OF THE

FRONTISPIECE and BOOK.

ALL Recreations do delight the mind,
But these are best, being of a learned kind:
Here Art and Nature strive to give content
In shewing many a rare Experiment:
Which you may read, and in their Schemes here see
Both in the Frontispiece, and in the Book.
Of these pleasant Table-Conceits are set,
Like dainty Dishes, [illegible]
And make your Judgment with new Appetite
To relish [illegible] delight.
The Senses Objects are but dull at best,
But Art delighting the Intellect [illegible]
[illegible]
That this same Table [illegible]
The [illegible] of Arithmetick are wrought
[illegible] Secrets [illegible] are brought
For Use in Geometry doth unfold
And [illegible] Cosmography are told
[illegible] desire,
With [illegible] Experiments in Astronomy,
Navigation, with each several Picture,
Musick, Opticks, and in Architecture:
In Staticks, Mechanicks, and Chymistry,
In Water-works, and to afford [illegible]
In Fire-works, [illegible] Artillery
[illegible]
[illegible]
[illegible] ARITHMETICK
[illegible] Recreations [illegible]
[illegible] BOOK [illegible]
[illegible] Lute, [illegible]

This Book is
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J Johnson
1726

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6 Sept. 28

ON THE
FRONTISPIECE and BOOK.

ALL Recreations *do delight the Mind;*
But these are best, being of a learned kind:
Here Art *and* Nature *strive to give content,*
In shewing many a rare Experiment:
Which you may read, and on their Schemes here look,
Both in the Frontispiece, *and in the* Book.
Upon whose Table new Conceits are set,
Like dainty Dishes, thereby for to whet
And win your Judgment with your Appetite
To taste them, and therein to take delight.
The Senses *Objects are but dull at best,*
But Art *doth give the Intellect a Feast.*
Come hither then, and here I will describe
What this same Table doth for you provide.
Here Questions of Arithmetick *are wrought,*
And hidden Secrets unto light are brought.
The like it in Geometry *doth unfold,*
And some too in Cosmography *are told:*
It divers pretty Dyals *doth descry,*
With strange Experiments in Astronomy,
And Navigation, *with each several* Picture,
In Musick, Opticks, *and in* Architecture:
In Statick, Machanicks, *and* Chymistry;
In Water-Works; *and, to ascend more high,*
In Fire-Works, *like to* Jove's Artillery.
All this I know thou in this Book shalt find,
And here's enough for to content thy Mind.
For from good Authors, this our AUTHOR *drew*
These Recreations, *which are Strange and True:*
So that this BOOK'*s a* Centre, *and 'tis fit*
That in this Centre, Lines of Praise *should meet.*

W. S.


MATHEMATICALL
Recreations
Or a Collection of
sundrie excellent
Problemes
out of ancient & moderne
Phylosophers
Both vsefull and
Recreatiue
Printed for William Leake
and are to be solde at the
Crowne in fleet streete
betweene the two
Temple gates
1674

Mathematical Recreations:

OR,

A Collection of many

PROBLEMS

Extracted out of the
Ancient and Modern Philosophers:

AS,

SECRETS and EXPERIMENTS

IN

Arithmetick, Geometry, Cosmography, Horologiography, Astronomy, Navigation, Musick, Opticks, Architecture, Statick, Mechanicks, Chymistry, Water-Works, Fire-Works, *&c.*

Not vulgarly manifest till now.

Written first in *Greek* and *Latin*, lately compil'd in *French* by *HENRY VAN ETTEN*, and now in *English*, with the *Examinations* and *Augmentations* of divers *Modern MATHEMATICIANS*.

Whereunto is added,

The DESCRIPTION and USE

OF

The Double HORIZONTAL DYAL,

AND

The General HOROLOGICAL RING:

Invented and Written by *William Oughtred*.

LONDON:
Printed for *William Leake*, and *John Leake*, at the Crown in *Fleetstreet*, between the Two Temple-Gates. 1674.

To the Thrice Noble,

and moſt Generous Lord,

The Lord *Lambert Verreyken*:

Lord of *Hinden*, *Wolverthem*, &c.

My Honourable Lord,

AMongſt the Rare and Curious Propoſitions which I have learned out of the Studies of the *Mathematicks* in the famous Univerſity of *Pont a Mouſſon*, I have taken ſingular pleaſure in certain *Problems*, no leſs Ingenious than Recreative, which drew me unto the ſearch of Demonſtrations more difficult and ſerious, ſome of which I have amaſſed, and cauſed to paſs the *Preſs*, and here dedi-

dedicate them now unto Your *Honour*: Not that I account them worthy of Your View, but in part to teſtifie my affectionate deſires to ſerve You, and to ſatisfie the Curious, who delight themſelves in theſe Pleaſant Studies; knowing well that the *Nobility* and *Gentry* rather ſtudy the *Mathematical Arts* to content and ſatisfie their Affections in the ſpeculation of ſuch admirable Experiments as are extracted from them, than in hope of gain to fill their Purſes. All which Studies, and others, with my whole Endeavours, I ſhall always dedicate unto Your Honour, with an ardent deſire to be accounted ever,

Your moſt humble and obedient

Nephew and Servant,

H. VAN ETTEN.

To the READER.

IT hath been obſerved by many, that ſundry fine Wits, as well amongſt the Ancient as Modern, have ſported and delighted themſelves upon ſeveral things of ſmall conſequence, as upon the Foot of a Fly, *upon a* Straw, *upon a* Point; *nay upon nothing: Striving as it were to ſhew the Greatneſs of their Glory, in the Smallneſs of the Subject: And have amongſt moſt ſolid and artificial Concluſions, compoſed and produced ſundry Inventions both* Philoſophical *and* Mathematical, *to ſolace the Mind, and recreate the Spi-*

rits, which the ſucceeding Ages have imbraced, and from them gleaned and extracted many admirable and rare Concluſions; judging that borrowed matter often-times yields praiſe to the induſtry of its Author.

Hence for thy uſe (Courteous Reader) I have with great ſearch and labour collected alſo and heaped up together in a body, of theſe pleaſant and fine Experiments to ſtir up and delight the Affectionate, (out of the Writings of Socrates, Plato, Ariſtotle, Demoſthenes, Pythagoras, Democrates, Pliny, Hyparchus, Euclides, Vitruvius, Diaphantus, Pergæus, Archimedes, Papus Alexandrinus, Vitellius, Ptolomæus, Copernicus, Proclus, Mauralicus, Cardanus, Valalpandus, Kepleirus, Gilbertus, Tychonius, Dureirus, Joſephus, Clavius, Gallileus Maginus, Euphanus Ty-

Tyberil, *and others*) *knowing Art imitates Nature, that glories always in the variety of things which ſhe produceth to ſatisfie the Minds of Curious Inquiſitors. And though perhaps theſe Labours to ſome humerous Perſons may ſeem vain and ridiculous, for ſuch it was not undertaken: But for thoſe which intentively have deſired and ſought after the knowledge of thoſe things, it being an Invitation and Motive to the ſearch of greater matters, and to imploy the Mind in Uſeful Knowledge, rather than to be buſied in vain* Pamphlets, Play-books, *fruitleſs* Legends, *and prodigious* Hiſtories, *that are invented out of Fancie, which abuſe many Noble Spirits, dull their Wits, and alienate their thoughts from laudable and honourable* Studies. *In this* Tractate *thou maiſt therefore make choice of ſuch*

Mathematical Problems *and* Con*clusions as may delight thee, which kind of Learning doth excellently adorn a man; seeing the Usefulness thereof, and the Manly Accomplishments it doth produce, is profitable and delightful for all sorts of People, who may furnish and adorn themselves with abundance of matter in that kind, to help them by way of use and discourse. And to this we have also added our* Pyrotechny, *knowing that* Beasts *have for their Object onely the surface of the* Earth, *but hoping that thy Spirit, which followeth the motion of* Fire, *will abandon the lower Elements, and cause thee to lift up thine Eyes to soar in an higher Contemplation, having so glittering a Canopy to behold, and these pleasant and recreative* Fires *ascending may cause thy affections also to ascend. The Whole whereof*

whereof we ſend forth to thee, that deſireſt the Scrutability of things ; Nature having furniſhed us with matter, thy Spirit may eaſily digeſt them, and put them finely in order, though now in diſorder.

AD AUTHOREM
D. D. *Henricum Van Etenium*,
Alumnum Academiæ
PONTA MOUSSON.

Ardua Walkeri sileant secreta profundi,
Desinat occultam carpere Porta Viam.
Itala Cardani mirata est Lampada docti
Terra, Syracusium Græcia tota senem:
Orbi terrarum, Ptolomæ; Clepsydra toti,
Rara dioptra Procli, mira fuêre duo.
Anglia te foveat doctus Pont Mousson alumnum,
Quidquid naturæ, qui legis, hortus habet.
Docta, coronet opus doctum, te sit tua docto
Digna, Syracusii, arca, corona, viri.
Arca Syracusiis utinam sit plumbea servis,
Aurea sed Dominis, aurea tota suis.

By

By way of

ADVERTISEMENT.

Five or six things I have thought worthy to declare, before I paſs further.

FIrſt, That I place not the ſpeculative Demonſtrations with all theſe *Problems*, but content my ſelf to ſhew them as at the Fingers end: Which was my Plot and Intention, becauſe thoſe which underſtand the Mathematicks can conceive them eaſily; others for the moſt part will content themſelves onely with the Knowledge of them, without ſeeking the Reaſon.

Secondly, To give a greater grace to the practice of theſe Things, they ought to be concealed as much as they may, in the ſubtilty of the way; for that which doth raviſh the Spirits is, *An Admirable Effect, whoſe Cauſe is Unknown*; which if it were diſcovered, half the pleaſure is loſt: therefore all the fineneſs conſiſts in the dexterity of the Act, concealing the means, and changing often the Stream.

Thirdly, Great care ought to be had that one deceive not himſelf, that would declare by way of Art to deceive another: This will make

make the matter contemptible to ignorant Perſons, which will rather caſt the Fault upon the Science, than upon him that ſhews it: When the Cauſe is not in the Mathematical Principles, but in him that fails in the acting of it.

Fourthly, In certain Arithmetical Propoſitions they have onely their Anſwers, as I found them in ſundry Authors, which any one, being ſtudious of Mathematical Learning, may find their Original, and alſo the way of their Operation.

Fifthly, Becauſe the Number of theſe *PROBLEMS*, and their Dependances, are many and intermixed, I thought it convenient to gather them into a Table: that

that ſo each one according to his Fancy might make beſt choice of that which might beſt pleaſe his Palate, the matter being not of one Nature, nor of like Subtilty: But whoſoever will have patience to read on, ſhall find the End better than the Beginning.

A TABLE
OF THE
Particular Heads of this Book,
Contracted according to the
SEVERAL ARTS
Specified in the Title-Page.

Experiments

A TABLE OF THE CONTENTS And Chief Points Contained in this BOOK.

PROB.

PROB. LXXVII.

Excellent Experiments in Opticks.

Of

PROB.

Mathema-

Mathematical RECREATION.

PROBLEM I.

To find a Number thought upon.

Bid him that he Quadruple the Number thought upon, that is, multiply it by 4, and unto it bid him to add 6, 8, 10, or any Number at pleaſure : and let him take the half of the ſum, then ask how much it comes to ? for then if you take away half the number from it which you willed him at firſt to add to it, there ſhall remain the double of the number thought upon.

Example.

The Number thought upon	5
The Quadruple of it	20
Put 8 unto it, makes	28
The half of it is	14
Take away half the number added, from it, *viz.* 4, the rest is	10
The double of the number thought upon, *viz.*	10

Another way to find what number was thought upon.

BId him which thinketh double his Number, and unto that double add 4, and bid him multiply that ſame product by 5, and unto that product bid him add 12, and multiply that laſt number by 10 (which is done eaſily by ſetting a Cypher at the end of the number) then ask him the laſt number or product, and from it ſecretly ſubtract 320; the remainder in the hundreth place is the number thought upon.

Example.

The number thought upon	7
His double	14
To it add 4, makes	18
Which multiplied by 5 makes	90
To which add 12, makes	102
This multiplied by 10 which is onely by adding a Cypher to it, makes	1020
From this ſubtract	320
Reſt	700

For which 700 account onely but the number of the hundreds, *viz.* 7. ſo have you the Number thought upon

To find Numbers conceived upon, otherwiſe than the former.

BId the party which thinks the number, that he tripple his thought, and cauſe him to take the half of it: (if it be odd, take the leaſt half, and put one unto it) then will him to tripple the half, and take half of it, as before: Laſtly, ask him how many Nines there is in the laſt half, and for every Nine, account four in your memory, for that ſhall ſhew the number thought upon, if both the tripples were even: but if it be odd at the firſt tripple, and even at the ſecond, for the one added unto the leaſt half keep one in memory: if the firſt tripple be even, and the ſecond odd, for the one added unto the leaſt half keep two in memory: laſtly, if at both times in trippling, the numbers be odd, for the two added unto the leaſt halfs, keep three in memory: Theſe cautions obſerved, and added unto as many fours as the party ſays there is Nines contained in the laſt half, ſhall never fail you to declare or diſcern truly what number was thought upon.

Example.

The Number thought upon	4 or 7
The tripple	12 or 21
The half thereof *6* or 10, one put to it makes	11
The tripple of the half	18 or 33
The half *9* or *16*, one put to it makes	17
The number of Nines in the laſt half	1 or 1

The first 1 representeth 4, the number thought upon, and the last 1 with the caution makes 7, the other number thought upon.

Note.

Order your Method so that you be not discovered, which to help, you may with dexterity and industry make *Additions*, *Substractions*, *Multiplications*, *Divisions*, *&c.* and instead of asking how many Nines there is, you may ask how many Eights, Tens, *&c.* there is, or subtract Eight, Ten, *&c.* from the Number which remains, for to find out the Number thought upon.

Now touching the *Demonstrations* of the former Directions, and others which follow, they depend upon the 2, 7, 8, and 9 *Books* of the Elements of *Euclide:* Upon which second *Book* and fourth *Proposition*, this may be extracted, for those which are more learned, for the finding of any Number that any one thinketh on.

Bid the party that thinks, that he break the Number thought upon into any two parts, and unto the Squares of the parts let him add the double Product of the parts; then ask what it amounteth unto? So the *Root Quadrat* shall be the Number thought upon.

Exam-

Example.

The Number thought upon 5
The parts ſuppoſe 3 and 2
The Square of 3 makes 9
The Square of 2 makes 4
The product of the parts, *viz.* 3 by 2 makes 6, which 6 doubled makes 12
the ſum of theſe three numbers 25, the *ſquare Root* of which is 5, the *number* thought upon

Or more compendiouſly it may be delivered thus:

Break the Number into two parts, and to the Product of the parts add the Square of half the difference of the parts, then the Root Quadrat of the Aggregate is half the Number conceived.

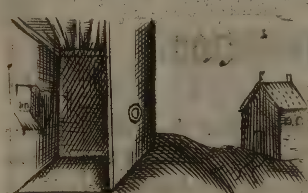
Examination.

THe Problems *which concern* Arithmetick, *we examine not : for theſe are eaſie to any one which hath read the Grounds and Principles of* Arithmetick ; *but we eſpecially touch upon that which tends to the Speculations of* Phyſick, Geometry, *and* Opticks, *and ſuch others which are of more difficulty, and more principally to be examined and conſidered.*

PROBLEM II.

How to repreſent to thoſe which are in a Chamber, that which is without, or all that which paſſeth by.

THis is one of the fineſt Experiments in the *Optiques*, and it is done thus: Chuſe a Chamber or Place which is towards the Street, frequented with People, or which is againſt ſome fair flouriſhing Object, that ſo it may be more delightful and pleaſant to the Beholders, then make the Room dark by ſhutting out the light, except a ſmall hole of ſixpence broad; this done, all the Images and Species of the Objects which are without, will be ſeen within, and you ſhall have pleaſure to ſee it, not only upon the Wall, but eſpecially upon a ſheet of white Paper, or ſome White Cloth hung near the hole: and if unto the hole you place a round Glaſs, that is, a Glaſs which is thicker in the middle than at the edge: ſuch as is the common Burning Glaſſes, or ſuch which old People uſe: for then the Images which before did ſeem dead, and of a darkiſh colour, will appear and

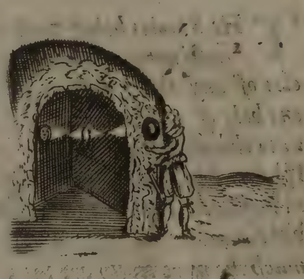


be

be ſeen upon the Paper, or white Cloth, according to their natnral colours, yea more lively than their natural, and the appearances will be ſo much the more beautiful and perfect, by how much the hole is leſſer, the day clear, and the Sun ſhining.

It is pleaſant to ſee the beautiful and goodly Repreſentation of the Heavens, intermixed with Clouds in the Horizon, upon a Woody Situation, the motion of Birds in the Air, of Men and other Creatures upon the Ground, with the trembling of Plants, Tops of Trees, and ſuch like: For every thing will be ſeen within, even to the life, but inverſed: Notwithſtanding, this beautiful Paint will ſo naturally repreſent it ſelf in ſuch a lively Perſpective, that hardly the moſt acurate Painter can repreſent the like.

Now the reaſon why the Images and Objects without are inverſed, is becauſe the Species do interſect one another in the hole, ſo that the ſpecies of the feet aſcend, and thoſe of the head deſcend.



But here note, that they may be repreſented right two manner of ways: Firſt, with a Concave Glaſs: ſecondly, by help of another Convex Glaſs, diſpoſed or placed between the Paper and the other Glaſs, as may be ſeen here by the Figure.

Now I will add here only by passing by, for such which affect Painting and Portraiture, that this Experiment may excellently help them in the lively painting of things perspective-wise, as *Topographical Cards*, &c. and for Philosophers, it is a fine Secret to explain the Organ of the sight, for the hollow of the Eye is taken as the close Chamber, the Ball of the Apple of the Eye, for the hole of the Chamber, the Crystaline humour at the small of the Glass, and the bottom of the Eye, for the Wall or Leaf of Paper.

Examination.

The Species being pressed together, or contracted, doth not perform it upon a Wall, for the species of any thing doth represent it self not onely in one hole of a Window, but in infinite holes, even unto the whole Sphere, *or at least unto a* Hemisphere *(intellectual in a free Medium) if the Beams or Reflections be not interposed, and by how much the* hole *is made less, to give passage to the Species, by so much the more lively are the* Images *formed.*

In Convex or Concave Glasses, *the* Images *will be disproportionable to the Eye, by how much they are more Concave, or Convex, and by how much the parts of the* Image *comes near to the* Axis, *for those that are near, are better proportioned than those which are farther off.*

But

But to have them more lively and true, according to the Imaginary Conical Section, let the hole be no greater than a pins head made upon a piece of thin Brass, or such like, which hole represents the top of the Cone, *and the Base thereof the Term of the Species: This practice is best when the Sun shines upon the hole, for then the Objects which are opposite to that Plain will make two like Cones, and will lively represent the things without in a perfect inversed Perspective, which drawn by the* Pencil *of some Artificial* Painter, *turn the Paper upside-down, and it will be direct, and to the life.*

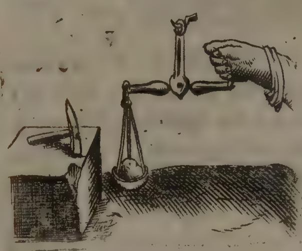
But the apparances may be direct, if you place another hole *opposite unto the former, so that the Spectator be under it; or let the Species reflect upon a Concave* Glass, *and let that* Glass *reflect upon a Paper, or some white thing.*

PROBLEM III.

To tell how much weighs the blow of ones fist, of a Mallet, Hatchet, or such like, or resting without giving the blow.

SCaliger in his 331 exercise against *Cardan*, relates that the *Mathematicians* of *Maximilian* the Emperour, did propose upon a day this *Question*, and promised to give the resolution; notwithstanding *Scaliger* delivered it not, and conceive it to be thus: Take a Balance, and let the Fist,

Fiſt, the Mallet, or Hatchet reſt upon the Scale, or upon the Beam of the Ballance, and put into the other Scale as much weight as may counterpoiſe it, then charging or laying more weight into the Scale, and ſtriking upon the other end, you may ſee how much one blow is heavier than another, and ſo conſequently how much it may weigh: for as *Ariſtotle* ſaith, *The motion that is made in ſtriking adds great weight unto it, and ſo much the more, by how much it is quicker*: therefore in effect, if there were placed a thouſand Mallets, or a Thouſand Pound weight upon a ſtone, nay, though it were exceedingly preſſed down by way of a Vice, by Levers, or other Mechanick Engine, it would be nothing to the rigor and violence of a blow.



Is it not evident that the edge of a Knife laid upon Butter, and a Hatchet upon a Leaf of Paper, without ſtriking makes no impreſſion, or at leaſt enters not? But ſtriking upon the Wood a little, you may preſently ſee what effect it hath; which is from the Quickneſs of the Motion, which breaks and enters without reſiſtance, if it be extream quick; as experience ſhews us in the blows of Arrows, of Cannons, Thunder-bolts, and ſuch-like.

Exami-

Examination.

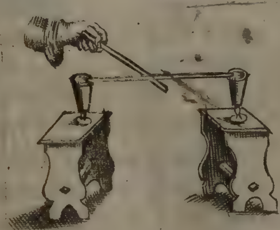
THis Problem *was extracted from* Scaliger, *who had it from* Ariſtotle, *but ſomewhat refractory compiled, and the ſtrength of the Effect he ſays depends onely in the violence of the Motion; then would it follow that a little light* Hammer *upon a piece of* Wood *being quickly cauſed to ſmite, would give a greater blow, and do more hurt than a great Sledge ſtriking ſoft; this is abſurd, and contrary to Experience. Therefore it conſiſts not totally in the Motion: for if two ſeveral Hammers, the one being twenty times heavier than the other, ſhould move with like Quickneſs, the Effect would be much different: there is then ſomething elſe to be conſidered beſides the Motion, which* Scaliger *underſtood not: for if one ſhould have asked him what is the reaſon that a* Stone *falling from a Window to a place near at hand, is not ſo forceable as if it fell farther down; and when a Bullet flying out of a* Piece, *and ſtriking the Mark near at hand, will not make ſuch an Effect as ſtriking the Mark further off. But we ſuppoſe that* Scaliger *and* Cardanus *who handles this ſubject, would not be leſs troubled to reſolve this, than they have been in that.*

PRO-

PROBLEM IV.

How to break a Staff which is laid upon two Glasses full of Water, without breaking the Glasses, or spilling the Water; or upon two Reeds or Straws, without breaking of them.

FIrst, place the Glasses which are full of Water upon two Joynt Stools, or such like, the one as high as the other from the ground, and distant one from another by two or three foot, then place the ends of the Staff upon the edges of the two Glasses, so that they be sharp: this done, with all the force you can, with another Staff strike the Staff which is upon the two Glasses in the middle, and it will break without breaking the Glasses, or spilling the Water.



In like manner may you do upon two Reeds, held with your hands in the Air without breaking them: Thence Kitchin-Boys often break Bones of Mutton upon their hand, or with a Napkin, without any hurt, in onely striking upon the middle of the Bone with a Knife.

Now in this Act, the two ends of the Staff in breaking slides away from the Glasses, upon which they were placed; hence it cometh that the Glasses are no wise endangered, no more than the Knee upon which a Staff is broken, forasmuch as in breaking it presseth not: as *Aristotle* in his *Mechanick Questions* observeth.

Examination.

IT were necessary here to note, that this thing may be experimented, first, without Glasses, *in placing a small slender Staff upon two props, and then making trial upon it; by which you may see how the* Staff *will either break, bow, or depart from its props, and that either directly, or obliquely: But why by this violence, that one Staff striking another, (which is supported by two* Glasses) *will be broken without offending the* Glasses, *is as great a difficulty to be resolved as the former.*

PROBLEM V.

How to make a fair Geographical Card in a Garden-Plot, fit for a Prince, or Great Personage.

IT is uſual amongſt Great Men to have fair *Geographical Maps*, large *Cards*, and great *Globes*, that by them they may as at once have a view of any place of the World, and ſo furniſh themſelves with a general knowledge not onely of their own Kingdoms Form, Situation, Longitude, Latitude, *&c.* but of all other places in the whole Univerſe, with their Magnitudes, Poſitions, Climates and Diſtances.

Now I eſteem that it is not unworthy for the Meditations of a Prince, ſeeing it carries with it many Profitable and Pleaſant Contentments: if ſuch a Card or Map by the Advice and Direction of an able Mathematician were Geographically deſcribed in a Garden-plot form, or in ſome other convenient place, and inſtead of which general deſcription might particularly and artificially be prefigured his whole Kingdoms and Dominions; the Mountains and Hills being raiſed like ſmall Hillocks with Turfs of Earth, the Valleys ſomewhat concave, which will be more agreeable and pleaſing to the Eye, than the Deſcription in plain Maps and Cards, within which may be preſented the Towns, Villages, Caſtles, or other

other remarkable Edifices, in ſmall green Moſſie Banks, or Spring-work proportional to the Platform, the Forreſts and Woods repreſented according to their form and capacity, with Herbs and Stoubs, the great Rivers, Lakes, and Ponds, to dilate themſelves according to their courſe from ſome artificial Fountain made in the Garden to paſs through Channels; then may there be compoſed Walks of Pleaſure, Aſcents, Places of Repoſe, adorned with all variety of delightful Herbs and Flowers, both to pleaſe the Eye and other Senſes. A Garden thus accommodated, ſhall far exceed that of my Lord of *Verulams*, ſpecified in his Eſſays; that being only for delight and pleaſure, this may have all the properties of that, and be alſo of ſingular uſe; by which a Prince may in little time perſonally viſit his whole Kingdom, and in ſhort time know it diſtinctly: and ſo in like manner may any particular man Geographically prefigure his own Poſſeſſion or Heritage.

PROBLEM VI.

How three Staves, Knives, or like Bodies, may be conceived to hang in the Air, without being ſupported by any thing but by themſelves.

TAke the firſt Staff A B, raiſe up in the Air the end B, and upon him croſs-wiſe place the Staff C B, then laſtly in Triangle wiſe place the third Staff E F, in ſuch manner that it may be be under A B, and yet upon C D. I ſay that theſe Staves ſo diſpoſed cannot fall, and the ſpace C B E is made the ſtronger, by how much the more it is preſſed down, if the Staves break not, or ſever themſelves from the triangular form: ſo that always the Center of gravity be in the Center of the Triangle: for A B is ſupported by E F, and E F is held up by C D, and C D is kept up from falling by A B, therefore one of theſe Staves cannot fall, and ſo by conſequence none.

PROBLEM VII.

How to diſpoſe as many men, or other things, in ſuch ſort, that rejecting or caſting away the 6, 9, 10 part, unto a certain number, there ſhall remain thoſe which you would have.

ORdinarily the propoſition is delivered in this wiſe: 15 *Chriſtians* and 15 *Turks* being at Sea in one Ship, an extream tempeſt being riſen, the Pilot of the Ship ſaith, it is neceſſary to caſt over-board half of the number of Perſons to disburthen the Ship, and to ſave the reſt: now it was agreed to be done by lot, and therefore they conſent

consent to put themselves in rank, counting by nine and nine, the ninth Person should always be cast into the Sea, until there were half thrown over-board: Now the Pilot being a Christian endeavoured to save the Christians; how ought he therefore to dispose the Christians, that the Lot might fall always upon the Turks, aud that none of the Christians be in the ninth place?

The resolution is ordinarily comprehended in this Verse:

Populeam virgam mater regina ferebat.

For having respect unto the Vowels, making *a* one, *e* two, *i* three, *o* four, and *u* five: *o* the first Vowel in the first Word sheweth that there must be placed four Christians; the next Vowel *u*, signifieth that next unto the four Christians must be placed five Turks; and so to place both Christians and Turks according to the quantity and value of the Vowels in the Words of the Verse, until they be all placed: for then counting from the first Christian that was placed, unto the ninth, the lot will fall upon a Turk, and so proceed. And here may be further noted, That this Problem is not to be limited, seeing it extends to any number and order whatsoever, and may many ways be useful for Captains, Magistrates, or others, which have divers persons to punish, and would chastise chiefly the unruliest of them, in taking the 10, 20, or 100 person, *&c.* as we read was commonly practiſed amongſt the ancient *Romans*: therefore to apply a general Rule in counting the third, 4, 9, 10, *&c.* amongſt 30, 40, 50 perſons, and more or leſs; this is to be obſerved, take as many Unites as there are Perſons, and diſpoſe them in order privately: As for example, Let 24 men be propoſed to have committed ſome outrage, 6 of them eſpecially are found acceſſary; and let it be agreed that counting by 8 and 8, the eighth man ſhould be always puniſhed. Take therefore firſt 24 units, or upon a piece of Paper write down 24 cyphers, and account from the beginning to the eighth, which eighth mark, and ſo continue counting, always marking the eighth, until you have markt 6, by which you may eaſily perceive how to place thoſe ſix men that are to be puniſhed, and ſo of others.

It is ſuppoſed that *Joſephus* the Author of the *Jewiſh Hiſtory* eſcaped the danger of death by help of this Problem: For a worthy Author of belief reports in his eighth Chapter of the third Book of the deſtruction of *Jeruſalem*, that the Town of *Jotapata* being taken by main force by *Veſpatian*, *Joſephus* being Governour of that Town, accompanied with a Troop of fourty Souldiers, hid themſelves in a Cave, in which they reſolved rather to famiſh, than to fall into the hands of *Veſpatian*: and with a bloudy reſolution in that great diſtreſs would have butchered one another for ſuſtenance, had not *Joſephus* perſwaded them to die by lot and order, upon which it ſhould fall: Now ſeeing that *Joſephus* did ſave himſelf by this Art, it is thought that his

his Induſtry was exerciſed by the help of this Problem, ſo that of the 40 perſons which he had, the third was always killed. Now by putting himſelf in the 16 or 31 place, he was ſaved, and one with him, which he might kill, or eaſily perſwade to yield unto the *Romans*.

PROBLEM VIII.

Three Things and three Perſons propoſed, to find which of them hath either of theſe three Things.

LEt the three things be a *Ring*, a piece of *Gold*, and a piece of *Silver*, or any other ſuch like, and let them be known privately to your ſelf by theſe three Vowels, *a*, *e*, *i*, or let there be three perſons that have different names, as *Ambroſe*, *Edmond*, and *John*, which privately you may note or account to your ſelf once known by the aforeſaid Vowels, which ſignifie for the firſt Vowel 1, for the ſecond Vowel 2, for the third Vowel 3.

Now if the ſaid three perſons ſhould by the mutual conſent of each other privately change their names, it is moſt facil by the courſe and excellency of Numbers, diſtinctly to declare each ones name ſo interchanged: Or if three perſons in private, the one ſhould take a *Ring*, the other a piece of *Gold*, and the third ſhould take a piece of *Silver*; it is eaſie to find which hath the Gold, the Silver, or the Ring, and it is thus done.

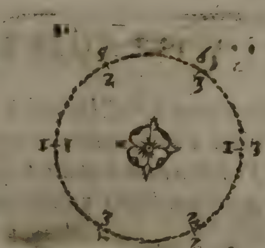
Take 30 or 40 Counters (of which there is but 24 neceſſary) that ſo you may conceal the way the better, and lay them down before the parties, and as they ſit or ſtand give to the firſt 1 Counter, which ſignifieth *a*, the firſt Vowel; to the ſecond 2 Counters, which repreſents *e*, the ſecond Vowel; and to the third 3 Counters, which ſtand for *i* the third Vowel: then leaving the other Counters upon the Table, retire apart, and bid him which hath the Ring take as many Counters as you gave him, and he that hath the Gold, for every one that you gave him, let him take 2, and he that hath the Silver for every one that you gave him, let him take 4: This being done, conſider to whom you gave one Counter, to whom two, and to whom three; and mark what number of Counters you had at the firſt; for there are neceſſarily but 24, as was ſaid before, the ſurpluſs you may privately reject. And then there will be left either 1, 2, 3, 5, 6, or 7, and no other number can remain; which if there be, then they have failed in taking according to the directions delivered: but if either of theſe numbers do remain, the reſolution will be diſcovered by one of theſe ſix words following, which ought to be had in memory, *viz.*

Salve,	*certa,*	*anima,*	*ſemita,*	*vita,*	*quies.*
1.	2.	3.	5.	6.	7.

As ſuppoſe 5 did remain, the word belonging unto it is *ſemita*, the Vowels in the firſt two Syllables

lables are *e* and *i*, which sheweth according to the former Directions, that to whom you gave 2 Counters, he hath the Ring, (seeing it is the second Vowel represented by two, as before) and to whom you gave the 3 Counters, he hath the Gold: for that *i* represents the third Vowel, or 3 in the former Direction, and to whom you gave one Counter, he hath the Silver; and so of the rest. The variety of changes in which exercise, is laid open in the Table following.

Rest.	Men	Hid.	Rest.	Men.	Hid.
	1	*a*		1	
1	2	*e*	5	2	
—	3	*i*	—	3	—
	1	*e*		1	
2	2	*a*	6	2	
—	3	*i*	—	3	—
	1	*a*		1	
3	2	*i*	7	2	
	3	*e*		3	



This feat may be also done without the former words, by help of the Circle A. for having divided the Circle into six parts, write 1 within and one without, two within and five without, *&c.* the first 1, 2, 3, which are within with the Numbers over them, belongs to the upper semicircle; the other Numbers both within and without, to the under semicircle;

 now

now if in the action there remaineth such a number which may be found in the upper semicircle without, then that which is opposite within shews the first, the next is the second, &c. as if 5 remain, it shews to whom he gave 2, he hath the Ring; to whom you gave 3, he hath the Gold, &c. But if the remainder be in the under semicircle, that which is opposite to it is the first, the next backwards towards the right hand is the second; as if 3 remains, to whom you gave 1 he hath the Ring, he that had 3 he had the Gold, &c.

PROBLEM IX.

How to part a Vessel which is full of Wine, containing eight Pints, into two equal parts, by two other Vessels which contain as much as the greater Vessel; as the one being 5 Pints, and the other 3 Pints.

Let the three Vessels be represented by A B C, A being full, the other two being empty; first, pour out A into B until it be full, so there will be in B 5 pints, and in A but 3 pints: then pour out of B into C until it be full: so in C shall be 3 pints, in B 2 pints, and in A 3 pints, then pour the Wine which is in C into A, so in A will be 6 pints, in B 2 pints, and in C nothing: then pour out the Wine which is in B into the pot C, so in C there is now 2 pints, in B nothing, and in A 6 pints. Lastly, pour out of A into B untill it be full, so there will be now in A only 1 pint

pint, in B 5 pints, and in C 2 pints. But it is now evident, that if from B you pour in unto the pot C until it be full, there will remain in B 4 pints, and if that which is in C, *viz.* 3 pints be poured into the vessel A, which before had 1 pint, there shall be in the vessel A but half of

its liquor that was in it at the first, *viz.* 4 pints, as was required. Otherwise pour out of A into C until it be full, which pour into B, then pour out of A into C again until it be full, so there is now in A only 2 pints, in B 3, and in C 3, then pour from C into B until it be full, so in C there is now but 1 pint, 5 in B, and 2 in A: pour all that is in B into A, then pour the Wine which is in C into B, so there is in C nothing, in B onely 1 pint, and in A 7 pints: Lastly, out of A fill the pot C, so there will remain in A 4 pints, or be but half full: then if the liquor in C be poured into B, it will be the other half. In like manner might be taken the half of a Vessel which contains 12 pints, by having but the measures 5 and 7, or 5 and 8. Now such others might be proposed, but we omit many, in one and the same nature.

PROBLEM X.

To make a Stick stand upon the tip of ones Finger, without falling.

FAsten the edges of two Knives, or ſuch like, of equal poiſe, at the end of the Stick, leaning out ſomewhat from the Stick, ſo that they may counterpoiſe one another; the Stick being ſharp at the end, and held upon the top of the Finger, will there reſt without ſupporting: if it fall, it muſt fall together, and that perpendicular, or plumb-wiſe, or it muſt fall ſide-wiſe, or before one another; in the firſt manner it cannot, for the Centre of Gravity is ſupported by the top of the Finger: and ſeeing that each part by the Knives is counterpoiſed, it cannot fall ſide-wiſe, therefore it can fall no wiſe.

In like manner may great Pieces of Timber, as Joiſts, &c. be ſupported, if unto one of the Ends be applied convenient proportional Counterpoiſes; yea a Lance or Pike may ſtand perpendicular in the Air, upon the top of ones Finger: or placed in the midſt of a Court, by help of his Centre of Gravity.

Exami-

Examination.

This Proposition seems doubtful; for to imagine absolutely, that a Pike, or such-like, armed with two Knives, or other things, shall stand upright in the air, and so remain, without any other support, seeing that all the parts have an infinite difference of propensity to fall; and it is without question that a Staff cannot be so accommodated upon his Centre of Gravity, but that it may incline to some one part, without some remedy to be applied, and such as is here specified in the Problem will not warrant the thing, nor keep it from falling; and if more Knives should be placed about it, it should cause it to fall more swiftly, forasmuch as the superiour part (by reason of the Centrical Motion) is made more ponderous, and therefore less in rest.

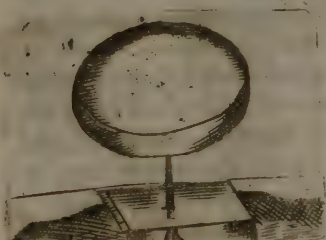
To place therefore this Prop really, let the two Knives, or that which is for counterpoise, be longer always than the Staff, and so it will hang together as one body: and it will appear admirable if you place the Centre of Gravity near the side of the top of the finger or point; for it will then hang Horizontal, and seem to hang onely by a touch; yet more strange, if you turn the point or top of the finger upside-down.

PRO-

PROBLEM XI.

How a Milstone or other Ponderosity may be supported by a small Needle, without breaking or any wise bowing the same.

LEt a Needle be set perpendicular to the *Horizon*, and the Centre of Gravity of the Stone be placed on the top of the Needle: it is evident that the Stone cannot fall, forasmuch as it hangs in *æquilibra*, or is counterpoysed in all parts alike; and moreover it cannot bow the Needle more on the one side, then on the other; the Needle will not therefore be either broken or bowed; if otherwise, then the parts of the Needle must penetrate and sink one with another; the which is absurd and impossible to Nature: therefore it shall be supported. The Experiments which are made upon Trencher-Plates, or such-like lesser thing, doth make it most credible in greater Bodies.



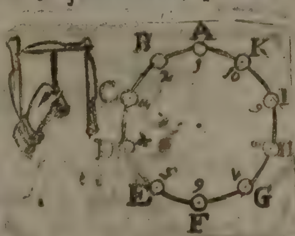
But here especially is to be noted, that the Needle ought to be uniform in matter and figure, and that it be erected perpendicular to the *Horizon*; and lastly, that the *Centre* of *Gravity* be exactly found.

PRO-

PROBLEM XII.

To make three Knives hang and move upon the poin. of a Needle.

FIt the three Knives in form of a Balance, and holding a Needle in your hand, place the back of that Knife which lies croſs-wiſe to the other two, upon the point of the Needle, as the figure here ſheweth you; for then in blowing ſoftly upon them, they will eaſily turn



and move upon the point of the Needle without falling.

PROBLEM XIII.

To find the weight of Smoak, which is exhaled of any combuſtible Body whatſoever.

LEt it be ſuppoſed that a great heap of Fagots, or a load of Straw weighing 500 pound ſhould be fired, it is evident that this groſs ſubſtance will be all inverted into ſmoak and

aſhes;

ashes: now it seems that the smoak weighs nothing, seeing it is of a thin substance now dilated in the Air, notwithstanding if it were gathered and reduced into the thickest that it was at first, it would be sensibly weighty: weigh therefore the ashes which admit 50 pound: Now seeing that the rest of the matter is not lost, but is exhaled into *smoak*, it must necessarily be, that the rest of the weight (to wit, 450 pound) must be the weight of the *smoak* required.

Examination.

Now although it be thus delivered, yet here may be noted, that a Ponderosity in his own Medium is not weighty: for things are said to be weighty, when they are out of their place or medium, and the difference of such Gravity, is according to the Motion: the smoak therefore certainly is light, being in its true medium (the Air) if it should change his Medium, then would we change our discourse.

PROBLEM XIV.

Many things being disposed circular, (or otherwise) to find which of them any one thinks upon.

Suppose that having ranked 10 things, as A B C D E F G H I K, Circular, as (the Figure sheweth) and that one had touched or thought upon

upon G, which is the 7 : ask the party at what letter he would begin to account (for account he muſt,otherwiſe it cannot be done) which ſuppoſe at E, which is the 5 place, then add ſecretly to this 5, 10, (which is the number of the Circle) and it makes 15, bid him account 15 backward from E, beginning his account with that number he thought upon, ſo at E he ſhall account to himſelf 7, at D account 8, at C account 9, *&c.* So the account of 15 will exactly fall upon G, the thing or number thought upon : and ſo of others : but to conceal it the more, you may will the party from E to account 25, 35, *&c.* and it will be the ſame.

There are ſome that uſe this play at Cards, turned upſide-down, as the ten ſimple Cards, with the King and Queen, the King ſtanding for 12, and the Queen for 11 : and ſo knowing the ſituation of the Cards, and thinking a certain hour of the day, cauſe the party to account from what Card he pleaſeth ; with this Proviſo, that when you ſee where he intends to account, ſet 12 to that number, ſo in counting as before, the end of the account ſhall fall upon the Card which ſhall denote or ſhew the hour thought upon, which being turned up, will give grace to the action, and wonder to thoſe that are ignorant in the cauſe.

PRO-

PROBLEM XV.

How to make a Door or Gate, which ſhall open on both ſides.

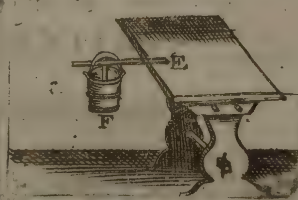
ALl the skill and ſubtilty of this, reſts in the artificial diſpoſure of four Plates of Iron, two at the higher end, and two at the lower end of the Gate: ſo that one ſide may move upon the Hooks or Hinges of the Poſts, and by the other end may be made faſt to the Gate; and ſo moving upon theſe Hinges, the Gate will open upon one ſide with the aforeſaid Plates or Hooks of Iron: and by help of the other two Plates will open upon the other ſide.

PROBLEM XVI.

To ſhew how a Ponderoſity, or heavy thing, may be ſupported upon the end of a Staff (or ſuch-like) upon a Table, and nothing holding or touching it.

TAke a Pail which hath a handle, and fill it full of Water, (or at pleaſure) then take a Staff or Stick which may not rowl upon the Table, as EC, and place the handle of the Pail upon the Staff; then place another Staff or Stick under the Staff CE, which may reach from the bottom

bottom of the Pail unto the former Staff C E, perpendicular wiſe, which ſuppoſe F G: then ſhall the Pail of Water hang without falling; for if it fall, it muſt fall perpendicularly, or plumb-wiſe; and that cannot be, ſeeing the Staff C E ſupports it, it being parallel to the Horizon, and ſuſtained by the Table: and it is



a thing admirable, that if the Staff C E were alone from the Table, and that end of the Staff which is upon the Table were greater and heavier than the other, it would be conſtrained to hang in that nature.

Examination.

Now without ſome Experience of this Problem, *a man would acknowledge either a poſſibility or impoſſibility; therefore it is that very Touchſtone of Knowledge in any thing, to diſcourſe firſt if a thing be poſſible in Nature, and then if it can be brought to Experience, and under Sence, without ſeeing it done. At the firſt, this Propoſition ſeems to be abſurd, and impoſſible. Notwithſtanding, being ſupported with two Sticks, as the figure declareth, it is made facile: for the Horizontal Line to the edge of the*

the Table, is the Centre of Motion; and passeth by the Centre of Gravity, which necessarily supporteth it.

PROBLEM XVII.

Of a deceitful Bowle to play withal.

MAke a hole in one side of the Bowl, and cast molten Lead therein, and then make up the hole close, that the knavery or deceit be not perceived: you will have pleasure to see that notwithstanding the Bowl is cast directly to the play, how it will turn away side-wise: for that on that part of the Bowl which is heavier upon the one side than the other, it never will go truly right, if artificially it be not corrected; which will hazard the Game to those which 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 side-wise.

PROBLEM XVIII.

To part an Apple into 2, 4, 8, or like parts, without breaking the Rind.

PAss a Needle and Thread under the Rind of the Apple, and then round it with divers turnings, until you come to the place where you began;

began; then draw out the Thread gently, and part the Apple into as many parts as you think convenient: and ſo the parts may be taken out between the parting of the Rind, and the Rind remaining always whole.

PROBLEM XIX.

