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

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 certaine *Problemes* no lesse ingenious than recreative, which drew me unto the search of demonstrations more difficult and serious; some of which I have amassed and caused to passe the *Presse*, and here 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 *Nobilitie*, and *Gentrie* rather studie the *Mathematicall Arts*, to content and satisfie their affections, in the speculation of such admirable experiments as are extracted from them, than in hope of gaine to fill their *Purses*. All which studies, and others, with my whole indevours, I shall alwayes dedicate unto your Honour, with an ardent desire to be accounted ever,

Your most humble and obedient Nephew and Servant,

H. VAN ETTEN.

Mathematicall RECREATIONS.

OR,

A Collection of many *Problemes*, extracted out of the Ancient and Modern Philosophers, as Secrets and Experiments in *Arithmetick*, *Geometry*, *Cosmographie*, *Horologiographie*, *Astronomie*, *Navigation*, *Musick*, *Opticks*, *Architecture*, *Statick*, *Mechanicks*, *Chemistry*, *Water-works*, *Fire-works*, &c. Not vulgarly manifest till now.

Written first in *Greek* and *Latin*, lately compil'd in 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 *Generall Horologicall Ring*.

And

The *Double Horizontall Diall*.

Invented and written by

WILLIAM OUGHTRED.

LONDON,
Printed for *William Leake*, at the Signe of the *Crown* in *Fleetstreet*, between the two *Temple-Gates*, *M DC LIII*.

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To the Reader.

IT hath been obſerved by many, that ſundry fine wits as well amongſt the Ancient as Moderne, have ſported and delighted themſelves upon ſeverall 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 greatneſſe of their glory in the ſmalneſſe of the ſubject: And have amongſt moſt ſolid and artificiall concluſions, compoſed and produced ſundry Inventions both Philoſophicall and Mathematicall, to ſolace the minde, and recreate the ſpirits, which the ſucceeding ages have imbraced, and from them gleaned and extracted many admirable, and rare concluſions; judging that borrowed matter often-times yeelds praiſe to the induſtry of its author. Hence for thy uſe (Courteous Reader) I have with

great

great ſearch and labour collected alſo, and heaped up together in a body of theſe pleaſant and fine experiments to ſtirre up and delight the affectionate, (out of the writings of Socrates, Plato, Ariſtotle, Demoſthenes, Pythagoras, Democrates, Plinie, Hyparchus, Euclides, Vitruvius, Diaphantus, Pergæus, Archimedes, Papus Alexandrinus, Vitellius, Ptolomæus, Copernicus, Proclus, Mauralicus, Cardanus, Valalpandus, Kepleirus, Gilbertus, Tychonius, Dureirus, Joſephus . Clavius, Gallileus Maginus, Euphanus Tyberill, *and others) knowing Art imitating Nature that glories alwayes in the variety of things, which ſhe produceth to ſatisfie the minde of curious inquiſitors. And though perhaps theſe labours to ſome humourous perſons may ſeeme vaine, 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 minde in uſefull knowledge, rather than to be buſied in vaine* Pamphlets, Play-books, *fruitleſſe* Legends, *and prodigious* Hiſtories *that are invented out of fancie, which abuſe many* Noble ſpirits, *dull their wits, & alien-*

ate

By vvay of advertisement.

Five or six things I have thought worthy to declare before I passe 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 subtiltie of the way; for that which doth ravish the spirits is, *an admirable effect, whose cause is unknowne*: which if it were discovered, halfe the pleasure is lost; therefore all the finenesse consists in the dexterity

dexterity of the Act, concealing the meanes, and changing often the streame.

Thirdly, great care ought to be had that one deceive not himselfe, that would declare by way of Art to deceive another: this will make the matter contemptible to ignorant Persons, which will rather cast the fault upon the Science, than upon him that shewes it: when the cause is not in the Mathematicall principles, but in him that failes in the acting of it.

Fourthly, in certaine Arithmeticall propositions they have onely their answers as I found them in sundry Authors, which any one being studious of Mathematicall learning, may finde their originall, and also the way of their operation.

Fifthly, because the number of these *Problemes*, and their dependances are many, and intermixed, I thought it convenient to gather them into a Table: that so each one according to his fancie, might make best choise of that which might best please his palate, the matter being not of one nature, nor of like subtiltie: But whosoever will have patience to read on, shall finde the end better than the beginning.

ate their thoughts from laudable and honourable Studies. *In this* Tractate *thou maist therefore make choise of such* Mathematicall Problemes *and Conclusions as may delight thee, which kinde of learning doth excellently adorne a man; seeing the usefulnesse thereof, and the manly accomplishments it doth produce, is profitable and delightfull for all sorts of people, who may furnish and adorne themselves with abundance of matter in that kinde, to help them by way of use, and discourse. And to this we have also added our* Pyrotechnie, *knowing that* Beasts *have for their object only 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 soare in an higher Contemplation, having so glittering a Canopie to behold, and these pleasant and recreative* fires *ascending may cause thy affections also to ascend. The Whole 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.*

A Table of the particular heads of this Book, contracted according to the ſeverall Arts ſpecified in the Title-page.

Experiments of Arithmetick

Experiments n Geometrie.

Experiments in Coſmographie.

Experiments in Horologiographie.

Experiments in Aſtronomie.

Experiments in Navigation.

Experiments in Muſick.

Ex-

FINIS.

The end.

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A Table of the Contents, and chiefe points conteined in this Book.

* Prob.

Prob. 39

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Of

Of

COROLARIE.

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Of

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Certaine

Certaine fine Obſervations.

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Prob.

FINIS.

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, Ptolemæi 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.

MATHEMATICAL RECREATION.

Problem I.

To finde 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 adde 6, 8, 10, or any Number at pleasure: and let him take the halfe of the sum, then ask how much it coms 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.

Examp'e

The Number thought upon	5
The Quadruple of it	20
Put 8 unto it, makes	28
The halfe of it is	14

Take away halfe the number added from it, *viz.* 4, the rest is } 10

The double of the number thought upon, *viz.* 10

Another way to finde what Number was thought upon.

Bid him which thinketh double his Number, and unto that double adde 4, and bid him multiply that same product by 5, and unto that product bid him adde 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	For which 700 account onely but the number of the hundreds *viz.* 7. so have you the number thought upon.
His double	14	
To it add 4, makes	18	
Which multiplyed by 5 makes	90	
To which add 12 makes	102	
This multiplyed by 10 which is only by adding a Cypher to it, makes	1020	
From this subtract	320	
Rest	700	

To finde numbers conceived upon, otherwiſe than the former.

BId the party which thinks the number, that he triple his thought, and cauſe him to take the half of it: (if it be odde take the leaſt half, and put one unto it:) then will him to triple 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 triples were even: but if it be odde at the firſt triple, and even at the ſecond, for the one added unto the leaſt halfe keep one in memory: if the firſt triple be even, and the ſecond odde, for the one added unto the leaſt halfe keepe two in memory: laſtly, if at both times in tripling, the numbers be odde, for the two added unto the leaſt halfes, keep three in memory, theſe cautions obſerved, and added unto as many fours as the party ſayes there is nines contained in the laſt halfe, ſhall never fail you to declare or diſcern truly what number was thought upon.

Example.

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

The first 1. representeth the 4. 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 8. 10. &c. from the Number which remains, for to finde 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 2. *Book* & 4. *proposition* this may bee extracted, for these 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 adde the double product of the parts, then ask what it amounteth unto, so the *root Quadrat* shall be the number thought upon.

The number thought upon 5, the parts suppose 3 and 2.

The

The ſquare of 3 makes 9
The ſquare of 2 makes 4
The product of the parts. *viz.* 3 by 2 makes 6, which doubled makes 12
the ſum of theſe three nũbers 25, the *ſqua e 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, adde the ſquare of half the difference of the parts, then the Root Quadrat of the aggregate is halfe 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* Optickes, *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 delightfull and pleasant to the beholders, then make the Room dark, by shutting out the light, except a small hole of six pence 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 neer the hole: & if unto the hole you place a round glasse, that is, a glasse wch 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 seeme dead, and of a darkish colour, will appear and be seen upon the paper, or white cloth, ac-

cording

cording to their naturall colours, yea more lively than their naturall, and the appearances wil be so much the more beautifull and perfect, by how much the hole is lesser, the day cleere, and the sun shining.

It is pleasant to see the beautifull and goodly representation of the heavens intermixed with clouds in the Horizon, upon a woody scituation, the motion of Birds in the Aire, 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 beautifull paint will so naturally represent it self in such a lively Perspective, that hardly the most accurate Painter can represent the like.

Now the reason why the Images and objects without are inversed, is because the species doe intersect one another in the hole, so that the species of the feet ascend, and these of the head descend.

But here note, that they may be represented right two manner of wayes; first, with a concave glasse: secondly, by help of another convex glasse, disposed or placed between the paper and the other Glasse: as may be seen here by the figure.

Now

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 perspectivewise, as *Topographicall 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 humor at the small of the Glasse, and the bottome of the eye, for the Wall or leafe 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 selfe not only in one hole of a window, but in infinite holes, even unto the whole Sphere, *or at least unto a* Hemisphere *(intellectuall 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 convexe, or concave Glasses *the* Images *will be disproportionable to the* eye, *by how much they are more concave, or convexe, & by how much the parts of the* image *comes neer*

neer to the Axis, *for these that are neer are better proportioned then these which are farther off.*

But to have them more lively and true, according to the imaginary conicall section, let the hole be no greater than a pins head made upon a piece of thin brasse, 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 plaine will make two like Cones, and will lively represent the things without in a perfect inversed perspective, which drawn by the* Pensill *of some artificiall* Painter, *turn the paper upside down, and it will be direct and to the life.*

But the apparences 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* glas *reflect upon a paper or some white thing.*

PROBLEM III.

To tell how much waighs 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 *Maximillian* the

the Emperour did propose upon a day this *Question*, and promised to give the resolution; notwithstanding *Scaliger* delivered it not, and I conceive it to be thus. Take a Balance, and let the Fist, the Mallet, or Hatchet rest upon the scale, or upon the beam of the Balance, and put into the other Scale as much weight as may counterpoyse it; then charging or laying more waight 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 waigh for as *Aristotle* saith, *The motion that is made in striking adds great waight 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 pounde waight 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 leafe 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 quicknesse of the motion, which breaks and enters without resistance, if it be extream quick, as experience shews us in the

blows

blows of Arrows, of Cannons, Thunder-boults, and such like.

EXAMINATION.

THis Problem *was extracted from* Scaliger, *who had it from* Aristotle, *but somwhat refractory compiled, & the strength of the effect he says depends only 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 severall hammers, the one being* 20 *times heavier than the other, should move with like quickness, the effect would be much different: there is then some thing 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 neer at hand, is not so forceable as if it fell farther down; and when a bullet flying out of a* peece *and striking the mark neer 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.*

PROBLEM IV.

How to break a staffe which is laid upon two Glasses full of Water, without breaking the Glasses, 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 stooles, or such like, the one as high as the other from the ground, and distant one from another by 2 or 3 foot, then place the ends of the staffe upon the edges of the two Glasses so that they be sharp, this done, with all the force you can, with another staffe strike the staffe which is upon the two Glasses in the middle, and it will breake without breaking the Glasses or spilling the water.

In like manner may you doe upon two Reeds, held with your hands in the aire without breaking them; thence Kitchin boyes often break bones of mutton upon their hand, or with a napkin without any hurt, in only striking upon the middle of the bone with a knife.

Now

Now in this act, the two ends of the staffe in breaking slides away from the Glasses, upon which they were placed; hence it commeth that the Glasses are no wise indangered, no more than the knee upon which a staffe 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 staffe upon two props, and then making tryall upon it, by which you may see how the* Staffe *will either break, bow, or depart from his props, and that either directly or obliquely: But why by this violence, that one* Staffe *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 faire Ge graphic ll Card in a Garden Plot, fit for a Prince, or great personage.

IT is usuall amongst great men to have faire *Geographicall 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 generall knowledge, not only of their own Kingdoms form, scituation, longitude, latitude, &c. but of all other places in the whole Universe, with their magnitudes, positions, Climats, 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 generall description might particularly and artificially be prefigured his whole Kingdoms and Dominions, the Mountains and hils being raised like small hillocks with turfs of earth, the valleys somwhat 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 remarkable edifices in small green mossie banks, or spring-work proportionall to the platform,

form, 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 artificiall Fountain made in the Garden to passe through chanels; then may there be composed walks of pleasure, ascents, places of repose, adorned with all variety of delightfull herbs and flowers, both to please the eye or other senses. A Garden thus accommodated shall farre exceed that of my Lord of *Verulams* specified in his Essayes; that being only for delight and pleasure, this may have all the properties of that, and also for singular use, by which a Prince may in little time personally visit his whole Kingdom, and in short time know them 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 aire, without being supported by any thing but by themselves.

TAke the first staffe A B, raise up in the aire the end B, and upon him cros-wise place the staffe C B, then lastly, in Triangle wise place the third staffe E F in such manner that it may be under A B, and yet upon C D. I say that these staves so disposed cannot fall, and the

the ſpace C B E is made the ſtronger, by how much the more it is preſſed downe, if the *ſtaves* break not, or ſever themſelves from the *triangular* forme: ſo that alwayes the Center of gravitie 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 remaine theſe which you would have.

ORdinarily the propoſition is delivered in this wiſe: 15 *Chriſtians* and 15 *Turkes* being at Sea in one *Shippe*, an extreame tempeſt being riſen, the Pilot of the *Shippe* ſaith, it is neceſſary to caſt over board halfe of the number of *Perſons* to disburthen the *Shippe*, and to save the rest: now it was agreed to be done by lot, and therefore they consent to put themselves in rank, counting by nine and nine, the ninth Person should alwayes be cast into the Sea, untill there were halfe throwne over board; Now the Pilote being a Christian indeavoured to save the Christians, how ought he therefore to dispose the Christians, that the lot might fall alwayes upon the Turkes, and 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* foure, and *u* five: *o* the first vowell in the first word sheweth that there must be placed 4. Christians; the next vowel *u*, signifieth that next unto the 4. Christians must be placed 5 Turkes, and so to place both Christians and Turkes according to the quantity and value of the vowels in the words of the verse, untill 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 Probleme is not to be limited, seeing it extends to any number and order whatsoever, and may many wayes be usefull for Captaines, Magistrates, or others which have divers persons to punish, and would chastise chiefely the unruliest of them, in taking the 10, 20, or 100. person, &c. as we reade was commonly practised amongst the ancient Romans: herefore to apply a generall rule in counting the third, 4, 9, 10, &c. amongst 30, 40, 50, persons, and more or lesse; this is to be observed, take as many units 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 eight man should be alwayes 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 alwayes marking the eighth, untill you have markt 6, by which you may easily perceive how to place those 6 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 beliefe 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, accompanyed with a Troop of forty 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 distresse would have butchered one another for sustenance, had not *Josephus* perswaded them to die by lot and order, upon which it should fall: Now feeing that *Josephus* did save himselfe by this Art, it is thought that his industry was exercised by the helpe of this Problem, so that of the 40 persons which he had, the third was alwayes killed. Now by putting himselfe in the 16 or 31 place he was saved, and one with him which he might kill, or easily perswade to yeild unto the Romans.

PROBLEM. VIII.

Three things, and three persons proposed, to finde 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 selfe once known by the aforesaid Vowels, which signifie for the first vowel 1, for the second vowell 2, for the third vowell 3.

Now if the said three persons should by the mutuall consent of each other privately change their names, it is most facill by the course and excellencie 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 finde 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 conceale 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 vowell; to the ſecond 2. Counters, which repreſent *e*, the ſecond vowel; and to the third 3. Counters, which ſtand for *i*, the third vowell: 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 ſurpluſe you may privately reject. And then there will be left either 1.2.3.5.6 or 7. and no other number can remaine, which if there be, then they have failed in taking according to the directions delivered: but if either of theſe numbers do remaine, the reſolution will be diſcovered by one of theſe 6 words following, which ought to be had in memory, *viz.*

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

As

As ſuppoſe 5. did remaine, the word belonging unto it is *ſemita* , the vowels in the firſt two ſyllables are *e* and *i*, vvhich ſhevveth according to the former directions , that to vvhom you gave 2 Counters, he hath the Ring (ſeeing it is the ſecond vovvell repreſented by tvvo as before) and to vvhom you gave the 3. Counters, he hath the Gold , for that *i* repreſents the third vovvel, or 3. in the former direction, and to vvhom you gave one Counter , he hath the Silver, and ſo of the reſt: the variety of changes, in vvhich 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 done alſo without the former words by help of the Circle *A.* for having divided the Circle into 6 parts , write 1. within and 1. vvithout, 2. vvithin and 5. vvithout, &c. the firſt 1.2. 3. vvhich are vvithin vvith the numbers over them , belongs to the upper ſemicircle ; the other numbers both vvithin and vvithout , to the under ſemicircle; novv 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 remains, 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 5 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 conteining eight pints into two equall parts, by two other vessels which conteine as much as the greater vessell; 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, poure out A into B until it be full, so there will be in B 5 pints, and in A but 3 pints: then poure out of B into C untill it be full: so in C shall be 3 pints, in B 2 pints, and in A 3 pints, then poure the wine which is in C into A, so in A will be 6 pints, in B 2 pints, and in C nothing: then poure out the wine which is in B into the

pot

pot C, so in C there is now 2 pints, in B nothing, and in A 6 pints,. Lastly, poure out of A into B untill it be full, so there will be now in A only 1 pint, in B 5 pints, and in C 2 pints. But it is now evident, that if from B you poure in unto the pot C untill it be full, there wil remain in B 4 pints, and if that which is in C, *viz.* 3 pints be poured into the vessell A, which before had 1 pint, there

shall be in the vessel A, but halfe of its liquor that was in it at the first, *viz.* 4 pints as was required. Otherwise poure out of A into C untill it be full, which pour into B, then poure out of A into C again untill it be full, so there is now in A onely 2 pints, in B 3, and in C 3, then pour from C into B untill it be full, so in C there is now but 1 pint, 5 in B, and 2 in A: poure all that is in B into A, then poure the wine which is in C into B, so there is in C nothing, in B onely 1 pint, and in 7 A 7 pints: Lastly, out of A fill the pot C, so there will remain in A 4 pints, or be but halfe 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 vessell which conteins 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 tvvo knives or ſuch like of equall poiſe, at the end of the ſtick, leaning out ſomevvhat 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, vvill there reſt vvithout 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 gravitie is ſupported by the top of the finger: and ſeeing that each part by the knives is counterpoiſed, it cannot fall ſidevviſe, therefore it can fall no vviſe.

In like manner may great pieces of Timber, as Joiſts, &c be ſupported, if unto one of the ends be applied convenient proportionall counterpoiſes, yea a Lance or Pike, may ſtand perpendicular in the Aire upon the top of ones finger: or placed in the midſt of a Court by help of his Centre of gravitie.

EXAMI-

EXAMINATION.

THis Proposition seems doubtfull; for to imagine absolutely, that a Pike, or such like, armed with two Knives, or other things, shall stand upright in the Aire, 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 so accommodated upon his Centre of gravity, but that it may incline to some one part without some remedy be applied, and such as is here specified in the Probleme 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 parts (by reason of the Centricall motion) is made more ponderous, and therefore lesse in rest.

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

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 center of gravitie 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 ſinke one with another: that which is abſurd and impoiſible 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 uniforme in matter and figure, and that it be erected perpendicular to the *Horizon*, and laſtly, that the *Center* of *gravity* be exactly found.

PROB.

Problem XII.

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

FIt the three *Knives* in form of a *Ballance*, and holding a *Needle* in your hand, and place the back of that Knife which lyes 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 turne and move upon the point of the Needle with ou falling.

Problem XIII.

To finde the weight of Smoak, which is exhaled of any combuſtible body whatſoever.

LEt it be ſuppoſed that a great heape of Fagots, or a load of ſtraw weighing 500 pound ſhould be fired, it is evident that this groſſe ſubſtance will be all inverted into ſmoak and aſhes: now it ſeems that the *ſmoak* weighs nothing; ſeeing it is of a thin ſubſtance now dilated in the Aire, 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

the reſt of the matter is not loſt, but is exhaled into *ſmoake*, 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 aire,) if it ſhould change his medium, then would we change our diſcourſe.

Problem XVI.

Many things being diſpoſed circular, (or otherwiſe) to finde 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 G, which is the 7: ask the party at what

letter

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 hee thought upon, so at E he shal account to himself 7, at D account 8, at C account 9, &c. So the account of 15 wil 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 downe, as the ten simple Cards, with the King and Queen, the King standing for 12, and the Queene for 11, and so knowing the situation of the Cards: and thinking a certain houre 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 houre thought upon, which being turned up will give grace to the action, and wonder to those that are ignorant in the cause.

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 artificiall disposer of foure 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 staffe (or such like) upon a Table, and nothing holding or touching it.

TAke a pale which hath a handle, and fill it full of water (or at pleasure:) then take a staffe or stick which may not rowle upon the Table as E C, and place the handle of the Pale upon the staffe; then place another staffe, or stick, under the staffe C B, which may reach from the bottom of the Pale unto the former staffe C E, perpendicular wise: which suppose F G, then shall the Pale of water hang without fal-

falling, for if it fall it must fall perpendicularly, or plumbe wise: and that cannot be seeing the staffe C E supports it, it being Parallel to the Horizon and susteined by the Table, and it is a thing admirable that if the staffe C E were alone from the table,

and that end of the staffe 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 Probleme, *a man would acknowledge either a possibility or impossibity; 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*

with two ſticks, as the figure declareth, it is made facile: for the Horizontall line to the edge of the Table, is the Centre of motion; and paſſeth by the Centre of gravity, which neceſſarily ſupporteth it.

