, 5 and 1 is 6, the triple of which and 1 is 19, which, with 5 is 24, and that bating 4 is 20, the fourth part of which, 5, an-swers the Sport.

5*th.* Take 1 from 5, the number thought of, double the remainder 4, from which, 8, take 1, and likewise the number thought of; after which, afk for the remainder 2, and add 3 to it, fo you have your number.

6*th.* Let the perfon that thinks add 1 to the five, the number thought of, and to the double of that, 12, 1 more, and fubtract from the fum, 13, the number thought of; then afk for the remainder 8, and taking 3 from it, what you leave behind, 5, is the number thought of.

7*th.* Bid the perfon that thinks take 1 from 5, the number thought of; and 1 from 12, the triple of the remainder; and then the double of the num-ber thought of; 10, from 11, the laft remainder. This done, afk for the remaimder of the third fub-traction, *viz.* 1, and adding 4 to it, you will find fatisfaction.

8*th.* Add 1 to the number thought of 5, adding 1 more to the tripple of that you have, 19, from which take 10, the double of the number thought of; then afk for the remainder, 9, from which take 4, and fo you are right.

9*th.* Order the perfon to tripple the number thought of, (5) andout of the triple number (15) to caft away the half, if it were poffible; and fince in this example it is not, to add one to it fo as to make it 16; the half of which 8, muft be trippled, and that makes 24. The perfon that thinks having done this, afk him how many 9's are in the laft triple (24); he anfwers two; fo you are to take 2 for every 9, which in this example makes 4, and by reafon of the 1 you gave to make the 15 an even number,

you

you are here to repay it by addition to the 4, and
fo you have 5, the number thought of. If there
happen to be no 9 in the laſt triple, the number
thought of is 1.

10*th*. Bid him add 1 to the number thought of
(which makes 6) ; then ſubtract it from it, and ſo
it leaves (4) a remainder; then bid him multiply the
ſum (6) into the remainder (4) and tell you the
product. To this product 24 add 1, and of the
ſum 25 take the ſquare root 5.

11*th*. Bid the perſon that thinks add 1 to the
number thought of (which we all along ſuppoſe to
be 5) and multiply the ſum (6) by the number
thought of (5), then let him ſubtract the number
thought of (5) from the product (30) and tell you
the remainder (25) the ſquare root of which 5 is
the number thought of.

12*th*. After taking 1 from the number thought
of, bid him multiply the remainder (4) by the num-
ber thought of (5) and add to the product (20) the
ſame number thought of, and tell you the ſum 25,
of which you are to extract the ſquare root 5.

13*th*. Bid him add 2 to the number thought of,
and clap a cypher to the right of the ſum, which
makes 70 ; and to that add 12, to the ſum of
which addition (82) let him clap another cypher,
ſo as to make it 820. From this decuple (820) let
him ſubtract 320, and tell you the remainder 500,
from which you are to cut off the two cyphers (each
of which did ſtill decuple the number it was put to)
and ſo you have the number thought of 5.

14*th*. Let him add 5 to the double of the num-
ber thought of : to the ſum 15 let him add a cypher
on the right-hand to decuple it ; then let him add
20 to the ſum (150) and to the laſt ſum (170) ſet
another decupling cypher ; at laſt let him ſubtract
700 from the laſt ſum of all (1700) and diſcover

o you the remainder 1000, which from you are
to ftrike off two cyphers to the right, and take the
half of the remainder (10) for the number thought
of.

Thefe two laft methods are not very fubtile; for
the laft number being known, it is an eafy matter,
by a retrogade view, to find out the other numbers,
and by confequence the number thought of. And
upon that confideration we fhall here fubjoin two
other methods that are more myfterious.

15th. Bid the perfon that thinks add 1 to the
triple of the number thought of, and triple the fum
(16) again: to which laft fum (48) bid him add
the number thought of (5); then afk him the fum
of all (53) and from that take off 3, and the right
hand cypher from the remainder 50; which leaves
you 5 to the left for the number thought of.

16th. Bid him take 1 from the triple of the
number thought of (15) and multiply the remainder
(14) by 3; and add to (42) the product, the num-
ber thought of (5); then afk the fum of the addi-
tion, 47, to which add 3, and cut off from the
fum 50 the cypher, which muft needs be on the
right-hand, and fo leaves to the left the number
thought of.

From thefe two laft methods we may draw this
inference, that *if we add an unit to the triple of
any number* (as to 18 the triple of 6) *and the fame
number* (6) *to the triple of the fum* (57) *the fecond
fum* (63) *will always terminate with* 3.

Another inference is, that *if we fubtract an unit
from* (18) *the triple of any number* (6) *and add the
fame number* (6) *to the triple of the remainder*
(51 the triple of 17) *the fum* (57) *will always end
with the figure* 7.

The laft inference is, that this double Sport is
impoffible, *viz. To find a number of fuch a quality,*
that

*that if you add to, or fubtract from its triple, an
unit, and add the fame number to the triple of the
fum of the remainder, the laft fum will be a perfect
fquare number;* for as we fhewed in Sport 9 no
number ending in 3 or 7 can be a true fquare. See
the following Sport.

SPORT XIX.

To find the number remaining after fome operations, without asking any queftions.

LET another think of a number at pleafure;
bid him add to the double of it an even num-
ber, fuch as you have a mind to. For example 8;
then bid him fubtract from half the fum the number
thought on, and what remains is the half of the
even number that you ordered him to add before;
and fo you may roundly tell him you are fure the
remainder is 4. Though the demonftration of this
is eafy, yet thofe who are not apprifed of the reafon
will be furprifed at it. However that you may light
exactly on the number thought of, conceal your
knowledge of the remainder 4, and bid him fubtract
that remainder, whatever it is, from the number
thought of, if fo be it be larger; or elfe if the
number be lefs, to fubtract it from the remainder;
and then afk him for the remainder of the laft fub-
traction; for if you add this remainder to the half
of the even number you gave him (*i. e.* 4 the half
of 8) when the number thought of is larger than
that of the half of the even number; or if you fub-
tract the remainder from the fame half (4) when
the number thought of is lefs than it, you will
have the number thought of. To exemplify the
matter, let 5 be the number thought of, and 8 ad-
ded to its double 10, which makes 18; the half of
that is 9; and 5, the number thought of, fubtract-
ed from 9 leaves 4, the half of the additional num-
ber

ber 8 ; and if you take this half 4 from the num-
ber thought of 5, there will remain 1, which being
added to the fame half 4 (the number thought of
being greater than that half) gives 5, the number
thought of. In like manner if to 10, the double
of 5 the number thought of, you add 12, you will
have 22, the half of which is 11 ; and from thence
taking the number thought of 5, there remains 6,
the half of the additional number 12 : and if from
that half 6 you take the number thought of 5,
(which in this example is lefs than the faid half)
there will remain 1, which being taken from the
fame half, fince the number thought of is lefs than
that half (6) leaves 5 for the number thought of.

But an eafier way to anfwer the fport is this :
Bid the perfon that thinks, take from the double
of the number thought of, any even number you
will that is lefs, for example 4 ; then let him take
the half of the remainder from the number thought
of, and what remains will be 2, the half of the
firft number fubtracted 4 ; and therefore to find the
number thought of, bid him add the number thought
of to that half 2, and then afk the fum, 7, from
which you are to take the fame half, and fo there
will remain 5 for the number thought of.

But another, and yet eafier way is this : Bid him
add what number you will to the number thought
of, and multiply the fum by the number thought of;
for if you make him fubtract the fquare of the num-
ber thought of from the product, and tell you the
remainder, you have nothing to do but to divide
that remainder by the number you gave him to
add before ; for the quotient is the number thought
of. Thus 4 added to 5 (the number thought of)
makes 9, which being multipled by 5, makes 49 ;
from which take 25, the fquare of the number
thought

thought of, and there remains 20, which being divided by 4, leaves 5 in the quotient.

Or elfe bid the perfon that thinks, take a certain leffer number from the number thought of, and multiply the remainder by the fame number thought of; for if you make him take the fquare of the number thought of from the product, and tell you the remainder; by dividing that remainder by the number you ordered to be taken from the number thought of, you have the number thought of in the quotient.

But of all the ways for finding out a number thought of, the following is certainly the eafieft; make him take from the number thought of what number you pitch upon that is lefs than it, and fet the remainder apart; then make him add the fame number to the number thought upon, and the preceding remainder to the fum, for a fecond fum; which he is to difcover to you, and the half of that fum is the number thought of. Thus 5 being thought of, and 3 taken from it, the remainder is 2; and the fame number 3 adder to 5 makes 8, and that, with the preceding remainder, 10, the half of which, 5, is the number thought of.

SPORT XX.

To find the number thought of by another, without asking any queftions.

BID the other perfon add to the number thought of, its half if it be even, or its greateft half if it be odd; and to that fum its half or greateft half, according as it is even or odd, for a fecond fum, from which bid him fubtract the double of the number thought of, and take the half of the remainder, or its leaft half, if the remainder be odd; and thus he is to continue to take half after half, till he comes to an unit. In the mean time you are to

obferve

obferve how many fubdivifions he makes, retaining in your mind for the firſt divifion 2, for the fecond 4, for the third 8, and fo on in a double proportion, remembring ſtill to add 1 every time he took the leaſt half; and that when he can make no fubdivifion, you are to retain only 8. By this means you have the number that he has halfed fo often, and the quadruple of that number is the number thought of, if fo be he was not obliged to take the greateſt half at the beginning, which can only happen when the number thought of is evenly even, or divifible by 4; in other cafes, if the greateſt half was taken at the firſt divifion, you muſt fubtract 3 from that quadruple; if the greateſt half was taken only at the fecond divifion, you fubtract but 2; and if he took the greateſt half at each of the two divifions, you are to fubtract 5 from the quadruple, and the remainder is the number thought of.

For example, let 4 be the number thought of, which by the addition of its half 2, becomes 6, and that, by the addition of its half 3, is 9: from which 8, the double of the number thought of, being fubtracted, the remainder is 1, that admits of no divifion; and for this reafon you retain only 1 in your mind, the quadruple of which, 4, is the number thought of.

Again; let 7 be the number thought of; this being odd, the greateſt half of it, 4, added to it makes 11, which is odd again; and fo the greateſt half of 11 added to 11, makes 17, from which we take 14, the double of the number thought of, and fo the remainder is 3, the leaſt half of which is 1, that admits of no further divifion. Here there being but one fubdivifion, we retain 2, and to that add 1 for the leaſt half taken, fo we have 3, the quadruple of which is 12. But becaufe the greateſt

moiety was taken both in the firſt and ſecond diviſion, we muſt ſubtract 5 from 12, and the remainder 7 is the number thought of.

SPORT XXI.

To find out two numbers thought of by any one.

HAVING bid the perſon that thinks add the two numbers thought of (for example, 3 and 5;) order him to multiply their ſum (8) by their difference (2) and to add to the product (16) the ſquare (9) of the leaſt of the two numbers (3) and tell you the ſum, 25, the ſquare root of which 5, is the greateſt of the two numbers thought of. Then for the leaſt, bid him ſubtract the firſt product (16) from the ſquare (25) of the greateſt number thought of (5) and tell you the remainder, 9, of which the ſquare root 3 is the leaſt number thought of.

An eaſier way of doing it is this: Bid him add to the ſum of the two put together (8) their difference (2) and tell you the laſt ſum, 10, for the half of it, 5, is the greateſt number thought of. And as for the leaſt, bid him ſubtract the difference of the two numbers thought of from their ſum, and aſk him the remainder, 6, the half of which, 3, is the number you look for.

This Sport may likewiſe be ſolved after the following manner: Bid him ſquare the ſum of the two numbers (*which is* 64 *in this example ;*) then bid him add to the leaſt number thought of (3) the double (10) of the greateſt (5) and multiply the the ſum (13) by the leaſt (3) and ſubtract the product (39) from the foregoing ſquare (64) and diſcover the remainder 25, the ſquare root of which is the greateſt number thought of; and as for the leaſt, order dim to add to the greateſt (5) the double (6) of the leaſt (3), and multiply the ſum (11) by the greateſt

reateſt (5) and ſubtract the product 55, from the foregoing ſquare (64) and tell you the remainder 9) the ſquare root of which is 3, the leaſt number thought of.

Another, and a very eaſy way, is this : bid him multiply the two numbers (5, 3,) together ; and then multiply the ſum of the two numbers (8) by the number you want to find, whether the greater or leſſer, and ſubtract the product of the two numbers (15) from that product (which is 40, if you want the greater, and 24, if you look for the leſſer number) and tell you the remainder, 25, or 9, the ſquare roots of which ſatisfies the demand.

Or elſe, bid him firſt take the product of the two numbers (15), then multiply their difference (2) by the number enquired for (3 or 5) and add to that product the product of the two numbers (15) if you want the greateſt, or ſubtract that product from the product of the two numbers, if you look for the leaſt. Then he telling you the ſum, or the remainder, their ſquare roots are the numbers in queſtion.

When the leaſt of the two numbers does not exceed 9, it is eaſy to find them out after this manner : let one be added to the tripple of the greateſt, and the two numbers thought of to the tripple of that ſum, and the total ſum diſcovered ; from which you are to take off 3, and then the right-hand figure is the leaſt, and the left-hand figure the greateſt number thought of. Thus 5 and 3 being thought of, 1 added to the tripple of 5, is 16, and the triple of that (48) added to 8, the ſum of the two numbers, makes 56, which loſing 3, is 53 ; 3 the right-hand figure being the leaſt, and 5 on the left the greateſt number thought of.

SPORT

SPORT XXII.

To find several numbers thought on by another.

IF the quantity of numbers thought of is odd, ask for the sums of the first and second, of the second and third, of the third and fourth, and so on till you have the sum of the first and last; and having written all these sums in order, so that the last sum is that of the first and last; subtract all the sums of the even places from all those in the odd places; and the half of the remainder is the first number thought of, which being subtracted from the first sum, leaves the second number remaining, and that subtracted from the second, leaves the third number remaining, and so on to the last. For example, suppose these five numbers thought of, 2, 4, 5, 7, 8, the sums of the first and second, of the second and third; and so on to the sum of the first and last, and 6, 9, 12, 15, 10: and 24 the sum of the even places, 9 and 15, being taken from 28, the sum of the odd places, there remains 4, the half of which, 2, is the first number thought of, and that being taken from the first number 6, leaves 4 for the second number, and 4 taken from the second, 9, leaves 5 for the third, and so on.

If the quantity of numbers thought upon is even, ask for the sums of the first and second, of the second and third, of the third and fourth, and so on to the sum of the second and last; write them all in order, so that the sum of the second and last may be the last in order; take all the sums in the odd places (excepting the first) from those in the even, and the half of the remainder is the second number thought of, and that taken from the first sum, leaves the first number, which taken from the third sum, leaves for a remainder the third number, and so on. Thus 2, 4, 5, 7, 8, 9, being the num-

bers

bers thought of, the fums propofed, as above, are 6, 9, 12, 15, 17, 13. Then take 29 the fum of 12 and 17 the odd places (excepting the firft) out of 37 the fum of 9, 15, 13, the three even ftations, and the remainder is 8, the half of which, 4, is the fecond number thought of; and that taken from 6, the firft fum, leaves 2 the firft number, as the fame fecond number 4, taken from the fecond fum 9, leaves 5 for the third number, which taken from the third fum 12, leaves 7 for the fourth, and fo on.

When each of the numbers thought of confifts only of one figure, they are eafily found in the fol-lowing manner : let the perfon add 1 to the double of the firft number thought of, and multiply the fum by 5, then add to the product the fecond number thought of. If there is a third number, add 1 to the double of the preceding fum, and after multiplying the whole by 5, add to the pro-duct the third number thought of. In like manner, if there is a fourth number, bid him add 1 to the double of the laft preceding fum, and after multi-plying the whole by 5, add to the product the fourth number thought of, and fo on, if there are more numbers. This dome, afk the fum arifing from the addition of the laft number thought of, and fub-tract from it 5 for two, 55 for three and 555 for four numbers thought of, and fo on, if there are more ; and then the firft left-hand figure of the remainder is the firft number thought of, the next (moving to the right) is the fecond, the next to that the third, and fo on till you come to the laft right-hand figure, which is the laft number thought of.

For example, let 3, 4, 6, 9, be the numbers thought of, and 1 added to 6, the double of the firft 3, and the fum 7 multiplied by 5, the product

G

of

of which, 35, with the addition of the second number 4, is 39; then 1 being added to 78, the double of 39, and the sum 79 multiplied by 5, the product 395, with the addition of the third number 6, is 401 ; and the double of that, with the addition of an unit is 803, which multiplied by 5 is 4015, and with the addition of the fourth number, 9, 4024. Now, if from this sum 4024, we take 555, the remainder is 3469, the four figures of which are the four numbers thought of.

But there is a method for this purpose that is still easier, *viz.* Let 1 be subtracted from the double of the first number, and the remainder multiplied by 5, to the product of which multiplication, let the second number thought of be added, then, if there be more numbers than two, let him add 5 to the last sum for a second sum ; let 1 be taken from the double of this second sum, and the remainder multiplied by 5, and the third number added to that product; this done, if there are no more numbers thought of (otherwise you must add 5, and go on again) ask for the last sum, add 5 to it, and the figures of the whole sum will represent the numbers thought of, as above.

For instance, let 3, 4, 6, 9, be thought of; take 1 from 6, the double of the first 3, multiply the remainder 5 by 5, add to the product 25, the second number 4; to the sum 29 add 5, which gives you 34 for a second sum, take 1 from 68, the double of this second sum, multiply the remainder 27 by 5, and to the product 335, add the third number 6, which makes 341 ; add 5 to this last sum, then it makes 346, the double of which, wanting 1, is 691, and that multiplied by 5, 3455, which, with the addition of the fourth number 9, is 3464. Now adding 5 to this sum, you have 3469, the four figures of which represent the four numbers thought of.

SPORT

SPORT XXIII.

A person has in one hand a certain even number of pistoles, and in the other an odd number; it is required to find out in which hand is the even or the odd number.

LET the number in the right-hand be multiplied by any even number you will, as 2, and the number in the left by such an uneven number as you pitch upon, as 3, then order the person to add together the two products, and take the half of their sum, and if he can take an exact half, so that the sum is even, you will know by that, that the number in the right-hand being multiplied by an even number is odd, and consequently that in the left multiplied by an odd number is even. But on the contrary, if he cannot take an exact half, the number in the right is even, and that in the left odd.

For example; suppose 9 pistoles in the right-hand, and 8 in the left; multiply 9 by 2, and 8 by 3; the sum of the two products 42 being an even number, shews that 9, the odd number, multiplied by the even 2, is in the right-hand, and consequently 8 the even in the left. This Sport directs us to the solution of the following question.

Question. *A man having a piece of gold in one hand and silver in the other, it is asked in what hand the gold or silver is in?*

Fix a certain value in an even number, as 8, on the gold, and an odd, as 5, upon the silver. Direct the person to multiply the number answering to the right-hand by any even number, as 2, and that in the left by a determined odd number, as 3, and ask him whether the joint sum of the products is even or odd; or bid him half it, and so you will learn whether it is even or odd, without asking. If this sum is odd, the gold is in the right-hand; if even, è contra.

SPORT

SPORT XXIV.

*To find two numbers, the Ratio and difference of
which is given.*

TO find two numbers, the first of which, for
example, is the second as 5 to 2, and
the difference or excess 12: multiply the difference
12 by 2, the *least* term of the given Ratio, and
divide the product 24 by 3, the difference of the
two terms 5, 2, and you will find the quotient 8,
the least of the two numbers looked for, and that
added to the difference 12, *viz.* 20, the greatest.

If you will, you may multiply the given diffe-
rence by the *greatest* term of the given Ratio, and
after dividing the product by the difference of the
two terms of the Ratio, you will find the quotient
the great number, which, upon the subtraction
of 12, leaves the lesser remaining. Or you may
take this way; multiply each of the two terms of
the given Ratio, by the difference given, and divide
each of the products by the difference of the two
terms, and the quotients are the numbers demanded.
This Sport furnishes an easy solution to the follow-
ing question.

Question. *If a man has as many pieces of money
in one hand as in the other, how shall we know
how much is in each hand?*

Bid him put two out of the left into the right-
hand, which by that means will have 4 more than
the left, and ask for the Ratio of the number of
pieces in the right to that in the left, which we
shall here suppose to be as 5 to 3. Then multiply
4, the difference of the two hands, by 3, the least
term of the given Ratio, and divide the product 12,
by 2, the difference of the two terms of the Ratio
5, 3: the quotient 6 is the number of pieces in the
left, to which if you add the difference 4, you have
10 for the right. These two put together make
16, and consequently at first the man had 8 in each
hand. SPORT

SPORT XXV.

Two perfons having agreed to take at pleafure lefs
numbers than a number propofed, and to continue
it alternately, till all the numbers make together
a determined number greater than the number
propofed, it is required how to do it.

SUPPOSE the firſt is to make up 100, and both
he and the ſecond are are at liberty to take al-
ternately any number under 11 ; let the firſt take
11 from 100 as often as he can, and theſe numbers
will remain, 1, 12, 23, 34, 45, 56, 67, 78, 89,
which he is to keep in mind ; and firſt take 1, for
then let the ſecond take what number he will (under
(11) he cannot hinder the firſt to come at the ſe-
cond number 12, for if the ſecond takes 3, for
example, which, with 1 makes 4, the firſt has no-
thing to do but to take 8, and ſo reach 12. After
that, let the ſecond perſon take what number he
will, he cannot hinder the firſt from coming at the
third number 23 ; for if he takes 1, for inſtance,
which with 12 is 13, the firſt takes 10 and ſo makes
23. In like manner, the firſt cannot be hindered
to reach the fourth number 34, then the fifth 45,
then 56, then 67, then 78, then 89, and at laſt
100.