To find a number thought upon, without asking of any queſtion, certain operations being done.

BId him add to the number thought (as admit 15) half of it, if it may be, if not, the greateſt half, that exceeds the other but by an unite, which is 8; and it makes 23. Secondly, unto this 23 add the half of it, if it may be, if not, the greateſt half, *viz.* 12, makes 35; in the mean time, note that if the number thought upon cannot be halfed at the firſt time, as here it cannot, then for it keep three in the memory; if at the ſecond time it will not be equally halved, reſerve two in memory, but if at both times it could not be equally halved, then may you together reſerve five in memory: this done, cauſe him from the laſt ſum, *viz.* 35, to ſubtract the double of the number thought, *viz.* 30, reſt five, will him to take the half of that, if he can, if not, reject 1, and then take the half of the reſt, which keep in your memory: then will him to take the half again, if he can, if not, take one from it, which reſerve in your memory;

mory, and ſo perpetually halving until 1 remain: for then mark how many halfs there were taken, for the firſt half acco nt 2, for the ſecond 4, for the third 8, &c. and add unto thoſe numbers the ones which you reſerved in memory: So there being 5 remaining in this Propoſition, there were 2 halvings: for which laſt I account 4, but becauſe it could not exactly be halved without rejecting of 1, I add the 1 therefore to this 4, makes 5, which half or ſum always multiplied by 4, makes 20. from which ſubtract the firſt 3 and 2, becauſe the half could not be formerly added, leaves 15, the number thought upon.

Another Example.

The number thought	12
The half of it	6
The ſum	18
The half of it	9
The ſum of it	27
The double of the number	24
Which taken away, reſts	3
The half of it	1
For which account	2
And 1 put to it becauſe the 3 could not be halved, makes	3
This multiplied by 4, makes	12

Which was the number thought upon.

Another

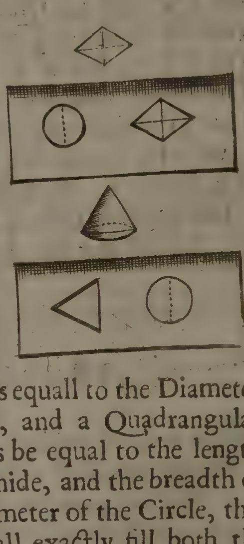
Another Example.

The number thought- ———————— 79
The greateſt half ———————— 40 3
The ſum- ———————— 119
The greateſt half of which is ———— 60 2
The ſum of it is ———————— 179
The double of 79 is ———————— 158
Which taken from it reſts-- ———— 21
The leſſer half 10, which halve :-- ————
The half of this is 5, which makes ————
The half of this is 2, which is ———— 10
The half of this is 1, with 10 and 11 is —— 21
This 21 which is the double of the laſt half, with the remainder, being multiplied by 4, makes 84, from which take the aforeſaid 3 and 2, reſts-- ———— 79
Which was the number thought upon.

PROBLEM XX.

How to make an uniform and inflexible Body to paſs through two ſmall holes of divers forms, as one being circular and the other ſquare, Quadrangular, and Triangular-wiſe, yet ſo that the holes ſhall be exactly filled.

THis Problem is extracted from Geometrical Obſervations, and ſeems at the firſt ſomewhat obſcure; yet that which may be extracted in this nature, will appear more difficult and admirable. Now in all Geometrical Practices, the leſſer or eaſier Problems do always make way to facilitate the greater: and the aforeſaid Problem is thus reſolved. Take a Cone or round Pyramide, and make a Circular hole in ſome board, or other hard material, which may be equal to the Baſes of the Cone, and alſo a Triangular hole, one of whoſe ſides may be equal to the Diameter of the Circle, and the other two ſides equal to the length of the Cone: Now it is moſt evident, that this Conical or Pyramidal Body, will fill up the Circular hole, and being placed ſide-wiſe, will fill up the Triangular hole. Moreover if you cauſe a body to be turned, which may be like to two Pyramides conjoyned, then if a Circular hole be



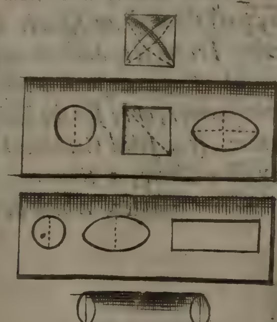
made, whoſe Diameter is equall to the Diameter of the Cones conjoyned, and a Quadrangular hole, whoſe ſloping ſides be equal to the length of each ſide of the Pyramide, and the breadth of the hole equal to the Diameter of the Circle, this conjoyned Pyramide ſhall exactly fill both the Circular hole, and alſo the Quadrangular hole.

PRO-

PROBLEM XXI.

How with one uniform Body, or such-like, to fill three several holes: of which the one is round, the other a just square, and the third an oval form.

THis Proposition seems more subtil than the former, yet it may be practised two ways: For the first, take a Cylindrical Body, as great or little as you please: Now it is evident that it will fill a Circular hole, which is made equal to the Basis of it, if it be placed down right, and will also fill a long Square, whose sides are equal unto the Diameter and length of the Cylinder, and according to *Pergeus*, *Archimedes*, *&c.* in their Cylindrical Demonstrations, a true Oval is made when a Cylinder is cut slope-wise, therefore if the Oval have breadth equal unto the Diameter of the Basis of the Cylinder, and any length whatsoever: the Cylinder being put into his own Oval hole, shall also exactly fill it.



 The

The ſecond way is thus: Make a circular hole in ſome board, and alſo a ſquare hole, the ſide of which ſquare may be equal to the Diameter of the Circle: and laſty, make a hole Oval-wiſe, whoſe breadth may be equal unto the Diagonal of the Square; then let a Cylindrical Body be made, whoſe Baſis may be equal unto the Circle, and the length equal alſo to the ſame: Now being placed down-right, ſhall fall in the Circle, and flat-wiſe will fit the Square hole, and being placed ſloping-wiſe will fill the Oval.

Examination.

You may note upon the laſt two Problems farther, that if a Cone be cut Ecliptick-wiſe, it may paſs through an Iſſocele Triangle, through many Scalen Triangles, and through an Ellipſis; and if there be a Cone cut ſcalen-wiſe, it will paſs through all the former, only for the Ellipſis place a Circle: and further, if a ſolid Colume be cut Ecliptick-wiſe, it may fill a Circle, a Square, divers Parallelograms, and divers Ellipſes, which have different Diameters.

PRO-

PROBLEM XXII.

To find a number thought upon, after another manner than what is formerly delivered.

Bid him that he multiply the number thought upon, by what number he pleaſeth, then bid him divide that product by any other number, and then multiply that Quotient by ſome other number; and that product again divide by ſome other, and ſo as often as he will: and here note, that he declare or tell you by what number he did multiply and divide. Now in the ſame time take a number at pleaſure, and ſecretly multiply and divide as often as he did: then bid him divide the laſt number by that which he thought upon. In like manner do yours privately, then will the Quotient of your Diviſor be the ſame with his, a thing which ſeems admirable to thoſe which are ignorant of the cauſe. Now to have the number thought upon without ſeeming to know the laſt Quotient, bid him add the number thought upon to it, and ask him how much it makes: then ſubtract your Quotient from it, there will remain the number thought upon. For Example: Suppoſe that the number thought upon were 5, multiply it by 4, makes 20; this divided by 2, the Quotient makes 10, which multiplied by 6, makes 60, and divided by 4, makes 15, in the ſame time admit you think upon 4, which multiplied by 4, makes 16, this divided by 2, makes 8, which multiplied by 6 makes 48, and divided by 4 makes 12; then divide 15 by the number thought, which was 5, the Quotient is 3; divide alſo 12 by the number you took, *viz.* 4, the Quotient is alſo 3, as was declared; therefore if the Quotient 3 be added unto the number thought, *viz.* 5, it makes 8; which being known, the number thought upon is alſo known.

8
3 6
4
10

PROBLEM XXIII.

To find out many numbers that ſundry perſons, or one man, hath thought upon.

If the multitude of numbers thought upon be odd, as three numbers, five numbers, ſeven, *&c.* As for example: Let 5 numbers thought upon be theſe, 2, 3, 4 5, 6, bid him declare the ſum of the firſt and ſecond, which will be 5, the ſecond and third, which makes 7, the third and fourth, which makes 9, the fourth and fifth, which makes 11, and ſo always adding the two next together, ask him how much the firſt and laſt makes together, which is 8, then take theſe ſums and place them in order, and add all theſe together which were in the odd places: that is, the firſt, third and fifth, *viz.* 5, 9, 8, makes 22. In like manner add all theſe numbers together, which

which are in the even places, that is in the ſecond and fourth places, *viz.* 7 and 11 makes 18, ſubtract this from the former 22, then there will remain the double of the firſt number thought upon, *viz.* 4, which known, the reſt is eaſily known: ſeeing you know the ſum of the firſt and ſecond; but if the multitude of numbers be even as theſe ſix numbers, *viz.* 2,3,4,5 6,7. cauſe the party to declare the ſum of each two, by antecedent and conſequent, and alſo the ſum of the ſecond and laſt, which will be 5, 7, 9, 11, 13, 10, then add the odd places together, except the firſt, that is, 9 and 13 makes 22; add alſo the even places together, that is 7, 11, 10, which makes 28; ſubtract the one from the other, there ſhall remain the double of the ſecond number thought upon, which known, all the reſt are known.

PROBLEM XXIV.

How is it that a man in one and the ſame time, may have his Head upward and his Feet upward, being in one and the ſame place?

THe Anſwer is very facil, for to be ſo, he muſt be ſuppoſed to be in the Centre of the Earth: for as the Heaven is above on every ſide, *Cœlum undique ſurſum*, all that which looks to the Heavens, being diſtant from the Centre, is upward; and it is in this ſenſe that *Maurolycus* in in his Cosmography, and first Dialogue, reported of one that thought he was led by one of the Muses to Hell, where he saw *Lucifer* sitting in the middle of the World, and in the Centre of the Earth, as in a Throne, having his Head and Feet upward.

PROBLEM XXV.

Of a Ladder by which two men ascending at one time, the more they ascend the more they shall be asunder, notwithstanding one being as high as another.

THis is most evident, that if there were a Ladder half on this side of the Centre of the earth, and the other half on the other side: and that two at the Centre of the World at one instant being to ascend, the one towards us, and the other towards our Antipodes, they should in ascending go farther & farther, one from another; notwithstanding both of them are of like height.

PRO-

PROBLEM XXVI.

How it is that a man having but a Rod or Pole of Land, doth brag that he may in a right line paſs from place to place above 3000 miles.

THe opening of this is eaſie, foraſmuch as he that poſſeſſeth a Rod of Ground, poſſeſſeth not only the exterior ſurface of the earth, but is Maſter alſo of that which extends even to the Centre of the Earth, and in this wiſe all Heritages and Poſſeſſions are as ſo many Pyramides, whoſe ſummets or points meet in the Centre of the Earth, and the Baſis of them are nothing elſe but each mans poſſeſſion, field, or viſiblequantity; and therefore if there were made or imagined ſo to be made a deſcent to go to the bottom of the Heritage, which would reach to the Centre of the Earth, it would be above 3000 miles in a right line, as before.

PROBLEM XXVII.

How it is that a man ſtanding upright, and looking which way he will, he looketh either true North or true South.

THis happeneth if the party be under either of the Poles; for if he be under the North-pole, then looking any way he looketh South, be-cauſe caufe all the Meridians concur in the Poles of the World ; and if he be under the South-Pole, he looks directly North by the fame reafon.

PROBLEM XXVIII.

To tell any one what number remains after certain operations being ended, without asking any queftion.

BId him to think upon a number, and will him to multiply it by what number you think convenient: and to the product bid him add what number you pleafe, provided that fecretly you confider, that it may be divided by that which multiplied, and then let him divide the fum by the number which he firft multiplied by, and fubtract from this Quotient the number thought upon: In the fame time divide apart the number which was added by that which multiplied, fo then your Quotient fhall be equal to his Remainder; wherefore without asking him any thing, you fhall tell him what did remain, which will feem ftrange to him that knoweth not the caufe. For Example: Suppofe he thought 7, which multiplied by 5 makes 35, to which add 10, makes 45, which divided by 5, yields 9, from which if you take away 1, the number thought, (becaufe the Multiplier divided by the Divifor gives the Quotient 1) the reft will be 2; which will be alfo proved, if 10, the number which was added, were divided by 5, *viz.* 2.

PROBLEM XXIX.

Of the Play with two ſeveral things.

IT is a pleaſure to ſee and conſider how the Science of Numbers doth furniſh us not onely with ſports to recreate the Spirits, but alſo brings us to the knowledge of admirable things, as ſhall in ſome meaſure be ſhewn in this enſuing Progreſſion. In the mean time, to produce always ſome of them : Suppoſe that a man hold divers things in his hand, as Gold and Silver, and in one hand he held the Gold, and in the other hand he held the Silver: to know ſubtilly, and by way of divination, or artificially, in which hand the Gold or Silver is; attribute to the Gold, or ſuppoſe it to have a certain price, and ſo likewiſe attribute to the Silver another price, conditionally that the one be odd, and the other even. As for example : Bid him that the Gold be valued at 4 Crowns, or Shillings, and the Silver at 3 Crowns or Shillings, or any other number, ſo that one be odd, and the other even, as before; then bid him tripple that which is in the right hand, and double that which is in the left hand, and bid him add theſe two products together, and ask him if it be even or odd ; if it be even, then the Gold is in the right hand; if odd, the Gold is in the left hand.

PRO-

PROBLEM XXX.

Two numbers being proposed unto two several parties, to tell which of these numbers is taken by each of them.

AS for Example: Admit you had proposed unto two men, whose names were *Peter* and *John*, two numbers or pieces of money, the one even, and the other odd, as 10 and 9; and let the one of them take one of the numbers, and the other party take the other number, which they place privately to themselves: how artificially, according to the congruity and excellency of numbers, to find which of them did take 10, and which 9, without asking any question: and this seems most subtil, yet delivered howsoever differing little from the former, and is thus performed: Take privately to your self also two numbers, the one even and the other odd, as 4 and 3; then bid *Peter* that he double the number which he took, and do you privately double also your greatest number; then bid *John* to triple the number which he hath, and do you the like upon your last number: add your two Products together, and mark if it be even or odd, then bid the two parties put their numbers together, and bid them take the half of it, which if they cannot do, then immediately tell *Peter* he took 10, and *John* 9, because the aggregate of the double

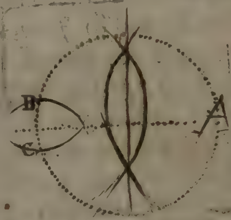
double of 4, and the tripple of 3, makes odd and ſuch would be the aggregate or ſum of the double of *Peters* number and *Johns* number, if *Peter* had taken 10; if otherwiſe, then they might have taken half, and ſo *John* ſhould have taken 10, and *Peter* 9: As ſuppoſe *Peter* had taken 10, the double is 20, and the tripple of 9, the other number, is 27, which put together makes 47, odd: in like manner the double of your number conceived in mind, *viz.* 4 makes 8, and the tripple of the 3, the other number makes 9, which ſet together makes 17, odd. Now you cannot take the half of 17 nor 47, which argueth that *Peter* had the greater number, for otherwiſe the double of 9 is 18, and the tripple of 10 is 30, which ſet together makes 48, the half of it may be taken; therefore in ſuch caſe *Peter* took the leſs number, and *John* the greater: And this being done cleanly, carries much grace with it.

PROBLEM XXXI.

How to deſcribe a Circle that ſhall touch 3 Points, placed howſoever upon a plain, if they be not in a right line.

LEt the three points be A B C, put one foot of the Compaſs upon A, and deſcribe an Arch of a Circle at pleaſure; and placed at B croſs that Arch in the two points E and F, and placed in C croſs the Arch in G and H, then lay a Ruler

ler upon G H, and draw a Line, and place a Ruler upon E and F, cut the other Line in K, ſo K is the Centre of the Circumference of a Circle, which will paſs by the ſaid three points A B C, or it may be inverted, having a Circle drawn ; to find the Centre of that Circle, make three points in the Circumference, and then uſe the ſame way; ſo ſhall you have the Centre: a thing moſt facil to every Practitioner in the Principles of Geometry.

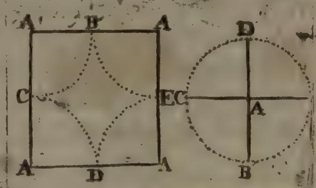


PROBLEM XXXII.

How to change a Circle into a Square Form.

MAke a Circle upon Paſt-board, or other material, as the Circle A B C D E, of which A is the Centre ; then cut it into four quarters, and diſpoſe them ſo, that A, at the Centre of the Circle, may always be at the Angle of the Square ; and ſo the four quarters of the Circle being placed ſo, it will make

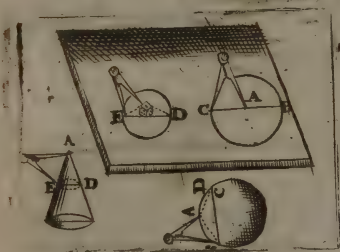
make a perfect Square, whose side A A is equal to the Diameter B D. Now here is to be noted that the Square is greater than the Circle by the vacuity in the middle, *viz.* M.



PROBLEM XXXIII.

With one and the same Compasses, and at one and the same extent or opening, how to describe many Circles Concentrical, that is, greater or lesser one than another.

IT is not without cause that many admire how this Proposition is to be resolved; yea, in the Judgment of some it is thought impossible, who consider not the Industry of an Ingenious Geometrician, who makes it possible, and that most facil, sundry ways: for in the first place, if you make a Circle upon a fine Plain, and upon the Centre of that Circle a small peg of Wood be placed, to be raised up and put down at pleasure, by help of a small hole made in the Centre, then with the same opening of the Compasses you may describe Circles Concentrical, that is, one greater or leſſer than another; for the higher the Centre is lifted up, the leſſer the Circle will be. Secondly, the Compaſs being at that extent upon a *Gibbous* body, a Circle may be deſcribed, which will be leſs than the former, upon a Plain, and more artificially upon a Globe, or round Bowle: and this again is moſt obvious upon a Round Pyramide, placing the Compaſſes upon the top of it, which will be far leſs than any of the former; and this



is demonſtrated by the Twentieth Propoſition of the firſt of *Euclids*, for the Diameter E D is leſs than the Lines A D, A E, taken together, and the Lines A D, A E, being equal to the Diameter B C, becauſe of the ſame diſtance or extent of opening the Compaſſes, it follows that the Diameter E D, and all his Circles together, is much leſs than the Diameter and the Circle B C, which was to be performed.

PRO-

PROBLEM XXXIV.

Any numbers under 10, being thought upon, to find what numbers they were.

LEt the firſt number be doubled, and unto it add 5, and multiply that ſum by 5, and unto it add 10, and unto this product add the next number thought upon; multiply this ſame again by 10, and add unto it the next number, and ſo proceed: Now if he declare the laſt ſum, mark if he thought but upon one figure, for then ſubtract onely 35 from it, and the firſt figure in the place of tens is the number thought upon: if he thought upon two figures, then ſubtract alſo the ſaid 35 from his laſt ſum, and the two figures which remain are the number thought upon: if he thought upon three figures, then ſubtract 350, and then the firſt three figures are the numbers thought upon, &c. ſo if one thought upon theſe numbers, 5, 7, 9, 6, double the firſt makes 10, to which add 5, makes 15, this multiplied by 5 makes 75, to which add 10, makes 85, to this add the next number, *viz.* 7, makes 92, this multiplied by 10, makes 920, to which add the next number, *viz.* 9, makes 929, which multiplied by 10, makes 9 90, to which add 6, makes 9296, from which ſubtract 3500, reſteth 5796, the four numbers thought upon. Now becauſe the two laſt figures are like the two numbers thought upon: to conceal this, bid him take the half of it, or put first 12, or any other number to it, and then it will not be so open.

PROBLEM XXXV.

Of the Play with the Ring.

Amongst a company of nine or ten persons, one of them having a Ring, or such-like, to find out in which Hand, upon which Finger and Joynt it is; this will cause great astonishment to ignorant Spirits, which will make them believe that he that doth it works by Magick, or Witchcraft: But in effect it is nothing else but a nimble Act of Arithmetick founded upon the precedent Problem: for first, it is supposed that the persons stand or sit in order, that one is first, the next second, *&c.* likewise there must be imagined, that of these two hands the one is first, and the other second; and also of the five fingers, the one is first, the next is second; and lastly, of the joynts, the one is as 1, the other is as 2, the other as 3, *&c.* from whence it appears that in performing this Play there is nothing else to be done than to think four numbers. For example: if the fourth person had the Ring in his left hand, and upon the fifth finger and third joynt, and I would divine and find it out, thus I would proceed, as in the XXXIV Problem, in causing him to double the first number, that is, the number of persons which

which was 4, and it makes 8, to which adde 5 makes 13, this multiplied by 5 makes 65, put 10 to it makes 75, unto this put 2 for the number belonging to the left hand, and so it makes 77, which multiplied by 10 makes 770, to this add the number of the fingers upon which the Ring is, *viz.* 5, makes 775, this multiplied by 10 makes 7750, to which add the number for the joynt upon which the Ring is, *viz.* the third joynt, makes 7753; to which cause him to add 14, or some other number, to conceal it the better, and it makes 7767: which being declared unto you, subtract 3514, and there will remain 4,2,5,3, which figures in order declares the whole mystery of that which is to be known: 4 signifieth the fourth person, 2 the left hand, 5 the fifth finger, and 3 the third joynt of that finger.

PROBLEM XXXVI.

The Play of 3, 4, or more Dice.

THat which is said of the two precedent Problems, may be applied to this of Dice, (and many other particular things) to find what number appeareth upon each Dice, being cast by some one: for the points that are upon any side of a Dice are always less than 10, and the Points of each side of a Dice may be taken for a number thought upon: therefore the Rule will be as the former: As for example, one having thrown three Dice, and you would declare the numbers of each one, or how much they make together, bid him double the points of one of the Dice, to which bid him add 5, then multiply that by 5, and to it add 10, and to the ſum bid him add the number of the ſecond Dice, and multiply that by 10: laſtly, to this bid him add the number of the laſt Dice, and then let him declare the whole number: then if from it you ſubtract 350, there will remain the number of the three Dice thrown.

PROBLEM XXXVII.

How to make Water in a Glaſs ſeem to boyl and ſparkle.

TAke a Glaſs near full of Water or other liquor, and ſetting one hand upon the foot of it, to hold it faſt: turn ſlightly one of the fingers of your other hand upon the brim or edge of the Glaſs; having before privately wet your finger, and ſo paſſing ſoftly on with your finger in preſſing a little: for then firſt the Glaſs will begin to make a noiſe; ſecondly, the parts of the Glaſs will ſenſibly appear to tremble, with notable *rarefaction* and *condenſation*: thirdly, the Water will ſhake, ſeem to boyl; fourthly, it will caſt it ſelf out of the Glaſs, and leap out by ſmall drops, with great aſtoniſhment to the ſtanders by; if they

they be ignorant of the cauſe of it, which is onl y in the Rarefaction of the parts of the Glaſs, occaſioned by the motion and preſſure of the Finger.

Examination.

THe cauſe of this is not in the Rarefaction of the parts of the Glaſs, but it is rather in the quick local Motion of the Finger, for reaſon ſheweth us that by how much a Body draweth nearer to a quality, the leſs it is ſubject or capable of another which is contrary unto it: Now Condenſation and Rarefaction are contrary Qualities, and in this Problem there are three Bodies conſidered, the Glaſs, the Water, and the Air, now it is evident that the Glaſs being the moſt ſolid and impenitrable Body is leſs ſubject and capable of Rarefaction than the Water, the Water is leſs ſubject than the Air, and if there be any Rarefaction, it is rather conſiderable in the Air than in the Water, which is inſcribed by the Glaſs, and above the Water, and rather in the Water than in the Glaſs: The agitation, or the trembling of the parts of the Glaſs to the ſenſe appears not: for it is a continued Body; if in part, why then not in the whole? and that the Water turns in the Glaſs, this appears not; but onely the upper contiguous parts of the Water; that at the bottom being leſs ſubject to this agitation: and it is moſt certain that by how much quicker the Circular Motion of the Finger upon the

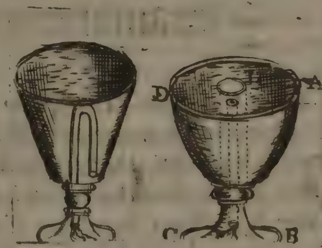
the edge of the Glaſs is, by ſo much the more ſhall the Air be agitated, and ſo the Water ſhall receive ſome apparent Affection more or leſs from it, according to that motion: as we ſee from the quickneſs of wind upon the Sea, or calm thereof, that there is a greater or leſſer agitation in the Water; and for further Examination, we leave it to the ſearch of thoſe which are Curious.

PROBLEM XXXVIII.

Of a fine Veſſel which holds Wine or Water, being caſt into it at a certain height, but being filled higher, it will run out of its own accord

LEt there be a Veſſel A B C D, in the middle of which place a Pipe, whoſe ends both above at E, and below at the bottom of the Veſſel, as at F, are open; let the end E be ſomewhat lower than the brim of the Glaſs: about this Pipe place another Pipe, as HL, which mounts a little above E, and let it moſt diligently be cloſed at H, that no Air enter in thereby, and this Pipe at the bottom may have a ſmall hole to give paſſage unto the Water; then pour in Water or Wine, and as long as it mounts not above E, it is ſafe; but if you pour in the Water ſo that it mount above it, farewel all, for it will not ceaſe until it be all gone out; the ſame may be done in diſpoſing any crooked Pipe in a Veſſel in the manner of a Faucet or Funnel, as in the Figure H;

H; for fill it under H at pleaſure, and all will go well; but if you fill it unto H you will ſee fine ſport, for then all the Veſſel will be empty incontinent, and the ſubtilty of this will ſeem more admirable, if you conceal the Pipe by a



Bird, Serpent, or ſuch-like, in the middle of the Glaſs. Now the reaſon of this is not difficult to thoſe which know the nature of a Cock or Faucet: for it is a bowed Pipe, one end of which is put into the water or liquor, and ſucking at the other end until the Pipe be full, then will it run of it ſelf, and it is a fine Secret in Nature to ſee, that if the end of the Pipe which is out of the water, be lower than the water, it will run out without ceaſing; but if the Mouth of the Pipe be higher than the water, or level with it, it will not run, although the Pipe which is without be many times bigger than that which is within the water: for it is the property of Water to keep always exactly level.

Exami-

Examination.

Here is to be noted, that if the face of the Water without be in one and the same Plain with that which is within, though the outermost Pipe be ten times greater than that which is within, the Water naturally will not run; but if the Plain of the Water without, be any part lower than that which is within, it will freely run. And here may be noted further, that if the Mouth of the Pipe which is full of Water doth but onely touch the Superficies of the Water within, although the other end of the Pipe without be much lower than that within the Water, it will not run at all; which contradicts the first ground: Hence we gather that the pressure or ponderosity of the Water within, is the cause of running in some respect.

PROBLEM XXXIX.

Of a Glass very pleasant.

Sometimes there are Glasses which are made of a double fashion, as if one Glass were within another, so that they seem but one, but there is a little space between them. Now pour Wine or other Liquor between the two edges by help

help of a Tunnel, into a little hole left to this end, ſo will there appear two fine deluſions or fallacies; for though there be not a drop of Wine within the hollow of the Glaſs, it will ſeem to thoſe which behold it that it is an ordinary Glaſs full of Wine, and that eſpecially to thoſe which are ſidewiſe of it; and if any one move it, it will much confirm it, becauſe of the motion of the Wine; but that which will give moſt delight, is, that if any one ſhall take the Glaſs, and putting it to his mouth ſhall think to drink the Wine, inſtead of which he ſhall ſup the Air, and ſo will cauſe laughter to thoſe that ſtand by, who being deceived, will hold the Glaſs to the light, and thereby conſidering that the Rayes or Beams of the Light are not reflected to the Eye, as they would be, if there were a liquid ſubſtance in the Glaſs, hence they have an aſſured proof to conclude that the hollow of the Glaſs is totally empty.

PROBLEM XL.

If any one ſhould hold in each hand as many pieces of money as in the other, how to find how much there is.

BId him that holds the money that he put out of one hand into the other what number you think convenient, (provided that it may be done) this done, bid him that out of the hand that he put the other number into, that he take out

of

of it as many as remain in the other hand and put it into that hand; for then be aſſured that in the hand which was put the firſt taking away, there will be found juſt the double of the Number taken away at the firſt. *Example*: Admit there were in each hand 12 Shillings or Counters, and that out of the right hand you bid him take 7, and put it into the left: and then put into the right hand from the left as many as doth remain in the right, which is 5, ſo there will be in the left hand 14, which is the double of the number taken out of the right hand, to wit 7, then by ſome of the Rules before-delivered, it is eaſie to find how much is in the right hand, *viz.* 10.

PROBLEM XLI.

Many Dice being caſt, how artificially to diſcover the number of the points that may ariſe.

Suppoſe any one had caſt three Dice ſecretly, bid him that he add the points that were upmoſt together: then putting one of the Dice apart unto the former ſum add the points which are under the other two, then bid him throw theſe two Dice, and mark how many points a pair are upwards, which add unto the former ſum: then put one of theſe Dice away, not changing the ſide, mark the points which are under the other Dice, and add it to the former ſum: laſtly, throw that one Dice, and whatſoever appears upward add it unto the former ſum, and let the Dice remain
thus;

thus: this done, coming to the Table, note what points do appear upward upon the 3 Dice, which add privately together, and unto it add 21, or 3 times 7: ſo this Addition or ſum ſhall be equal to the ſum which the party privately made of all the operations which he formerly made. As if he ſhould throw 3 Dice, and there ſhould appear upward 5,3,2, the ſum of them is 10, and ſetting one of them apart, (as 5) unto 10 add the points which are under 3 and 2, which is 4 and 5, and it makes 19; then caſting theſe 2 Dice, ſuppoſe there ſhould appear 4 and 1, this added unto 19 makes 24, and ſetting 1 of theſe 2 Dice apart, as the 4 unto the former 24, I add the number of points which is under the other Dice, *viz.* under 1, that is 6, which makes 30. Laſt of all, I throw that 1 Dice, and ſuppoſe there did appear 2, which I add to the former 30, and it makes 32, then leaving the 3 Dice thus, the points which are upward will be theſe, 5,4,2, unto which add ſecretly 21, (as before was ſaid) ſo have you 32, the ſame number which he had; and in the ſame manner you may practice with 4,5,6, or many Dice or other Bodies, obſerving onely that you muſt add the points oppoſite of the Dice, for upon this depends the whole demonſtration or ſecret of the play; for alway that which is above and underneath makes 7: but if it make another number, then muſt you add as often that number.

PRO-

PROBLEM XLII.

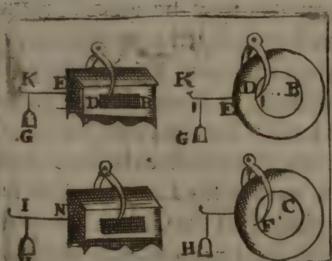
Two Metals, as Gold and Silver, or of other kind, weighing alike, being privately placed into two like Boxes, to find which of them the Gold or Silver is in.

IT is ſaid that an Emperour was requeſted by one of his Servants, after he had long time remained with him, to aſſign him ſome Reward: to which after a few days the Emperour condeſcended, and cauſed him to come into his Treaſury, where he had prepared two Boxes, one full of Gold, and the other full of Lead, both weighing, and of form and magnitude alike: and bid him chuſe which he would have. Now many think that in this Problem one muſt be guided only by Fortune in this Choice, and it is that which moſt makes a man happy in ſuch a Choice: but the want of knowledge cauſeth them ſo to judge which know not otherwiſe. A Mathematician accounts it an eaſie Propoſition, and will infallibly chuſe the Cheſt of Gold, and leave the Cheſt of Lead, without either breaking or opening any of the Cheſts, and not go by chance and fortune: for if he may be permitted to weigh thoſe Cheſts firſt in the Air, then in the Water, it is a thing clear by the proportion of Metals, and according to the Principles of *Archimedes* that the Gold ſhall be leſs weighty by his eighteenth part

part, and the Lead by his eleventh part, wherefore there may be gathered in which is the Gold, and in which is the Lead.

But becauſe that this experiment in Water hath divers Accidents, and therefore ſubject to a caution; and namely becauſe the matter of the Cheſt, metal, or other things, may hinder.

Behold here a more ſubtil and certain invention to find and diſcover it out, without weighing it in the Water: Now Experience and Reaſon ſheweth us, that two like Bodies or Magnitudes of equal weight, and of divers Metals, are not of equal quantity: and ſeeing that Gold is the heavieſt of all Metals, it will occupy leſs room or place; from which will follow



that the like weight of Lead in the ſame form, will occupy or take up more room or place. Now let there be therefore preſented two Globes or Cheſts of Wood, or other matter alike, and equal one to the other, in one of which in the middle there is another Globe or body of Lead weighing 12 pound, (as C) and in the other a Globe or like body of Gold weighing 12 pound (as B.) Now it is ſuppoſed that the Wooden Globes or Cheſts are of equal weight, form, and Magnitude: and to diſcover which the Gold or Lead is in, take a broad

broad pair of Compaſſes, and clip one of the Coffers or Globes ſomewhat from the middle, as at D; then fix in the Cheſt or Globe a ſmall piece of Iron between the feet of the Compaſſes, as E K, at the end of which hang a weight G, ſo that the other end may be counterpoyſed, and hang in *æquilibrio*: and do the like to the other Cheſt or Globe. Now if that the other Cheſt or Globe being clipped in like diſtance from the end, and hanging at the other end the ſame weight G, there be found no difference, then clip them nearer towards the middle, that ſo the points of the Compaſs may be againſt ſome of the Metal which is incloſed; or juſt againſt the extremity of the Gold as in D, and ſuppoſe it hang thus in *æquilibrio*, it is certain that in the other Coffer is the Lead; for the points of the Compaſſes being advanced as much as before, as at F, which takes up a part of the Lead (becauſe it occupies a greater place than the Gold) therefore that ſhall help the Weight G to weigh, and ſo will not hang in *æquilibrio*, except G be placed near to F. Hence we may conclude that there is the Lead; and in the other Cheſt or Globe there is the Gold.

Examina-

Examination.

If the two Boxes being of equal magnitude weighed in the Air be found to be of equal weight, they shall necessarily take up like place in the Water, and therefore weigh also one as much as another: Hence there is no possibility to find the Inequality of the Metals which are inclosed in these Boxes in the Water: the intention of Archimedes *was not upon contrary Metals inclosed in equal Boxes, but consisted of comparing Metals, simple in the Water one with another. Therefore the Inference is false and absurd.*

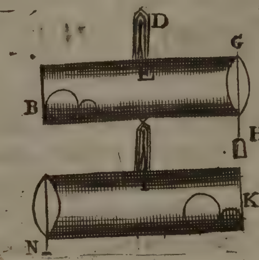
PROBLEM XLIII.

Two Globes of diverse Metals, (as one Gold, and the other Copper) yet of equal weight, being put into a Box, as B G, to find in which end the Gold or Copper is.

This is discovered by the changing of the places of the two Bowles or Globes, having the same Counterpoise H to be hung at the other side, as in N; and if the Gold which is the lesser Globe, were before the nearest to the handle D E, having now changed his place, will be farthest from the handle D E, as in K;

F there-

therefore the Centre of Gravity of the two Globes taken together, ſhall be farther ſeparate from the middle of the handle (under which is the Centre of Gravity of the Box) than it was before, and ſeeing that the handle is always in the middle of the Box, the weight N muſt be augmented, to keep



it in *æquilibrio*: and by this way one may know, that if at the ſecond time, the counterpoiſe be too light, it is a ſign that the Gold is fartheſt off the handle, as at the firſt trial it was neareſt.

PROBLEM XLIV.

How to repreſent divers ſorts of Rainbows here below.

THe Rainbow is a thing admirable in the World, which raviſheth often the Eyes and Spirits of men in conſideration of its rich intermingled colours which are ſeen under the Clouds, ſeeming as the gliſtering of the Stars, precious Stones, and Ornaments of the moſt beauteous Flowers: ſome part of it as the reſplendent Stars, or as a Roſe, or burning Cole of fire, in it one may ſee Dyes of ſundry ſorts, the Violet, the Blew,

Blew, the Orange, the Saphir, the Jacinct, and the Emerald colours, as a lively plant placed in a green Soil: and as a most rich Treasure of Nature, it is a high work of the Sun who casteth his Rays or Beams as a curious Painter draws strokes with his Pencil, and placeth his Colours in an exquisite situation; and *Solomon* saith, *Eccles*.4.3. It is a chief and principal Work of God. Notwithstanding there is left to industry how to represent it from above here below, though not in perfection, yet in part, with the same intermixture of colours that is above.

Have you not seen how by Oars of a Boat it doth exceeding quickly glide upon the Water with a pleasant grace? *Aristotle* says, that it coloureth the Water, and makes a thousand atoms, upon which the Beams of the Sun reflecting, make a kind of coloured Rainbow: Or may we not see in Houses or Gardens of pleasure Artificial Fountains, which pour forth their droppy Streams of Water, that being between the Sun and the Fountain, there will be presented as a continual Rainbow? But not to go farther, I will shew you how you may do it at your Door, by a fine and facil Experiment.

Take Water in your Mouth, and turn your Back to the Sun, and your Face against some obscure place, then blow out the Water which is in your Mouth, that it may be sprinkled in small Drops and Vapours: You shall see those Atomes Vapours in the Beams of the Sun to turn into a fair Rainbow, but all the grief is, that it lasteth not, but soon is vanished.

F 2 But

But to have one more ſtable and permanent in his colours: Take a Glaſs full of Water, and expoſe it to the Sun, ſo that the Rays that paſs through ſtrike upon a ſhadowed place, you will have pleaſure to ſee the fine form of a Rainbow by this reflection. Or take a Trigonal Glaſs or Cryſtal Glaſs of divers Angles, and look through it, or let the Beams of the Sun paſs through it; or with a Candle let the Appearances be received upon a ſhadowed place: you will have the ſame contentment.

PROBLEM XLV.

How that if all the Powder in the world were incloſed within a Bowl of Paper or Glaſs, and being fired on all parts, it could not break that Bowl.

IF the Bowl and the Powder be uniform in all his parts, then by that means the Powder would preſs and move equally on each ſide, in which there is no poſſibility whereby it ought to begin by one ſide more than another. Now it is impoſſible that the Bowl ſhould be broken in all its parts, for they are infinite.

Of like fineneſs or ſubtilty may it be that a Bowl of Iron falling from a high place upon a plain pavement of thin Glaſs, it were impoſſible any wiſe to break it; if the Bowl were perfectly round, and the Glaſs flat and uniform in all his parts: for the Bowl would touch the Glaſs but

but in one point, which is in the middle of infinite parts which are about it : neither is there any cauſe why it ought more on one ſide than on another, ſeeing that it may not be done with all his ſides together ; it may be concluded as ſpeaking naturally, that ſuch a Bowl falling upon ſuch a Glaſs will not break it. But this matter is meer Metaphyſical, and all the Workmen in the world cannot ever with all their Induſtry make a Bowl perfectly round, or a Glaſs uniform.

PROBLEM XLVI.

To find a number which being divided by 2, there will remain 1 ; being divided by 3, there will remain 1 ; and ſo likewiſe being divided by 4, 5, or 6, there would ſtill remain 1 ; but being divided by 7, there will remain nothing.

IN many Authors of Arithmetick this Problem is thus propoſed : A Woman carrying Egges to market in a Basket, met an unruly fellow who broke them, who was by order made to pay for them : and ſhe being demanded what number ſhe had, ſhe could not tell : but ſhe remembred that counting them by 2 and 2, there remained 1 ; likewiſe by 3 and 3, by 4 and 4, by 5 and 5, by 6 and 6 ; there ſtill remained 1,

 but

but when ſhe counted them by 7 and 7, there re-remained nothing: Now how may the number of Eggs be diſcovered?

Find a Number which may exactly be meaſured by 7, and being meaſured by 2, 3, 4, 5, and 6, there will ſtill remain a unite; multiply theſe numbers together, makes 720, to which add 1, ſo have you the number, *viz.* 721. In like manner 301 will be meaſured by 2,3,4,5,6; ſo that 1 remains: but being meaſured by 7, nothing will remain; to which continually add 220, and you have other numbers which will do the ſame: Hence it is doubtful what number ſhe had. Therefore not to fail, it muſt be known whether they did exceed 400, 800, &c. in which it may be conjectured that it could not exceed 4 or 5 hundred, ſeeing a Man or Woman could not carry 7 or 8 hundred Eggs, therefore the number was the former 301, which ſhe had in her Basket: which being counted by 2 and 2, there will remain 1, by 3 and 3, &c. but counted by 7 and 7, there will remain nothing.

PRO-

PROBLEM XLVII.

One had a certain number of Crowns, and counting them by 2 and 2, there rested 1; counting them by 3 and 3, there rested 2; counting them by 4 and 4, there rested 3; counting them by 5 and 5, there rested 4; counting them by 6 and 6, there rested 5; but counting them by 7 and 7, there remained nothing: How many Crowns might he have?

THis Queſtion hath ſome affinity to the precedent, and the Reſolution is almoſt in the ſame manner: for here there muſt be found a number, which multiplied by 7, and then divided by 2,3,4,5,6, there may always remain a number leſs by 1 than the Diviſor: Now the firſt number which arrives in this nature is 119, unto which if 420 be added, makes 539, which alſo will do the ſame: and ſo by adding 420, you may have other numbers to reſolve this propoſition.

PROBLEM XLVIII.

How many ſorts of Weights in the leaſt manner muſt there be to weigh all ſorts of things between 1 pound and 40 pound, and ſo unto 121, & 364 pound.

TO weigh things between 1 & 40, take numbers in tripple proportion, ſo that their ſum be equal, or ſomewhat greater than 40, as are the numbers 1, 3, 9, 27, I ſay that with 4 ſuch Weights, the firſt being of 1 pound, the ſecond being 3 pound, the third being 9 pound, and the fourth being 27: any weight between 1 & 40 pound may be weighed. As admit to weigh 21 pound, put unto the thing that is to be weighed the 9 pound weight, then in the other Ballance put 27 pound and 3 pound, which doth counterpoiſe 21 pound and 9 pound, and if 20 pound were to be weighed, put to it in the Ballance 9 and 1, and in the other Ballance put 27 and 3, and ſo of others.

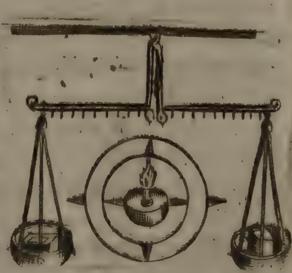
In the ſame manner take thoſe 5 Weights, 1, 3, 9, 27, 81, you may weigh with them between 1 pound, and 121 pound: and taking thoſe 6 Weights, as 1, 3, 9, 27, 81, 243, you may weigh even from 1 pound unto 364 pound. This depends upon the property of continued Proportionals, the latter of which containing twice all the former.

PRO-

PROBLEM XLIX.

Of a deceitful Ballance, which being empty ſeems to be juſt, becauſe it hangs in æquilibrio: notwithſtanding putting 12 pound in one Ballance, and 11 in the other, it will remain in æquilibrio.

ARiſtotle m keth mention of this Ballance in his Mechanick Queſtions, and ſaith, That the the Merchants of purpoſe in his time uſed them to deceive the World: the ſubtilty or craft of which is thus, that one arm of the Ballance is longer than another, by the ſame proportion that one weight is heavier than another: As if the Beam were 23 inches long, and the handle placed ſo that 12 inches ſhould be on one ſide of it, and 11 inches on the other ſide: Conditionally that the ſhorter end ſhould be as heavy as the longer, a thing eaſie to be done: then afterwards put into the ballance two unequal weights in ſuch proportion as the parts of the beam have one



unto another, which is 12 to 11, but ſo that the greater be placed in the ballance which hangs upon the ſhorter part of the Beam, and the leſſer weight

weight in the other ballance : it is moſt certain that the ballances will hang *in æquilibrio*, which will ſeem moſt ſincere and juſt ; though it be moſt deceitful, abominable, and falſe.

The reaſon of this is drawn from the Experiments of *Archimedes*, who ſhews that two unequal weights will counterpoiſe one another, when there is like proportion between the parts of the Beam (that the handle ſeparates) and the Weights themſelves: for in one and the ſame counterpoiſe, by how much it is farther from the Centre of the Handle, by ſo much it ſeems heavier ; therefore if there be a diverſity of diſtance that the Ballances hang from the handle, there muſt neceſſarily be an inequality of weight in theſe Ballances to make them hang in *æquilibrio* ; and to diſcover if there be deceit, change the Weight into the other Ballance: for as ſoon as the greater Weight is placed in the Ballance that hangs on the longer parts of the Beam, it will weigh down the other inſtantly.