Problem XVII.

Of a deceitfull Bowle to play withall.

MAke a hole in one ſide of the Bowle, 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 Bowle is caſt directly to the play, how it wil turn away ſide-wiſe: for that on that part of the Bowle which is heavier upon the one ſide then on 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.or 8. like parts, without breaking the Rinde.

PAsse a needle and threed under the kindof the Apple, and then round it with divers turnings, untill you come to the place where you began: then draw out the threed 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 alwayes whole.

Problem XIX.

To finde a number thought upon without asking of any question, certaine operations being done.

BId him adde to the number thought (as admit 15) halfe of it, if it may be, if not the greatest halfe that exceeds the other but by an unite, which is 8; and it makes 23. Secondly, unto this 23. adde the halfe of it if it may be, if not, the greatest halfe, *viz.* 12. makes 35. in the meane time, note that if the number thought upon cannot be halfed at the first time, as here it cannot, then for it keep 3 in the memory, if at the second time it will not be equally halfed, reserve 2 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 summe, *viz.* 35. to subtract the double of the number thought, *viz.* 30. rest 5. will him to take the halfe of that if he can, if not, reject 1. and then take the halfe of the rest, which keep in your memory: then will him to take the halfe againe if he can, if not, take one from it, which reserve in your memory, and so perpetually halveing untill 1. remaine: for then mark how many halfes there were taken, for the first halfe account 2, for the second 4, for the third 8, &c. and adde unto those numbers the ones which you reserved in memory, so there being 5 remaining in this proposition, there were 2 halfings: for which last I account 4, but because it could not exactly be halved without rejecting of 1. I adde the 1 therefore to this 4, makes 5, which halfe or summe alwayes multiplied by 4, makes 20. from which subtract the first 3 and 2, because the halfe could not be formerly added, leaves 15, the number thought upon.

Other Examples.

The number thought 12
The halfe of it 6
The summe 18
The halfe of it 9
The summe of it 27
The double of the number, 24
Which taken away, rests 3

The halfe of it 1
For which account 2
and 1 put to it because the 3
could not be halfed, makes 3
this multiplied by 4 makes 12

The number thought upon.

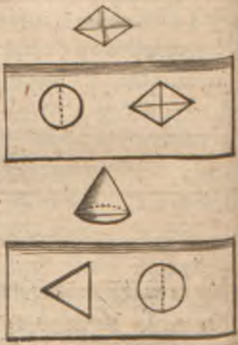
The number thought 79
The greatest halfe 40 3
The summe 119
The greatest halfe of which is 60 2
The summe of it is 179
The double of 79 is 158
Which taken from it, rests 21
The lesser half 10. wch halves
The halfe of this is 5 which makes
The half of this is 2 wch is 10
The half of this is 1, with 10 and 11 is 21.
this 21 which is the double of the last halfe with the remainder being multiplied by 4. makes 84, from which take the aforesaid 3 and 2, rest 79, the number thought upon.

PROBLEM. XX.

How to make an uniforme, & an inflexible body, to passe through two small holes of divers formes, as one being circular, and the other square, Quadrangular, and Triangular-wise, yet so that the holes shall be exactly filled.

THis Probleme is extracted fr[illegible] Geometricall observations, and se[illegible]es at the first some-

ſomewhat obſcure, yet that which may be extracted in this nature, will appeare more difficult and admirable. Now in all Geometricall practiſes, the leſſer or eaſier Problemes do alwayes make way to facilitate the greater: and the aforeſaid Probleme is thus reſolved. Take a Cone or round Pyramide, and make a Circular hole in ſome board, or other hard material, which may be equall to the baſes of the Cone, and alſo a Triangular hole, one of whoſe ſides may be equall to the Diameter of the circle, and the other two ſides equall to the length of the Cone: Now it is moſt evident, that this Conicall or Pyramidall 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 equal to the Diameter of the Cones conjoyned, and a Quadrangular hole, whoſe ſloping ſides be equall 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 Quadrangle hole.

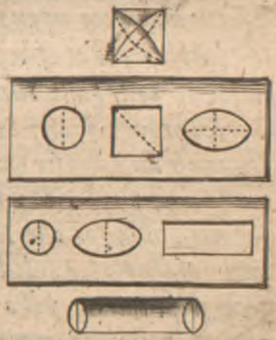


PROB.

PROBLEM. XXI.

How with one uniforme body or ſuch like to fill three ſeverall holes: of which the one is round, the other a juſt ſquare, and the third an ovall forme?

THis Propoſition ſeemes more ſubtill then the former, yet it may be practiſed two wayes: for the firſt, take a Cylindricall body as great or little as you pleaſe: Now it is evident that it will fill a Circular hole, which is made equall to the baſis of it, if it be placed downe right, and will alſo fill a long ſquare; whoſe ſides are equall unto the Diameter and length of the Cylinder, and acording to *Pergeus*, *Archimedes*, &c. in their Cylindricall demonſtrations, a true Ovall is made when a Cylinder is cut ſlopewiſe, therefore if the oval have breadth equall unto the Diameter of the Baſis of the Cylinder, & any length whatſoever: the Cylinder being put into his owne Ovall hole ſhall alſo exactly fill it.



The ſecond way is thus, make a Circular hole in ſome board, & alſo a ſquare hole, the ſide of which Square may be equall to the Diameter of the Circle: and laſtly,make a hole Oval-wiſe, whoſe breadth may be equal unto the diagonall of the Square ; then let a Cylindricall body be made, whoſe Baſis may be equall unto the Circle, and the length equall alſo to the ſame : Now being placed downe right ſhall fall in the Circle, and flat-wiſe will fit the Square hole, and being placed ſloping-wiſe will fill the O-vall.

EXAMINATION.

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

PROBLEM XXII.

To finde a number thought upon after another manner, then 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 againe 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 & 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 seemes 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 adde the number thought upon to it, and aske him how much it makes: then subtract your Quotient from it, there will remaine the number thought upon. For example, suppose the number thought upon were 5, multiply it by 4 makes 20. this divided by 2, the Quotient makes 10, which multiplyed 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 12 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 knowne.

Problem XXIII.

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

IF the multitude of numbers thoughtupon be odde, 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, vvhich makes 11, and ſo alvvayes adding the tvvo next together, aske him hovv much the firſt and laſt makes togerher, vvhich is 8. then take theſe ſummes, and place them in order, and adde all theſe together, vvhich vvere in the odde places: that is the firſt, third, and fifth, *viz.* 5, 9, 8, makes 22. In like manner adde all theſe numbets together, vvhich are in the even places, that is in the ſecond and fourth places, *viz.* 7 and 11 makes 18, ſubſtract this from the former 22, then there vvill remaine the double of the first number thought upon, *viz.* 4. which known, the rest is easily known: seeing you know the summe 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 partie to declare the summe of each two, by antecedent and consequent, and also the summe of the second and last, which will be 5,7,9,11,13,10, then adde the odde places together, except the first, that is 9, and 13, makes 22; adde also the even places together, that is 7,11,10, which makes 28; substract the one from the other, there shall remaine the double of the second number thought upon, which known all the rest are knowne.

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 facill, 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 his Cosmographie, & first dialogue, reported of one that thought he was led by one of the Muses to hell, where he saw Lucifer sitting in 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 halfe on this side of the Centre of the earth, and the other halfe 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 and farther, one from another; notwithstanding both of them being of like height.

Problem. XXVI.

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

THe opening of this is easie, forasmuch as he that possesseth a Rod of ground posses-

seth

ſeth 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 & 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 viſible quantity; and therefore if there were made or imagined ſo to be made, a deſcent to go to the bottome 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 that if the partie be under either of the Poles, for if he be under the North-pole, then looking any way he looketh South, becauſe all the Meridians concurre in the Poles of the world, and if he be under the South-pole, he looks directly North by the ſame reaſon.

Problem XXVIII.

To tell any one what number remaines after certaine operations being ended, without asking any question.

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 adde what number you please, provided that secretly you consider, that it may be divided by that which multiplied, and then let him divide the sum by the number which he first multi lied by, and substract from this Quotient the number thought upon: In the same time divide apart the number which was added by that which multiplied, so then your Quotient shall be equall to his remainder, wherefore without asking him any thing, you shall tell him what did remaine, which will seem strange to him that knoweth not the cause: for example, suppose he thought 7, which multiplied by 5 makes 35, to which adde 10, makes 45, which divided by 5, yields 9, from which if you take away one the number thought, (because the Multiplier divided by the Divisor gives the Quotient 1,) the rest will be two, which will be also proved, if 10 the number which was added, were divided by 5, *viz.* 2.

Problem XXIX.

Of the play with two severall things.

IT is a pleasure to see and consider how the science of numbers doth furnish us, not only with sports, to recreate the spirits, but also bring us to the knowledge of admirable things, as shall in some measure be shewen in this ensuing progression. In the meane time to produce alwayes 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 have a certaine 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 Crownes, or Shillings, and the Silver at 3 Crownes, or 3 Shillings, or any other number, so that one be odde, and the other even, as before; then bid him triple that which is in the right hand, & double that which is in the left hand, and bid him adde these two products together, and aske him if it be even or odde; if it be even, then the Gold is in the right hand; if odde, the Gold is in the left hand.

Problem. XXX.

Two numbers being proposed unto two severall 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 odde, as 10. and 9. and let the one of them take one of the numbers, and the other partie take the other number, which they place privately to themselves: how artificially, according to the congruity, and excellency of numbers, to finde which of them did take 10. and which 9. without asking any qustion: and this seems most subtill, yet delivered howsoever differing little from the former, and is thus performed: Take privately to your selfe also two numbers, the one even, and theother odde, 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: adde your two products together, & mark if it be even or odde, then bid the two parties put their numbers together, and bid them take the halfe of it, which if they cannot do, then immediately tell *Peter* he took 10. and *John* 9. because the aggregate of the double of 4. and the triple of 3. makes odde, and such would be the aggregate or summe of the double of *Peters* number and *Johns* number, if *Peter* had taken 10. if otherwise, then they might have taken halfe, and so *John* should have taken 10. and *Peter* 9. as suppose *Peter* had taken 10. the double is 20. and the triple of 9. the other umber is 27. which put together makes 47. odde: in like manner the double of your number conceived in minde, *viz.* 4. makes 8. and the triple of the 3. the other number, makes 9. which set together makes 17. odde. Now you cannot take the halfe of 17, nor 47. which argueth that *Peter* had the greater number, for otherwise the double of 9. is 18. & the triple of 10. is 30. which set together makes 48. the halfe of it may be taken: therefore in such case *Peter* the took lesse number: and *John* the greater, and this being don cleanly carries much grace with it.

PROBLEM. XXXI.

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

LEt the three points be *A. B. C.* put one foot of the Compasse upon *A.* and describe an Arch of a Circle at pleasure: and placed at *B.* crosse that Arch in the two points *E.* and *F.* and placed in *C.* crosse the Arch in *G.* and *H.* then lay a ruler upon *G. H.* and draw a line, and place

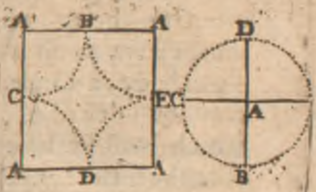
place a Ruler upon *E.* and *F.* cut the other line in *K*, so *K* is the Centre of the Circumference of a Circle, which will passe by the said three points *A. B. C.* or it may be inverted, having a Circle drawne; to finde the Centre of that Circle, make 3. points in the circumference, and then use the same way: so shall you have the Centre, a thing most facill to every practitioner in the principles of Geometrie.

Problem. XXXII.

How to change a Circle into a square forme?

Make a Circle upon past-board or other materiall, as the Circle *A.C.D E.* of which *A.* is the Centre; then cut it into 4.quarters, and dispose them so, that *A.* at the centre of the Circle may alwayes be at the *Angle* of the square, and so the foure quarters of the Circle

Circle being placed so, it will make a perfect square, whose side *A. A.* is equall to the Diameter *B. D.* Now here is to be noted that the square is greater then 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 concentricall, that is, greater or lesser one then another?

IT is not without cause that many admire how this Proposition is to be resolved; yea in the judgement of some it is thought impossible: who consider not the industrie of an ingenious Geometrician, who makes it possible, and that most facill, sundry wayes; for in the first place if you make a Circle upon a fine plaine, and upon the Centre of that Circle, a small pegge of wood be placed, to be raised up and put downe at pleasure by help of a small hole made in the Centre, then with the same opening of the Compasses, you may describe Circles Concentricall, that is, one greater or lesser than another; for the higher the Center is lifted up, the lesser the Circle will be. Secondly, the compasse being at that extent upon a *Gibus* body, a Circle may be described, which will be lesse than the former, upon a plaine, and more artificially upon a Globe, or round bowle: and this againe is most obvious upon a round Pyramide, placing the Compasses upon the top of it, which will be farre lesse than any of the former; and this is demonstrated by the 20. Prop. of the first of *Euclids*, for the Diameter *E D*. is lesse than the line *A D*. & *A E*. taken together, and the lines *A D*. *A E*. being equall to the Diameter *B C*. because of the same distance or extent of opening the compasses, it followes that the Diameter *E*.*D*. and all his Circles together is much lesse than the Diameter, and the Circle *B C*. which was to be performed.

PROB.

Problem XXXIV.

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

LEt the first number be doubled, and unto it adde 5. and multiply that summe by 5. and unto it adde 10. and unto this product add the next number thought upon; multiply this same againe by 10. and adde unto it the next number, and so proceed: now if he declare the last summe; marke if he thought but upon one figure, for then subtract only 35. from it, and the first figure in the place of tennes is the number thought upon: if he thought upon two figures, then subtract also the said 35. from his last summe, and the two figures which remaine 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 adde 5. makes 15. this multiplied by 5. makes 75. to which adde 10. makes 85. to this adde the next number, *viz.* 7. makes 92. this multiplied by 10. makes 920. to which adde the next number, *viz.* 9. makes 929. which multiplied by 10. makes 9290. to which adde 6. makes 9296. from which subtract 3500. resteth 5796. the foure numbers thought upon. Now because the two last figures are like the two numbers thought upon: to conceale this, bid him take the halfe of it, or put first 12. or any othet number to it, and then it will not be so open.

PROBLEM. XXXV.
Of the Play with the Ring.

AMongst a company of 9. or 10. persons, one of them having a Ring, or such like: to finde out in which hand: upon which finger, & joynt it is; this will cause great astonishment to ignorant spirits, which will make them beleeve 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 Probleme: 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 appeares that in performing this Play there is nothing else to be done than to think 4. 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 finde it out: thus I would proceed, as in the 34 Problem: in causing him to double the first number: that is, the number of persons

ſons, which was 4 and it makes 8. to which add 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 adde the number of the fingers upon which the Ring is, *viz.* 5. makes 775. this multiplied by 10. makes 7750. to which adde the number for the joynt upon which the Ring is, *viz.* the third joynt, makes 7753. to which cauſe him to adde 14. or ſome other number, to conceale it the better: and it makes 7767. which being declared unto you, ſubſtract 3514. and there will remaine 4.2.5.3. which figures in order declares the whol 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 34. or more Dice.

THat which is ſaid of the two precedent Problemes may be applied to this of Dice (and many other particular things) to finde what number appeareth upon each Dice being caſt by ſome one, for the points that are upon any ſide of a Dice are alwayes leſſe 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 adde 5, then multiply that by 5. and to it adde 10, and to the summe bid him adde the number of the second Dice: and multiply that by 10: lastly, to this bid him adde the number of the last Dice, and then let him declare the whole number: then if from it you subtract 350. there will remaine the number of the three Dice throwne.

PROBLEM. XXXVII.

How to make water in a Glasse seeme to boyle and sparkle?

TAke a Glasse neere full of water or other liquor; and setting one hand upon the foot of it, to hold it fast: turne slightly one of the fingers of your other hand upon the brimme, or edge of the Glasse; having before privately wet your finger: and so passing softly on with your finger in pressing a little: for then first, the Glasse will begin to make a noyse: secondly, the parts of the Glasse will sensibly appeare to tremble, with notable *rarefaction* and *condensation*: thirdly, the water will shake, seeme to boyle: fourthly, it will cast it selfe out of the Glasse, and leap out by small drops, with great astonishment to the standers by; if they be ignorant of the cause of it, which is is onely in the Rarefaction of the parts of the Glasse, occasioned by the motion and pressure of the finger.

EXAMINATION.

THe cause of this, is not in the rarefaction of the parts of the Glasse, but it is rather in the quick locall motion of the finger, for reason sheweth us that by how much a Body draweth nearer to a quality, the lesse is it subject or capable of another which is contrary unto it? now condensation, and rarefaction are contrary qualities, and in this Probleme there are three bodies considered, the Glasse, the Water, and the Aire, now it is evident that the Glasse being the most solid, and impenitrable Body, is lesse subject and capable of rarefaction than the water, the water is lesse subject than the Aire, and if there be any rarefaction, it is rather considerable in the Aire then in the Water, which is inscribed by the Glasse, and above the Water, and rather in the Water then in the Glasse: the agitation, or the trembling of the parts of the Glasse to the sense appeares not: for it is a continued body; if in part, why then not in the whole? and that the Water turnes in the Glasse, this appeares not, but only the *upper contiguous parts of the Water: that at the bottome being lesse subiect to this agitation, and it is most certaine that by how much quicker the Circular motion of the finger upon the edge of the Glasse is, by so much the more shall the Aire be agitated, and so the water shall receive some apparant affection more or lesse from it, according to that motion: as we see from the quicknesse of winde upon the Sea, or calme 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 vessell which holds wine or water, being cast into it at a certaine height, but being filled higher, it will runne out of its owne accord.

LEt there be a vessell *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 vessell as at *F*, are open; let the end *E* be somewhat lower than the brimme of the Glasse: about this Pipe, place another Pipe as *H. L*, which mounts a little above *E* and let it most diligently be closed at *H*, that no Aire enter in thereby, and this Pipe at the bottome may have a small hole to give passage unto the water; then

then poure in water or wine, and as long as it mounts not above *E*, it is ſafe; but if you poure in the water ſo that it mount above it, farewell all: for it will not ceaſe untill it be all gone out; the ſame may be done in diſpoſing any crooked Pipe in a veſſell in the manner of a Faucet or funnell, as in the figure *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 veſſell

will be empty incontinent, and the ſubtiltie of this will ſeeme more admirable, if you conceale the Pipe by a Bird, Serpent, or ſuch like, in the middle of the Glaſſe. 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 untill the Pipe be full, then will it run of it ſelfe, 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 then the water, it will run out without ceaſing: but if the mouth of the Pipe be higher then the water or levell with it, it will not runne, although the Pipe which is without be many times bigger than that which is in the water: for it is the property of water to keep alwayes exactly levell,

EXAM-

EXAMINATION.

HEre is to be noted, that if the face of the water without be in one and the ſame plaine, with that which is within, though the outtermoſt Pipe be ten times greater than that which is within; the water naturally will not runne, but if the plaine of the water without be any part lower then that which is within, it will freely runne: and here may be noted further, that if the mouth of the Pipe which is full of water, doth but only 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 Glaſſe very pleaſant.

SOmetimes there are Glaſſes which are made of a double faſhion, as if one Glaſſe were within another, ſo that they ſeem but one, but there is a little ſpace between them. Now poure Wine or other liquor between the two edges

edges by help of a Tunnell, into a little hole left to this end, so vvill there appeare tvvo fine delusions or fallacies; for though there be not a drop of Wine vvithin the hollovv of the Glasse, it vvill seem to those vvhich behold it that it is an ordinary Glasse full of Wine, and that especially to those vvhich are side-vvise of it, and if any one move it, it vvill much confirme it, because of the motion of the Wine; but that vvhich vvill give most delight, is that, if any one shall take the Glasse, and putting it to his mouth shall think to drink the Wine, instead of vvhich he shall sup the Aire, and so vvill cause laughter to those that stand by, vvho being deceived, vvill hold the Glass to the light, & thereby considering that the raies or beames of the light are not reflected to the eye, as they vvould be if there vvere a liquid substance in the Glasse, hence they have an assured proofe to conclude, that the hollovv of the Glasse is totally empty.

PROBLEM. XL.

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

Bid him that holds the money that he put out of one hand into the other vvhat 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

take out of it as many as remaine 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 remaine 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 finde 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.

SVppose any one had cast three Dice secretly, bid him that he adde the points that were upmost together: then putting one of the Dice apart, unto the former summe adde the points which are under the other two, then bid him throw these two Dice, and mark how many points a paire are upwards, which adde unto the former summe: then put one of these Dice away not changing the side, mark the points which are under the other Dice, and adde it to the

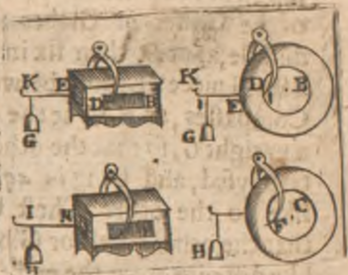
the former ſumme: laſtly, throw that one Dice, and whatſoever appeares upward adde it unto the former ſumme; and let the Dice remaine thus: this done, comming to the Table, note what points do appeare upward upon the three Dice, which adde privataly together, and unto it adde 21 or 3 times 7: ſo this Addition or ſumme ſhall be equall to the ſumme which the party privately made of all the operations which he formerly made. As if he ſhould throw three Dice, and there ſhould appeare upward 5,3,2. the ſum of them is 10. and ſetting one of them apart, (as 5.) unto 10, adde the points which are under 3 and 2, which is 4 and 5, and it makes 19. then caſting theſe two Dice ſuppoſe there ſhould appeare 4 and 1, this added unto 19 makes 24. and ſetting one of theſe two Dice apart as the 4. unto the former 24, I adde 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 one Dice, and ſuppoſe there did appeare 2, which I adde 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 adde ſecretly 21, (as before was ſaid) ſo have you 32, the ſame number whi h he had; and in the ſame manner you may practiſe with 4,5,6, or many Dice or other bodies, obſerving only that you muſt adde the points oppoſite of the Dice; for upon which depends the whole demonſtration or ſecret of the play; for alwayes that which is above and under-

underneath makes 7. but if it make another number, then must you adde as often that number.