As for the ſecond perſon, he can never touch at
100, if the firſt underſtands the way. Indeed if
the firſt takes 2 at the beginning, his buſineſs is to
take 10, and ſo clap in upon 12, with the ſame ad-
vantage the firſt had above. But if the firſt is ac-
quainted with the artifice, he will be ſure to take 1,
and ſo the ſecond can never make 12, nor 23, &c.
nor, in fine 100.

If the firſt would be ſure to win, he muſt take
care that the leſſer number propofed does not mea-
ſure the greater ; for if it does, he has no infallible
rule to go by. For example, if, inſtead of 11, 10

were

were the number propofed; taking 10 continually
from 100, you have thefe numbers, 10, 20, 30, 40,
50, 60, 70, 80, 90; now the firft being obliged to
pitch under 10, cannot hinder the other from
making 10, and fo 20, 30, &c. and in fine 100.

You need not be at the pains to make a continu-
ed fubtraction of the leffer number from the greater,
in order to know the numbers the firft is to run
upon; for if you divide the greater by the leffer, the
remainder of the divifion is the firft number you
are to take. Thus divide 100 by 11, 1 is the re-
mainder for the firft number, add to that 11, it
makes 12 for the fecond, and 12 with 11 makes
23 for the third, and fo on to 100.

S P O R T   XXVI.

*To divide a given number into two parts, the Ratio
of which is equal to that of two numbers given.*

SUPPOSE 60 is to be divided into two num-
bers, the leaft of which muft be to the greater
as 1 to 2: add together the two terms of the given
Ratio 1, 2, and divide 60 by their fum 3: the quo-
tient 20 is the leaft number wanted, and that fub-
tracted from 60 leaves 40 the greater. Or, multi-
ply the two terms 1, 2, feperately, by 60, and di-
vide each of the products, 60, 120, by 3, the fum
of the terms; and the two quotients, 20, 40, are
the numbers you look for. This Sport gives an
eafy folution to the following queftion.

Queftion. *To divide the value of a crown into
two different fpecies or denominations, the number
of which fhall be equal.*

The folution being demanded in integers, it is
impoffible to folve this or the like Spo:t, unlefs the
fum of the two terms of the Ratio of the different
fpecies propofed does exactly divide the crown when
reduced to fmaller money. Thus it is impoffible to
divide an Englifh crown according to the tenour of
the

the Queftion, into fhillings and pence; becaufe the
Ratio of thefe fpecies or denominations is 12, 1 : and
13, the fum of thefe two terms, does not exactly
divide 60 pence, the value of the crown : but make
the two fpecies pence and farthings it will do; fince
4, 1, the terms of their Ratio, make together 5,
which exactly divides 240, the value of the crown
in farthings; and the quotient 48, folves the Quef-
tion, that is, 48 pence, and 48 farthings, make a
crown.

SPORT XXVII.

*To find a number which being divided by given
numbers feparately, leaves 1 the remainder of
each divifion; and when divided by another
number given leaves no remainder.*

TO find a number which leaves 1 remaining,
when divided by 5 and by 7, and nothing
when divided by 3 : multiply into one another the
two firft numbers given, 5, 7; to their product 35,
add 1, which makes 36, the number demanded.
For if you divide 36 by 5 and by 7, the remainder
is 1; and when you divide it by 3, there is as it
happens, no remainder.

After finding this firft and loweft number of the
propofed quality 36, you may find an infinite qnan-
tity of greater numbers of the fame quality, and
that in the following manner. Add the firft num-
ber found 36, to 105, the product of the three
given nnmbers 5, 7, 3, and the fum 141 is a fe-
cond number of the fame quality, then add to 141
the product above-mentioned 105, and you have
246 for a third; which, with the addition of 105,
makes 351 for a fourth number : and fo on.

To find a number that divided feparately by 2,
3, 5, leaves 1 remaining, and no remainder when
divided by 11 : if you take 30, the product of the
firft three numbers 2, 3, 5, and add one to it, you

have

have the number 31, which divided by each of the three firſt numbers, 2, 3, 5, there ſhould remain 11, and by 11, the fourth number, nothing : but ſo it is, that 31, when divided by 11, leaves 9 remaining, and therefore 31 is not the right number; but in order to find out the right number, take 30 the product of the three terms 2, 3, 5, and quadruple it, which makes 120, which with the addition of 1, is the number required 121, and that added to 1320, the product of the four numbers given, 2, 3, 5, 11, makes 1441 for a ſecond number of the ſame quality : and ſo on, as above. In this caſe, 30, the product of 2, 3, 5, being divided by 11, left 8 remaining, and the quadruple of that 8, 32, being but 1 ſhort of 33, the multiple or triple of 11, we quadrupled the 30, and added to the ſum.

In like manner, to find a number that divided ſeparately by 3, 5, 7, leaves 2 remaining, and no remainder when divided by 8 : divide 105, the product of the three firſt numbers 3, 5, 7, by the fourth 8; and becauſe there remains 1, multiply the product 105 by 6, that the product 630 divided by 8 may leave a remainder of 6, which is leſs than 8 by 2, and then adding 2 to the laſt product 630, you have 632 the number required, which added to the product of the four given numbers, makes a ſecond number of the ſame quality; and that with the ſame addition, a third, and ſo on.

To find a number that divided ſeparately by 3, 5, 7, leaves 2 remaining, and divided by 11 leaves no remainder : divide 105, the product of the firſt three numbers given, 3, 5, 7, by the fourth 11; and in regard there remains 6, the double of which, 12, ſurpaſſes the diviſor 11 by 1; multiply the product 105 by 2, that 210 being divided by 11, there may remain 1; and ſince it is deſired that 9 may be the remainder, which is leſs than the diviſor 11

by 2, multiply the laſt product 210 by 9, and then the product 1890 being divided by 11, the remainder will be 9; and therefore adding 2 to that laſt product, you will have a number 1892, which leaves no remainder, being divided by 11.

In like manner to find a number that being divided by 5, or 7, or 8, leaves 3 remaining, and nothing when divided by 11: multiply by 9, 280 the product of the firſt three numbers given, 5, 7, 8, and the product 2520 being divided by 11, there remains 1, upon which you may make the remainder 8, which is leſs than 11 by the given number 3, by multiplying the foregoing product 2520 by 8, which makes 20163, and conſequently that ſum, with the addition of 3, viz. 20163, is the number ſought for. This Sport directs us to ſolve the following Queſtion.

Queſtion. *To find how many piſtoles were in a purſe that a man has loſt, but remembers, that when he told them by two's, by threes, or by fives, there always remained an odd one, and when he counted them by ſevens, there remained none.*

Here we are to find a number that, when divided by either 2, or 3, or 5, ſtill leaves 1 remainder; and when divided by 7 leaves 0. Now there are ſeveral numbers of that quality, as appears from the foregoing Sport; and therefore to find the number that really was in the purſe, it behoves us to be directed by the bulk or weight of the purſe, in order to determine the real number.

Now to find the leaſt of all theſe numbers, let us firſt of all try for a number that is exactly diviſible by 2, by 3, and by 5, and likewiſe by 7 when 1 is added to it. If you multiply together the three firſt numbers given, 2, 3, 5, their product 30 will be diviſible by each of theſe three numbers; but when you have added 1 to it, the ſum 31 is not

diviſible

divifible by the fourth number given, 7, for there remains 3, and fince the product 30, when divided by 7 leaves 2, its double 60 will leave 4 upon the like divifion, and by the fame confequence its triple 90 will leave 6 remaining. Now 6 wanting but one of 7, add that one to this triple number 90, and fo 91 will be exactly divifible by 7, and confequently is the number fought for.

To find the next larger number that anfwers the Queftion, multiply together the four given numbers 2, 3, 5, 7, and to their product 210 add the firft and leaft number found 91; the fum 301 is the fecond number fought for; and if you add to this fecond number the foregoing product 210, the fum 511 will be the third number that folves the Queftion; and fo on *in infinitum*.

Thus, to refolve the Queftion, you may anfwer, that there might be in the purfe 91 Louis d'Ors, or 301, or 511; and the bulk of the purfe will ferve to direct you which of the numbers was really in it.

SPORT XXVIII.

Of feveral numbers given to divide each into two
parts, and to find two numbers of fuch a quality,
that when the firft part of each of the given num-
bers is multiplied by the firft number given, and
the fecond by the fecond, the fum of the two pro-
ducts is ftill the fame.

SUPPOSE, for example, thefe three numbers given, 10, 25, 30, and the folution is required in entire numbers; take any two numbers for the two numbers fought for, provided their difference be 1, or fuch as may exactly divide the product under the greateft of thefe two numbers and the difference of any two of the three given numbers, and fo, that the greateft of thefe two numbers
multiplied

multiplied by the leaft given number 10, may be greater than the leaft of thefe two numbers multi-plied by the greateft given number 30; fuch are 2 and 7.

The two numbers required, 2 and 7, being thus found; the firft part of the firft given number 10, may be taken at pleafure, provided it is lefs than 10, and then the number arifing from the fubtrac-tion of the leaft found number 2, multiplied by the greateft given number 30, from the greateft found number 7, multiplied by the leaft given number 10; and then the number arifing from the divifion of the remainder 10 by 5, the difference of the two numbers found 2, 7; that is, lefs than 2, which is 1, which being fubtracted from the firft given number 10, leaves the remainder 9 for the other part; and that being multiplied by the fecond num-ber found 7, and the firft part 1 being multiplied by the firft number found 2, the fum of the two products 63 and 2 is 65.

To find the firft part of the fecond number given, 25, multiply 15, the difference of the firft two numbers given, 10, 25, by the greateft number found 7; and divide the product 105 by 5 the dif-ference of the two numbers found 2, 7; then add the quotient 21 to 1, the firft part found of the firft number given 10; and the fum 22 will be the firft part of the fecond number given 25, and confe-quently the other part will be 3, which being mul-tiplied by the fecond number found 7, and the firft part 22, being multiplied by the firft number given 2, the fum of their two products 21, 44, makes likewife 65.

Laft of all, to find the firft part of the third num-ber given 30, multiply 5, the difference of the two laft numbers given 25, 30, by the greateft number found,

found, 7, and divide the product 35 by 5, the dif-
ference of the two numbers found 2, 7 ; then add
the quotient 7 to 22, the firſt part of the ſecond
number given 30, and the ſum 29 will be the firſt
part of the third number given 30, and conſequent-
ly the other part will be 1, which being multiplied
by the ſecond number found 7, and the firſt part
29 being multiplied by the firſt number found 2,
the ſum of the two products 7, 58, makes ſtill 65.

Or elſe multiply 20, the difference of the firſt
and the third number given, by the greateſt number
found 7, and divide the product 140 by 5, the dif-
ference of the two numbers found 2, 7; then add
the quotient 28 to 1, the firſt part of the firſt num-
ber given 10, and you will have 29 as above, for
the firſt part of the third number given 30.

If you take 1 and 6 for the two numbers ſought
for, and 4 for the firſt part of the firſt number giv-
en 10, in which caſe the other part will be 6,
which being multiplied by the ſecond number
found, 6, and the firſt part 4 by the firſt number
found 1, the ſum of the two products 36 and 4, is
40. Upon this ſuppoſition, I ſay, the firſt part of
the ſecond number given 25, will be 22, and con-
ſequently the other part 3, which being multiplied
by the ſecond number found 6, and the firſt part
22 by the firſt found number 1, the ſum of the two
products 18, 22, is likewiſe 40 ; and in fine, the
firſt part of the third number given 30, will be 28,
and the other 2, which being multiplied by the
ſecond number given 6, and the firſt 28 by the firſt
1, the ſum of the two products is ſtill 40. This
Sport directs us to the ſolution of the following
Queſtion.

Queſtion. *One woman ſold at market 10 apples
at a certain rate apiece ; another ſold 25 at the
ſame rate ; and a third ſold 30 ſtill at the ſame*
price ;

price ; and yet each of them brought the same sum of money home with them. The question is how this could be ?

It is manifest, that to save the possibility of the Question, the women must sell their apples at two different sales, and at two different rates, seeing at each sale or division they sell at the same rate. Let the two different rates be 2 and 7, which are the two numbers that we found in the foregoing Sport; and we will suppose.

Apples		*Farthings*	*Apples*		*Farth.*	
X.	1	at 2	9	at	7	
XXV.	22	at 2	3	at	7	65
XXX.	29	at 2	1	at	7	

that at the first sale they sold at 2 farthings an apple, and that at this rate the first sells 1 apple, the second 22, and the third 29; the three numbers 1, 22, 29, being the first parts of the three given numbers X, XXV, XXX, which were found in the foregoing Sport; in this case the first woman will take 2 farthings, the second 44, and the third 58. In the next place, if we suppose they sell the rest of their apples at 7 farthings, then the first woman will take 63 farthings for the 9 apples she had left, the second will take 21 farthings for the 3 apples she had left, and the third 7 farthings for the 1 apple she had left; and so each of them will take in all 65 farthings.

Or, if you will, make the two different rates 1 and 6, which were the two numbers found in the last Sport; and suppose at the first sale they sell at a farthing an apple, at which price the first sells 4, the second 22,

Apples		*Farthings*	*Apples*		*Farth.*	
X.	4	at 1	6	at	6	
XXV.	22	at 1	3	at	6	40
XXX.	28	at 1	2	at	6	

and

and the third 28 ; thefe three numbers 4, 22, 28, being the firft parts of the given numbers X, XXV, XXX, which were found in the laft Sport ; the firft woman will take 4 farthings, the fecond 22, and the third 28. Then fuppofe again that they fell the reft of their apples at 6 farthings a piece, the firft woman will take 36 farthings for the 6 apples fhe had left, the fecond 18 for the 3 apples fhe had left, and the third 12 farthings for the 2 apples fhe had left. And thus every one of them will take in all 40 farthings.

SPORT XXIX.

Many numbers which proceed from 1 or unity, in a progreffion, according to the natural order of numbers, (fuch as thefe, 1, 2, 3, 4, 5, 6, &c.) being placed in a round form like a ring ; to dif-cover which of thefe numbers any one has thought upon.

LET any multitude of numbers in the afore-faid progreffion, fuppofe thefe ten, to wit, 1, 2, 3, 4, 5, 6, 7, 8, 9, 10, be marked upon ten ivory-counters (or for want thereof upon ten fmall pieces of paper) which may be reprefented by thefe ten letters, A, B, C, D, E, F, G, H, K, L, *viz.* fup-pofe 1 to be writ upon the counter A, 2 upon B, 3 upon C, &c. Then having placed thofe counters circularly as you fee (with their blank faces upper-moft, and the figures underneath, that the fubtilty

A
1
L 10   2 B
K 9   3 C
H 8   4 D
G 7   5 E
6
F

of
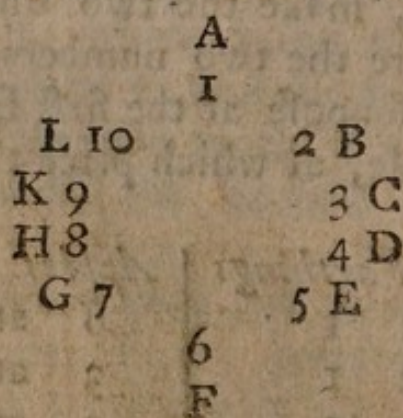
f the fport may the better be concealed) let any
ne think upon any number of units which does not
xceed 10; that done, bid him touch one of thofe
ounters at pleafure, and to the number on the
ack-fide of the counter touched (which you cannot
e ignorant of, having noted well the place of t or
ı) add fecretly in your mind, the juft number of
ll the counters and referve the fum; then bid him
magine in his mind the counter touched to be the
umber which he thought, and from that counter
o count backwards, until he has made up the
forefaid fum, which you referved, fo will his com-
utation infallibly end on the counter upon which
he number thought of is marked.

For example, fuppofe he thought 7 or G, and
hat he touched B, to wit, 2; add to 2 the number
f all the counters, to wit, 10, fo the fum will be
2; then bid him count to 12, beginning at B and
oing backward, and efteeming B to be the number
hought, to wit, 7; fo will 8 fall upon A, 9 upon
., 10 upon K, 11 upon H; and laftly, 12 upon the
ounter G, which being turned up will fhew the
umber thought.

The reafon of this rule is not difficucult to be ap-
rehended, two principles being prefuppofed, the
ne is this; to wit, many counters or things what-
oever being difpofed orderly one after the other, in
ne continued line, whether it be right or circular;
f you value or name the firft counter to be fome
umber of units at pleafure, and continue the count
orward according to the natural order of numbers,
ntil another number be named which falls upon
he laft counter: Or, if you imagine or name the
aft counter, to be the fame number of units as
efore you put upon the firft, and continue to count
ackwards to the firft counter; I fay that the fame
umber will be named at the end of both thefe
com-

computations: For example, in thefe 9 letters, A, B. C. D. E. F. G. H. K. if the letter A be efteemed to be 4, and from thence you count forwards unto K, according to the natural order of numbers, the letter K will fall upon the number 12. In like manner, if you efteem K to be 4, and count back-wards from K to A, the letter A will likewife fall upon 12.

4.	5.	6.	7.	8.	9.	10.	11.	12.
A.	B.	C.	D.	E.	F.	G.	H.	K.
12.	11.	10.	9.	8.	7.	6.	5.	4.

The other principle is this, to wit, many coun-ters being difpofed in a round form like a ring; if you efteem any one of thofe counters to be fome number at pleafure, and then from that counter if you count circularly, until you end upon the counter where you began, the number laft named will be equal to the fum of the number of all the counters, and of the number which you put upon the firft counter; for example, if D be one of ten letters placed in a circumference, and that imagining D to be 7, you begin with it, and count round the whole circumference, according to the natural

<div align="center">

A
1

L 10   2 B
K 9   3 C
H 8   4 D
G 7   5 E
6
F

</div>
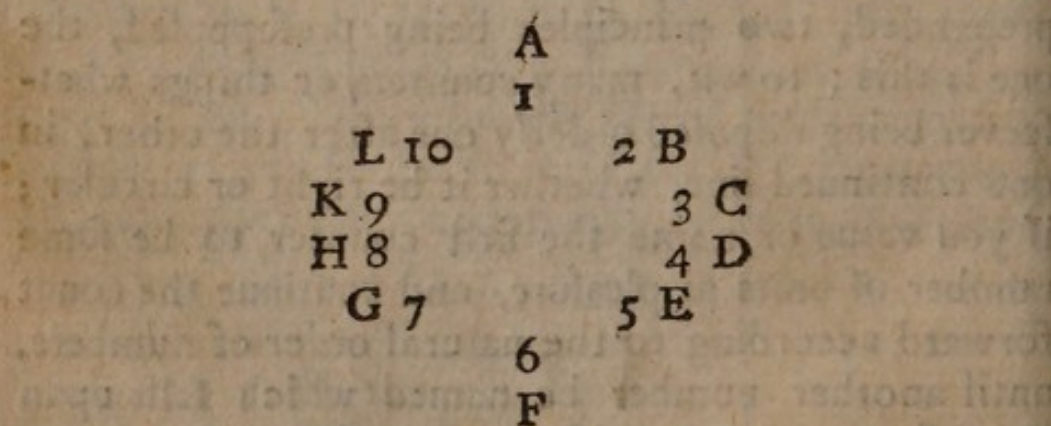
progreffion of numbers till you end with D where you began; the number 17, which is compofed of 10 and 7, will neceffarily fall upon D; for 9 (which is the number of letters in the circumference befides D)

D) being added to 7 (which was firſt put upon D) makes 16, to which 1 being added, (becauſe D ends as well as begins the circumference) the ſum is 17.

Now theſe two principles being preſuppoſed, it will not be difficult to apprehend the reaſon of the aforeſaid Rule in all caſes that can happen; for imagine that one has thought upon 7, or the coun-ter G, then that counter which he ſhall touch muſt either be the ſame counter G, or ſome other that precedes or follows G.

Firſt therefore, ſuppoſing the counter or number touched to be the ſame with the number thought, the truth of the Rule will be then evident; for by the Rule given, he will begin to count from the ſame G to 17, putting 7 upon G, therefore by the ſecond preſuppoſition the number 17 will fall up-on G.

Secondly, imagine that he touched a counter or number following G the number thought, as L or 10; then according to the Rule adding 10 (the numbers of all the counters placed circularly) to 10 or L, the (counter touched) bid him count back-wards to 20 by beginning at L, and eſteem L to be 7. Now, becauſe by beginning to count at G which is 7, and proceeding to count forward, the number 10 will fall upon L; therefore by the firſt preſuppoſed principle, if we eſteem L to be 7, and count backwards, the number 10 will infallibly fall upon G, and then the number 20 ſhall alſo fall upon the ſame G by the ſecond preſuppoſed prin-ciple.