PROBLEM L.

To heave or lift up a Bottle with a Straw.

TAke a Straw that is not bruiſed, bow it that it make an Angle, and put it into the Bottle ſo that the greateſt end be in the Neck, then the Reed being put in the bowed part will caſt ſidewiſe, and make an Angle, as in the figure may

may be ſeen: then may you take the end which is out of the Bottle in your hand, and heave up the Bottle, and it is ſo much ſurer, by how much the Angle is acuter or ſharper; and the end which is bowed approacheth to the other perpendicular parts which come out of the Bottle.

PROBLEM LI.

How in the middle of a Wood or Deſert, without the ſight of the Sun, Stars, Shadow, or Compaß, to find out the North or South, or the four Cardinal Points of the World, East, *Weſt,* &c.

IT is the Opinion of ſome, that the Winds are to be obſerved in this: if it be hot, the South is found by the winds that blow that way, but this Obſervation is uncertain, and ſubject to much Error: Nature will help you in ſome meaſure to make it more manifeſt than any of the former, from a Tree, thus: Cut a ſmall Tree off, even to the ground, and mark the many Circles that are about the ſap or pith of the Tree, which ſeem nearer together in ſome part than in other, which is by reaſon of the Suns motion about the Tree: for that the humidity of the parts of the Tree

Tree towards the South by the heat of the Sun is rarified, and cauſed to extend : and the Sun not giving ſuch heat towards the North part of the Tree, the Sap is leſſer rarified, but condenſed; by which the Circles are nearer together on the North part than on the South part : therefore if a Line be drawn from the wideſt to the narroweſt part of the Circles, it ſhall ſhew the North and South of the World. Another Experiment may be thus : Take a ſmall Needle, ſuch as Women work with : place it gently down flat-wiſe upon ſtill Water, and it will not ſink, (which is againſt the general Tenet that Iron will not ſwim) which Needle will by little and little turn to the North and South points. But if the Needle be great, and will not ſwim, thruſt it through a ſmall piece of Cork, or ſome ſuch-like thing, and then it will do the ſame : for ſuch is the property of Iron when it is placed in *æquilibrio*, it ſtrives to find out the Poles of the World, or Points of North and South in a manner as the *Magnes* doth.

Exami-

Examination.

HEre is obſervable, that the moiſture which addeth to the growth of the Tree, is dilated and rarified by the Meridional heat, and contracted by the Septentrional cold: this Rarefaction works upon the part of the humour or moiſture that is more thin, which doth eaſily diſſipate and evaporate: Which evaporation carries a part of the Salt with it; and becauſe that Solidation or Condenſation, ſo that there is left but a part of the Nouriſhment which the heat bakes up and conſumes: ſo contrarily on the other ſide the Condenſation and Reſtrictive Quality of the Moiſture cauſeth leſs Evaporation and Perdition: and ſo conſequently there remains more Nouriſhment, which makes a greater increaſe on that ſide than on the other ſide: for as Trees have their growth in Winter, becauſe of their Pores, and theſe of the Earth are ſhut up: ſo in the Spring, when their Pores are open, and when the Sap and Moiſture is drawn by it, there is not ſuch Cold on the North ſide that it may be condenſed at once: But contrarily to the ſide which is South, the heat may be ſuch, that in little time by continuance, this moiſture is diſſipated greatly: And Cold is nothing but that which hardeneth and contracteth the moiſture of the Tree, and ſo converteth it into Wood.

PRO-

PROBLEM LII.

Three Persons having taken Counters, Cards, or other things, to find how much each one hath taken.

CAuſe the third party to take a number which may be divided by 4, and as often as he takes four, let the ſecond party take 7, and the firſt take 13, then cauſe them to put them all together, and declare the ſum of it; which ſecretly divide by 3, and the Quotient is the double of the number which the third perſon did take. Or cauſe the third to give unto the ſecond and firſt, as many as each of them hath; then let the ſecond give unto the firſt and third, as many as each of them hath; laſtly, let the third give unto the ſecond and firſt, as many as each of them hath; and then ask how much one of them hath: (for they will have then all alike) ſo half of that number is the number that the third perſon had at the firſt; which known, all is known.

PROBLEM LIII.

How to make a Conſort of Muſick of many parts, with one Voice, or one Inſtrument onely.

THis Problem is reſolved, ſo that a Singer or Player upon an Inſtrument, be near an Echo which anſwereth his Voice or Inſtrument; and if the

the Echo anſwereth but once at a time, he may make a double; if twice, then a tripple; if three times, then an harmony of four parts: for it muſt be ſuch a one that is able to exerciſe both tune and note, as occaſion requires. As when he begins *ut*, before the Echo anſwer, he may begin *ſol*, and pronounce it in the ſame tune that the Echo anſwereth, by which means you have a fifth agreeable Conſort of Muſick: then in the ſame time that the Echo followeth, to ſound the ſecond note *ſol*, he may ſound forth another *ſol* higher or lower, to make an eight, the moſt perfect Conſort of Muſick, and ſo of others, if he will continue his Voice with the Echo, and ſing alone with two parts. Now Experience ſheweth this to be true, which often comes to paſs in many Churches, making one to believe that there are many more parts in the Muſick of a Quire, than in effect truly there are, becauſe of the reſounding and multiplying of the Voice, and redoubling of the Quire.

PROBLEM LIV.

To make or deſcribe an Oval form, or that which near reſembles unto it, at one turning with a pair of common Compaſſes.

THere are many fine ways in Geometrical practices, to make an Oval Figure, or one near unto it, by ſeveral Centres: any of which I will not touch upon, but ſhew how it may be done promptly

promptly upon one Centre onely. In which I will ſay nothing of the Oval form, which appears, when one deſcribeth Circles with the points of a common Compaſs, ſomewhat deep upon a Skin ſtretched forth hard: which contracting it ſelf in ſome parts of the Skin maketh an Oval form. But it will more evidently appear upon a Column or Cylinder: if Paper be placed upon it, then with a pair of Compaſſes deſcribe as it were a Circle upon it, which Paper afterwards being extended, will not be circular, but oval-wiſe: and a pair of Compaſſes may be ſo accommodated, that it may be done alſo upon a Plain thus: As let the length of the Oval be H K, faſten 2 Pins or Nails near the end of that Line, as F G, and take a thread which is double to the length of G H, or F K, then if

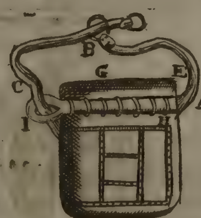
you take a Compaſs which may have one foot lower than another, with a Spring between his legs, and placing one foot of this Compaſs in the Centre of the Oval, and guiding the thred by the other foot of the Compaſſes, and ſo carrying it about: the Spring will help to deſcribe and draw the Oval form. But inſtead of the Compaſſes it may be done with ones hand only, as in the Figure may appear.

PRO-

PROBLEM LV.

Of a Purſe difficult to be opened.

IT is made to ſhut and open with Rings: firſt at each ſide there is a ſtrap or ſtring as A B and C D, at the end of which are 2 Rings, B and D, and the ſtring C D paſſeth through the Ring B, ſo that it may not come out again, or be parted one from another: and ſo that the Ring B may ſlide up and down upon the ſtring *C D*, then over the purſe there is a piece of Leather *E F G H*, which covers the opening of the purſe, and there is another piece of Leather *A E*, which paſſeth thorow many Rings, which hath a ſlit towards the end *I*, ſo great that the ſtring *BC* may ſlide into it: Now all the cunning or craft is how to make faſt or to open the purſe, which conſiſts in making



the ſtring *B C* ſlide through the ſide at *I*, therefore bring down *B* to *I*, then make the end *I* paſs thorow the ring *B*, and alſo *D* with his ſtring to paſs through the ſlit *I*, ſo ſhall the Purſe be faſt, and then may the ſtrings be put as before, and it will ſeem difficult to diſcover how it was done. Now to open the Purſe, put through the end *I* through the Ring *B*, and then through the ſlit *I*, by which you put through the String *D C*, by this way the Purſe will be opened.

PROBLEM LVI.

Whether it is more hard and admirable, without Compasses to make a perfect Circle, or being made, to find out the Centre of it.

IT is ſaid that upon a time paſt, two Mathematicians met, and they would make trial of their Induſtry: The one made inſtantly a Perfect Circle without Compaſſes, and the other immediately pointed out the Centre thereof with the point of a Needle: Now which is the chiefeſt Action? It ſeems the firſt, for to draw the moſt nobleſt Figure upon a Plain Table without other help than the Hand and the Mind, is full of admiration; to find the Centre is but to find out onely one point, but to draw a Round, there muſt be almoſt infinite points, equidiſtant from the Centre or middle; that in Concluſion it is both the Circle and the Centre together. But contrarily it may ſeem that to find the Centre is more difficult: for what attention, vivacity, and ſubtilty muſt there be in the Spirit, in the Eye, in the Hand, which will chuſe the true point amongſt a thouſand other points? He that makes a Circle keeps always the ſame diſtance, and is guided by a half diſtance to finiſh the reſt; but he that muſt find the Centre, muſt in the ſame time take heed to the parts about it, and chooſe one onely point which is equally diſtant from an infinite of other

other points which are in the Circumference; which is very difficult. *Ariſtotle* confirms this amongſt his Morals, and ſeems to explain the difficulty which is to be found in the middle of Vertue; for it may want a thouſand ways, and be far ſeparated from the true Centre of the end of a right Mediocrity of a vertuous Action: for to do well, it muſt touch the middle point, which is but one, and there muſt be a true point which reſpects the end, and that's but one onely. Now to judge which is the moſt difficult, as before is ſaid, either to draw the Round, or to find the Centre, the Round ſeems to be harder than to find the Centre, becauſe that in finding of it is done at once, and hath an equal diſtance from the whole; But, as before, to draw a Round, there is a viſible point imagined, about which the Circle is to be drawn. I eſteem that it is as difficult therefore, if not more, to make the Circle without a Centre, as to find the middle or Centre of that Circle.

PROBLEM LVII.

Any one having taken 3 Cards, to find how many points they contain.

THis is to be exercifed upon a full Pack of Cards of 52, then let one chooſe any three at pleaſure ſecretly from your ſight, and bid him ſecretly account the points in each Card, and will him to take as many Cards as will make up 15 to each of the points of his Cards, then will him to give you the rest of the Cards, for 4 of them being rejected, the rest shew the number of points that his three Cards which he took at the first did contain. As if the 3 Cards were 7, 10, and 4; now 7 wants of 15, 8; take 8 Cards therefore for your first Card: the 10 wants of 15, 5; take 5 Cards for your second Card: lastly, 4 wants of 15, 11; take 11 Cards for your third Card, and giving him the rest of the Cards there will be 25; from which take 4, there remains 21, the number of the three Cards taken, *viz.* 7, 10, and 4.

Whosoever would practise this play with 4, 5, 6, or more cards, and that the whole number of cards be more or less than 52; and that the term be 15, 14, 12, *&c.* this general Rule ensuing may serve: multiply the term by the number of cards taken at first; to the product add the number of cards taken, then subtract this sum from the whole number of cards; the remainder is the number which must be subtracted from the cards, which remains to make up the Game: if there remain nothing after the subtraction, then the number of cards remaining doth justly shew the number of points which were in the cards chosen. If the subtraction cannot be made, then subtract the number of cards from that number, and the remainder added unto the cards that did remain, the sum will be the number of points in the cards taken, as if the cards were 7, 10, 5, 8, and the term given were 12; so the first wants 5, the second wants 2, the third wants 7, and the fourth wants 4 cards, which taken, the party gives you the

the reſt of the cards: then ſecretly multiply 12 by 4, makes 48; to which add 4, the number of cards taken makes 52, from which 52 ſhould be taken, reſt nothing: therefore according to the direction of the remainder of the cards, which are 30, is equal to the points of the four cards taken, *viz.* 7, 10, 5, 8. Again, let theſe 5 cards be ſuppoſed to be taken, 8, 6, 10, 3, 7; their differences to 15, the terms are 7, 9, 5, 12, 8, which number of cards taken, there will remain but 6 cards: then privately multiply 15 by 5, makes 75, to which add 5 makes 80, from this take 52, the number of cards, reſts 28, to which add the remainder of cards, makes 34, the ſum with 8, 6, 10, 3, 7.

PROBLEM LVII.

Many Cards placed in divers ranks, to find which of theſe Cards any one hath thought.

TAke 15 Cards, and place them in 3 heaps in rank-wiſe, 5 in a heap: now ſuppoſe any one had thought one of theſe Cards in any one of the heaps, it is eaſie to find which of the Cards it is, and it is done thus: ask him in which of the heaps it is, which place in the middle of the other two; then throw down the Cards by 1 and 1 into three ſeveral heaps in rank-wiſe, until all be caſt down, then ask him in which of the ranks his Card is, which heap place in the middle of the other two heaps always, and this do four times at least, so in putting the Cards altogether, look upon the Cards, or let their back be towards you, and throw out the eight Card, for that was the Card thought upon without fail.

PROBLEM LVIII.

Many Cards being offered to sundry Persons, to find which of these Cards any one thinketh upon.

ADmit there were 4 persons, then take 4 Cards and shew them to the first, bid him think one of them, and put these 4 away; then take 4 other Cards, and shew them in like manner to the second person, and bid him think any one of these Cards, and so do to the third person, and so the fourth, &c. Then take the 4 Cards of the first person, and dispose them in 4 ranks, and upon them the 4 Cards of the second person, upon them also these of the third person, and lastly, upon them these of the fourth person; then shew unto each of these parties each of these ranks, and ask him if his Card be in it which he thought, for infallibly that which the first party thought upon will be in the first rank, and at the bottom the Card of the second person will be in the second rank, the Card of the third thought upon will be in the third rank, and the fourth mans

mans Card will be in the fourth rank, and ſo of others; if there be more perſons, uſe the ſame method. This may be practiſed by other things, ranking them by certain numbers allotted to pieces of money, or ſuch-like things.

PROBLEM LIX.

How to make an Inſtrument to help Hearing, as Galileus *made to help the Sight.*

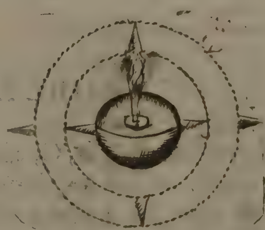
THink not that the Mathematicks (which hath furniſhed us with ſuch admirable helps for Seeing) is wanting for that of Hearing; it's well known that long Trunks or Pipes make one hear well far off, and Experience ſhews us that in certain places of the *Orcades* in a hollow vault, that a man ſpeaking but ſoftly at one corner thereof, may be audibly underſtood at the other end: notwithſtanding thoſe which are between the parties cannot hear him ſpeak at all: and it is a general Principle, that Pipes do greatly help to ſtrengthen the Activity of Natural Cauſes: We ſee that fire contracted in a Pipe, burns 4 or 5 foot high, which would ſcarce heat, being in the open air: the rupture or violence of water iſſuing out of a Fountain, ſhews us that water being contracted into a Pipe, cauſeth a violence in its paſſage. The Glaſſes of *Galileus* makes us ſee how uſeful Pipes or Trunks are to make the Light and Species more visible and proportionable to our Eye. It is ſaid that a Prince of *Italy* hath a fair Hall, in which he can with facility hear diſtinctly the Diſcourſes of thoſe which walk in the adjacent Gardens, which is by certain Veſſels and Pipes that anſwer from the Garden to the Hall. *Vitruvius* makes mention alſo of ſuch Veſſels and Pipes to ſtrengthen the Voice and Action of *Comedians*: and in theſe times amongſt many Noble Perſonages, the new kind of Trunks are uſed to help the hearing, being made of Silver, Copper, or other reſounding material; in funnel-wiſe putting the wideſt end to him which ſpeaketh, to the end to contract the Voice, that ſo by the Pipe applied to the Ear it may be more uniform, and leſs in danger to diſſipate the Voice, and ſo conſequently more fortified.

PROBLEM LX.

Of a fine Lamp which goes not out, though one carry it in ones pocket.: or being rolled upon the ground will ſtill burn.

IT muſt be obſerved that the Veſſel in which the Oil is put into, have two pins on the ſides of it, one againſt another, being included within a circle: this circle ought to have two other pins, to enter into another circle of braſs, or other ſolid matter: laſtly, this ſecond circle hath two pins

pins, which may hang within ſome Box to contain the whole Lamp, in ſuch manner, that there be ſix pins in different poſition: Now by the aid of theſe pegs or pins, the Lamp that is in the middle will be always well ſituated according to his Centre of Gravity, though it be turned any way: though if you endeavour to turn it upſide-down, it will lie level: which is pleaſant and admirable to behold to thoſe which know not the cauſe.



And it is facil from this to make a place to reſt quiet in, though there be great agitation in the outward parts.

PROBLEM LXI.

Any one having thought a Card amongſt many Cards, how artificially to diſcover it out.

TAke any number of cards, as 10, 12, &c. and open ſome four or five to the parties ſight, and bid him think one of them, but let him note whether it be the firſt, ſecond, third, &c. then with promptneſs learn what number of Cards you had in your hands, and take the other part of the Cards, and place them on the top of theſe you hold in your hand; and having done ſo, ſo, ask him whether his Card were the firſt, ſecond, &c. then before knowing the number of Cards that were at the bottom, account backwards until you come to it: ſo ſhall you eaſily take out the Card that he thought upon.

PROBLEM LXII.

Three Women, A, B, C, *carried Apples to a Market to ſell,* A *had* 20, B 30, *and* C 40; *they ſold as many for a penny the one as the other, and brought home one as much money as another: How could this be?*

THe Anſwer to the Problem is eaſie: As ſuppoſe at the beginning of the Market, *A* ſold her Aples at a penny an Apple, and ſold but two, which was two pence, and ſo ſhe had 18 left; but *B* ſold 17, which was 17 pence, and ſo had 13 left: C ſold 32, which was 32 pence, and ſo had 8 Apples left. Then *A* ſaid ſhe would not ſell her Apples ſo cheap, but would ſell them for 3 pence a piece, which ſhe did, and ſo her Apples came to 54 pence: And *B* having left but 13 Apples, ſold them at the ſame rate, which came to 39 pence:

A 20
2
18 and 54 is 56
30
17 and 39 is 56
and 24 is 56

pence: And laſtly, *C* had but 8 Apples, which at the ſame rate came to 24 pence: Theſe ſums of money which each others before received come to 56 pence, and ſo much each one received; and ſo conſequently brought home one as much as another.

PROBLEM LXIII.

Of the Properties of ſome Numbers.

FIrſt, any two numbers is juſt the ſum of a number, that have equal diſtance from the half of that number: the one augmenting, and the other diminiſhing: as 7 and 7, of 8 and 6, of 9 and 5, of 10 and 4, of 11 and 3, of 12 and 2, of 13 and 1, as the one is more than the half, the other is leſs.

Secondly, It is difficult to find two numbers whoſe ſum and product is alike, (that is) if the numbers be multiplied one by another, and added together, will be equal, which two numbers are 2 and 2, for to multiply 2 by 2 makes 4, and adding 2 unto 2 makes the ſame: this property is in no other two whole numbers, but in broken numbers there are infinite, whoſe ſum and product will be equal one to another. As *Clavius* ſhews upon the 36 *Prob.* of the 9th Book of *Euclide.*

Thirdly,

Thirdly, The numbers 5 and 6 are called circular numbers, becauſe the circle turns to the point from whence it begins: ſo theſe numbers multiplied by themſelves, do end always in 5 and 6, as 5 times 5 makes 25, that again by 5 makes 125, ſo 6 times 6 makes 36, and that by 6 makes 216, *&c.*

Fourthly, The number 6, is the firſt which Arithmeticians call a perfect number, that is, whoſe parts are equal unto it, ſo the ſixth part of it is 1, the third part is 2, the half is 3, which are all his parts: now 1, 2, and 3, is equal to 6. It is wonderful to conceive that there is ſo few of them, and how rare theſe numbers are, ſo of perfect men: for betwixt 1 and 1000000000000 numbers there is but ten, that is, 6, 28, 486, 8128, 120816, 2096128, 33550336, 536854528, 8589869056, and 137438691328, with this admirable property, that alternately they end all in ſix and eight, and the Twentieth Perfect Number is 1511157274515537689 1328.

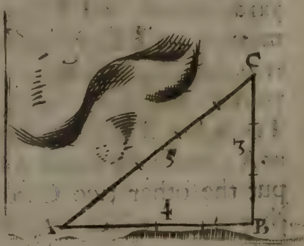
Fifthly, The number 9 amongſt other priviledges carries with it an excellent property; for take what number you will, either in groſs or in part, the nines of the whole or in its parts rejected, and taken ſimply will be the ſame, as 27 it makes 3 times 9, ſo whether the nines be rejected of 27 or of the ſum of 2 and 7, it is all one; ſo if the nines were taken away of 240, it is all one if the nines were taken away of 2, 4, and 0; for there would remain 6 in either; and ſo of others.

Sixthly,

Sixthly, 11 being multiplied by 2,4,5,6,7,8, or 9, will end and begin with like numbers; ſo 11 multiplied by 5 makes 55, if multiplied by 8, it makes 88, &c.

Seventhly, the numbers 220 and 284 being unequal, notwithſtanding the parts of the one number do always equalize the other number: ſo the *aliquot* parts of 220 are 110, 54, 44, 22, 20, 11, 10, 5, 4, 2, 1, which together makes 284, the *aliquot* parts of 284, are 142, 71, 4, 2, 1, which together makes 220, a thing rare and admirable, and difficult to find in other numbers.

Eightly, The numbers 3, 4 5, (found out by *Pythagoras*) have an excellent property in making of Rectangle Triangles: upon which the 47 *Pro.* of the firſt Book of *Euclide* was grounded, that the ſquare of the *Hypothenuſal* in any ſuch Triangle, is equal to the ſquare of the other two ſides: that is 5, the *Hypothenuſal* multiplied in 5 makes 25, and 4 multipled in 4 makes 16, and 3 multipli'd in 3 makes 9, but 9 and 16 is equal to 25, or if theſe numbers 3, 4, 5, be doubled, *viz.* 6, 8,

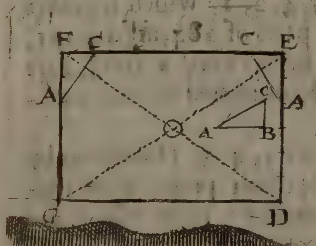


10: the ſquare of 10 is equal to the ſquare of 8 and 6, *viz.* 10 times 10 makes 100, and 8 times 8 makes 64, and 6 times 6 is 36; which

36

36 and 64, put together makes 100, as before: and so may they be *Tripled*, *Quadrupled*, &c.

The use of these numbers 3, 4, 5, are manifold, but it may be applied thus, for the help of such which plot out Gardens, Houses, encamp Horse or Foot, *&c.* Example, take 3 Cords, one of 5 yards, another of 4 yards, and another of 3 yards, or the double, tripple, decuple, *&c.* or all in one line, and make knots at the terms of these measures, so these three parts will make a right angled Triangle, as *A*, *B*, *C*; and it is easie with this Triangular Cord to plot out a Garden-plat, a square building plat, or other long square. As suppose there is a figure, E D F G to be plotted, E D of 60 yards broad, and F G 100 yards long. First measure out E D 60 yards, and at E and D place two pins or pegs; then at E place the Angle of your Triangular Cord B, and let the line of the Triangle A B be in the line E D, which suppose at A; make the Cord A B fast in E and A, then put the other two Cords of the Triangle until they meet, which will be in C, and place a peg at C; take afterwards a long Cord, and by the points E and C augment it unto F 100 yards from E, and at F place a peg; then at F apply your Triangular Cord as you did at E, and so may you draw the line F G as long as E D, *viz.* 60 yards.



yards. Laſtly, it is eaſie to draw the Line G D, and ſo the Rectanguled Figure or Long Square ſhall be plotted, whoſe breadth is 60 yards, and length 100 yards, as was required: and to examine this, meaſure E G, then if F D be as long, the figure is true: otherwiſe it is defective, and may eaſily be amended.

If one be taken from any ſquare nnmber which is odd, the ſquare of half of it being added to the firſt ſquare, will make a ſquare number.

The ſquare of half any even number +. 1 being added to that even number makes a ſquare number, and the even number taken from it leaves a ſquare number.

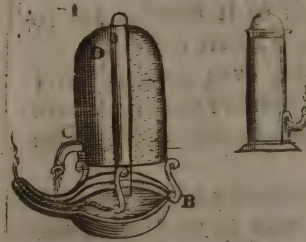
If odd numbers be continually added from the unity ſucceſſively, there will be made all ſquare numbers, and if cubick numbers be added ſucceſſively from the unity, there will be likewiſe made ſquare numbers.

PROBLEM LXIV.

Of an Excellent Lamp, which ſerves or furniſheth it ſelf with Oil, and burns a long time.

I Speak not here of a common Lamp which *Cardanus* writes upon in his Book *de ſubtilitate*, for that's a little Veſſel in Columne-wiſe, which

which is full of Oyl, and becauſe there is but one little hole at the bottom near the Week or Match, the Oil runs not, for fear that there be emptineſs above: When the Match is kindled it begins to heat the Lamp, and rarifying the Oil it iſſueth by this occaſion: and ſo ſends his more airy parts above, to avoid vacuity.



But that which I here deliver is more ingenious, the principal piece of which is a veſſel, as C D, which hath near the bottom a hole, and a funnel or pipe C, and then a bigger funnel, which paſſeth thorow the middle of the Veſſel, having an opening at D near the E top, and another at the bottom, as at E, near the Veſſel under it, ſo that the Pipe touch it not: the Veſſel being thus made, fill it with Oyl, and opening the hole C, the Oil running out will ſtop the hole at E, or throwing in Oil into the Veſſel underneath, until E be ſtopped; then the Oil at C will not run: becauſe no air can come into the Pipe D E. Now as the Oil burneth and conſumeth in the Veſſel A B, the hole at E will begin to open, then immediately will C begin to run to fill up A B, and E being ſtopped with the Oil, the Oil at C ceaſeth to run.

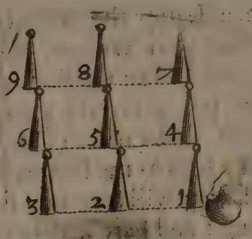
It is certain that ſuch a Lamp the *Athenians* uſed, which laſted a whole year without being touched: which was placed before the Statue of *Minerva*, for they might put a certain quantity of Oyl in the Lamp C D, and a match to burn without being conſumed: ſuch as the Naturaliſts write of, by which the Lamp will furniſh it ſelf, and ſo continue in burning: and here may be noted that the Oyl may be poured in at the top of the Veſſel at a little hole, and then made faſt again that the Air get not in.

PROBLEM LXV.

Of the play at Keyles or Nine-Pins.

YOu will ſcarce believe that with one Bowl, and at one blow playing freely, one may ſtrike down all the Keyles at once: yet from Mathematical Principles it is eaſie to be demonſtrated, that if the hand of him that plays were ſo well aſſured by Experience as Reaſon induceth one thereto, one might at one blow ſtrike down all the Keyls, or at leaſt 7 or 8, or ſuch a number as one pleaſeth.

For they are but Nine in all, diſpoſed or placed in a perfect Square, having Three every way. Let us ſuppoſe then that a good Player beginning to play at 1 ſomewhat low, ſhould ſo ſtrike it, that it ſhould ſtrike down the Keyles 2 and 5, and theſe might in their violence ſtrike



down the Keyles 3, 6, and 9, and the Bowl being in motion may ſtrike down the Keyle 4, and 7; which 4 Keyle may ſtrike the Keyl 8, and ſo all the 9 Keyles may be ſtriken down at once.

PROBLEM LXIV.

Of Spectacles of pleaſure.

SImple Spectacles of blew, yellow, red or green colour, are proper to recreate the ſight, and will preſent the Objects died in like colour that the Glaſſes are, only thoſe of the Green do ſomewhat degenerate; inſtead of ſhewing a lively colour, it will repreſent a pale dead colour, and it is becauſe they are not died green enough, or receive not light enough for green: and colour theſe Images that paſs through theſe Glaſſes unto the bottom of the Eye.

Examination.

IT is certain, that not onely Glasses dyed green, but all other Glasses coloured, yield the appearances of Objects strong or weak in colour according to the quantity of the dye, more or less, as one being very yellow, another a pale yellow; now all colours are not proper to Glasses to give colour, hence the defect is not that they want faculty to receive light, or resist the penetration of the beams; for in the same Glasses those which are most dyed, give always the Objects more high-coloured and obscure, and those which are less dyed, give them more pale and clear: and this is daily made manifest by the painting of Glass, which hinders more the penetration of the light than dying doth, where all the matter by fire is forced into the Glass, leaving it in all parts transparent.

Spectacles of Crystal cut with divers Angles Diamond-wise, do make a marvellous multiplication of the appearances, for looking towards a House it becomes as a Town, a Town becomes like a City, an armed man seems as a whole Company, caused solely by the diversity of Refractions, for as many Plains as there are on the out side of the Spectacle, so many times will the Object be multiplied in the appearance, because of divers Images cast into the Eye. These are pleasurable Spectacles for avaritious persons that love Gold and Silver, for one Piece will seem many, or one *heap of Money will ſeem as a Treaſury: but all the miſchief is, he will not have his end in the enjoying of it, for endeavouring to take it, it will appear but a deceitful Image, or deluſion of nothing. Here may you note, that if the finger be directed by one and the ſame ray or beam, which pointeth to one and the ſame object, then at the firſt you may touch that viſible Object without being deceived: otherwiſe you may fail often in touching that which you ſee. Again, there are Spectacles made which do diminiſh the thing ſeen very much, and bring it to a fair perſpective form; eſpecially if one look upon a fair Garden-plat, a greater Walk, a ſtately Building, or great Court; the induſtry of an exquiſite Painter cannot come near to expreſs the lively form of it as this Glaſs will repreſent it; you will have pleaſure to ſee it really experimented; and the cauſe of this is, that the Glaſſes of theſe Spectacles are hollow and thinner in the middle, than at the edges, by which the viſual Angle is made leſſer: You may obſerve a further ſecret in theſe Spectacles, for in placing them upon a Window one may ſee thoſe that paſs to and fro in the Streets, without being ſeen of any; for their property is to raiſe up the Objects that it looks upon.*

Now I would not paſs this Problem without ſaying ſomething of Galileus *admirable Glaſs: for the common ſimple perſpective Glaſſes, give to Aged Men but the Eyes or ſight of Young Men, but this of* Galileus *gives a Man an Eagles Eye, or an Eye that pierceth the Heavens: Firſt it diſcovereth the ſpotty and ſhadowed opacous Bodies that are found about the Sun, which darkeneth and diminiſheth the ſplendor of that beautiful and ſhining Luminary:*

Secondly,

Secondly, It ſhews the New Planets that accompany Saturn *and* Jupiter*: Thirdly, in* Venus *is ſeen the New, Full, and Quartile Increaſe; as in the Moon by her ſeparation from the Sun: Fourthly, the artificial ſtructure of this Inſtrument helpeth us to ſee an innumerable number of Stars, which otherwiſe are obſcured, by reaſon of the natural weakneſs of our ſight; yea the Stars in* Via Lactea *are ſeen moſt apparently; where there ſeem no Stars to be, this Inſtrument makes apparently to be ſeen, and further delivers them to the Eye in their true and lively colour, as they are in the Heavens, in which the ſplendor of ſome is as the Sun in his moſt glorious Beauty.*

This Glaſs hath alſo a moſt excellent uſe in obſerving the Body of the Moon in time of Eclipſes, for it augments it manifold, and moſt manifeſtly ſhews the true form of the cloudy ſubſtance in the Sun; and by it is ſeen when the ſhadow of the Earth begins to eclipſe the Moon, and when totally ſhe is overſhadowed. Beſides the Cœleſtial Uſes which are made of this Glaſs, it hath another Noble Property, it far exceedeth the ordinary Perſpective Glaſſes, which are uſed to ſee things remote upon the Earth: For as this Glaſs reacheth up to the Heavens, and excelleth them there in his performance, ſo on the Earth it claimeth preheminency, for the Objects which are fartheſt remote, and moſt obſcure, are ſeen plainer than thoſe which are near at hand, ſcorning as it were all ſmall and trivial ſervices, as leaving them to an inferiour help: great uſe may be made of this Glaſs in diſcovering Ships, Armies, &c. Now the apparel or parts of this Inſtrument or Glaſs is mean *or ſimple, which makes it the more admirable (ſeeing it performs ſuch great Service) having but a Convex Glaſs, thickeſt in the middle, to unite and amaſs the Rays, and make the Object the greater: to the augmenting the viſual Angle, as alſo a Pipe or Trunk to amaſs the Species, and hinder the greatneſs of the light which is about it* : (to ſee well, the Object muſt be well inlightened, and the Eye in obſcurity) *then there is adjoyned unto it a Glaß of a ſhort ſight to diſtinguiſh the Rays, which the other would make more confuſed if alone. As for the proportion of thoſe Glaſſes to the Trunk, though there be certain Rules to make them, yet it is often by hazard that there is made an excellent one, there being ſo many difficulties in the action; therefore many ought to be tried, ſeeing that exact proportion in Geometrical Calculation cannot ſerve for diverſity of ſights in the Obſervation.*

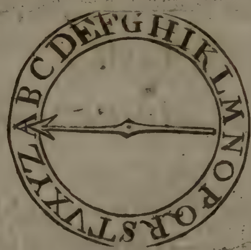
PRO-

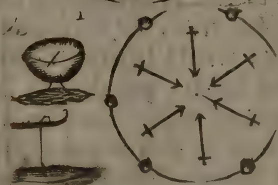
PROBLEM LXVII.

Of the Adamant or Magnes, and the Needles touched therewith.

WHo would believe, if he ſaw not with his Eyes, that a Needle of Steel being once touched with the *Magnes*, turns not once, not a year, but as long as the World laſteth, his end towards the North and South; yea though one remove it, and turn it from its poſition, it will come again to his points of North and South? Who would have ever thought that a brute Stone, black and ill formed, touching a Ring of Iron, ſhould hang it in the Air, and that Ring ſupport a ſecond, that to ſupport a third, and ſo unto 10, 12, or more, according to the ſtrength of the *Magnes*; making as it were a Chain without a Line, without ſouldering together, or without any other thing to ſupport them onely; but a moſt occult and hidden vertue, yet moſt evident in this effect, which penetrateth inſenſibly from the firſt to the ſecond, from the ſecond to the third, &c.

Is it not a wonder to ſee that a Needle touched once will draw other Needles; and ſo a Nail, the point of a Knife, or other pieces of Iron? Is it not a pleaſure to ſee how the *Magnes* will turn File-duſt, or move Needles, or Nails being upon a Table, or upon a piece of paper? For as ſoon as the *Magnes* turns or moves over, it moves alſo: who is it that would not be raviſhed as it were to ſee a hand of Iron write upon a Plank, without ſeeing the *Magnes* which cauſeth that motion behind the Plank, or to make an Image of Iron to run up and down a Turret: now infinite of ſuch inventions is proper to be extracted from the properties of the *Magnes*.





What is there in the World that is more capable to caſt a deeper aſtoniſhment in our minds than a great maſſie ſubſtance of Iron to hang in the Air in the midſt of a Building without any thing in the World touching it, but only the Air? As ſome Hiſtories aſſure us that by the aid of a *Magnes* or Adamant, placed at the Roof of one of the Turkiſh Synagogues in *Meca*, the Sepulchre of that infamous *Mahomet* reſts ſuſpended in the Air; and *Pliny* in his Natural Hiſtory writes that the Architector *Democrates* did begin to vault the Temple of *Arſinoe* in *Alexandria*, with ſtore of *Magnes* to produce the like deceit, to hang the Sepulchre of that Goddeſs likewiſe in the air.

I ſhould paſs the bounds of my counterpoiſe, if I ſhould divulge all the ſecrets of this Stone, and

and ſhould expoſe my ſelf to the laughter of the World, if I ſhould brag to ſhew others the cauſe how this appeareth, than in its own natural ſympathy, for why is it that a *Magnes* with one end will caſt the Iron away, and attract it with the other? From whence cometh it that all the *Magnes* is not proper to give a true touch to the Needle, but onely in the two Poles of the Stone: which is known by hanging the Stone by a thread in the air until it be quiet, or placed upon a piece of Cork in a Diſh of Water, or upon ſome thin Board, for the Pole of the Stone will then turn towards the Poles of the World, and point out the North and South, and ſo ſhew by which of theſe ends the Needle is to be touched?

From whence comes it that there is a variation in the Needle, and pointeth not out truly the North and South of the World, but only in ſome place of the Earth?

How is it that the Needle made with pegs and incloſed within two Glaſſes, ſheweth the height of the Pole, being elevated as many degrees as the Pole is above the Horizon?

What's the cauſe that Fire and Garlick takes away the Property of the *Magnes?* There are many great hidden Myſteries in this Stone, which have troubled the Heads of the moſt Learned in all Ages, and to this time the World remains ignorant of declaring the true cauſe thereof.

Some ſay, that by help of the *Magnes* perſons which are abſent may know each others mind,

mind, as if one being here at *London*, and another at *Prague* in *Germany*, if each of them had a Needle touched with one *Magnes*, then the virtue is ſuch that in the ſame time that the Needle which is at *Prague* ſhall move, this that is at *London* ſhall alſo; provided that the parties have like ſecret Notes or Alphabets, and the obſervation be at a ſet hour of the day or night; and when the one party will declare unto the other, then let that party move the Needle to theſe Letters which will declare the matter to the other, and the moving of the other parties Needle ſhall open his intention.

The invention is ſubtile, but I doubt whether in the World there can be found ſo great a Stone, or ſuch a *Magnes* which carries with it ſuch virtue: neither is it expedient, for Treaſons would be then too frequent and open.

Examination.

The Experimental Difference of Rejection and Attraction proceeds not from the different Nature of Stones, but from the Quality of the Iron; and the virtue of the Stone conſiſteth onely and eſpecially in his Poles, which being hanged in the Air turns one of his ends always naturally towards the South, and the other towards the North: but if a Rod of Iron be touched with one of the ends thereof, it hath the like property in turning North and South, as the Magnes

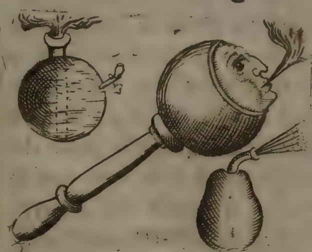
Magnes *hath: Notwithstanding the end of the Iron Rod touched, hath a contrary position, to that end of the Stone that touched it; yet the same end will attract it, and the other end reject it, and so contrarily. This may easily be experimented upon two Needles touched with one or different Stones, though they have one and the same position; for as you come unto them apply one end of the* Magnes *near unto them, the North of the one will abhor the North of the other, but the North of the one will always approach to the South of the other: and the same affection is in the Stones themselves. For the finding of the Poles of the* Magnes,*it may be done by holding a small Needle between your fingers softly, and so moving it from part to part over the Stone, until it be held perpendicular, for that shall be one of the Poles of the Stone which you may mark out; in like manner find out the other Pole. Now to find out which of those Poles is North or South, place a Needle being touched with one of the Poles upon a smooth Convex Body, (as the Nail of ones Finger, or such-like) and mark which way the end of the Needle that was touched turneth: if to the South, then the point that touched it was the South-Pole,* &c. *and it is most certain, and according to Reason and Experience, that if it be suspended in* æquilibrio *in the Air, or supported upon the Water, it will turn contrary to the Needle that toucheth it: for then the Pole that was marked for the South shall turn to the North,* &c.

PRO-

PROBLEM LXVIII.

Of the Properties of Æolipiles or Bowels to blow the Fire.

These are concave Veſſels of Braſs or Copper or other material, which may indure the Fire; having a ſmall hole very narrow, by which it is filled with Water: then placing it to the fire, before it be hot there is no effect ſeen; but as ſoon as the heat doth penetrate it, the Water begins to rarifie, and iſſueth forth with a hideous and marvelous force; it is pleaſure to ſee how it blows the fire with great noiſe.



Vitruvius in his firſt Book of *Architecture*, *Cap.* 8. approves from theſe Engines, that Wind is no other thing than a quantity of vapours and exhalations agitated with the air by rarifaction and condenſation, and we may draw a conſequence from it, to ſhew that a little Water may ingender a very great quantity of Vapours and Air: for a Glaſs of Water thrown into an *Æolipile* will keep blowing near a whole hour, ſending forth his vapours a thouſand times greater than it is extended.

Now

Now touching the form of theſe Veſſels, they are not made of one like faſhion: ſome make them like a Bowl, ſome like a head painted, repreſenting the Wind, ſome make them like a Pear: as though one would put it to roſt at the fire, when one would have it to blow, for the Tail of it is hollow, in form of a funnel, having at the top a very little hole no greater than the head of a Pin.

Some do accuſtom to put within the *Æolipile* a crooked Funnel of many foldings, to the end that the Wind that impetuouſly rolls to and fro within, may imitate the Noiſe of Thunder. Others content themſelves with a ſimple Funnel placed right upward, ſomewhat wider at the top than elſewhere, like a Cone, whoſe Baſis is the mouth of the Funnel: and there may be placed a Bowl of Iron or Braſs, which by the vapours that are caſt out will cauſe it to leap up, and dance over the Mouth of the *Æolipile*.

Laſtly, Some apply near to the hole ſmall Wind-mills, or ſuch-like, which eaſily turn by reaſon of the Vapours; or by help of two or more bowed Funnels, a Bowl may be made to turn: theſe *Æolipiles* are of excellent uſe for the melting of Metals, and ſuch-like.

Now it is cunning and ſubtilty to fill one of theſe *Æolipiles* with Water at ſo little a hole, and therefore requires the knowledge of a Philoſopher to find it out: and the way is thus:

Heat

Heat the *Æolipiles* being empty, and the Air which is within it will become extreamly rarified; then being thus hot, throw it into Water, and the Air will begin to be condenſed : by which means it will occupy leſs room : therefore the Water will immediately enter in at the hole to avoid vacuity. Thus you have ſome Practical Speculation upon the *Æolipile*.

PROBLEM LXIX.

Of the Thermometer : *or an Inſtrument to meaſure the degrees of Heat and Cold in the Air.*

THis Inſtrument is like a *Cylindrical* Pipe of Glaſs, which hath a little Ball or Bowl at the top, the ſmall end of which is placed into a Veſſel of Water below, as by the Figure may be ſeen.

Then put ſome coloured Liquor into the Cylindrical Glaſs, as blew, red, yellow, green, or ſuch-like : ſuch as is not thick. This being done, the uſe may be thus.

Firſt, I ſay, that as the Air incloſed in the *Thermometer* is rarified or condenſed, the Water will evidently aſcend or deſcend in the Cylinder : which you may try eaſily by carrying the *Thermometer* from a place that is hot unto a place that is cold, or without removing of it; if you ſoftly apply the Palm of the Hand upon the Ball of the

Thermo-

Thermometer: the Glaſs being ſo thin, and the Air ſo capable of Rarifaction, that at the very inſtant you may ſee the Water deſcend; and your hand being taken a way, it will ſoftly aſcend to his former place again. This is yet more ſenſible when one heats the Ball at the top with his breath, as if one would ſay a word in his ear, to make the Water to deſcend by Command, and the reaſon of this motion is, that the Air heated in the *Thermometer*, doth rarifie and dilate, requiring a greater place; hence preſſeth the Water, and cauſeth it to deſcend: contrariwiſe when the Air cooleth and condenſeth, it occupieth leſs room; now Nature abhorring vacuity, the Water naturally aſcendeth.

In the ſecond place, I ſay, that by this means one may know the degrees of Heat and Cold which are in the Air each hour of the day; foraſmuch as the exterior Air is either hot or cold, the Air which is incloſed in the *Thermometer* doth likewiſe either rarifie or condenſe, and therefore the Water aſcends or deſcends; ſo you ſhall ſee that the Water in the morning is mounted high, afterward by little and little it will deſcend towards noon or mid-day; and towards evening it will again aſcend: ſo in Winter it will mount ſo high, that all the Cylinder of the *Thermometer* will be full,

full, but in Summer it will deſcend ſo low that ſcarce there will be perceived in it any water at all.

Thoſe that will determine this change by numbers and degrees, may draw a Line upon the Cylinder of the *Thermometer*; and divide it into 4 degrees, according to the ancient *Philoſophers*, or into 4 degrees, according to the Phyſicians, dividing each of theſe 8 into 8 others, to have in all 64 diviſions; and by this way they may not onely diſtinguiſh upon what degree the Water aſcendeth in the morning, at mid-day, and at any other hour: but alſo one may know how much one day is hotter or colder than another, by marking how many degrees the Water aſcendeth or deſcendeth, one may compare the hotteſt and coldeſt days in a whole year together, with thoſe of another year: Again one may know how much hotter one room is than another, by which alſo one might keep a Chamber, a Furnace, a Stove, &c. always in an equality of heat, by making the water of the *Thermometer* reſt always upon one and the ſame degree. In brief, one may judge in ſome meaſure the burning of Fevers, and near unto what extenſion the air can be rarified by the greateſt heat.