Problem. XLII.

Two mettals, as Gold and Silver, or of other kinds weighing alike, being privately placed into two like Boxes, to finde 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 assigne him some reward: to which after few dayes 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 forme and magnitude alike: and bid him chuse which he would have. Now many think that in this Probleme one must be guided only by fortune in this choise, and it is that which most makes a man happy in such a choise: but the want of knowledge causeth them so to judge which know not otherwise. A Mathematician accounts it an easie proposition, & 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 Aire, then in the water: it is a thing cleare by the proportion of Mettalls,& according to the principles of *Archimedes*, that the Gold ſhal be leſſe weighty by his eighteenth part, & the Lead by his 11th 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 ; andnamely, becauſe the matter of the cheſt, mettall or other things may hinder.

Behold here a more ſubtill and certaine invention to finde and diſcover it out without weighing it in the water : Now experience and reaſon ſheweth us that two like bodies or magnitudes of equall weight, and of divers mettalls, are not of equal quantity: and ſeeing that Gold is the heavieſt of all mettalls,it will occupie leſs roome or place ; from which will follow that the like weight of Lead in the ſame forme , will occupie or take up more roome or place. Now let there be therefore preſented two Globes or Cheſts of wood or other matter alike , & equall one to the other,in one of which in the middle there is another Globeor body of lead weighing 12.l. (as *C*,) and in the other a Globe or like body of Gold weighing 12 pound (as *B*.)Now

it

it is ſuppoſed that the wooden Globes or Cheſts are of equall weight, forme, and magnitude: and to diſcover in which the Gold or Lead is in, take a broad paire 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 vveight *G*, ſo that the other end may be counterpoyſed, and hang *in æquilibrio*: and do the like to the other Cheſt or Globe. Novv 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 tovvards the middle, that ſo the points of the Compaſſe may be againſt ſome of the mettall vvhich is incloſed; or juſt againſt the extremitie of the Gold as in *D*, and ſuppoſe it hang thus in *æquilibrio*; it is certaine that in the other Coffer is the Lead; for the points of the Compaſſes being advanced as much as before, as at *F*, vvhich takes up a part of the Lead, (becauſe it occupies a greater place than the Gold) therefore that ſhall help the vveight *G*. to vveigh, and ſo vvill not hang in *æquilibrio*, except *G* be placed neare to *F*. hence vve may conclude, that there is the Lead; and in the other Cheſt or Globe, there is the Gold.

EXAMINATION.

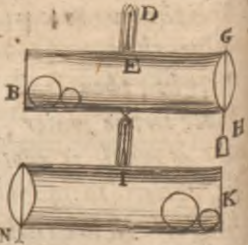
IF the two Boxes being of equall magnitude weighed in the aire be found to be of equall weight, they ſhall neceſſarily take up like place in the water, and therefore weigh alſo one as much as another: hence there is no poſſibilitie to finde the inequalitie of the mettalls which are incloſed in theſe Boxes in the water: the intention of Archimedes *was not upon contrary mettalls incloſed in equall Boxes, but conſiſted of comparing mettalls, ſimple in the water one with another: therefore the inference is falſe and abſurd.*

PROBLEM. XLIII.

Two Globes of diverſe mettalls, (as one Gold, and the other Copper) yet of equall weight being put into a box, as B G, to finde in which end the Gold or Copper is.

THis is diſcovered by the changing of the places of the tvvo Bovvles or Globes, having the ſame counterpoyſe *H* to be hung at the other ſide, as in *N.* and if the Gold vvhich is the leſſer Globe, vvere before the neareſt to the handle *D*, having novv changed his place vvill be fartheſt from the handle *D E*, as in *K.*

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 alwayes in the middle of the Box, the vveight *N.* muſt be augmented, to keep it in *æquilibrio*: and by this way one may knovv, that if at the ſecond time, the counterpoiſe be too light, it is a ſigne that the Gold is fartheſt off the handle, as at the firſt triall it vvas neareſt.



Problem. XLIIII.

How to repreſent diverſe ſorts of Rainebowes here below?

THe Rainbovve is a thing admirable in the vvorld, vvhich raviſheth often the eyes and ſpirits of men in conſideration of his rich intermingled colours vvhich are ſeen under the clouds, ſeeming as the gliſtering of the Starres, precious ſtones, and ornaments of the moſt beauteous flovvers: 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, the Orange, the Saphir, the Jacinct, and the Emerald colours, as a lively plant placed in a green soile: and as a most rich treasure of nature, it is a high work of the Sun who casteth his raies or beames as a curious Painter drawes strokes with his pensill, and placeth his colours in an exquisite situation; and *Solomon* saith, *Eccles.* 43. it is a chiefe and principall work of God. Notwithstanding there is left to industrie 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 Oares of a Boate it doth exceeding quickly glide upon the water with a pleasant grace? *Aristotle* sayes, that he coloureth the water, and makes a thousand atomes, upon which the beames of the Sunne reflecting, make a kinde of coloured Rainbowe: or may we not see in houses or Gardens of pleasure artificiall fountaines, which poure forth their droppie streames of water, that being between the Sunne and the fountaine, there will be presented as a continuall Rainbowe? But not to go farther, I will shew you how you may do it at your doore, by a fine and facill experiment.

Take water in your mouth, and turne your back to the Sunne, 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 beames of the Sunne to turne into a faire Rainebowe, but all the griefe is, that it lasteth not, but soone is vanished.

But to have one more stable and permanent in his colours: Take a Glasse full of water, and expose it to the Sunne, so that the raies that passe through strike upon a shadowed place, you will have pleasure to see the fine forme of a Rainebovve by this reflection. Or take a Trigonall Glasse or Crystall Glasse of diverse Angles, and look through it, or let the beames of the Sunne passe through it; or vvith a candle let the appearances be received upon a shadved place: you vvill have the same contentment.

Problem XLV.

How that if all the Powder in the world were inclosed within a bowle of paper or glasse, and being fired on all parts, it could not break that bowle?

If the bowle and the powder be uniforme in all his parts, then by that means the powder would presse 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 bowle should be broken in all his parts: for they are infinite.

Of like finenesse or subtiltie may it be that a bowle of Iron falling from a high place upon a plaine pavement of thin Glasse, it were impossible

ſible any wiſe to break it; if the bowle were perfectly round, and the Glaſſe flat and uniforme in all his parts. for the bowle would touch the Glaſſe 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 bovvle falling upon ſuch a glaſſe vvill not break it. But this matter is meere Metaphyſicall, and all the vvorkmen in the vvorld cannot ever vvith all their induſtrie make a bovvle perfectly round, or a Glaſſe uniforme.

Problem. XLVI.

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

IN many Authors of Arithmetick this Probleme is thus propoſed: A vvoman carrying Egges to Market in a basket, met an unruly fellovv who broke them, who vvas 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 & 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 when ſhe counted them by 7 and 7, there remained nothing: Now how may the number of Egges be diſcovered?

Finde a number which may exactly be meaſured by 7, and being meaſured by 2,3,4,5, and 6; there vvill ſtill remaine a unite: multiply theſe numbers together, makes 720, to which adde 1; ſo have you the number, *viz.* 721. in like manner 301 vvill be meaſured by 2,3,4,5, 6; ſo that 1 remaines: but being meaſured by 7, nothing vvill remaine; to vvhich continually adde 220, and you have other numbers vvhich vvill do the ſame: hence it is doubtfull vvhat number ſhe had, therefore not to faile, it muſt be knovvn vvhether they did exceed 400, 800, &c. in vvhich it may be conjectured that it could not exceed 4 or 5 hundred, ſeeing a man or vvoman could not carry 7 or 8 hundred Egges, therefore the number vvas the former 301. vvhich ſhe had in her Basket: vvhich being counted by 2 and 2, there vvill remaine 1, by 3 and 3, &c. but counted by 7 and 7, there vvill remaine nothing.

PROB.

PROBLEM. XLVII.

One had a certaine number of crownes, 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 & 6, there rested 5. but counting them by 7 and 7, there remained nothing: how many crownes might he have?

THis Queſtion hath ſome affinitie to the precedent, and the reſolution is almoſt in the ſame manner: for here there muſt be found a number, vvhich multiplied by 7, and then divided by 2, 3, 4, 5, 6; there may alvvayes remaine a number leſſe by 1 than the Diviſor: Novv the firſt number vvhich arrives in this nature is 119, unto vvhich if 420 be added, makes 539, vvhich alſo vvill 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 vveigh things betvveen 1 and 40, take numbers in triple proportion, ſo that their ſumme be equall, 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 and 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.

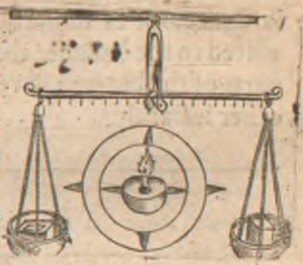
In the ſame manner take thoſe 5 weights, 1, 3, 9, 27, 81, you may weigh with them between 1 pound, and 121 pound: and taking thoſe 6 weights, as 1, 3, 9, 27, 81, 243, you may weigh even from 1 pound unto 364 pound: this depends upon the property of continued proportionals, the latter of which containing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

PROBLEM. XLIX.

Of a deceitfull ballance which being empty ſeemes to be juſt, becauſe it hangs in æquilibrio: notwithſtanding putting 12 pound in one ballance, and 11 in the other, it will remaine in æquilibrio.

ARiſtotle maketh 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 subtiltie or craft of which is thus, that one arme of the ballance is longer then another, by the same proportion, that one weight is heavier then another: As if the beame 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 beame 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 beame, and the lesser weight in the other ballance: it is most certaine that the ballances will hang *in equilibrio*, which will seem most sincere and just; though it be most deceitfull, abominable, and false.



The reason of this is drawne from the experiments of *Archimedes*, who shewes that two unequall weights will counterpoyse one another, when there is like proportion betweene the parts of the beame (that the handle separates)

rates) and the vveights themselves: for in one and the same counterpoise, by hovv much it is farther from the Centre of the handle, by so much it seems heavier, therefore if there be a diversitie of distance that the ballances hang from the handle, there must necessarily be an ineqality 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 soone as the greater vveight is placed in the ballance that hangs on the longer parts of the beame: it vvill vveigh dovvne the other instantly.

Problem. L.

To heave or lift up a bottle with a straw.

TAke a stravv that is not bruised, bovv it that it make an Angle, and put it into the bottle so that the greatest end be in the neck, then the Straw [redacted] being put in the bovved part vvil cast side-vvise, and make an Angle as in the figure may be seen: then may you take the end vvhich is out of the bottle in your hand, and heave up the bottle,

and

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 Sunne, Starres, Shadow or Compaſſe, to finde out the North or South, or the foure Cardinall points of the world, Eaſt, Weſt, &c?

IT is the opinion of ſome, that the windes are to be obſerved in this: if it be hot, the South is found by the windes that blow that way, but this obſervation is uncertaine 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 humiditie of the parts of the 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 rarefied, but condenſed; by which the circles are nearer together on the North-part, than on the South-part: therefore if a line be drawne from the wideſt

widest to the narrowest part of the circles, it shall shew the North & South of the world. Another Experiment may be thus: Take a small needle, such as women work with: place it gently downe flatwise upon still water, and it will not sink,

(which is against the generall tenet that Iron will not swimme) which needle will by little and little turne 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 finde out the Poles of the world or points of North and South in a manner as the *magnes* doth.

EXAMINATION.

Here is observable, that the moisture which aideth to the growth of the tree, is dilated and rarefied by the Meridionall heat, and contracted by the Septentrionall *cold: this rarefaction works upon the part of the humour or moisture that is more thinne, which doth easily dissipate and evaporate: which*

evapo-

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 leſſe evaporation and perdition: and ſo conſequently there remaines 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 ſappe and moiſture is drawne 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 hardneth and contracteth the moiſture of the tree, and ſo converteth it into wood.

PROBLEM. LII.

Three perſons having taken Counters, Cards, or other things, to finde 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 4, let the ſecond party take 7, and the firſt

first take 13, then cause them to put them all together, and declare the summe 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 aske how much one of them hath: (for they will have then all alike,) so halfe of that number is the number that the third person had at the first: which knowne all is knowne.

PROBLEM. LIII.

How to make a consort of musick of many parts with one voyce, or one instrument only?

THis Probleme is resolved, so that a singer or player upon an instrument, be neare an Echo which answereth his voice or instrument; and if the Echo answereth but once at a time, he may make a double; if twice, then a triple, if three times, then an harmonie of foure 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 meanes you have a fifth, agreeable consort of musick: then in 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 paſſe in many Churches, making one to beleeve that there are many more parts in the muſick of a Quire, then in effect truly there are because of the reſounding and multiplying of the voic ,and redoubling of the Quire.

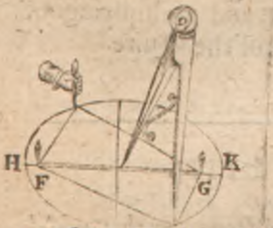
PROBLEM: LIIII.

To make or deſcribe an Ovall forme, or that which neare reſembles unto it, at one turning with a paire of common Compaſſes.

THere are many fine wayes in Geometricall practices, to make an Ovall figure or one neare unto it, by ſeverall centres: any of which I will not touch upon, but ſhew how it may be done promptly upon one centre only. In which I will ſay nothing of the Ovall forme, which appeares, when one deſcribeth circles with the points of a common Compaſſes, ſomewhat deep upon a skinne ſtretched forth hard: which contracting it ſelfe in ſome parts of the skinne maketh an Ovall forme. But it will more evidently appeare upon a Columne or Cylinder: if pa-

per

per be placed upon it, then with a paire of Compasses describe as it were a circle upon it, which paper afterwards being extended, will not be circular but ovall-wise: and a paire of Compasses may be so accommodated, that it may be done also upon a plaine thus. As let the length of the Ovall be *H. K*, fasten 2 pinnes or nailes neare the end of that line as *F.G*, and take a threed which is double to the length of *G.H*, or *F.K*, then if you take a Compasse which may have one foot lower than another, with a spring between his legges: and placing one foot of this Compasse in the Centre of the Ovall, and guiding the threed by the other foot of the Compasses, and so carrying it about: the spring will help to describe and draw the Ovall forme. But in stead of the Compasses it may be done with ones hand only, as in the figure may appeare.



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

and *C D*, at the end of which are 2 rings, *B* & *D*, and the ſtring *C D* paſſeth through the ring *B*, ſo that it may not come out againe; or be parted one from another: and ſo that the ring *B*, may ſlide up and downe 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 through many rings: which hath a ſlit towards the end *I*, ſo great that the ſtring *B C* 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* paſſe through the ring *B*, and alſo *D* with his ſtring to paſſe 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 finde out the Centre of it?

IT is ſaid that upon a time paſt, two Mathematicians met, and they would make tryall 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 plaine Table without other help than the hand, and the minde, is full of admiration; to finde the Centre is but to finde out only 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 finde the Centre is more difficult, for what attention, vivacitie, and ſubtiltie 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 alwayes the ſame diſtance, and is guided by a halfe diſtance to finiſh the reſt; but he that muſt finde the Centre, muſt in the ſame time take heed to the parts about it, and chooſe one only point which is equall diſtant from an infinite of other

points

points which are in the circumference ; which is very difficult. *Aristotle* confirmes this amongst his morals, and seems to explaine the difficultie which is to be found in the middle of vertue; for it may want a thousand wayes, and be farre separated from the true Centre of the end of a right mediocritie 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 only. Now to judge which is the most difficult, as before is said, either to drawthe round or to finde the Centre, the round seems to be harder than to finde the Centre, because that in finding of it, it is done at once, and hath an equall distance from the whole; But,as before,to draw a round there is a visible point imagined, about which the circle is to be drawne. I esteeme that it is as difficult therefore ,if not more, to make the circle without a Centre, as to finde the middle or Centre of that circle.

Problem. LVII.

Any one having taken 3 Cards, to finde how many points they containe

THis is to be exercised 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 conteine. 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, & giving him the reſt of the Cards, there will be 25; from which take 4, there remaines 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 leſſe than 52; and that the terme be 15, 14, 12, &c, this generall rule enſuing may ſerve: multiply the terme by the number of Cards taken at firſt: to the product adde the number of Cards taken, then ſubtract this ſumme from the whole number of Cards; the remainder is the number which muſt be ſubtracted from the Cards, which remaines to make up the game: if there remaine 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 remaine, the ſumme will be the number of points in the Cards taken, as if the Cards were 7, 10, 5, 8, and the terme given were 12;

ſo

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 reſt of the Cards: then ſecretly multiply 12 by 4, makes 48; to which adde 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 equall to the points of the foure Cards taken, *viz.* 7,10,5,8. Againe, let theſe five Cards be ſuppoſed to be taken, 8,6,10,3,7; their differences to 15, the termes are 7,9,5,12,8, which number of Cards taken, there will remaine but 6 Cards: then privately multiply 15 by 5, makes 75, to which adde 5 makes 80, from this take 52 the number of Cards, reſt 28, to vvhich add the remainder of Cards, make 34. the ſumme with 8, 6,10,3,7.

PROBLEM. LVII.

Many Cards placed in diverſe ranks, to finde 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 finde vvhich of the Cards it is, and it is done thus; ask him in vvhich of the heaps it is, vvhich place in the middle of the other tvvo; then throvv dovvne the Cards by 1 and 1 into three ſeverall heaps in rank-vviſe, untill all be caſt dovvne, then aske him in which of the rankes his Card is, which heap place in the middle of the other two heaps alwayes, and this do foure 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 faile.

Problem. LVIII.

Many Cards being offered to sundry persons, to finde 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 rankes, 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 aske him if his Card be in it which he thought, for infallibly that vvhich the first partie thought upon vvill be in the first rank, and at the bottome, the Card of the second person vvill be in the second ranke, the

the Card of the third thought upon will be in the third rank, and the fourth 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 certaine 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 Mathematickes (which hath furniſhed us with ſuch admirable helps for ſeeing) is wanting for that of hearing, its well knowne that long trunks or pipes make one heare well farre off, and experience ſhewes us that in certaine 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 heare him ſpeak at all: And it is a generall Principle, that pipes do greatly help to ſtrengthen the activitie of naturall cauſes: we ſee that fire contracted in a pipe, burnes 4 or 5 foot high, which would ſcarce heat, being in the open aire: the rupture or violence of water iſſuing out of a fountaine, ſhewes us that vvater being contracted into a pipe, cauſeth a violence in its Paſſage. The Glaſſes of *Galeileus* makes us ſee how uſefull pipes or trunkes are to make the light and ſpecies more viſible, and proportionable to our eye. It is ſaid that a Prince of *Italy* hath a faire hall, in which he can with facility heare diſtinctly the diſcourſes of thoſe which walk in the adjacent Gardens, which is by certaine 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 kinde of trunkes are uſed to help the hearing, being made of ſilver, copper, or other reſounding materiall; in funnell-wiſe putting the wideſt end to him which ſpeaketh, to the end to contract the voice, that ſo by the pipe applied to the eare it may be more uniform and leſſe 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 burne.

It muſt be obſerved that the veſſell in which the oile is put into, have two pinnes on the ſides of it, one againſt another, being included within a circle: this circle ought to have two other pinnes, to enter into another circle of braſſe,

braſſe, or other ſolid matter: laſtly, this ſecond circle hath two pinnes, which may hang within ſome box to containe the whole lamp, in ſuch manner, that there be 6 pinnes in different poſition: Now by the aid of theſe pegges or pinnes, the lamp that is in the middle will be alwayes well ſituated according to his Centre of gravity, though it be turned any way; though if you endeavour to turne it upſide downe, it will lie levell: which is pleaſant and admirable to behold to thoſe which know not the cauſe: And it is facil from his to make a place to reſt quiet in, though there be great agitation in the outvvard 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 4 or 5 to the parties ſight, and bid him think one of them, but let him note vvhether it be the firſt, ſecond, third, &c. then vvith promptneſs learn vvhat number of Cards

you

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, aske him whether his Card were the first, second, &c. then before knowing the number of Cards that were at the bottome, account backwards untill 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 Probleme is easie, as suppose at the beginning of the Market: *A*, sold her apples at a penny an apple: and sold but 2. which was 2 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,

A. 20 2 18 and 54 is 56.
B. 30 17 13 and 39 is 56.
C. 40 32 8 and 24 is 56.

cheap, but would ſell them for 3 pence the peece, 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: and laſtly, *C*. had but 8 apples, which at the ſame rate came to 24 pence: theſe ſummes 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 ſumme of a number, that have equall diſtance from the halfe 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 halfe, the other is leſſe.