Laſtly, imagine he touched ſome number or counter which precedes 7 the number ſought, as B or 2; then adding 10 to 2, you are to bid him count unto 12, he having firſt imagined B to be the number thought 7; and going backward to A,

H   L, K,

L, K, &c. Now becaufe by proceeding to count at B, which is 2, and beginning to count forward to C, D, &c. the number 7 falls upon G; there-fore if one imagine that G is 2, and from thence count backwards towards F, E, &c. the number 7 will fall upon B (by the firft prefuppofed principle;) therefore when one affumes B to be 7, and counts towards A, L, &c. to any affigned number, it is in effect as much as when one imagines G to be 2, and counts towards F, E, unto the faid af-figned number, for each of thofe computations will end in the fame point; but it is manifeft (by the fecond prefuppofed principle) that efteeming G to be 2, and counting towards F, E, D, &c. round the whole circumference; the number 12 will fall upon the fame G. And becaufe G being fuppofed to be 2, and counting on the fame coaft as before, the number 7 falls upon B; therefore if the com-putation be continued on the fame coaft as before, the number 7 falls upon B; therefore if the compu-tation be continued on the fame coaft from B 7, to 12, the number 12 will fall upon the fame G. So that the practice of this fport in all its cafes is de-monftrated.

Note, That to the number of the counter touched you may not only add the number of all the counters once (as the Rule directs) but twice, thrice or more times: For example, B being touched, you may caufe him to count to 12, or 22; or to 32, 42, &c. the reafon whereof is evident from the fecond pre-fuppofed principle.

SPORT XXX.

Many numbers being fhewed by pairs, to wit, two
by two unto any perfon, that he may think upon
any one of thofe pairs at pleafure, to difcover th
pair that was thought upon.

LET 20 numbers, fuppofe thefe, 1, 2, 3, 4
5, 6, 7, 8, 9, 10, 11, 12, 13, 14, 15, 16

17

17, 18, 19, 20, be writ upon ivory counters (or for want thereof upon ſmall pieces of paper) to wit, 1 upon one counter, 2 upon another, 3 upon a third, &c. Then diſpoſe them into pairs as you ſee, viz. ſuppoſe 1 and 2 to be one pair, 3 and 4 to be another pair, &c. and of theſe pairs let any

1	2
3	4
5	6
7	8
9	10
11	12
13	14
15	16
17	18
19	20

one think upon which pair he pleaſes. That done, you are to diſtribute the ſaid 20 numbers into ranks, in form of a long ſquare, until there be 5 numbers in length, and 4 in breadth, after this manner, viz. lay the three firſt numbers, 1, 2, and 3, in a rank (as you ſee in the ſecond figure) from A towards B; then place 4 under 1, and 5 after 3, (in the ſaid rank A B.) Again, place 6 under 4, and 7 after 5, (in the ſaid rank A B.) Then place 8 under 6,

H 2   alſo

alſo 9, 10, 11, on the right-hand of 4, in the rank
C D. Again, place 12 under 9, and 13 on the right
hand of 11, in the rank C D, and 14 under 12.
Moreover, place 15, 16, 17, on the right hand of
12, in the rank E F. Laſtly, place 18, 19, 20,
on the right-hand of 14, in the rank G H, ſo will
all the numbers be ranked as you ſee in the Ta-
ble. That done, you are to demand of him that
thought upon two numbers as aforeſaid, in what
rank or ranks the ſaid numbers happen to be found,
viz in which of the ranks A B, C D, E F, G H,

A	I	2	3	5	7	B
C	4	9	0	11	13	D
E	6	12	15	16	17	F
G	8	14	18	19	20	H

or in which two of the ſaid ranks : Now if he an-
ſwer, that the two numbers he firſt thought upon
are in the firſt rank A B, then 1 and 2 will be the
numbers thought or kept in mind; if in the ſecond
C D, then 9 and 10 ſhall be the numbers thought
of; if in the third rank E F, then 15 and 16 will
be the numbers thought : If they are in the fourth
rank G H, then 19 and 20 ſhall be the numbers
thought; but if he ſay that the numbers thought
are in different ranks, then you are heedfully to
mark the ſaid numbers 1 2, 9 and 10, 15 and 16,
19 and 20, which may be called the keys of the
ſport, in regard they ſerve not only to diſcover the
two numbers thought, when they are both in one and
the ſame rank (as aforeſaid;) but even when they
are in two different ranks : For in this latter caſe,
as ſoon as it hath been declared to you in which
two ranks the two numbers thought are placed, you
are

are to take the key of the higheſt of thoſe two ranks, and deſcending in a down-right line from the firſt number of that key to the lower of the ſaid two ranks, you'll there find one of the two numbers thought, and upon the right-hand of the ſecond number of the ſaid key, at the ſame diſtance ſideways, from the ſecond number of the key, (as one of the numbers thought was diſtant from the firſt number of the key,) you will find the other number thought.

For example, ſuppoſe the two numbers thought are 7 and 8, and it is declared to you, that they are in the firſt and fourth ranks; take then the key of the higheſt of thoſe two ranks ; to wit, of the firſt, which is 1 and 2, and deſcending downright from 1 to the fourth rank, you'll there find 8 one of the numbers thought : then ſeek ſideways on the right-hand of 2 (the ſecond number of the key) a number as far ſeperated from 2, as 8 is diſtant from 1, and you'll find 7 the other number thought.

Again, ſuppoſe he ſays that the numbers thought are in the ſecond and third ranks : Take then the key of the ſecond rank which is 9 and 10, and deſcending down-right from 9 to the third rank, you ſhall there find 12, which is one of the numbers thought ; then ſeek ſideways on the right-hand of 10, (the ſecond number of the key a number as far diſtant from 10, as 12 is from 9, and you'll find 11, which is the other number thought.

The reaſon of this will be apparent, from a ſerious conſideration of the placing of the numbers according to the Rules before given : for it is thereby evident, that of the firſt numbers coupled two by two, there can never be found more than one pair in one and the ſame rank ; and of all the other pairs, one number is always found in one rank, and the other number in another rank.

Note

Note alfo, that this fport may be practifed with divers perfons at once, and not only with 20 numbers, but with any fuch multitude of numbers as is produced by the multiplication of any two numbers that differ by 1, or unity; as 30, which is the product of 5 multiplied by 6, and 42, which is the product of the multiplication of 6 and 7. That which is chiefly to be regarded is, the placing of the numbers in ranks according to the directions before given: And for the more eafy comprehending of that order, I have, in the following Table, ranked 30 numbers in their due places, which being compared with the former Table, and well viewed, will be a clearer illuftration than can be expreffed by many words.

1	2	3	5	7	9
4	11	12	13	15	17
6	14	19	20	21	23
8	16	22	25	26	27
10	18	24	28	29	30

SPORT XXXI.

Among three perfons, to find how many cards or counters each of them has got.

LET the third perfon take what number of cards or counters he pleafes, provided it be evenly even, that is, divifible by 4; let the fecond take as many 7's as the other has taken 4's; and the firft as many 13's. Then bid the firft give to the other two as many of his counters as each of them had before; and the fecond to give to the remaining two as many of his counters as each of
them;

them; and in like manner, the third to give to
each of the other the fame number that they have.
By this means it will fo fall out, that they will all
have the fame number of counters, and each of
them will have double the number that the third
had at firft. And for this reafon, if you afk one
of the three how many counters he has got, half
his number is the number the third had at firft;
and if you take as many 7's, and as many 14's as
there were 4's in the third perfon's number, you
will have the number of cards or counters that the
fecond and firft took.

For example, if the third took 8 cards, it be-
hoved the fecond to take 14, that is, twice 7, be-
caufe there is twice 4 in 8; and the firft muft take
26, that is twice 13 by the fame
reafon. If the firft, who has 26
cards, gives to the fecond 14, that
is, as many as he had at firft:
and to the third 8, that being his
firft number, he will have only 4
left to himfelf; and the fecond will

1ft	2d.	3d.
26	14	8
4	28	16
8	8	32
16	16	16

have 28; and the third 16. But if the fecond,
who has 28 cards, gives out of his cards 4 to the
firft, who had juft as many before, and 16 to the
third, who had likewife as many; he will have 8
left to himfelf, and the firft will have 8, and the
third 32. In fine, if the third, who has got 32,
gives 8 to each of the others, all the three will
have 16, which is the double of 8, the number
that the third took up at firft.

S P O R T   XXXII.

*Of three unknown cards, to find what card each of
three perfons has taken up.*

THE number of each card taken up muft not
exceed 9. Then, to find out that number,

bid

bid the firſt ſubtract 1 from double the number of
the points of his card, and after mtltiplying the
remainder by 5, add to the product the number of
the points of the ſecond perſon's card. Then cauſe
him to add to that ſum 5, in order to have a ſecond
ſum; and after he has taken 1 from the double of
that ſecond ſum, make him to multiply the remain-
der by 5, and add to the product the number of the
points of the third perſon's card. Then aſk him the
ſum ariſing from this laſt addition; for if you add
5 to it, you will have another ſum compoſed of
three figures, the firſt of which towards the left is
the number of the points of the card that the firſt
perſon took up; the middle figure will be that of
the ſecond perſon's card; and the laſt towards the
right directs you to the third perſon's card.

For example; if the firſt took a 3, the ſecond a
4, and the third a 7; by taking 1 from 6, the
double of the firſt 3, and multiplying the remainder
5 by 5, we have 25 product, to which we add 4,
the number of the ſecond perſon's card, which
makes 29, and that, with the addition of 5, makes
the ſecond ſum 34, the double of which is 68, and
taking 1 from that, there remains 67, which being
multiplied by 5, makes 335, and this by the addi-
tion of 7, the number of the third perſon's card,
and 5 over and above, makes the laſt ſum 347, the
three figures of which ſeverally repreſent the num-
ber of each card.

Another way, Or, if you will, you may bid the
firſt add 1 to the double of the number of the points
of his card, and multiply the ſum by 5, and add
to the product the number of the ſecond perſon's
card. Then bid him add in like manner 1 to the
double of the preceding ſum, and multiply the
whole by 5, and add to the product the number of
the third perſon's card. Then aſk him the ſum

rifing from the laſt addition, and ſubtract 55 fiom
t, that ſo there may remain a number compoſed of
hree figures, each of which reprefents, as above,
he number of each card.

As in the foregoing example, by adding 1 to 6
he double of 3, the number of the firſt perſon's
ard, and by multiplying the ſum 7 by 5, we have
5, which, with the addition of 4, the number of
he ſecond peaſon's card, makes 39, the double of
which is 78, to which if we add 1, and multiply the
um 79 by 5, we have 395; to that we add 7, the
umber of the third perſon's card, and ſo have
02, from which if we ſubtract 55, the remainder
s 347, the three figures of which ſeverally reprefent
he number of each card.

SPORT XXXIII.

*If three cards known, to find which and which is
taken up by each of three perſons.*

OF the three known cards, we ſhall call one A,
the other B, and the third C, and leave each
f the three perſons to pitch upon 1 of the three,
which may be done ſix different ways, as you ſee in
the annexed ſcheme. Give
the firſt perſon the num-
ber 12, the ſecond 24,
the third 36. Then di-
rect the firſt perſon to add
together the half of the
number of that perſon
that has taken the card A,
the third part of the num-
ber of the perſon that takes

ſt.	2d.	3d.	Sums.
2	24	36	
A	B	C	23
A	C	B	24
B	A	C	25
B	A	B	27
B	C	A	28
B	B	A	29

he card B, and the fourth part of the number of
he perſon that takes the card C; and then aſk
im the ſum, which you will find to be either 23,
r 24, or 25, or 27, or 28, or 29, as you ſee in
the

the table or fcheme, which fhews, that if the fum
is, for example, 25, the firft will have taken the
card B, the fecond the card A, and the third the
card C; and if the fum is 28, the firft has taken
the card B, the fecond the card C, and the third
the card A; and fo on in the other cafes.

SPORT XXXIV.

To find out among feveral cards, one that another has thought of.

HAVING taken out of a pack of cards a cer-
tain number of cards at pleafure, and fhewn
them in order upon the table, before the perfon
that is to think, beginning with the lowermoft,
and laying them cleverly one above another, with
their figures and points upwards, and counting
them readily, that you may find out the number
which, for example, we fhall here fuppofe to be
12; bid him keep in mind the number that ex-
preffes the order of the card he has thought of,
namely, 1, if he has thought of the firft, 2, if he
has thought of the fecond, 3, if he has thought of
the third, &c. Then lay your cards one after
another, upon the reft of the pack, in a contrary
fituation, and putting that upon the pack firft that
was firft fhewn upon the table, and that laft that
was laft fhewn. Then afk the number of the card
thought of, which we fhall here fuppofe to be 4,
that is, the fourth card in order of laying down,
is the card thought of. Lay your cards, with their
faces up, upon the table, one after another, begin-
ning with the uppermoft, which you are to reckon
4, the number of the card thought of; fo the fe-
cond next to it will be 5, and the third under that
6, and fo on till you come to 12, the number of
the cards you firft pitched upon to fhew the perfon;

and

nd you will find the card that the number 12 falls
o, to be the card thought of.

SPORT XXXV.

*everal parcels of cards being propofed or fhewn,
to as many different perfons, to the end that
each perfon may think upon one, and keep it in
his mind; to guefs the refpective card that each
perfon has thought of.*

WE will fuppofe there are 3 perfons, and 3
cards fhewn to the firft perfon, that he may
hink upon one of them, and thefe three cards laid
fide by themfelves; then 3 other cards held before
he fecond perfon, for the fame end, and laid apart;
nd at laft, 3 different cards again to the third
erfon, for the fame end, and likewife laid apart.
This done, turn up the 3 firft cards, laying them
n three ftations; upon thefe three lay the next
hree other cards that were fhewn to the fecond
erfon; and above thefe again the three laft cards.
Thus you have your cards in three parcels, each of
which confifts of 3 cards. Then afk each perfon in
that lift is the card he thought of; after which it
ill be eafy to diftinguifh it; for the firft perfon's
ard will be the firft of his heap; and in like man-
er the fecond's will be the fecond in his; and the
hird perfon's card will be the third in his.

SPORT XXXVI.

*everal cards being forted into three equal heaps,
to guefs the card that one thinks of.*

IT is evident that the number of cards muft be
divifible by 3, fince the three lifts are equal.
uppofe then there are 36 cards, by confequence
here are 12 in each lift: afk in what lift is the
ard thought upon; then put all the heaps together,

fo

ſo as to put that which contained the card thou
upon between the other two; then deal off the
cards again into three equal h nds, obſerving t
order of the firſt card to be firſt, the ſecond to
ſecond, the third to the third, the fourth to the f
again, and ſo round, dealing one card at a tin
till the cards are dealt off. Then aſk again,
what hand or heap is the card thought upon, a
after laying together the cards, ſo as to put that
which contained the card between the other tv
deal off again, as you did before, into three eq
lifts. Thus done, aſk once once more, what
the card is in, and you will eaſily diſtinguiſh whi
is it, for it lies in the middle of the lift to which
belongs; that is, in this example, it is the ſix
card; or, if you will, to cover the artifice t
better, you may lay them all together, as befor
and the card will be in the middle of the who
that is, the eighteenth.

SPORT XXXVII.

*To gueſs the number of a card drawn out of a cor
plete ſtock.*

AFTER one hath drawn what card he pleaſ
out of a complete ſtock of 52 cards, for i
ſtance, ſuch as we play at Ombre with, you m
know how many points are in the card thus draw
by reckoning every fac'd card 10, and the reſt a
cording to the number of their points; then lookir
upon the reſt of the cards one after anoher, add tl
points of the firſt card to the points of the ſecon
and the ſum to the points of the third, and ſo o
till you come to the laſt card, taking care all alor
to caſt out 10, when the number exceeds it; upc
which account you ſee it is needleſs to reckon in tl
10's or the faced cards, ſince they are to be ca
out however. Then if you ſubtract your laſt ſur
fror

om 10, the remainder is the number of the drops
the card drawn.

It is eafy to know that when nothing remains,
ie card drawn is either a 10 or a faced card : and
iat in this cafe, if it be a faced card, one cannot
iftinguifh whether it be king, queen or knave :
ow, in order to be mafter of that diftinction, the
eft way is to make ufe of a ftock of 36 cards on-
, fuch as we formerly ufed for Piquet, and reckon
knave 2, a queen 3, and a king 4.

If you make ufe of a ftock of 32 cards only, fuch
s is now ufed for Piquet, you are to follow the
me courfe as is above prefcribed, only you muft
lways add 4 to the laft fum, in order to have an-
ther fum, which being fubtracted from 10 if it
e lefs, or from 20, if it furpaffes 10, the remain-
er will be the number of the card drawn ; fo that
2 remains it is a knave, if 3 a queen, if 4 a
ing, &c.

If the ftock is not full, you muft take notice
hat cards are wanting, and add to the laft fum
he number of all the cards that are wanting, after
ibtracting from that number as many 10's as are
be had ; upon which, the fum arifing from this
ddition is to be fubtracted, as above, from 10 or
om 20, according as it is above or under 10.
his done, is is evident by cafting your eye once
ore upon the cards, you may tell what card was
rawn.

SPORT XXXVIII.

To guefs the number of the points or drops of two
cards drawn out of a complete ftock of cards.

LET a man draw at pleafure two cards out of
a ftock of 52 cards ; bid him add to each of
he cards drawn as many other cards as his num-
er is under 25, which is the half of all the cards,

<div align="right">wanting</div>

wanting 1, fixing upou each faced card what nur
ber he pleafes ; as if the firſt card be 10, add to
15 cards; and if the fecond cârd be 7, add to
18 cards ; fo that in this example there will remai
but 17 cards in the ſtock, the whole number take
out amounting to 35. Then taking the remainde
of the pack into your hands, and finding they ar
but 17, conclude that 17 is the joint number of a
the points of the two cards drawn.

To cover the artifice the better, you need no
touch the cards, but order the drawer to ſubtrad
the number of the points of each of the two drawi
cards from 26, which is half the number of all th
cards, and direct him to add together the two re
mainders, and acquaint you with the fum, to th
end you may ſubtract it from the number of th
whole ſtook, i. e. 52; for the remainder of tha
ſubſtraction is what you look for.

For *Example.* Suppofe a 10 and a 7 are th
cards drawn ; take 10 from 26, there remains 16
and taking 7 from 26, the remainder is 19 : th
addition of the two remainders 16, 19, makes
fum of 35, which ſubtracted from 52, leaves 1
for the number of the drops of the two card
drawn.

The fame is the management in a ſtock of 36
or 32 cards; only to colour the trick the better,
inſtead of 26, the half of the cards, when they
make 52, take another leſſer number, but greater
than 10, as 24, from which taking 10 and 7,
there remains 14 and 17, the fum of which, 31,
being ſubtracted from 52, the fum of all the cards,
leaves 21 the remainder ; from which ſubtract again
4, which is the double of the excefs of 26 above
24, and fo the remainder is 17, the number of
the points of the two cards drawn, *viz.* 10 and 7.

If

If you make ufe of a Piquet-ftock, confifting of 6 cards, inftead of 18, the half of 36, the number of all the cards, take in like manner a leffer number, fuch as 16, from which take 10 and 7, and there remains 6 and 9, the fum of which, 15, being fubtracted from 36, the number of all the cards, leaves 21 remaining ; from which fubtract again 4, the double of the excefs of 18 above 16, and fo the 17 remaining is the number of the points of the two cards drawn.

In like manner, if this Piquet-ftock confifts only of 32 cards, inftead of 16, the half of 32, the number of the whole ftock, take any leffer number you will, provided it be greater than 10, fuch as 14, from which take 10 and 7, and the remainders are 4 and 7, the fum of which, 11, being taken from 32, leaves 21, and taking from that 4, the double of the excefs of 16 above 14, you have 17 remaining, the number of the points of the 10 and the 7 drawn.

SPORT XXXIX.

To guefs the number of all the drops of three cards drawn at pleafure out of a complete ftock of cards.

TO folve this Sport as the former, after the fhorteft way, the number of cards contained in the ftock muft be divifible by 3 ; fo that neither a ftock of 52, nor one of 32, are proper ; but one of 36 is, in regard 36, the number of all the cards, has 12 for its third part, which will affift us in the folution of the queftion, as follows—

Let a man draw at pleafure three cards out of a Piquet-ftock of 36 cards; bid him add to each of thefe cards as many other cards as the number of their points falls fhort of 11, which is the third part of the number of all the cards, wanting, on allotting. as in the foregoing Sport, to each

faced

faced card what number he pleafes : as if the firft card is 9, he adds to it 2 cards ; if the fecond is 7, he adds to it 4 ; and if the third is 6, he adds 5 ; which make in all 14 cards ; fo that in this example the remainder of the whole ftock is 22 cards, which denotes the number of all the points of the three cards drawn.

The better to colour the artifice, you need not touch a card, but bid him fubtraȼt the number of the points of each of the three drawn cards from 12, the third part of 36, the number of the whole ftock, and add together the three remainders, and tell you the additional fum, which you are to fubtraȼt from 36, and the remainder of that fubtraȼtion is what you look for.

As in this Example—Suppofe he drew a nine, a feven and a fix ; take 9 from 12, there remains 3 ; take 7 from 12, there remains 5 ; and take 6 from 12, there remains 6 ; add the three remainders, 3, 5, 6, the fum is 14, which taken from 36 leaves 22 for the number of the drops of the three cards drawn.

To colour the trick the better, and to apply the rule to a ftock that confifts of fewer or more than 36 cards, fuch as one of 52 cards, make ufe of a number greater than 10, and leffer than 17, the third part of 52 ; for inftance 15 : bid him who drew the three cards add to each of his drawn cards as many other cards as the number of their refpective points is under 15 : for example, if the firft card be 9, he adds to it 6 cards, if the fecond is 7, he adds 8 ; if the third is 6, he adds 9 ; which makes in all 26 cards ; fo that in this example there will remain in the main ftock 26 cards. Taking the main ftock into your hands, and finding you have 26 cards, fubtraȼt from 26 the number 4, which is the excefs of 52, the number of the whole ftock,

above

above the triple of 15+3, *i. e.* 48; and the remainder 22 is the number of all the points of the three cards drawn.