Many make uſe of theſe Glaſſes to judge of the Weather: for it is obſerved that if the Water fall in 3 or 4 hours a degree, or thereabout, that rain inſueth, and the Water will ſtand at that ſtay until the Weather change: Mark the Water at your going to bed, for if in the morning it hath deſcended, rain followeth; but if it be mounted

mounted higher, it argueth fair weather: ſo in very cold weather, if it fall ſuddenly, it is ſnow, or ſome ſleekey weather that will inſue.

PROBLEM LXX.

Of the Proportion of Humane Bodies, of Statues, of Coloſſus, or huge Images, and of monſtrous Giants.

PYthagoras had reaſon to ſay, That Man is the meaſure of all things:

Firſt, Becauſe he is the moſt perfect amongſt all bodily Creatures; and according to the Maxime of Philoſophers, That which is moſt perfect, and the firſt in Rank, meaſureth all the reſt.

Secondly, Becauſe in effect the ordinary meaſure of a foot, the inch, the cubit, the pace, have taken their names and greatneſs from Humane Bodies.

Thirdly, Becauſe the ſymmetry and concordancy of the parts is ſo admirable, that all Works which are well proportionable, as namely the building of Temples, of Ships, of Pillars, and ſuch-like pieces of Architecture, are in ſome meaſure faſhioned and compoſed after his Proportion. And we know that the Ark of *Noah*, built by the Commandment of God, was in length 300 Cubits, in breadth 50 Cubits, in height or depth 30 Cubits, ſo that the length contains the breadth ſix times, and ten times the depth: Now a Man being meaſured, you will find him to have the ſame proportion in length, breadth, and depth.

Vilalpandus treating of the Temple of *Solomon* (that Chieftain of Works) was modulated all of good *Architecture*, and curiouſly to be obſerved in many pieces to keep the ſame proportion as the Body to his parts: ſo that by the greatneſs of the Work, and proportionable *ſymmetry*, ſome dare aſſure themſelves that by knowledge of one onely part of that building, one might know all the meaſures of that goodly Structure.

Some *Architects* ſay that the Foundation of Houſes, and Baſis of Columns, are as the Foot; the Top and Roof as the Head, the reſt as the Body. Thoſe which have been ſomewhat more curious, have noted that as in humane Bodies the parts are uniform, as the Noſe, the Mouth, *&c.* theſe which are double are put on one ſide or other, with a perfect equality in the ſame *Architecture*.

In like manner ſome have been yet far more curious than ſolid; comparing all the Ornaments of a Corinth to the parts of the Face, as the Brow, the Eyes, the Noſe, the Mouth; the rounding of Pillars to the writhing of Hair, the Channels of Columns to the Foldings of Womens Robes, *&c.*

Now building being a Work of the beſt *Artiſt*, there is much reaſon why man ought to make his imitation from the chief Work of Nature, which is man.

Hence it is, that *Vitruvius* in his Third Book, and

and all the best *Architectes* treat of the proportion of man; amongst others, *Albert Durews* hath made a whole Book of the measures of Mans Body, from the Foot to the Head; let them read it who will, they may have a perfect knowledge thereof. But I will content my self, and it may satisfie some, with that which followeth.

First, the length of a man well made, which commonly is called height, is equal to the distance from one end of his finger to the other: when the Arms are extended as wide as they may be.

Secondly, if a man have his Feet and Hands extended or stretched in form of S. *Andrews* Cross, placing one foot of a pair of Compasses upon his Navil, one may describe a Circle which will pass by the ends of his Hands and Feet, and drawing Lines by the terms of the Hands and Feet, you have a Square within a Circle.

Thirdly, the breadth of Man, or the space which is from one side to another; the Breast, the Head, and the Neck, make the sixth part of all the Body taken in length or height.

Fourthly, the length of the Face is equal to the length of the Hand, taken from the small of the Arm unto the extremity of the longest Finger.

Fifthly, the thickness of the Body taken from the Belly to the Back; the one or the other is the tenth part of the whole Body, or as some will have it, the ninth part, little less.

Sixthly, the height of the brow, the length of the

the Nose, the space between the Nose and the Chin, the length of the Ears, the greatness of the Thumb, are perfectly equal one to the other.

What would you say to make an admirable report of the other parts, if I should reckon them in their least? But in that I desire to be excused, and will rather extract some conclusion upon that which is delivered.

In the first place, knowing the proportion of a Man, it is easie to Painters, Image-makers, *&c* perfectly to proportionate their work; and by the same is made most evident, that which is related of the Images and Statues of *Greece*, that upon a day diverse Workmen having enterprised to make the Face of a man, being severed one from another in sundry places, all the parts being made and put together, the Face was found in a most lively and true proportion.

Secondly, It is a thing most clear, that by the help of proportion, the Body of *Hercules* was measured by the knowledge of his Foot onely, a Lion by his Claw, the Giant by his Thumb, and a Man by any part of his Body. For so it was, that *Pythagoras* having measured the length of *Hercules* foot, by the steps which were left upon the ground, found out all his height: and so it was that *Phidias* having onely the Claw of a Lion, did figure and draw out all the Beast according to his true type or form, so the exquisite Painter *Timantes*, having painted a *Pygmey* or Dwarf, which he measured with a fadome made with the inch of a Giant, it was sufficient to know the greatness of that Giant.

To

To be ſhort, we may by like method come eaſily to the knowledge of many fine Antiquities touching Statues, Coloſſus, and monſtrous Giants, onely ſuppoſing one had found but one only part of them, as the Head, the Hand, the Foot, or ſome Bone mentioned in ancient Hiſtories.

Of Statues, of Coloſſus, or huge Images.

V*Itruvius* relates in his ſecond Book, that the Architect *Dinocrates* being deſirous to put out to the World ſome notable thing, went to *Alexander* the Great, and propoſed unto him a high and ſpecial piece of work which he had projected: As to figure out the Mount *Athos* in form of a great Statue, which ſhould hold in his right hand a Town capable to receive ten thouſand men; and in his left hand a Veſſel to receive all the Water that floweth from the Mountain, which with an Engine ſhould be caſt into the Sea. This is a pretty project, ſaid *Alexander*: but becauſe there was not field-room thereabout to nouriſh and retain the Citizens of that place, *Alexander* was wiſe not to entertain the Deſign.

Now let it be required of what greatneſs this Statue might have been, the Town in his right hand, and the Receiver of Water in his left hand, if it had been made.

For the Statue, it could not be higher than the Mountain it ſelf, and the Mountain was about a mile in height plumb or perpendicular; therefore

therefore the Hand of this Statue ought to be the 10th part of his height, which would be 500 foot, and so the breadth of his hand would be 250 foot, the length now multiplied by the breadth, makes an hundred twenty five thousand square feet, for the quantity of his hand to make the Town in, to lodge the said 10000 men, allowing to each man near about 12 foot of square ground: Now judge the capacity of the other parts of this *Colossus* by that which is already delivered.

Secondly, *Pliny* in his 34 Book of his Natural History, speaks of the famous *Colossus* that was at *Rhodes*, between whose legs a Ship might pass with his Sails open or displayed, the Statue being of 70 cubits high: and other Histories report that the *Sarasens* having broken it, did load 900 Camels with the Metal of it. Now what might be the greatness and weight of this Statue?

For answer, It is usually allowed for a Camels burthen 1200 pound weight; therefore all the *Colossus* did weigh 1080000 pound weight, which is ten hundred and fourscore thousand pound weight.

Now according to the former Rules, the Head being the tenth part of the Body, this Statues Head should be of 7 cubits, that is to say, 10 foot and a half, and seeing that the Nose, the Brow, and the Thumb, are the third part of the Face, his Nose was three foot and a half long, and so much also was his Thumb in length: now the thickness being always the third part of the

length,

length, it ſhould ſeem that his Thumb was a foot thick at the leaſt.

Thirdly, The ſaid *Pliny* in the ſame place reports that *Nero* did cauſe to come out of *France* into *Italy*, a brave and bold Statue-maker called *Zenodocus*, to erect him a *Coloſſus* of Braſs, which was made of 120 foot in height, which *Nero* cauſed to be painted in the ſame height. Now would you know the greatneſs of the Members of this *Coloſſus*? The breadth would be 20 foot, his Face 12 foot, his Thumb and his Noſe 4 foot, according to the proportion before delivered.

Thus I have a fair field or ſubject to extend my ſelf upon, but it is upon another occaſion that it was undertaken. Let us ſpeak therefore a word touching the Giants, and then paſs away to the matter.

Of Monſtrous GIANTS.

You will hardly believe all that which I ſay touching this, neither will I believe all that which Authors ſay upon this Subject: notwithſtanding you nor I cannot deny but that long ago there have been Men of a moſt prodigious greatneſs: for the Holy Writings witneſs this themſelves, in *Deut.* iii. that there was a certain Giant called *Og*, of the Town of *Rabath*, who had a Bed of Iron, the length thereof was 9 cubits, and in breadth 4 cubits.

So in the Firſt of *Kings*, Chap. 17. there is mention made of *Goliah*, whoſe height was a palm, and *6* cubits, that is more then *9* foot, he was armed from the Head to the Foot, and his Curiaſs onely, with the Iron of his Lance, weighed five thouſand and ſix hundred Shekels, which in our common Weight is more than 233 pound, of 12 ounces to the pound. Now it is certain, that the reſt of his Arms, taking his Target, Helmet, Bracelets, and other Armour together, did weigh at the leaſt five hundred pound, a thing prodigious; ſeeing that the ſtrongeſt man that now is, can hardly bear 200 pound; yet this Giant carries this as a Veſture without pain.

Solinus reporteth in his 5 Chapter of his Hiſtory, that during the *Grecians* War after a great overflowing of the Rivers, there was found upon the Sands the Carcaſe of a man, whoſe length was 33 Cubits, (that is *49* foot and a half) therefore according to the proportion delivered, his Face ſhould be five foot in length, a thing prodigious and monſtrous.

Pliny in his 7 Book and 16 Chap. ſaith, that in the Iſle of *Crete*, or *Candy*, a Mountain being cloven by an Earth-quake, there was a Body ſtanding upright, which had *46* cubits of height. Some believe that it was the body of *Orion* or *Othos*, (but I think rather it was ſome Ghoſt, or ſome Deluſion) whoſe Hand ſhould have been *7* foot, and his Noſe two foot and a half long.

But that which *Plutarch* in the Life of *Sertorius* reports of, is more ſtrange, who ſaith, That in *Timgy*, a Morative Town, where it is thought

 that

that the Giant *Anthеus* was buried: *Sertorius* not believing that which was reported of his prodigious greatneſs, cauſed his Sepulchre to be opened, and found that his Body did contain ſixty Cubits in length, then by proportion he ſhould be ten Cubits, or fifteen foot in breadth; nine foot for the length of his Face, three foot for his Thumb, which is near the capacity of the *Coloſſus* at *Rhodes*.

But behold here a fine Fable of *Symphoris Campeſius*, in his Book intituled *Hortus Gallicus*, who ſays that in the Kingdom of *Sicily*, at the foot of a Mountain near *Trepane*, in opening the foundation of a Houſe, they found a Cave in which was laid a Giant, which held inſtead of a Staff a great Poſt like the Maſt of a Ship; and going to handle it, it moulder'd all into Aſhes except the Bones which remained of an exceeding great meaſure, that in his Head there might be eaſily placed 5 Quarters of Corn, and by proportion it ſhould ſeem that his length was 200 cubits, or 300 foot; if he had ſaid that he had been 300 cubits in length, then he might have made us believe that *Noahs* Ark was but great enough for his Sepulchre.

Who can believe that any man ever had 20 cubits, or 30 foot in length for his Face, and a Noſe of ten foot long? But it is very certain that there have been men of very great ſtature, as the holy Scriptures before witneſs, and many Authors worthy of belief relate.

Joſephus Acoſta in his firſt Book of the Indian Hiſtory, *Chap.* 19. a late Writer, reporteth, that at at *Peru* was found the Bones of a Giant which was 3 times greater than these of ours are, that is 18 foot; for there is usually attributed to the tallest ordinary man in these our times but six foot of length; and Histories are full of the description of other Giants of 9, 10, and 12 foot of height, and there hath bin seen in our times some which have had such heights as these.

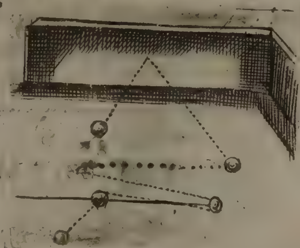
PROBLEM LXXI.

Of the Game at the Palm, at Trap, at Bowles, Pail-mail, and others.

THe Mathematicks often findeth place in sundry Games to aid and assist the Gamesters, though not unknown unto them; hence by Mathematical Principles, the Games at Tennis may be assisted, for all the moving in it is by right Lines and Reflections. From whence comes it, that from the appearances of flat or convex Glasses, the production and reflection of the Species are explained? Is it not by Right Lines? In the same proportion one might sufficiently deliver the motion of a Ball or Bowl by Geometrical Lines and Angles.

But the exercise, experience, and dexterity of the Player seems more in this action than any other Precepts: Notwithstanding I will deliver here some *Maximes*, which being reduced to Practice, and joyned to Experience, will give a great advan-

advantage to thoſe which would make uſe of them in ſuch gamings.



And the firſt Maxime is thus: When a Bowl toucheth another Bowl, or when a Trap-ſtick ſtriketh the Ball, the moving of the Ball is made in a right line, which is drawn from the Centre of the Bowl by the point of contingency.

Secondly, In all kind of ſuch motion, when a Ball or Bowl rebounds, be it either againſt Wood, a Wall, upon a Drum, a Pavement, or upon a Racket, the incident Angle is always equal to the Angle of reflection.

Now following theſe *Maximes*, it is eaſie to conclude,

Firſt, In what part of the Wood or Wall one may make the Bowl or Ball go to reflect or rebound, to ſuch a place as one would.

Secondly, How one may caſt a Bowl upon another, in ſuch ſort that the firſt or the ſecond ſhall go and meet with the third, keeping the reflection or Angle of incidence equal.

Thirdly, How one may touch a Bowl to ſend it to what part one pleaſeth: ſuch and many other practices may be done. At the exerciſes at Keyls there muſt be taken heed that the motion ſlack or diminiſh by little and little, and may be noted that the *Maximes* of Reflections cannot be exactly

exactly obſerved by local motion, as in the beams of light, and of other qualities, whereof it is neceſſary to ſupply it by induſtry or by ſtrength: otherwiſe one may be fruſtrated in that reſpect.

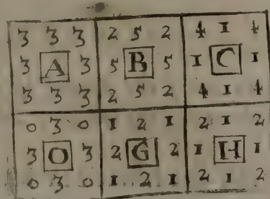
PROBLEM LXXII.

Of the Game of Square Forms.

NUmbers have an admirable ſecrecy, diverſly applied, as before in part is ſhewed, and here I will ſay ſomething by way of Tranſmutation of Numbers.

It is reported that at a certain paſſage of a ſquare form, there were 4 Gates oppoſite one to another; that is, one in the middle of each ſide, and that there were appointed 9 men to defend each front thereof, ſome at the Gates, and the other at each corner or Angle, ſo that each Angle ſerved to aſſiſt two Faces of the ſquare, if need required: Now this ſquare paſſage being thus manned to have each ſide 9, it happened that 4 Souldiers coming by, deſired of the Governour of the paſſage, that they might be entertained into ſervice, who told them he could not admit of more than 9, upon each ſide of the ſquare: then one of the Souldiers being verſed in the Art of Numbers, ſaid, that if he would take them into pay, they would eaſily place themſelves amongſt the reſt, and yet keep ſtill the order of 9, for each face of the ſquare to defend the Angles

gles and Gates, to which the Governour agreed, and these Souldiers being there some few weeks, liked not their service, but indeavoured to remove themselves,



and so laboured with some of the rest, that each of these four Souldiers took away his Comrade with him, and so departed; yet left to defend each side of the passage, and how may this be?

It's answered thus: In the first form the men were as the figure *A*, then each of these 4 Souldiers placed themselves at each Gate, and removing one man from each Angle to each Gate, then would they be also 9 in each side, according to the figure *B*. Lastly, these 4 Souldiers at the Gates take away each one his Comrade, and placing 2 of these men which are at each Gate to each Angle, there will be still 9 for each side of the square, according to the figure *C*. In like manner if there were 12 men, how might they be placed about a Square that the first side shall have 3 every way, then disordered, so that they might be 4 every way; and lastly, being transposed might make 5 every way? And this is according to the Figures *F*, *G*, *H*.

PRO-

PROBLEM LXXIII.

How to make the String of a Viol ſenſibly ſhake, without any one touching it?

THis is a Miracle in Muſick, yet eaſie to be experimented. Take a Viol, or other Inſtrument, and chooſe two Strings, ſo that there be one between them; make theſe two Strings agree in one and the ſame tune: then move the Viol-bowe upon the greater String, and you ſhall ſee a wonder: for in the ſame time that that ſhakes which you play upon, the other will likewiſe ſenſibly ſhake without any one touching it; and it is more admirable that the String which is between them will not ſhake at all: and if you put the firſt String to another tune or note, and looſing the pin of the String, or ſtopping it with your finger in any fret, the other String will not ſhake: and the ſame will happen if you take two Viols, and ſtrike upon a ſtring of the one, the ſtring of the other will ſenſibly ſhake.

Now it may be demanded, how comes this ſhaking? Is it in the occult ſympathy, or is it in the ſtrings being wound up to like notes or tunes, that ſo eaſily the other may receive the impreſſion of the Air, which is agitated or moved by the ſhaking or the trembling of the other? And whence is it that the Viol-bowe moved upon the firſt ſtring, doth inſtantly in the ſame time move the third ſtring, and not the ſecond, if the cauſe be be not either in the firſt or ſecond? I leave to others to deſcant on.

Examination.

In this Examination we have ſomething elſe to imagine than the bare ſympathy of the Cords one to another: for firſt there ought to be conſidered the different effect that it produceth by extention upon one and the ſame Cord in capacity: then what might be produced upon different Cords of length and bigneſs to make them accord in a Uniſone or Octavo, or ſome Conſort intermediate: this being naturally examined, it will be facil to lay open a way to the knowledge of the true and immediate cauſe of this noble and admirable Phœnomeny. *Now this will ſenſibly appear when the Cords are of equal length and greatneſs, and ſet to an Uniſone; but when the Cords differ from their equality, it will be leſs ſenſible: hence in one and the ſame Inſtrument, Cords at a Uniſone ſhall excite or ſhake more than that which is at an Octavo, and more than thoſe which are of an intermediate proportional Conſort: as for the other Conſorts they are not exempted, though the effect be not ſo ſenſible, yet more in one than in another: and the Experiment will ſeem more admirable in taking two Lutes, Viols, &c. and in ſetting them to one tune: for then in touching the Cord of the one, it will give a ſenſible motion to the Cord of the other: and not only ſo, but alſo a Harmony.*

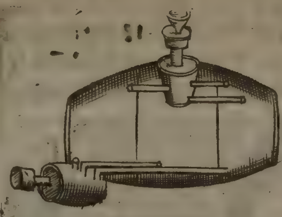
PRO-

PROBLEM LXXIV.

Of a Veſſel which contains three ſeveral kinds of Liquor, all put in at one Bung-hole, and drawn out at one Tap ſeverally without mixture.

THe Veſſel is thus made, it muſt be divided into three Cells, for to contain the three Liquors, which admit to be Sack, Claret, and White-wine: Now in the Bung-hole there is an Engine with three Pipes, each extending to his proper Cell, into which there is put a Broach or Funnel pierced in three places, in ſuch ſort, that placing one of the holes right againſt the pipe which anſwereth unto him, the other two pipes are ſtopped; then when it is full, turn the Funnel, and then the former hole will be ſtopped, and another open, to caſt in other Wine without mixing it with the other.

Now to draw out alſo without mixture, at the bottom of the Veſſel there muſt be placed a Pipe or Broach, which may have three Pipes; and a Cock pierced with three holes ſo artificially done, that turning the Cock, the hole which anſwereth to ſuch of the Pipes that is placed at the bottom may iſſue forth ſuch Wine as belongeth to that Pipe, and turning the Cock to another Pipe, the former hole will be ſtopped; and ſo



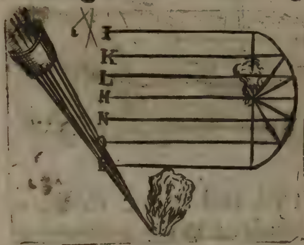
so there will issue forth another kind of Wine without any mixtures ; but the Cock may be so ordered that there may come out by it two Wines together, or all three kinds at once : but it seems best when that in one Vessel and at one Cock, a man may draw several kinds of Wine, and which he pleaseth to drink.

PROBLEM LXXV.

Of Burning-Glasses.

IN this insuing Discourse I will shew the invention of *Prometheus*, how to steal fire from Heaven, and bring it down to the Earth ; this is done by a little round Glass, or made of Steel, by which one may light a Candle, and make it flame, kindle Fire-brands to make them burn, melt Lead, Tin, Gold, and Silver, in a little time : With as great ease as though it had been put into a Cruzet over a great fire.

Have you not read of *Archimedes* of *Syracusa*, who when he could not come to the Ships of *Marcellus* which besieged that place, to hinder and impeach their approach, he flung huge stones by his Engines to sink them into the Sea, and transformed himſelf into *Jupiter*, thundering down from the higheſt Towers of the Town, his Thunder-bolts of Lightning into the Ships, cauſing a terrible burning, in deſpite of *Neptune*



and his Watry Region: *Zonaras* witneſſeth that *Proclus* a brave Mathematician, burned in the ſame manner the Ships of *Vitalian*, which were come to beſieg *Conſtantinople*; and daily experience may let you ſee great effects of burning: for a Bowl of Cryſtal poliſhed, or a Glaſs thicker in the middle than at the edges, will burn exceedingly; nay a Bottle full of Water expoſed to the Sun, will burn when the Sun ſhineth hot; and children uſe with a Glaſs to burn Flies which are againſt the Walls, and their fellows Cloaths.

But this is nothing to the burning of thoſe Glaſſes which are hollow, namely thoſe which are of Steel well poliſhed, according to a parabolical or oval ſection. A ſpherical Glaſs, or that which is according to the ſegment of a *Sphere*, burns very effectually about the fourth part of the Diameter; notwithſtanding the Parabolic and Ecliptick ſections have a great effect: by which Glaſſes there are alſo divers Figures repreſented forth to the Eye.

The cauſe of this burning is the uniting of the beams of the Sun, which heat mightily in the point

point of concourſe or inflammation, which is either by Tranſmiſſion or Reflection: Now it is pleaſant to behold when one breatheth in the point of concourſe, or throweth ſmall duſt there, or ſprinkles vapours of hot Water in that place, by which the Pyramidal point, or point of inflammation is known. Now ſome Authors promiſe to make Glaſſes which ſhall burn a great diſtance off, but yet not ſeen vulgarly produced, of which if they were made, the Parabolie makes the greateſt effect, and is generally held to be the invention of *Archimedes* or *Proclus*.

Maginus in the 5 Chap. of his Treatiſe of Spherical Glaſſes, ſhews how one may ſerve himſelf with a concave Glaſs, to light fire in the ſhadow, or near ſuch a place where the Sun ſhines not, which is by help of a flat Glaſs, by which may be made a percuſſion of the beams of the Sun into the concave Glaſs, adding unto it that it ſerves to good uſe to put fire to a Mine, provided that the combuſtible matter be well applied before the concave Glaſs; in which he ſays true: but becauſe all the effect of the practice depends upon the placing of the Glaſs and the Powder which he ſpeaks not of: I will deliver here a Rule more general.

How one may place a Burning-glaſs with his combuſtible matter, in ſuch ſort, that at a convenient hour of the day, the Sun ſhining, it ſhall take fire & burn.

IT is certain that the point of inflammation or burning, is changed as the Sun changeth place, and no more nor leſs than the ſhadow turns about the Style of a Dyal; therefore have regard to the Suns motion and his height and place: a Bowl of Cryſtal in the ſame place that the top of the Style is, and the Powder or other combuſtible matter under the Meridian, or hour of 12, 1, 2, 3, &c. or any other hour, and under the Suns Arch for that day: Now the Sun coming to the hour of 12, to 1, 2, 3, &c. the Sun caſting his Beams through the Cryſtal Bowl, will fire the material or combuſtible thing, which meets in the point of burning: The like may be obſerved of other Burning-glaſſes.

Examination.

IT is certain in the firſt part of this Problem, that Conical, Concave, and Spherical Glaſſes, of what matter ſoever, being placed to receive the beams of the Sun, will excite heat, and that heat is ſo much the greater, by how much it is near the point of concourſe or inflammation. But that Archimedes *or* Proclus *did fire or burn Ships with ſuch Glaſſes, the ancient Hiſtories are ſilent, yea themſelves ſay nothing: beſides the great difficulty that doth oppoſe it in remoteneſs, and the matter that the effect is to work upon. Now by a common Glaſs we fire things near at hand, from which it ſeems very facil to ſuch which are leſs read, to do it at a far greater diſtance, and ſo by relation ſome deliver to the World by ſuppoſition that which was never done in action: this we ſay the*

rather,

rather, not to take away the most excellent and admirable effects which are in Burning-glasses, but to shew the variety of Antiquity, and truth of History: and as touching to burn at a great distance, as is said of some, it is absolutely impossible; and that the Parabolical and Oval Glasses were of Archimedes *and* Proclus *invention is much uncertain; for besides the construction of such Glasses, they are more difficult than the obtuse concave ones are; and further, they cast not a great heat but near at hand; for if it be cast far off, the effect is little, and the heat weak, or otherwise such Glasses must be greatly extended to contract many beams to amass a sufficient quantity of Beams in Parabolical and Conical Glasses, the point of inflammation ought to concur in a point, which is very difficult to be done in a due proportion. Moreover if the place be far remote, as is supposed before, such a Glass cannot be used but at a great inclination of the Sun, by which the effect of burning is diminished by reason of the weakness of the Sun-beams.*

And here may be noted in the last part of this Problem, that by reason of obstacles if one plain Glass, be not sufficient, a second Glass may be applied to help it: that so if by one simple reflection it cannot be done, yet by a double reflection the Sun-beams may be cast into the said Cavern or Mine, and though the reflected Beams in this case be weak, yet upon a fit combustible matter it will not fail to do the effect.

PROBLEM LXXVI.

Containing many pleaſant Queſtions by way of Arithmetick.

I Will not inſert in this Problem that which is drawn from the Greek Epigrams, but propoſing the Queſtion, immediately will give the Anſwer alſo, without ſtaying to ſhew the manner how they are anſwered; In this I will not be tied to the Greek Terms, which I account not proper for this place, neither to my purpoſe. Let thoſe that will read *Diophanta Sebeubelius* upon *Euclide* and others, and they may be ſatisfied.

Of the Aſs and the Mule.

IT happened that the Mule and the Aſs upon a day making a Voyage, each of them carried a Barrel full of Wine: now the lazy Aſs feeling her ſelf over-loaden, complained and bowed under her burthen; which the Mule ſeeing, ſaid unto her, being angry, (for it was in the time when Beaſts ſpake) Thou great Aſs, wherefore complaineſt thou? If I had but onely one meaſure of that which thou carrieſt, I ſhould be loaden twice as much as thou art; and if I ſhould give a meaſure of my loading to thee, yet my burthen would be as much as thine.

Now

Now how many meaſures did each of them carry? Anſwer: The Mule did carry 7 meaſures, and the Aſs 5 meaſures: For if the Mule had one of the meaſures of the Aſſes loading, then the Mule would have 8 meaſures, which is double to 4, and giving one to the Aſs, each of them would have equal burthens: to wit, 6 meaſures apiece.

Of the Number of Souldiers that fought before Old Troy.

HOmer being asked by *Heſiodus* how many Grecian Souldiers came againſt *Troy*? Anſwered him thus: The Grecians, ſaid *Homer*, made 7 Fires, or had 7 Kitchins, and before every Fire, or in every Kitchin there were 50 Broaches turning to roaſt a great quantity of Fleſh, and each Broach had Meat enough to ſatisfie 900 men: Now judge how many men there might be. Anſwer: 315000; that is, three hundred and fifteen thouſand men: which is clear by multiplying 7 by 50, and the product by 900 makes the ſaid 315000.

Of the Number of Crowns that two Men had.

JOhn and *Peter* had a certain number of crowns: *John* ſaid to *Peter*, If you give me 10 of your crowns, I ſhall have three times as much as you have: but *Peter* ſaid to *John*, If you give me 10 of your crowns, I ſhall have 5 times as much as you have: How much had each of them? Anſwer,

ſwer, *John* had 15 crowns and 5 ſevenths of a crown, and *Peter* had 18 crowns and 4 ſevenths of a crown. For if you add 10 of *Peters* crowns to thoſe of *Johns*, then ſhould *John* have 25 crowns and 5 ſevenths of a crown, which is triple to that of *Peters*, viz. 8, and 4 ſevenths; and *John* giving 10 to *Peter*, *Peter* ſhould have then 28 crowns, and 4 ſevenths of a crown, which is *Quintupla*, or 5 times as much as *John* had left, *viz.* 5 crowns and 5 ſevenths.

In like manner two Gameſters playing together, *A* and *B*, after play *A* ſaid to *B*, Give me 2 crowns of thy money, and I ſhall have twice as much as thou haſt: and *B* ſaid to *A*, Give me 2 crowns of thy money, and I ſhall have 4 times as much as thou haſt: now how much had each? Anſwer, *A* had 3 and 5 ſevenths, and *B* had 4 and 6 ſevenths.

About the hour of the day.

SOme one asked a Mathematician what a clock it was; who anſwered that the reſt of the day is four thirds of that which is paſt: Now judge what a clock it is. Anſwer: If the day were according to the Jews and ancient Romans, which made it always to be 12 hours, it was then the 5 hour, and one ſeventh of an hour, ſo there remained of the whole day $6\frac{6}{7}$, that is, 6 hours, and 6 ſevenths of an hour. Now if you take the $\frac{1}{3}$ of $5\frac{1}{7}$, it is $\frac{12}{7}$, or 1 and $\frac{5}{7}$ 7, which multiplied by 4 makes 6 and $\frac{6}{7}$, which is the remainder of the day, as before: but if the day had been 24 hours, then the hour had been ten of the clock

and

and two sevenths of an hour, which is found out by dividing 12, or 24 by $\frac{7}{}$.

There might have been added many curious Propositions in this kind, but they would be too difficult for the most part of People: therefore I have omitted them.

Of Pythagoras *his Schollars.*

PYthagoras being asked what number of Schollars he had, answered that half of them studied *Mathematicks*, the fourth part Physick, the seventh part *Rhetorick*, and beside he had 3 Women: Now judge you, saith he, how many Schollars I have. Answer: He had in all 28, the half of which is 14, the quarter of which is 7, and the seventh part of which is 4, which 14, 7, and 4, makes 25, and the other 3 to make up the 28, were the 3 Women.

Of the Number of Apples given amongst the Graces and the Muses.

THe Three Graces carrying Apples upon a day, the one as many as the other, met with the Nine Muses, who asked of them some of their Apples; so each of the Graces gave to each of the Muses alike, and the Distribution being made, they found that the Graces and the Muses had one as many as the other: The question is, How many Apples each Grace had, and how

how many they gave to each Muſe? To anſwer the queſtion, joyn the number of Graces and Muſes together, which makes 12, and ſo many Apples had each Grace: Now may you take the double, tripple, &c. of 12, that is 24, 36, &c. conditionally, that if each Grace had but 12, then may there be allotted to each Muſe but one onely; if 24, then to each 2 Apples, if 26, then to each Muſe 3 Apples, and ſo the diſtribution being made, they have a like number, that is, one as many as the other.

Of the Teſtament or laſt Will of a dying Father.

A Dying Father left a thouſand Crowns among his two Children, the one being legitimate, and the other a Baſtard; conditionally, that the fifth part which his legitimate Son ſhould have, ſhould exceed by 10 the fourth part of that which the Baſtard ſhould have: What was each ones part? Anſwer: The legitimate Son had 577 crowns, and $\frac{7}{9}$, and the Baſtard 422 crowns and $\frac{2}{9}$, now the fifth part of 577 and 7 ninths is 115, and $\frac{5}{9}$, and the fourth part of 422 and $\frac{2}{9}$ is 105 and $\frac{5}{9}$, which is leſs than 115 $\frac{5}{9}$ by 10, according to the will of the *Teſtator*.

Of the Cups of Crœſus.

C*Rœſus* gave to the Temple of the Gods ſix Cups of Gold, which weighed together 600 Drams, but each Cup was heavier one than another by one Dram: How much did each of them therefore weigh? Anſwer: The firſt weighed 102 Drams and a half, the ſecond 101 Drams and a half, the third 100 Drams and a half, the fourth 99 and a half, the fifth 98 and a half, and the ſixth Cup weighed 97 Drams and a half; which together make 600 Drams, as before.

Of Cupid's *Apples.*

CUpid complained to his Mother that the Muſes had taken away his Apples; *Clio*, ſaid he, took from me the fifth part, *Euterpe* the twelfth part, *Thalia* the eighth part, *Melpomene* the twentieth part, *Erates* the ſeventh part, *Terpomenes* the fourth part, *Polyhymnia* took away 30, *Urania* 120, and *Caliope* 300; ſo there were left me but 5 Apples: How many had he in all at the firſt? I anſwer 3360.

There are an infinite of ſuch-like Queſtions amongſt the Greek Epigrams: but it would be unpleaſant to expreſs them all: I will onely add one more, and ſhew a general Rule for all the reſt.

Of a Mans Age.

A Man was ſaid to paſs the ſixth part of his Life in Childhood, the fourth part in his Youth, the third part in Manhood, and 18 years beſide in old Age: What might his Age be? The Anſwer is, 72 years: which, and all others, is thus reſolved: multiply $\frac{1}{6}$ $\frac{1}{4}$ and $\frac{1}{3}$ together, that is, 6 by 4 makes 24, and that again by 3 makes

72,

72, then take the third part of 72, which is 24, the fourth part of it, which is 18, and the ſixth part of it, which is 12, theſe added together make 54, which taken from 72 reſts 18, this divided by 18, (ſpoken in the Queſtion) gives 1, which multiplied by the ſum of the parts, *viz.* 72, makes 72, the Anſwer as before.

Of the Lion of Bronze *placed upon a Fountain with this Epigram:*

OUt of my right Eye if I let Water paſs, I can fill the Ciſtern in 2 days: if I let it paſs out of the left Eye, it will be filled in 3 days: if it paſs out of my feet, the Ciſtern will be 4 days a filling; but if I let the Water paſs out of my mouth, I can fill the Ciſtern then in 6 hours: in what time ſhould I fill it, if I pour forth the Water at all the paſſages at once?

The Greeks (the greateſt talkers in the world) variouſly apply this Queſtion to divers Statues and Pipes of Fountains: and the Solution is by the Rule of Three, by a general Rule, or by *Algebra.* They have alſo in their *Anthology* many other Queſtions, but becauſe they are more proper to exerciſe than to recreate the Spirit, I paſs them over (as before with ſilence.

PRO-

PROBLEM LXXVII.

Divers Excellent and Admirable Experiments upon Glaſſes.

THere is nothing in the world ſo beautiful as Light: and nothing more recreative to the ſight, than Glaſſes which reflect: therefore I will now produce ſome Experiments upon them, not that I will dive into their depth (that were to lay open a myſterious thing) but that which may delight and recreate the Spirits: Let us ſuppoſe therefore theſe Principles, upon which is built the demonſtration of the apparances which are made in all ſorts of Glaſſes.

Firſt, That the Rays or Beams which reflect upon a Glaſs, make the Angle of Incidence equal to the Angle of Reflection, by the firſt Theo. of the *Catoptick* of *Euc.*

Secondly, That in all plain Glaſſes, the Images are ſeen in the perpendicular Line to the Glaſs, as far within the Glaſs as the Object is without it.

Thirdly, In concave or convex Glaſſes, the Images are ſeen in the right line which paſſeth from the Object, and through the Centre in the Glaſs. Theo.17. and 18.

And here you are to underſtand, that there is not meant onely thoſe which are ſimple Glaſſes, or Glaſſes of Steel, but all other Bodies, which may repreſent the viſible Image of things, by reaſon

reaſon of their reflection, as Water, Marble, Metal, or ſuch like. Now take a Glaſs in your hand, and make Experiment upon that which followeth.

Experiments upon flat and plain Glaſſes.

FIrſt, A man cannot ſee any thing in theſe Glaſſes, if he be not directly and in a perpendicular line before it, neither can he ſee an Object in theſe Glaſſes, if it be not in ſuch a place that makes the Angle of Incidence equal to the Angle of Reflection: therefore when a Glaſs ſtands upright, that is, perpendicular to the Horizon, you cannot ſee that which is above, except the Glaſs be placed down flat: and to ſee that on the right hand, you muſt be on the left hand, *&c.*

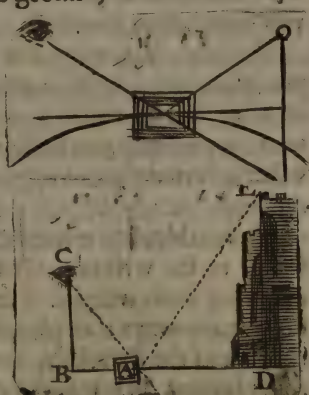
Secondly, An Image cannot be ſeen in a Glaſs, if it be not raiſed above the ſurface of it; or place a Glaſs upon a Wall, you ſhall ſee nothing which is upon the plain of the Wall; and place it upon a Table or Horizontal Plain, you ſhall ſee nothing of that which is upon the Table.

Thirdly, In a plain Glaſs all that is ſeen appears or ſeems to ſink behind the Glaſs, as much as the Image is before the Glaſs, as before is ſaid.

Fourthly, (As in Water) a Glaſs lying down flat or Horizontal, Towers, Trees, Men, or any height doth appear inverſed or upſide-down; and a Glaſs placed upright, the right hand of the Image ſeems to be the left, and the left ſeems to be the right. Fifthly,

Fifthly, Will you ſee in a Chamber that which is done in the Street, without being ſeen? Then a Glaſs muſt be ſo diſpoſed, that the Line upon which the Images come on the Glaſs, make the Angle of Incidence equal to that Angle of Reflection.

Sixthly, An height, (as ſuppoſe *D E*) may be meaſured by a plain Glaſs, as let the Glaſs be *G*, placed down upon the ground, and let the Eye be at *C*, ſo far removed from the Glaſs, that the Eye at *C*, may ſee the top of the Tower E in the Angle or edge of the Glaſs at *A*, but in the line of reflection *CA*, then meaſure the diſtance between your foot *B*, and the point *A*, and alſo the diſtance between the Glaſs *A*, and the foot of the Tower *D*, *viz.* *A D*.



Now as often as *A B* is found in *A D*, ſo often doth the height of the Tower E D contain the diſtance from your Eye to the foot, *viz.* *C B*, for the Triangles *A*, *B*, *C*, and *A*, *D*, E, are equal Triangles: therefore as *B A* to *A D*, ſo *C B*, to E *D*, or alternately as *B A* to *B C*, ſo *A D* to *D E*.

Seventhly, Preſent a Candle upon a plain Glaſs, and look ſlaunting upon it, ſo that the Candle and the Glaſs be near in a right Line, you ſhall

ſhall ſee 3,4,5,&c. Images,from one and the ſame Candle

Eighthly, Take two plain Glaſſes, and hold them one againſt the other, you ſhall alternately ſee them oftentimes one within the other, yea within themſelves, again and again.

Ninthly, If you hold a plain Glaſs behind your head, and another before your face, you may ſee the hinder part of your head, in that Glaſs which you hold before your face.

Tenthly, You may have a fine Experiment if you place two Glaſſes together, that they make an acute Angle, and ſo the leſſer the Angle is, the more apparances you ſhall ſee, the one direct, the other inverſed,the one approaching,and the other retiring.

Eleventhly, It is a wonder and aſtoniſhment to ſome, to ſee within a Glaſs an Image, without knowing from whence it came, and it may be done many ways: as place a Glaſs higher than the Eye of the Beholder, and right againſt it is ſome Image; ſo it reſteth not upon the Beholder, but doth caſt the Image upwards. Then place another object, ſo that it reflect, or caſt the Image downward to the Eye of the Spectator, without perceiving it being hid behind ſomething, for then the Glaſs will repreſent a quite contrary thing,either that which is before the Glaſs,or that which is about it, to wit, the other hidden object.

Twelfthly, If there be ingraved behind the back-ſide of a Glaſs,or drawn any Image upon it, it will appear before as an Image, without any appearance or portraicture to be perceived.

Exami-

Examination.

*T*HIS *Twelfth* Article *of engraving an Image behind the Glaſs, will be of no great conſequence; becauſe the lineaments will ſeem ſo obſcure ; but if there were painted ſome Image, and then that covered according to the uſual covering of Glaſſes behind, and ſo made up like an ordinary Looking-Glaſs, having an Image in the middle, in this reſpect it would be ſufficiently pleaſant: and that which would admire the ignorant, and able to exerciſe the moſt ſubtilleſt, and that principally if the Glaſs be in an obſcure place, and the Light which is given to it be ſomewhat far off.*

THirteenthly, Place a Glaſs near the floor of a Chamber, and make a hole through the place under the Glaſs, ſo that thoſe which are below may not perceive it, and diſpoſe a bright Image under the hole, ſo that it may caſt his ſpecies upon the Glaſs, and it will cauſe admiration to thoſe which are below that know not the cauſe. The ſame may be done by placing the Image in a Chamber adjoyning, and ſo make it to be ſeen upon the ſide of a Wall.

Fourteenthly, In theſe Channel-Images which ſhew one ſide a Deaths Head, and another ſide a fair Face, and right before ſome other thing; it is a thing evident, that ſetting a plain Glaſs ſidewiſe to this Image, you ſhall ſee it in a contrary thing, than that which was preſented before ſidewiſe.

Fifteenthly, Laſtly, It is a fine ſecret to preſent unto a plain Glaſs Writing with ſuch induſtry, that one may read it in the Glaſs, and yet out of the Glaſs there is nothing to be known, which will thus happen, if the Writing be writ backward : but that which is more ſtrange, to ſhew a kind of Writing to a plain Glaſs, it ſhall appear another kind of Writing both againſt ſenſe and form; as if there were preſented to the Glaſs WEL, it would ſhew it MET; if it were written thus, MIV, and preſented to the Glaſs, it would appear thus VIM; for in the firſt, if the Glaſs lie flat, then the things are inverſed that are perpendicular to the Glaſs; if the Glaſs and the Object be upright, then that on the right hand is turned to the left, as in the latter.

And here I ceaſe to ſpeak further of theſe plain Glaſſes, either of the admirable multiplications, or appearances, which is made in a great number of them; for to content the ſight in this particular, one muſt have recourſe to the Cabinets of Great Perſonages who inrich themſelves with moſt beautiful ones.

Experiments upon Gibbous or Convex Spherical Glaſſes.

IF they be in the form of a Bowl, or part of a great Globe of Glaſs, there is ſingular contentment to contemplate on them.

First

First, Becaufe they prefent the Objects lefs and more gracious, and by how much more the Images are feparated from the Glafs, by fo much the more they diminifh in magnitude.

Secondly, They that fhew the Images plaiting, or folding, which is very pleafant, efpecially when the Glafs is placed down, and behold in it fome blanching, feeling, *&c.* The upper part of a Gallery, the porch of a Hall, *&c.* for they will be reprefented as a great Veffel having more belly in the middle than at the two ends, and Pofts and Joifts of Timber will feem as Circles.

Thirdly, That which ravifheth the Spirits by the Eye, and which fhames the beft Perfpective Painting that a Painter can make, is the beautiful contraction of the Images, that appear within the fphericity of thefe fmall Glaffes: for prefent the Glafs to the lower end of a Gallery, or at the Corner of a great Court full of People, or towards a great Street, Church, Fortification, an Army of Men, to a whole City; all the fair Architecture and appearances will be feen contracted within the circuit of the Glafs with fuch variety of Colours, and diftinctions in the leffer parts, that I know not in the world what is more agreeable to the fight, and pleafant to behold, in which you will not have an exact proportion, but it will be variable, according to the diftance of the Object from the Glafs.

Experiments upon hollow or concave ſpherical Glaſſes.