Secondly, it is difficult to finde two numbers whoſe ſumme and product is alike, (that is) if the numbers be multiplied one by another, and added together, will be equall, 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 ſumme and product will be equall one to another. As *Clavius* ſhewes upon the 36 *Pro.* of the 9th book of *Euclide*.

Thirdly,

Thirdly, the numbers 5 and 6 are called circular numbers, becauſe the circle turnes to the point from whence it begins: ſo theſe numbers multiplied by themſelves, do end alwayes in 5 and 6, as 5 times 5 makes 25, that againe 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 equall unto it, ſo the 6 part of it is 1, the third part is 2, the halfe is 3, which are all his parts: now 1, 2, and 3, is equall to 6. It is wonderfull to conceive that there is ſo few of them, and how rare theſe numbers are, ſo of perfect men: for betwixt 1 & 10000000000 000 numbers there is but ten, that is; 6, 28, 486. 8128. 120816. 2096128. 33550336. 536854528. 8589869056, & 137438691328: with this admirable property, that alternately they end all in 6 and 8, & the twentieth perfect number is 151115727451553768931328.

Fiftly, the number 9 amongſt other priviledges carries with it an excellent property: for take what number you will, either in groſſe 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 vvhether the nines be rejected of 27, or of the ſumme of 2 and 7, it is all one, ſo if the nines vvere taken avvay of 240. it is all one, if the nines vvere taken avvay of 2, 4, and 0; for there vvould remaine 6 in either; and ſo of others.

Sixtly, 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.*

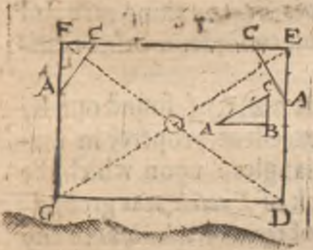
Seventhly, the numbers 220 and 284 being unequall, notwithstanding the parts of the one number do alwayes equalize the other number: so the *aliquot* parts of 220 are 110, 54, 44, 22, 20, 11, 10, 5, 4, 2, 1, which together makes 284. the *aliquot* parts of 284, are 142, 71, 4, 2, 1, which together makes 220, a thing rare and admirable, and difficult to finde 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 multiplied in 4 makes 16, and 3 multiplied in 3, makes 9. but 9 and 16 is equall to 25 or if these numbers 3, 4, 5, be doubled, *viz.* 6, 8, 10: the square of 10 is equall to the quare 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, triple, decuple, &c. or all in one line, and make knots at the tearmes 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 G F.* to be plotted, *E D* of 60 yards broad, and *D G* 100 yards long. First measure out *E* D 60 yards, and at *E* and *D* place two pinnes or pegges; 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 untill they meet, which will be in *C*, and place a pegge 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

pegge

pegge; 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. Lastly, it is easie to draw the line *G D*, and so the rectangu-led figure or long square shall be plotted, whose breadth is 60 yards, & length 100 yards, as was required: and to examine this, measure *E G*, then if *F D* be as long, the figure is true: other-wise it is defective, and may easily be amended.

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

The square of halfe 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 odde numbers be continually added from the unitie successively, there will be made all square numbers, and if cubick numbers be ad-ded successively from the unitie, there will be likewise made square numbers.

PROBLEM. LXIV.

Of an excellent lamp, which serves or furnisheth it selfe with oile, and burnes a long time.

I Speak not here of a common lamp which *Cardanus* writes upon in his book *de subtilita-te*, for that's a little vessell in columne-wise, which

which is full of Oile, and because there is but one little hole at the bottome neare the weeke or match; the oile runnes not, for feare that there be emptinesse above: when the match is kindled it begins to heat the lamp, and rarefying the oile it issueth by this occasion: and so sends his more airie parts above to avoid vacuitie.

But that which I here deliver, is more ingenious, the principall peece of which is a vessel, as *C D*. which hath neare the bottome a hole, and a funnell or pipe *C*. & then a bigger funnell, which passeth through the middle

of the vessell, having an opening at *D* neare the top, and another at the bottome as at *E*, neare the vessell under it, so that the pipe touch it not: the vessell being thus made, fill it with oyle, and opening the hole *C* the oile running out will stop the hole at *E*, or throwing in oile into the vessell underneath, untill *E* be stopped; then the oile at *C* will not runne: because no aire can come into the pipe *D E*. Now as the oile burneth and consumeth in the vessell *A B*, the hole at *E*, will begin to be open, then immediately will *C* begin to runne to fill up *A B*. and *E* being stopped with the oile, the oile at *C* ceaseth to run.

It

It is certaine that such a lampe the *Athenians* used, which lasted a whole yeare without being touched; which was placed before the statue of *Minerva*, for they might put a certaine quantitie of oile in the lamp C D, and a match to burne without being consumed: such as the naturalists write of, by which the lamp will furnish it selfe, and so continue in burning: and here may be noted that the oile may be poured in, at the top of the vessell at a little hole, and then made fast againe that the aire get not in.

Problem. LXV.

Of the play at Keyles or nine Pinnes.

YOu will scarce beleeve that with one bowle and at one blow playing freely, one may strike downe all the Keyles at once: yet from Mathematicall principles it is easie to be demonstrated, that if the hand of him that playes were so well assured by experience, as reason induceth one thereto; one might at one blow strike downe all the Keyles, or at least 7 or 8, or such a number as one pleaseth.

For they are but 9 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

downe the Keyles 3, 6, and 9, and the bowle being in motion may ſtrike down the Keyle 4, and 7; which 4 Keyle may ſtrike the Keyle 8, & 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 greene do ſomewhat degenerate; inſtead of ſhewing a lively colour it will repreſent a pale dead colour, and it is becauſe they are not dyed greene enough, or receive not light enough for greene: and colour theſe images that paſſe through theſe Glaſſes unto the bottome of the eye.

EXAMINATION.

It is certaine, 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 leſſe, as one being very yellow,

another

another a pale yellow; now all colours are not proper to Glasses to give colour, hence the defect is not that they want facultie to receive light, or resist the penetration of the beams; for in the same Glasses those which are most dyed, give alwayes the objects more high coloured and obscure, and those which are lesse dyed give them more pale and cleare: and this is daily made manifest by the painting of Glasse, which hinders more the penetration of the light than dying doth, where all the matter by fire is forced into the Glasse, leaving it in all parts transparent.

Spectacles of Crystall cut with divers Angles diamond-wise do make a marvellous multiplication of the appearances, for looking towards a house it becomes as a Towne, a Towne becomes like a Citie, an armed man seems as a whole company caused solely by the diversity of refractions, for as many plaines as there are on the outside of the spectacle, so many times will the object be multiplied in the appearance, because of diverse Images cast into the eye. These are pleasurable spectacles for avaricious persons that love Gold and silver, for one piece will seeme many, or one heap of money will seeme as a treasury: but all the mischiefe is, he will not have his end in the enjoying of it, for indeavouring to take *it, it will appeare but a deceitfull 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 faile often in touching that which you see. Againe, there are Spectacles made which do diminish the thing seen very much, and bring it to a faire perspective forme, especially if one look upon a faire Garden plat, a greater walk, a stately building, or great Court, the industry of an exquisite Painter cannot come neare to expresse the lively forme of it as this Glasse 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 visuall 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 passe to and fro in the streets, without being seen of any, for their property is to raise up the objects that it lookes upon.*

Now I would not passe this Probleme without saying something of Galileus *admirable Glasse, 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 spottie and shadowed opacous bodies that are found about the Sunne, which darkneth and diminisheth the splendour of that beautifull and shining Luminary: secondly, it shewes the new Planets that accompany*

company

company Saturne *and* Jupiter: *thirdly, in* Venus *is ſeen the new, full, and quartill increaſe; as in the Moon by her ſeparation from the Sunne: fourthly, the artificiall ſtructure of this inſtrument helpeth us to ſee an innumerable number of ſtars, which otherwiſe are obſcured, by reaſon of the naturall weakneſſe of our ſight, yea the ſtarres in* via lactea *are ſeen moſt apparautly; where there ſeem no ſtarres to be, this Inſtrument makes apparantly 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 Sunne in his moſt glorious beauty. This Glaſſe hath alſo a moſt excellent uſe in obſerving the body of the Moone in time of Eclipſes, for it augments it manifold, and moſt manifeſtly ſhewes the true forme of the cloudy ſubſtance in the Sunne; and by it is ſeene when the ſhadow of the earth begins to eclipſe the Moon, & when totally ſhe is over ſhadowed: beſides the celeſtiall uſes which are made of this Glaſſe, it hath another noble property; it farre exceedeth the ordinary perſpective Glaſſes, which are uſed to ſee things remote upon the earth, for as this Glaſſe reacheth up to the heavens and excelleth them therein 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 neere at hand, scorning as it were all small and triviall services, as leaving them to an inferiour help: great use may be made of this Glass in discovering of* Ships, *Armies, &c. Now the apparell or parts of this instrument or Glasse, is very meane or simple, which makes it the more admirable (seeing it performes such great service) having but a convex Glasse thickest in the middle, to unite and amasse the rayes, and mak the object the greater: to the augmenting the visuall Angle, as also a pipe or trunk to amasse 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 Glasse of a short sight to distinguish the rayes, which the other would make more confused if alone. As for the proportion of those Glasses to the Trunk, though there be certaine 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 tryed, seeing that exact proportion, in Geometricall calculation cannot serve for diversity of sights in the observation.*

PROB.

PROBLEM. LXVII.
Of the Adamant or Magnes, and the needles touched therewith.

WHo would beleeve if he ſaw not with his eyes, that a needle of ſteel being once touched with the *magnes*, turnes not once, not a yeare, but as long as the World laſteth; his end towards the North and South, yea though one remove it, and turne it from his poſition, it will come againe 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 aire, 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 vvere a chaine 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 naile, the point of a knife, or other pieces of Iron? Is it not a pleaſure to ſee how the *magnes* will turne file duſt, or move needles, or nailes being upon a Table, or upon a piece of paper? for as ſoone as the *magnes* turnes or moves over, it moves alſo: who is it that would not be ra-

viſhed as it were, to ſee a hand of Iron write upon a planke, without ſeeing the *Magnes* which cauſeth that motion behinde the planke, or to make an image of Iron to run up and downe 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 aſtoniſment in our minds than a great maſſie ſubſtance of Iron to hang in the aire in the middeſt of a building without any thing in the world touching it, only but the aire? 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 aire; and *Plinie* in his naturall Hiſtorie 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 Goddeſſe likewiſe in the aire.

I ſhould paſſe the bounds of my counterpoiſe, if I ſhould divulge all the ſecrets of this ſtone,

ſtone, and ſhould expoſe my ſelfe to the laughter of the world: if I ſhould brag to ſhew others the cauſe how this appeareth, than in its owne naturall ſympathy, for why is it that a *magnes* with one end will caſt the Iron away, & attract it with the other? from whence commeth it that all the *magnes* is not proper to give a true touch to the needle, but only in the two Poles of the ſtone: which is known by hanging the ſtone by a threed in the aire untill it be quiet, or placed upon a peece of Cork in a diſh of water, or upon ſome thinne board, for the Pole of the ſtone will then turne 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 pegges 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 propertie 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 remaines ignorant of declaring the rrue cauſe thereof.

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

minde, 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 vertue 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 houre 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 vertue: neither is it expedieut, for treaſons would be then too frequent and open.

EXAMINATION.

THe experimentall difference of rejection, and attraction proceeds not from the different nature of Stones, but from the quality of the Iron; and the vertue of the ſtone conſiſteth only, and eſpecially in his poles, which being hanged in the Aire, turnes one of his ends alwayes 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

turning North and South, *as the* 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 *neare unto them*, *the North of the one will abhorre the North of the other*, *but the North of the one will alwayes 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 untill it be held perpendicular*, *for that shall be one of the Poles of the stone which you may marke out*; *in like manner finde out the other Pole*: *Now to finde 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 naile of ones finger or such like*,) *and marke which way the end of the needle that was touched turneth*: *if to the South*, *then the point that*

touched

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 aire, or supported upon the water, it will turne contrary to the needle that toucheth it; for then the pole that was marked for the South shall turne to the North, &c.

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 soone as the heat doth penetrate it, the water begins to rarefie, & issueth forth with a hidious and marvelous force; it is pleasure to see how it blowes the fire with great noise.

Vitruvius in his first book of *Architecture*, *Cap.* 8: approves from these Engines, that winde is no other thing than a quantity of vapours and exhalations agitated with the aire by rarefaction and condensation, and we may draw a consequence from it, to shew that a little water

ter may ingender a very great quantitie of vapours and aire: for a Glasse of water throwne into an *Æolipile* will keep blowing neare a vvhole houre, sending forth his vapours a thousand times greater than it is extended.

Novv touching the forme of these vessels, they are not made of one like fashion: some makes them like a bovvle, some like a head painted representing the vvinde, some make them like a Peare: as though one vvould put it to rost at the fire, vvhen one vvould have it to blovv, for the taile of it is hollovv, in forme of a funnell, having at the top a very little hole no greater than the head of a pinne.

Some do accustome to put vvithin the *Æolipile* a crooked funnell of many foldings, to the end that the vvinde that impetuously rolles, to and fro vvithin, may imitate the noise of thunder. Others content themselves vvith a simple funnell placed right upvvard, somevvhat vvider at the top than elsevvhere like a Cone, vvhose basis is the mouth of the funnell: and there may be placed a bovvle of Iron or Brasse, vvhich by the vapours that are cast out vvill cause it to leap up, and dance over the mouth of the *Æolipile*.

Lastly, some apply near to the hole smal Windmils, or such like, vvhich easily turne by reason of the vapours; or by help of tvvo or more bovved funnels, a bowle may be made to turne: these *Æolipiles* are of excellent use for the melting of mettalls and such like.

Novv

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

Heat the *Æolipiles* being empty, and the aire which is within it will become extreamely rarefied; then being thus hot throw it into water, and the aire will begin to be condensed: by which meanes it will occupie lesse roome, therefore the water will immediately enter in at the hole to avoide vacuitie: thus you have some practicall speculation upon the *Æolipile*.

Problem. LXIX.

Of the Thermometer: or an instrument to measure the degrees of heat and cold in the aire.

This Instrument is like a *Cylindricall* pipe of Glasse, which hath a little ball or bowle at the toppe: the small end of which is placed into a vessell of water below, as by the figure may be seene.

Then put some coloured liquor into the Cylindricall glasse, 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 aire inclosed in the *Thermometer* is rarefied 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 palme of the hand upon the ball

ball of the *Thermometer* : the Glasse being so thinne, and the aire so capable of rarefaction, that at the very instant you may see the water descend: and your hand being taken away, it will softly ascend to his formes place againe. 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 eare to make the water to descend by command, and the reason of this motion is, that the aire heated in the *Thermometer*, doth rarefie and dilate, requiring a greater place; hence presseth the water and causeth it to descend: contrariwise when the aire cooleth and condenseth, it occupieth lesse roome; now nature abhorring vacuity, the water naturally ascendeth. In the second place, I say, that by this meanes one may know the degrees of heat and cold, which are in the aire each houre of the day; forasmuch as the exterior aire is either hot or cold, the aire which is inclosed in the *Thermometer* doth likewise either rarefie 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 noone or midday; and towards evening it will againe ascend: so in winter it will mount so high, that all the Cylinder of the *Thermometer* will be full, but

in

in Summer, it will descend so low that scarce there will be percea ved 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, & by this vvay they may not only distinguish upon vvhat degree the vvater ascendeth in the morning, at midday, & at any other houre: but also one may knovv hovv much one day is hotter or colder than another: by marking hovv many degrees the vvater ascendeth or descendeth, one may compare the hottest and coldest dayes in a vvhole year together vvith these of another year: againe one may knovv hovv much hotter one roome is than another, by vvhich also one might keep a chamber, a furnace, a stove, &c. alvvayes in an equalitie of heat, by making the vvater of the *Thermometer* rest alvvayes upon one & the same degree: in brief, one may judge in some measure the burning of Fevers, and neare unto what extension the aire canbe rarefied by the greatest heat.

Many make use of these glasses to judge of the vveather: for it is observed that if the vvater fall in 3 or 4 hours a degree or thereabout, that raine insueth; and the vvater vvill stand at that stay, untill the vveather change: marke the water at your going to bed, for if in the morning it hath descended raine followeth, but if it be mounted

mounted higher, it argueth faire 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, & 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 greatnesse from humane bodies.

Thirdly, because the *symmetrie* and concordancie of the parts is so admirable, that all workes which are well proportionable, as namely the building of Temples, of Shippes, of Pillars, and such like pieces of Architecture, are in some measure fashioned and composed after his proportion. And we know that the Arke of *Noah* built by the commandement of God, was in length 300 Cubits, in breadth 50 Cubits, in height or depth 30 cubits, so that the length containes the breadth 6 times, and 10 times the depth: now a man being measured you will finde him to have the ſame proportion in length, breadth, and depth.

Vilalpandus treating of the Temple of *Solomon* (that chieftaine 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 greatneſſe of the work and proportionable *ſymmetrie*, 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 columnes, are as the foot; the top, and roofe as the head; the reſt as the body: thoſe which have beene ſomewhat more curious, have noted that as in humane bodies, the parts are uniforme, 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 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 vvrithing of haire, the channells of columnes, to the fouldings of vvomens Robes, &c.

Novv building being a vvork of the beſt *Artiſt*, there is much reaſon vvhy man ought to make his imitation from the chiefe vvork of nature; vvhich is man.

Hence it is that *Vitruvius* in his third book, and

and all the best *Architectes*, treate of the proportion of man; amongst others *Albert Durens* hath made a whole book of the measures of mans body, from the foot to the head, let them read it who wil, they may have a prefect knowledge thereof: But I will content my selfe and it may satisfie some with that which followeth.

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

Secondly, if a man have his feet and hands extended or stretched in forme of S. *Andrews* Crosse, placing one foot of a paire of Compasses upon his navill, one may describe a circle which will passe by the ends of his hands and feet, and drawing lines by the termes 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 6 part of all the body taken in length or height.

Fourthly, the length of the face is equall to the length of the hand, taken from the small of the arme, unto the extremity of the longest finger.

Fiftly, the thicknesse 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 lesse.

Sixtly, the height of the brow, the length of the nose, the space between the nose and the chinne, the length of the eares, the greatnesse of the thumbe, are perfectly equall 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 cleare, 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 oneiy the claw of a Lion, did figure and draw out all the beast according to his true type or forme, so the exquisite Painter *Timantes*, having painted a *Pygmey* or Dwarfe, which he measured with a fadome made with the inch of a Giant, it was sufficient to know the greatnesse of that Giant.

To be short, we may by like methode 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* was desirous to put out to the world some notable thing, went to *Alexander* the great, and proposed unto him a high and speciall piece of work which he had projected: as to figure out the mount *Athos* in forme of a great Statue, which should hold in his right hand a Towne capable to receive ten thousand men: and in his left hand a vessell to receive all the water that floweth from the Mountaine, which with an ingine should cast into the Sea. This is a pretty project, said *Alexander*, but because there was not field-roome thereabout to nourish and reteine the Citizens of that place, *Alexander* was wise not to entertaine the designe.

Now let it be required of what greatnesse this Statue might have been, the Towne 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 Mountaine it selfe, and the Mountaine was about a mile in height plumb or perpendicular;

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 multiplyed by the breadth, makes an hundred twenty five thousand square feet, for the quantitie of his hand to make the towne in, to lodge the said 10 thousand men, allowing to each man neere about 12 foot of square ground: now judge the capacitie of the other parts of this *Collossus* by that which is already delivered.

Secondly, *Plinie* in his 34. book of his natural History, speakes of the famous *Colossus* that was at *Rhodes*, between whose legges a Shippe might passe with his sailes 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 mettal of it, now what might be the greatnesse and weight of this Statue?

For answer, it is usually allowed for a Camels burthen 1200 pound weight, therefore all the *Collosus* did weigh 108coco pound weight, which is ten hundred and fourescore thousand pound vveight.

Novv 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 halfe, and seeing that the Nose, the brovv, and the thumbe, are the third part of the face, his Nose vvas 3 foot and a halfe long, and so much also yvas his thumbe in length: novv the thicknesse being alvvayes the third part of the

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

Thirdly, the said *Plinie* 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 brasse, which was made of 120 foot in height, which *Nero* caused to be painted in the same height. Now would you know the greatnesse of the members of this *Colossus*, the breadth would be 20 foot, his face 12 foote, his thumb and his nose 4 foot, according to the proportion before delivered.

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

Of monstrous Giants.

YOu will hardly beleeve all that which I say touching this, neither will I beleeve all that which Authors say upon this subject: notwithstanding you nor I canuot deny but that long ago there have been men of a most prodigious greatnesse; for the holy vvritings vvitnesse this themselves in *Deut, Chap.* 3. that there vvas a certaine Giant called *Og*, of the Town of *Rabath*, vvho had a bed of Iron, the length thereof vvas 9 cubits, and in breadth 4 cubits.

So in the first of *Kings Chap.* 17. there is mention made of *Goliah*, vvhose height vvas a palme and 6 cubits, that is more then 9 foot, he was armed from the head to the foot, and his Curiat 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 certaine, that the rest of his armes taking his Target, Helmet, Bracelets, and other Armour together, did weigh at the least 5 hundred pound, a thing prodigious; seeing that the strongest man that now is, can hardly beare 200 pound, yet this Giant carries this as a vesture without paine.

Solinus reporteth in his 5 *Chap.* of his Historie, that during the Grecians warre 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 halfe) therefore according to the proportion delivered, his face should be 5 foot in length, a thing prodigious and monstrous.