Or elfe you need not touch the cards, but bid the perfon that draws fubtract the number of the drops of each of the three cards drawn, from 16, which is 1 more than the firft number 15, and add together all the remainders, and acquaint you with the fum; then do you fubtract that fum from the number abovementioned, 48, and you will find the remainder to be the number of all the points of the three cards drawn.

For Example—Suppofe he drew a 9, a 7, and a 6; take 9 from 16, there remains 7; take 7 from 16, there remains 9; take 6 from 16, there remains 10; add thefe three remainders, 7, 9, 10, the fum is 26, which fubtracted from 48, leaves 22 for the number of the points of the three cards drawn.

In like manner, in a pack of 36 cards, take a larger number than 10, for inftance 15; and taking notice of the additional cards, which amount to 26, as you faw but now, fubtract that number, 26, from 36, the number of the whole pack, and to the remainder 10 add 12, which is the excefs of the triple of 15+3, *i. e.* 48, above 36, the number of the whole; and you will find the fum 22 to be the number of points enquired after. In a Piquet-pack of 32 cards, inftead of 12 you muft add 16, by reafon that 16 is the remainder of 32 fubtracted from 48.

In imitation of this and the foregoing Sport it will be eafy to folve the queftion upon four or more cards drawn.

SPORT XL.

The Game of the Ring.

THIS is an agreeable game in a company of feveral perfons, not exceeding 9 (unlefs you have a mind to it) in order to the eafier application

I

of

of the 22d Sport, *viz.* by reckoning the firſt per-
ſon 1, the ſecond 2, the third 3, and ſo on ; and
in like manner, reckoning the right-hand 1, the
left-hand 2 ; the thumb of the hand 1, the fore-
finger 2, the third finger 3, the fourth 4, and
the little one 5 ; the firſt joint 1, the ſecond 2,
and the third 3. For if you put the ring to one in
the company, for inſtance, the fifth perſon, and
that upon the firſt joint of the fourth finger of the
left hand, it is evident, that in order to gueſs who
has the ring, and upon which hand, which finger,
and whice joint, one has only theſe four numbers
to gueſs, 5, 1, 4, 2, the firſt number 5 repreſent-
ing the fifth perſon ; the ſecond 1, the firſt joint ;
the third 4, the fourth finger ; and the laſt 2, the
left-hand. Now this is performed by obſerving the
laſt method of Sport 22 foregoing, as appears
from the following operation.

Taking 1 from 10, the double of the firſt num-
ber 5, and multiplying 9, the remainder by 5, you
have 45 ; adding to that the ſecond number 1, you
have 46, to which if you add 5, you have 51 for
a ſecond ſum : the double of this ſecond ſum is
102, from which take 1, there remains 101, which
being multiplied by 5, makes 505, and that with
the addition of 4, the third number, makes 509
to which if you add 5, you have this ſecond ſum
514, the double of this 1028 leſſened by 1, and
the remainder multiplied by 5 makes 5135, to
which adding the fourth humber 2, you have this
ſum 5137, and that augmented by 5 gives this ſe
cond ſum 5142, the four figures of which repreſen
the four numbers inquired for, and by conſequenc
denote that the ring is upon the firſt joint of th
fourth finger of the left hand of the fifth perſon.

PAR

PART II.

Artificial *Fire-Works.*

S P O R T XLI.
To make Silent Powder, or such as may be discharged without a noise.

THIS *unsounding powder*, if any such there is, goes commonly under the name of White Powder, because, possibly, the first made was of that colour. It is not probable it can be of any great force, for as much as the noise of gun-powder proceeds from the violent percussion of the air, occasioned by the strength of it. I have not indeed seen this powder myself, yet I have read in authors several ways of making the same, of which the following two only occur to my memory.

The first is thus. To one pound of common Gun-powder take half as much Venetian Borax, which having pulverised, mixed, and well incorporated together, reduce the mixture into grains, and you have the powder required.

The other way is—To four pounds of common Gun-powder add two pounds of Venetian Borax, one pound of Lapis Calaminaris, and one pound of Sal-armoniac; pulverise them all together, to make of them a powder in grains, as before.

I 2　　　　　SPORT

SPORT XLII.

To prepare an Oil of Sulphur required in Fireworks.

HAVING melted what quantity of Sulphur you think fit, upon a moderate fire, in an earthen or copper veffel, throw into it fome old, or, in defect of this, fome new brick, that is well burnt, and was never wetted, broken into many fmall pieces about the bignefs of a bean; ftir them continually with a ftick, till they have drunk up and confumed all the fulphur; this done, fet them upon a furnace to diftil in an Alembic; fo you fhall have a very inflammable oil, fit for your purpofe.

You may make it otherways thus—Fill one third or fourth part of a glafs-bottle with a long neck with Sulphur pulverifed; then pouring upon it fpirit of Turpentine, or oil of Walnuts, or of Juniper, till the bottle is half full, fet it upon hot cinders, leaving it there eight or nine hours, and you fhall find an oil therein of the abovefaid quality.

SPORT XLIII.

To prepare the Oil of Saltpetre ufeful in Fireworks.

PUT upon a fir-board, well plained and dry, what quantity of purified Saltpetre you pleafe, and caufe it to melt by putting thereupon burning coals; and you fhall fee the liquor to pafs through the board, and to fall down drop by drop, which muft be received in an earthen or copper pot, where you have an oil of Salt-petre, fit to be ufed in fireworks, as we fhall declare in its proper place.

SPORT

SPORT XLIV.

To prepare the Oil of Sulphur and Saltpetre mixed together.

HAVING mixed and well incorporated equal portions of Sulphur and Saltpetre, reduce all into a fine powder, which must be passed through a fine searce; put this powder thus searced into a new earthen pot, or one that hath not been used, and pour upon it good white-wine vinegar, or else brandy, till it is covered. Then cover your pot so that no air may get into it, and set it to stand in some hot place, till all the vinegar is consumed or disappears. Last of all, draw from the remaining matter the oil by means of an Alembic; which will serve to several purposes of Fireworks.

SPORT XLV.

To make Moulds, Rowlers, and Rammers for Rockets of all sorts.

A Rocket, which the French call *Fusee*, the Latins *Rochetta*, and the Greeks *Byrobolos*; consists of a Cartouch or paper tube called the Coffin, and a combustible composition, with which it is loaded; which being fired, mounts into the air, in a manner most agreeable to behold.

There are three sorts of them; the Small, the Middling and the Great. All such are reckoned Small, whereof the diameters do not exceed that of a lead bullet of one pound, or whose moulds admit not a bullet above that weight. The Middleing are those the moulds of which will admit bullets from one to three pounds weight. The Great will carry from a three pound to an hundred pound ball.

To

To determine the bignefs of thefe Coffins to a required meafure, that is, length and thicknefs, and to make any demanded number of them, of the fame reach, and of equal force, they muft be fitted to a concave cylinder, made of fome hard matter, and turned exactly in a lathe: this is called the Mould or Form, which is fometimes made of metal, but moft commonly of hard wood, fuch as Box, Juniper, Afh, Cyprefs, wild Plum-tree, Italian Walnut-tree, and fuch like.

Befides this, there is another but a convex and folid cylender of wood required, called a Rowler, upon which the thick paper, whereof the Coffin is made, muft be rowled, till it is of a bignefs exactly to fill the concavity of the Mould. The diameter of this Rowler muft contain five eighth parts of that of the Mould, the length of which muft be fix times the diameter of its bore, in fmall rockets; but in the middling and the large ones it muft be only five, or four times the length of the diameter of their bore.

Another cylinder of wood muft alfo be had, which is to be a little fmaller than the former, that it may go into the Coffin with the greater eafe. And this is to ferve for a Rammer, to drive down the Compofition into the Coffin when you charge it. But firft your Coffin muft be ftraitened or choaked, which is done by winding a cord about the end of it, after you have a little withdrawn the Rowler, turning in the mean time the Coffin, and drawing the cord, till there remains only a little hole, which then muft be tied with ftrong packthread. This done, you muft draw out the Rowler, and introducing the Rammer into the Coffin, put all into the Mould; and when you have ftruck five or fix blows with a mallet upon the Rammer, to give a good

form

form to the neck of the Rocket, the Coffin is finish-
ed, and ready to be filled upon occasion.

This Rammer must be bored lengthwise to some
depth, that it may receive into its concavity the
Needle which must be in the mould, together with
the Coffin and Rammer, the use of this needle,
which must be one third part of the length of the
Coffin or Mould is to make a vent for the priming
in the bottom of the Composition, of which we
speak in the ensuing Sport.

SPORT XLVI.

To prepare a Composition for Rockets of any size.

THE Composition wherewith the coffins are
to be filled is different according to the dif-
ferent bigness of them ; for it is found by experi-
ence, that what is fit for small rockets, burns too
violently, and too quickly in those that are large,
because the fire is bigger, and the matter also dri-
ven closer together : hence it is that no gunpowder
is used in the larger sort. In making up this com-
position, according to the different sizes of rockets,
the following proportions must be observed.

For Rockets from 60 to 100 pounds, you must
to three pounds of Saltpeter, add one pound of
Sulphur, and two pounds of good Wood-coal.

If they are from 30 to 50 pounds, to 30 pounds
of Saltpeter, put seven pounds of Sulphur, and
sixteen pounds of Coal.

Rockets from 18 to 20 pounds, to twenty one
pounds of Saltpeter, require six of Sulphur and thir-
teen of Coal.

From 12 to 15 pounds, require to four pounds
of Saltpeter one pound of Sulphur, and two pounds
of Coal.

If they be from 9 to 12 pounds; to sixty two

I 4   pounds

pounds of Saltpeter, add 9 pounds of Sulphur, and twenty of Coal.

From 6 to 9 pounds ; add to seven pounds of Saltpetre, one of Sulphur, and two of Coal.

From 4 to 5 pounds; to eight pounds of Saltpetre, add one pound of Sulphur, and two of Coal.

From 2 to 3 pounds ; to sixty pounds of Saltpetre, add two of Sulphur and 15 of Coal.

For one pound ; to sixteen pounds of Gunpowder, add one pound of Sulphur, and three of Coal: or to nine pounds of Powder, four of Saltpetre, one of Sulphur, and two of Coal.

For twelve ounces ; put to nine pounds of powder, four of Saltpeter, one of Sulphur, and two of Coal.

For eight ounces ; add to thirty pounds of Powder, twenty four of Saltpetre, three of Sulphur, and eight of Coal.

For five and six ounces ; to thirty pounds of powder add twenty four pounds of Saltpetre, three pounds of Sulphur, and eight pounds of Coal.

For four ounces; add to twenty four pounds of powder, four pounds of Saltpetre, two pounds of Sulphur, and three pounds of Coal.

For two and three ounces ; to twenty four pounds of powder, put four pounds of Saltpetre, one pound of Sulphur, and three pounds of Coal.

For an half ounce, and an ounce ; take fifteen pounds of Powder, and two pounds of Coal.

For the smaller Rockets : to nine or ten pounds of Powder, add one pound, or one and a half of Coal.

Here follow also other proportions, which experience
hath taught to succeed extremely well.

For Rockets that contain one o two ounces of matter. Add to one pound of Gunpowder, two
ounces

ounces of good Coal : or, to one pound of Musket-powder, take one pound of coarse Cannon-powder : or, to nine ounces of Musket-powder, put two ounces of Coal : or to one once of Powder, an ounce and a half of Saltpetre, with as much Coal.

For Rockets of two or three ounces ; add to four ounces of Powder, one ounce of Coal : or to nine ounces of Powder, two ounces of Saltpetre.

For a Rocket of four ounces; add to four pounds of Powder, one pound of Saltpetre, and four ounces of Coal, and if you please half an ounce of Sulphur: or to one pound two ounces and an half of Powder, four ounces of Sulphur, and two ounces of Coal : or to one pound of Powder, four ounces of Salpeter, and one ounce of Coal ; or to seven ounces of powder, four ounces of Saltpetre, and as much Coal : or, add to three ounces and an half of Powder, ten ounces of Saltpetre, and three ounces and an half of Coal. The composition will be yet more strong, if it be made up of ten ounces of Powder, three ounces and an half of Saltpetre, and three ounces of Coal.

For Rockets of five or six ounces, take two pounds five ounces of Powder, to half a pound of Saltpetre, two ounces of Sulphur, six ounces of Coal, and two ounces of Filings of Iron.

For Rockets of seven or eight ounces ; add to seventeen ounces of Powder, four ounces of Saltpetre, and three ounces of Sulphur.

For Rockets from eight to ten ounces ; to two pounds five ounces of Powder, put half a pound of Saltpetre, two ounces of Sulphur, seven ounces of Coal, and three ounces of Filings.

For Rockets from ten to twelve ounces; take to seventeen ounces of Powder, four ounces of Saltpetre, three ounces and an half of Sulphur, and one ounce of Coal.

For

For Rockets from fourteen to fifteen ounces, t
two pounds four ounces of Powder muft be added
nine ounces of Saltpetre, three ounces of Sulphui
five ounces of Coal, and three ounces of File duft

For Rockets of one pound, to one pound (
Powder, take one ounce of Sulphur, and thre
ounces of Coal.

For a Rocket of two pounds, add to one poun
four ounces of Powder, twelve ounces of Saltpetr(
one ounce of Sulphur, three ounces of Coal, an
two ounces of File-duft of Iron.

For a Rocket of three pounds, to thirty ounce
of Saltpetre, put feven ounces and an half of Su
phur, and 11 ounces of Coal.

For Rockets of four, five, fix, or feven pound
add to thirty one pounds of Saltpetre, four poun(
and an half of Sulphur, and ten pounds of Coal.

For Rockets of eight, nine, or ten pounds, tal
to eight pounds of Saltpetre, one pound four oui
ces of Sulphur, and two pounds twelve ounces (
Coal.

The proportion of the different materials bein
thus determined, each of them muft be well beate
and fearced apart, and afterward weighed an
mixed. Thus is your Compofition ready wher(
withal to charge your Coffins, which muft be mac
of ftrong paper well pafted.

S P O R T XLVII.

To make a Rocket.

YOUR Coffins and different Compofitions beir
in readinefs, you muft chufe a Compofitic
fuitable to the largenefs of your defigned Rocke
which muft neither be too wet nor too dry, but
little moiftened with fome oily liquor, or with brai
dy; then take your Coffin, the length of whic

muſt be proportioned to the bigneſs of its concavity; put it, with the Rammer, into the Mould; then put into it ſome of your Compoſition, taking good care not to put in too much at a time, but only one ſpoonful or two; then put in your Rammer and with a Mallet ſuited to the bigneſs of the Coffin, ſtrike three or four ſmart blows directly upon it; then withdraw the Rammer again, and pour in an equal quantity of your Compoſition, and drive it down in like manner with your Rammer and Mallet, giving the ſame number of blows; continue thus doing till the coffin is filled to the height of the Mould, or rather a little below it, that five or ſix folds of the paper may be doubled down upon the Compoſition thus driven into the Coffin, which ſometimes inſtead of paper is made of wood.

The Coffin being filled with the mixture, and the paper doubled down upon it, you muſt beat it hard with the Rammer and Mallet to preſs down the folds of the paper, upon which you may put ſome Corn-powder, that it may give a report. In this paper folded down, you muſt make three or four holes with a bodkin, which muſt penetrate to the Compoſition, to ſet fire to the Stars, Serpents, and Ground-rockets, when ſuch there are; otherwiſe it will ſuffice to make one hole only, with a broach or bodkin, which muſt be neither too ſmall nor too great, but about one fourth of the diameter of the bore, as ſtraight as poſſible, and in the very middle, in order to fire the Corn-powder.

SPORT XLVIII.

To make Sky-Rockets that mount into the air with ſticks.

IT is to be noted, that the Head of a Rocket, is the higheſt end, by which it is loaded, and which riſes firſt when it is fired: the Neck of the
Rocket,

Rocket, or its Tail, is the lower end, where it w
choaked or ftraightened, and the priming is pu
which muft be of good Corn-powder.

Your Rocket being charged, as was taught in th
preceding Sport, you muft have a long rod or ftick
of fome light wood, fuch a Ofier, or Fir, whic
muft be bigger and flat at one end, growing flen
derer towards the other. This ftick muft be ftraigh
and fmooth, without knots, and plained if need
be. Its length and weight muft be proportioned
to the fize of the Rocket, being fix, feven, o
eight times the length of it; to the larger end o
this, where it is flatted, you muft tie your Rocket
its Head reaching a little beyond the end of th
ftick, and being thus fixed, lay it upon your finger
two or three inches from the neck of the Rocket
which fhould then be exactly balanced by the ftick
if it is rightly fitted; after which you have nothing
to do, but to hang it loofly, upon two nails, per-
pendicular to the horizon, with its head up, and
then it is ready for firing. But if you would have
it to rife very high, and in a ftraight line, you
muft put a pointed paper cap upon its head, and it
will pierce the air with greater facility.

To thefe Rockets, for the greater diverfion of the
fpectators, feveral other things may be added: as
Petards or Crackers, thus; get a box of iron folder-
ed, of a convenient bignefs, fill it with fine grain-
powder; put it into the Coffin upon the compofiti-
on, with the touch-hole down, double the reft of
the paper upon it to hold it faft till the mixture is
confumed, and then firing it will give a report in
the air.

You may add to them likewife, Stars, Golden-
rain, Serpents, Fire-links, and other fuch agreeable
works, the making of which fhall be taught after-
wards. In order to this, you muft have in readi-
                                                    nefs

nefs an empty Coffin, of a larger diameter than your Rocket. This muft be choaked at one end, fo as only to admit the head of the Rocket, to which it muft be faftened. Into this large Coffin, having firft ftrewed the bottom of it with Meal-powder, you muft put your Serpents, or Golden-rain, or Fire-links, with the primed end downwards; and a-mongft, and over your ftars you muft throw a little powder. Then you may cover this additional Coffin with a piece of paper, and fit to it a pointed cap as before, to facilitate its afcention.

SPORT XLIX.

To make Sky-Rockets which rife into the Air with-out a ftick.

SKY-Rockets without Sticks muft be fmall, be-caufe they are held in the hand, from whence they rife, after you have put fire to the prim-ing they are made as the foregoing; but that they may the better fly into the air, you muft fit to them four wings difpofed Crofs-wife, like the fea-thers of darts or arrows; their length muft be one third part of that of the rocket, their breath at the lower part half their length, and their thicknefs about a fixth or eight part of the diameter of the orifice of the rocket.

Inftead of four of thefe wings, you may ufe three of the fame dimenfions with equal fuccefs; but with this caution, that in placing them upon your rocket the lower ends of them muft be let down below the tail of it the length of one diameter of its orifice. There are many other ways of making thefe rock-ets, according to the various fancies of artifts, which would be too tedious for this work.

If the Compofition for your Rockets is defective, as is known when they rife, either not at all, or

with

with difficulty, or fall down again before co
fumption of the mixture; or when they mount n
with an equal and upright motion, but turning ar
winding, or whirling in the air; to amend yo
compofition, you muft diminifh the quantity
coal when it is too weak, and add to it if too ftron
as it is when it burfts the rocket, the coal fervin
to abate the force of the powder, and to give
fine train to your rocket. Wherefore it would b
convenient, before you make up a quantity of rock
ets, to try your mixture and correct its faults.

To preferve your rockets in good condition, the
muft be kept in a place neither too dry, nor to
moift, but temperate; and the compofition fhoul
not be made up, but upon occafion to ufe it. You
rocket muft not be pierced, till you defign to play
it; which muft not be in a feafon of wind or rain
or when the nights are moift with fogs and mifts
all which are prejudicial to the agreeable effects o
a rocket.

If you would have your rocket to burn with a pal
white flame, mix fome Camphire with your com-
pofition; inftead of which if you take rafpings o
Ivory, the flame will be of a clear filver-colour, but
fomewhat inclining to that of lead; if Colophony
or Grecian-pitch, it will be of a reddifh copper-
colour; if black or common pitch, the flame will
be dark and gloomy; if Sulphur, it will be blue;
if Sal-armoniack, it will appear greenifh; if crude
Antimony, or the rafpings of yellow Amber, it will
emit flames of a like colour.

SPORT L.

To make Ground Rockets, which run upon the earth.

ROckets that run along the Ground, called there-
fore Ground-rockets, require not fo ftrong a
compo-

compofition, as thofe that mount into the air; and therefore continue longer, burning as well as moving more flowly: Wherefore they vary from the others, as well in the demenfions of their Coffins, as in the compofition wherewith thefe are charged. The length of the bore or concavity, may be eleven times that of its diameter; the rowler on which the coffin is made, may be five lines in diameter, and the rammer a little lefs, that it may go cafily into the coffin without fpoiling it.

The Compofition may be of cannon powder only, well beaten and fearced till it is as fine as flower, wherewith you muft fill the coffin, by little and little as before, within a finger's breath of the brim of the mould; then doubling down one third part of the paper, knock it down with the rammer and mallet, and after with a bodkin, make a fmall hole which may penetrate to the compofition; then put in a piftol-charge of fine powder, doubling down fome more of the paper upon it, the reft of which muft be choak'd tying it hard with pack-thread.

Thefe rockets being fmall are charged only with powder finely pulverized, without any coal, herein differing from the large ones, that have no powder at all, except in their priming, which in both forts muft be of well grained powder: The reafon of which is, becaufe in a greater concavity there is a greater fire acting upon a greater quantity of matter, and confequently with more violence; there being alfo a greater quantity of air to be rarified in a great than in a fmall rocket.