I Have heretofore ſpoken how they may burn, being made of Glaſs or Metal, it remains now that I deliver ſome pleaſant Uſes of them, which they repreſent unto our ſight; and ſo much the more notable it will be, by how much the greater the Glaſs is, and the Globe from whence it is extracted: for it muſt in proportion as a ſegment of ſome be made Circle or Orb.

Examination.

IN this we may obſerve that a Section of two, three, or four Inches in Diameter, may be ſegments of Spheres, of two, three, or four foot; nay of ſo many fadom, for it is certain that amongſt thoſe which comprehend a great portion of a leſſer Sphere, and thoſe which comprehend a little ſegment of a great Sphere, whether they be equal or not in ſection, there will happen an evident difference in one and the ſame Experiment, in the number, ſituation, quantity and figure of the Images of one or many different objects, and in burning there is a great difference.

MAginus, in a little Tractate that he had upon theſe Glaſſes, witneſſeth of himſelf that he had cauſed many to be poliſhed for ſundry

dry great Lords of *Italy* and *Germany*, which were ſegments of Globes of two, three, and four foot diameter; and I wiſh you had ſome ſuch-like to ſee the experiments of that which followeth; it is not difficult to have ſuch made, or bought here in Town, the contentment herein would bear with the coſt.

Examination.

T*Ouching* Maginus *he hath nothing aided us to the knowledge of the truth by his Extract out of* Vitellius, *but left it; expecting it from others, rather than to be plunged in the ſearch of it himſelf affecting rather the forging of the matter, and compoſition of the Glaſſes, than Geometrically to eſtabliſh their Effects.*

FIrſt therefore in concave Glaſſes, the Images are ſometimes ſeen upon the ſurface of the Glaſſes, ſometimes as though they were within it and behind it, deeply ſunk into it, ſometimes they are ſeen before, and without the Glaſs, ſometimes between the Object and the Glaſs; ſometimes in the place of the Eye, ſometimes farther from the Glaſs than the Object is: which comes to paſs by reaſon of the divers concourſe of the beams, and change of the place of the Images in the line of reflection.

Examination.

THe relation of these appearances pass current amongst most men, but because the Curious may not receive prejudice in their Experiments, something ought to be said thereof, to give it a more lively touch: in the true causes of these appearances, in the first place it is impossible that the Image can be upon the surface of the Glass, and it is a principal point to declare truly in which place the Image is seen in the Glass: those that are more learned in Optical knowledge affirm the contrary, and Nature it self gives it a certain place according to its position, being always seen in the line of Reflection which Alhazen, Vitellius, and others full of great knowledge, have confirmed by their Writings: but in their particular they were too much occupied by the Authority of the Ancients, who were not sufficiently circumspect in experience, upon which the principles of this subject ought to be built, and searched not fully into the true cause of these appearances, seeing they leave unto Posterities many falsities in their Writings, as those that followed them for the most part fell into the like errors.

As for the Images to bide in the Eye, it cannot be, but is impertinent and absurd; but it followeth that by how much nearer the Object approacheth to the Glass, by so much the more the appearances seem to come to the Eye: and if the Eye be without the point of concourse, and the Object also; as long as the Object

ject approacheth thereto, the representation of the Image *cometh near the* Eye, *but passing the point of concourse, it goes back again: These appearances thus approaching, do not a little astonish th se whi h are ignorant of the cause: they are inversed, if the* Eye *be without the point of concourse until the Object be within, but contrarily if the* Eye *be between the point of concourse and the* Glass, *then the* Images *are direct: and if the* Eye *or the Object be in the point of concourse, the* Glass *will be enlightened, and the* Images *confused, and if there were but a spark of fire in the said point of concourse, all the* Glass *would seem a burning* fire-brand, *and we dare say it would occur without chance, and in the night be the most certain and subtilest light that can be, if a candle were placed there. And whosoever shall enter into the search of the truth of new* Experiments *in this subject, without doubt he will confirm what we here speak of, and will find new Lights with a conveniable position to the* Glass, *he will have reflection of quantities of Truth, and fine Secrets in Nature, yet not known, which he may easily comprehend if he have but an indifferent sight, and may assure himself that the Images cannot exceed the sight, nor trouble it, a thing too much absurd to Nature.*

And it is an absolute verity in this Science, that the Eye being once placed in the line of Reflection of any Object, and moved in the same line: the Object is seen in one and the same place immutable; or if the Image and the Eye move in their own lines, the representation in the Glass seems to invest it self continually with a different figure.

Now the Image coming thus to the Eye, those which know not the secret, draw their Sword when they see an Image thus to issue out of the Glass, or a Pistol which some one holds behind: and some Glasses will shew a Sword wholly drawn out, separated from the Glass, as though it were in the Air: and it is daily exercised, that a man may touch the Image of his hand or his face out of the Glass, which comes out the farther, by how much the Glass is great, and the Centre remote,

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Examination.

Now that a Pistol being presented to a Glass behind a man, should come out of the Glass, and make him afraid that stands before, seeming to shoot at him, this cannot be: for no Object whatsoever presented to a concave Glass, if it be not nearer to the Glass than the Eye is, it comes not out to the sight of the party; therefore he needs not fear that which is said to be behind his back, and comes out of the Glass; for if it doth come out, it must then necessarily be before his face, so in a concave Glass whose Centre is far remote, if a Sword, Stick, or such-like, be presented to the Glass, it shall totally seem to come forth of the Glass, and all the hand that holds it. And here generally note, that if an Image be seen to issue out of the Glass to come towards the face of any one that

that ſtands by, the Object ſhall be likewiſe ſeen to thruſt towards that face in the Glaſs, and may eaſily be known to all the ſtanders by: ſo, many perſons ſtanding before a Glaſs, if one of the company take a Sword, and would make it iſſue forth towards any other that ſtands there, let him chuſe his Image in the Glaſs, and carry the Sword right towards it, and the effect will follow. In like manner ones hand being preſented to the Glaſs as it is thruſt towards the Centre, ſo the repreſentation of it comes towards it, and ſo the hands will ſeem to be united, or to touch one another.

FRom which may be concluded, if ſuch a Glaſs be placed at the ſeeling or planching of a Hall, ſo that the face be *Horizontal*, and look downward; one may ſee under it as it were a man hanging by the feet, and if there were many placed ſo, one could not enter into that place without great fear or ſcaring: for one ſhould ſee many men in the Air as if they were hanging by the feet.

Examination.

TOuching a Glaſs tied at a Seeling or Planching, that one may ſee a man hang by the Feet in the Air, and ſo many Glaſſes, ſo many Men may be ſeen: without caution this is very abſurd, for if the Glaſs or Glaſſes be not ſo great that the Centre of the Sphere upon which it was made, extend not near to the Head of him that is under it, it will

will not pleaſantly appear; and though the Glaſs *ſhould be of that capacity that the* Centre *did extend ſo far, yet will not the Images be ſeen to them which are from the Glaſs, but onely to thoſe which are under it or near unto it: and to them it will notably appear. And it would be moſt admirable to have a Gallery vaulted over with ſuch Glaſſes, which would wonderfully aſtoniſh any one that enters into it: for all the things in the Gallery would be ſeen to hang in the Air, and you could not walk without encountering Airy Apparitions.*

SEcondly, In flat or plain Glaſſes the Image is ſeen equal to his Object, and to repreſent a whole man, there ought to be a Glaſs as great as the Image is: In convex Glaſſes the Images are ſeen always leſs, in concave Glaſſes they may be ſeen greater or leſſer, but not truly proportionable, by reaſon of the divers reflections which contracts or enlargeth the Species: when the eye is between the Centre and the ſurface of the Glaſs, the Image appears ſometimes very great and deformed; and thoſe which have but the appearance of the beginning of a Beard on their Chin, may chear up themſelves to ſee they have a great Beard; thoſe that ſeem to be fair, will thruſt away the Glaſs with deſpight, becauſe it will transform their beauty: thoſe that put their hand to the Glaſs, will ſeem to have the hand of a Giant, and if one puts his finger to the Glaſs, it will be ſeen as a great Pyramide of Fleſh, inverſed againſt his finger.

Thirdly,

Thirdly, It is a thing admirable that the Eye being approached to the point of concourſe of the Glaſs, there will be ſeen nothing but an intermixture or confuſion: but retiring back a little from that point (becauſe the Rays do there meet) he ſhall ſee his Image inverſed, having his Head below, and his Feet above.

Fourthly, The divers appearances cauſed by the motion of Objects, either retiring or approaching: whether they turn to the right hand or to the left hand, whether the Glaſs be hung againſt a Wall, or whether it be placed upon a Pavement, as alſo what may be repreſented by the mutual aſpect of Concave Glaſſes, with plain and Convex Glaſſes: but I will with ſilence paſs them over, only ſay ſomething of two rare Experiments more as followeth.

The firſt is to repreſent by help of the Sun ſuch letters as one would upon the front of a houſe, ſo that one may read them: *Maginus* doth deliver the way thus: Write the Letters, ſaith he, ſufficiently big, but inverſed upon the ſurface of the Glaſs, with ſome kind of colour, or theſe Letters may be written with Wax, (the eaſier to be taken out again) for then placing the Glaſs to the Sun, the Letters which are written there will be reverberated or reflected upon the Wall: hence it was perhaps that *Pythagoras* did promiſe with this invention to write upon the Moon.

In the ſecond place, how a man may ſundry ways help himſelf with ſuch a Glaſs, with a lighted Torch or Candle, placed in the point of concourſe or inflammation, which is near the fourth

part

part of the Diameter : for by this means the light of the Candle will be reverberated into the Glaſs, and will be caſt back again very far by parallel lines, making ſo great a light that one may clearly ſee that which is done far off, yea in the camp of an Enemy; and thoſe which ſhall ſee the Glaſs afar off, will think they ſee a Silver Baſin inlightened, or a fire more reſplendent then the Torch. It is this way that there are made certain Lanthorns which dazel the Eyes of thoſe which come againſt them; yet it ſerves ſingular well to enlighten thoſe which carry them, accommodating a Candle with a little hollow Glaſs, ſo that it may ſucceſſively be applied to the point of inflammation.

In like manner by this reflected Light one may read far off, provided that the Letters be indifferent great, as an Epitaph placed high, or in a place obſcure; or the Letter of a Friend which dares not approach without peril or ſuſpition.

Examination.

This will be ſcarce ſenſible upon a Wall remote from the Glaſs, and but indifferently ſeen upon a Wall which is near the Glaſs, and withal it muſt be in obſcurity or ſhadowed, or elſe it will not be ſeen. To caſt Light in the night to a place remote, with a Candle placed in the point of concourſe or inflammation, is one of the moſt notableſt properties which can be *be ſhewn in a concave Glaſs: for if in the point of inflammation of a Parabolical Section, a Candle be placed, the Light will be reflected by Parallel Lines, as a Column or Cylinder; but in the Spherical Section it is defective in part, the beams being not united in one point, but ſomewhat ſcattering: notwithſtanding it caſteth a very great beautiful Light.*

LAſtly, Thoſe which fear to hurt their ſight by the approach of Lamps or Candles, may by this artifice place at ſome corner of a Chamber a Lamp with a hollow Glaſs behind it, which will commodiouſly reflect the Light upon a Table, or to a place aſſigned: ſo that the Glaſs be ſomewhat raiſed to make the Light to ſtreek upon the Table with ſharp Angles, as the Sun doth when it is but a little elevated above the Horizon, for this Light ſhall exceed the Light of many Candles placed in the Room, and be more pleaſant to the ſight of him that uſeth it.

Of other Glaſſes of Pleaſure.

FIrſt, The Columnary and Pyramidal Glaſſes that are contained under right lines, do repreſent the Images as plain Glaſſes do, and if they be bowing, then they repreſent the Image as the concave and convex Glaſſes do.

Secondly, Thoſe Glaſſes which are plain, but have aſcents of Angles in the middle, will ſhew one to have four Eyes, two Mouths, two Noſes, *&c.*

Examination.

These Experiments will be found different, according to the diverse meeting of the Glasses, which commonly are made scuing-wise at the end, by which there will be two divers superficies in the Glass, making the exteriour Angle somewhat raised, at the interiour onely one superficies, which may be covered according to ordinary Glasses to cause a reflection, and so it will be but one Glass, which by refraction according to the different thickness of the Glass, and different Angles of the scuing form, do differently present the Images to the Eye, as four Eyes, two Mouths, two Noses; sometimes three Eyes, one Mouth, and one Nose, the one large, and the other long, sometimes two Eyes onely, with the Mouth and the Nose deformed, which the Glass (impenitrable) will not shew. And if there be an interiour solid Angle, according to the difference of it, (as if it be more sharp) there will be represented two distinct double Images, that is, two entire Visages, and as the Angle is open, by so much the more the double Images will reunite, and enter one within another, which will present sometimes a whole Visage extended at large, to have four Eyes, two Noses, and two Mouths: and by moving the Glass the Angle will vanish, and so the two superficies will be turned into one, and the duplicity of Images will also vanish, and appear but one onely: and this is easily experimented with two little

little Glaſſes of Steel, or ſuch-like, ſo united that they make divers Angles and Inclinations.

THirdly, There are Glaſſes which make men ſeem pale, red, and coloured in divers manners, which is cauſed by the dye of the Glaſs, or the diverſe refraction of the Species: and thoſe which are made of Silver, Latin, Steel, *&c.* do give the Images a diverſe colour alſo. In which one may ſee that the appearances by ſome are made fairer, younger, or older than they are; and contrarily others will make them foul and deformed, and give them a contrary viſage: for if a Glaſs be cut as it may be, or if many pieces of Glaſs be placed together to make a conveniable reflection: there might be made of a Mole (as it were) a Mountain, of one Hair a Tree, a Fly to be as an Elephant, but I ſhould be too long if I ſhould ſay all that which might be ſaid upon the property of Glaſſes. I will therefore conclude this Diſcourſe of the properties of theſe Glaſſes, with theſe four recreative Problems following.

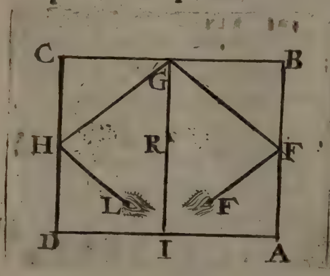
PRO-

PROBLEM LXXVIII.

How to shew to one that is suspitious what is done in another Chamber or Room, notwithstanding the interposition of the Wall.

FOr the performance of this, there must be placed three Glasses in the two Chambers, of which one of them shall be tied to the planching or seeling, that it may be common to communicate the Species to each Glass by reflection, there being left some hole at the top of the Wall against the Glass to this end: the two other Glasses must be placed against the two Walls at right Angles, as the figure here sheweth at *B* and *C*.

Then the sight at *E* by the line of incidence *F E*, shall fall upon the Glass *B A*, and reflect upon the superficies of the Glass *B C*, in the point *G*; so that if the Eye be at *G*, it should see E, and E would reflect upon the third Glass in the point *H*, and the Eye that is at *L* will see the Image that is at E in the point of the *Catheti*: which Image



shal

ſhall come to the eye of the ſuſpicious, *viz* at L. by help of the third Glaſs, upon which is made the ſecond reflection, and ſo brings unto the eye the object, though a wall be between it.

COROLARY 1.

BY this invention of Reflections the beſiegers of a Town may be ſeen upon the Rampart: notwithſtanding the Parapet, which the beſieged may do, by placing a Glaſs in the hollow of the Ditch, and placing another upon the top of the Wall, ſo that the Line of Incidence coming to the bottom of the Ditch, make an Angle equal to the Angle of Reflection, then by this ſituation and reflection, the Image of the beſiegement will be ſeen to him is upon the Rampart.

COROLARY 2.

BY which alſo may be inferred, that the ſame Reflections may be ſeen in a Regular *Polygon*, and placing as many Glaſſes as there are ſides, counting two for one; for then the object being ſet to one of the Glaſſes, and the eye in the other, the Image will be ſeen eaſily.

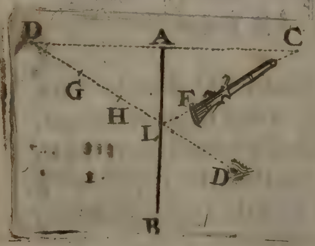
COROLARY 3.

FArther, notwithſtanding the interpoſition of many Walls, Chambers, or Cabinets, one may ſee that which paſſeth through the moſt remoteſt of them, by placing of many Glaſſes, as there are openings in the Walls, making them to receive the incident Angles equal: that is, placing them in ſuch ſort by ſome Geometrical aſſiſtant, that the incident points may meet in the middle of the Glaſſes: but here all the defect will be, that the Images paſſing by ſo many reflections, will be very weak, and ſcarce obſervable.

PROBLEM LXXIX.

How with a Musket to ſtrike a mark, not looking towards it, as exact as one aiming at it.

As let the Eye be at *O*, and the mark *C*, place a plain Glaſs perpendicular as *A B*, ſo the mark *C* ſhall be ſeen in *Catheti C A*, *viz.* in *D*, and the Line of Reflection is *D*, now let the Musket *F E*, upon a reſt, be moved to and fro, until it be ſeen in the line *O D*, which admit to be *HG*, ſo giving fire to the Musket, it ſhall undoubtedly ſtrike the Mark.

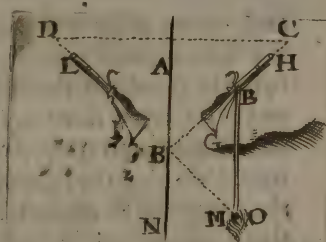


CORO-

COROLARIES.

From which may be gathered, that one may exactly ſhoot out of a Musket to a place which is not ſeen, being hindered by ſome Obſtacle, or other interpoſition.

AS let the Eye be at *M*, the mark *C*, and the Wall which keeps it from being ſeen, admit to be *Q R*, then ſet up a plain Glaſs, as *A B*, and let the Musket be *G H*, placed upon his reſt *B O*. Now becauſe the mark *C* is ſeen at *D*, move the Musket to and fro, until it doth agree with the Line



of Reflection *M B*, which ſuppoſe at *L I*, ſo ſhall it be truly placed, and giving fire to the Musket, it ſhall not fail to ſtrike the ſaid mark at *C*.

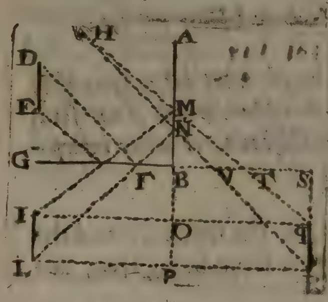
PROBLEM LXXX.

How to make an Image to be ſeen hanging in the air, having his Head downward.

TAke two Glaſſes, and place them at right Angles one unto the other, as admit *A B*, and *C B*, of which admit *C B* Horizontal, and

 let

let the Eye be at *H*, and the Object or Image to be *D E*; so *D* will be reflected at *F*, so to *N*, so to *H E*: then at *G*, so to *M*, and then to *H*, and by a double reflection *E D* will seem in *Q R*, the highest point *D* in *R*, and the point *E* in *Q* inversed as was

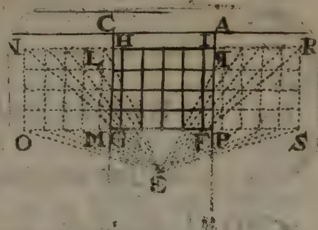


said, taking *D* for the head, and *E* for the feet; so it will be a man inversed, which will seem to be flying in the air, if the Image had wings unto it, and had secretly some motion: and if the Glass were big enough to receive many Reflections, it would deceive the sight the more by admiring the changing of colours that would be seen by that motion.

PROBLEM LXXXI.

How to make a Company of representative Souldiers seem to be a Regiment, or how few in number may be multiplied to seem to be many in number.

TO make the Experiment upon men, there must be prepared two great Glasses; but in stead of it we will suppose 2 lesser, as *G H*, & *F I*, one placed right against another perpendicular to the Horizon, upon a plain level Table: between which



which Glaſſes let there be ranged in Battalia-wiſe upon the ſame Table a number of ſmall men according to the ſquare *G, H, I, F*, or in any other form or poſture: then may you evidently ſee how the ſaid Battel will be multiplied and ſeem far bigger in the appearance, than it is in effect.

COROLARY.

BY this invention you may make a little Cabinet of four foot long, and two foot large, (more or leſs) which being filled with Rocks or ſuch like things, or there being put into it Silver, Gold, Stones of luſtre, Jewels, *&c.* and the Walls of the ſaid Cabinet being all covered, or hung with plain Glaſs; theſe viſibles will appear manifoldly increaſed, by reaſon of the multiplicity of reflections; and at the opening of the ſaid Cabinet, having ſet ſomething which might hide them from being ſeen, thoſe that look into it will be aſtoniſhed to ſee ſo few in number, which before ſeemed to be ſo many.

PROBLEM LXXXII.

Of fine and pleaſant Dyals.

COuld you chooſe a more ridiculous one than the natural Dyal written amongſt the Greek Epigrams, upon which ſome ſound Poet made verſes, ſhewing that a man carrieth about him always a Dyal in his Face by means of the Noſe and Teeth? And is not this a jolly Dyal? For he need not but open the Mouth, the Lines ſhall be all the Teeth, and the Noſe ſhall ſerve for the Style.

Of a Dyal of Herbs.

CAn you have a finer thing in a Garden, or in the middle of a Compartment, than to ſee the Lines and the number of Hours repreſented with little buſhie Herbs, as of Hyſop, or ſuch which is proper to be cut in the borders; and at the top of the Style to have a Fan to ſhew which way the wind bloweth? This is very pleaſant and uſeful.

Of the Dyal upon the Fingers and the Hand.

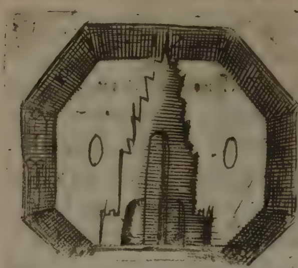
IS it not a commodity very agreeable, when one is in the field or in ſome village, without any other Dyal, to ſee onely by the hand what of the clock

clock it is? which gives it very near; and may be practiſed by the left hand, in this manner.

Take a Straw or like thing of the length of the *Index*, or the ſecond finger; hold this Straw very right between the Thumb and the fore Finger, then ſtretch forth the hand, and turn your back and the palm of your hand towards the Sun; ſo that the ſhadow of the muſcle which is under the Thumb touch the Line of Life, which is between the middle of the two other great Lines, which is ſeen in the palm of the hand, this done, the end of the ſhadow will ſhew what of the clock it is: for at the end of the firſt Finger it is 7 in the morning, or 5 in the evening, at the end of the Ring-Finger it is 8 in the morning, or 4 in the evening; at the end of the Little Finger or firſt Joynt, it is 9 in the morning, or 3 in the afternoon, 10 and 2 at the ſecond Joynt, 11 and 1 at the third Joynt, and mid-day in the Line following, which comes from the end of the *Index*.

Of a Dyal which was about an Obelisk at Rome.

WAs not this a pretty fetch upon a Pavement, to chooſe an *Obelisk* for a *Dyal*, having 106 foot in height, without removing the Baſis of it? *Pliny* aſſures us in his 26 Book and 8 Chap. that the Emperour *Auguſtus* having accommodated in the Field of *Mars* an *Obelisk* of this height, he made about it a Pavement, and by the induſtry of *Manilius* the Mathematician, there were enchaced marks of Copper upon the Pave-



ment, and placed alſo an Apple of Gold upon the top of the ſaid *Obelisk*, to know the hour and the courſe of the Sun, with the increaſe and decreaſe of days by the ſame ſhadow: and in the ſame manner do ſome by the ſhadow of their head or other Style, make the like Experiments in Aſtronomy.

Of Dyals with Glaſſes.

PTolomy writes, as *Cardanus* reports, that long ago there were Glaſſes which ſerved for Dyals, and preſented the face of the beholder as many times as the hour ought to be; 2 if it were 2 of the clock, 9 if it were 9, *&c.* But this was thought to be done by the help of water, & not by Glaſſes, which did leak by little and little out of the veſſel, diſcovering firſt 1 Glaſs, then 2 Glaſſes, then 3, 4. 5 Glaſſes, *&c.* to ſhew ſo many faces as there were hours, which was onely by leaking of water.

Of a Dyal which hath a Glaſs in place of the Style.

WHat will you ſay of the invention of Mathematicians, which find out daily ſo many fine and curious Novelties? They have now a way to make Dyals upon the Wainſcot or Seeling of a Chamber, and there where the Sun can never ſhine,

ſhine, or the beams of the Sun cannot directly ſtrike: and this is done in placing of a little Glaſs in the place of the Style, which reflecteth the light with the ſame condition that the ſhadow of the Style ſheweth the hour: and it is eaſie to make experiment upon a common Dyal, changing only the diſpoſition of the Dyal, and tying to the end of the Style a piece of plain Glaſs. The *Almains* uſe it much, who by this way have no greater trouble, but to put their Noſes out of their Beds aud ſee what a clock it is, which is reflected by a little hole in the Window upon the Wall or Sieling of the Chamber.

Examination.

IN this there are two Experiments conſiderable, the firſt is with a very little Glaſs placed ſo that it may be open to the Beams of the Sun, the other hath reſpect to a ſpacious or great Glaſs placed to a very little hole, ſo that the Sun may ſhine on it, for then the ſhadow which is caſt upon the Dyal is converted into beams of the Sun, and will reflect and be caſt upon a plain oppoſite: and in the other it is a hole in the Window, or ſuch-like, by which may paſs the Beams of the Sun, which repreſent the extremity of the Style, and the Glaſs repreſenteth the plain of the Dyal, upon which the beams being in manner of ſhadows reflect caſt upon a plain oppoſite: and it is needful that in this ſecond way the Glaſs may be ſpacious, as before, to receive the delineaments of the Dyal.

Other-

Otherwiſe you may draw the Lineaments of a Dyal upon any plain Looking-Glaſs which reflecteth the Sun-beams, for the applying a Style or a Pearl at the extremity of it; and placed to the Sun, the reflection will be anſwerable to the delineaments on the Glaſs: but here note, that the Glaſs ought to be great, and ſo the delineaments thereon.

But that which is moſt Noble, is to draw hour-lines upon the out-ſide of the Glaſs of a Window, and placing a Style thereto upon the out-ſide, the ſhadow of the Style will be ſeen within, and ſo you have the hour more certain, without any difficulty.

Of Dyals with Water.

SUch kind of Dyals were made in ancient times, and alſo thoſe of Sand: before they had skill to make Sun-Dyals, or Dyals with Wheels: for they uſed to fill a Veſſel with Water, and having experience by trial that it would run out all in a day, they did mark within the Veſſel the hours noted by the running of the Water; and ſome did ſet a piece of light board in the Veſſel to ſwim upon the top of the Water, carrying a little Statue, which with a ſmall ſtick did point out the hour upon a Column or Wall, figured with hour-notes, as the Veſſel was figured within.

Vitruvius writes of another manner of Water-Dyal more difficult; and *Baptiſta à Porta* amongſt his Natural Secrets, delivers this Invention following: Take a Veſſel full of Water like a Caldron, and another Veſſel of Glaſs like unto a Bell, (with

(with which ſome accuſtom to cover *Melons*) and let this Veſſel of Glaſs be almoſt as great as the Caldron, having a ſmall hole at the bottom, then when it is placed upon the water, it will ſink by little and little: by this one may mark the hours on the ſurface of the Glaſs to ſerve another time.

But if at the beginning one had drawn the water within the ſame Veſſel of Glaſs in ſucking by the little hole, the water would not fall out, but as faſt as the air would ſucceed it, entering ſlowly at the little hole: for contrarily the hours may be diſtinguiſhed by diminution of water, or by augmentation.

Now it ſeems a ſafer way that the water paſs out by drop and drop, and drop into a Cylindrical Glaſs by help of a Pipe: for having marked the exteriour part of the Cylinder in the hour-notes, the Water it ſelf which falls within it will ſhew what of the clock it is, far better than the running of Sand; for by this may you have the parts of the hours moſt accurate, which commonly by Sand is not had: and to which may be added the hours of other Countries with greater eaſe. And here note, that as ſoon as the Water is out of one of the Glaſſes, you may turn it over into the ſame again out of the other, and ſo let it run anew.

PRO-

PROBLEM LXXXIII.

Of Cannons or great Artillery.

Souldiers and others would willingly ſee this Problem, which contains 3 or 4 ſubtile Queſtions.

1.

The firſt is, How to charge a Cannon without Powder.

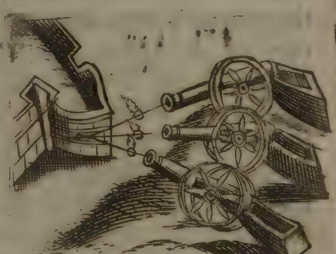
THis might be done with air and water only, having thrown cold water into the Cannon, which might be ſquirted forceably in by the cloſure of the mouth of the Piece, that ſo by this preſſure the air might more condenſe; then having a round piece of Wood very juſt, and oiled well, for the better to ſlide, and thruſt the Bullet when it ſhall be time: This piece of Wood may be held faſt with ſome Pole, for fear it be not thruſt out before his time: then let fire be made about the *Trunion* or hinder part of the Piece to heat the air and water, and then when one would ſhoot it, let the pole be quickly looſened, for then the air ſearching a greater place, and having way now offered, will thruſt out the Wood and the Bullet very quick: The Experiment which we have in long Trunks ſhooting out pellats with air only, ſheweth the verity of this Problem.

2. *In*

2.

In the ſecond Queſtion it may be demanded, How much time doth the Bullet of a Cannon ſpend in the air before it falls to the ground?

THe Reſolution of this Queſtion depends upon the goodneſs of the Piece and Charge thereof, ſeeing in each there is great difference. It is reported that *Ticho Brahe*, and the *Landſgrave* did make an Experiment upon a Cannon in *Germany*, which being charged and ſhot off, the Bullet ſpent 2 min. of time in the air before it fell: and the diſtance was a German mile, which diſtance proportionated to an hours time, makes 120 Italian miles.



3.

In the third Queſtion it may be asked, How it comes to paſs, that a Cannon ſhooting upward, the Bullet flies with more violence than being ſhot point-blank, or ſhooting downward?

IF we regard the effect of a Cannon when it is to batter a Wall, the Queſtion is falſe, ſeeing it is moſt evident that the blows which fall

Per-

Perpendicular upon a Wall, are more violent than thoſe which ſtrike byas-wiſe or glancingly.

But conſidering the ſtrength of the blow only, the Queſtion is moſt true, and often experimented to be found true: a Piece mounted at the beſt of the Randon, which is near half of the right, conveys her Bullet with a far greater violence than that which is ſhot at point blank, or mounted parallel to the Horizon. The common reaſon is, that ſhooting high, the fire carries the bowl a longer time in the air, and the air moves more facil upwards than downwards,becauſe that the airy circles that the motion of the Bullet makes, are ſooneſt broken. Howſoever this be the general Tenet, it is curious to find out the inequality of moving of the air; whether the Bullet fly upward, downward, or right forward, to produce a ſenſible difference of motion; and ſome think that the Cannon being mounted, the Bullet preſſing the powder maketh a greater reſiſtance, and ſo cauſeth all the powder to be inflamed before the Bullet is thrown out,which makes it to be more violent than otherwiſe it would be. When the Cannon is otherwiſe diſpoſed, the contrary arrives, the fire leaves the Bullet, and the Bullet rolling from the Powder reſiſts leſs: and it is uſually ſeen, that ſhooting out of a Musket charged onely with Powder, to ſhoot to a mark of Paper placed point blank, that there are ſeen many ſmall holes in the Paper, which cannot be other than the grains of Powder which did not take fire: but this latter accident may happen from the overcharging of the Piece, or the

length

length of it, or windy, or dampneſs of the Powder.

From which ſome may think that a Cannon pointed right to the *Zenith*, ſhould ſhoot with greater violence than in any other mount or form whatſoever: and by ſome it hath been imagined that a Bullet ſhot in this faſhion hath been conſumed, melted, and loſt in the air, by reaſon of the violence of the blow, and the activity of the fire, and that ſundry Experiments have been made in this nature, and the Bullet never found. But it is hard to believe this aſſertion: it may rather be ſuppoſed that the Bullet falling far from the Piece cannot be diſcerned where it falls, and ſo comes to be loſt.

4.

In the fourth place it may be asked, Whether the diſcharge of a Cannon be ſo much the greater, by how much it is longer?

IT ſeemeth at the firſt to be moſt true, that the longer the Piece is, the more violent it ſhoots: and to ſpeak generally, that which is direction by a Trunk, Pipe, or other concavity, is conveyed ſo much the more violent, or better, by how much it is longer, either in reſpect of the Sight, Hearing, Water, Fire, &c. and the reaſon ſeems to hold in Cannons, becauſe in thoſe that are long, the fire is retained a longer time in the concavity of the Piece, and ſo throws out the Bullet with more violence; and experience lets us ſee that taking

taking Cannons of the ſame bore, but of diverſity of length from 8 foot to 12, that the Cannon of 9 foot long hath more force than that of 8 foot long, and 10 more than that of 9, and ſo unto 12 foot of length. Now the uſual Cannon carries 600 Paces, ſome more, ſome leſs, yea ſome but 200 Paces from the Piece, and may ſhoot into ſoft earth 15 or 17 foot, into ſand or earth which is looſe, 22 or 24 foot, and in firm ground, about 10 or 12 foot, &c.

It hath been ſeen lately in *Germany*, where there were made Pieces from 8 foot long to 17 foot of like bore, that ſhooting out of any piece which was longer than 12 foot; the force was diminiſhed, and the more in length the Piece increaſeth, the leſs his force was: therefore the length ought to be in a mean meaſure, and it is often ſeen the greater the Cannon is, by ſo much the ſervice is greater: but to have it too long or too ſhort, is not convenient, but a mean proportion of length to be taken, otherwiſe the flame of the fire vvill be overpreſſed vvith Air, vvhich hinders the motion in reſpect of ſubſtance, and diſtance of getting out.

PRO-

PROBLEM LXXXIV.

Of prodigious Progression and Multiplication of Creatures, Plants, Fruits, Numbers, Gold, Silver, &c. when they are always augmented by certain proportion.

HEre we ſhall ſhew things no leſs admirable than recreative, and yet ſo certain and eaſie to be demonſtrated, that there needs not but Multiplication onely, to try each particular: and firſt,

Of Grains of Muſtard-ſeed.

FIrſt, Therefore it is certain that the increaſe of one grain of Muſtard ſeed for 20 years ſpace, cannot be contained within the viſible World, nay if it were an hundred times greater than it is; and holding nothing beſides from the Centre of the Earth even unto the Firmament, but onely ſmall Grains of Muſtard-ſeed: Now becauſe this ſeems but words, it muſt be proved by Art, as may be done in this wiſe: As ſuppoſe one Muſtard-ſeed ſowen to bring forth a Tree or Branch, in each extendure of which might be a thouſand grains: but we will ſuppoſe onely a thouſand in the whole Tree, and let us proceed to 20 years, every Seed to bring forth yearly a thouſand grains; now multiplying always by a thouſand, in leſs than 17 years, you ſhall have ſo many grains which will ſurpaſs the ſands, which are able to fill the whole Firmament: for following the ſuppoſition of *Archimedes*, & the moſt probable opinion of the greatneſs of the Firmament which *Ticho Brahe* hath left us; the number of grains of Sand will be ſufficiently expreſſed with 49 Cyphers, but the number of grains of Muſtard-ſeed at the end of 17 years will have 52 Cyphers: and moreover, grains of Muſtard-ſeed are far greater than theſe of the Sands: It is therefore evident that at the ſeventeenth year, all the grains of Muſtard-ſeed which ſhall ſucceſſively ſpring from one grain onely, cannot be contained within the limits of the whole Firmament; what ſhould it be then, if it ſhould be multiplied again by a thouſand for the eighteenth year, and that again by a thouſand for every years increaſe, until you come to the twentieth year? It's a thing as clear as the day, that ſuch a heap of Muſtard-ſeed would be an hundred thouſand times greater than the Earth: and bring onely but the increaſe of one grain in twenty years.

Of Pigs.

SEcondly, Is it not a ſtrange Propoſition, to ſay, That the Great Turk with all his Revenues, is not able to maintain for one years time all the Pigs that a Sow may pig with all her Race, that is, the increaſe with the increaſe, unto 12 years: this ſeems impoſſible, yet it is moſt true, for

for let us ſuppoſe and put the caſe, that a Sow bring forth but 6, 2 Males and 4 Females, and that each Female ſhall bring forth as many every year, during the ſpace of 12 years, at the end of the time there will be found above 33 millions of Pigs: Now allowing a crown for the maintenance of each Pig for a year, (which is as little as may be, being but near an half of a farthing allowance for each day) there muſt be at leaſt ſo many crowns to maintain them one year, *viz.* 33 millions, which exceeds the Turks Revenue by much.

Of Grains of Corn.

Thirdly, It will make one aſtoniſhed to think that a Grain of Corn with his increaſe ſucceſſively, for the ſpace of 12 years will produce in Grains 244140625000000000000, which is able to load almoſt all the Creatures in the World.

To open which, let it be ſuppoſed that the firſt year one grain being ſowed brings forth 50, (but ſometimes there is ſeen 70, ſometimes 100 fold) which grains ſowen the next year, every one to produce 50, and ſo conſequently the whole and increaſe to be ſowen every year, until 12 years be expired, there will be of increaſe the aforeſaid prodigious ſum of grains, *viz.* 244140625000000000000, which will make a Cubical Heap of 6258522 Grains every way, which is more than a Cubical Body of 31 miles every way: for allowing 40 grains in length to each foot, the Cube would be 156463 foot every way: from which it is evident that if there were two hundred thouſand Cities as great as *London*, allowing to each 3 miles ſquare every way, and 100 foot in height, there would not be ſufficient room to contain the aforeſaid quantity of Corn: and ſuppoſe a Buſhel of Corn were equal unto two cubick feet, which might contain twenty hundred thouſand grains, then would there be 12207046 2500000 buſhels, and allowing 30 buſhels to a Tun, it would be able to load 8138030833 Veſſels, which is more than eight thouſand one hundred and thirty eight millions, ſhip loadings of 500 Tun to each Ship: a quantity ſo great, that the Sea is ſcarce able to bear, or the Univerſal World able to find Veſſels to carry it. And if this Corn ſhould be valued at half a Crown the buſhel, it would amount to 152588078125000 pounds Sterling, which I think exceeds all the Treaſures of all the Princes, and of other particular men in the whole World: And is not this good Husbandry to ſow one grain of Corn, and to continue it in ſowing the increaſe onely for 12 years, to have ſo great a profit?

Of the Increaſe of Sheep.

FOurthly, Thoſe that have great flocks of ſheep may be quickly rich, if they would preſerve their Sheep without killing or ſelling of them: ſo that every Sheep produce one each year, for at the end of 16 years 100 Sheep will multiply and increaſe

increaſe unto 6553600, which is above ſix millions, five hundred fifty three thouſand Sheep: Now ſuppoſing them worth but a crown a piece, it would amount unto 1638400 pounds Sterling, which is above 1 million 6 hundred 38 thouſand pounds. A fair increaſe of one Sheep, and a large portion for a Child, if it ſhould be allotted.

Of the increaſe of Cod-fiſh, Carps, &c.

FIfthly, If there be any creatures in the world that do abound with increaſe or fertility, it may be rightly attributed to fiſh; for they in their kinds produce ſuch a great multitude of Eggs, and bring forth ſo many little ones, that if a great part were not deſtroyed continually, within a little while they would fill all the Sea, Ponds, and Rivers in the World; and it is eaſie to ſhew how it would ſo come to paſs, onely by ſuppoſing them to increaſe without taking or deſtroying them for the ſpace of 10 or 12 years: having regard to the ſolidity of the Waters, which are allotted for to lodge and contain theſe Creatures, as their bounds and place of reſt to live in.

Of the increaſe and multiplication of Men.

SIxthly, There are ſome that cannot conceive how it can be that from eight perſons (which were ſaved after the Deluge or *Noahs* Flood) ſhould ſpring ſuch a World of People to begin a Monarchy under *Nimrod*, being but 200 years after the Flood, and that amongſt them ſhould be raiſed an Army of 200000 fighting men: But it is eaſily proved if we take but one of the Children of *Noah*, and ſuppoſe that a new Generation of People begun at every 30 years, and that it be continued to the ſeventh Generation, which is 200 years; for then of one only Family there would be produced 111000 Souls, 305 to begin the World: though in that time men lived longer, and were more capable of multiplication and increaſe: which number ſpringing onely from a ſimple production of one yearly, would be far greater if one Man ſhould have many Wives, which in ancient times they had: from which it is alſo that the Children of *Iſrael*, who came into *Egypt* but only 70 Souls, yet after 210 years captivity, they came forth with their Hoſts, that there were told 600000 fighting men, beſides old People, Women, and Children; and he that ſhall ſeparate but one of the Families of *Joſeph*, it would be ſufficient to make up that number: How much more ſhould it be then, if we ſhould joyn many Families together?

Of the Increaſe of Numbers.

SEventhly, What ſum of money ſhall the City of *London* be worth, if it ſhould be ſold, and the money be paid in a year after this manner: The firſt week to pay a Pin, the ſecond week 2 Pins, the third week 4 Pins, the fourth week 8

Pins,

Pins, the fifth week 16 Pins, and ſo doubling until the 52 Weeks, or the year be expired?

Here one would think that the value of the Pins would amount but to a ſmall matter, in compariſon of the Treaſures or Riches of the whole City: Yet it is moſt probable that the number of Pins would amount unto the ſum of 4519599628681215, and if we ſhould allow unto a quarter a hundred thouſand Pins, the vvhole vvould contain ninety eight millions, four hundred thouſand Tun: vvhich is able to load 45930 Ships of a thouſand Tun apiece: And if vve ſhould allow 1000 Pins for a Penny, the ſum of money vvould amount unto above eighteen thouſand eight hundred and thirty millions of pounds ſterling: An high Price to ſell a City at, yet certain, according to that firſt propoſed.

So if 40 Towns were ſold upon condition to give for the firſt a penny, for the ſecond 2 pence, for the third 4 pence, &c. by doubling all the reſt unto the laſt, it would amount unto this number of pence 1099511627776, which in pounds is 4581298444, that is, four thouſand five hundred, and fourſcore millions of pounds, and more.

Of a man that gathered up Apples, Stones, or such-like, upon a condition.

EIghtly, Admit there were 100 Apples, Stones, or ſuch-like things, that were plac'd in a ſtraight line or right form, a Pace one from another, and a basket being placed a Pace from the firſt: how many Paces would there be made to put all theſe Stones into the Basket, by fetching one by one? This would require near half a day to do it, for there would be made 10092 paces before he ſhould gather them all up.

Of Changes in Bells, in Muſical Inſtruments, Tranſmutation of places in Numbers, Letters, Men, or ſuch-like.

NInthly, Is it not an admirable thing to conſider how the Skill of Numbers doth eaſily furniſh us with the knowledge of myſterious and hidden things? which ſimply look'd into by others that are not verſed in Arithmetick, do preſent unto them a world of confuſion and difficulty.

As in the firſt place it is often debated amongſt our common Ringers, what number of Changes there might be made in five, ſix, ſeven, eight, or more Bells: who ſpend much time to anſwer their own doubts, entering often into a Labyrinth in the ſearch thereof: or if there were 10 Voices, how many ſeveral notes might there be? Theſe are propoſitions of ſuch facility, that a Child which can but multiply one number by another, may eaſily reſolve it, which is but onely to multiply every number from the unite successively in each others product, unto the term assigned: so the 6 number that is against 6 in the Table, is 720, and so many Changes may be made upon 6 Bells, upon 5 there are 120, &c.

1	a	1
2	b	2
3	c	6
4	d	24
5	e	120
6	f	720
7	g	5040
8	h	40320
9	i	362880
10	k	3628800
11	l	39916800
12	m	479001600
13	n	6227020800
14	o	87178291200
15	p	1307674368000
16	q	20922789888000
17	r	355687537996000
18	s	6402375683928000
19	t	121645137994632000
20	u	2432902759892640000
21	w	51090957957745440000
22	x	1124001075070399680000
23	y	25852024726619192640000
24	z	620448593438860623360000

In like manner against 10 in the Table is 3628800, that is, three millions, six hundred twenty

twenty eight thouſand, eight hundred; which ſhews that 10 Voices may have ſo many Conſorts, each man keeping his own note, but onely altering his place; and ſo of ſtringed Inſtruments, and the *Gamat* may be varied according to which, anſwerable to the number that is againſt r, *viz.* 11240010750703996800000 Notes.