Plinie in his 7. book and 16 *Chap.* saith, that in the Isle of *Crete* or *Candie*, a mountaine being cloven by an Earth-quake, there was a body standing upright, which had 46 Cubits of height: some beleeve that it was the body of *Orion* or *Othus*, (but I think rather it was some Ghost or some delusion) whose hand should have beene 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 Towne, where

it

it is thought that the Giant *Antheus* was buried, *Sertorius* could not beleeve that which was reported of his prodigious greatnesse, caused his sepulchre to be opened, and found that his body did containe 60 Cubits in length, then by proportion he should be 10 Cubits or 15 foot in breadth; 9 foot for the length of his face, 3 foot for his thumb, which is neare the capacitie of the *Colossus* at *Rhodes*.

But behold here a fine fable of *Symphoris Campesius*, in his book intituled *Hortus Gallicus*, who sayes that in the Kingdome of *Sicilie*, at the foot of a mountaine neare *Trepane*, in opening the foundation of a house, they found a Cave in which was laid a Giant, which held in stead of a staffe a great post like the mast of a Ship: and going to handle it, it mouldered 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 seeme 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 beleeve 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 10 foot long? but it is very certaine that there have been men of very great stature, as the holy Scriptures before witnesse, and many Authours worthy of beliefe 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 it is usually attributed to the tallest ordinary man in these our times but 6 foot of length; and Histories are full of the description of other Giants of 9, 10, and 12 foot of height, and it hath been seen in our times some which have had such heights as these.

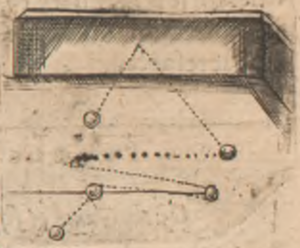
Problem. LXXI.

Of the game at the Palme, at Trap, at Bowles, Paile-maile, and others.

THe Mathematickes often findeth place in sundry Games to aid and assist the Gamesters, though not unknowne unto them, hence by Mathematicall 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 Bowle by Geometricall lines and angles.

But the exercise, experience, and dexteritie 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

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



And the first maxime is thus: When a Bowle toucheth another Bowle, or when a trapstick striketh the Ball, the moving of the Ball is made in a right line, which is drawne from the Centre of the Bowle by the point of contingencie.

Secondly, in all kinde of such motion; when a Ball or Bowle rebounds, be it either against wood, a wall, upon a Drumme, a pavement, or upon a Racket; the incident Angle is alwayes equall to the Angle of reflection.

Now following these *maximes*, it is easie to canclude, first, in what part of the wood or wall, one may make the Bowle or Ball go to reflect or rebound, to such a place as one would. Secondly, how one may cast a Bowle 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.

Thirly, how one may touch a Bowle 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

may be noted that the *Maximes* of reflections cannot be exactly obſerved by locall motion, as in the beames of light and of other quallities, 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 formes.

NVmbers have an admirable ſecrecie, 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 certaine paſſage of a ſquare forme, 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, & 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 happed that 4 Souldiers comming by, deſired of the Governour of the paſſage, that they might be entertained into ſervice, who told them he could not admit of more then 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

keep ſtill the order of 9, for each face of the ſquare to defend the Angles & Gates, to which the Governours 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 the reſt; that each of theſe foure Souldiers took away his cumrade 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 forme 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 Cumrade, and placing two 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 tranſported might make 5 every way? & this is according to the figures, *F.G.H*

PROB.

PROBLEM. LXXIII.

How to make the string of a Viole sensibly shake; without any one touching it?

THis is a miracle in musick, yet easie to be experimented. Take a Viole 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 Viole-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 Violes, and strike upon a string of the ono, the string of the other will sensibly shake.

Now it may be demanded, how comes this shaking, is it in the occult sympathie, 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 aire, which is agitated or moved by the shaking or the trembling of the other? & whence is it that the Viole-bowe moved upou the first string, doth instantly in the same time move the third string, and not the second? if the cause be not either in the first or second? I leave to others to descant on.

EX-

EXAMINATION.

IN this Examination we have ſomething elſe to imagine, than the bare ſympathie 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 capacitie: 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 facill to lay open a way to the knowledge of the true and immediate cauſe of this noble and admirable Phænomeny. *Now this will ſenſibly appeare when the Cords are of equall length and greatneſſe, and ſet to an uniſone; but when the Cords differ from their equalitie, it will be leſſe 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 proportionall 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 2 Lutes, Viols, &c. & in ſetting them to one tune: for then in touching the Cord of the one, it will give*

give a ſenſible motion to the Cord of the o-ther : and not onely ſo but alſo a harmony.

Problem. LXXIIII.

Of a veſſell which containes three ſeverall kindes of liquor, all put in at one bung-hole, and drawn out at one tap ſeverally without mixture.

THe veſſell is thus made, it muſt be divided into three Cells for to conteine 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 funnell pierced in three places, in ſuch ſort, that placing one of the holes right againſt the pipe which anſwereth unto him, the other tvvo pipes are ſtopped; then vvhen it is full, turne the funnel, and then the former hole vvill be ſtopped, and another open, to caſt in other vvine vvithout mixing it vvith the other.

Novv to dravv out alſo vvithout mixture, at the bottome of the veſſell there muſt be placed a pipe or broach, vvhich may have three pipes; and a cock pierſed vvith three holes ſo artificially done, that turning the cock, the whole vvhich anſvvereth to ſuch of the pipes that is placed at the bottom, may iſſue forth ſuch vvine as belongeth to that pipe, & turning the Cock to another pipe, the former hole vvil be ſtopped; and

and so there will issue forth another kinde of wine without any mixtures; but the Cocke may be so ordered that there may come out by it two wines together, or all three kindes at once: but it seems best when that in one vessell and at one Cocke, a man may draw severall kindes of wine, and which he pleaseth to drink.

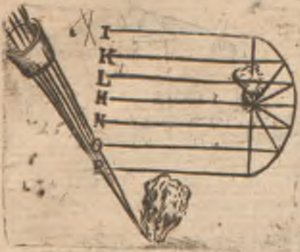
PROBLEM. LXXV.

Of burning-Glasses.

IN this insuing discourse I will shew the invention of *Prometheus*, how to steale fire from Heaven, and bring it down to the Earth; this is done by a little round Glasse, or made of steele, by which one may light a Candle, and make it flame, kindle Fire-brands to wake them burne, melt Lead, Tinne, 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 *Ma cellus* which besieged that place, to hinder and impeach their aproach, he flung huge stones by his Ingines to sink them into the Sea, and transformed himselfe into *Jupiter*, thundering downe 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 watery region: *Zonaras* witnesseth that *Proclus* a brave Mathematician, burned in the same manner the Ships of *Vitalian*, which were come to besiege *Constantinople*; and daily experience may let you see great effects of burning: for a Bowle of Crystall polished, or a Glasse thicker in the middle than at the edges, will burne exceedingly, nay a bottle full of water exposed to the Sunne will burne when the Sunne shineth hot, and children use with a Glasse to burne Flies which are against the walles, and their fellowes cloaths.



But this is nothing to the burning of those Glasses which are hollow, namely those which are of steele well polished, according to a parabolicall or ovall section. A sphericall Glasse, or that which is according to the segment of a *Sphere*, burnes very effectually about the fourth part of the Diameter; notwithstanding the Parabolie and Ecliptick sections have a great effect: by which Glasses there are also diverse figures represented forth to the eye.

The cause of this burning is the uniting of the beames of the Sunne, which heat mightily in the point of concourse or inflammation,

which

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 Pyramidall point, or point of inflammation is knowne. Now some Authors promise to make Glasses which shall burne 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 sphericall Glasses, shewes how one may serve himselfe with a concave Glasse, to light fire in the shadow, or neare such a place where the Sunne shines not, which is by help of a flat Glasse, by which may be made a percussion of the beames of the Sun into the concave Glasse, adding unto it that it serves to good use to put fire to a Mine, provided that the combustible matter be well applyed before the concave Glasse; in which he saies true: but because all the effect of the practice depends upon the placing of the Glasse and the Powder which he speaks not of: I will deliver here a rule more generall.

How one may place a Burning-glasse with his combustible matter in such sort, that at a convenient houre of the day, the Sun shining, it shall take fire and burne: Now it is certaine that the point of inflammation or burning, is changed as the Sun changeth place, and no more nor lesse, than the shadow turnes about the style of a Dyall; therefore have regard to the Suns motion, and his height and place: a Bowle of Crystall in the same place that the top of the style is, and the Powder or other combustible matter under the Meridian, or houre of 12,1,2,3,&c. or any other houre, and under the Suns arch for that day: now the Sunne comming to the houre of 12, to 1,2,3, &c. the Sunne casting his beames through the Crystall Bowle, will fire the materiall or combustible thing, which meets in the point of burning: the like may be observed of other Burning-glasses.

EXAMINATION.

IT is certaine in the first part of this Probleme that Conicall, concave and sphericall Glasses, of what matter soever, being placed to receive the beames of the Sun will excite heat, and that heat is so much the greater, by how much it is neere the point of concurse or inflamation. But that Archimedes or Proclus did fire or burne Shipps with such Glasses, the ancient Histories are silent, yea theselves say nothing: besides the great difficultie that doth oppose it in remotenesse, and the matter that the effect is to work upon: Now by *by a common Glasse we fire things neare at hand, from which it seems very facil to such which are lesse read, to do it at a farre greater distance, and so by relation some deliver to the World by supposition that which never was done in action: this we say the 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 burne at a great distance, as is said of some, it is absolutely impossible; and that the Parabolicall and Ovall Glasses were of* Archimedes *and* Proclus *invention is much uncertaine: 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 neere at hand; for if it be cast farre off, the effect is little, and the heat weake, or otherwise such Glasses must be greatly extended to contract many beames to amasse a sufficient quantity of beames in Parabolicall and Conicall 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 farre remote, as is supposed before, such a Glasse cannot be used but at a great inclination of* *the Sunne, by which the effect of burning is diminished, by reason of the weaknesse of the Sunne-beames.*

And here may be noted in the last part of this Probleme, that by reason of obstacles if one plaine Glasse be not sufficient, a second Glasse may be applyed to help it: that so if by one simple reflection it cannot be done, yet by a double reflection the Sun-beames may be cast into the said Caverne or Mine, and though the reflected beams in this case be weak, yet upon a fit cumbustible matter it will not faile to do the effect.

PROBLEM. LXXVI.

Containing many pleasant Questions by Way of Arithmeticke.

I Will not insert in this Probleme that which is drawne 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 tearms, which I account not proper to this place, neither to my purpose: let those read that will *Diophanta Schenbelius* upon *Euclide* and others, and they may be satisfied

Of the Asse and the Mule.

IT happened that the Mule and the Asse upon a day making a voyage, each of them carried

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a Barrell full of Wine: now the lasie Asse felt her selfe over-loaden, complained and bowed under her burthen; which thr Mule seeing said unto her being angry, (for it was in the time when beasts spake) Thou great Asse, 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 J should give a measure of my loading to thee, yet my burthen would be as much as thine.

Now how many measures did each of them carry? Answer, the Mule did carry 7 measures, and the Asse 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 Asse, each of them would have equall 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? who 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 rost a great quantitie 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 cleare by multiplying 7 by 50, and the product by 900 makes the said 315000.

Of the number of Crownes that two men had.

John and *Peter* had certaine number of crowns: *John* said to *Peter*, If you give me 10 of your crownes, I shall have three times as much as you have: but *Peter* said to *John*, If you give me 10 of your crownes I shall have 5 times as much as you have: how much had each of them? Answere, *John* had 15 crownes and 5 sevenths of a crowne, and *Peter* had 18 crownes, and 4 sevenths of a crowne. For if you adde 10 of *Peters* crownes to those of *Johns*, then should *John* have 25 crownes and 5 sevenths of a crowne, which is triple to that of *Peters*, viz. 8, and 4 sevenths: and *John* giving 10 to *Peter*, *Peter* should have then 28 crownes, and 4 sevenths of a crowne, which is *Quintupla*, or 5 times as much as *John* had left, *viz.* 5 crownes and 5 sevenths.

In like manner two Gamesters playing together, *A* and *B*, after play *A* said to *B*, Give me 2 crownes of thy money, and I shall have twice as much as thou hast: and *B* said to *A*, Give me 2 crownes 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 seventhes, and *B* had 4 and 6 seventhes.

About the houre of the day.

SOme one asked a Mathemacian what a clocke it was; who answered that the rest of the day is foure thirds of that which is past: now judge what a clock it is. Answer, if the day were according to the Jewes and ancient Romanes, which made it alwayes to be 12 houres, it was then the 5 houre, and one seventh of an houce, so there remained of the whole day $6\frac{6}{7}$ that is, 6 houres, 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 multipled by 4 makes 6 and $\frac{6}{7}$, which is the remainder of the day, as before: but if the day had been 24 houres, then the houre had been 10 of the clock, and two seventhes of an houre, which is found out by dividing 12, or 24 by $\frac{7}{3}$.

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

Of Pythagoras his Schollers.

PYthagoras being asked what number of Schollers he had, answered, that halfe of them studied *Mathematickes*, the fourth part Physick, the seventh part Rethorick, and besides he had 3 women: now judge you saith he, how many Schollers I have. Answer, he had in all 28, the halfe of which is 14, the qnarter of of which is 7, and the seventh part of which is 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 9 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 & the Muses had one as many as the other: The question is how many Apples each Grace had, and how many they gave to each Muse? To answer the qeustion, joyne the number of Graces and Muses together vvhich makes 12, and so many Apples had each Grace: Novv may you take the double, triple, &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 36, 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 Crovvnes amongst his tvvo children; the one being legitimate, and the other a Bastard, conditionally

nally that the fifth part which his legittimate Sonne should have, should exceed by 10, the fourth part of that which the Bastard should have: what was each o nes part? Answer, the legitimate Sonne had 577 crownes and $\frac{7}{9}$, and the Bastard 422 crownes and $\frac{2}{9}$ now the fifth part of 577 and 7 ninthes is 115, aud $\frac{5}{9}$, and the fourth part of 422 and $\frac{2}{9}$ is 105 and $\frac{5}{9}$, which is lesse then 115 $\frac{5}{9}$ by 10, according to the Will of the *Testator.*

Of the Cups of Crœsus.

CRœsus gave to the Temple of the Gods six Cups of Gold, which weighed together 600 Drammes, but each cup was heavier one than another by one Dram: how much did each of them therefore weigh? Answer, the first weighed 102 Drammes and a halfe; the second 101 Drammes and a halfe, the third 100 Drammes and $\frac{1}{2}$, the fourth 99 a& halfe, the fifth 98 & a halfe; and the sixt Cup weighed 97 Drammes and a halfe. which together makes 600 Drams as before.

Of Cupids Apples.

CUpid complained to his mother that the Muses had taken away his Apples, *Clio*, said he, took from me the fifth part, *Euterp* the twelfth part, *Thalia* the eighth part, *Melpomene* the twentieth part, *Erates* the seventh part, *Terpomene* the fourth part, *Polyhymnia* took away 30, *Vrania* 120, and *Calliope* 300. so there

there vvere left me but 5 Appls, hovv many had he in all at the first? I anſvver 3360.

There are an infinite of ſuch like queſtions amongſt the Greek Epigrams: but it would be unpleaſant to expreſſe them all: I will onely adde one more, and ſhew a generall rule for all the reſt.

Of a Mans Age.

A Man vvas ſaid to paſſe the ſixth part of his life in childe-hood, the fourth part in his youth, the third part in Manhood, and 18 yeares beſides in old age: what might his Age be? the anſvver is, 72 yeares: vvhich 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 againe by 3 makes 72, then take the third part of 72, vvhich is 24, the fourth part of it, vvhich is 18, and the ſixth part of it vvhich is 12, theſe added together make 54, vvhich taken from 72, reſts 18. this divided by 18 (ſpoken in the Queſtion) gives 1, which multiplied by the ſumme of the parts, *viz.* 72, makes 72, the Anſvver as before.

Of the Lion of Bronze placed upon a Fountaine with this Epigramme.

OVt of my right eye if I let vvater paſſe, I can fill the Ciſterne in 2 dayes: if I let it paſſe out of the left eye, it vvill be filled in 3 dayes: if it paſſe out of my feet, the Ciſtern vvill be 4 dayes a filling; but if I let the vvater paſſe out of my mouth, I can fill the Ciſtern then in 6 houres:

houres: in vvhat time ſhould I fill it, if I poure forth the vvater at all the paſſages at once?

The Greeks (the greateſt talkers in the vvorld) variouſly apply this queſtion to divers ſtatues, and pipes of Fountaines : and the ſolution is by the Rule of 3, by a generall Rule , or by *Algebra.* They have alſo in their *Anthologie* many other queſtions , but becauſe they are more proper to exerciſe, than to recreate the ſpirit , I paſſe them over (as before) with ſilence.

PROBLEM. LXXVII.

Divers excellent and admirable experiments upon Glaſſes.

THere is nothing in the world ſo beautifull as light: and nothing more recreative to the ſight, than Glaſſes vvhich reflect : therefore I vvill novv produce ſome experiments upon them, not that I vvill dive into their depth (that vvere to lay open a myſterious thing) but that vvhich may delight and recreate the ſpirits: Let us ſuppoſe therefore theſe principles , upon vvhich is built the demonſtration of the apparances which are made in all ſort of Glaſſes.

Firſt, that the rayes or beames, vvhich reflect upon a Glaſſe , make the Angle of incident equall 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 Glaſſe,

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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 Glaſſe. Theo. 17. and 18.

And here you are to underſtand, that there is not meant only thoſe which are ſimple Glaſſes or Glaſſes of ſteele, but all other bodies, which may repreſent the viſible Image of things by reaſon of their reflection, as Water, Marble, Mettal, or ſuch like. Now take a Glaſſe in your hand and make experiment upon that which followeth.

Experiment upon flat and plaine 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 eqnall to the Angle of reflexion: therefore when a Glaſſe ſtands upright, that is, perpendicular to the Horizon, you cannot ſee that which is above, except the Glaſſe be placed down flat: and to ſee that on the right hand, you muſt be on the left hand, &c.

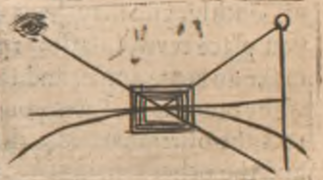
Secondly, an image cannot be ſeen in a Glaſs if it be not raiſed above the ſurface of it; or place a Glaſſe upon a wall, you ſhall ſee nothing which is upon the plaine of the wall, and place it upon a Table or Horizontal Plaine, you ſhall ſee nothing of that which is upon the Table.

Thirdly,

Thirdly, in a plaine Glasse all that is seene appeares or seemes to sink behinde the Glasse, as much as the image is before the Glasse, as before is said.

Fourthly, (as in water) a Glasse lying downe flat, or Horizontall, Towers, Trees, Men, or any height doth appeare, inversed or upside downe; and a Glasse placed upright, the right hand of the Jmage seems to be the left, and the left seems to be the right. Fifthly, will you see in a Chamber that which is done in the street, without being seen: then a Glasse must be disposed, that the line upon which the Jmages come on the Glasse, make the Angle of incidence equall to that Angle of reflexion.

Sixtly, an height (as suppose *D E*.) may be measured by a plaine Glasse, as let the Glasse be G. placed downe upon the ground, and let the eye be at *C*. so farre removed from the Glasse, that the eye at C. may see the toppe of the Tower *E* in the Angle or edge of the Glass at *A*, but in the line of reflexion *C A*, then measure the distance between your foot *B*, and the point *A*, & also the distance betweene the Glasse *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



Tower

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 plaine Glasse,and look flaunting upon it , so that the Candle and the Glasse be neere in a right line, you shall see 3,4,5, &c. images , from one and the same Candle.

Eightly,take tvvo plaine Glasses , and hold them one against the other,you shall alternately see them oftentimes one vvithin the other , yea vvithin themselves,againe and againe.

Ninthly, if you hold a plaine Glasse behinde your head,and another before your face , you may see the hinder part of your head, in that Glasse vvhich you hold before your face.

Tenthly, you may have a fine experiment if you place tvvo 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 vvonder & astonishment to some,to see vvithin a Glasse an Image vvithout knovving from vvhence it came, and it may be done many vvayes: 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 upvvards. Then place another object , so that it reflect , or cast the Image downeward to the eye of the spectator, without perceiving it being hid behinde something, for then the Glasse will represent a quite contrary thing, either that which is before the Glasse, or that which is about it, to wit, the other hidden object.

Twelfthly, if there be ingraved behinde the backside of a Glasse, or drawne any Image upon it, it will appeare before as an Image, without any appearance: or portraicture to be perceived.

EXAMINATION.

This 12 Article *of ingraving an Image behinde the Glasse, 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 usuall covering of Glasses behinde; and so made up like an ordinary looking-Glasse 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 Glasse be in an obscure place, and the light which is given to it be somewhat farre off.*

Place a Glasse neare the floor of a Chamber, & make a hole through the place under the Glasse, 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 Glaſſe, 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 the Wall.

14 In theſe Channel-Images which ſhew one ſide a deaths head, & another ſide a faire face: and right before ſome other thing : it is a thing evident, that ſetting a plaine Glaſſe ſidewiſe to this Image you ſhall ſee it in a contrary thing , then that which was preſented before ſidewiſe.