When you choak or ftraighten the end of your Rocket, whether fmall or great, you muft have a hook or ftaple driven into a poft, or into a wall, to this tie one end of your cord, which muft be of a fize proportionable to your rocket, or to the bar of

a win-

a window, and the other to a ftrong ftick, which you maft put between your legs : thus the cord being winded about your rocket in the defigned place, you may draw, turning, and ftraightning it by degrees as you defire.

SPORT LI.

To make Rockets that fly on a line, called Air-Rockets.

THIS is done with ordinary rockets that muft not be too big, by faftening to them two iron rings, or, which in my opinion is better, a wooden pipe or cane, thro' which muft pafs a well ftretched line : thus if you fet fire to your rocket, it will run along the line without ceafing till all the matter is fpent.

If you would have yonr rocket to run back, as well as forward, after you have filled one half of the coffin with the compofition, feperate this from the empty half by a wheel of wood fitted exactly to the cavity; in the middle of this wheel muft be a hole, from which a fmall pipe, filled with meal-powder, muft pafs along the middle of the empty half, which then muft be filled with the compofition; and fo after the firft half of the rocket is confumed, the fire being communicated by the little pipe, will light it at the other extremity, and fo drive it back to the place from whence it came.

The fame thing may be effected by the means of two rockets tied together, the tail of the one to the head of the other, one of which being burnt to the end fires the other, making it to run back : but leaft the fecond fhould catch fire at the head, it muft be defended with a cover of paper or waxed cloth.

This fort of rockets is commonly ufed to fet fire to other machines in fire-works for diverfion, to
which,

which, for the greater pleasure, they give the figures of several animals, such as serpents or dragons, which then are called Flying Dragons ; and are extreme-ly agreeable, chiefly when filled with several other works, as golden rain, hairs dipt in wild-fire, small nut shells filled with the rocket compofition, and many other diverting things, of which afterwards.

SPORT LII.

To make rockets that burn in the water, called Water-Rockets.

THO' the fire and water are oppofite elements mutually deftroying one another ; yet the rockets we have hitherto difcribed, being once lighted will continue to burn even in the water, and will have their full effect ; but for as much as it is done under water, we are deprived of the pleafure of beholding it. In order therefore, to make them to fwim upon the water, we muft alter fomewhat the proportions of their mould, as well as the materials of their compofition.

The mould, then, required to fuch rockets, may be eight inches in length, and its bore an inch over. The rowler muft be of nine lines diameter, and the rammer not quite fo thick : no needle is required to this mould.

The compofition, if you would have your rocket burn on the water with a clear flame like a candle, muft be made of three ounces of powder beaten and fearced, one pound of falt-petre, and eight ounces of fulphur mixed together : when you defire your rocket to appear on the water with a fine tail, you muft, to eight ounces of common powder, add one pound of falt-petre, eight ounces of fulphur, and two ounces of coal.

The compofition being prepared, and the coffin charged with it, as is taught above, put a fire-link

K

at the end of it ; and covering your rocket with wax, pitch, or rofin, to preferve the paper from the water, faften to it a ftick of white willow about two foot long, which will caufe it to fwim upon the water.

Many other different ways may fuch rockets be made without altering either the mould or compofition, for which the curious may confult the authors that have writ particular treatifes of Pyrotechny.

A rocket alfo may be made, which, after burning fome time in the water, will throw up into the air fparkles and fttars ; which is done by dividing the rocket into two parts with a wooden wheel having a hole in the middle, one partition being filled with the common compofition, the other with ftars, having fome powder ftrewed amongft them.

Moreover you may contrive a rocket, which, having buint one half of its time in the water, will mount up in the air with great fwiftnefs ; thus : having filled two equal coffins with good compofition, paft them together flightly only at the middle, the head of the one anfwering the tail of the other ; betwixt them muft pafs a little pipe at the extremity, to light the other, when one is confumed. Then faften the rocket to which the other is joined, to a ftick of fuch length and bignefs as is required for balancing it, and to the lower end of the rocket tie a pack-thread, to which you muft faften a large mufket-ball that muft hang upon the ftick by means of a bent wire. This done fet fire to your rocket, it being in the water : and its compofition being confumed, will light, by means of a little pipe, the other rocket, which will mount into the air, through the ftrength of the fire, the firft being kept down by the weight it fuftains.

SPORT

S P O R T LIII.

To make Fire-Links.

A *Fire-Link*, fo called from its refemblance to the links of a faucidge, is a kind of Rocket, that is ufually tied to the end of a bigger one, to render the effect more agreeable. I faid, ufually, becaufe there are fome of them made that fly into the air as Sky-rockets, and are called Flying Fire-links, to diftinguifh them from the others which are named fixed Fire-links. We fhall here briefly teach the making of both forts.

And firft the fixed kind to be faftened to a Rock-et is made thus: Take a coffin of what bignefs you think fit, and having choaked it at the end, fill it with fine Powder, and choak it at the other end: then roll it ftrongly with fmall cord from one end to the other, gluing the cord with good glue, to keep it faft, and to ftrengthen the Coffin, that it may give the greater noife when it breaks : thus is your fire-link ready to be faftened to the end of a Rocket, either with paper, parchment, or cord, or otherwife ; but note, that you muft pierce the end of your Fire-link, which joins to the Rocket, and prime it with Corn-powder.

To make flying Fire-links, you muft have fuch Coffins as for the former, only they muft be a little longer, and having choaked them at one end, charge them with corn-powder, adding at laft meal-powder to the thicknefs of one inch, driving all down, as in fky-rockets, with a mallet. Then ftrengthen the coffin with a line, as in the former, after you have choaked the other end, leaving a hole about the bignefs of a goofe-quill, to which you muft put a little moiftened powder for priming.

Or, having choaked at one end, and charged your coffin within one inch of the other end, choa

it there, leaving only a fmale hole, which if quite
fhut up, or too fmall, muft be opened with a
bodkin ; then fill up your empty fpace with powder
finely flowered, or with the compofition for fky-
rockets, which muft be driven clofe with a rammer
and mallet, doubling down the remaining paper,
if any, upon your compofition, which will give a
fine tail to your link ; and when you have made a
hole in the middle of this laft paper, and primed
it, your flying link is ready to be thrown into the
air, which is done thus.

You muft provide guns or cannons with a vent at
bottom, where there muft be a tail fomewhat long,
which muft pafs through a piece of wood, that it
may reach to a fire-conveyance running along un-
derneath, to fet fire to the cannons one after ano-
ther, which will alfo throw up into the air the
links with a noife in the fame order.

SPORT LIV.

To make Fire-Lances.

LANCES of fire, are long and thick pipes
or cannons of wood, with handles at the end,
whereby they are made faft to ftakes or pofts, well
fixed, that may fuftain the force of the fire, having
feveral holes to contain rockets or petards. They
are ufed in feftival Fireworks that reprefent noctur-
nal fights, as well for throwing rockets, as making
vollies of reports.

You muft ufe them thus—Put a Rocket into every
hole, and fill the bore of the cannon with Compo-
fition, which fired will, as it confumes, fire the
Rockets one after another, and throw them up in-
to the air. But if you would have many thrown
up at once, cover the bottom of the Lance with
compofition, and thereupon place a long fmall pipe
filled

filled with the fame compofition, about which put your Rockets, till you have filled your cannon, the primed end being downwards, that fo firing the compofition in the pipe, this may light that at the bottom of the Lance, which firing the Rockets, they will mount all at once into the air.

There may be many other ways of contriving Fire-lances in imitation of this, of which I fhall not fpeak: I fhall only mention one other fort of thefe Lances. This confifts of a Coffin made of ftrong paper well glued, which may be of what dimenfions you think fit, according as it is defigned to give more or lefs light; this muft be filled with the Star-compofition, pulverifed and primed with Meal-powder moiftened: the lower end muft be ftopped with a round piece of wood, which muft appear two inches without the coffin, that thereby it may be faftened at pleafure.

Remark. The name of fiery or burning Lances, and Pikes, is alfo given to a kind of pikes like a javelin or dart, with a ftrong iron-pointed head, called by the Latins *Phalorica*, and *Dardi di Fuoco* by the Italians, which were formerly thrown, being firft fired againft the enemies, either by the hand or from engines, being covered between the iron and wood with tow dipt in fulphur, rofin, Jews' pitch, and boiling oil; where they lighted they ftuck, fetting on fire whatever was inflammable.

This fort of Lances is not now in ufe, but inftead of them we have Buruing Arrows, that are not lefs terrible, though not much now in efteem; however, we will here gratify the curious with a brief defcription of them. Flaming Arrows are artificial firebrands thrown amongft the enemies' works, to reduce them to afhes: they are made thus—Prepare a little bag of ftrong courfe cloth,

about

about the bignefs of a goofe's or fwan's egg, of a globular or fphæriodal figure, which muft be filled with a compofition made of four pounds of beaten Powder, as much refined Saltpetre, two pounds of Sulphur, and one pound of Grecian Pitch : or you may make it of two pounds of Meal powder, eight pounds of Saltpetre refined, two pounds of Sulphur, one pound of Camphire, and one pound of Colophony : or yet more fimply thus—of three pounds of powder, four pounds of Saltpetre, and two pounds of Sulphur. With one of thefe mixtures fill the bag, preffing it hard, and make an hole through the middle of it lengthwife, to receive an arrow, like thofe of the ordinary bows or crofs-bows, the head of it remaining without the bag, which muft be faftened fo as it may not move or flide towards the feathers. This done, roll your bag with ftrong packthread as thick as poffible from one end to another, and then cover it all over with Meal-powder mixed with melted pitch. Thus it is ready to be fhot out of a bow or crofs-bow, after it is fired by two little holes made for that purpofe near the head of your arrow.

SPORT LV.

To make Stars for Sky-rockets.

STARS are little balls about the bignefs of a mufquet-bullet, or an hazle-nut, made of an inflamable compofition, which gives a fplendid light, refembling that of ftars, from whence is the name. When they are put into the rocket, they muft be covered with prepared tow, the manner of making which fhall be taught, after that of ftars.

They are made thus : to one pound of powder finely flowered, add four pounds of falt-petre, and two pounds of fulphur ; and having mixed all very well, roll up about the bignefs of a nutmeg of this

mixture

mixture in a piece of old linnen or in paper; then tie it well with pack-thread, and make a hole through the middle with a pretty big bodkin, to receive fome prepared tow, which will ferve for priming: this being lighted, fires the compofition, which emiting a flame through both holes, gives the refemblance of a pretty large ftar.

If inftead of a dry compofition, you ufe a moift one in form of pafte, you need only roll it into a little ball, without wrapping it up in any thing, fave, if you will, in prepared tow, becaufe of itfelf it will preferve its fpherical figure; nor needs there any priming, becaufe while moift you may rowl it in meal-powder, which will ftick to it, and when fired will light the compofition, and this at falling forms itfelf into drops.

Remark. There are many other ways of making ftars, too long now to be mentioned; I fhall only here fhew how to make Stars of Report, that is, ftars that give a crack like that of a piftol or mufqnet, as follows.

Take fmall links, made as is taught in Sport 53. which you may choofe either to roll with line or not; tie to one end of them, which muft be pierced, your ftars if made after the firft manner, that is, of the dry compofition: otherwife you need only leave a little piece of the coffin empty beyond the choak of the pierced end, to be filled with moift compofition, having firft primed your vent with grain-powder.

You may alfo contrive ftars, which, upon confumption of the compofition, may appear to be turned into ferpents, a thing eafy to be performed by fuch as underftand what precedes; upon which account, and becaufe they are but little in ufe, I fhall fay no more of them.

K 4   SPORT

SPORT LVI.

To make prepared Tow for priming to Fire-works.

PRepared Tow, called alſo Pyrotechnical Match, and Quick-match, to diſtinguiſh it from Common Match, is uſed for priming all ſorts of machines for Fire-works of diverſion, ſuch as rockets, fire-lances, ſtars, and the like ; and it is made as follows.

Take thread of flax, hemp or cotton, and double it eight or nine times, if it is for priming your large rockets, or fiery lances; but four or five times only, if it is to be put through your ſtars. Having made it of a bigneſs proportioned to your deſigned uſe, and twiſted it, but not too hard, wet it in clean water, which muſt be after ſqueezed out with your hands. Then put ſome gun-powder in a little water, ſo a to thicken it a little ; in this ſoak your match well, turning and ſtiring it till it is thoroughly impregnated with the powder ; and then taking it out rowl it in ſome good powder duſt, and hang it upon lines to dry either in the ſun or ſhade: thus you have a Pyrotechnical Match ready for uſe on all occaſions.

Common Match, called alſo Fire-cord, is thus made : Take an unglazed earthen pot ; cover its botom with red ſand well waſhed and dryed ; upon this lay ſpiral-wiſe plain match of cotton, or well-cleaned tow, half an inch thick, the diſtance of half an inch being between each revolution, and then cover it with ſand ; upon which again place a lay of maich as before, and upon this another of ſand, and ſo interchangeably till the pot is full, but finiſhing always with a lay of ſand: then cover it with an earthen cover, and lute with clay the joining, ſo as no air may get entrance. This done put burning coals round the pot, and after it has been

kept

kept hot for some hours, let it cool of itself; so your match is prepared, which will burn without smoak or offensive smell.

SPORT LVII.

To make Golden-rain for Sky-rockets.

THERE are some sky-rockets, which in falling make little waves in the air, like unto hair half curled, and are therefore called Hairy-Rockets; they end in a sort of rain of fire, called Golden Rain. 'Tis thus made.

Fill with the composition for sky-rockets goose-quills, the feathers being cut off; putting some wet -Powder in the open end of each, both to keep in the composition, and to serve for priming : with these fill the head of your sky-rocket, and it will end in a golden rain very agreeable to behold.

Remark. This golden-rain calls to my mind a Pyrotechnical Hail, so called from its resemblance to the natural, which is a quantity of small hard bodies, being either pieces of flint, round stones, leaden bullets, or square pieces of iron, inclosed in a catridge of wood, iron, or copper, and is therefore called Catridge or Case-shot ; they are used in war, either in open field to disorder an enemy's army, or in a siege to drive them away from a breach or gate to be seized, being shot either out of a mortar, or a great-gun of a large bore.

SPORT LVIII.

To represent with Rockets, several figures in the air.

IF you take a rocket of the larger sort, and place round the head of it many small ones, fixing their sticks all round the large coffin upon the head of your big rocket, which uses to contain the head works, ordering it so, that your small rockets take

take

fire whilft the great one is mounting up, you will have the refemblance of a tree, very delightful to the fight; whereof the big one will reprefent the trunk, and the little ones the branches.

But if the fmall rockets take fire when the great one is half turned in the air, they will have the appearance of a comet: and when the large one is altogether turned, fo that its head paints downwards to the earth, they will exhibit the fimilitude of a fountain of fire.

If you put on the head of a large rocket many goofe-quills, the feathers being cut off, filled with fky-rocket compofition, as in the preceding fport; when fired, they will appear to thofe under them as a fine fhower of fire; but to thofe who view them on one fide, like half curled hair, very delightful to the view.

Finally, with ferpents tyed to a rocket with packthread by the ends which are not fired, leaving two or three inches of the thread between each, you may reprefent at pleafure feveral forts of figures moft entertaining and agreeable to the fight.

SPORT LIX.
To make Fire-Pots for fireworks of diverfion.

A Pot of fire is a large Coffin filled with Rockets that take fire all together, and are difcharged from the Pot without hurting it. The bottom of the Pot muft be covered with Powder-duft, which being fired by a match that muft pafs through a hole in the middle of the Pot, will fet fire to all the Rockets at once.

When there are many Fire-pots, they muft be covered with fingle paper, that they may not play all at once; otherways, one when fired might fet fire to another; and you muft ufe only a fingle leaf of paper, that it may not hinder the Rockets to fly out. Pots of Fire are alfo made for war-fervice.

SPORT

SPORT LX.

To make Shining-balls for diversion, and for service in war.

FIRST, to make shining balls for recreation: to four pounds of salt-petre, put six pounds of sulphur, two pounds of crude antimony, four pounds of colophony, and four pounds of coal: or, to two pounds of salt-petre, take one pound of sulphur, as much antimony, two pounds of colophony, as much coal, and one pound of black pitch; melt these, being well beaten, in a kettle, or in a glazed earthen pot, and thereinto throw such a quantity of hards of flax or of hemp, as will just suffice to imbibe all the liquor, of which as it cools make little pellets or round balls, to be covered over with prepared tow, which I taught to make in Sport 56 and after put into sky-rockets, or balls for eiverfion, as is usual to be done with fiery stars.

Next, to make Shining or Flaming-balls for service in war, to be thrown from a mortar, against the enemy, you must melt in a kettle, or glazed earthen pot, as above, equal parts of sulphur, black pitch, rosin, and turpentine, into which dip an iron, or stone bullet, somewhat lower than the bore of the mortar, and when its surface is covered with this matter, rowl it in corn-powder: which done cover it over with calico, and dip it again into the same liquor; rolling it after in grain powder; this must be reiterated several times, covering, dipping, and rowling it, till it fills exactly the bore of the mortar or cannon, into which you design to put it, remembering still to end your operations with rolling it in grain-powder, that being put into your piece, immediately above the charge of the powder, it may take fire as it is thrown into the air against the

<div align="right">enemy</div>

enemy, either to annoy them, or to difcover their defigns, which is ufually done in fieges.

Inftead of thefe fhining-balls, red-hot-balls are more frequently ufed for offending the enemy, by burning them, their houfes, or works. Thefe bullets are of iron, and being hated red-hot in a furnace are thus ufed. Your cannon being charged with powder, freed from corns, and pointed fomething upwards, you muft have in readinefs a cylinder of wood fitted exactly to its bore, which you muft put into your gun next the powder, and upon it you muft ram down a wad of wet ftraw, hay, or tow of hemp, or fome fuch moift materials : then putting in your red-hot-ball with a ladle, immediately put fire to your gun.

S P O R T LXI.

To make a Wheel of Fire-works.

A Wheel of Fire, or Fire-works, is a wheel of light wood, fet round with rockets of a midfize, the head of one regarding the tail of another, that when the firft is fpent, it may fet fire to the next, which makes the wheel turn round its fixed axel-tree without intermiffion, till all the rockets are confumed.

Upon this account it is called a Fire-wheel, and it is alfo called a *Fiery Sun*, becaufe placed horizontally upon a ftake fomewhat large and perpendicular to the horizon, it turns round, and reprefents a fun in night combats, which is very diverting.

You may alfo make fire-wheels which have a fituation perpendicular to the horizon, and turn upon an axis parellel to it, very agreeable to behold. Fire-wheels are likewife ufed to light other works at a diftance, in afcending or defcending upon a ftretched rope, like flying-dragons ; and on

many

many other occasions, to the pleasure of the Spectators.

SPORT LXII.

To make a Balloon, or fiery Foot-ball.

BALLOONS are coffins of a large diameter, shot out of a mortar whither one pleases, filled commonly with Serpents about the thickness of a Ground-rocket, but not so long, with two small Firelinks of the same length and breadth, which being fired by their priming, burst the Coffin, this having below a fire-conveyance, at the mouth of which there is a priming of cotton dipt in Powder.

The Coffin is made with a thick wooden Rowler, about which is rowled strong card-paper, glued to keep it from undoing, which being choaked below, a hole is made there for a fire conveyance, filled with a Composition more flow than that of Ground-rockets, being like to that of Sky-rockets: after this it may be filled with Serpents, and sometimes with Stars, and then choaked above.
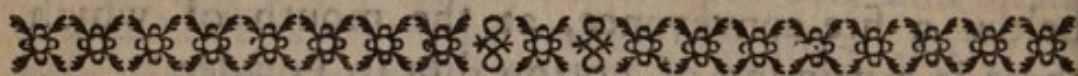
SPORT LXIII.

To make an Ointment excellent for curing all sorts of burnings.

BOIL, over a gentle fire, in common water, Hogs' Lord, or the fat of fresh Pork, skimming it perpetually till no furthe scum arises; then expose it thus melted to cool in the clear open air three or four nights. After this melt the same lard or grease in an earthen vessel over a flow fire, and strain it through a linen cloth into cold water, and after wash it well in fair river or fountain water, to take away its salt, which will make it become white as snow. Finally, being thus purified, put it up in a glazed earthen vessel, to be kept for use upon occasion.

If

If it falls out, as commonly it happens, that by a burning, blisters rise upon the skin, they must not be cut or broken, till the ointment has been used to it for three or four days. You may also use the following, which you will find to be of great efficacy, and is made of Hogs' Lard melted and mixed with two drams of the water of Nightshade, and one dram of Oil of Saturn; or with two ounces of Juice of Onions, and one ounce of Oil of Walnuts.

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PART III.

Miscellaneous SPORTS.

SPORT LXIV.

To describe an artificial lantern, by which one may read at night at a great distance.

MAKE a lantern in the form of a cylinder or of a small cask laid on one side; put in one of its two ends a concave parabolic glass, in order to apply to its focus the flame of a wax-candle, the light of which will reflect to a great distance in passing through the other end that ought to be open and will appear with such a splendor, that by it one may read at night very small letters at a great distance, with telescopes; and those who see the light of the candle at a great distance, will take it to be a great fire, which will be still the lighter if the lantern is tinned within, and made in the form of an elypsis.

The

The Magical Lantern.