From which may be drawn this or the like Propoſition:

Suppoſe that 7 Schollars were taken out of a Free School to be ſent to an Univerſity, there to be entertained in ſome Colledge at Commons for a certain ſum of money, ſo that each of them have two meals daily, and no longer to continue there, then that ſitting all together upon one Bench or Form at every Meal, there might be a divers tranſmutation of place of account in ſome one of them, in compariſon of another, and never the whole company to be twice alike in ſituation: How long may the Steward entertain them? (who being not skilled in this fetch, may anſwer unadviſedly.) It is moſt certain that there will be five thouſand and forty ſeveral poſitions or changings in the ſeatings, which makes fourteen years time, wanting ten weeks and three days.

Hence from this mutability of tranſmutation, it is no marvel that by 24 Letters there ariſeth and is made ſuch variety of Languages in the World, and ſuch infinite number of words in each Language; ſeeing the diverſity of Syllables produceth that effect, and alſo by the interchanging and placing of Letters amongſt the Vowels, and amongſt

amongst themselves maketh these syllables,which Alphabet of 24 Letters may be varied so many times, *viz.* 620448593438860623360000, which is six hundred twenty thousand, four hundred forty eight millions of millions of millions five hundred ninety three thousand, four hundred thirty eight millions of millions, and more.

Now allowing that a man may read or speak one hundred thousand words in an hour, which is twice more words than there are contained in the Psalms of *David*, (a Task too great for any man to do in so short a time) and if there were four thousand six hundred and fifty thousand millions of men, they could not speak these words (according to the hourly proportion aforesaid) in threescore and ten thousand years; which variation and transmutation of Letters, if they should be written in Books, allowing to each Leaf 28000 words, (which is as many as possibly could be inserted) and to each Book a Ream or 20 Quire of the largest and thinnest Printing-Paper, so that each Book being about 15 inches long. 12 broad, and 6 thick: The Books that would be made of the transmutation of the twenty four Letters aforesaid, would be at the least 387780378992878 : And if a Library of a mile square every way, of 50 foot high, were made to contain 250 Galleries of 20 foot broad apiece, it would contain four hundred millions of the said Books: so there must be to contain the rest no less than 96945092 such Libraries; and if the Books were extended over the surface of the

the Globe of the Earth, it would be a decuple covering unto it, a thing seeming most incredible, that 24 Letters in their transmutation should produce such a prodigious number, yet most certain and infallible in computation.

Of a Servant hired upon certain conditions.

A Servant said unto his Master, that he would dwell with him all his life-time, if he would but only lend him land to sow one grain of Corn with all his increase for 8 years time; how think you of this bargain? For if he had but a quarter of an inch of ground for each grain, and each grain to bring forth yearly an increase of 40 grains the whole sum would amount unto, at the term aforesaid, 6553600000000 grains: and seeing that 3 thousand and 6 hundred millions of inches do but make one mile square in the superficies, it shall be able to receive 14 thousand and 4 hundred millions of grains, which is 14400000000, thus dividing the aforesaid 6553600000000, the Quotient will be 455, and so many square miles of land must there be to sow the increase of one grain of Corn for 8 years, which makes at the least 420000 Acres of Land, which rated but at five shillings the Acre *per Annum*, amounts unto 100000 pound; which is 12500 pound a year, to be continued for 8 years: a pretty pay for a Masters Servant 8 years service.

PRO-

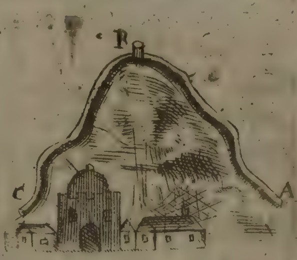
PROBLEM LXXXV.

Of Fountains, Hydriatiques, Machineck, and other Experiments upon Water or other Liquor.

1.

First how to make Water at the Foot of a Mountain to aſcend to the Top of it, and ſo to deſcend on the other ſide.

TO do this there muſt be a Pipe of Lead, which may come from the Fountain *A*, to the top of the Mountain *B*; and ſo to deſcend on the other ſide, a little lower than the Fountain, as at *C*, then make a hole in the Pipe, at the top of the Mountain, as at *B*, and ſtop the end of the Pipe at *A* and *C*; and fill this Pipe at *B* with Water, and cloſe it very carefully again at *B*, that no Air get in: then unſtop the end at *A*, and at *C*; then will the Water perpetually run up the Hill, and deſcend on the other ſide, which is an invention of great conſequence to furniſh Villages that want Water.



2. *Secondly,*

2.

Secondly, How to know what Wine or other Liquor there is in a Veſſel, without opening the Bung-hole, and without making any other hole than that by which it runs out at the top.

IN this Problem there is nothing but to take a bowed Pipe of Glaſs, and put it into the faucets hole, and ſtopping it cloſe about: for then you ſhall ſee the Wine or Liquor to aſcend in this Pipe, until it be juſt even with the Liquor in the Veſſel: by which a man may fill the Veſſel, or put more into it: and ſo if need were, one may empty one Veſſel into another, without opening the Bung-hole.

3.

Thirdly, How is it that it is ſaid that a Veſſel holds more Water, being placed at the foot of a Mountain, than ſtanding upon the top of it?

THis is a thing moſt certain, becauſe that water and all other Liquor diſpoſeth it ſelf ſpherically about the Centre of the Earth; and by how much the Veſſel is nearer the Centre, by ſo much the more the ſurface of the Water makes a leſſer ſphere, and therefore every part more *gibbous* or ſwelling than the like part in a greater

ſphere:

ſphere: and therefore when the ſame Veſſel is farther from the Centre of the Earth, the ſurface of the water makes a greater ſphere, and therefore leſs *gibbous* or ſwelling over the Veſſel: from whence it is evident that a Veſſel near the Centre of the Earth holds more Water than that which is farther remote from it; and ſo conſequently a Veſſel placed at the bottom of the Mountain holds more Water, than being placed on the top of the Mountain.

First, Therefore one may conclude, that one and the ſame Veſſel will always hold more, by how much it is nearer the Centre of the Earth.

Secondly, If a Veſſel be very near the Centre of the Earth, there will be more Water above the brims of it, than there is within the Veſſel.

Thirdly, a Veſſel full of Water coming to the Centre will ſpherically increaſe, and by little and little leave the Veſſel; and paſſing the Centre, the Veſſel will be all emptied.

Fourthly, One cannot carry a Pail of Water from a low place to a higher, but it will more and more run out and over; becauſe that in aſcending it lies more level, but deſcending it ſwells, and becomes more *gibbous*.

4. *Fourthly*,

4.

Fourthly, To conduct Water from the top of one Mountain, to the top of another.

AS admit on the top of a Mountain there is a Spring, and at the top of the other Mountain there are Inhabitants which want Water: Now to make a Bridge from one Mountain to another, were difficult, and too great a charge; by way of Pipes it is easie, and of no great price: for if at the Spring on the top of the Mountain be placed a Pipe to descend into the Valley, and ascend to the other Mountain, the Water will run naturally, and continually, provided that the Spring be somewhat higher than the passage of the Water at the Inhabitants.

5.

Fifthly, Of a fine Fountain which spouts Water very high, and with great violence, by turning of a Cock.

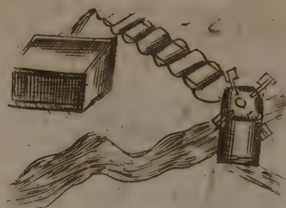
LEt there be a Vessel as *A B*, made close in all his parts, in the middle of which let *C D* be a Pipe open at *D* near the bottom, and then with a Squirt squirt in the Water at *C*, stopped above by the Cock or Faucet *C*, with as great violence as possible you can; and turn the Cock imme-

immediately. Now there being an indifferent quantity of Water and Air in the Veſſel, the Water keeps it ſelf in the bottom, and the Air which was greatly preſſed, ſeeks for more place, that turning the Cock, the Water iſſueth forth at the Pipe, and flies very high, and that eſpecially if the Veſſel be a little heated. Some make uſe of this for an Ewer to waſh hands withall, and therefore putting a moveable Pipe above C, ſuch as the Figure ſheweth: which the Water will cauſe to turn very quick, pleaſurable to behold.

6.

Sixthly, Of Archimedes'*s Screw, which makes Water aſcend by deſcending.*

THis is nothing elſe but a Cylinder, about the which is a Pipe in form of a Screw, and when one turns it, the Water deſcends always in reſpect of the Pipe: for it paſſeth from one part which is higher to that which is lower, and at the end of the Engine the Water is found higher than it was at the Spring. This great Engineer, admirable in all Mathematical Arts, invented this Inſtrument to waſh King *Hieroies*



great Veſſels,as ſome Authors ſay, alſo to water the fields of *Egypt*, as *Diodorus* witneſſeth: and *Cardanus* reporteth that a Citizen of *Milan* having made the like Engine, thinking himſelf to be the firſt Inventer, conceived ſuch exceeding joy, that he became mad, *Fol.* 2.

Again, A thing may aſcend by deſcending, if a ſpiral Line be made, having many circulations or revolutions; the laſt being always leſſer than the firſt, yet higher than the Plain ſuppoſed: It is moſt certain that then putting a Ball into it, and turning the ſpiral Line ſo, that the firſt circulation may be perpendicular, or touch always the ſuppoſed Plain, the Ball ſhall in deſcending continually aſcend, until at laſt it come to the higheſt part of the ſpiral Line, and ſo fall out. And here eſpecially may be noted, That a moving Body, as Water, or a Bullet, or ſuch-like, will never aſcend, if the Helical Revolution of the Screw be not inclining to the Horizon: ſo that according to this Inclination the Ball or Liquor may deſcend always by a continual motion and revolution. And this Experiment may be more uſeful naturally made with a Thread of Iron or Latine, turned or bowed Helically about a Cylinder, with ſome diſtinction of diſtances between the *Helices*, for then having drawn out the Cylinder, or having hung or tied ſome weight at it, in ſuch

ſort

ſort that the Water may eaſily drop if one lift up the ſaid Thread: theſe *Helices* or Revolutions notwithſtanding will remain inclining to the Horizon, and then turning it about forward, the ſaid weight will aſcend; but backward, it will deſcend. Now if the Revolutions be alike, and of equality amongſt themſelves, and the whirling or turning motion be quick, the ſight will be ſo deceived, that producing the action it will ſeem to the ignorant no leſs than a Miracle.

7.

Seventhly, Of another fine Fountain of Pleaſure.

THis is an Engine which hath two Wheels with Cogges or Teeth, as *A B*, which are placed within an Oval *C D*, in ſuch ſort, that the Teeth of the one may enter into the Notches of the other; but ſo juſt, that neither Air nor Water may enter into the Oval Coffer, either by the middle, or by the ſides, for the Wheel muſt joyn ſo near to the ſides of the Coffer, that there be no vacuity: To this there is an Axletree with a handle to each Wheel, ſo that they may be turned, and *A* being turned, that turneth the other Wheel that is oppoſite: by which motion the air that is in *E*, and the water that is carried by

the hollow of the Wheels of each ſide, by continual motion, is conſtrained to mount and flie out by the Funnel F. Now to make the Water run what way one would have it, there may be applied upon the top of the Pipe F, two other moveable Pipes inſerted one within another; as the Figure ſheweth. But here note that there may acrue ſome inconveniency in this Machine, ſeeing that by quick turning the Cogs or Teeth of the Wheels running one againſt another, may near break them, and ſo give way to the Air to enter in, which being violently incloſed will eſcape to occupy the place of the Water, whoſe weight makes it ſo quick: howſoever, if this Machine be curiouſly made as an able Workman may eaſily do, it is a moſt ſoveraign Engine, to caſt Water high and far off for to quench fires. And to have it to rain to a place aſſigned, accommodate a Socket having a Pipe at the middle, which may point towards the place, being ſet at the top thereof, and ſo having great diſcretion in turning the Axis of the Wheel, it may work exceeding well, and continue long.

8.

Eightly, Of a fine Watering-Pot for Gardens.

THis may be made in form of a Bottle, according to the laſt figure, or ſuch-like, having at the bottom many ſmall holes, and at the neck of it another hole ſomewhat greater than thoſe

those at the bottom, which hole at the top you must unstop when you would fill this Watering-Pot, for then it is nothing but putting the lower end into a Pail of Water; for so it will fill it self by degrees: and being full, put your Thumb on the hole at the Neck to stop it, for then may you carry it from place to place, and it will not sensibly run out; something it will, and all in time, (if it were never so close stopped) contrary to the ancient Tenet in Philosphy, That Air will not penetrate.

9.

Ninthly, How easily to take Wine out of a Vessel at the Bung-hole, without piercing of a hole in the Vessel.

IN this there is no need but to have a Cane or Pipe of Glass, or such-like, one of the ends of which may be closed up almost, leaving some small hole at the end; for then if that end be set into the Vessel at the Bung-hole, the whole Cane or Pipe will be filled by little and little; and once being full, stop the other end which is without, and then pull out the Cane or Pipe, so will it be full of Wine, then opening a little the top above, you may fill a Glass or other

Pot with it, for as the Wine issueth out, the air cometh into the Cane or Pipe, to supply vacuity,

 10. *Tenthly,*

10.

Tenthly, How to measure irregular Bodies by help of Water.

SOme throw in the Body or Magnitude into a Vessel, and keep that which floweth out over, saying it is always equal to the thing cast into the Water: But it is more neater this way, to pour into a Vessel such a quantity of Water, which may be thought sufficient to cover the Body or Magnitude, and make a mark how high the Water is in the Vessel, then pour out all this Water into another Vessel, and let the Body or Magnitude be placed into the first Vessel; then pour in Water from the second Vessel until it ascend unto the former mark made in the first Vessel, so the Water which remains in the second Vessel, is equal to the Body or Magnitude put into the Water: But here note that this is not exact or free from error, yet nearer the Truth than any Geometrician can otherwise possibly measure; and these Bodies that are not so full of pores, are more truly measured this way, than others are.

11.

To find the Weight of Water.

SEeing that $\frac{574}{1000}$ part of an ounce weight, makes a Cubical Inch of Water, and every pound weight *Haverdupoiz* makes 27 Cubical

Inches

Inches, and $\frac{9}{10}$ *fere*, and that 7 Gallons and a half Wine-meaſure makes a foot Cubical, it is eaſie by inverſion, that knowing the quantity of a Veſſel in Gallons to find his content in Cubical feet or weight: and that late famous Geometrician Maſter *Brigs* found a Cubical Foot of Water to weigh near 62 pound weight *Haverdupoiz.* But the late Learned *Simon Stevin* found a Cubical Foot of Water to weigh 65 pound; which difference may ariſe from the inequality of Water; for ſome Waters are more ponderous than others; and ſome difference may be from the weight of a pound, and the meaſure of a Foot. Thus the weight and quantity of a ſolid foot ſetled, it is eaſie for Arithmeticians to give the contents of Veſſels or Bodies which contain Liquids.

12.

To find the Charge that a Veſſel may carry, as Ships, Boats, or ſuch-like.

THis is generally conceived, that a Veſſel may carry as much weight as that Water weigheth which is equal unto the Veſſel in bigneſs, in abating only the weight of the Veſſel: We ſee that a Barrel of Wine or Water caſt into the Water, will not ſink to the bottom, but ſwim eaſily; and if a Ship had not Iron and other ponderoſities in it, it might ſwim full of Water without ſinking: In the ſame manner if the Veſſel were loaden with Lead, ſo much ſhould the Water weigh: Hence it is that Mariners call Ships of 50000 Tuns, becauſe they may contain one or 2000 Tun, and ſo conſequently carry as much.

13.

How comes it that a Ship having ſafely ſailed in the vaſt Ocean, and being come into the Port or Harbour, without any tempeſt will ſink down right?

THe cauſe of this is, That a Veſſel may carry more upon ſome kind of Water than upon other; now the Water of the Sea is thicker and heavier than that of Rivers, Wells, or Fountains; therefore the loading of a Veſſel which is accounted ſufficient in the Sea, becomes too great in the Harbour; or Sweet Water. Now ſome think that it is the depth of the Water that makes Veſſels more eaſie to ſwim, but it is an abuſe: for if the loading of a Ship be no heavier than the Water that would occupy that place, the Ship ſhould as eaſily ſwim upon that Water, as if it did ſwim upon a thouſand fathom deep of Water; and if the Water be no thicker than a leaf of Paper, and weigheth but an ounce under a heavy body, it will ſupport it, as well as if the Water under it weighed ten thouſand pound weight: Hence it is, if there be a Veſſel capable of a little more than a thouſand pound weight of Water, you may put into this Veſſel a piece of Wood which ſhall weigh a thouſand pound weight; (but lighter in his kind than the like magnitude of Water)

for

for then pouring in but a quart of Water, or a very little quantity of Water, the Wood will ſwim on the top of it, (provided that the Wood touch not the ſides of the Veſſel) which is a fine Experiment, and ſeems admirable in the performance.

14.

How a groſs Body of Metal may ſwim upon the Water.

THis is done by extending the Metal into a thin Plate, to make it hollow in form of a Veſſel; ſo that the greatneſs of the Veſſel which the air with it containeth, be equal to the magnitude of the Water, which weighs as much as it, for all Bodies may ſwim without ſinking, if they occupy the place of Water equal in weight unto them, as if it weighed 12 pound, it muſt have the place of 12 pound of Water: Hence it is that we ſee floating upon the Water great Veſſels of Copper or Braſs, when they are hollow in form of a Caldron. And how can it be otherwiſe conceived of Iſlands in the Sea, that ſwim and float? Is it not that they are hollow and ſome part like unto a Boat, or that their Earth is very light and ſpongeous, or having many Concavities in the Body of it, or much Wood within it.

And it would be a pretty propoſition to ſhew how much every kind of Metal ſhould be inlarged to make it ſwim upon the Water: which

which doth depend upon the proportion that is between the weight of the Water and each Metal. Now the proportion that is between Metals and Water of equal magnitude, according to ſome Authors, is as followeth:

A magnitude of 10 pound weight of Water will require for the like magnitude of	*GOLD*	$187\frac{1}{2}$
	LEAD	$116\frac{1}{2}$
	SILVER	104
	COPPER	91
	IRON	81
	TINNE	75

From which is inferred, That to make a piece of Copper of 10 pound weight to ſwim, it muſt be made ſo hollow that it may hold 9 times that weight of Water, and ſomewhat more, that is to ſay 91 pound: Seeing that Copper and VVater of like magnitudes in their ponderoſities, are as before, as 10 to 91.

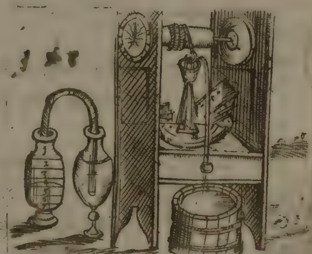
15.

How to weigh the lightneſs of the Air.

PLace a Ballance of wood turned upſide down into the water, that ſo it may ſwim, then let water be incloſed within ſome body, as within a Bladder or ſuch-like, and ſuppoſe that ſuch a quantity of Air ſhould weigh one pound, place it under one of the Ballances, and place under the other as much weight of lightneſs as may counter-ballance and keep the other Ballance that

it

it riſe not out of the water: by which you ſhall ſee how much the lightneſs is.



But without any Ballance do this: Take a Cubical hollow Veſſel, or that which is Cylindrical, which may ſwim on the water, and as it ſinketh by placing of weights upon it, mark how much; for then if you would examine the weight of any body, you have nothing to do but to put it into this Veſſel, and mark how deep it ſinks: for ſo many pound it weighs as the weights put in do make it ſo to ſink.

16.

A Body being given, to mark it about, and ſhew how much of it will ſink in the Water, or ſwim above the Water.

THis is done by knowing the weight of the Body which is given, and the quantity of Water, which weighs as much as that body; for then certainly it will ſink ſo deep, until it occupieth the place of that quantity of Water.

17.

To find how much ſeveral Metals or other Bodies do weigh leſs in the Water than in the Air.

TAke a Ballance, and weigh (as for example) 9 pound of Gold, Silver, Lead, or Stone, in the Air, ſo it hang in *æquilibrio*; then coming to the Water, take the ſame quantity of Gold, Silver, Lead or Stone, and let it ſoftly down into it, and you ſhall ſee that you ſhall need a leſs Counterpoiſe in the other Ballance to counter-ballance it: Wherefore all Solids or Bodies weigh leſs in the Water than in the Air, aud ſo much the leſs it will be, by how much the Water is groſs and thick becauſe the weight finds a greater reſiſtance, and therefore the Water ſupports more than Air; and further, becauſe the Water by the ponderoſity is diſpleaſed, and ſo ſtrives to be there again, preſſing to it, by reaſon of the other Waters that are about it, according to the proportion of his weight. *Archimedes* demonſtrateth, that all Bodies weigh leſs in the VVater (or in like Liquor) by how much they occupy place: and if the VVater weigh a pound weight, the magnitude in the VVater ſhall weigh a pound leſs than in the Air.

Now by knowing the proportion of Water and Metals, it is found that Gold loſeth in the Water the 19 part of his weight, Copper the 9 part, Quickſilver the 15 part, Lead the 12 part, Silver the 10 part, Iron the 8 part, Tin the 7 part and

and a little more: wherefore in material and absolute weight, Gold in respect of the Water that it occupieth weigheth 18 and $\frac{3}{4}$ times heavier than the like quantity of Water, that is, as $18\frac{3}{4}$ to the Quicksilver 15 times, Lead 11 and $\frac{1}{5}$, Silver 10 and $\frac{2}{3}$, Copper 9 and $\frac{1}{10}$, Iron 8 and $\frac{1}{2}$, and Tin 8 and $\frac{1}{3}$. Contrarily in respect of greatness, if the Water be as heavy as the Gold, then is the Water almost 19 times greater than the magnitude of the Gold, and so you may judge of the rest.

18.

How is it that a Ballance having like weight in each Scale, and hanging in æquilibrio *in the Air, being placed in another place, (without removing any weight) it shall cease to hang* in æquilibrio *sensibly, yea by a great difference of weight?*

THis is easie to be resolved by considering different Metals, which though they weigh equal in the Air, yet in the Water there will be an apparent difference; as suppose so that in the Scale of each Ballance be placed eighteen pound weight of several Metals, the one Gold, and the other Copper, which being *in æquilibrio* in the Air, placed in the Water will not hang so, because that the Gold loseth near the eighteenth part of his weight, which is about one pound, and the Copper loseth but his ninth part, which is two pound: wherefore the Gold in the water

water weigheth but 17 pound, and the Copper 16 pound, which is a difference moſt ſenſible to confirm that point.

19.

To ſhew what Waters are heavier one than another, and how much.

PHyſicians have an eſpecial reſpect unto this, judging that water which is lighteſt is moſt healthful and medicinal for the Body, and Seamen know that the heavieſt waters do bear moſt. And it is known which water is heavieſt thus: Take a piece of Wax, and faſten Lead unto it, or ſome ſuch-like thing, that it may but preciſely ſwim, for then it is equal to the like magnitude of water, then put it into another Veſſel which hath contrary water, and if it ſink, then is that water lighter than the other: But if it ſink not ſo deep, then it argueth the water to be heavier or more groſſer than the firſt water; or one may take a piece of Wood, and mark the quantity of ſinking of it into ſeveral waters, by which you may judge which is lighteſt or heavieſt, for in that which it ſinks moſt, that is infallibly the lighteſt, and ſo contrarily.

20. *How*

20.

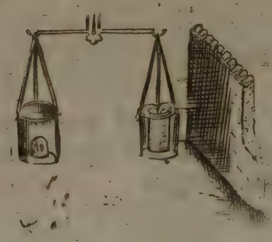
How to make a pound of Water weigh as much as 10, 20, 30, or 100 pound of Lead; nay as much as 1000 or 10000 pound weight.

THis Propoſition ſeems very impoſſible, yet Water incloſed in a Veſſel, being conſtrained to dilate it ſelf, doth weigh ſo much as though there were in the concavity of it a ſolid body of Water.

There are many ways to experiment this Propoſition, but to verifie it, it may be ſufficient to produce two excellent ones onely: which had they not been really acted, little credit might have been given unto it.

The firſt way is thus: Take a Magnitude which takes up as much place as 100 or 1000 pound of Water, and ſuppoſe that it were tied to ſomething that it may hang in the Air; then make a Ballance that one of the Scales may inviron it, yet ſo that it touch not the ſides of it, but leave ſpace enough for one pound of Water: Then having placed 100 pound weight in the other Scale, throw in the Water about the Magnitude, ſo that one pound of Water ſhall weigh down the 100 pound in the other Ballance.

The ſecond way is yet more admirable: Take a common Ballance that is capable to receive 10 or 20 pound of Water, then put into it a magnitude which may take up the place of 9 or 19 pound of



of water, which must be hung at some Iron or beam which is placed in a wall; so that it hang quiet: (now it is not material whether the magnitude be hollow or massie) so that it touch not the Balance in which it is put, for then having put the Lead or Weight into the other Ballance, pour in a pound of Water into the Ballance where the Magnitude is, and you shall see that this one pound of Water shall counterpoise the 10 or 20 pound of Lead which is set in the other Ballance.

PROBLEM LXXXVI.

Of sundry Questions in ARITHMETICK.

And first of the Number of Sands.

IT may be said incontinent, that to undertake this were impossible, either to number the Sands of *Lybia*, or the Sands of the Sea; and it was this that the Poets sung, and that vvhich the Vulgar believes; nay, that vvhich long ago certain Philosophers to *Gelon* King of *Sicily* reported, that the grains of Sand vvere innumerable. But I ansvver vvith *Archimedes*, that not onely

one-

one may number those which are at the border, and about the Sea, but those which are able to fill the whole world, if there were nothing else but Sand, and the grains of Sands admitted to be so small, that 10 may make but one grain of Poppy: for at the end of the account there need not to express them but this number 30840979456, and 35 Cyphers at the end of it. *Clavius* and *Archimedes* make it somewhat more, because they make a greater Firmament than *Ticho Brahe* doth; and if they augment the Universe, it is easie for us to augment the number, and declare assuredly how many grains of Sand there are requisite to fill another World, in comparison that our visible World were but as one grain of Sand, an atom, or a point; for there is nothing to do but to multiply the number by it self, which will amount to 90 places, whereof twenty are these: 95143798134910955936, and 70 Cyphers at the end of it, which amounts to a most prodigious number, and is easily supputated: for supposing that a grain of Poppy doth contain 10 grains of Sand, there is nothing but to compare that little bowl of a grain of Poppy, with a bowl of an inch or of a foot, and that to be compared with that of the Earth, and then that of the Earth with that of the Firmament, and so of the rest.

2.

Divers Metals being melted together in one body, to find the mixture of them.

THis was a notable Invention of *Archimedes*, related by *Vitruvius* in his Architecture, where he reporteth that the Goldſmith which King *Hiero* imployed for the making of the Golden Crown which was to be dedicated to the Gods, had ſtolen part of it, and mixed Silver in the place of it: The King ſuſpicious of the work propoſed it to *Archimedes*, if by Art he could diſcover without breaking of the Crown, if there had been made mixture of any other Metal with the Gold. The way which he found out was by bathing himſelf; for as he entred into the Veſſel of Water (in which he bathed himſelf) ſo the Water aſcended or flew out over it; and as he pulled out his Body, the Water deſcended: from which he gathered that if a Bowl of pure Gold, Silver, or other Metal, were caſt into a Veſſel of Water, the Water proportionally, according to the thing caſt in, would aſcend; and ſo by way of Arithmetick the Queſtion lay open to be reſolved: who being ſo intenſively taken with the invention, leaps out of the Bath all naked, crying as a man tranſported, *I have found*, *I have found*, and ſo diſcovered it.

Now ſome ſay that he took two Maſſes, the one of pure Gold, and the other of pure Silver; each equal to the weight of the Crown, and therefore unequal in magnitude or greatneſs; and then knowing

knowing the ſeveral quantities of water which was anſwerable to the Crown, and the ſeveral Maſſes, he ſubtilly collected, that if the Crown occupied more place within the water than the Maſs of Gold did, it appeared that there was Silver or other Metal melted with it. Now by the Rule of Poſition, Suppoſe that each of the three Maſſes weighed 18 pound apiece, and that the Maſs of Gold did occupy the place of one pound of water, that of Silver a pound and a half, and the Crown one pound and a quarter onely: Then thus he might operate: The Maſs of Silver which weighed 18 pounds, caſt into the Water, did caſt out half a pound of water more than the Maſs of Gold which weighed 18 pound; and the Crown which weighed alſo 18 pound, being put into a Veſſel full of water, threw out more water than the Maſs of Gold by a quarter of a pound, (becauſe of mixt Metal which was in it) therefore by the Rule of Proportion, If half a pound of water (the Exceſs) be anſwerable to 18 pound of Silver, one quarter of a pound of Exceſs ſhall be anſwerable to 9 pound of Silver, and ſo much was mixed in the Crown.

Some judge the way to be more facil by weighing the Crown firſt in the air, then in the water; in the air it weighed 18 pound, and if it were pure Gold, in the water it would weigh but 17 pound; if it were Copper it would weigh but 16 pound; but becauſe we will ſuppoſe that Gold and Copper is mixed together, it will weigh leſs than 17 pound, yet more than 16 pound, and that according to the proportion mixed: let it then be ſupposed that it weighed in the water 16 pound and 3 quarters, then might one say by proportion, If the difference of one pound of loss (which is between 16 and 17) be answerable to 18 pound, to what shall one quarter of difference be answerable to, which is between 17 and $16\frac{3}{4}$, and it will be 4 pound and a half, and so much Copper was mixed with the Gold.

Many men have delivered sundry ways to resolve this proposition, since *Archimedes* invention, and it were tedious to relate the diversities.

Baptista Benedictus, amongst his Arithmetical *Theorems*, delivers his way thus: if a Mass of Gold of equal bigness to the Crown, did weigh 20 pound, and another of Silver, at a capacity or bigness at pleasure, as suppose did weigh 12 pound, the Crown or the mixt body would weigh more than the Silver, and lesser than the Gold: Suppose it weighed 16 pound, which is 4 pound less than the Gold by 8 pound; then one may say, If 8 pound of difference come from 12 pound of Silver, from whence comes 4 pound, which wlll be 6 pound, and so much Silver was mixed in it, &c.

3. *Three*

3.

Three men bought a quantity of Wine, each paid alike, and each was to have alike, ; it happened at the last partition that there were 21 Barrels, of which 7 were full, 7 were half full, and 7 empty, how must they share the Wine and Vessels, that each have as many Vessels one as another, and as much Wine one as another ?

THis may be anſwered two ways as followeth, and theſe numbers, 2, 2, 3, or 3, 3, 1, may ſerve for direction, and ſignifies that the firſt perſon ought to have 3 Barrels full and as many empty ones, and one which is half full ; ſo he ſhall have 7 Veſſels, and 3 Barrels and an half of Liquor ; and one of the other ſhall in like manner have as much , ſo there will remain for the third man 1 Barrel full, 5 which are half full, and 1 empty, and ſo every one ſhall have alike both in Veſſels and Wine. And generally to anſwer ſuch Queſtions, divide the number of Veſſels by the number of perſons, and if the Quotient be not an intire number, the Queſtion is impoſſible ; but when it is an intire number, there muſt be made as many parts as there are 3 perſons, ſeeing that each part is leſs than the half of the ſaid Quotient: as dividing 21 by 3 there comes 7 for the Quotient, which may be parted in theſe 3 parts, 2, 2, 3, or 3, 3, 1, each of which being leſs than half of 7.

4.

There is a Ladder which ſtands upright againſt a Wall of 10 foot high, the foot of it is pulled out 6 foot from the Wall upon the Pavement: How much hath the top of the Ladder deſcended?

THe anſwer is, 2 foot: for by *Pythagoras* Rule the ſquare of *D B*, the *Hypothenuſal* is equal to the ſquare of *D A* 6, and *A B* 10. Now if *D A* be 6 foot, and *A B* 10 foot, the ſquares are 36, and 100, which 36 taken from 100, reſts 64, whoſe root-quadrate is 8, ſo the foot of the Ladder being now at *D*, the top will be at *C*, two foot lower than it was when it was at *B*.

PROBLEM LXXXVII.

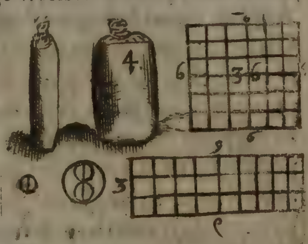
Witty Suits or Debates between Caius *and* Sempronius, *upon the form of Figures, which Geometricians call* Iſoperimeter, *or equal in circuit or compaſs.*

MArvel not at it, if I make the Mathematicks take place at the Bar, and if I ſet forth here *Bartoleus*, who witneſſeth of himſelf, that

that being then an ancient Doctor in the Law, he himself took upon him to learn the Elements and Principles of Geometry, by which he might set forth certain Laws touching the divisions of Fields, Waters, Islands, and other incident places: Now this shall be to shew in passing by, that these Sciences are profitable and behoveful for Judges, Counsellors, or such, to explain many things which fall out in Laws, to avoid ambiguities, contentions, and suits often.

The first Incident.

Caius had a Field which was directly square, having 24 measures in circuit, that was 6 on each side: *Sempronius* desiring to fit himself, prayed *Caius* to change with him for a field which should be equivalent unto his, and the bargain being concluded, he gave him for Counter-change a piece of Ground which had just as much in circuit as his had, but it was



not square, yet *Quadrangular* and *Rectangled*, having 9 measures in length for each of the two longest sides, and 5 in breadth for each shorter side: Now *Caius* which was not the most subtillest nor wisest in the world, accepted his bargain at the first, but afterwards having conferred with a Land-measurer and Mathematician, found that he was over-reached in his bargain, and that his Field contained 36 ſquare meaſures, and the other Field had but 27 meaſures, (a thing eaſie to be known by multiplying the length by the breadth) *Sempronius* conteſted with him in ſuit of Law, and argued that Figures which have equal *Perimeter*, or *Circuit*, are equal amongſt themſelves: My Field, ſaith he, hath equal circuit with yours, therefore it is equal unto it in quantity. Now this was ſufficient to delude a Judge which was ignorant in Geometrical Proportions, but a Mathematician will eaſily declare the deceit, being aſſured that figures which are *Iſoperemiter*, or equal in circuit, have not always equal capacity or quantity: ſeeing that with the ſame circuit there may be infinite figures made, which ſhall be more and more capable, by how much they have more Angles, equal ſides, and approach nearer unto a Circle, (which is the moſt capableſt Figure of all) becauſe that all his parts are extended one from another, and from the middle or centre as much as may be: ſo we ſee by an infallible Rule of Experience, that a Square is more capable of quantity, than a Triangle of the ſame circuit, and a Pentagone more than a Square, and ſo of others, ſo that they be regular Figures that have their ſides equal; otherwiſe there might be that a regular Triangle having 24 meaſures in circuit, might have more capacity than a rectangled Paralellogram, which had alſo 24 meaſures of circuit, as if it were 11 in length, and 1 in breadth, the circuit is ſtill 24, yet the quantity is but 11; and if it had 6 every way, it gives the ſame Peri-

Perimeter, *viz.* 24, but a quantity of 36, as before.

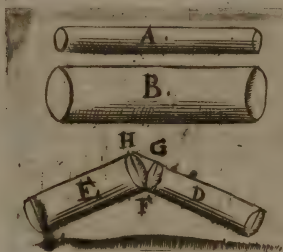
The Second Incident.

SEmpronius having borrowed of *Caius* a Sack of Corn, which was 6 foot high, and 2 foot broad, and when there was queſtion made to repay it, *Sempronius* gave *Caius* back two Sacks full of Corn which had each of them 6 foot high, and 1 foot broad: who believed that if the Sacks were full, he was repaid; and it ſeems to have an appearance of truth, barely looked on. But it is moſt evident in demonſtration, that the 2 Sacks of Corn paid by *Sempronius* to *Caius*, is but half of that one Sack which he lent him: for a Cylinder or Sack having one foot of diameter and 6 foot of length, is but the fourth part of another Cylinder, whoſe length is 6 foot, and his diameter is 2 foot: therefore two of the leſſer Cylinders or Sacks is but half of the greater; and ſo *Caius* was deceived in half his Corn.

The Third Incident.

SOme one from a common Fountain of a City hath a Pipe of Water of an inch diameter; to have it more commodious he hath leave to take as much more water; whereupon he gives order that a Pipe be made of two inches diameter. Now you will ſay preſently, that it is reaſon to be ſo big, to have juſt twice as much

much water as he had before: but if the Magiſtrate of the City underſtood Geometrical Proportions, he would ſoon cauſe it to be amended, and ſhew that he hath not onely taken twice as much water as he had before, but four times as much: for a circular hole which is two inches diameter, is four times greater than that of one inch, and therefore will caſt out four times as much water as that of one inch, and ſo the deceit is double alſo in this.



Moreover, if there were a heap of Corn of 20 foot every way, which was borrowed to be paid next year: the party having his Corn in heaps of 12 foot every way, and of 10 foot every way, proffers him 4 heaps of the greater, or 7 heaps of the leſſer, for his own heap of 20 every way, which was lent: Here it ſeems that the proffer is fair, nay with advantage, yet the loſs would be near 1000 foot. Infinite of ſuch cauſes do ariſe from Geometrical Figures, which are able to deceive a Judge or Magiſtrate, which is not ſomewhat ſeen in *Mathematical Documents.*

PRO-

PROBLEM LXXXVIII.

Containing sundry Questions in matter of Cosmography.

FIrst, It may be demanded where is the middle of the World? I speak not here Mathematically, but as the vulgar People, who ask, Where is the middle of the World? In this sence to speak absolutely there is no point which may be said to be the middle of the surface; for the middle of a Globe is every where: notwithstanding the Holy Scriptures speak respectively, and make mention of the middle of the Earth, and the Interpreters apply it to the City of *Jerusalem*, placed in the middle of *Palestina*, and the habitable world, that in effect taking a Map of the World, and placing one foot of the Compasses upon *Jerusalem*, and extending the other foot to the extremity of *Europe*, *Asia*, and *Africa*, you shall see that the City of *Jerusalem* is as a Centre to that Circle.

2.

How much is the depth of the Earth, the height of the Heavens, and the compass of the World?

FRom the surface of the Earth unto the Centre according to ancient traditions, is 3436 miles, so the whole thickness is 6872 miles, of which the

the whole compaſs or circuit of the Earth is 21600 miles.

From the Centre of the Earth to the Moon there is near 56 Semidiameters of the Earth, which is about 192416 miles: unto the Sun there is 1142 Semidiameters of the Earth, that is in miles 3924912; from the ſtarry firmament to the Centre of the Earth there is 14000 Semidiameters, that is, 48184000 miles, according to the opinion and obſervation of that learned *Ticho Brahe*.

From theſe meaſures one may collect by Arithmetical ſupputations, many pleaſant propoſitions in this manner:

Firſt, If you imagine there were a hole through the Earth, and that a Mill-ſtone ſhould be let fall down into this hole, and to move a mile in each minute of time, it would be more than two days and a half before it would come to the Centre, and being there it would hang in the Air.

Secondly, If a man ſhould go every day 20 miles, it would be three years wanting but a fortnight, before he could go once about the Earth; and if a Bird ſhould fly round about it in two days, then muſt the motion be 450 miles in an hour.

Thirdly, The Moon runs a greater compaſs each hour, than if in the ſame time ſhe ſhould run twice the Circumference of the whole Earth.

Fourthly, Admit it be ſuppoſed that one ſhould go twenty miles in aſcending towards the Heavens

vens every day, he ſhould be above fifteen years, before he could attain to the Orb of the Moon.

Fifthly, The Sun makes a greater way in one day than the Moon doth in 20 days, becauſe that the Orb of the Suns Circumference is at the leaſt twenty times greater than the Orb of the Moon.

Sixthly, If a Mill-ſtone ſhould deſcend from the place of the Sun a thouſand miles every hour; which is above 15 miles in a minute, far beyond the proportion of motion) it would be above 163 days before it would fall down to the Earth.

Seventhly, The Sun in his proper Sphere moves more than ſeven thouſand five hundred and ſeventy miles in one minute of time : now there is no Bullet of a Cannon, Arrow, Thunderbolt, or Tempeſt of Wind that moves with ſuch quickneſs.

Eighthly, It is of a far higher nature to conſider the exceeding and unmoveable quickneſs of the ſtarry firmament, for a Star being in the *Æquator*, (which is juſt between the Poles of the World) makes 12598666 miles in one hour, which is two hundred nine thouſand nine hundred and ſeventy four miles in one minute of time: and if a Horſeman ſhould ride every day 40 miles, he could not ride ſuch a compaſs in a Thouſand Years, as the Starry Firmament moves in one hour, which is more than if one ſhould move about the Earth a thouſand times in one hour, and quicker than poſſible thought

can

can be imagined: and if a Star ſhould fly in the Air about the Earth with ſuch a prodigious quickneſs, it would burn and conſume all the World here below. Behold therefore how time paſſeth, and death haſteth on: This made *Copernicus* not unadviſedly to attribute this motion of *Primum mobile* to the Earth, and not to the ſtarry Firmament; for it is beyond humane ſenſe to apprehend or conceive the rapture and violence of that motion, being quicker than thought; and the Word of God teſtifieth that the Lord made all things in *Number*, *Meaſure*, *Weight*, and *Time*.

PROBLEM XCII.

To find the Biſſextile-Year, the Dominical-Letter, and the Letters of the Month.

LEt 123, or 124, or 125, or 26, or 27, (which is the remainder of 1500, or 1600) be divided by 4, which is the number of the Leap-year, and that which remains of the diviſion ſhews the Leap-year; as if one remain, it ſhews that it is the firſt year ſince the Biſſextil or Leap year; if two, it is the ſecond year, &c. and if nothing remain, then it is the Biſſextile or Leap-year: and the Quotient ſhews you how many Biſſextiles or Leap-years, there are contained in ſo many years.

To

To find the Circle of the Sun by the Fingers.

LEt 123, 24, 25, 26, or 27, be divided by 28, (which is the Circle of the Sun, or whole revolution of the Dominical Letters) and that which remains is the number of Joynts which is to be accounted upon the Fingers, by *Filius esto Dei, cœlum bonus accipe gratis* : and where the number ends, that Finger ſheweth the year which is preſent, and the words of the Verſe ſhew the *Dominical Letter*.

Example.

DIvide 123 by 28 for the year (and ſo of other years) and the Quotient is 4, and there remaineth 11, for which you muſt account 11 words: *Filius eſto Dei, &c.* upon the Joynts, beginning from the firſt joynt of the *Index*, and you ſhall have the anſwer.

For the preſent to know the *Dominical Letter* for each month, account from *January* unto the month required, including *January*, and if there be 8, 9, 7, or 5, you muſt begin upon the end of the Finger from the Thumb, and account, *Adam degebat, &c.* as many words as there are months, for then one ſhall have the Letter which begins the month; then to know what day of the month it is, ſee how many times 7 is comprehended in the number of days, and take the reſt, ſuppoſe 4, account upon the firſt finger within and without by the joynts, unto the number of 4, which ends

at

at the end of the Finger: from whence it may be inferred that the day required was *Wednesday*, *Sunday* being attributed to the first Joynt of the first Finger or Index: and so you have the present year, the Dominical Letter, the Letter which begins the Month, and all the days of the Month.

PROBLEM XCIII.

To find the New and Full Moon in each Month.

ADd to the Epact for the year the Month from *March*, then subtract that surpluss from 30, and the rest is the day of the Month that it will be New Moon, and adding unto it 14, you shall have that Full Moon.

Note.

THat the Epact is made always by adding 11 unto 30, and if it pass 30, subtract 30, and adde 11 to the remainder, and so *ad infinitum*: as if the Epact were 12, add 11 to it, makes 23 for the Epact next year, to which add 11 makes 34, subtract 30, rests 4 the Epact for the year after; and 15 for the year following that, and 26 for the next, and 7 for the next, *&c.*

PRO-

PROBLEM XCIV.

To find the Latitude of a Countrey.

THose that dwell between the North-Pole and the *Tropick* of *Cancer*, have their Spring and Summer between the 10 of *March* and the 13 of *September*: and therefore in any day between that time, get the Suns distance by instrumental observation from the Zenith at noon, and add the declination of the Sun for that day to it: So the Aggregate sheweth such is the latitude or Poles height of that Countrey. Now the declination of the Sun for any day is found out by Tables calculated to that end: or Mechanically by the Globe, or by Instrument it may be indifferently had. And here note, that if the day be between the 13 of *September* and the 10 of *March*, then the Suns declination for that day must be taken out of the distance of the Sun from the Zenith at noon: so shall you have the Latitude, as before.

PROBLEM XCV.

Of the Climates of Countreys, and to find what Climate any Countrey is under.