15 Laſtly, it is a fine ſecret to preſent unto a plaine Glaſſe writing with ſuch induſtry, that one may read it in the Glaſſe, 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 kinde of writing to a plaine Glaſſe, it ſhall appear another kinde of writing both againſt ſenſe and forme, as if there were preſented to the Glaſſe WEL .it would ſhew it MET ; if it were written thus MIV , and preſented to the Glaſſe, it would appeare thus VIM; for in the firſt , if the Glaſſe ly 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 plaine Glaſſes, either of the Admirable multiplications, or appearances , which is made in a great number of them;for to content the ſight

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in this particular, one must have recourse to the Cabinets of great Personages who inrich themselves with most beautifull ones.

Experiments upon Gibbous, or convex Sphericall Glasses.

IF they be in the forme of a Bowle, or part of a great Globe of Glasse, there is singular contentment to contemplate on them.

First, because they present the objects lesse and more gracious, and by hovv much more the Images are separated from the Glasse, by so much the more they diminish in Magnitude.

Secondly, they that shew the Images plaiting, or foulding, which is very pleasant, especially when the Glasse is placed downe, and behold in it some Blanching, seeling, &c. The upper part of a Gallerie, the porch of a Hall, &c. for they will be represented as a great vessel having more belly in the middle then at the two ends, and Posts, and Joists of Timber will seeme as Circles.

Thirdly, that which ravisheth the spirits, by the eye, and which shames the best perspective Painting that a Painter can make, is the beautifull contraction of the Images, that appeare within the sphericity of these small Glasses: for present the Glasse to the lower end of a Gallarie, 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 Cittie; all the faire Architecture, and appearances will be ſeene contracted within the circuit of the Glaſſe with ſuch varietie of Colours, and diſtinctions in the leſſer parts, that I know not in the world what is more agreeable to the ſight, and pleaſant to behold, in which you will not have an exact proportion, but it will be variable, according to the diſtance of the Object from the Glaſſe.

Exptriments upon hollow, or Concave ſphericall Glaſſes.

I Have heretofore ſpoken how they may burne, being made of Glaſſe, or Metall, it remaines 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 Glaſſe is, and the Globe from whence it is extracted for it muſt in proportion as a ſegment of ſome be made circle or orbe.

EXAMINATION.

IN this we may obſerve that a ſection of 2. 3. or 4. Inches in diameter, may be ſegments of ſpheres of 2. 3. or 4 foot nay of ſo many fadome, for it is certaine that amongſt thoſe which comprehend a great portion of a leſſer ſphere, and thoſe which comprehend a little ſegment of a great ſpheere, whether they be equall or not in ſection, there will happen an evident difference in one and the ſame experiment

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riment, in the number, situation, quantitie, 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 himselfe that he hath caused many to be polished for sundry great Lords of *Italy*, and *Germanie*, which were segments of Globes of 2. 3. and 4. 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 beare with the cost.

EXAMINATION.

TOuching Maginus *he hath nothing ayded 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 himselfe, 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 seene sometimes upon the surface of the Glasses, sometimes as though they were within it and behinde it, deeply sunk into it, sometimes they are seene before, and without the Glasse, sometimes between the object and the

Glasse; sometimes in the place of the Eye, sometimes farther from the Glasse then the object is: which comes to passe by reason of the divers concourse of the beames, and change of the place of the Images in the line of reflection.

EXAMINATION.

The relation of these appearances passe 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* Glasse, *and it is a principall point to declare truly in which place the* Image *is seen in the* Glasse: *those that are more learned in* Opticall *knowledge affirme the contrary, and nature it selfe gives it a certaine place according to its position; being alwayes 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 fasities in their writings, and those that followed them*

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 neerer the object approcheth to the Glasse, 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 approacheth thereto, the representation of the Image cometh neere the eye, but passing the point of concourse it goes back againe: these appearances thus approaching do not a little astonish those which are ignorant of the cause: they are inversed, if the eye be without the point of concourse untill the object be within, but contrarily if the eye be between the point of concourse and the Glasse, then the Images are direct: and if the eye or the object be in the point of concourse, the Glasse will be enlightened, and the Images confused, and if there were but a spark of fire in the said point of concourse, all the Glasse would seeme a burning fire-brand, and we dare say it would occurre without chance, and in the night be the most certaine 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 confirme what we here speak of: & will finde new lights with a conveniable position to the Glasse, 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 himselfe 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 seene in one and the same place immutable; or if the Image and the eye move in their owne lines, the representation in the Glasse seemes to invest it selfe continually with a different figure.

NOw the Image comming thus to the eye, those which know not the secret, draw their sword when they see an Image thus to issue out of the Glasse, or a Pistoll which some one holds behinde: and some Glasses will shew a sword wholly drawne out, separated from the Glasse, as though it were in the aire: and it is daily exercised, that a man may touch the Image of his hand or his face out of the Glasse, which comes out the farther, by how much the Glasse is great and the Centre remote.

EXAMINATION.

NOw that a Pistoll being presented to a Glasse behinde a man, should come out of the Glasse, and make him afraid that stands before, seeming to shoot at him: this cannot be: for no object whatsoever presented

presented to a concave Glasse, if it be not neerer to the Glasse then the eye is, it comes not out to the sight of the party; therefore he needs not feare that which is said to be behinde his back, and comes out of the Glasse; for if it doth come out, it must then necessarily be before his face, so in a concave Glasse whose Centre is farre remote, if a sword, stick, or such like be presented to the Glasse, it shall totally be seen to come forth of the Glasse, and all the hand that holds it. And here generally note that if an Image be seen to issue out of the Glasse to come towards the face of any one that stands by, the object shall be likewise seen to thrust towards that face in the Glass and may easily be knowne to all the standers by: so many persons standing before a Glasse, 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 Glasse and carry the sword right towards it, and the effect will follow. In like manner ones hand being presented to the Glosse as it is thrust towards the Centre, so the representation of it comes towards it, and so the hands will seeme to be united, or to touch one another.

FRom which may be concluded, if such a Glasse be placed at the seeling or planching of a Hall, so that the face be *Horizontall* 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 feare or scaring: for one

one ſhould ſee many men in the *aire* as if they were hanging by the feet.

EXAMINATION.

T*Ouching a* Glaſſe *tyed at a ſeeling or planching, that one may ſee a man hang by the feet in the* aire, *and ſo many* Glaſſes, *many men may be ſeen: without caution this is very abſurd, for if the* Glaſſe *or* Glaſſes *be not ſo great that the Centre of the ſphere upon which it was made, extend not neere to the head of him that is under it, it will not pleaſantly appeare, and though the* Glaſſe *ſhould be of that capacity that the* Centre *did extend ſo farre, yet will not the* Images *be ſeene to them which are from the* Glaſſe, *but only to thoſe which are under it, or neere unto it: and to them it will notably appeare, and it would be moſt admirable to have a* Gallerie *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* aire, *and you could not walk without incountering airie apparitions.*

SEcondly, in flat or plaine Glaſſes the Image is ſeen equall to his object, and to repreſent a whole man, there ought to be a Glaſſe as great as the Image is: In convex Glaſſes the Images are ſeen alwayes leſſe, in concave Glaſſes they

they may be ſeen greater or leſſer, but not truly proportionable, by reaſon the diverſe reflexions which contracts or inlargeth the Species: when the eye is between the Centre and the ſurface of the Glaſſe; the Image appeares ſometimes very great and deformed, and thoſe which have but the appearance of the beginning of a beard on their chinne, may cheare up themſelves to ſee they have a great beard; thoſe that ſeeme to be faire will thruſt away the Glaſſe with deſpight, becauſe it will transforme their beauty: thoſe that put their hand to the Glaſſe vvill ſeeme to have the hand of a Giant, and if one puts his finger to the Glaſſe it vvill be ſeen as a great *Pyramide* of fleſh, inverſed againſt his finger.

Thirdly, it is a thing admirable that the eye being approached to the point of concourſe of the Glaſſe, there vvill be ſeen nothing but an intermixture or confuſion: but retiring back a little from that point, (becauſe the rayes do there meet.) he ſhall ſee his Image inverſed, having his head belovv and his feet above.

Fourthly, the divers appearances cauſed by the motion of objects, either retiring or approaching: whether they turne to the right hand or to the left hand, whether the Glaſſe be hung againſt a wall, or whether it be placed upon a Pavement, as alſo what may be repreſented by the mutuall aſpect of concave Glaſſes with plaine and convex Glaſſes: but I will with ſilence paſſe them over, only ſay ſomething of two rare experiments more as followeth.

The

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, sufficieutly bigge, but inversed upon the surface of the Glasse, with some kinde of colour, or theseletters may be written with wax, (the easier to be taken out againe :) for then placing the Glasse to the Sunne, 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 Moone.

In the second place, how a man may sundry wayes help himselfe with such a Glasse, with a lighted Torch or Candle, placed in the point of concourse or inflammation, which is neare the fourth part of the Diameter : for by this meanes the light of the Candle will be reverberated into the Glasse, and vvill be cast back againe very farre by parrallel lines , making so great a light that one may clearly see that vvhich is done farre off, yea in the camp of an Enemie : and those which shall see the Glasse a farre 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 certaine Lanthorns which dazell the eyes of those which come against them; yet it serves singular well to enlighten those which carry them, accom modating a Candle with a little hollow Glasse, so that it may successively be applyed to the point of inflammation.

In

In like manner by this reflected light, one may reade farre 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 perill or ſuſpition.

EXAMINATION.

This will be ſcarce ſenſible upon a wall remote from the Glaſſe, and but indifferently ſeen upon a wall which is neare the Glaſſe, and withall it muſt be in obſcuritie 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 ſhewne in a concave Glaſſe: for if in the point of inflammation of a parabolicall ſection, a Candle be placed, the light will be reflected by parallel lines, as a columne or Cylinder; but in the ſphericall ſection it is defective in part, the beames being not united in one point, but ſomewhat ſcattering: notwithſtanding it caſteth a very great beautifull light.

Laſtly, thoſe which feare to hurt their ſight by the approach of Lampes or Candles, may by this artifice place at ſome corner of a Chamber, a Lamp with a hollow Glaſſe behinde

it,

it, which will commodiously reflect the light upon a *Table*, or to a place assigned: so that the *Glasse* be somewhat raised to make the light to streeke upon the Table with sharp Angles, as the Sunne doth when it is but a little elevated above the *Horizon*, for this light shall exceed the light of many Candles placed in the Roome, and be more pleasant to the sight of him that useth it.

Of other Glasses of pleasure.

FIrst, the *Columnary* and *Pyramidall Glasses* that are contained under right lines, do represent the *Images* as plaine *Glasses* do; and if they be bowing, then they represent the *Image*, as the concave and convex *Glasses* do.

Secondly, those *Glasses* which are plaine, but have ascents of Angels in the middle, will shew one to have foure Eyes, two Mouthes, two Noses, &c.

EXAMINATION.

These experiments will be found different according to the diverse meeting of the Glasses, *which commonly are made sewing-wise at the end, by which there will be two divers superficies in the* Glasse, *making the exteriour Angle somewhat raised, at the interiour onely one superficies, which may*

may be covered according to ordinary Glasses *to cause a reflexion, and so it will be but one* Glasse, *which by refraction according to the different thicknesse of the* Glasse, *and different Angles of the scuing forme, do differently present the Images to the eye, as foure eyes, two mouthes, 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* Glasse *(impenetrable) 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 foure eyes, two noses, and two mouthes: and by moving the* Glasse *the Angle will vanish, and so the two superficies will be turned into one, and the duplicity of Images will also vanish and appeare but one onely: and this is easily experimented with two little* Glasses *of Steel, or such like so united, that they make divers Angles and inclinations.*

THirdly, there are *Glasses* which make men seeme *pale, red,* and coloured in diverse manners, which is caused by the dye of the *Glasse*, or the diverse refraction of the *Species*: and those which are made of *Silver, Latine, Steele*, *&c.* do give the *Images* a diverse colour also.

In

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 foule and deformed: and give them a contrary viſage: for if a Glaſſe be cut as it may be, or if many pieces of Glaſſe be placed together to make a conveniable reflexion: there might be made of a Mole (as it were) a mountaine, of one Haire 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 foure recreative Problemes following.

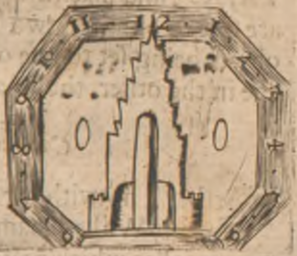
PROBLEM. LXXVIII.

1 How to ſhew to one that is ſuſpitious, what is done in another Chamber or Roome: 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 tyed to the planching or ſeeling, that it may be common to communicate the Species to each Glaſſe by reflexion, there being left ſome hole at the top of the Wall againſt the Glaſſe 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

Then the ſight at *E* by the line of incidence *F E*, ſhall fall upon the Glaſſe *B A*, and reflect upon the ſuperficies of the Glaſſe *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 ſhall come to the eye of the ſuſpicious, *viz.* at *L*. by help of the third Glaſſe, upon which is made the ſecond reflexion, and ſo brings unto the eye the object, though a wall be between it.



Corolarie. 1.

BY this invention of reflections the beſiegers of a Towne may be ſeene upon the Rampart: notwithſtanding the Parapet, which the beſieged may do by placing a Glaſſe in the hollow of the Ditch, and placing another upon the toppe of the wall, ſo that the line of incidence comming to the bottom of the Ditch, make an Angle equall to the Angle of reflexion, then by this ſituation and reflexion, the Image of the beſiegement will be ſeen to him is upon the Rampart.

Corolarie 2.

BY which also may be inferred, that the same reflexions 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 Jmage will be seen easily.

Corolarie 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 equall: that is, placing them in such sort by some Geometricall assistant, that the incident points may meet in the middle of the Glasses: but here all the defect will be, that the Jmages passing by so many reflexions, 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 plaine Glasse perpendicular as *A B*. so the marke *C* shall be seen in *Catheti C A*, viz. in in *D*, and the line of reflexion is *D*, now let the Musket *F E*, upon a rest, be moved to and fro untill 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.

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.

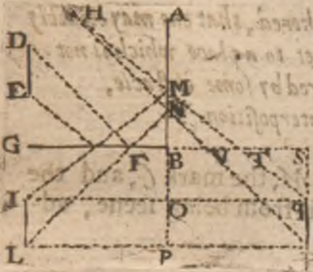
As let the eye be at *M*, the mark *C*, and the wall which keeps it from being seene, admit to be *Q R*, then set up a plaine Glass as *A B*, and let the Musket by *G H*, placed upon his rest *P O*. Now because the marke *C* is seen at *D*, move the Musket to and fro, untill it doth agree with the line of reflection *MB*;

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

Problem. LXXX.

How to make an Image to be seen hanging in the aire, having his head downeward.

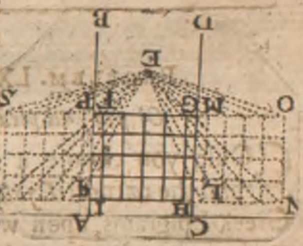
TAke two Glasses, and place them at right Angles one unto the other, as admit *A B*, and *C B*, of which admit *C B*, *Ho izontall*, and let the eye be at *H*, and the object or image to be *D E*; so *D* will be reflected at *F*, so to *N*, so to *H E*: then at *G*, so to *M* and then to *H*, and by a double reflection *E D* will seeme 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 aire, if the Image had wings unto it, and had secretly some motion: and if the Glasse were bigge enough to receive many reflexions, 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 seeme to be a Regiment, or how few in number may be multiplyed 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 two lesser, as *G H.* and *F I*, one placed right against another perpendicular to the *Horizon*, upon a plaine levell Table: betvveene vvhich Glasses let there be ranged in Battalia-vvise upon the same Table as number of small men according to the square *G, H, I, F*, or in any other forme or posture: then may you evidently see hovv the said battel vvill be multiplyed and seem farre bigger in the appearance than it is in effect.



Corolarie.

BY this invention you may make a little Cabinet of foure foot long, and tvvo foot large, (more or lesse) vvhich being filled vvith

Rockes or ſuch like things, or there being put into it Silver, Gold, Stones of luſter, Jewels, &c. and the walls of the ſaid Cabinet being all covered, or hung with plaine glaſſe; theſe viſibles will appeare manifoldly increaſed, by reaſon of the multiplicitie of reflexions, 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 *Dyall* written amongſt the Greek Epigrams, upon which ſome ſound Poet made verſes; ſhewing that a man carrieth about him alwayes a *Dyall* in his face by meanes of the Noſe and Teeth? and is not this a jolly *Dyall*? 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 Dyall of hearbes.

Can you have a finer thing in a Garden, or in the middle of a Compartemeet, than to ſee the lines and the number of houres repreſented with little buſhie hearbes, as of Hyſope or or ſuch which is proper to be cut in the borders; and at the top of the ſtyle to have a Fanne to ſhew which way the winde bloweth? this is very pleaſant and uſeful.

Of the Dyall upon the fingers and the hand.

IS it not a commoditie very agreeable, when one is in the field or in ſome village vvithout any other *Dyall*, to ſee onely by the hand what of the clock it is? vvhich gives it very neare; and may be practiſed by the left hand, in this manner.

Take a ſtravv or like thing of the length of the *Index* or the ſecond finger, hold this ſtraw very right betvveen the thumb and the fore-finger, then ſtretch forth the hand and turne your back, and the palm of your hand tovvards the Sunne; ſo that the ſhadovv of the muſcle vvhich is under the Thumb, touch the line of life, vvhich is betvveen the middle of the tvvo other great lines, vvhich is ſeen in the palme of the hand, this done, the end of the ſhadovv vvill ſhevv vvhat 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 after-noone, 10 & 2 at the ſecond joynt, 11 and 1 at the third joynt, and midday in the line follovving, vvhich comes from the end of the *Index*.

Of a Dyall which was about an Obeliske at Rome.

WAs not this a pretty fetch upon a pavement, to chooſe an *Obeliske* for a *Dyall*, having 106 foot in height, without removing the Baſis of it? *Plinie* aſſures us in his 26 book and 8 *Chap.* that the Emperour *Augustus* having accommodated in the field of *Mars* an *Obeliske* of this height, he made about it a pavement, and by the induſtry of *Manilius* the Mathematician, there were enchaced markes of Copper upon the Pavement, and placed alſo an Apple of Gold upon the toppe of the ſaid *Obeliske*, to know the houre and the courſe of the Sunne, with the increaſe and decreaſe of dayes 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 Aſtronomie.

Of Dyals with Glaſſes.

PTolomie writes, as *Cardanus* reports, that long ago there were Glaſſes which ſerved for *Dyals*, and preſented the face of the beholder

holder as many times as the houre ought to be, twice 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, and not by Glasses, which did leake by little and little out of the vessell, discovering anon one Glasse, then anon two Glasses, then 3,4,5 Glasses, &c. to shew so many faces as there were houres, which was onely by leaking of water.

Of a Dyall which hath a Glasse in the place of the Style.

WHat will you say of the invention of Mathematicians, which finde out daily so many fine and curious novelties? they have now a way to make *Dyals* upon the wainscot or seeiing of a Chamber, and there where the Sunne can never shine, or the beames of the Sunne cannot directly strike: and this is done in placing of a little Glasse in the place of the style which reflecteth the light, with the same condition that the shadow of the style sheweth the houre: and it is easie to make experiment upon a common *Dyall*, changing only the disposition of the *Dyall*, and tying to the end of the style a piece of plaine Glasse. The *Almaines* use it much, who by this way have no greater trouble, but to put their Noses out of their beds and see what a clock it is, which is reflected by a little hole in the Window upon the wall or seeling of the Chamber.

EXAMINATION.

IN this there are two experiments considerable, the first is with a very little Glasse placed so that it may be open to the beames of the Sunne, the other hath respect to a spacious or great Glasse placed to a very little hole so that the Sun may shine on it, for then the shadow which is cast upon the Dyall is converted into beames of the Sunne, 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 passe the beames of the Sun, which represent the extreamity of the style, & the Glasse representeth the plaine of the Dyall, upon which the beames being in manner of shadowes reflect cast upon a plaine opposite: and it is needfull that in this second way the Glasse may be spacious, as before, to receive the delineaments of the Dyall.

Otherwise you may draw the lineaments of a Dyall upon any plaine looking-glasse which reflecteth the Sunne-beames, for the applying a style or a pearle at the extreamitie of it: and placed to the Sunne, the reflexion will be answerable to the delineaments on the Glasse: but here note, that the Glasse ought to be great, and so the delineaments thereon.

But

But that which is most noble, is to draw houre-lines upon the outside of the Glasse of a window, and placing a style thereto upon the outside, the shadow of the style will be seen within, and so you have the hour, more certaine without any difficulty.

Of Dyals with water.

SVch kinde of Dyals were made in ancient times, and also these of sand: before they had skill to make Sun-dyals or Dyals with wheeles; for they used to fill a vessell with water, and having experience by tryall that it would runne out all in a day, they did marke within the vessell the houres noted by the running of the water; and some did set a piece of light board in the vessell to swimme upon the top of the water, carrying a little statue, which with a small stick did point out the houre upon a columne or wall, figured with houre-notes, as the vessell was figured within.

Vitruvius writes of another manner of water-Dyal more difficult; and *Baptista à Porta* amongst his naturall secrets, delivers this invention following. Take a vessel full of water like a caldron, & another vessell of glasse like unto a Bell, (with which

some accustome to cover *Melons*:) and let this Vessell

vessell of Glasse be almost as great as the Caldron, having a small hole at the bottome, then when it is placed upon the vvater, it vvill sink by little and little: by this one may marke the houres on the surface of the Glasse to serve another time. But if at the beginning one had drawn the water vvithin the same vessell of Glasse in sucking by the little hole, the vvater vvould not fall out, but as fast as the aire vvould succeed it, entering slovvly at the little hole: for contrarily the houres may be distinguished by diminution of water, or by augmentation.