We likewise make use of such a glass for a magical lantern, so called, because by means of it we can make any thing appear on the white wall of a dark room; such as monsters and fearful apparitions, which the ignorant impute to magic. The light reflected by virtue of this glass passes through a hole in the lantern, in which there is a lens of glass ; and between them there is a thin piece of wood containing several glasses painted with monstrous and formidable figures, which they move up and down through a slit in the body of the lantern, and which cast their representation to any opposite wall in the same colours and proportions, but much enlarged.

SPORT LXV.

By the means of two plain looking-glasses to make a face appear under different forms.

HAVING placed one of the two glasses horizontally, raise the other to about right angles over the first; and while the two glasses continue in this posture, if you come up to the perpendicular glass, you will see your face quite deformed and imperfect; for it will appear without forehead, eyes, nose or ears, and nothing will be seen but a mouth and a chin raised bold. Do but incline the glass never so little from the perpendicular, and your face will appear with all its parts excepting the eyes and the forehead. Stoop it a little more, and you will see two noses and four eyes; and then a little further, and you will see three noses and six eyes. Continue to incline it still a little more, and you will see nothing but two noses, two mouths and two chins ; and then a little further again and you will see one nose, and one mouth. At last incline a little further, that is, till the angle of

incli-

inclination comes to be 44 degrees, and your face will quite difappear.

If you incline the two glaffes the one towards the other, you will fee your face perfect and intire, and by the different inclinations, you will fee the reprefentation of your face, upright and inverted alternately, &c.

SPORT LXVI.

To defcribe a vertical dial upon a pane of glafs fo as to denote the hours without a gnomon.

I Once made fuch a dial for a friend after the following manner.

I took off a pane of glafs that was foldered on the out-fide to the frame of a window, and calculating the thicknefs of the frame for the gnomon, had the pane glewed on again to the infide of the frame, allotting to the meridian line a fituation perpendicular to the horizon, as it fhould be in vertical dials, and on the outfide, I caufed to be glewed to to the frame oppofite to the dial, a ftrong piece of paper un-oiled, that fo the rays of the fun might penetrate it the lefs, and keep the furface of the dial darker. Then to diftinguifh the hours without a ftyle, I made a little hole in the paper with a pin, over-againft the foot of the ftyle marked upon the dial; and thus the hole reprefenting the tip or end of the ftyle, and the rays of the fun paffing through it, caft upon the glafs a fmall light that pointed out the hours very prettily in the obfcurity of the dial.

SPORT LXVII.

To find in all parts and at all times, the four cardinal points of the world, without feeing the fun, or the ftars, or making ufe of a compafs.

THE four cardinal parts of the world, *viz.* the eaft, the weft, the fouth and the north, are

are eafily found by a compafs, the needle of which being touched with a loadftone, turns always one of its points towards the fouth and the other towards the north, which is enough to direct us to eaft and weft; for when one fets his face to the north, the eaft is on his right and the weft is on his left hand.

The north is eafily diftinguifhed in the night by the ftars, particularly by minding the polar ftar, which is but two degrees diftant from the arctic pole : and in the day-time aftronomers mark the meridian line upon an horizontal plain, by means of the two points of a fhadow marked before and after noon upon the circumference of a circle defcribed from the point of the ftylus, the fhadow of which is made ufe of to fhew by its extremity mpon that circumference two points equally remote from the meridian.

But without all thefe helps you may at all times, and in all parts, find out the meridian line, after the following manner.

Take a platter or bafin full of water, and when the water is fettled and ftill, put foftly into it an iron or fteel needle, fuch as a common fewing needle; and if the needle is dry, and be laid all along upon the furface of the water, it will not fink; but after feveral turns will ftop in the plan of the meridian circle, fo that it reprefents the meridian line; and by confequence one end of it will point to the fouth, and the other to the north : but without feeing the fun or the ftars, it is not eafy to know which of the two ends points to the fouth, and which to the north.

Father Kircher lays down an eafy way of knowing fouth and north. He orders you to cut horizontally a very ftraight tree growing in the middle of a plain at a diftance from any eminence or wall that

L   may

may shelter it from the wind or the rays of the sun: in the section of that trunk you will find several curve lines round the sap which lie closer on one side than the other:

And, as he says, the north lies on that side where the lines are most contracted, perhaps because the cold arising from the north binds up, and the heat from the south spreads and rarifies the humours and matter, of which these crooked lines are formed. These lines, says that author, are as the circumferences of concentrical circles in ebony or Brazil wood.

S P O R T LXVIII.

To break with a stick another stick resting upon two glasses without breaking the glasses.

THE stick that is to be broken must not be very thick, nor yet lean much upon the glasses; it ought, as near as possible, to be equally thick all over, for the easier finding of its center of gravity, which will then be in the middle.

The stick being thus qualified, we lay its two ends, which ought to terminate in a point, upon the brim or edge of two glasses of equal height, so that the stick does not lean to one side or end more than the other, and the two points ends rest but lightly upon the edge of each glass, to the end that when it bends a little through the violence of the stroke, it may easily slip off, and break at the same time. This done, we take another stick, and with that give a smart blow upon the midling point, which being the centre of gravity will receive all the force of the blow; thus will the stick break, and that the more easily that the blow is violent, and fall clear of the two glasses which remain unbroken, because the stick lay but very gently and equally upon the brim of each; for if it rests more upon one glass than

than the other, it will prefs that one moft, and fo may break it.

SPORT LXIX.

To make a lamp fit to carry in one's pocket, that fhall not go out though you roll it upon the ground.

TO make a lamp that never fpills its oil, and never goes out in any pofition whatfoever, make faft the veffel that contains the oil and the match to an iron or brafs ring, with two fmall pivots or hinges diametrically oppofite, that fo the veffel may by its weight continue in æquilibrio round the two hinges and turn with freedom within the circle, fo as to keep always to an horizontal pofiti-on, as in your fea-compaffes, which have two fuch circles to keep them horizontally ; and in like man-ner this firft circle ought to have two other pivots diametrically oppofite, which enter into another circle of the fame fubftance ; and that fecond circle has two other little hinges inferted in another con-cave body that furrounds the whole lamp. Thus the lamp with its two circles may turn freely upon its fix hinges, which give to the lamp when it is turned, fix different pofitions, *viz.* up and down, forwards and backwards, to the right and left, and which ferve to keep the lamp in an horizon-tal pofition, which, being in the middle does always reft upon its center of gravity, that is, its center of gravity is always in the line of direction, which hinders the oil to fpill, turn it which way you will.

SPORT LXX.

To take up a boat that is funk with a cargo of goods.

IF a boat finks in a deep river, you may bring her up again, by getting two other boats, one

empty,

empty, and the other deep loaded with some heavy subftance, as ftones, &c. You muft tie thefe two boats to the boat that is funk with two ropes, and extending the rope of the deep laden boat, unload her into the other that is empty; which will raife the firft boat a little, and make it draw along with it the boat that is under water, and at the fame time make the fecond boat fwim fo much deeper in the water. The fecond boat being thus loaded, you muft bend her roap and unload her again into the empty boat, and thereupon fhe becoming light-er, will rife and draw the boat under water fo far further up. Thus you continue to load and unload till you bring the boat even with the water, and then tow her to the fide.

SPORT LXXI.

To make a boat go of itfelf up a rapid current.

THE more rapid a river is, the eafier it is to make a boat go of itfelf up againft the cur-rent, by a rope and a wheel with its axeltree that has wings like the wings or fweeps of a mill-wheel.

Fix the wheel with its axeltree at the place to which you would have the boat conducted, and let its fweeps be as deep in the water as there is occafion for turning it round: tie a roap to the boat and to the axeltree of the wheel, which turning with its axeltree by virtue of the rapidity of the water, will wind up the rope on its axeltree, and fo by the fucceffive abreviation of the rope, drag it againft the current to the place propofed: which it will reach fo much the fooner that the current is rapid, the rapidity quickening the motion of the wheel.

SPORT

SPORT LXXII.

To know which of two different waters is the lightest, without any scales.

TAKE a solid body, the specific gravity of which is less than that of water, dale or fir-wood, for instance; and put it into each of the two waters, and rest assured that it will sink deeper in the lighter than in the heavier water; and so by observing the difference of the sinking you will know which is the lightest water, and consequently the wholsomest for drinking.

SPORT LXXIII.

To know if a suspicious piece of money is good or bad.

IF it be a piece of silver that is not very thick, as a crown or half crown, the goodness of which you want to try; take another piece of good silver of equal balance with it, and tie both pieces with thread or horse-hair to the scales of an exact balance (to avoid the wetting of the scales themselves) and dip the two pieces thus tied in water; for then if they are of equal goodness, that is, of equal purity, they will hang in æquilibrio in the water as well as in the air; but if the piece in question is lighter in the water than the other, it is certainly false, that is, there is some other metal mixed with it that has less specific gravity than silver, such as copper; if it is heavier than the other, it is likewise bad, as being mixed with a metal of greater specific gravity than silver, such as lead.

If the piece proposed is very thick, such as that crown of gold that Hiero king of Syracusa sent to Archimedes to know if the goldsmith had put into it all the 18 pounds of gold that he had given him

for

for that end; take a piece of pure gold of equal weight with the crown propofed, *viz.* 18 pounds, and without taking the trouble of weighing them in water, put them into a veffel full of water, one after another, and that which drives out moft water, muft neceffarily be mixed with another metal of lefs fpecific gravity than gold, as taking up more fpace though of equal weight.

S P O R T LXXIV.

To know how the wind ftands, without ftirring out of one's chamber.

FIX to the cieling of your room a circle divided into 32 equal parts, with the names of the 32 rumbs or wind-points, the points of north and fouth being upon the meridian line. The circle or dial thus divided, muft have a needle or hand movable round its centre, like the hand of a watch or clock; and that hand mnft be fixed to an axeltree that is perpendicular to the horizon, and may move eafily upon the leaft wind, by virtue of a fane on its upper end above the roof of the houfe, and then the wind turning the fane, will at the fame time turn its axeltree, and the hand that is fixed to it, which will accordingly point to the rumb from whence the wind blows.

S P O R T LXXV.

When two veffels or chefts are like one another, and of equal weight, being filled with different metals, to diftinguifh the one from the other.

THIS fport is eafily performed, if we confider that two pieces of different metals of equal weight in air, do not weigh equally in water: becaufe that of greateft fpecific gravity takes up a leffer fpace in water, it being a certain truth, that any metal weighs lefs in water than in air, by reafon

of

of the water, the room of which it fills. For ex-
ample, if the water weighs a pound, the metal will
weigh in that water a pound lefs than in the air.
This gravitation diminifhes more or lefs according
as the fpecific gravity of the metal is greater than
that of the water.

We will fuppofe then two chefts perfectly like one
another, of equal weight in the air, one of which
is full of gold, and the other of filver; we weigh
them in water, and that which then weighs down
the other muft needs be the gold cheft, the fpecific
gravity of gold being greater than that of filver,
which makes the gold lofe lefs of its gravitation in
water than the filver. We know by experience,
that gold lofes in water about an eighteenth part
only, whereas filver lofes near a tenth part: fo that
if each of the two chefts weighs in the air, for
example, 180 pounds, the cheft that is full of gold
will lofe in the water ten pounds of its weight;
and the cheft that is full of filver will lofe eighteen;
that is, the cheft full of gold will weigh 170 pounds,
and that of filver only 162.

Or, if you will, confider that gold is of a greater
fpecific gravity than filver, the cheft full of gold,
though fimilar and of equal weight with the other,
muft needs have a leffer bulk than the other. And
therefore if you dip feperately each of them into a
veffel full of water, you may conclude that the
cheft which expels lefs water has the leffer bulk,
and confequently contains the gold.

SPORT LXXVI.

To meafure the depth of the fea.

TIE a great weight to a very long cord, or
rope; and let it fall into the fea till you find
it can defcend no farther, which will happen when
the weight touches the bottom of the fea, if the
quantity

quantity or bulk of water the room of which is
taken up by the weight and the rope, weighs lefs
than the weight and rope themfelves ; for if they
weighed more, the weight would ceafe to defcend,
though it did not touch the bottom of the fea.

Thus one may be deceived in meafuring the
length of a rope let down into the water, in order
to determine the depth of the fea; and therefore to
prevent miftakes, you had beft tie to the end of
the fame rope another weight heavier than the for-
mer, and if this weight does not fink the rope deep-
er than the other did, you may reft affured that the
length of the rope is the true depth of the fea : if
it does fink the rope deeper, you muft tie a third
weight yet heavier, and fo on till you find two
weights of unequal gravitation that run juft the fame
length of the rope, upon which you may conclude
that the length of the wet rope is certainly the fame
with the depth of the fea.

S P O R T LXXVII.

To reprefent lightning in a room.

THE room in which you are to reprefent
lightening muft not be large, but quite dark,
and fo very clofe that the air cannot readily enter
it. The room being thus in order, take a bafin
into it with fpirit of wine and camphyr, which muft
boil there till it is all confumed, and nothing left
in the bafin. This will rarify the camphyr, and
turn it into a very fubtile vapour, which will dif-
perfe itfelf all over the room ; infomuch that if any
one enters the room with a lighted flambeau, all
the imprifoned vapour will in a moment take fire,
and appear as lightening, but without hurting either
the room or the fpectators.

Remark. Camphyr is of a nature fo proper to
retain and keep an unextinguifhable fire that it will

burn

burn entirely, and that very eafily upon ice or among fnow, which it melts, notwithftanding their coldnefs; and if it be reduced to powder and thrown upon the furface of any ftill water, and then lighted, it will produce a very pleafant fort of fire, for the water will appear all fire and flame; the reafon of which I take to be, becaufe the camphyr is of a fat nature which refifts water, and of a light and fiery fubftance, which the fire grafps fo keenly that it is impoffible for this fubftance to difengage itfelf when once it is entangled.

SPORT LXXVIII.

To melt at the flame of a lamp a ball of lead in paper, without burning the paper.

TAKE a very round and fmooth leaden ball, wrap it up in white paper, that is not rumpled, but clings equally about the ball without wrinkles, at leaft as far as is poffible; hold the ball thus wrapped up over the flame of a lamp or flambeau, and it will grow hot by degrees, and in a little time melt and fall down in drops through a hole in the paper without burning it.

SPORT LXXIX.

To reprefent an Iris or rainbow in a room.

EVERY one knows that the rainbow is a great arch of a circle that appears all on a fudden in the clouds before or after the rain, towards that part of the air that is oppofite to the fun, by virtue of the refolution of the cloud into rain; this arch is adorned with feveral different colours, of which the principal are five in number, namely red which is outermoft, yellow, green, blue, and violet and purple, which is interior.

This

This Iris feldom appears alone, and is called the firft and the principal rainbow, to diftinguifh it from another that commonly appears along with it, and for that reafon is called the fecond rainbow, the colours of which are not fo lively as thofe of the firft, though they are difpofed after the fame manner, but in a contrary order, upon which account a great many take it for a reflection of the firft.

If you want to reprefent, at one time two fuch Iris's in your room, put water into your mouth and ftep to the window (upon which the fun is fuppofed to fhine) then turn your back to the fun, and your face to the dark part of the room ; and blow the water which is in your mouth, making it fpurt out with violence, into little drops or atoms ; and among thefe little attoms or vapours, you will fee by the rays of the fun, two rainbows refembling the two that appear in the heavens in rainy weather.

Oftentimes we fee rainbows in waterworks or fpouts, when we ftand between the fun and the fountain, efpecially when the wind blows hard, for then it difperfes and divides the water into little drops. Which is full evidence, that the rainbow, which the philofophers admire as much as the ignorant people do thunder, is formed by the reflection and refraction of the rays of the fun darted againft feveral little drops of water, that fall from the clouds in time of rain.

A rainbow may likewife be very eafily reprefented, in a room with a window that the fun fhines upon, by a triangular prifm expofed to the rays of the fun, which in paffing through the glafs, will by their different reflections and refractions produce upon the wall or ceiling of the room, a very agreeable Iris, or at leaft a texture of feveral different colours refembling thofe of the rainbow ; and the further the

ceiling

ceiling or wall is diftant, and the more it is dark, the colours will appear the more charming and lively. You may likewife imitate the colours of the rainbow by expofing to the fun a fphere of cryftal or glafs, or a glafs full of clean water.

SPORT LXXX.

To make a confort of mufick of feveral parts with only one voice.

THE found conveyed diftinctly to the ear, by remote bodies, againft which the air is driven by the voice of an animal or otherwife, and then reflected, is what we call an echo; which is fometimes double, triple, &c. when the voice is ftrong enough to make feveral bodies, at different diftances, beat back at feveral times the parts of the air to our ears, fo that one echo is no fooner ended than another begins.

Though moft eccho's make us hear only the laft words of the voice, becaufe the air, though ftrongly impreffed, has not the fame force at the end that it had at the beginning; yet it may be fo contrived as to make a confort of mufic of feveral parts, that is, a confort of feveral fongs tuned together, by only one voice or one inftrument, to the found of which the eccho anfwers.

For if the echo anfwers only once to the voice or the found of the inftrument, he who fings or plays may make a Duo, that is, a mufic of two parts; and again a Trio or mufic of three parts, if the echo anfwers twice. But indeed he muft be an expert mufician, and one that is well verfed in varying the tune and the note.

Thus commencing, for example at Ut, he may begin Sol a little before the echo anfwers, fo as to finifh the pronunciation of Sol by the time that the eccho has completed its anfwer, and then he will

have

have a fifth, which is a perfect confonance in mu-
fic ; and in like manner, if at the fame time with
the echo's anfwering to the fecond note Sol, or a
little before, he repeats it upon a higher or low-
er note, he will make a diapafon or eighth,
which is perfect harmony in mufic. And fo on, if
he has a mind to continue the chace with the echo,
and fing alone the two parts.

To this purpofe we fee by experience in feveral
churches, when they are finging, that there feems
to be many more parts in the chorus than there
really are, the quantity of echo's making the air to
refound on all fides, and fo multiplying the voice
and redoubling the chorus.

S P O R T   LXXXI.

To make a firing of a vial fhake without touch-ing it.

CHOOSE at pleafure three ftrings in a viol,
or any other inftrument of that fort, without
any intermediating ftring, and tune the firft and the
third to the fame note, without touching that in
the middle ; then ftrike one of the two ftrings thus
tuned pretty hard with a bow, and you will find
that when it fhakes the other will tremble fenfibly
and vifibly, and the middle ftring, though nearer,
fhall ftir no manner of way.

This fport may likewife be refolved by two ftring-
ed inftruments of the fame fort, as two viols, two
lutes, two harps, two fpinets, &c. by putting the
two in the fame tune, and then placing them at a
convenient diftance, and in a proper pofition ; for
one of the two inftruments being touched with a
midling force, will move the other, that is, the
ftrings of the other, which are fuppofed to be in
unifon, will produce fuch another harmony, efpe-
cially if the ftrings in one and the other inftrument

are

are equally long and equally thick. For this I can assign no other reason but experience.

SPORT LXXXII.

To make a deaf man hear the found of a musical instrument.

IT must be a stringed instrument, with a neck of some length, as a lute, a guitarre, or the like; and before you begin to play, you must by signs direct the deaf man to take hold with his teeth of the end of the neck of the instrument; for then if one strikes the strings with a bow one after another, the found will enter the deaf man's mouth, and be conveyed to the organ of hearing through the hole in the palate : and thus the deaf man will hear with a great deal of pleasure the found of the instrument, as has been several times experienced. Nay, those who are not deaf may make the experiment upon themselves, by stopping their ears so as not to hear the instrument, and then holding the end of the instrument in their teeth while another touches the strings.

SPORT LXXXIII.

To make an egg enter a vial without breaking.

LET the neck of the vial be never so strait, an egg will go into it without breaking, if it be first steeped in very strong vinegar, for in process of time the vinegar does so soften it, that the shell will bend and extend lengthways without breaking. And when it is in, cold water thrown upon it will recover its primitive hardness, and, as Cardan says, its primitive figure.

SPORT LXXXIV.

To make an egg mount up of itself.

MAKE a little hole in the shell of the egg, and so take out the yelk and the white, and
fill

fill the egg-fhell with dew, then ftop up the hole and expofe it to the rays of the fun at noon day; for then the dew not being able to bear the light, nor too great heat, will rife up with the egg-fhell, efpecially if it leans againft a little ftick or piece of wood, that flopes never fo little, and if the hole is well ftopped. May dew is faid to be beft; and it is obferved by the farmers, that the more May abounds in dew, the more plentifully does the earth bring forth: for dew being a fubtile vapour produced in the morning by a weak heat, and preferved by a moderate cold, it is very well difpofed for the reception of celeftial virtues; and when it infinuates itfelf into vegetables, it communicates to them the virtues it retains; and hence it comes that plants moiftened with it thrive better, than when they are nourifhed with fpring, well, or river water.

SPORT LXXXV.

To make water freeze any time in a hot room.

FILL a vial with warm water, the neck of which is fomewhat narrow, and having ftopped it clofe, put it in a veffel full of fnow mixed with common falt and faltpetre, fo as to leave the vial covered all over with fnow: and in a little time the water will be quite frozen, though in the fummer time, and in a very hot room.

If you throw cold water with fnow upon a table, and upon the fnow fet a platter full of fnow with a fufficient quantity of falt and faltpetre pounded; the falt and the faltpetre will make the fnow fo cold, that in a little time the water under the platter will be turned to ice, and make the platter ftick fo faft to the table, that you cannot move it without fome difficulty.

Remark. The faltpetre and fal-armoniac are likewife poffeffed of the virtue of making water fo
<div align="right">extremely</div>

extremely cold, that if you put a fufficient quantity of them in common water, it will become fo cold that your teeth can fcarce bear it. They might therefore be very ufefully employed in fummer for cooling wine or any other liquor, by fetting the wine bottles in water thus refrigerated.