CLimates as they are taken Geographically signifie nothing else but when the length of the ngest day of any place, is half an hour longer or ſhorter than it is in another place, (and ſo of the ſhorteſt day) and this account to begin from the Equinoctial Circle, ſeeing all Countreys under it have the ſhorteſt and longeſt day that can be but 12 hours; But all other Countreys that are from the Equinoctial Circle either towards the North or South of it unto the Poles themſelves, are ſaid to be in ſome one Climate or other; from the Equinoctial to either of the Poles Circles, (which are in the Latitude of 66 deg. 30 min.) between each of which Polar Circles and the Equinoctial Circle there is accounted 24 Climates, which differ one from another by half an hours time: then from each Polar Circle to each Pole there are reckoned 6 other Climates which differ one from another by a months time: ſo the whole Earth is divided into 60 Climates, 30 being allotted to the Northern Hemiſphere, and 30 to the Southern Hemiſphere. And here note, that though theſe Climats which are between the Equinoctial and the Polar Circles are equal one unto the other in reſpect of time, to wit, by half an hour; yet the Latitude, breadth, or internal, contained between Climate and Climate, is not equal: and by how much any Climate is farther from the Equinoctial than another Climate, by ſo much the leſſer is the internal between that Climate and the next: ſo thoſe that are neareſt the Equinoctial are largeſt, and thoſe which are fartheſt off moſt contracted: and to find what Climate any Country is under, ſubtract the length of an Equinoctial day, to wit, 12 hours, from the length of the longeſt day of that Countrey, the

remain-

remainder being doubled ſhews the Climate: So at *London* the longeſt day is near 16 hours and a half; 12 taken from it, there remains 4 hours and a half, which doubled makes 9 half hours, that is, 9 Climates; ſo *London* is in the 9 Climate.

PROBLEM XCVI.

Of Longitude and Latitude of the Earth, and of the Stars.

Longitude of a Countrey or place, is an Arck of the *Æquator* contained between the Meridian of the Azores, and the Meridian of the place, and the greateſt Longitude that can be is 360 degrees.

Note, That the firſt Meridian may be taken at pleaſure upon the Terreſtrial Globe or Map, for that ſome of the ancient Aſtronomers would have it at *Hercules* Pillars, which is at the ſtraights at *Gibraltar*: *Ptolomy* placed it at the *Canary Iſlands*, but now in theſe latter times it is held to be near the *Azores*. But why it was firſt placed by *Ptolomy* at the *Canary Iſlands*, was, becauſe that in his time theſe Iſlands were the fartheſt Weſtern parts of the World that was then diſcovered. And why it retains his place now at St. *Michaels* near the *Azores*, is that becauſe of many accurate obſervations made of late by many expert Navigators and Mathematicians, they have found the Needle there to have no variation, but to point North and South: that is, to each Pole of the

World: And why the Longitude from thence is accounted Eaſtward, is from the motion of the Sun Eaſtward, or that *Ptolomy* and others did hold it more convenient to begin from the Weſtern part of the World, and ſo account the Longitude Eaſtward from Country to Country that was then known, till they came to the Eaſtern part of *Aſia*, rather than to make a beginning upon that which was unknown: and having made up their account of reckoning the Longitude from the Weſtern part to the Eaſtern part of the world known, they ſuppoſed the reſt to be all Sea, which ſince their deaths hath been found almoſt to be another habitable World.

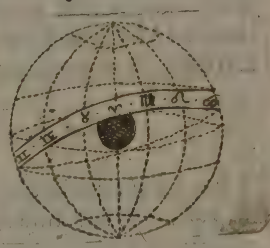
To find the Longitude of a Countrey.

IF it be upon the Globe, bring the Countrey to the Braſen Meridian, and whatſoever degree that Meridian cuts in the Equinoctial, that degree is the Longitude of that Place. If it be in a Map, then mark what Meridian paſſeth over it, ſo have you the Longitude thereof; if no Meridian paſs over it, then take a pair of Compaſſes, and meaſure the diſtance between the Place and the next Meridian, and apply it to the divided Parallel or *Æquator*, ſo have you the Longitude required.

Of the Latitude of Countreys.

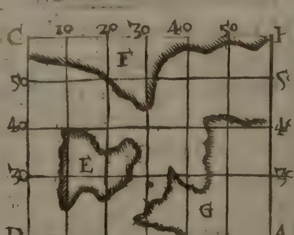
LAtitude of a Countrey is the diſtance of a Countrey from the Equinoctial, or it is an Ark of the Meridian contained between the Zenith of the place and the *Æquator*, which is twofold, *viz.* either North-Latitude, or South-Latitude,

tude, either of which extendeth from the Equinoctial to either Pole; ſo the greateſt Latitude that can be is but 90 degrees. If any Northern Countrey have the Artick Circle vertical, which is in the Latitude of 66 gr. 30 m. the Sun will touch the Horizon in the North part thereof, and the longeſt day will be there then 24 hours: If the Countrey have leſs Latitude than 66 gr 30 m. the Sun will riſe and ſet, but if it have more Latitude than 66 gr. 30 m. it will be viſible for many days. And if the Countrey be under the Pole, the Sun will make a circular motion above the Earth, and be viſible for half a year: ſo under the Pole there will be but one day and one night in the whole year.



To find the Latitude of Countreys.

IF it be upon a Globe, bring the place to the Braſen Meridian, and the number of degrees which meeteth therewith, is the Latitude of the place: Or with a pair of Compaſſes take the diſtance between the Countrey and the Equinoctial, which applied unto the Equi-



noctial will ſhew the Latitude of that Countrey, which is equal to the Poles height. If it be upon a Map, then mark what Parallel paſſeth over the Countrey, and where it croſſeth the Meridian, that ſhall be the Latitude: But if no Parallel paſſeth over it, then take the diſtance between the place and the next Parallel, which applied to the divided Meridian from that Parallel will ſhew the Latitude of that place.

To find the diſtance of places.

IF it be upon a Globe, then with a pair of *Compaſſes* take the diſtance between the two Places, and apply it to the divided Meridian or *Æquator*, and the number of degrees ſhall ſhew the diſtance, each degree being 60 miles. If it be in a Map (according to *Wright*'s projection) take the diſtance with a pair of Compaſſes between the two places, and apply this diſtance to the divided Meridian on the Map, right againſt the two places; ſo as many degrees ás is contained between the feet of the Compaſſes, ſo much is the diſtance between the two places. If the diſtance of two places be required in a particular Map, then with the Compaſſes take the diſtance between the two places, and apply it to the Scale of miles, ſo have you the diſtance: If the Scale be too ſhort, take the Scale between the Compaſſes, and apply that to the two places as often as you can, ſo have you the diſtance required.

Of

Of the Longitude, Latitude, Declination, and Distance of the Stars.

THe Declination of a Star is the neareſt diſtance of a Star from the *Æquator*; the Latitude of a Star is the neareſt diſtance of a Star from the *Ecliptick*: the Longitude of a Star is an Ark of the *Ecliptick* contained between the beginning of *Aries*, and the Circle of the Stars Latitude, which is a Circle drawn from the Pole of the *Ecliptick* unto the Star, and ſo to the *Ecliptick*. The diſtance between two Stars in Heaven is taken by a Croſs-Staff, or other Inſtrument; and upon a Globe it is done by taking between the feet of the Compaſſes the two Stars, and applying it to the *Æquator*, ſo have you the diſtance between thoſe two Stars.

How is it that two Horſes or other Creatures being foaled or brought forth into the World at one and the ſame time, that after certain days travel, the one lived more days than the other, notwithſtanding they died together in one and the ſame moment alſo?

THis is eaſie to be anſwered: Let one of them travel toward the Weſt, and the other towards the Eaſt: then that which goes towards the Weſt followeth the Sun, and therefore ſhall have the day ſomewhat longer than if there had been no travel made; and that which goes Eaſt, by going againſt the Sun ſhall have the day ſhorter, and ſo in reſpect of travel, though they die at one and the ſelf-ſame hour and moment of time, the one ſhall be older than the other.

From which conſideration may be inferred, That a *Chriſtian*, a *Jew*, and a *Saracen* may have their Sabbaths all upon one and the ſame day, though notwithſtanding the *Saracen* holds his Sabbath upon the *Friday*, the *Jew* upon the *Saturday*, and the *Chriſtian* upon the *Sunday*: For being all three reſident in one place, if the *Saracen* and the *Chriſtian* begin their travel upon the *Saturday*, the *Chriſtian* going Weſt, and the *Saracen* Eaſtwards, ſhall compaſs the Globe of the Earth; thus the *Chriſtian* at the concluſion ſhall gain a day, and the *Saracen* ſhall loſe a day, and ſo meet with the *Jew* every one upon his own Sabbath.

Certain fine Obſervations.

I. UNder the Equinoctial the Needle hangs in *æquilibrio*, but in theſe parts it inclines under the Horizon; and being under the Pole it is thought it will hang vertical.

II. In theſe Countreys which are without the Tropical Circles, the Sun comes Eaſt and Weſt every day for a half year; but being under the Equinoctial the Sun is never Eaſt nor Weſt, but twice in the year, to wit, the 10 of *March*, and the 13 of *September*.

III. If a Ship be in the Latitude of 23 gr. 30 m. that is, if it hath either of the Tropicks vertical; then at what time the Suns Altitude is equal to his diſtance from any of the Equinoctial points, then the Sun is due Eaſt or Weſt.

IV. If a Ship be between the Equinoctial and either of the Tropicks, the Sun will come twice to one point of the Compaſs in the fore-noon, that is in one and the ſame poſition.

V. Under the Equinoctial near *Guinea* there is but two ſorts of Winds all the year, 6 months a Northerly wind, and 6 months a Southerly wind, and the flux of the Sea is accordingly.

VI. If two Ships under the Equinoctial be 100 leagues aſunder, and ſhould ſail Northerly until they were come under the Artick Circle, they ſhould then be but 50 leagues aſunder.

VII. Thoſe which have the Artick circle vertical, when the Sun is in the Tropick of *Cancer*, the Sun ſetteth not, but toucheth the weſtern part of the Horizon.

VIII. If the complement of the Suns height at noon be found equal to the Suns Declination for that day, then the Equinoctial is vertical; or a Ship making ſuch an obſervation, the Equinoctial is in the Zenith, or direct over them, by which Navigators know when they croſs the Line, in their travels to the *Indies*, or other parts.

IX. The Sun being in the Equinoctial, the extremity of the Style in any Sun-Dyal upon a Plain maketh a right Line, otherwiſe it is *Ecliptical*, *Hyperbolical*, &c.

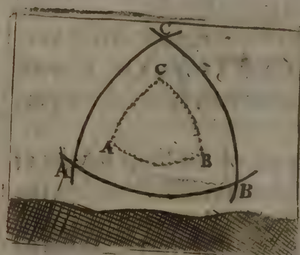
X. When the ſhadow of a man, or other thing upon a Horizontal Plain, is equal unto it in length then is the Sun in the middle point between the Horizon and the Zenith, that is 45 degrees high.

PRO-

PROBLEM XCVII.

To make a Triangle that shall have three right Angles.

OPen the Compasses at pleasure, and upon *A* describe an Ark *B C*, then at the same opening place one of the feet in B, and describe the Ark *A C.* Lastly, Place one of the feet of the Compasses in *C*, and describe the Ark *A B.* So shall you have the Spherical *Æquilateral Triangle ABC*, right angled at *A*, at B, and at *C*, that is, each angle comprehended 90 degrees: which can never be in any plain Triangle, whether it be *Æquilateral*, *Isocelse*, *Scaleve*, *Orthogonal*, or *Opigonal*.



PROBLEM XCVIII.

To divide a Line in as many equal parts as one will, without Compasses, or without seeing of it.

THis Proposition hath a fallacy in it, and cannot be practised but upon a *Maincordion*: for the Mathematical Line which proceeds from the flux of a point, cannot be divided in that wise: One

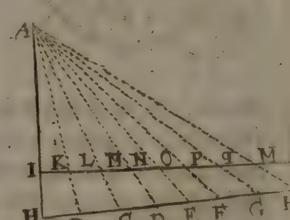
One may have therefore an Inſtrument which is called *Maincordion*, becauſe there is but one cord: and if you deſire to divide your line into 3 parts, run your finger upon the frets until you ſound a third in Muſick: If you would have the fourth part of the Line, then find the fourth ſound, a fifth, *&c.* ſo ſhall you have the anſwer.

PROBLEM XCIX.

To draw a Line which ſhall incline to another Line, yet never meet, againſt the Axiome of Parallels.

THis is done by help of a Conoeide line, produced by a right line upon one and the ſame plain, held in great account amongſt the Ancients, and it is drawn after this manner.

Draw a right line infinitely, and upon ſome end of it, as at *I*, draw a perpendicular Line *I A*, augment it to *H*, then from *A* draw Lines at pleaſure to interſect the Line *I M*, in each of which Lines from the right Line *IM*, transfer *IH*, *viz.* *KB*, *LC*, *OD*, *PE*, *QF*, *MG*,



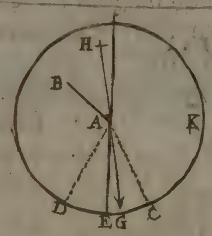
then from thoſe points draw the Line *HB*, *CD*, *E*, *F*, *G*, which will not meet with the Line *IM*, and yet incline nearer and nearer unto it.

PRO-

PROBLEM C.

To observe the variation of the Compasses, or Needle, in any places.

First describe a circle upon a plain, so that the Sun may shine on it both before noon and after noon; in the centre of which circle place a Gnomon or Wire perpendicular, as A B, and an hour before noon mark the extremity of the shadow of A B, which suppose it be at C, describe a circle at that semidiameter C D F; then after noon mark when the top of the shadow of A B toucheth the circle, which admit in D; divide the distance C D into two equal parts, which suppose at E, draw the line EAF, which is the Meridian Line, or Line of North and South: Now if the Ark of the circle C D be divided into degrees, place a Needle G H upon a plain set up in the centre, and mark how many degrees the point of the Needle G is from E, so much doth the Needle vary from the North in that place.



PROBLEM CI.

How to find at any time which way the Wind is in ones Chamber, without going abroad.

UPon the Planking or Floor of a Chamber, Parlor, or Hall where you intend to have this device, let there come down from the top of the Houſe a hollow Poſt, in which place an Iron Rod, that it aſcend above the Houſe ten or ſix foot with a Vane or Scouchen at it to ſhew the winds without: and at the lower end of this rod of iron, place a Dart which may by the moving of the Vane with the Wind without, turn this

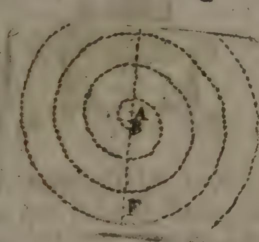
Dart which is within: about which upon the Plaiſter muſt be deſcribed a circle divided into the 32 points of the Mariners Compaſs, pointed and diſtinguiſhed to that end; then may it be marked by placing the Compaſs by it: for having noted the North point, the Eaſt, &c. it is eaſie to note all the reſt of the points: and ſo at any time coming into this room, you have nothing to do but to look up to the Dart, which will point you out what way the Wind bloweth at that inſtant.

PRO-

PROBLEM CII.

How to draw a Parallel Spherical Line with great ease.

FIrst draw an obscure line *G F*, in the middle of it make two points, A B, (which serves for Centres) then place one foot of the Compasses in B, and extend the other foot to A, and describe the Semicircle A C; then place one foot of the Compasses in A, and extend the other foot to C, and describe the Semicircle C D. Now place the Compasses in B, and extend the other foot unto D, and describe the Semicircle D E, and so *ad infinitum*; which being done neatly, that there be no right line seen, nor where the Compasses were placed, will seem very strange how possibly it could be drawn with such exactness, to such which are ignorant of that way.



PROBLEM CIII.

To measure an inaccessible distance, as the breadth of a River with the help of ones Hat onely.

THe way of this is easie: for having ones Hat upon his Head, come near to the Bank of the River, and holding your Head upright, which

(which may be by putting a ſmall ſtick to ſome one of your Buttons to prop up the Chin) pluck down the brim or edge of your Hat until you may but ſee the other ſide of the water, then turn about the body in the ſame poſture that it was before towards ſome Plain, and mark where the ſight by the brim of the Hat glaunceth on the ground; for the diſtance from that place to your ſtanding, is the breadth of the River required.

PROBLEM CIV.

How to meaſure a height with two Straws, or two ſmall Sticks.

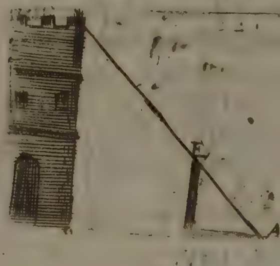
TAke two Straws or two Sticks, which are one as long as another, and place them at right Angles one to the other, as A B, and A C, then holding A B parallel to the ground, place the end A to the Eye at A, and looking to the other top B C at C, by going backward or forward until you may ſee the top of the Tower or Tree, which ſuppoſe at E. So the diſtance from your ſtanding to the Tower or Tree, is equal to the height thereof above the level of the Eye:

to which if you add your own height, you have the whole height.

Other-

Otherwise.

TAke an ordinary Square which Carpenters or other Workmen uſe, as H K L, and placing H to the Eye ſo that H K be level, go back, or come nearer, until that by it you may ſee the top M, for then the diſtance from you to the height, is equal to the height.



PROBLEM CV.

How to make Statues, Letters, Bowls, or other things which are placed in the ſide of a high Building, to be ſeen below of an equal bigneſs.

LEt *B C* be a Pillar 7 yards high, and let it be required that 3 yards above the level of the Eye *A*, *viz.* at *B.* be placed a Globe, and 9 yards above *B* be placed another, and 22 yards above that be placed another Globe: how much ſhall the Diameter of theſe *Globes* be, that at the Eye at *A*, they may all appear to be of one and the ſame magnitude? It is thus done: Firſt draw a

line,

line, as AK, and upon K erect a perpendicular, KX; divide this line into 27 parts, & according to AK, describe an Ark KY, then from K in the perpendicular KX account 3 parts, *viz.* at L, which shall represent the former 3 yards, and draw the line L A from L, in the said perpendicular reckon the diameter of the lesser Globe of what magnitude it is intended to be: Suppose S L, and draw the line S A, cutting the Ark U K, in N, then from K in the perpendicular account 9 yards, which admit at T, draw T A, cutting Y K in O, transfer the Ark M N, from A to P, and draw A P, which will cut the perpendicular in U, so a line drawn from the middle of U F, unto the visual Lines A I, and A U, shall be the diameter of the next Globe: Lastly, Account from K in the perpendicular X K 22 parts, and draw the line W A, cutting Y K in Q, then take the Ark M N, and transfer it from Q to R, and draw A R, which will cut the perpendicular in X, so the line which passeth by the middle of X W perpendicular to the visual line A W, and A X be the Diameter of the third Globe, to wit 5, 6, which measures transferred in the Pillar B C, which sheweth the true magnitude of the Globes 1, 2, 3. From this an Architector doth proportion his Images, and the foldings of the Robes which are most deformed at the Eye below in the making, yet most perfect when it is set in his true height above the Eye.

R PRO-

PROBLEM CVI.

How to disguise or disfigure an Image, as a Head, an Arm, a whole Body, &c. *so that it hath no proportion; the Ears to become long, the Nose as that of a Swan, the Mouth as a Coaches entrance,*&c. *yet the Eye placed at a certain point will be seen in a direct and exact proportion.*

I Will not strive to set a Geometrical Figure here,for fear it may seem too difficult to understand,but I will endeavour by discourse, how mechanically with a Candle you may perceive it sensible: first there must be made a figure upon Paper, such as you please, according to his just proportion, and paint it as a Picture (which Painters know well enough to do) afterwards put a Candle upon the Table, and interpose this figure obliquely, between the said Candle and the Books of Paper, where you desire to have the figure disguised in such sort that the height pass athwart the hole of the Picture, then will it carry all the form of the Picture upon the Paper,but with deformity; follow these tracts,and mark out the light with a coals black head or Ink,and you have your desire.

To find now the point where the eye must see it in his natural form: it is accustomed according to the order of Perspective,to place this point in the line drawn in height,equal to the largeness of the narrowest side of the deformed square, and it is by this way that it is performed.

PRO-

PROBLEM CVII.

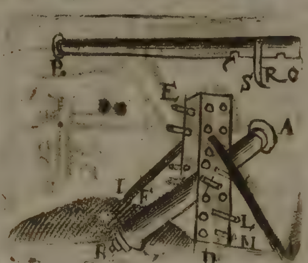
How a Cannon after that it hath shot, may be covered from the battery of the Enemy.

LEt the mouth of a Cannon be *I*, the Cannon *M*, his charge *N O*, the Wheel *L*, the Axletree *P B*, upon which the Cannon is placed, at which end towards *B*, is placed a Pillar *A E*, supported with Props, *D*, *C*, *E*, *F G*, about which the Axletree turneth: Now the Cannon being to shoot, it retires to *H*, which cannot be directly, because of the Axletree, but makes a segment of a circle, and hides himself behind the Wall *Q R*, and so preserves it self from the Enemies battery, by which means one may avoid many inconveniences which might arise: and moreover, one man may more easily replace it again for another shot, by help of Poles tied to the Wall, or other help which may multiply the strength.

PROBLEM CVIII.

How to make a Lever, by which one man may alone place a Cannon upon his Carriage, or raiſe what other weight he would.

FIrſt place two thick boards upright, as the figure ſheweth, pierced with holes, alike oppoſite one unto another, as CD and EF, and let L and M be the two Bars of Iron which paſs through the holes, GH and FK the 2 ſupports, or props, AB the Cannon, OP the Lever, RS the two Notches in the Lever, and Q the Hook which the Burthen or Cannon is tied to. The reſt of the operation is facil, that the youngeſt Schollars or Learners cannot fail to perform it: to teach *Minerva* were in vain, and it were to Mathematicians injury in the ſucceeding Ages.



PRO-

PROBLEM CIX.

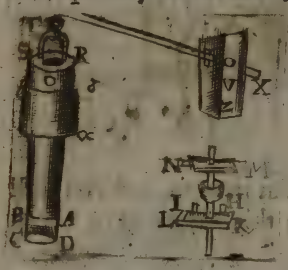
How to make a Clock with one onely Wheel.

MAke the body of an ordinary Dyal, and divide the hour in the Circle into 12 parts; make a great Wheel in height above the Axletree, to the which you ſhall place the Cord of your counterpoize, ſo that it may deſcend, that in 12 hours of time your *Index* or *Needle* may make one Revolution, which may be known by a Watch which you may have by you: then put a Ballance which may ſtop the courſe of the Wheel, and give it a regular motion, and you ſhall ſee an effect as juſt from this, as from a Clock with many *Wheels*.

PROBLEM CX.

How by help of two Wheels to make a Child to draw up alone a Hogſhead of Water at a time; and being drawn up, ſhall caſt out it ſelf into another Veſſel, as one would have it.

LEt *R* be the Pit from whence Water is to be drawn, *P* the Hook to throw out the Water when it is brought up, (this Hook muſt be moveable) let *A B* be the Axis of the Wheel *SF*, which Wheel hath divers forks of Iron made at *G*, equally fastened at the Wheel; let *I* be a Cord which is drawn by *K*, to make the Wheel *S* to turn, which Wheel *S* bears proportion to the Wheel *T*, as 8 to 2, let *N* be a Chain of Iron to which is tied the Vessel *O*, and the other which is in the Pit *E F* is a piece of Wood which hath a mortes in 1, and 2, by which the Cord *I* passeth, tied at the Wall as *K H*, and the other piece of Timber of the little Wheel, as *M*, mortised in likewise for the Chain to pass through: Draw the Cord *I*, by *K*, and the Wheel will turn, and so consequently the Wheel *T*, which will cause the Vessel *O* to raise; which being empty, draw the Cord again by *T*, and the other Vessel which is in the Pit will come out by the same reason. This is an invention which will save la-



bour if practised; but here is to be noted that the Pit must be large enough, to the end that it contain two great Vessels to pass up and down one by another.

PRO-

PROBLEM CXI.

To make a Ladder of Cords which may be carried in ones Pocket, by which one may easily mount up a Wall or Tree alone.

TAke two Pullies, *A* and *D*, unto that of *A* let there be fastened a Cramp of Iron, as *B*, and at *D* let there be fastened a Staff of a foot and an half long, as *F*, then the Pully *A*: place a hand of Iron, as *E*, to which tie a cord of an half inch thick, (which may be of Silk because it is for the pocket) then strive to make fast the Pully *A*, by the help of the Cramp of Iron *B*, to the place that you intend to scale; and the Staff *F* being tied at the Pully *D*, put it between your legs as though you would sit upon it: then holding the cord C in your hand, you may guide your self to the place required: wch may be made more facil by the multiplying of Pullies. This secret is most excellent in War, and for Lovers; its supportableness avoids suspicion.

PROBLEM CXII.

How to make a Pump whose strength is marvellous by reason of the great weight of Water that it is able to bring up at once, and so by continuance.

LEt $\alpha\,\beta\,\gamma\,\delta$ be the height of the case about 2 or 3 foot high, and broader according to discretion: the rest of the case or concavity let be *O*, let the Sucker of the Pump which is made be just for the case or Pump's head, $\alpha\,\beta\,\gamma\,\delta$ and may be made of Wood or Brass of 4 inches thick, having a hole at *E*, which descending raiseth up the cover *P*, by which issueth forth the water, and ascending or raising up, it shuts it or makes it close: *R S* is the handle of the Sucker, tied to the handle *TX*, which works in the post *V Z*. Let *A,B,C,D*, be a piece of Brass, *G* the piece which enters into the hole to *F*, to keep out the Air; *H, I, K, L*, the piece tied at the funnel or pipe: in which plays the Iron Rod or Axis *G*, so that it pass through the other piece *MN*, which is tied with the end of the Pipe of Brass.

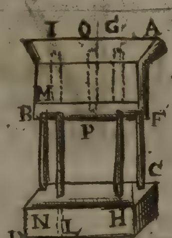
Note, That the lower end of the Cistern ought to be rested upon a Gridiron or Iron Grate, which may be tied in the Pit, by which means lifting up and putting down the handle, you may draw ten times more Water than otherwise you cold.

PRO-

PROBLEM CXIII.

How by means of a Ciſtern to make Water of a Pit continually to aſcend without ſtrength, or the aſſiſtance of any other Pump.

LEt *I L* be the Pit where one would cauſe water to aſcend continually to each office of a houſe, or the places which are ſeparated from it: let there be made a Receiver, as *A*, well cloſed up with Lead or other matter, that Air enter not in, to which faſten a Pipe of Lead,as at E,which may have vent at pleaſure,then let there be made a Ciſtern, as *B*, which may be communicative to *A*,by help of the pipe *G*, from which Ciſtern *B*, may iſſue the water of Pipe *D*,which may deſcend to *H*, which is a little below the level of the water of the pit, as much as is *GH*,to the end of which ſhall be ſoldered cloſe a cock which ſhall caſt out the water by *K H*. Now to make uſe of



it,let *B* be tilled full of water,and when you would have it run, turn the Cock, for then the water in *B* will deſcend by *K*, and for fear that there ſhould be vacuity, Nature which abhors it,will labour to furniſh and ſupply that emptineſs out of the Spring *F*,and that the Pit dry not,the Pipe ought to be ſmall, of an indifferent capacity, according to the greatneſs or ſmallneſs of the Spring.

PRO-

PROBLEM CXIV.

How out of a Fountain to cast the Water very high, different from a Problem formerly delivered.

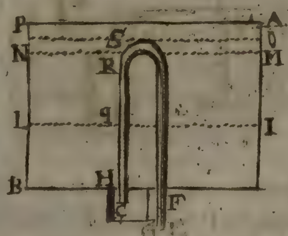
Let the Fountain be *BD*, of a round form, (seeing it is the most capable and most perfect figure) place into it two Pipes conjoyned, as *EA*, and *HC*, so that no air may enter in at the place of joyning: let each of the Pipes have a cock, *G* and *I*, the cock at *G* being closed, open that at *I*, and so with a Squirt force the Water through the hole at *H*, then close the cock at *A*, and draw out the Squirt, and

open the cock at *G*, the air being before rarified will extend his dimensions, and force the Water with such violence, that it will mount above the height of one or two Pipes; and so much the more, by how much the Machine is great: this violence will last but a little while, if the Pipe have too great an opening; for as the Air approacheth to his natural place, so the force will diminish.

PROBLEM CXV.

How to empty the Water of a Ciſtern by a Pipe which ſhall have a motion of it ſelf.

LEt *AB* be the Veſſel, *CDE* the Pipe; *HG* a little Veſſel under the greater, in which one end of the Pipe is, *viz.* *C*, and let the other end of the Pipe E, paſſing through the bottom of the Veſſel at F, then as the Veſſel filleth, ſo will the Pipe; and when the Veſſel ſhall be full as far as *P O*, the Pipe will begin to run at E of his own accord, and never ceaſe until the Veſſel be wholly empty.



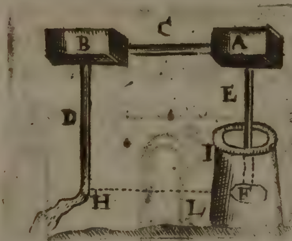
PROBLEM CXVI.

How to ſquirt or ſpout out a great height, ſo that one Pot of Water ſhall laſt a long time.

LEt there be prepared two veſſels of Braſs, Lead, or of other matter of equal ſubſtance, as are the two Veſſels *A B* and *B D*, and let them be joyned together by the two Pillars *MN* and *EF*; then let there be a Pipe *HG*, which may paſs thorow the cover of the Veſſel *CD*, and paſs through *AB* into *G*, making a little bunch or riſing in the cover of the Veſſel *A B*, ſo that the Pipe touch it

not

not at the bottom : then let there be ſoldered faſt another Pipe I L, which may be ſeparated from the bottom of the Veſſel, and may have his bunchy ſwelling as the former, without touching the bottom : as is repreſented in L,& paſſing through the bottom of A B, may be continued unto I, that is to ſay, to make an opening to the cover of the veſſel AB, and let it have a little mouth as a Trumpet, to that end to receive the water: then there muſt further be added a very ſmall pipe



which may paſs through the bottom of the Veſſel *AB*, as let it be O P, and let there be a bunch or ſwelling over it, as at P, ſo that it touch not alſo the bottom : let there be further made to this leſſer Veſſel an edge in form of a Baſin to receive the water, which being done, pour water into the Pipe I L, until the Veſſel C D be full, then turn the whole Machine up-ſide-down, that the Veſſel C D may be uppermoſt, and A B undermoſt; ſo by help of the Pipe G H, the water of the Veſſel C D will run into the Veſſel A B, to have paſſage by the Pipe P O. This motion is pleaſant at a feaſt in filling the ſaid Veſſel with Wine, which will ſpout it out, as though it were from a boiling Fountain in the form of a Thread, very pleaſant to behold.

PRO-

PROBLEM CXVII.

How to practise excellently the re-animation of Simples, in case the Plants may not be transported to be re-planted by reason of distance of places.

TAke what Simple you please, burn it, and take the Ashes of it, and let it be calcinated 2 hours between 2 Creusets well luted, and extract the Salt: that is, to put water into it in moving of it; then let it settle, and do it two or three times: afterwards evaporate it, that is, let the water be boiled in some Vessel, until it be all consumed: then there will remain a Salt at the bottom, which you shall afterwards sow in good ground well prepared, such as the Theatre of Husbandry sheweth, and you shall have your desire.

PROBLEM CXVIII.

How to make an infallible perpetual motion.

MIx 5 or 6 ounces of *Mercury* with his equal weight of *Jupiter*, grind it together with ten or twelve ounces of Sublimate dissolved in a Cellar upon a Marble the space of four days, and it will become like Oil-Olive, which distil with fire of chaff, or driving fire, and it will sublime dry substance, then put water upon the Earth (in form of Lye) which will be at the bottom of the Limbeck, and dissolve that which you can; filter it, then distil it, and there will be produced very subtil Atomes, which put into a bota bottle close stopped, and keep it dry, and you shall have your desire, with astonishment to all the World, and especially to those which have travelled herein without fruit.

PROBLEM CXIX.

Of the admirable Invention of making the Philosophers Tree, which one may see with his Eye to grow by little and little.

TAke two ounces of *Aqua-fortis*, and dissolve in it half an ounce of fine Silver refined in a Cappel: then take an ounce of *Aqua-fortis*, and two drams of Quick-silver, which put in it, and mix these two dissolved things together, then cast into it a Vial of half a pound of Water, which may be well stopped; for then every day you may see it grow both in the Tree and in the branch. This Liquid serves to black hair which is red or white, without fading untill they fall: But here is to be noted that great care ought to be had in anointing the hair, for fear of touching the flesh: for this composition is very corrosive or searching, that as soon as it toucheth the flesh it raiseth blisters and bladders very painful.

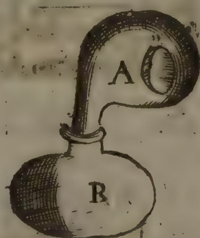
PROBLEM CXX.

How to make the representation of the Great World.

DRaw Salt Nitre out of Salt Earth which is found along the Rivers side, and at the foot of Mountains, where especially are Minerals of

Gold

Gold and Silver: mix that Nitre well cleansed with ☿, then calcinate it hermetically; then put it in a Limbeck, and let the Receiver be of Glass well luted, and always in which let there be placed Leaves of Gold at the bottom, then put fire under the Limbeck until vapours arise which will cleave unto the Gold; augment your fire until there ascend no more then take away your Receiver, and close it hermetically, and make a Lamp fire under it, until you see presented in it that which Nature affords us, as *Flowers*, *Trees*, *Fruits*, *Fountains*, *Sun*, *Moon*, *Stars*, &c. Behold here the form of the Limbeck, and the Receiver: *A* represents the Limbeck, *B* stands for the Receiver.



PROBLEM CXXI.

How to make a Cone or Pyramidal Body move upon a Table, without springs or other artificial means; so that it shall move by the edge of the Table without falling.

THis Proposition is not so thorny and subtile as it seems to be, for putting under a Cone of Paper a Beetle or such-like Creature, you shall have pleasure, with astonishment and admiration to those which are ignorant in the cause: for this Animal

Animal will ſtrive always to free herſelf from the captivity in which ſhe is by the impriſonment of the *Cone*: for coming near the edge of the Table ſhe will return to the other ſide, for fear of falling.

PROBLEM CXXII.

To cleave an Anvil with the blow of a Piſtol.

THis is proper to a Warrier, and to perform it, let the Anvil be heated red hot as one can poſſible, in ſuch ſort that all the ſolidity of the body be ſoftened by the fire: then charge the Piſtol with a Bullet of Silver, and ſo have you infallibly the Experiment.

PROBLEM CXXIII.

How to roſt a Capon carried in a Budget at a Saddle-Bow, in the ſpace of riding 5 or 6 miles.

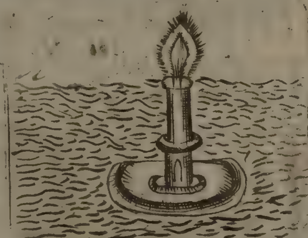
HAving made it ready and larded it, ſtuff it with Butter, then heat a piece of Steel, which may be formed round according to the length of the Capon, and big enough to fill the Belly of it, and then ſtop it with Butter; then wrap it up well, and incloſe it in a Box in the Budget, and you ſhall have your deſire: It is ſaid

Count Mansfield ſerved himſelf with no others, but ſuch as were thus made ready, for that it loſeth none of its ſubſtance, and it is dreſſed very equally.

PROBLEM CXXIV.

How to make a Candle burn and continue three times as long as otherwiſe it would.

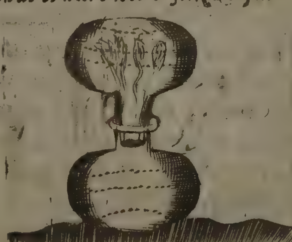
UNto the end of a Candle half burned ſtick a farthing, leſs or more, to make it hang perpendicular in a Veſſel of water, ſo that it ſwim above the water; then light it, and it will ſuſtain it ſelf, and float in this manner, and being placed into a Fountain, Pond, or Lake that runs ſlowly, where many people aſſemble, it will cauſe an extreme fear to thoſe which come therein in the night, knowing not what it is.



PROBLEM CXXV.

How out of a quantity of Wine to extract that which is moſt windy and evil, that it hurt not a ſick Perſon.

TAke 2 vials in ſuch ſort that they be of like greatneſs both in the belly and the neck, fill one of them of wine, and the other of water: let the mouth of



that which hath the water be placed into the mouth of that which hath the wine, ſo the water ſhall be uppermoſt: now becauſe the water is heavier than the wine, it will deſcend into the other Vial ; and the wine which is loweſt, becauſe it is lighteſt will aſcend above, to ſupply the place of the water,& ſo there will be a mutual interchange of liquids, and by this penetration the wine will loſe her vapors in paſſing through the water.

PROBLEM CXXVI.

How to make two Marmouzets, one of which ſhall light a Candle, and the other put it out.

UPon the ſide of a Wall make the figure of a Marmouzet, or other Animal or form,and right againſt it on the other wall make another ; in the mouth of each put a pipe or quill ſo artificially that it be not perceived ; in one of which place Salt-peter very fine, and dry, and pulveriſed ; and at the end ſet a little match of paper, in the other place Sulphur beaten ſmall, then holding a candle lighted in your hand,ſay to one of theſe Images by way of command,*Blow out the Candle* ; then lighting the paper with the candle, the Salt-peter will blow out the candle immediately ; and going to the other Image (before the match of the candle be out) touch the Sulphur with it, and ſay, *Light the Candle*, and it will immediately be lighted ; which will cauſe an admiration to thoſe which ſee the action, if it be well done, with a ſecret dexterity.

PRO-

PROBLEM CXXVII.

How to keep Wine fresh as if it were in a Cellar, in the heat of Summer, and without Ice or Snow, yea though it were carried at a Saddle-bow, and exposed to the Sun all the day.

SEt your wine in a vial of Glass, and place it in a Box made of wood, leather, or such like, about which vial place Salt-peter, and it will preserve it and keep it very fresh: this experiment is not a little commodious for those which are not near fresh waters, & whose dwellings are exposed to the Sun.

PROBLEM CXXVIII.

To make a Cement which lasteth as Marble, & resisteth air & water, without dis-joyning or uncementing.

TAke a quantity of strong and gluing Morter well beaten, mix with this as much new-slaked lime, & on it cast *Oil-Olive*, or *Linseed-Oil*, and it will be hard as Marble, being applied in time.

PROBLEM CXXIX.

How to melt Metal very quickly, yea in a Shell upon a little Fire.

MAke a bed upon a bed of Metal with pouder of Sulphur, of Salt-peter, & Saw-dust alike; then put fire to the said pouder with a burning Charcoal, and you shall see that the metal will dissolve incontinent, and be in a mass. This secret is most excellent, & hath been practised by the reverend Father *Mercenno* of the Order of the *Minims*.

PROBLEM CXXX.

How to make Iron or Steel exceeding hard.

QUench your Blade or other Inſtrument ſeven times in the blood of a male hog mixt with Gooſe-greaſe,and at each time dry it at the fire before you wet it,and it will become exceeding hard and not brittle,which is not ordinary according to other temperings and quenchings of Iron: an experiment of ſmall coſt,often proved, and of great conſequence for Armory,& warlike Negotiations

PROBLEM CXXXI.

To preſerve Fire as long as you will, imitating the inextinguiſhable Fire of Veſtals.

AFter you have extracted the burning ſpirit of the Salt of ♃, by the degrees of fire,as is required according to the Art of *Chymiſtry*, the fire being kindled of it ſelf, break the Limbeck, & the Irons which are found at the bottom will flame & appear as burning coals,as ſoon as they feel the air; which if you promptly incloſe in a vial of Glaſs,& that you ſtop it exactly with ſome good lute; or to be more aſſured, it may be cloſed up with *Hermes* wax, for fear the air get in. Then will it keep more than 1000 years (as a man may ſay) yea at the bottom of the Sea; and opening it at the end of the time, as ſoon as it feels the air it takes fire, with which you may light a Match. This Secret merits to be travelled after, and put in practice, for that it is not common, & full of aſtoniſhment, ſeeing all kind of fire laſteth but as long as his matter laſteth,and there is no matter to be found that will ſo long indure.

Artificial Fire-Works:

Or the manner of making ROCKETS and BALLS of FIRE, As well for the Water as the Air.

With the Compoſition of Stars, Golden-Rain, Serpents, Lances, Wheels of Fire, and ſuch-like, Pleaſant and Recreative.

Of the Compoſition for Rockets.

IN the making of Rockets, the chiefeſt thing to be regarded is the compoſition that they ought to be filled with; foraſmuch as that which is proper to Rockets which are of a leſs ſort, is very improper to thoſe which are of a more greater form; for the fire being lighted in a great concave, which is filled with a quick Compoſition, burns with great violence; contrarily, a weak compoſition being in a ſmall concave, makes no effect. Therefore we ſhall here deliver in the firſt place Rules and Directions which may ſerve for the true compoſition or matter with which you may charge any Rocket, from Rockets which are charged but with one ounce of Powder, unto great Rockets which require for their charge 10 pound of Powder, as followeth:

For Rockets of one ounce.

Unto each pound of good Musket Powder small beaten, put two ounces of Small-coal-dust, and with this composition charge the Rocket.

For Rockets of 2 or 3 ounces.

Unto every four ounces and a half of Powder-dust, add an ounce of Salt-peter, or to every four ounces of Powder-dust, adde an ounce of Coal-dust.

For Rockets of 4 ounces.

Unto every pound of Powder-dust, add four ounces of Salt-peter, and one ounce of Coal-dust: but to have it more slow, unto every ten ounces of good powder-dust, add 3 ounces of Salt-peter, and 3 ounces of Coal-dust.

For Rockets of 5 or 6 ounces.

Unto every pound of Powder-dust add three ounces and an half of Salt-peter, and two ounces and an half of Coal-dust, as also an ounce of Sulphur, and an ounce of File-dust.

For Rockets of 7 or 8 ounces.

Unto every pound of Powder-dust add 4 ounces of Salt-peter, and 3 ounces of Sulphur.

Of Rockets of 10 or 12 ounces.

Unto the precedent composition add half an ounce of Sulphur, and it will be sufficient.

For Rockets of 14 or 15 ounces.

Unto every pound of Powder-dust add four ounces of Salt-peter, of Coal-dust $2\frac{1}{4}$ ounces, of Sulphur and File-dust $1\frac{1}{4}$ of an ounce.

For

For Rockets of 1 pound.

Unto every pound of Powder-duſt add 3 ounces of Coal-duſt, and 1 ounce of Sulphur.

For Rockets of 2 pound.

Unto every pound of Powder-duſt add $9\frac{1}{2}$ ounces of Salt-peter, of Coal-duſt $2\frac{1}{2}$ ounces, of File-duſt $1\frac{1}{2}$ ounce, and of Sulphur $\frac{3}{4}$ of an ounce.

For Rockets of 3 pound.

Unto every pound of Salt-peter add 6 ounces of Coal-duſt, and of Sulphur 4 ounces.

For Rockets of 4, 5, 6, or 7 pound.

Unto every pound of Salt-peter add 5 ounces of Cole-duſt, and $2\frac{1}{2}$ ounces of Sulphur.

For Rockets of 8, 9, or 10 pound.

Unto every pound of Salt-peter add $5\frac{1}{2}$ ounces of Coal-duſt, and of Sulphur $2\frac{1}{2}$ ounces.

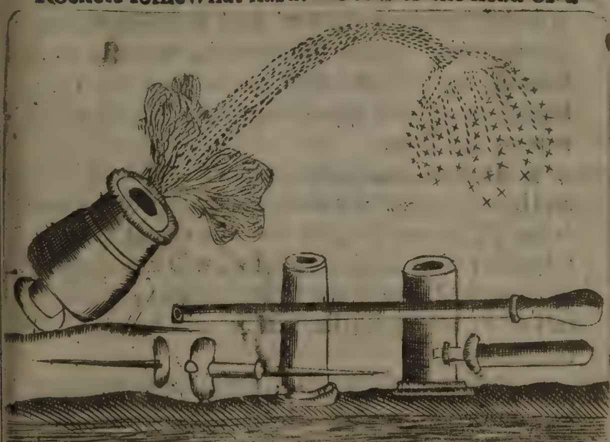
Here note, That in all great Rockets there is no Powder put, becauſe of the greatneſs of the fire which is lighted at once, which cauſeth too great a violence,therefore ought to be filled with a more weak compoſition.

Of the making of Rockets, and other Fire-works.