Novv it seemes a safer vvay that the vvater passe out by drop and drop, and drop into a Cylindricall Glasse by help of a Pipe: for having marked the exterior part of the Cylinder in the houre notes, the vvater it selfe vvhich falls vvithin it, vvill shevv vvhat of the clock it is, farre better than the running of sand, for by this may you have the parts of the houres most accurate, vvhich commonly by sand is not had: and to vvhich may be added the houres of other Countreys vvith greater ease. And here note, that as soone as the vvater is out of one of the Glasses, you may turne it over into the same againe out of the other, and so let it runne anevv.

PROB.

PROBLEM. LXXXIII.

Of Cannons or great Artillery. Souldiers, and others would willingly see this Probleme, which containes three or foure subtile questions: The first is, how to charge a Cannon without powder?

THis may be done vvith aire and vvater, only having throvvn cold vvater into the Cannon, vvhich might be squirted forceably in by the closure of the mouth of the Piece; that so by this pressure the aire might more condense; then having a round piece of vvood very just, and oiled vvell for the better to slide, and thrust the Bullet vvhen it shall be time: This piece of vvood may be held fast vvith some Pole, for feare 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 aire and vvater, and then vvhen one vvould shoot it, let the Pole be quickly loosened, for then the aire searching a greater place, and having vvay novv offered, vvill thrust out the vvood and the bullet very quick: the experimentvvhich vve have in long trunkes shooting out pellats vvith aire only, shevveth the verity of this Probleme.

2 In the second question it may be demanded, how much time doth the Bullet of a Cannon spend in the aire before it falls to the ground?

THe resolution of this Question depends upon the goodnesse of the Piece & 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 two minutes of time in the aire before it fell: and the distance was a Germane 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 passe, that a Cannon shooting upwards, the Bullet flies with more violence th in being shot point-blanke, or shooting downeward?

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 blowes which fall Perpendicular upon a wall, are more violent than those which strike byas-wise or glaunsingly.

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 neare halfe of the right, conveyes her Bullet with a farre greater violence then that which is shot at Point blanke, or mounted parallel to the Horizon. The common reason is, that shooting high, the fire carries the bowle a longer time in the aire, and the aire moves more facill upwards, than dovvnevvards, because that the airy circles that the motion of the bullet makes, are soonest broken. Hovvsoever this be the generall tenet, it is curious to finde out the inequality of moving of the aire; vvhether the Bullet fly upvvard, dovvnevvard, or right forvvard, to produce a sensible dfference of motion; & some think that the Cannon being mounted, the Bullet pressing the povvder maketh a greater resistance, and so causeth all the Povvder to be inflamed before the Bullet is throvvne out, vvhich makes it to be more violent than othervvise it vvould be. When the Cannon is othervvise disposed, the contrary arives, the fire leaves the Bullet, and the Bullet rolling from the Povvder resists lesse: and it is usually seene, that shooting out of a Musket charged onely vvith Povvder, to shoot to a marke of Paper placed Point blanke, that there are seene many small holes in the paper, vvhich cannot be other than the graines of Powder which did not take fire: but this latter accident may happen

from

from the over-charging of the Piece, or the length of it, or windy, or dampenesse of the Powder.

From which some may think, that a Cannon pointed right to the *Zenith*, should shoot with greater violence, then in any other mount or forme whatsoever: and by some it hath beene imagined, that a Bullet shot in this fashion hath been consumed, melted, and lost in the Aire, 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 Ballet never found. But it is hard to believe this assertion: it may rather be supposed that the Bullet falling farre 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 Trunke, Pipe, or other concavitie, 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. & the reason seems to hold in Cannons, because in those that are long, the fire is retained a longer time in the concavitie of the Piece, and so throwes

throwes out the Bullet with more violence; and experience lets us ſee that taking Cannons of the ſame boare, but of diverſitie 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 foote of length. Now the uſuall Cannon carries 600 Paces, ſome more, ſome leſſe, 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 firme 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 boare, 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 leſſe his force was: therefore the length ought to be in a meane meaſure, and it is often ſeene, 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 meane proportion of length to be taken, otherwiſe the flame of the fire will be over-preſſed with Aire: whic hinders the motion in reſpect of ſubſtance, and diſtance of getting out.

Problem. LXXXIIII.

Of prodigious progression and multiplication, of Creatures, Plants, Fruits, Numbers; Gold, Silver, &c. when they are alwayes augmented by certaine proportion.

HEre we shall shew things no lesse admirable, as recreative, and yet so certaine and easie to be demonstrated, that there needs not but Multiplication only, to try each particular; and first,

Of graines of Mustard-seed.

FIrst, therefore it is certaine that the increase of one graine of Mustard-seed for 20 yeares space, cannot be contained within the visible world, nay if it were a hundred times greater than it is: and holding nothing besides from the Centre of the earth even unto the firmament, but only 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 sowne to bring forth a tree or branch, in each extendure of which might be a thousand graines: but we will suppose onely a thousand in the whole tree, and let us proceed to 20 yeares, every seed to bring forth yearely a thousand graines, now multiplying alwayes by a thousand, in lesse then 17 years you

you ſhall have ſo many graines which will ſurpaſſe the ſands, which are able to fill the whole firmament: for following the ſuppoſition of *Archimedes*, and the moſt probable opinion of the greatneſs of the firmament which *Ticho Brabe* hath left us; the number of graines of ſand will be ſufficiently expreſſed with 49 Ciphers, but the number of graines of Muſtard-ſeed at the end of 17 yeares will have 52 Ciphers: and moreover, graines of Muſtard-ſeed, are farre greater than theſe of the ſands: it is therefore evident that at the ſeventeenth yeare, all the graines of Muſtard-ſeed which ſhall ſucceſſively ſpring from one graine onely, cannot be contained within the limits of the whole firmament; what ſhould it be then, if it ſhould be multiplied againe by a thouſand for the 18 yeare: and that againe by a thouſand for every yeares increaſe untill you come to the 20 yeare, it's a thing as cleare as the day, thet ſuch a heap of Muſtard-ſeed would be a hundred thouſand times greater than the Earth: and bring onely but the increaſe of one graine in 20 yeares.

Of Pigges.

SEcondly, is it not a ſtrange propoſition, to ſay that the great Turke with all his Revenues, is not able to maintaine for one yeares time, all the Pigges that a Sow may pigge with all her race, that is, the increaſe with the increaſe unto 12 years: this ſeemes impoſſible, yet it is moſt true, for let us ſuppoſe and put the caſe, that

that a Sow bring forth but 6, two Males, and 4 Females, and that each Female ſhall bring forth as many every yeare, during the ſpace of 12 yeares, at the end of the time there will be found above 33 millions of Pigges: now allowing a crowne for the maintenance of each Pigge for a yeare, (which is as little as may be, being but neare a halfe of a farthing allowance for each day;) there muſt be at the leaſt ſo many crownes to maintaine them, one a year, *viz.* 33 millions, which exceeds the Turkes revenue by much.

Of graines of Corne.

THirdly, it will make one aſtoniſhed to think that a graine of Corne, with his increaſe ſucceſſively for the ſpace of 12 yeares 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 yeare one graine being ſowed brings forth 50, (but ſometimes there is ſeen 70, ſometimes 100 fold) which graines ſowen the next yeare, every one to produce 50, and ſo conſequently the whole and increaſe to be ſowen every yeare, until 12 yeares be expired, there will be of increaſe the aforeſaid prodigious ſumme of graines, *viz.* 244140625000000000000, which will make a cubical heap of 6258522 graines every way, which is more than a cubicall body of 31 miles every way: for allowing 40 graines in 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 roome to containe the aforesaid quantitie of Corne: and suppose a bushel of Corne were equal unto two Cubicke feet, which might containe twenty hundred thousand graines, then would there be 1220704625000000. bushells, and allowing 30 bushels to a Tunne, it would be able to load 8138030833 vessels, which is more than eight thousand one hundred and thirty eight millions, ship loadings of 500 Tunne to each ship a: quantity so great that the Sea is scarce able to beare, or the universal world able to finde vessels to carry it. And if this Corne should be valued at halfe a crown the bushel, it would amount unto 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 sowe one grain of Corne; and to continue it in sowing, the increase only for 12 yeares 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 yeare, for at the end of 16 yeares, 100 Sheepe will multiply and increaſe unto 6553600, which is above 6 millions, 5 hundred 53 thouſand Sheep: now ſuppoſing them worth but a crown apiece, it would amount unto 1638400 pounds ſterling, vvhich is above 1 million 6 hundred 38 thouſand pounds, a faire increaſe of one Sheep: and a large portion for a Childe if it ſhould be allotted.

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

Fifthly, if there be any creatures in the vvorld that do abound vvith increaſe or fertilitie, it may be rightly attributed to fiſh; for they in their kindes produce ſuch a great multitude of Eggs, and brings forth ſo many little ones, that if a great part vvere not deſtroyed continually, vvithin a little vvhile they vvould fill all the Sea, Ponds, and Rivers in the vvorld; and it is eaſie to ſhevv hovv it vvould come ſo to paſſe, onely by ſuppoſing them to increaſe without taking or deſtroying them for the ſpace of 10 or 12 yeares: having regard to the ſoliditie of the waters which are allotted for to lodge and containe 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 Monarchie under *Nimrod*, being but 200 yeares after the flood, and that amongst them should be raised an army of two hundred thousand fighting men: But it is easi y proved if vve take but one of the Children of *Noah*, and suppose that a nevv generation of people begun at every 30 yeares, and that it be continued to the seventh generation vvhich is 200 yeares; for then of oneonly family there vvould be produced one hundred and eleven thousand soules, three hundred and five to begin the vvorld: though in that time men lived longer, and vvere more capable of multiplication and increase: vvhich number springing onely from a simp e production of one yearly, vvould be farre greater, if one man should have many vvives, vvhich in ancient times they had: from vvhich it is also that the Children of *Israel*, vvho came into Egypt but onely 70 sou es, yet after 210 yeares captivity, theycame forth vvith their hostes, that there vvere told six hundred thousand 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 adjoyne many families together?

Of the increase of numbers.

SEventhly, what summe of money shall the City of *London* be worth, if it should be sold, and the money be paid in a yeare after this manner: the firſt week to pay a pinne, the ſecond week 2 pinnes, the third week 4 pinnes, the fourth week 8 pinnes, the fifth week 16 pinnes. and ſo doubling untill the 52 weeks, or the yeare be expired.

Here one would think that the value of the pinnes 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 pinnes would amount unto the ſum of 4519599628681215, and if we ſhould allow unto a quarter a hundred thouſand pinnes, the whole would contain ninetie eight millions, foure hundred thouſand Tunne: which is able to load 45930 Shippes of a thouſand Tunne apiece: and if we ſhould allow a thouſaud pins for a penny, the ſumme of money would amount unto above eighteen thouſand, eight hundred and thirty millions of pounds ſterling, an high price to ſell a Citie at, yet certain, according to that firſt propoſed. So if 40 Townes 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 foure thouſand five hundred and fourescore millions of pounds and more.

of

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

EIghtly, admit there were an hundred Apples, Stones, or ſuch like things that were plac'd in a ſtraight line or right forme, 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 halfe a day to do it, for there would be made ten thouſand and ninety two paces before he ſhould gather them all up.

Of Changes in Bells, in muſicall Inſtruments, tranſmutation of places, in numbers, letters, men or ſuch like.

NInethly, 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 looked into by others that are not verſed in Arithmetick, do preſent unto them a world of confuſion and difficultie.

As in the firſt place, it is often debated amongſt our common Ringers, what number of Changes there might be made in 5,6,7,8, or more Bells: who ſpend much time to anſwer their owne doubts, entring often into a Labyrinth in the ſearch thereof: or if there were 10 voyces, how many ſeverall notes might there be?

be? These are propositions of such facility, that a childe which can but multiply one number by another, may easily resolve it, which is but only to multiply every number from the unite successively in each others product, unto the terme assigned : so the 6 uumber 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.

In like manner against 10 in the Table is 3618800, that is, three millions, six hundred twenty eight thousand, eight hundred : which shews that 10 voices may have so many consorts, each man keeping his owne note, but only altering his place ; and so of stringed Instruments, and the *Gamat* may be varied according to which, answerable to the uumber against *X*, viz. 1124001075070399680000 notes, from which may be drawne this, or the like proposition. Suppose that 7 Schollers were taken out of a free Schoole to be sent to an *Universitie*, there to be entertained in some *Colledge* at commons for a certaine summe of money, so that each of them have two meales daily, and no longer to continue there, then that sitting all together upon one bench or forme at every meale, 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 entertaine them? (who being not skilled in this fetch may answere unadvisedly.) It is most certaine that there will be

five

five thousand and forty severall Positions or changings in the seatings, which maks 14 years time wanting 10 weeks and 3 dayes. Hence from this mutability of transmutation, it is no marvell that by 24 letters there ariseth and is made such variety of languages in the world, & such infinite number of words in each language; seeing the diversity of syllables produceth that effect, and also by the interchanging & placing of letters amongst the vowels, & amongst

1	*a*	1
2	*b*	2
6	*c*	3
24	*d*	4
120	*e*	5
720	*f*	6
5040	*g*	7
40320	*h*	8
362880	*i*	9
3628800	*k*	10
39916800	*l*	11
479001600	*m*	12
6227020800	*n*	13
87178291200	*o*	14
1307674368000	*p*	15
20922789888000	*q*	16
355687537996000	*r*	17
6402375683928000	*s*	18
121645137994632000	*t*	19
2432902759892640000	*u*	20
51090957957745440000	*w*	21
1124001075070399680000	*x*	22
25852024726619192640000	*y*	23
620448597428860623360000	*z*	24

themselves maketh these syllables: vvhich Alphabet of 24 letters may be varied so many times, *viz.* 620448593438860623360000 vvhich is six hundred tvventy thousand, foure hundred forty eight millions of millions of millions five hundred ninety three thousand, foure hundred thirty eight milions of milions, & more.

Novv allovving that a man may reade or speak one hundred thousand vvords in an houre vvhich is tvvice more vvords than there are contained teined in the Psalmes of *David*, (a taske too great for any man to do in so short a time) and if there were foure thousand six hundred and fifty thousand millions of men, they could not speak these words (according to the hourely proportion aforesaid) in threescore and ten thousand yeares; which variation & transmutation of letters, if they should be written in bookes, allowing to each leaf 28000 words, (which is as many as possibly could be inserted,) and to each book a reame 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 24 letters aforesaid, would be at least 387780370899288788: and if a Library of a mile square every way, of 50 foot high, were made to containe 250 Galleries of 20 foot broad apiece, it would containe foure hundred millions of the said books: so there must be to containe the rest no lesse than 96945092 such Libraries; and if the books were extended over the surface of 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 certaine and infallible in computation.

Of a Servant hired upon certaine conditions.

A Servant said unto his Master, that he would dwell with him all his life-time, if he he would but onely lend him land to ſowe one graine of Corne with all his increaſe for 8 years time; how think you of this bargaine? for if he had but a quarter of an inch of ground for each graine, and each graine to bring forth yearely of increaſe 40 graines, the whole ſum would amount unto, at the terme aforeſaid, 6553600000000 graines: and ſeeing that three thouſand and ſix hnndred millions of inches do but make one mile ſquare in the ſuperficies, it ſhall be able to receive foureteene thouſand and foure hundred millions of graines, which is 14400000000. thus dividing the aforeſaid 6553600000000, the Quotient will be 455, and ſo many ſquare miles of land muſt there be to ſowe the increaſe of one graine of Corne for 8 yeares, which makes at the leaſt foure hundred and twenty thouſand Acres of land, which rated but at five ſhillings the Acre *per Annum*, amounts unto one hundred thouſand pound; which is twelve thouſand and five hundred pound a yeare, to be continued for 8 yeares; a pretty pay for a Maſters Servant 8 yeares ſervice.

Problem. LXXXV.

Of Fountaines, Hydriatiques, Machinecke, and other experiments upon water, or other liquor.

1. *First how to make Water at the foot of a mountaine 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 fountaine *A*, to the top of the Mountaine *B*; and so to descend on the other side a little lower then the Fountaine, as at *C*. then make a hole in the Pipe at the top of the Mountaine, as at *B*, and stop the end of the Pipe at *A* and *C*; and fill this Pipe at *B* with water: & close it very carefully againe at *B*, that no aire get in: then unstop the end at *A*, & at *C*; then will the water perpetually runne 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 vessell without opening the bung-hole, and without making any other hole, than that by which it runnes out at the top?*

IN this problem there is nothing but to take a bowed pipe of Glasse, 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, untill 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 vessell holds more water being placed at the foot of a Mountaine, than standing upon the top of it?*

THis is a thing most certaine, because that water and all other liquor disposeth it selfe 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: and therefore when the same vessell is farther from the Centre of the earth, the surface of the water makes a greater sphere, and therefore lesse *gibbous*, or swelling over the vessel:

vessell: from whence it is evident that a vessell 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 bottome of the Mountaine holds more water, than being placed on the top of the Mountaine. First, therefore one may conclude, that one and the same vessel will alwayes hold more: by how mnch it is nearer the Centre of the earth. Secondly, if a vessell be very neare 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

comming to the Centre wil 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 Paile 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 levell, but descending it swels and becomes more *gibbous*.

4. *Fourthly, to conduct water from the top of one Mountaine, to the top of another.*

AS admit on the top of a Mountaine there is a spring, and at the toppe of the other Moun-

Mountaine there are Inhabitants which want water: now to make a bridge from one Mountaine 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 Mountaine be placed a Pipe, to descend into the valley, and ascend to the other Mountlaine, the water will runne naturally, and continually, provided that the spring be somewhat higher than the passage of the water at the inhabitants.

5. *Fifthly, of a fine Fountaine which spouts water very high, and with great violence by turning of a Cock.*

LEt there be a vessell as *A B*, made close in all his parts, in the middle of which let *C D* be a Pipe open at *D* neare the bottome, and then with a Squirt squirt in the water at *C*, stopped above by the cock or faucet *C*, vvith as great violence as possible you can; and turne the cock immediatly.

Novv there being an indifferent quantity of vvater and aire in the vessel, the vvater keeps it selfe in the bottome, and the aire vvhich vvas greatly pressed, seeks for more place, that

O turning

turning the Cock the water issueth forth at the Pipe, and flyes very high, and that especially if the vessell 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 turne very quick, pleasurable to behold.

6. *Sixtly, of Archimedes 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 turnes it, the water descends alwayes 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 Enginer admirable in all Mathematicall Arts invented this Instrument to wash King *Hieroies* great vessells, as some Authors saye, also to water the fields of Egypt, as *Diodorus* witnesseth: and *Cardanus* reporteth that a Citizen of *Milan* having made the like Engine, thinking himselfe to be the first inventer, conceived such exceeding joy, that he became mad, *foll.* 2.

Againe a thing may ascend by descending, if if a ſpiral line be made having many cir ulations or revolutions ; the laſt being alwayes leſſer than the firſt, yet higher than the Plaine ſuppoſed it is moſt certaine that then putting a ball into it, and turning the ſpirall line ſo ; that the firſt circulation may be perpendicular, or touch alwayes the ſuppoſed Plain: the ball ſhall in deſcending continually aſcend, untill at laſt it come to the higheſt part of the ſpirall line, & 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 Helicall revolution of the ſcrew be not inc'ining to the Horizon : ſo that according to this inclination the ball or liquor, may deſcend alwayes by a continuall motion and revolution. And this experiment may be more uſefull, naturally made with a thred of 'ron, or Latine turned or bowed Helically about a Cylinder, with ſome diſtinction of diſtances between the *Heli es*, for then having drawn out the Cylinder, or having hung or tyed ſome weight at it in ſuch ſort, that the water may eaſily drop if one lift up the ſaid thred: theſe *Helices* or revolutions, notwithſtanding will remaine 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 equallity amongſt themſelves, and the whirling or turning motion be quicke, the ſight vvill be ſo deceived, that producing the action it vvill ſeeme to the ignorant no leſſe than a Miracle.

O 2 *7. Seventh*

7. *Seventhly, of another fine Fountaine of pleasure.*

THis is an Engine that hath two wheeles with Cogges, or teeth as *A B*, which are placed within an *Ovall C D*, in ſuch ſort, that the teeth of the one, may enter into the notches of the other; but ſo juſt that neither aire nor water may enter into the Ovall coffer, either by the middle or by the ſides, for the wheele muſt joyne ſo neare to the ſides of the coffer, that there be no vacuitie: to this there is an axeltree with a handle to each wheele, ſo that they may be turned, and *A* being turned, that turneth the other wheele that is oppoſite: by which motion the aire that is in *E*, & the water that is carried by the hollow of the wheeles of each ſide, by continuall motion, is conſtrained to mount and flie out by the funnell *F:* now to make the water runne 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 Cogges

or teeth of the wheeles running one againſt another, may neare break them, and ſo give way to the aire to enter in, which being violently incloſed vvill eſcape to occupie the place of the vvater, vvhoſe vveight makes it ſo quick: hovvſoever, if this Machine be curiouſly made as an able vvorkeman may eaſily do, it is a moſt ſovereigne Engine, to caſt vvater high and farre off for to quench fires. And to have it to raine to a place aſſigned, accommodate a ſocket having a Pipe at the middle, vvhich may point tovvards the place being ſet at the top thereof, and ſo having great diſcretion in turning the Axis of the vvheele, it may vvork exceeding vvell, and continue long.