If you diffolve a pound of nitre in a pail of water, the water will be exceffive cold, and fo very proper for the ufes above-mentioned. It is well known that wine is cooled with ice ; and in regard ice cannot always be had in fummer, I fhall prefcribe a way of making it.

To make Ice in fummer.

To make ice in fummer, put two ounces of re-fined faltpetre, and half an ounce of florentine Oris, into an earthen bottle filled with boiling water, ftop the bottle clofe, and convey it forthwith into a very deep well, and there let it fteep in the well-water for two or three hours, at the end of which you will find the water in the bottle all ice : fo you have nothing to do but to break your bottle and take out your ice.

SPORT LXXXVI.

To kindle a fire by the fun-beams.

THIS Sport may be performed either by re-fraction in ufing lenticular glaffes thicker in the middle than in the fides, called burning-glaffes, through which when the rays pafs they refract and unite into one point called the Focus, at which you may light a match or any other combuftible matter : or elfe by reflexion, in ufing a concave looking-glafs of metal well polifhed in its conca-vity, which may be either fpherical or parabolic, and is likewife called a burning-glafs, but much better than the former fort ; for by it you may in a moment fet fire to a piece of wood, and in a

short time melt lead, and even iron, and vitrify stone.

SPORT LXXXVII.

To make a fowl roasting at the fire, turn round of itself with the spit.

TAKE a wren and spit it upon a hazel stick, and lay it down before the fire, the two ends of the hazle stick being supported by something that is firm; and you will see with admiration the spit and the bird turn by little and little without discontinuing, till it is quite roasted. This experiment was first found out by Cardinal Palotti at Rome, who shewed it father Kircher, in order to know the physical cause of it; which to my mind is easily discovered, for the hazel wood is composed of several long and porous fibres, into which the heat insinuates itself, and so makes it turn round when the wood is hung right.

SPORT LXXXVIII.

To make an egg stand on its smallest end, without falling, upon a smooth plain such as glass.

PLACE a looking-glass quite level, or horizontally, without inclining to either side; toss the egg with your hand till the yelk bursts, and the matter of it is equally disperced through all the parts of the white, so that the white and the yelk make but one body. Then set the end of the egg upon the horizontal plain, holding it till it is upright, and then it will continue in that situation without falling, by reason of the æquilibrium made on all sides by the parts of the yelk equally mixed with the white, so that the center of gravity in the egg continues in the line of direction.

SPORT

SPORT LXXXIX.

To make a piece of gold or silver disappear, with-
out altering the position of the eye or the piece,
or the intervention of any thing.

PUT the piece of gold in a porringer full of
water, or a veffel that is broader than it is
deep, and let the eye be in fuch a pofition, as juft
barely to fee the piece at the bottom over the brim
of the veffel; then take out the water, and though
the porringer continues in the fame pofition as well
as the eye, the piece which appeared before by vir-
tue of the refraction made in the water, will then
be covered from the fight by the fides of the por-
renger.

SPORT XC.

To make a loaf dance while it is baking in the oven.

PUT into the dough a nutfhell filled with live
fulphur, faltpetre and quickfilver, and ftop-
ped clofe; as foon as the heat comes to it, the
bread will dance in the oven; which is occafioned
by the nature of quickfilver, for it can bear no heat
without being in a continual motion. Thus, by
the means of quick-filver put into a pot where peafe
are to be boiled, all the peafe will leap out of the
pot as foon as the water begins to heat. In like
manner quickfilver put into hot bread, will make
it dance up and down the table.

SPORT XCI.

To see in a dark room what passes abroad.

MAKE your room fo clofe and dark, that the
light can come in no where but through a
little hole left in a window upon which the fun
fhines; over againft this hole, at a reafonable dif-
tance from it, place fome white paper, or a piece

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of

of linen; and you will fee every thing that paffes by the outfide of the window appear on the paper or linen, only their figures are inverted.

SPORT XCII.

To hold a glafs full of water, with the mouth down, fo as that the water fhall not run out.

TAKE a glafs full of water, cover it with a cup that is a little hollow, inverting the cup upon the glafs ; hold the cup firm in this pofition with one hand, and the glafs with the other, then with a jerk turn the glafs and the cup upfide-down, and fo the cup will ftand upright, and the glafs will be inverted, refting its mouth upon the interior bottom of the cup. This done, you will find that part of the water contained in the glafs will run out by the void fpace between the bottom of the cup and the brim of the glafs ; and when that fpace is filled, fo that the water in it reaches the brim of the glafs, all paffage being then denied to the air, fo that it cannot enter the glafs, nor fucceed in the room of the water, the water remaining in the glafs will not fall lower, but continue fufpended in the glafs.

If you would have a little more water defcend into the cup, you muft with a pipe or otherwife draw the water out of the cup, to give paffage to the air in the glafs ; upon which part of the water will fall into the glafs till it has ftopped up the paf-fage of the air afrefh, in which cafe no more will come down ; or, without fucking out the water in the cup, you may incline the cup and glafs fo that the water in the cup fhall quit one fide of the brim of the glafs, and fo give paffage to the air, which will then fuffer the water in the glafs to defcend till the paffage is ftopped again.

This

This Sport may likewife be performed by cover-
ing the brim of the glafs that is full of water, with
a leaf of ftrong paper, and then turn the glafs, as
above ; and without holding your hand any longer
upon the paper, you will find it as it were glewed
for fome time to the brim of the glafs, and during
that time the water will be kept in the glafs.

SPORT XCIII.

*To make new wine keep its fweetnefs for feveral
years.*

MR. Lentin informs us, that if you let new
wine heat by itfelf, it lofes in a little time
all its fweetnefs, efpecially if the cafks are left
open ; but if you boil it upon a fire immediately
after the grapes are preffed, moft of the volatile
principles of the fweetnefs concentrate, and link
themfelves with the more fixed parts of the wine,
which preferves its fweetnefs for feveral years.

Remark. A fweet and new wine may preferve
its fweetnefs at leaft a whole year, if you pitch the
cafk well both within and on the outfide, to hinder
the water to penetrate into it, and fo fpoil the wine,
which ought to be put into it before it boils ; and
keep the cafk well ftopped in a ciftern of water, fo
as to be covered all over for a month or thirty
days ; and then take out the cafk and place it in a
cellar.

In the year 1692, I had a cafk full of Burgundy
wine brought me in the fummer to Paris by water,
which immediately upon its arrival was clapped
into my cellar, and after a few days ftanding, I
found it boiling as if it had been quite new, and
that it had reaffumed its former fweetnefs, which
continued about a month , and after that it proved
extraordinary good wine. Some tell you that a

piece

piece of cheefe or pumice-ftone thrown into the cafk, will break the violence of fermenting wine.

To recover the fweetnefs of new wine.

When the new wine has loft its fweetnefs, it may be recovered by cafking it up immediately, and putting in the bottom of the cafk half a pound of muftard-feed, lefs or more, according to the fize of the cafk.

SPORT XCIV.

To know when there is water in wine, and to fepe-rate it from the wine.

IF the wine is neither fweet nor new, but fine and clear of its lee, you may know, (according to Porta and father Schott) whether it is mixed with water or not, by throwing into it apples or pears, for if the wine is unmixed they will fink to the bottom, if it is mixed they will fwim above, becaufe the fpecific gravity of water is greater than that of wine.

Some order wild apples or pears, and if thefe cannot be had, ripe apples or pears. Others make ufe of an egg, and alledge, that when the wine is pure the egg falls fwiftly to the bottom, but if it is mixed with water, the egg defcends more flowly, the water having, by virtue of its gravity more force to bear up the egg than the wine has.

Now the contrary will happen, if the wine be fweet and new, that is, when fuch wine is unmixed, the egg will defcend flower than when it is mixed; by reafon that new wine unmixed is by virtue of its lee heavier than water, and confequently becomes lighter, by the addition of water.

When you have difcovered that the wine is mixed, you may feperate the water by a dry bulrufh, according to Mizauld; for the rufh being a plant that grows and thrives in watry marfhy places, if it be

dried

dried, and one end of it put into mixed wine, the water will infinuate itfelf into the rufh, and fo the wine will be left alone. By the fame reafon, the rufh may ferve to difcover whether the wine is mixed with water or not.

Remark. On the other hand, fome pretend you may feparate the wine from the water, by putting in a long narrow piece of linen, woollen or cotton cloth, one end of which hangs out of the veffel, as if the wine being lighter would rife and flow out upon the cloth while the water ftays behind ; but this and feveral other ways for the fame purpofe, are difapproved by other authors.

To pour water into wine without mixing.

You may pour wine upon water, without mixing, if you put a toaft of bread upon the water in a glafs, and while this toaft fwims above the water, pour in the wine very foftly ; for then you will fee the water remain unmixed at the bottom of the glafs without any alteration in its colour.

To know if milk is mixed with water.

Here by the bye I fhall fhew you the way of knowing when water is mixed with milk ; put a little ftick into the milk, then pull it out, and let a drop of the milk fall from it upon the nail of your thumb ; and if the milk is pure, the drop being thick will ftand for fome time upon your nail; but if it is deluted with water it will run off im-mediately.

To turn water feemingly into wine.

You may turn water into wine in appearance, by fetting a vial full of water in a cafk full of wine, turning the mouth of the vial downwards ; for then the water will run out, and the vial will be filled with wine ; which the ignorant will take to be a turning water into wine.

M 3 SPORT

SPORT XCV.

To make a metallic body swim above water.

THOUGH the specific gravity of water is inferior to that of metals, and consequently water is uncapable, absolutely speaking, to bear up a metallic body, such as a ball of lead, yet this ball may be flatted and beat out to a very thin plate, which when very dry and put softly upon still water, will swim upon it without sinking, by virtue of its dryness. Thus we see a steel needle will swim upon the water, when it is dry, and laid softly lengthways upon the surfacce of still water.

But if you would have a metallic body to swim necessarily upon water, you must reduce it to a very thin plate, and that concave like a kettle, in which case the air it contains weighs less than the water, whose room it possesses. It is by this contrivance that coppor boats or pontons are made for passing whole armies over rivers without any danger.

Remark. If you put tis concave metallic vessel upon the water, with its mouth perpendicularly down, it will still swim, by reason that the air contained in its cavity finds no exit; insomuch that if you push it under water and hold it there by force, the detained air will keep the bottom from being wet on the inside. And by the same reason you may have a burning coal in the bottom, and find it not extinguished when you take it out of the water, provided you do not hold it long under water, for fire stands in need of air to keep it in.

SPORT XCVI.

To make Aquafortis put up close in a bottle boil without fire.

PUT a small quantity of Aquafortis, and of the filings of brass in a bottle, and you will

see

see so great an ebullition, that the bottle will appear quite full, and be so hot that you cannot touch it without burning yourself.

Remark. In like manner if you mix oil of tartar and oil of vitriol together, you will presently see a very great ebullition with a sensible heat, though neither of these liquors is composed of any combustible matter.

Of *Aquafortis and Aqua Regia.*

Aqafortis is so called with respect to its strength in dissolving almost all metals and minerals. It is commonly a distillation from saltpetre and vitrol or green copperas; and it is yet better, if it be a distillation from saltpetre and roach allum. It dissolves all metals but gold; but is rendered capable of the dissolution of gold by dissolving sal armoniac or sea-salt in it, after which it assumes the name of Aqua Regia.

Of *Sal Armoniac, Roch Allum, and Saltpetre.*

To avoid all obscurity of terms; I shall here acquaint you by the bye, that Sal Armoniac is a composition of bay-salt, chimney-foot, and the urine of animals: That roch allum is a mineral earthy sharp salt, filled with an acid spirit, which is oftentimes found condensated in the veins of the earth, or is taken from aluminous springs by evaporation; or is found among mineral stones, and disengaged from them by dissolution in water and evaporation. And in fine, that saltpetre is a salt that is partly sulphureous and volatile, and partly terrestrial; it is found in the dark cavernous places of the earth, and likewise in stables, by reason of the great quantity of volatile salt in the urine and excrements of animals, which joins in with the salt of the earth by the continual action of the air.

Vitriol.

The oil of Vitriol (mentioned above) is a caustic

M 4

oil

oil diftilled by a ftrong reverberating fire from Vi-
triol. Now, Vitriol is a mineral falt, approaching
to the nature of roach-allum, which is found chryf-
talifed in the earth of fuch mines as abound in me-
tals, which gives us to know that it contains in it
fome metallic fubftance, and particularly iron or
copper. When it is loaded with copper, if you rub
it againft iron, it will ftain it with a copper colour.
But it is beft for all manner of preparations when
it partakes moft of iron.

Tartar.

The oil of Tartar, (mentioned above) is diftilled
from Tartar along with the fpirit, from which it
is feparated by a funnel lined with brown pa-
per. Tartar itfelf is an earthy incorruptible fub-
ftance, formed like a reddifh cruft round the infide
of wine-cafks, which thickens and congeals to the
hardnefs of a ftone, and is feparated from the pure
parts of the wine, by the action of the fermentative
fpirit.

SPORT XCVII.

To make fulminating or thundering powder.

TAKE three parts of faltpetre, two parts of
falt of Tartar, and one part of fulphur, poun-
ded and mixed together; heat in a fpoon 60 grains
of this compofition, and it will fly away with a
fearful noife like thunder, and as loud as a cannon,
breaking through the fpoon and every thing under-
neath it, for it exerts itfelf downwards, contrary
to the nature of gunpowder, which exerts itfelf up-
wards.

Salt of Tartar.

The Salt of Tartar, here ufed, is only a folution
in water of the black fubftance that remains after
the diftillation of the oil of Tartar, and an evapo-
ration of that folution to a dry falt, which muft be
kept very clofe, leaft the moifture of the air fhould
melt it.   SPORT

SPORT XCVIII.

To make the Aurum Fulminans, or thundering gold.

PUT into a matrafs, upon hot fand, the filings of fine gold, with a tripple quantity of Aqua Regia, which will diffolve the gold : mix this folution with a fextuple quantity of fpring water, and then pour upon it, drop by drop, the oil of Tartar or volatile fpirit of Sal Armoniac, till the ebullition ceafes, and the corrofion of the Aqua Regia is over, for then the powder will precipitate to the bottom, which may be dulcified with warm water, and dried with a very flow fire.

This powder is much ftronger than the laft defcribed ; for if you fet fire to 20 grains of it, it will act with more violence, and have a louder crack, than half a pound of gunpowder, and two grains of it kindled at a candle have a ftronger report than a mufket fhot.

SPORT XCIX.

To make the Sympathetic Powder.

THE Sympathetic powder is nothing elfe but the Roman Vitriol calcined and reduced to a white light powder, which is faid to cure wounds at a diftance, by being put upon a linen cloth dipped in the wounded perfon's blood, or upon a fword whereon is the blood or pus that comes out of the wound. This cloth or fword is wrapped up in a white linen cloth, which is opened every day, in order to ftrew fome frefh powder upon the blood or pus of the wound. This courfe they continue till the wound is perfectly cured, which happens the fooner, if the cloth upon which is the blood and the powder, is kept in a place that is neither too hot, nor too cold, nor too moift. Nay, it is

necef-

neceſſary ſometimes to ſhift the cloth from place to place, according to the different diſpoſitions of the wound, by putting it, for example, in a cold place, when the patient finds an exceſſive heat in the wound.

To calcine the vitriol for the ſympathetic pow-der, take ſome Roman vitriol, when the ſun is in the ſign of Leo, or in the month of July, diſſolve it in rain water, and filtrate the water through ſink-ing pater. Then let the water evaporate upon a gentle fire, and you will find at the bottom the vitriol in little hard ſtones of a fire-green colour. Spread theſe ſtones carefully, and expoſe them to the rays of the ſun, ſtirring them often (with a wooden ſpatula; not an iron ſpatula, becauſe the ſpirits of the vitriol are ready to join in with iron, which would rob the ſympathetic powder of its vo-latile ſpirits, in which all its virtue conſiſts) that the ſtones may be the better penetrated by the ſun, and calcined and reduced to a powder, which will be as white as ſnow. And to render the ſubſtance of the vitriol more pure and homogenous, the diſ-ſolution, filtration, coagulation and calcination ought to be repeated three times.

This wonderful powder muſt be carefully kept in a vial cloſe ſtopped, and in a dry place, for the leaſt moiſture of the air may turn it to vitriol again, and ſo make it loſe its ſympathetic virtue.

We are told that this powder ſtops all bleedings, and mitigates very much all ſorts of pains in any part of the body, particularly the tooth-ach; and that, by application not to the part affected, but to the blood taken from it, and covered up in a linen cloth as above.

Remark. The chymiſts have another calcination of vitriol called Colcothar, which being put into the noſe, ſtops a bleeding at noſe, and provokes

to

to sneeze; being of sovereign use in rouzing the senses, wherefore it is given in lethargies. It is also successfully used for drying up wounds and ulcers. This colcothar is only the vitriol kept melted upon a fire till all its humidity is evaporated, and it is reduced to a hard reddish brown mass, whereby it is rendered fit for the cure of the aforesaid maladies, and many othert not here to be mentioned.

SPORT C.

Of the magnetical cure of diseases by transplantation.

THE magnetic cure by transplantation, is, that which is performed by communicating the disease to some beast, tree, or herb; and, as some will have it, is founded upon the efflux of the morbific particles, which pass by insensible transpiration out of the body of the patient into another animal or plant.

Froman informs us, that a young student got rid of a malignant fever by giving it to a dog that lay in the bed with him, and died of it: which if true, must needs proceed from the insensible transpiration of the subtile matter, that thereupon entered the pores of the dog.

Thomas Bartholin says, his uncle was cured of a violent cholic by applying a dog to his belly, which was thereupon seized with it; and that his maid-servant was cured of the tooth-ach by clapping the same dog to her cheek, and when the dog was gone from her he howled and made such motions, as gave them to know he had the maid's toothach.

Hoffman speaks of a man cured of the gout by a dog lying in the bed with him, who thereupon was seized with it. And frequently after the dog had

fits

fits of the gout, as his master had used to have before. However this be, certain it is, that dogs are often subject to the gout, without any infection from men ; and this, and the other stories of transplantation are not here offered for conclusive proofs, but by way of recreation.

Monsieur de Valemont, who seems inclinable to believe transplantation of diseases, says, it is done not only by insensible transpiration, but likewise by sweat, by urine, by the blood, by the hair, or by taking up what falls from the skin, upon a strong friction. For this he brings several instances, and particularly that which follows.

A person of quality in England used to cure the jaundice at a great distance from the patient, by mixing the ashes of ash-wood with the patient's urine; and making of that composition three, or seven, or nine little balls, with a hole in each of them, in which he put a leaf of saffron, and then filled it up with the same urine. This done he hung these balls in a private place where no body could touch them ; and from that time the disease began to abate.

The great virtues of the Ash tree.

Remark. The Ash, which is a common tree all over Europe, has merited the appellation of the Vulnerary wood, by reason of its peculiar property in curing several diseases, and above all wounds and ulcers. Not to mention the almost incredible virtues ascribed to it, it is said to stop bleeding at nose, if the face be but rubbed with the wood, and then washed with fair water, and if the patient holds in the hand of that side where the bleeding is, a piece of the wood till it heats his hand.

SPORT

SPORT CI.

To stop a bleeding at nose, or at any other part of the body.

FATHER Schott the Jesuit says, that to stop a bleeding at the nose, you need only to hold to the nose the dung of an ass very hot, wrapped up in an handkerchief, upon the plea that the smell will presently stop it. Wecher did the same with hogs dung, very hot done up in fine taffata, and put into the nose.

I have several times experienced, that a piece of red coral held in the mouth, will stop a bleeding at the nose. Some tell you that the constriction of the thumb of the side of the nostril that bleeds, will do the business.

To stop the bleeding of a wound, take a linen cloth in the spring when the frogs lay their eggs in the water, and wash it in that water till it is well impregnated with the frogs eggs; then dry it at the sun; and after repeating this impregnation and desiccation three or four times, keep the cloth to be applied to the wound twice in the form of a cataplasm. We are told the second application will do.

SPORT CII.

To prepare an ointment that will cure a wound at a distance.

THE ointment mentioned by Paracelsus is prepared thus, according to Goclenius. Take of the Usnea or moss of the scull of a man that was hanged, two ounces; mummy, human blood, of each half an ounce; earth-worms washed in water or wine, and dried, two ounces and a half; human fat, two ounces; the fat of a wild boar, and the fat of a bear, of each half an ounce; oil of linseed and oil of turpentine, of each two drams.

John

John Baptiſt Porta preſcribes it a little otherwiſe by throwing in ſome bole armeniac, and leaving out the earth-worms, and the bears and boars fat. But let the compoſition be which it will, it muſt be well mixed and beat in a mortar, and kept in a long narrow vial. Some ſay it ſhould be made when the ſun is in Libra. The way of uſing it is this.

Put into the ointment the weapon or inſtrument that gave the wound, and leave it there; then let the patient waſh his wound every morning with his own urine, and apply nothing elſe to it; after it is well waſhed and cleanſed, let him tie it up tight with a clean white linen cloth, and he will find it will heal without any pain.

Monſieur Vallemont ſays, if you cannot get the inſtrument with which the wound was given, you may take another, which if gently conveyed into the wound, and impregnated with the blood and animal ſpirits reſiding there, will have the ſame effect. He adds, that if you want a ſpeedy cure, you muſt anoint the inſttument often, otherwiſe you may let it lie a day or two without touch-ing it.