FOr the making of Rockets of ſundry kinds, divers moulds are to be made, with their Rolling-pins, Breaths, Chargers, *&c.* as may be ſeen here in the figure. And having rolled a Caſe of Paper upon the Rolling-pin for your mould, fill it with the compoſition belonging to that mould, as before is delivered: now may you load it on the top with Serpents, Reports, Stars, or

Golden Rain: The Serpents are made about the bigneſs of ones little finger, by rolling a little paper upon a ſmall Stick, and then tying one end of it, and filling it with the mixt compoſition ſomewhat cloſe, and then tying the other end. The Reports are made in their Paper-Caſes, as the Serpents, but the Paper ſomewhat thicker to give the greater report. Theſe are filled with grain-

Powder, or half-Powder and half Compoſition, and tying both ends cloſe, they are finiſhed. The beſt kind of Stars are made with this mixture following; unto every 4 ounces of Salt-peter add 2 ounces of Sulphur, and to it put one ounce of Powder-duſt, and of this compoſition make your Stars, by putting a little of it within a ſmall quantity city of Towe; and then tying it up in the form of a Ball as great as an Haſel-Nut or a little Wal-Nut, through which there muſt be drawn a little Primer to make it take fire. Touching the making of the Golden-Rain, that is nothing but filling of Quills with the compoſition of your Rockets ſomewhat hard. Now if the head of a



Rocket be loaded with a thouſand of thoſe Quills, its a goodly ſight to ſee how pleaſantly they ſpread themſelves in the Air, and come down like ſtreams of Gold much like the falling down of Snow, being agitated by ſome turbulent Wind.

Of Recreative FIRES.

1. PHilostrates saith, That if Wine in a Platter be placed upon a Receiver of burning Coals, to exhale the spirit of it, and be inclosed within a Cupboard or such-like place, so that the Air may not go in nor out, and so being shut up for 30 years, he that shall open it, having a Wax Candle lighted, and shall put it into the Cupboard, there will appear unto him the figure of many clear Stars.

2. If *Aqua-vitæ* have Camphire dissolved in it, and be evaporated in a close Chamber, where there is but a Charcoal fire, the first that enters into the Chamber with a Candle lighted, will be extreamly astonished, for all the Chamber will seem to be full of Fire very subtile, but it will be of little continuance.

3. Candles which are deceitful are made of half Powder, covered over with Tallow, and the other half is made of clean Tallow or Wax, with an ordinary Week; this Candle being lighted, and the upper half consumed, the Powder will take fire, not without great noise and astonishment to those which are ignorant of the cause.

4. A dozen or twenty small Serpents placed secretly under a Candlestick that is indifferent big, which may have a hole pass through the Socket of it to the Candle, through which a piece of Primer may be placed, and setting a small Candle in the Socket to burn according to a time limited;

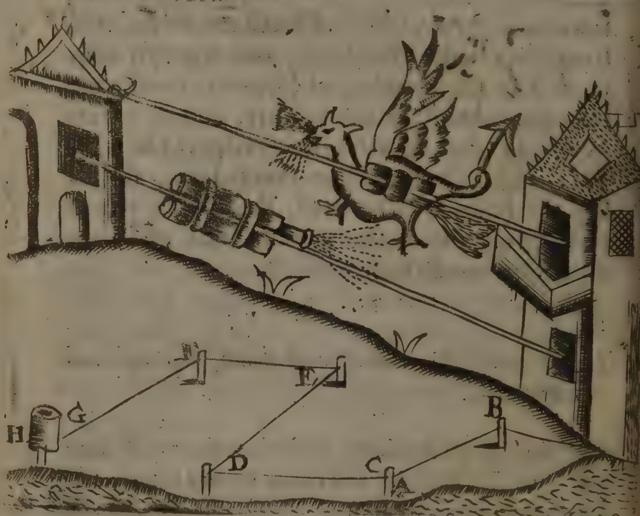
limited; which Candleſtick may be ſet on a ſide-Table without ſuſpition to any; then when the Candle is burned, that it fires the Primer, that immediately will fire all the Serpents, which overthrowing the Candleſtick will fly here and there, intermixing themſelves, ſometimes in the Air, ſometimes in the Planching, one amongſt another, like the crawling of Serpents, continuing for a pretty while in this poſture, and in extinguiſhing every one will give his Report like a Piſtol: This will not a little aſtoniſh ſome, thinking the houſe will be fired, though the whole powder together makes not an ounce, and hath no ſtrength to do ſuch an effect.

How to make Fire run up and down, forward and backward.

TAke ſmall Rockets, and place the tail of one to the head of the other upon a Cord, according to your fancy; as admit the Cord to be *A*, *B*, *C*, *D*, *E*, *F*, *G*; give fire to the Rocket at *A*, which will fly to *B*, which will come back again to *A*, and fire another at *C*, that will flie at *D*, which will fire another there, and fly to *E*, and that to *F*, and ſo from *F* to *G*, and at *G* may be placed a pot of Fire, *viz.* G H, which fired will make good ſport, becauſe the Serpents which are in it will variouſly intermix themſelves in the air and upon the ground, and every one will extinguiſh with a report: and here may you note that upon the Rockets may be placed Fiery Dragons,

Com-

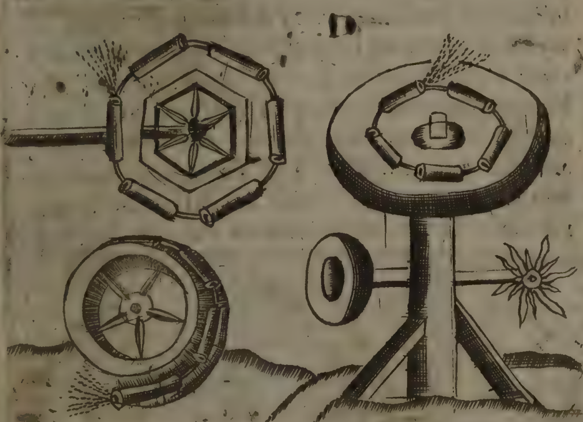
Combatants, or such-like, to meet one another, having Lights placed in the Concavity of their Bodies, which will give great grace to the Action.



How to make Wheels of Fire.

TAke a Hoop, and place two Laths across one the other; upon the crossing of which make a hole, so that it may be placed upon a pin to turn easily, as the figure Q sheweth, upon the sides of which Hoop or round Circle place your Rockets, to which you may place Lances of Fire between each Rocket: let this Wheel be placed upon a Standard, as is here represented, and place a piece

piece of Primer from one Lance to another, then give fire at *G*, which will fire *F*, that *E*, that will fire *D*, that *C*, and that will fire the Rocket at *A*; then immediately the Wheel will begin to move,



and repreſent unto the Spectators a Circle of changable Fire, and if Pots of Fire be tied to it, you will have fine ſport in the turning of the Wheel, and caſting out of the Serpents.

Of Night-Combatants.

CLubs, Targets, Faulchons, and Maces, charged with ſeveral Fires, do make your Night-Combatants, or are uſed to make place amongſt a throng of People. The Clubs at the Ends are made like a round Pannier with ſmall ſticks filled with little Rockets in a ſpiral form, glued and ſo placed that they fire but one after another. The Maces are of divers faſhions, ſome made oblong

at

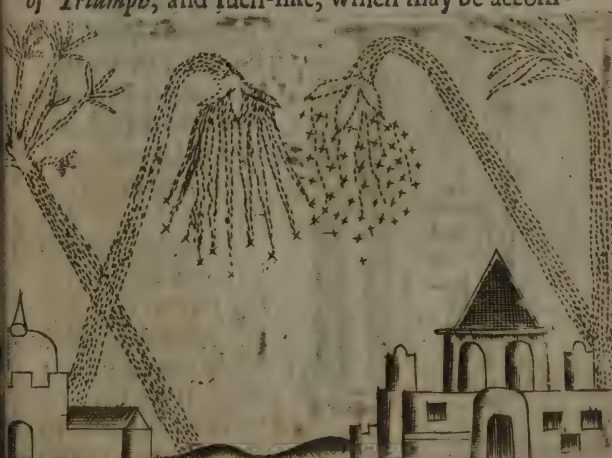
at the end: ſome made of a ſpiral form, but all made hollow, to put in ſeveral compoſitions, and are boared in divers places, which are for ſundry Rockets and Lances of weak compoſition to be fired at pleaſure. The Faulchons are made of wood in a bowing form, like the figure *A*, having their backs large to receive many Rockets, the head of one near the neck of another, glued and faſtend well together, ſo that one being ſpent, another may be fired. The Targets are made of wooden thin boards, which are channeled in ſpiral Lines to contain Primer to fire the Rockets

one after another, which is all covered with thin covering of wood or paſtboard, bored with holes ſpirally alſo; which Rockets muſt be glued and made faſt to the place of the Channel. Now if two men

men, the one having a Target in his hand, and the other a Faulchon or Mace of Fire, ſhall begin to fight, it will appear very pleaſant to the Spectators: for by the motion of fighting, the place will ſeem to be full of ſtreams of Fire: and there may be adjoyned to each Target a Sun or a burning Comet with Lances of fire, which will make them more beautiful and reſplendent in that action.

Of ſtanding Fires.

SUch as are uſed for Recreation, are *Colloſſus*, *Statues*, *Arches*, *Pyramides*, *Chariots*, *Chairs of Triumph*, and ſuch-like, which may be accom-

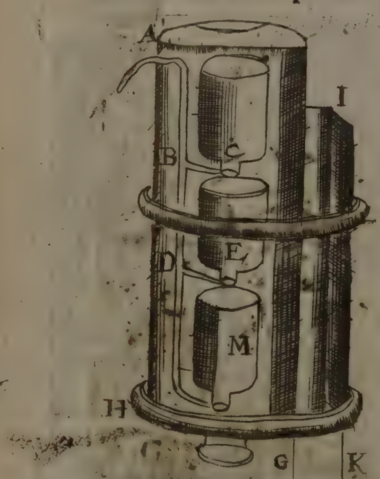


modated with Rockets of Fire, and beautified with ſundry other artificial Fires, as Pots of Fire for the Air, which may caſt forth ſeveral figures, Scutchions, Rockets of divers ſorts, Stars, Crowns, Letters,

Letters, and ſuch-like, the borders of which may be armed with ſundry Lances of Fire, of ſmall flying Rockets, with reports, flames, of ſmall Birds of Cypres, Lanthorns of Fire, Candles of divers uſes, and colours in burning, and whatſoever the fancy of an ingenious head may allude unto.

Of Pots of Fire for the Air, which are thrown out of one Caſe one after another, of a long continuance.

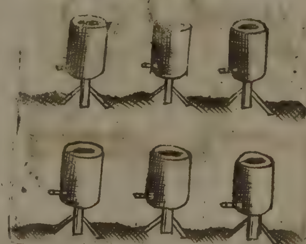
MAke a long Trunk, as *A G*, and by the ſide *A H*, let there be a Channel which may be fiered with ſlow primer or compoſition ; then having charged the Trunk *A G*, with the Pots of Fire for the Air, at *I G E C*, and make the Trunk *AG* very faſt unto a poſt, as *IK*, give fire at the top, as at *A*, which burning downwards will give fire to *C*, & ſo throw out that Pot in the Air, which being ſpent, in the mean time the fire will burn from *B* to *D*, and ſo fire *E*, and throw it out alſo into the Air, and ſo all the reſt one after another will be thrown out : and if the Pots of Fire for the Air which are caſt out, be filled with divers Fire-works they



they will be ſo much the more pleaſant to the Beholders. Theſe Trunks of Fire do greatly adorn a Fire-work, and may conveniently be placed at each Angle of the whole Work.

Of Pots of Fire for the Ground.

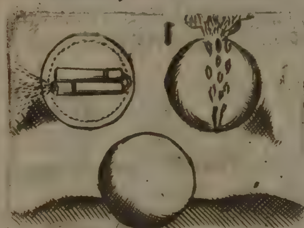
MAny Pots of Fire being fired together, do give a fine repreſentation and recreation to the Spectators, and cauſe a wonderful ſhout amongſt the common people wch are ſtanders by; for thoſe Pots being filled with Balls of Fire and flying Serpents for the Air, they will



ſo intermix one within another, in flying here and there a little above the ground, and giving ſuch a volley of reports that the Air will rebound with their Noiſe, and the whole place be filled with ſundry ſtreams of pleaſant fire; which Serpents will much occupy thoſe about the place to defend themſelves in their upper parts, when they will no leſs be buſied by the Balls of Fire which ſeem to annoy their Feet.

Of Balls of Fire.

THeſe are very various, according to a mans fancy; ſome of which are made with very ſmall Rockets, the head of one tied to the neck of another: The Ball being made, may be covered over with Pitch, except the hole to give fire to it; this Ball will make fine ſport amongſt the ſtanders by, which will take all a fire, and roll ſometimes this way, ſometimes that way, between the legs of thoſe that are ſtanders by, if they take not heed, for the motion will be very irregular;



and in the motion will caſt forth ſeveral fires with reports. In the ſecond kind there may be a Channel of Iron placed in divers places in ſpiral manner, againſt which may be placed as many ſmall Petards of Paper as poſſible may be, the Channel muſt be full of ſlow compoſition, and may be covered as the former, and made fit with his Rockets in the middle: This Ball may be ſhot out of a Mortar-Piece, or charged on the top of a Rocket: for in its motion it will fly here and there, and give many reports in the Air, becauſe of the diſcharge of the Petards.

Of Fire upon the Water.

PLaces which are ſituated upon Rivers or great Ponds, are proper to make Recreative Fires on: and if it be required to make ſome of conſequence, ſuch may conveniently be made upon two Boats, upon which may be built two Beaſts, Turrets, Pageants, Caſtles, or ſuch-like, to receive

ceive or hold the diverſity of Fire-Works that may be made within it, in which may play divers Fires, Petards, *&c.* and caſt out many ſimple Granadoes, Balls of Fire to burn in the Water, Serpents, and other things; and often times theſe Boats in their incounters may hang one in another, that ſo the Combatants with the Targets and Maces may fight; which will give great content to the Eyes of thoſe which are Lookers on, and in the concluſion fire one another, (for which end they were made: by which the dexterity of the one may be known in reſpect of the other, and the triumph and victory of the fight gotten.

Of Balls of Fire which move upon the Water.

These may be made in form of a Ball ſtuffed with other little Balls, glued round about, and filled with compoſition for the Water, which fiered will produce marvellous and admirable effects, for which there must be had little Cannons of white Iron, as the ends of small funnels; these Iron Cannons may be pierced in sundry places, to which holes, may be set small Balls full of composition, for the Water; which small Balls must be pierced deep and large, and covered with Pitch except the hole: in which hole must be first placed a little quantity of grain-powder, and the rest of the hole filled up with composition; and note further, that these Iron Cannons must be filled with a slow composition, but

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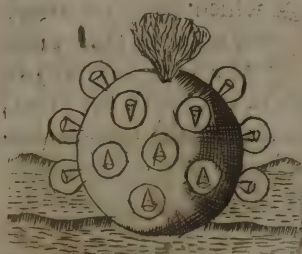
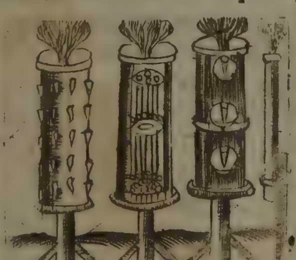


such which is proper to burn in the Water: then must these Cannons with their small Balls be put so together that it may make a Globe, and the holes in the Cannons be answerable to the hollow Balls, and all covered over with Pitch and Tallow; afterwards pierce this Ball against the greatest Cannon (to which all the lesser should answer) unto the composition, then fire it, and when it begins to blow, throw it into the Water, so the fire coming to the holes will fire the grain-Powder, the which will cause the Balls to separate, and fly here and there, sometimes two at a time, sometimes three, sometime more, which will burn within the Water, with great astonishment and content to those which see it.

Of

Of Lances of Fire.

STanding Lances of Fire are made commonly with hollow wood to contain ſundry Petards or Rockets, as the figure here ſheweth, by which it is eaſie to invent others, according to ones fancy. Theſe Lances have wooden handles that ſo they may be faſtened at ſome Poſt, ſo that they be not overthrown in the flying out of the Rockets or Petards: There are leſſer ſorts of Lances whoſe caſes are of three or four foldings of Paper of a foot long, and about the bigneſs of ones finger, which are filled with a compoſition for Lances. But if theſe Lances be filled with a compoſition, then (unto every 4 ounces of powder add 2 ounces of Salt-peter, and unto that add 1 ounce of Sulphur) it will make a Brick fire red before it be half ſpent, if the Lance be fiered and held to it: and if 20 ſuch Lances were placed about a great Rocket, and ſhot to a Houſe or Ship, it would produce a miſchievous effect.



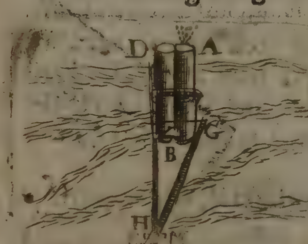
How to ſhoot a Rocket Horizontal, or otherwiſe.

UNto the end of the Rocket place an Arrow which may not be too heavy, but inſtead of the feathers let that be of thin white Tin plate,

and place it upon a reſt, as here you may ſee by the Figure, then give fire unto it, and you may ſee how ſerviceable it may be. To the head of ſuch Rockets may be placed Petards, Balls of Fire, Granadoes, &c. and ſo may be applied to War-like affairs.

How a Rocket burning in the Water for a certain time, at laſt ſhall fly up in the Air with an exceeding quickneſs.

TO do this, take two Rockets, the one equal to the other, and joyn them one unto another in the middle at *C*, in ſuch ſort that the fire may eaſily paſs from one to another: it being thus done, tie the two Rockets at a Stick in *D*, and let it be ſo long and great, that it may make the



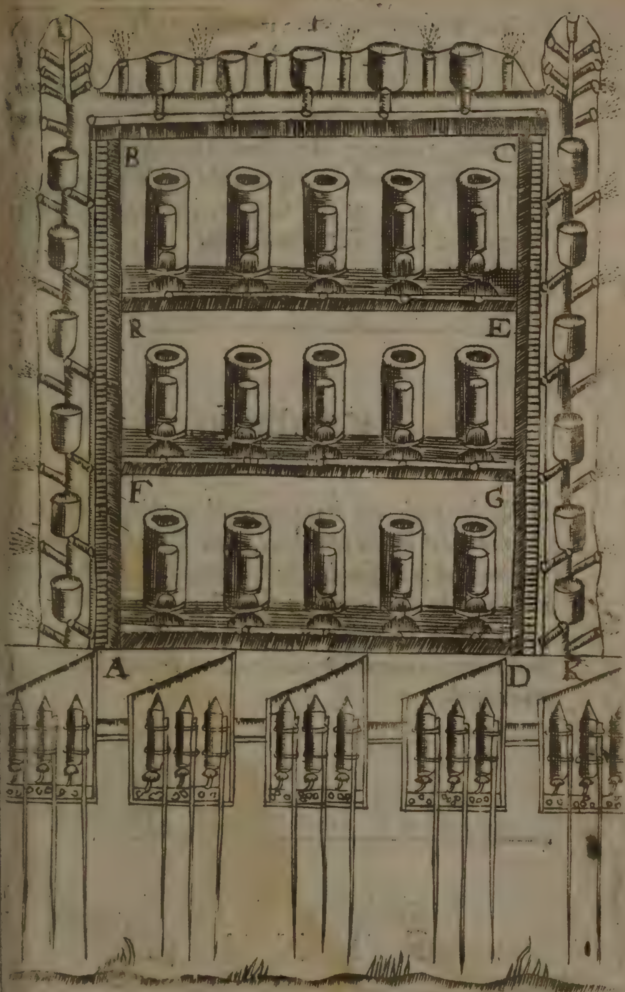
Rockets in the water hang, or lie upright, then take a pack-thread, and tie it at *G*, and let it come double about the ſtick *DM* at *H*, and at that point hang a Bullet of ſome weight, as *K*, for then giving fire at *A*, it will burn to *B*, by a ſmall Serpent filled there, and tied at the

the end, and covered ſo that the Water injure it not, which will fire the Rocket *B D*, and ſo mounting quick out of the Water by the looſe tying at *C*, and the Bullet at the pack-thread will leave the other Rocket in the Water, and ſo aſcend like a Rocket in the Air, to the admiration of ſuch as know not the ſecrecy.

Of the framing of the Parts of a Fire-Work together, that the ſeveral Works may fire one after another.

CAuſe a Frame to be made, as A B C D, of two foot ſquare every way, or thereabouts, (according to the quantity of your ſeveral works) then may you at each angle have a great Lance of Fire to ſtand, which may caſt out Pots of Fire, as they conſume: Upon the ledges AB, BC, and CD, may be placed ſmall Lances of Fire, about the number of 30 or 60, ſome ſide-wiſe, and others upright; between theſe Lances may be placed Pots of Fire ſloping outwards, but made very faſt, and covered very cloſe, that they chance not to fire before they ſhould; then upon the ledges RE, FG, HI, and AD, may be placed your Souciſons, and behind all the Work may be ſet your Boxes of Rockets, in each of which you may place 6, 9, 12, or 20 ſmall Rockets: Now give fire at *A*, (by help of a piece of Primer going from one Lance to another) all the Lances will inſtantly at once be lighted, and as ſoon as the Lance at A is conſumed, it will fire the Channel which is made in the ledge of the frame, which runs under the Pots of Fire, and as the Fire goes along burning, the Pots will be cast forth, and so the rank of Pots upon the sides of the frame *AB*, *BC*, and *CD*, being spent, the Soucisons will begin to play, being fiered also by a Channel which runs under them, upon the ledges *AD*, *HI*, *FG*, and *RE*, then when the *Soucisons* are spent upon the last ledge, *RE*, there may be a secret channel in the ledge *CD*, which may fire the Box of Rockets at *K*, & may fire all the rest one after another; which Boxes may be all charged with several Fire-works: for the Rockets of the first Box may be loaden with Serpents, the second with Stars, the third with Reports, the fourth with Golden-Rain, and the fifth with small flying Serpents; these mounting one after another, and flying to and fro, will much inlighten the Air in their ascending; but when these Rockets discharge themselves above, then will there be a most pleasant representation: for these Fires will dilate themselves in divers beautiful forms, some like the branching of Trees, others like Fountains of Water gliding in the Air, others like flashes of Lightning, others like the glittering of Stars, giving great contentment and delight to those which behold them: But if the work be furnished also with Balons, (which is the chiefest in recreative Fire-works) then shall you see ascending in the air but as it were only a quill of Fire, but once the Balon taking fire, the Air will seem more than 100 foot square full of crawling and flying Serpents, which will extinguish with a volley of more than 500 reports, and so fill the Air and Firmament with their rebounding clamour.

The


B
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The making of which with many other rare and excellent Fire-Works, and other practiſes, not onely for Recreation, but alſo for Service; you may find in a Book intituled **Artificial Fire-Works**, made by Mr. *Malthas* (a Maſter of his Knowledge) and are to be ſold by *William Leak*, and *John Leak*, at the Crown in *Fleetſtreet*, between the Two Temple-Gates.

Concluſion.

IN this Book we have omitted nothing that was material in the Original, but have abundantly augmented it in ſundry Experiments. And though the Examinations are not ſo full and manifold, yet (by way of Brevity) we have expreſſed fully their Subſtance, to avoid Prolixity, and ſo paſt by things reiterated.

FINIS.

THE DESCRIPTION and USE OF THE Double Horizontal DYAL.

WHEREBY,

Not onely the Hour of the Day is ſhewn, but alſo the *Meridian Line* is found.

And moſt

Aſtronomical Queſtions

Which may be done by the GLOBE, Are Reſolved.

Whereunto is Added,

The Deſcription of the General

Horological Ring.

Invented and Written by W. O.

LONDON:

Printed for *William Leak* and *John Leak*, at the Crown in *Fleetſtreet*, between the Two Temple-Gates. 1674.

THE DESCRIPTION and USE OF THE Double Horizontal Dyal.

There are upon the Plate two ſeveral Dyals. That which is outermoſt, is an ordinary Dyal, divided into hours and quarters, and every quarter into three parts, which are five minutes apiece: ſo that the whole hour is underſtood to contain 60 minutes. And for this Dyal the ſhadow of the upper oblique or ſlanting edge of the Style or Cock doth ſerve.

The other Dyal which is within, is, *The Projection of the Upper Hemiſphere upon the Plain of the Horizon:* The Horizon it ſelf is underſtood to be the innermoſt circle of the Limb, and is divided on both ſides from the points of Eaſt and Weſt into to degrees noted with 10, 20, 30, &c. as far as need requireth: And the centre of the Instrument is the *Zenith* or *Vertical point*.

Within the *Horizon*, the middle straight Line pointing *North* and *South*, upon which the Style standeth, is the *Meridian* or Twelve a Clock Line; and the other short arching Lines on both sides of it, are the *Hour-Lines*, distinguished accordingly by their figures; and are divided into quarters by the smaller Lines drawn between them, every quarter containing 15 minutes.

The two Arches which cross the Hour-Lines, meeting on both sides in the points of intersection of the Six a Clock Lines with the Horizon, are the two Semicircles of the *Ecliptick*, or annual circle of the Sun: the upper of which Arches serveth for the Summer half-year, and the lower for the Winter half-year, and therefore divided into 365 days, which are also distinguished into twelve months, with longer Lines, having their names set down: and into tenths and fifths with shorter Lines; and the rest of the days with pricks, as may plainly be seen in the Dial.

And this is for the ready finding out of the *place of the Sun every day*: and also for the shewing of the *Sun's yearly Motion*, because by this motion the Sun goeth round about the Heavens in the compass of a year, making the four parts or seasons thereof, namely, the *Spring* in that quarter of the *Ecliptick* which begins at the intersection on the East side of the Dyal, and is therefore called, *The Vernal Intersection*. Then the *Summer* in that quarter of the *Ecliptick* which begins

at

at the interſection with the *Meridian* in the higheſt point next the *Zenith*. After that, *Autumn* in that quarter of the *Ecliptick* which beginneth at the interſection on the Weſt-ſide of the Dyal,and is therefore called, *The Autumnal Interſection*. And laſtly, the *Winter* in that quarter of the *Ecliptick* which beginneth at the interſection with the *Meridian* in the loweſt point next the *Horizon*.

But beſides this *Yearly Motion*, the Sun hath a *Diurnal* or *Daily Motion*, whereby it maketh day and night, with all the diverſities and inequalities thereof: which is expreſſed by thoſe other Circles drawn croſs the Hour-lines; the middlemoſt whereof, being groſſer than the reſt, meeting with the *Ecliptick* in the points of the *Vernal* and *Autumnal Interſections*, is the *Equinoctial*; and the reſt on both ſides of it are called the Parallels, or *Diurnal Arch of the Sun*, the two outermoſt whereof are the *Tropicks*, becauſe in them the Sun hath his furtheſt *Digreſſion* or *Declination* from the *Equinoctial*, which is degrees $23\frac{1}{2}$, and thence beginneth again to return towards the *Equinoctial*. The upper of the two *Tropicks* in this our Northern *Hemiſphere*, is the *Tropick* of *Cancer*, and the Sun being in it is higheſt into the North, making the longeſt day of Summer: And the lower next the *Horizon* is the *Tropick* of *Capricorn*; and the Sun being in it, is loweſt into the *South*, making the ſhorteſt day of Winter.

Between the two *Tropicks* and the *Equinoctial*, infinite ſuch *Parallel Circles* are underſtood to be contained: for the Sun in what point ſoever of the

the *Ecliptick* it is carried, describeth by his *Station* a Circle parallel to the *Equinoctial*; yet those Parallels which are in the Instrument, though drawn but to every second degree of *Declination*, may be sufficient to direct the Eye in imagining and tracing out through every day of the whole year in the Ecliptick a proper Circle which may be the Diurnal Arch of the Sun for that Day: For upon the right estimation of that imaginary Parallel doth the manifold Use of this Instrument especially rely, because the true place of the Sun all that day is in some part or point of that Circle. Wherefore for the better conceiving and bearing in mind thereof, every fifth Parallel is herein made a little grosser than the rest.

For this inner Dyal serveth the shadow of the upright edge of the Style, which I therefore call the Upright Shadow.

And thus, *By the Eye and View onely to behold and comprehend the Course of the Sun throughout the whole Year, both for his Annual and Diurnal Motion*, may be the first Use of this Instrument.

USE II.

To find the Declination of the Sun every Day.

Look the day of the month proposed in the Ecliptick, and mark how many degrees the prick shewing that day is distant from the Equinoctial, either on the Summer or Winter side, *viz.* North or South.

Example

Example 1. What will the *Declination* of the Sun be upon the 11th day of *August?* Look the 11th day of *August*, and you ſhall find it in the 6th circle above the Equinoctial: Now becauſe each Parallel ſtandeth (as hath been ſaid before) for two degrees, the Sun ſhall that day decline Northwards 12 degrees.

Example 2. What Declination hath the Sun upon the 24 day of *March?* Look the 24 day of *March*, and you ſhall find it between the ſecond and third Northern Parallels, as it were an half and one fifth part of that diſtance from the ſecond: Reckon therefore four degrees for the two circles, and one degree for the half ſpace: So ſhall the Suns Declination be five degrees, and about one fifth part of a degree Northward, that ſame day.

Example 3. What Declination hath the Sun upon the 13 day of *November?* Look the 13 day of *November*, and you ſhall find it below the Equinoctial ten Parallels, and about one quarter, which is 20 degrees and an half Southward. So much is the Declination. And according to theſe Examples judge of all the reſt.

USE III.

To find the Diurnal Arch or Circle of the Suns courſe every day.

The Sun every day by his motion (as hath been ſaid) deſcribeth a Circle parallel to the Equinoctial, which is either one of the Circles in the Dyal, al, or somewhere between two of them. First therefore seek the day of the month, and if it fall upon one of those Parallels, that is the Circle of the Suns course that same day: But if it fall between any two of the Parallels, imagine in your mind, and estimate with your eye, another parallel through that point between those two parallels, keeping still the same distance from each of them.

As in the first of the three former Examples, The Circle of the Suns course upon *August* 11. shall be the very sixth Circle above the Equinoctial towards the Centre.

In example 2. The Circle of the Suns course upon the 24 of *March* shall be an imaginary Circle between the second and third Parallels, still keeping an half of that space, and one fifth part more of the rest, from the second.

In example 3. The Circle of the Suns course upon the 13 of *Novemb.* shall be an imaginary Circle between the 10th and 11th Parallels below the Equinoctial, still keeping one quarter of that space from the tenth.

USE IV.

To find the Rising and Setting of the Sun every day.

Seek out (as was last shewed) the imaginary Circle or Parallel of the Suns course for that day, and mark the point where it meeteth with the Horizon, both on the *East* and *West* sides, for that is the very point of the Suns Rising and Setting that ſame day, and the hour-lines which are on both ſides of it, by proportioning the diſtance reaſonably, according to 15 minutes for the quarter of the hour, will ſhew the hour of the Suns Riſing on the Eaſt ſide, and the Suns Setting on the Weſt ſide.

USE V.

To know the reaſon and manner of the Increaſing and Decreaſing of the Days and Nights throughout the whole Year.

When the Sun is in the Equinoctial, it riſeth and ſetteth at 6 a clock: for in the inſtrument the interſection of the Equinoctial and the Ecliptick with the Horizon, is in the 6 a clock Circle on both ſides. But if the Sun be out of the Equinoctial, declining toward the North, the interſections of the Parallel of the Sun with the Horizon is before 6 in the morning, and after 6 in the evening: and the Diurnal Arch greater than 12 hours, and ſo much more great, the greater the Northern Declination is. Again, if the Sun be declining toward the South, the interſections of the Parallel of the Sun with the Horizon is after 6 in the morning, and before 6 in the evening: and the Diurnal Arch leſſer then 12 hours; and by ſo much leſſer, the greater the Southern Declination is.

And in thoſe places of the Ecliptick in which the Sun moſt ſpeedily changeth his Declination, the length alſo of the day is moſt altered: and where the Ecliptick goeth most parallel to the Equinoctial changing the Declination, but little altered. As for example: When the Sun is near unto the Equinoctial on both sides, the days increase and also decrease suddenly and apace; because in those places the Ecliptick inclineth to the Equinoctial in a manner like a straight Line, making sensible declination. Again, when the Sun is near his greatest declination, as in the height of Summer, and the depth of Winter, the days keep for a good time as it were at one stay, because in those places the Ecliptick is in a manner parallel to the Equinoctial, the length of the day also is bnt little, scarce altering the declination: And because in those two times of the year the Sun standeth as it were still at one declination, they are called the *Summer Solstice*, and *Winter-Solstice*. And in the mean space the nearer every place is to the Equinoctial, the greater is the diversity of days.

Wherefore we may hereby plainly see that the common received opinion, that in every month the days do equally increase, is erronious.

Also we may see that in Parallels equally distant from the Equinoctial, the day on the one side is equal to the night on the other side.

USE VI.

To find how far the Sun Riseth and Setteth from the true East and West Points, which is called the Suns Amplitude Ortive and Occasive.

Seek out (as was shewed in Use III.) the imaginary

ginary Circle or Parallel of the Suns courſe, and the points of that Circle in the Horizon, on the Eaſt and Weſt ſides cutteth the degree of the *Amplitude Ortive*, and *Occaſive*.

USE VII.

To find the Length of every Day and Night.

Double the hour of the Suns ſetting, and you ſhall have the length of the Day; and double the hour of the Suns riſing, and you ſhall have the length of the Night.

USE VIII.

To find the true place of the Sun upon the Dyal, that is, the point of the Inſtrument which anſwereth to the place of the Sun in the Heavens at any time, which is the ground of all the Queſtions following.

If the Dyal be fixed upon a Poſt, look what a clock it is by the outward Dyal, that is, look what hour and part of the hour the ſhadow of the ſlanting edge of the Style ſheweth in the outward Limb. Then behold the ſhadow of the upright edge, and mark what point thereof is upon that very hour and part in the inner Dyal among the Parallels, that point is the true place of the Sun at the ſame inſtant.

If the Dyal be not fixed, and you have a Meridian Line noted in any Window where the Sun ſhineth: place the Meridian of your Dyal upon the Meridian Line given, ſo that the top of the

Style may point into the North, and so the Dyal is as it were fixed, wherefore by the former Rule you may find the place of the Sun upon it.

If the Dyal be not fixed, neither you have a Meridian Line, but you know the true hour of the day exactly: hold the Dyal even and parallel to the Horizon, moving it till the slanting edge of the Style cast his shadow justly upon the time or hour given; for then the Dyal is truly placed, as upon a post. Seek therefore what point of the upright shadow falleth upon that very hour, and there is the place of the Sun.

But if your Dyal be loose, and you know neither the Meridian nor the time of the day; First, by the day of the month in the Ecliptick, find the Suns Parallel or Diurnal Arch for that day, then holding the Dyal level to the Horizon, move it every way until the slanting shadow of the Style in the outward Limb, and the upright shadow in the Suns Diurnal Arch, both shew the very same hour and minute; for that very point of the Suns Parallel which the upright shadow cutteth, is the true place of the Sun on the Dyal at that present.

But note that by reason of the thickness of the Style, and the bluntness of the angle of the upright edge, the Sun cannot come unto that edge for some space before and after noon. And so during the time that the Sun shineth not on that upright edg the place of the Sun in the Dyal cannot be found. Wherefore they that make this kind of Double Dyal, are to be careful to file the upright edge of the Style as thin and sharp as possible may be.

That which hath here been taught concerning

the

the finding out the Suns true place in the Dyal, ought perfectly to be underſtood, that it may be readily and dexterouſly practiſed, for upon the true performance thereof dependeth all that followeth.

USE IX.

To find the Hour of the Day.

If the Dyal be faſtened upon a Poſt, the hour by the outward Dyal or Limb, is known of every one, and the upright ſhadow in the Suns Parallel or Diurnal Arch will alſo ſhew the very ſame hour.

But if the Dyal be looſe, either hold it or ſet it parallel to the Horizon, with the Style pointing into the North, and move it gently every way, until the hour ſhewed in both Dyals exactly agreeeth; or which is all one, find out the true place of the Sun upon the Dyal, as was taught in the former queſtion, for that point among the hour-lines ſheweth the hour of the day.

USE X.

To find out the Meridian, and other points of the Compaſs.

Firſt you muſt ſeek the true hour of the day (by the laſt queſtion) for in that ſituation the Meridian of the Dyal ſtandeth directly North and South: and the Eaſt pointeth into the Eaſt, and the Weſt into the Weſt, and the reſt of the points may be given by allowing degrees $11\frac{1}{4}$ unto every point of the Compaſs.

USE XI.

To find out the Azimuth of the Sun, that is, the distance of the Vertical Circle, in which the Sun is at that present from the Meridian.

Set your Dyal upon any plain or flat, which is parallel to the Horizon, with the Meridian pointing directly North or South, as was last shewed: then follow with your Eye the upright shadow in a straight Line, till it cutteth the Horizon: for the degree in which the point of intersection is, shall shew how far the Suns *Azimuth* is distant from the East and West points, and the Complement thereof unto 90, shall give the distance thereof from the Meridian.

USE XII.

To find out the Declination of any Wall upon which the Sun shineth; that is, how far that Wall swerveth from the North or South, either Eastward or Westward.

Take a board, having one straight edge, and a Line stricken perpendicular upon it; apply the streight edge unto the Wall at what time the Sun shineth upon it, holding the board parallel to the Horizon: Set the Dyal thereon, and move it gently every way, until the same hour and minute be shewed in both Dyals, and so let it stand: then if the Dyal have one of the sides parallel to the Meridian strike a Line along that side upon the board

crossing

croſſing the perpendicular, or elſe with a Bodkin make a point upon the board, at each end of the Meridian, and taking away the inſtrument from the board, and the board from the wall, lay a Ruler to thoſe two points, and draw a line croſſing the perpendicular: for the angle which that line maketh with the perpendicular, is the angle of the declination of the Wall. And if it be a right angle, the wall is exactly eaſt or weſt: but if that line be parallel to the perpendicular, the wall is direct north or ſouth, without any declination at all.

You may alſo find out the declination of a wall if the Dyal be fixed on a Poſt not far from that wall, in this manner: Your board being applied to the Wall, as was ſhewed, hang up a thread with a plummet, ſo that the ſhadow of the thread may upon the board croſs the perpendicular line, make two pricks in the ſhadow, and run inſtantly to the Dyal, and look the horizontal diſtance of the Suns Azimuth or upright ſhadow from the Meridian. Then through the two pricks draw a line croſſing the perpendicular: and upon the point of the interſection make a Circle equal to the Horizon of your Inſtrument, in which Circle you ſhall from the line through the two pricks meaſure the Horizontal Diſtance of the Upright Shadow or Azimuth from the Meridian, that way toward which the Meridian is: draw a line out of the centre to the end of that Arch meaſured: and the angle which this laſt line maketh with the perpendicular, ſhall be equal to the declination of the wall.

USE

USE XIII.

How to place the Dyal upon a Post without any other Direction, but it self.

Set the Dyal upon the Post, with the Stile into the North, as near as you can guess: then move it this way and that way, till the same hour and minute be shewed, both in the inward and outward Dyals by the several shadows, as hath been already taught, for then the Dyal standeth in its truest situation; wherefore let it be nailed down in that very place.

USE XIV.

To find the height of the Sun at high noon every day.

Seek out the Diurnal Arch or Parallel of the Suns course for that day, (by Use III.) and with a pair of Compasses, setting one foot in the centre, and the other in the point of intersection of that Parallel with the Meridian, apply that same distance unto the Semidiameter divided: for that measure shall therein shew the degree of the Suns altitude above the Horizon that day at high noon.

USE XV.

To find the height of the Sun at any hour or time of the day.

Seek out the Diurnal Arch, or Parallel of the Suns course for that day: and mark what point of of it is in the very hour and minute propoſed. And with a pair of Compaſſes, ſetting one foot in the centre, and the other in that point of the Parallel, apply the ſame diſtance upon the Semidiameter divided: for that meaſure ſhall ſhew the degree of the Suns altitude above the Horizon at that time.

And by this means you may finde the height of the Sun above the horizon at every hour throughout the whole year, for the making of Rings and Cylinders, and other Inſtruments, which are uſed to ſhew the hour of the day.

USE XVI.

The height of the Sun being given, to find out the hour, or what it is a Clock.

This is the converſe of the former: Seek therefore in the Semidiameter divided, the height of the Sun given: and with a pair of Compaſſes, ſetting one foot in the centre, and the other at that height, apply the ſame diſtance unto the Diurnal Arch or Parallel of the Sun for that day: for that point of the Diurnal Arch upon which that ſame diſtance lights, is the true place of the Sun upon the Dyal; and ſheweth among the hour-lines the true time of the day.

USE XVII.

Conſiderations for uſing the Inſtrument in the night.

In ſuch queſtions as concern the night, or the time before Sun-riſing and after Sun-ſetting, the Inſtrument repreſenteth the lower Hemiſphere, wherein the Southern Pole is elevated. And therefore the Parallels which are above the Æquinoctial towards the centre, ſhall be for the Southern or Winter-Parallels: and thoſe beneath the Equinoctial for the Northern or Summer-Parallels; and the Eaſt ſhall be accounted for Weſt, and the Weſt for Eaſt; altogether contrary to that which was before, when the Inſtrument repreſented the upper Hemiſphere.

USE XVIII.

To find how many degrees the Sun is under the Horizon at any time of the night.

Seek the Declination of the Sun for the day propoſed, (by Uſe II.) and at the ſame declination the contrary ſide, imagine a Parallel for the Sun that night, and mark what point of it is in the very hour and minute propoſed: And with a pair of Compaſſes, ſetting one foot in the Centre, and the other in that point of the Parallel, apply that ſame diſtance unto the Semidiameter divided: for that meaſure ſhall ſhew the degree of the Suns depreſſion below the Horizon at that time.

USE XIX.

To find out the length of the Crepuſculum, or Twylight every day.

Seek the declination of the Sun for the day propoſed

posed, (by Use II.) And at the same declination on the contrary side, imagine a Parallel for the Sun that night: And with a pair of Compasses, setting one foot in the Centre, and the other at 72 degrees upon the semidiameter divided, apply that same distance unto the Suns Nocturnal Parallel: for that point of the Parallel upon which that same distance shall light, sheweth among the hour-lines the beginning of the Twilight in the morning, or the end of the Twilight in the evening.

USE XX.

If the day of the month be not known, to find it out by the Dyal.

For the working of this Question, either the Dyal must be fixed rightly on a Post, or else you must have a true Meridian Line drawn in some Window where the Sun shineth; wherefore supposing the Dyal to be justly set, either upon the Post, or upon the Meridian; Look what a clock it is by the outward Dyal, and observe what point of the upright shadow falleth upon the very same minute in the inner Dyal, and through that same point imagine a Parallel circle for the Suns course, that Imaginary Circle in the Ecliptick shall cut the day of the month.

Of

Of the General Horological Ring.

I. *The Description of it.*

THis Instrument serveth as a Dyal to find the hour of the day, not in one place onely (as the most part of Dyals do) but generally in all Countreys lying North of the Equinoctial; and therefore I call it, *The General Horological Ring.*

It consisteth of two Brazen Circles, a Diameter, and a little Ring to hang it by.

The two Circles are so made, that though they are to be set at right angles when you use the Instrument; yet for more convenient carrying, they may be one folded into the other.

The lesser of the two Circles is for the Equinoctial, having in the midst of the inner side or thickness a line round it, which is the true Equinoctial Circle, divided into twice 12 hours, from the two opposite points in which it is fastened within the greater.

The greater and outer of the two Circles is the Meridian: One quarter whereof, beginning at one of the points in which the Equinoctial is hung, is divided into 90 degrees.

The Diameter is fastened to the Meridian in two opposite points or poles, one of them being the very end of the Quadrant, and is the North Pole: Wherefore it is perpendicular to the Equinoctial, having his due position. The Diameter is broad, and slit in the middle, and about the slit on both sides are the months and days of the year.

And

And within this ſlit is a little ſliding Plate pierced through with a ſmall hole: which hole in the motion of it, while it is applied to the days of the year, repreſenteth the Axis of the World.

The little Ring whereby the Inſtrument hangeth, is made to ſlip up and down along the Quadrant: that ſo by help of a little Tooth annexed, the Inſtrument may be rectified to any Elevation of the Pole.

II. *The Uſe of it.*

IN uſing this Inſtrument, 1. The tooth of the little Ring muſt carefully be ſet to the height of the *Pole* in the *Quadrant*, for the place wherein you are.

2. The hole of the ſliding plate within the ſlit, muſt be brought exactly to the day of the month.

3. The *Equinoctial* is to be drawn out, and by means of the two ſtuds in the Meridian ſtaying it, it is to be ſet perpendicular thereto.

4. Gueſs as near as you can at the hour, and turn the hole of the little Plate toward it.

Laſtly, Hold the *Inſtrument* up by the little *Ring* that it may hang freely with the *North Pole* thereof toward the North, and move it gently this way and that way, till the beams of the Sun ſhining thorow that hole, fall upon that middle line within the Equinoctial: for there ſhall be the hour of the day: And the Meridian of the Inſtrument ſhall hang directly North and South.

FINIS.

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