The effect of this unguent he imputes to the ſubtile particles, which are theſe little agents that diſengage themſelves from the moſt ſpirituous and tranſpirable ingredients of which this unguent is compoſed.

To add to the credibility of its operation, he quots father Lana, who obſerved that when the vines in France were in flower, the wines in Ger-many, though at a great diſtance, ſuffer an efferve-ſcene; which he explained by the effluviums of the ſubtile matter, making theſe to reach as far as the ſtars, and alledging that if the attoms, which tranſpire from the terreſtrial globe, were not carried

to

to the ftars, and fent back from the ftars to the earth by a perpetual flux and reflux, there would be no phyfical commerce between the heavens and the earth.

SPORT CIII.

To pierce the head of a pullet with a needle without killing it.

THIS is a very eafy Sport, for there is a place in the middle of a pullet's head, that may be pierced without hurting the Cerebellum. But the needle muft not be kept in above a quarter of an hour.

SPORT CIV.

To make handfome faces appear pale and hideous in a dark room.

BURN fome brandy and common falt in a glafs, then put out the fire and all the lights in the room ; and the particles of the falt and brandy evaporating into the air fhut up in the room, will make the faces of the people in the room appear through that air hideous, and frightful.

I intimated above, that if, inftead of brandy, you take good fpirits of wine mixed with camphyr in a glazed earthen pan put upon hot burning coals, he that enters the room with a lighted candle will be agreeably furprifed ; for the candle fetting fire to the particles of the fpirit and the camphyr, with which the air is replenifhed, that air will feem to be all in a fire, and the perfon will fee himfelf in the midft of flames without being burned.

SPORT CV.

To lift a mortar of ten pounds weight with a wine glafs.

TURN the mortar up-fide down, rub the bottom very fmooth, fo that there be not the
leaft

leaft unevennefs; make a circle the bignefs of the rim of the glafs with clay ufed by diftillers; then take a lighted paper, put it into the glafs, turn it down on the mortar, fixing it to the circle of clay and luting it quickly with the fame, fo as not the leaft air may enter: when the paper is burned out, and the glafs is cool, proceed to the experiment and you will find it anfwer.

SPORT CVI.

To make an egg move upon a table.

TAKE an egg, make a fmall hole at each end, and after you have blown out the contents through thefe holes put a live leech into it, then ftop up the holes with wax: the egg thus prepared being fet upon the table, place fome frefh water at a little diftance, which the leech immediately fmelling will make towards, and give a motion to the egg, to the agreeable furprize of the fpectators.

SPORT CVII.

To make an artificial flame.

ANY of the following oils, mixed with compound fpirits of Nitre, burft into a flame, *viz.* oil of Carroways, Cloves, Saffafras, Guiacum, Box, Camphyr, Pepper, Hartfhorn, Blood, and many other oils.

SPORT CVIII.

To make an artificial earthquake.

TO twenty pounds of iron filings add as many pounds of fulphur; mix, work, and temper the whole together with a little water, fo as to form a mafs, half moift and half dry: this being buried three or four foot under ground, in fix or feven hours time will have a prodigious effect; the earth
will

will begin to tremble, crack and smoke, and fire and flame burst through.

SPORT CIX.

To prepare a lamp that will make a company look of any colour you please.

IF you would have a green assembly, order a lamp to be made of green transparent glass, put green oil and a green wick in it, and the company will appear green. If you would have a black company, you must do the same in black, and so in any colour.

SPORT CX.

To bake an egg upon your head.

TAKE a loaf of bread just from the oven, cut a hole in it, put the egg in this hole and cover it with the bread cut out, then wrap the loaf in a linen cloth and hold it upon your head for some time, the egg will be soon done enough.

SPORT CXI.

To make flames issue from an egg.

BLOW out the contents of an egg and dry the shell in the sun, then fill it with brimstone, saltpetre, and unquenched lime; close the holes of the egg through which you blew the contents, then throw it into water and it will flame.

SPORT CXII.

To make a ring leap about.

PREPARE a ring made of copper, hollow, fill it with quickfilver and stop close the hole again that the quickfilver may not find any vent. This ring put upon an iron plate made very hot with coals underneath, will skip about briskly.

N   SPORT

SPORT CXIII.

Of a deceitful bowl, to play withal.

MAKE a hole in one side of the bowl, and cast melted lead therein, and then stop up the hole close, that the knavery or deceit be not perceived ; you will have pleasure to see that not-withstanding the bowl is cast directly to the play, how it will turn away sideways ; for that on that part of the bowl which is heavier upon one side than the other, it never will go truly right, if artificially it be not corrected, which will hazard the game to those who know it not ; but if it be known that the leady side in rolling be always under or above, it may go indifferently right ; if otherwise, the weight will carry it always sideways.

SPORT CXIV.

To contrive a vessel which keeps its liquor when filled to a certain height, but loses or spills it all when filled a little fuller with the same liquor.

TAKE a glass and run through the middle of it a small bended pipe or crane, open at the end next the bottom of the glass, and likewise at the other end, which must be lower than the bottom of the glass; for then the water or wine poured into the glass continues in it while the branch is filling, and till it comes to the bend or the uppermost part of the crane, which withal should be a little lower than the upper edge of the glass : but after that if you continue to pour more in, it will rise higher in the concavity of the glass, and not finding place for a farther ascent into the crane by reason of its bending downwards, it will change its ascent into a descent through the branch, and continue to descend and run out by the end, as long

as

as you continue to pour in; nay, when you have done pouring, you will fee that all that was in the glafs before is gone.

You may make the water run out at the lower end, though the glafs is not filled up to the top of the crane, namely, by fucking at the lower aperture the air contained in the crane, for then the water will neceffarily fucceed in the room of the air, and continue to defcend through the branch, till the glafs is empty, efpecially if the orifice touches the bottom of the glafs.

Or elfe; run the fmall pipe perpendicular down through the glafs; let the pipe be open at both ends, the uppermoft of which ought to be a little lower than the brim of the glafs, and the other end a little lower than the bottom of the glafs. Put this fmall pipe in another larger pipe ftopped at the upper end, which muft be a little higher than the end of the firft and fmaller pipe, and open at the lower end, which muft touch the bottom of the glafs if you would have all the water run out; which it will do when it rifes, for then paffing through the orifice of the pipe, it will enter the pipe by one end and run out at the other.

S P O R T CXV.

To make a coach that a man may travel in without horfes.

THE two four-wheels muft be little, and moveable round their common Axeltree, as in the ordinary coaches and the hinder wheels muft be large, and firmly fixed to their common axel-tree, infomuch that the axeltree cannot move, without the wheels move along wito it.

Round the middle of the Axel-tree put a trundle-head, with ftrong and clofe fpindles, and near to that fix upon the beam a notch'd wheel, the

notches

notches of which may catch the spindles of the
trundle-head, and so in turning with the handle,
that wheel round its axeltree, which ought to be
perpendicular to the horizon, it will turn the trun-
dle, and with that the axeltree and the wheels,
which will thereupon set forward the coach, without
horses or any other animal. I need not tell you
that the axeltree must enter into the beam, in or-
der to turn within it.

There was invented at Paris, some years ago, a
coach or chaise, which a footman behind it made
to go with his two feet alternately, by virtue of two
little wheels hid in the box between the two hind-
wheels, and made fast to the axeltree of the
coach.

In short, the contrivance of the machine is this.
In a roller, the two ends of which are made fast to
the box behind the chaise, is a pulley upon which
runs the rope that fastens the end of the planks,
upon which the footman puts his feet, where is a
piece of wood that keeps fast the two planks at the
other end, allowing them to move up and down by
the two ropes, tied to their two ends, where there
are two little plates of iron which serve to turn the
wheels that are fixed to their axeltree, which is
likewise fixed to the two great wheels.

Thus, you will readily apprehend that the foot-
man putting his feet alternately upon the end of
each plank, one of the plates will turn out of the
notch'd wheels; for example, if he leans with his
foot upon one plank it descends and raises the other,
which can't rise but at the same time the plate of
iron that enters the notches of the wheel, must
needs make it turn with its axeltree, and confe-
quently the two great wheels. Then the footman,
leaning upon one plank, the weight of his body
will make it descend and raise the other plank,

which

which turns the wheel again; and fo the motion will be continued.

'Tis eafy to imagine that while the two hind-wheels advance, the two fore-wheels muft likewife advance; and that thefe will always advance ftraight if the perfon that fits in the chaife manages them with reins made faft to the forebeam.

SPORT CXVI.

To make two Images, one fhall light a candle and the other blow it out.

UPON the fide of a wall make the figure of two images, in the mouth of each put a pipe or quill, fo artificially that it be not perceived, in one of which place falt-petre very fine and dry and pulverized, and at the end fet a little match of paper: in the other quill fulphur beaten fmall. Then, holding a lighted candle in your hand, fay to one of thofe images, by way of command, *Blow out the candle*, then lighting the paper with the candle, the falt-petre will blow out the candle immediately, and going to the other image (before the fnuff of the candle be out) touch the fulphur with it, and fay, *Light the candle*, and it will immediately be lighted.

SPORT CXVII.

To feem to turn water into wine.

TAKE four beer-bowl-glaffes, rub one in the infide with a piece of allum; let the fecond have a drop of vinegar in it, the third empty, and the fourth as much clean water in it as your mouth will contain: have ready in your mouth a clean rag with ground brafil tied clofe in it, that the bulk may be no bigger than a fmall nut, which muft lie betwixt your hind teeth and your cheek; then take of the water out of the glafs into your

mouth

mouth, and return it into the glafs that hath the drop of vinegar in it, which will caufe it to have the perfect colour of fack; then turn it in your mouth again, and chew your rag of brafil betwixt your teeth, and fquirt the liquor into the empty glafs, and it will have the perfect colour and fmell of claret, returning the brafil into its former place, take the liquor into your mouth again, and prefently fquirt it into the glafs you rubbed with allum, and it will have the perfect colour of mulberry wine; and fo in many other ways, which for brevity I omit.

SPORT CXVIII.

To deceive one with feeming pieces of tobacco-pipe.

ROUL up a piece of white paper as hard as your lottery tickets, till it is as thick as a tobacco pipe, then faften the outward edge with a little ftarch or pafte, having fo done, cut the ends even; have this in your hand, break two pieces in the fight of the company, fhake the three together in your hat, then caft them upon the table, faying, how many pieces of pipe is there under the hat? Every one will be apt to fay, three; lift up the hat the better to urge them, clapping it down prefently, faying, now I'll hold you a wager there are but two pieces of pipe under the hat; which when laid, take up the hat, and their folly will foon be difcerned, by your cutting the paper with your knife.

SPORT CXIX.

To write letters fecretly, that cannot be difcovered.

TAKE a fheet of white paper, and double it in the middle, then cut holes through both the half fheets, let the holes be cut like the panes of glafs windows, or other forms what you beft fancy, and

and then with a pin prick two little holes at each end and cut your paper in two halves, give one half to your friend (to whom you intend to write) the other half keep to yourfelf: now when you do write, lay your cut paper on a half fheet of writing paper, and ftick two pins through the two holes that it ftir not; then through thofe holes that you did cut, write your mind to your friend; when you have done, take off your paper with the holes again, and then write fome other idle words both before and after your lines; but if they were written to make fome little fenfe, it would carry the lefs fufpicion; then feal it up and fend it.

When your friend hath received it, he muft lay his paper on the fame, putting pins into the pinholes, and then he can read nothing but your mind which you writ, for all the reft of the lines are covered.

S P O R T   CXX.   *Secret Writing.*

WRITE a letter (what you pleafe) on one fide of paper with common ink, then turn your paper, and write on the other fide with milk, (that which you would have fecret) and let it dry; but this muft be written with a clean pen: Now when you would read it, hold that fide which is written with ink to the fire, and the milky letters will then fhew blewifh on the other fide, which may be perfectly difcerned.

S P O R T   CXXI.   *Secret Writing.*

PUT the powder of roach allum into a litttle water, and with that write upon the paper: when the letters are dry they will difappear; but clap the paper in fair water, and the letters will look white and fhining, the paper being a little blacked with the allum.

SPORT

SPORT CXXII. *Secret Writing.*

WRITE with the water in which fal armoniac well pulverized is diffolved : when the letters thus written are dry, they will difappear, but hold them near the fire, and then they become vifible again. The fame may be performed by writing with the juice of a lemon, or an onion.

SPORT CXXIII.

To make Glafs-Drops.

GLafs-Drops are thick little pieces of glafs, made almoft like a drop, which have a long flender end, which being broken at its exttemity, the drop breaks prefently with a crack, and flies into white powder and little fragments to two or three foot round.

Thefe drops, which have excited the curiofity, and perplexed the reafon of moft philofophers, are made by letting a little of the melted matter of which the ordinary glaffes are made, fall into a veffel full of cold water ; for then this melted matter which is very glutinous while 'tis red, makes a long ftring, by which they hold the drop in the middle of the water, where it cools and hardens in a little time ; after which they feparate the ftring which is out of the water, fo that the remaining part in the water does not break, commonly called a glafs drop, to this drop there fticks a fmall end, part of which may be feparated, by making it red at the flame of a candle, without breaking the drop; nor will this drop break if you lay it upon wood, and with a hammer ftrike upon its thickeft part, for its external parts are very hard, and fupport one another like a vault. And they only break upon bending the flender end till it breaks, by virtue of the fpring raifed by that effort in all its parts, which

<div align="right">fhake</div>

shake and tremble like an extended string, put into motion by forcing it to bend; whence it comes that these parts do in a little time return with very great velosity to their first disposition; and that the parts which are less united, and only contiguous, as it were, disunite and separate, and that occasions the disunion and separation of all the rest, and their flying all about with a noise. See upon this head Mr. *Mariotte's* discourse of the nature of the air published in 1679, in which he has, in my opinion, wrote more pertinently of this subject, than any one besides.

SPORT CXXIV.

To represent the four elements in a vial.

THE four elements of which the author of nature has composed the elementary world, are the *earth, water, air,* and *Fire*; of which, the earth being the heaviest is said to have the lowermost station in the center of the world: water being lighter covers the earth; air being lighter than water covers it; and at last fire the lightest of all surrounds the air. So that in this sense these four make four concentrical orbs, the common center of which is the centre of the world.

We may represent the four elements in this order, in a long vial of glass or crystal, by the help of four heterogeneous liquors, that is liquors of a different specific gravity, which are of such qualities, that, though shaked together by a violent agitation, they soon after return to their natural stations, and all the particles of one and the same liquor unite in a separate body from the rest, the lighter giving way to the heavier.

To represent the earth, make use of crude antimony, or blue smalt well refined, or black smalt
<div align="right">coarsly</div>

coarfly pounded, which by its weight will fink to the bottom of the vial.

To reprefent water, pour upon the laft the ter-reftrious fubftance of the fpirit of tartar, or calcin'd tartar, or the clean folution of pot-afhes with a little roch-azur, which will give a fea colour.

To reprefent the air, pour upon this compofition fpirit of wine rectified three times, till it has a co-lour of air, or elfe the moft fpirituous brandy with a little turnfol, which will give it a celeftial blew or air colour.

To reprefent fire, pour upon all three the oil of Behn, which by its colour, likenefs and fubtilty, will make a pretty near refemblance.

SPORT CXXV. *A Trick.*

TAKE a ball (or any thing elfe) in each hand, and ftretching them as far as you can afun-der, lay a wager with any perfon, that without bringing your hands nearer together, or throwing either ball from one hand to the other, you will have them both in which hand the perfon pleafes who lays the wager with you: which is no more than to lay one ball down upon the table, and turning yourfelf round take it up with the other hand, without bringing your hands any clofer.

THE END.

Explanation of the technical and abftrufe terms, ufed in the foregoing Recreations.

A

ANALOGY, the relation which one thing bears to another.

ALIQUOT, a part contained in the number pre- cifely fo many times.

ALTITUDE, height. Altitude of a figure is the neareft diftance between the top of its bafe.

ALEMBIC, a veffel for diftilling.

ALUMINOUS, belonging to allum.

B

BASIS, foundation, or bottom.

BIQUADRATE, the fourth power arifing from the multiplication of a fquare number or quantity by itfelf.

C

GONCAVE, hollownefs of a roundifh body.

CONVEX, the external round part of any body oppofite to the hollow.

COAGULATION, a curdling or thick fubftance.

CATAPLASM, a poultice of herbs or roots.

CONCENTRICAL, that hath one of the fame cen- ter.

CYLINDER, a roller, or rolling ftone.

CURVE, a crooked line.

CIRCUMVOLUTION, a rolling or turning about.

CONDENSATE, to thicken or grow thick.

CRYSTALLIZE, to fhoot into cryftals by being diffolved in liquor.

CORRODE, to gnaw or fret.

CALCINE, to burn to a cinder.

CONSTRICTION, crouding the parts clofe toge- ther.   CENTER,

CENTER, the heart, or middle point of a thing.

CEREBELLUM, the hinder part of the brain.

CONSECUTIVE, fucceeding one another.

CUBE, a folid body in fix equal fquares.

CUBE NUMBER, is that which arifes from the multiplication of any number by itfelf, and then by the product.

CUBE-ROOT, is the fide of a cube-number; fo 3 is the fide or root of 27.

D

DEFERENS, that hath not the fame center.

DIURNAL, daily, or belonging to the day.

DULCIFIE, to make fweet, or fweeten.

DESICCATION, a drying up.

DIAGONAL, a line drawn from angle to angle.

DECUPLE, ten fold.

DENOMINATOR, of a fraction, is that part of the fraction that ftands below the line of feparation.

DIVIDEND, a number to be divided.

DIVISOR, the number by which the dividend is to be divided.

E

ECCENTRIC, that hath not the fame centre.

ECLIPTIC, is a great circle of the Heavens, in which the fun moves in its annual motion.

EFFLUX, a flowing out.

EFFLUVIUMS, fmall particles flowing out of mixt bodies.

EBULLITION, boiling or bubling.

EFFERVENCENCY, a boiling over, or being very hot.

EXHALATIONS, fumes or vapours.

EXPONENT, a quotient arifing when the antecedent is divided by the confequent; and being placed over any power fhews how many multiplications are neceffary to produce that power.

EQUILATERAL, whofe fides are all equal.

F

F

FOCUS, a point where the rays meet and crofs the axis after their refraction by the glafs.

FILTRATE, to ftrain through cloth or paper.

FERMENT, to puff up or work, as ale or beer.

FLUX, floowing or loofening.

FIBRES, threads of hair like ftrings of mufcles, veins, plants, roots, &c.

G

GNOMON, the cock of a dial.

GENERATE, to engender or beget.

H

HOMOGENEOUS, of the fame kind, nature, and pvoperties.

HORIZON, the circle which bounds the fight of any perfon, who in a large plain, or in the midft of the fea, looks round about.

HUMID, damp or moift..

HYPOTHENUSE, in a right-angled triangle, is that fide which fubtends the right angle.

HARMONIC, the divifion of a line.

I

IMPREGNATE, to foak or drink in.

L

LENS, a concave or convex glafs, that is made to throw the rays of vifion into a point.

LENTICULAR, belonging to the humour of the eye.

LUTING, covering or ftopping up with loom or clay.

LONGITUDINAL, at length, or lengthways as op-pofed to tranfverfe.

M

MAGNETIC, endued with the property of attracting iron to itfelf.

MEDIUM, the middle ftate.

MERIDIAN, is a great circle paffing through the poles of the world, when the fun comes to this circle,

circle, it is then mid-day or noon.

MORBIFIC, caufing difeafes.

N

NUMERATOR, of a fraction, is the number fixed above the feparating line.

O

OCTODECUPLE, eighteen-fold.

P

PERFORATION, a boring through.

PERABOLIC, a folid figure, fo called from its formation.

PRISM, a folid glafs, through which the fun's rays being tranfmitted, are refracted into the vivid colours of the rainbow.

POLYGON, having many corners.

PYRAMIDAL, in the form of a pyramid.

PENTAGON, a figure having five fides and five angles.

PERCUSSION, a ftriking or knocking.

PRODUCT, is the number fought or arifing from the multiplication of feveral numbers.

Q

QUOTIENT, the number that fhews how many times the divifor is contained in the dividend.

R

REFRACT, to break again, or refift.

REFRACTION, a fudden change of determination in a body moved

RAREFY, to make thin.

REFRIGERATE, to refrefh or cool.

REVERBERATE, to ftrike or beat back.

RATIO, the rate or proportion which feveral quantities or numbers have one to another.

RECTANGULAR, when one or more of the angles are equal.

RETROGRADE, going backwards.

S

S

STYLUS, a line whose shadow on the plane of the dial shews the true hour-line, and is the upper edge of the gnomon.

SPECIFIC, a particular that distinguishes a thing from another of a different species.

SEXTUPLE, six-fold.

SPATULA, an instrument for spreading salves, &c.

SYMPATHY, a conformity in nature, a fellow-feeling.

SURSOLID, the fifth power from any given root in species or numbers.

SPHERICAL, belonging to, or round like a sphere.

SEARCED. dry, or consumed.

SPONTANEOUS, acting of its own accord.

SQUARE-NUMBER, any number which is squared or multiplied by itself, as 2 by 2, which is 4.

SQUARE-ROOT, the side of a square-number, so 4 is the side of 16.

T

TRANSPIRATION, breathing of vapours through the pores.

TRANSPLANTATION, the removing things from one place to another.

TRANSVERSE, that runs acrofs.

TARIFF, a book of rates.

V

VERTICAL, a line perpendicular to the horizon.

VULNERARY, good to cure wounds.

VEGITATE, to grow, or make lively.

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