8. *Eightly, of a fine watering pot for gardens.*

THis may be made in forme of a Bottle according to the laſt figure or ſuch like, having at the bottome many ſmall holes, and at the neck of it another hole ſomevvhat greater than thoſe at the bottome, vvhich hole at the top you muſt unſtop vvhen you vvould fill this vvatering pot, for then it is nothing but putting the lovver end into a paile of vvater, for ſo it vvill fill it ſelfe 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 vvill not ſenſibly runne out, ſomething it vvill, and all in time (if it vvere never ſo cloſe ſtopped) contrary to the ancient tenet in Philoſophy, that aire will not penetrate.

9. Ninthly, how easily to take wine out of a vessell at the bung-hole, without piercing of a hole in the vessell?

IN this there is no need but to have a Cane or Pipe of Glasse 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 vessell 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 ful of wine, then opening a little the top above, you may fill a Glasse or other Pot with it, for as the Wine issueth out, the aire commeth into the Cane or Pipe to supply vacuity.

10. Tenthly, how to measure irregular bodies by help of water?

SOme throw in the body or magnitude into a vessell, and keep that which floweth out over, saying it is alwayes equal to the thing cast into the water: but it is more neater this way to poure into a vessell such a quantity of water, hich which may be thought sufficient to cover the body or magnitude, and make a marke how high the water is in the vessell, then poure out all this water into another vessell, and let the body or magnitude be placed into the first vessel; then poure in water from the second vessell, until it ascend unto the former marke made in the first vessell, so the vvater vvhich remaines in the second vessel is equall 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 bod ies that are not so full of pores are more truly measured this way, than others are.

11. *To finde the weight of water.*

SEeing that $\frac{574}{1000}$ part of an ounce weight, makes a cubicall inch of water: and every pound weight *Haverdepoize* makes 27 cubicall inches, and $\frac{9}{16}$ *fere*, and that 7 Gallons and a halfe wine measure makes a foot cubicall, it is easie by inversion, that knowing the quantity of a vessel in *Gallons*, to finde his content in cubicall feet or weight: and that late famous *Geometrician* Master *Brigs* found a cubical foot of vvater to vveigh neare 62 pound vveight *Haverdepoize*. But the late learned *Simon Stevin* found a cubicall foot of vvater to vveigh 65 pound, vvhich difference may arise from the inequalitie of vvater; for some vvaters 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 quantitie of a solid foot settled, it is easie for Arithmeticians to give the contents of vessells or bodies which containe liquids.

12. *To finde the charge that a vessell may carry as Shippes, Boates, or such like.*

THis is generally conceived, that a vessel may carry as much weight as that water weigheth, which is equall unto the vessell in bignesse, in abating onely the weight of the vessell: we see that a barrel of wine or water cast into the water, will not sink to the bottome, 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 vessell were loaden with lead, so much should the watter weigh: hence it is that Marriners call Shippes of 50 thousand Tunnes, because they may containe one or two thousand Tunne, and so consequently carry as much.

13. *How comes it that a Shippe having safely sayled 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 kinde of water than upon other; now the water of the Sea is thicker and heavier than that of Rivers, Wels, or Fountains; there-

therefore the loading of a vessell which is accounted sufficient in the Sea, becomes too great in the hurbour or sweet water. Now some think that it is the depth of the water that makes vessells more easie to swimme, but it is an abuse; for if the loading of a Ship be no heavier than the water that would occupie 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 vvater be no thicker than a leafe of paper, and weigheth but an ounce under a heavy body, it vvill support it, as vvell as if the vvater under it vveighed ten thousand pound vveight: hence it is if there be a vessell capable of a little more than a thousand pound vveight of vvater, you may put into this vessell a piece of vvood, vvhich shall vveigh a thousand pound vveight; (but lighter in his kinde than the like of magnitude of vvater:) for then pouring in but a quart of vvater or a very little quantitie of vvater, the vvood vvill svvim on the top of it, (provided that the vvood touch not the sides of the vessell:) vvhich is a fine experiment, and seems admirable in the performance.

14. *How a grosse body of mettle may swimme upon the water?*

THis is done by extending the mettle into a thin Plate, to make it hollovv in forme of a vessel; so that the greatnesse of the vessell which the aire vvith it containeth, be equal to the

the magnitude of the vvater, vvhich vveighes as much as it, for all bodies may ſvvim vvithout ſinking, if they occupie the place of vvater equal in vveight unto them, as if it vveighed 12 pound it muſt have the place of 12 pound of vvater: hence it is that vve ſee floating upon the vvater great veſſells of Copper or Braſſe, vvhen they are hollovv in forme 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 kinde of metall ſhould be inlarged, to make it ſwim upon the water: which doth depend upon the proportion that is between the vveight of the vvater and each metall. Novv the proportion that is betvveene metalls and water of equall 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.	$116\frac{1}{3}$
	Silver.	104
	Copper.	91
	Iron.	81
	Tinne.	75

From which is inferred, that to make a piece of Copper of 10 pound weight to ſwimme, it muſt be ſo made hollow, that it may hold 9 times that weight of water and ſomewhat more, that is to ſay, 91 pound: ſeeing that Copper

per and water of like magnitudes in their ponderosities, are as before, as o to 91.

15. *How to weigh the lightnesse of the aire?*

PLace a Ballance of wood turned upside downe 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 quantitie of aire should weigh one pound, place it under one of the Ballances, and place under the other as much weight of lightnesse as may counter-ballance and keep the other Ballance that it rise not out of the water: by which you shall see how much the lightnesse is.

But without any Ballance do this; take a Cubicall hollow vessell, or that which is *Cylindricall*, which may swimme on the water, and as it sinketh by placing of weights upon it, marke hovv much, for then if you vvould examine the vveight of any body, you have nothing to do but to put it into this vessell, and marke hovv deep it sinkes, for so many pound it vveighes as the vveights put in do make it so to sinke.

16. *Being given a body, to marke it about, and shew how much of it will sink in the water, or swim above the water.*

THis is done by knovving the vveight of the body vvhich is given, and the quantity of vvater, vvhich vveighes as much as that body; for then certainly it vvill sink so deep, untill it occupieth the place of that quantitie of vvater.

17. *To finde how much severall mettle or other bodies doe weigh lesse in the water than in the aire:*

TAke a Ballance, & vveigh (as for example) 9 pound of Gold, Silver, Lead, or Stone in the aire, so it hang *in æquilibrio*; then comming to the vvater, take the same quantity of Gold Silver, Lead, or Stone, and let it softly dovvne into it, and you shall see that you shall need a lesse counterpoise in the other Ballance to counter-ballance it: vvherefore all solids or bodies vveigh lesse in the vvater than in the aire, and so much the lesse it vvill be, by hovv much the vvater is grosse and thick, because the vveight findes a greater resistance, and therefore the vvater supports more than aire; and further, because the vvater by the ponderositie is displeased, and so strives to be there againe, pressing to it, by reason of the other vvaters that are about it, according to the proportion of his

his weight. *Archimedes* demonstrateth, that all bodies weigh lesse in the water (or in like liquor) by how much they occupie place: and if the water weigh a pound weight, the magnitude in the water shall weigh a pound lesse than in the aire.

Now by knowing the proportion of water and mettles, 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, Tinne the 7 part and a little more: wherefore in materiall and absolute weight, Gold in respect of the water that it occupieth weigheth 18, and $\frac{3}{4}$ times heavier than the like quantitie of water, that is, as 18 $\frac{3}{4}$ to the Quicksilver 15 times, Lead 11 and $\frac{3}{7}$, Silver 10 and $\frac{2}{3}$, Copper 9 and $\frac{1}{10}$, Iron 8 and $\frac{1}{2}$, and Tinne 8 and $\frac{1}{3}$. Contrarily in respect of greatnesse, 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 may you judge of the rest.

18. *How is it that a ballance having like weight in each scale, and hanging* in æquilibrio *in the aire, 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 mettles, which though they weigh vveigh equall in the aire, yet in the vvater there vvill be an apparant difference; as ſuppoſe ſo that in the ſcale of each Ballance be placed 18 pound vveight of ſeverall metalls, the one Gold, and the other Copper, vvhich being *in æquilibrio* in the aire, placed in the vvater, vvill not hang ſo, becauſe that the Gold loſeth neare the 18 part of his vveight, vvhich is about 1 pound, and the Copper loſeth but his 9 part, vvhich is 2 pound: vvherefore the Gold in the vvater vveigheth but 17 pound, and the Copper 16 pound, vvhich is a difference moſt ſenſible to confirme that point.

19. *To ſhew what waters are heavier one than another, and how much.*

PHyſicians have an eſpeciall reſpect unto this, judging that vvater vvhich is lighteſt is moſt healthfull and medicinall for the body; & Sea-men knovv that the heavieſt vvaters do beare moſt, and it is knovvne vvhich water is heavieſt thus. Take a piece of wax, and faſten Lead unto it, or ſome ſuch like thing that it may but preciſely ſwimme, for then it is equal to the like magnitude of water, then put it into another veſſell which hath contrary water, and if it ſinke, then is that water lighter than the other: but if it ſinke 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 vvood, and marke the quantitie of ſinking of it into ſeverall waters, by vvhich you may judge vvhich which is lighteſt or heavieſt, for in that which it ſinkes moſt, that is infallibly the lighteſt, and ſo contrarily.

20. *How to make a Pound of water weigh as much as* 10, 20, 30, *or a hundred pound of Lead; nay as much as a thouſand, or ten thouſand pound weight?*

THis propoſition ſeems very impoſſible; yet water incloſed in a veſſell, being conſtrained to dilate it ſelfe, doth weigh ſo much as though there were in the concavitie of it a ſolid body of water.

There are many wayes 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 a hundred or a thouſand pound of water, and ſuppoſe that it were tied to ſome thing that it may hang in the aire; 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 downe the hundred pound in the other Ballance.

The ſecond vvay 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 water, which must be hung at some Iron or beame which is placed in a wall; so that it hang quiet: (now it is not materiall whether the magnitude be hollow or massie) so that it touch not the Ballance in which it is put, for then having put the Lead or weight into the other Ballance, poure 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 of 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 vvas this that the Poets sung, and that vvhich the vulgar beleeves; nay, that vvhich long ago certaine Philosophers to *Gelon* King of *Sici-*

ly reported, that the graines of ſand vvere innumerable: But I anſvvere vvith *Archimedes*, that not only one may number thoſe vvhich are at the border and about the Sea; but thoſe vvhich are able to fill the vvhole vvorld, if there vvere nothing elſe but ſand; and the graines of ſands admitted to be ſo ſmall, that 10 may make but one graine of *Poppy*: for at the end of the account there need not to expreſſe them, but this number 3084097945 6, and 35 Ciphers at the end of it: *Clavius* and *Archimedes* make it ſomevvhat more; becauſe they make a greater firmament than *Ticho Brahe* doth; and if they augment the Vniverſe, it is eaſie for us to augment the number, and declare aſſuredly how many graines of ſand there are requiſite to fill another vvorld, in compariſon that our viſible vvorld vvere but as one graine of ſand, an atome or a point; for there is nothing to do but to multiply the number by it ſelfe, vvhich vvill amount to ninety places, vvhereof tvventie are theſe, 95143798134910955936, and 70 Ciphers at the end of it: vvhich amounts to a moſt prodigious number, and is eaſily ſupputated: for ſuppoſing that a graine of Poppy doth containe 10 graines of ſand, there is nothing but to compare that little bovvle of a graine of Poppy, vvith a bovvle of an inch or of a foot, & that to be compared vvith that of the earth, and then that of the earth vvith that o t he firmament; and ſo of the reſt.

2. *Divers metalls being melted together in one body, to finde the mixture of them.*

THis wat a notable invention of *Archimedes*, related by *Vitrivius* in his Architecture, where he reporteth that the Gold-ſmith which King *Hiero* imployed for the making of the Golden Crowne, 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 Crowne, if there had been made mixture of any other metall with the Gold. The way which he found out was by bathing himſelfe; for as he entred into the veſſell of water, (in which he bathed himſelfe) 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 Bowle of pure Gold, Silver, or other metall were caſt into a veſſell 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, leapes 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 equall to the weight of the Crowne, and therefore unequall in magnitude or greatneſſe; and

and then knowing the ſeverall quantities of water which was anſwerable to the Crown, and the ſeverall Maſſes, he ſubtilly collected, that if the Crowne occupied more place within the water than the Maſſe of Gold did: it appeared that there was Silver or other metall melted with it. Now by the rule of poſition, ſuppoſe that each of the three Maſſes weighed 18 pound apiece, and that the Maſſe of Gold did occupie the place of one pound of water, that of Silver a pound and a halfe, and the Crown one pound and a quarter only: then thus he might operate the Maſſe of Silver which weighed 18 pounds, caſt into the water, did caſt out halfe a pound of water more then the Maſſe of Gold, which weighed 18 pound, and the Crowne which weighed alſo 18 pound, being put into a veſſell full of water, threw out more water than the Maſſe of Gold by a quarter of a pound, (becauſe of mixt metall which was in it:) therefore by the rule of proportion, if halfe a pound of water (the exceſſe) be anſwerable to 18 pound of Silver, one quarter of a pound of exceſſe ſhall be anſwerable to 9 pound of Silver, and ſo much was mixed in the Crowne.

Some judge the way to be more facill by weighing the Crowne firſt in the aire, then in the water; in the aire 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 vve vvill ſuppoſe that Gold and Copper is mixed together, it vvill vveigh leſſe then 17 pound, yet more than 16 pound, and that according to the proportion mixed : let it then be ſuppoſed that it vveighed in the vvater 16 pound and 3 quarters, then might one ſay by proportion, if the difference of one pound of loſſe, (vvhich is betvveen 16 and 17) be anſvverable to 18 pound, to vvhat ſhall one quarter of difference be anſvverable to , vvhich is betvveen 17 and $16\frac{3}{4}$, and it vvil be 4 pound and a halfe; and ſo much Copper vvas mixed vvith the Gold.

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

Baptiſta Benedictus amongſt his Arithmeticall *Theoremes*, delivers his vvay thus: if a Maſſe of Gold of equall bigneſſe to the Crovvne did vveigh 20 pound, and another of Silver at a capacity or bigneſſe at pleaſure , as ſuppoſe did vveigh 12 pound, the Crovvne or the mixt body would vveigh more than the Silver , and leſſer than the Gold, ſuppoſe it vveighed 16 pound vvhich is 4 pound leſſe than the Gold by 8 pound, then may one ſay , if 8 pound of difference come from 12 pound of Silver , from vvhence comes 4 pound vvhich vvill be 6 pound and ſo much Silver vvas mixed in it, &c.

3. Three

3. Three men bought a quantitie of wine, each paid alike, and each was to have alike; it happened at the last partition that there were 21 Barrells, of which 7 were full, 7 halfe full, and 7 empty, how must they share the wine and vessells, that each have as many vessells one as another, & as much Wine one as another?

THis may be answered two wayes 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 Barrells full, and as many empty ones, and one which is halfe full; so he shall have 7 vessells and 3 Barrels, and a halfe of liquor; and one of the other shall in like manner have as much, so there will remaine for the third man 1 Barrell full, 5 which are halfe full, and 1 empty, and so every one shall have alike both in vessells and wine. And generally to answer such questions, divide the number of vessells 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 lesse than the halfe of the said Quotient: as dividing 21 by 3 there comes 7 for the Quotient, which may be parted in these three parts, 2, 2, 3, or 3, 3, 1, each of which being lesse than halfe of 7.

 4. There

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 ansvver is, 2 foot: for by *Pythagoras* rule the square of *D B*, the *Hypothenusal* is equall to the square of *D A* 6, & *A B* 10. Novv if *D A* be 6 foot, and *A B* 10 foot, the squares are 36 and 100, vvhich 36 taken from 100 rests 64, vvhose Roote-quadrate is 8 so the foot of the Ladder being novv at *D*, the toppe vvill be at *C*, 2 foot lovver than it vvas vvhen it vvas at *B*.

PROBLEM. LXXXVII.

Witty suits or debates between Caius *and* Sempronius, *upon the forme of figures, which Geometricians call Isoperimeter, or equall in circuit or compasse.*

MArvell not at it if I make the Mathematicks take place at the Barre, and if I set forth

forth here *Bartoleus*, who witneſſeth of himſelfe, that being then an ancient Doctor in the Law, he himſelfe took upon him to learne the elements and principles of *Geometry*, by which he might ſet forth certaine Lawes 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 behovefull for Judges, Counſellors, or ſuch, to explaine many things which fall out in Lawes, to avoid ambiguities, contentions, and ſuits often.

1. *Incident.*

C*Aius* had a field which was directly ſquare, having 24 meaſures in Circuit, that was 6 on each ſide: *Sempronius* deſiring to fit himſelfe, prayed *Caius* to change with him for a field which ſhould be equivalent unto his, and the bargaine being concluded, he gave him for counterchange 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 3 in breadth for each ſhorter ſide: Now *Caius* which was not the moſt ſubtilleft nor wifeft in the world accepted his bargaine at the firft, but afterwards having conferred with a Land-meafurer and Mathematician, found that he was over-reached in his bargaine, and that his field contained 36 fquare meafures, and the other field had but 27 meafures, (a thing eafie to be knowne by multiplying the length by the breadth:) *Sempronius* contefted with him in fuite of Law, and argued that figures which have equall *Perimeter* or *circuit*, are equall amongft themfelves: my field, faith he, hath equall circuit with yours, therefore it is equall unto it in quantitie. Now this was fufficient to delude a Judge which was ignorant in Geometricall proportions, but a Mathematician will eafily declare the deceit, being affured that figures which are *Ifoperemiter*, or equall in circuit, have not alwayes equall capacitie or quantitie: feeing that with the fame circuit, there may be infinite figures made which fhall be more and more capable, by how much they have more Angles, equall fides, and approach nearer unto a circle, (which is the moft capableft figure of all,) becaufe that all his parts are extended one from anothes, and from the middle or Centre as much as may be: fo we fee by an infallible rule of experience, that a fquare is more capable of quantitie than a Triangle of the fame circuit, and a *Pentagone* more than a fquare, and fo of others, fo that they be regular figures that have their fides equall,

otherwife

otherwise there might be that a regular Triangle, having 24 measures in circuit might have more capacitie than a rectangled *Parallelogram*, which had also 24 measures of circuit, as if it were 11 in length, and 1 inbreadth, the circuit is still 24, yet the quantitie is but 11. and if it had 6 every way, it gives the same *Perimeter, viz.* 24, but a quantitie of 36 as before.

2. *Incident.*

SEmpronius having borrowed of *Caius* a sack of Corne, 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 Corne, which had each of them 6 foot high & 1 foot broad: who beleeved that if the sackes 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 halfe 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 4 part of another *Cylinder*, whose length is 6 foot, and his diameter is 2 foot: therefore two of the lesser *Cylinders* or sackes, is but halfe of the greater; and so *Caius* was deceived in halfe his Corne.

3. *Incident.*

SOme one from a common Fountaine of a City hath a Pipe of water of an inch diameter;

ter;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 bigge, to have juſt twice as much water as he had before : but if the Magiſtrate of the Citie underſtood Geometricall proportions, he would ſoon cauſe it to be amended , & ſhew that he hath not only taken twice as much water as he had before,but foure times as much : for a

Circular hole which is two inches diameter is foure times greater than that of one inch , and therefore vvill caſt out four times as much vvater as that of one inch , and ſo the deceit is double alſo in this.

Moreover, if there vvere a heap of Corne of 20 foot every vvay, vvhich vvas borrovved to be paid next yeare. the party having his Corne in heapes of 12 foot every vvay,and of 10 foot every vvay,proffers him 4 heapes of the greater or 7 heaps of the leſſer, for his ovvne heap of 20 every vvay , vvhich vvas lent : here it ſeems that the proffer is faire, nay vvith advantage , yet the loſſe vvould be neare 1000 foot. Infinite of ſuch cauſes do ariſe from Geometricall figures, vvhich are able to deceive a Judge or

Magiſtrate

Magiſtrate, vvhich is not ſomevvhat ſeene in *Mathematicall Documents.*

Problem. LXXXVIII.

Containing ſundry Queſtions in matter of Coſmography.

FIrſt, it may be demanded, vvhere is the middle of the vvorld? I ſpeak not here Mathematically, but as the vulgar people, vvho ask, vvhere is the middle of the vvorld? in this ſence to ſpeak abſolutely there is no point vvhich may be ſaid to be the middle of the ſurface, for the middle of a Globe is every vvhere: notvvithſtanding the *Holy Scriptures* ſpeake reſpectively, and make mention of the middle of the earth, and the interpreters apply it to the Citie of *Jeruſalem* placed in the middle of *Paleſtina*, and the habitable vvorld, that in effect taking a mappe of the vvorld, 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 Citie of *Jeruſalem* is as a Centre to that Circle.

2. *Secondly, how much is the depth of the earth, the height of the heavens, and the compaſſe of the World?*

FRom the ſurface of the earth unto the Centre according to ancient traditions, is 3436. miles, ſo the vvhole thickneſſe is 6872 miles, of of which the whole compaſſe or circuit of the earth is 21600 miles.

From the Centre of the earth to the Moone there is neare 56 Semidiameters of the earth, which is about 192416 miles. unto the Sunne 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 Arithmeticall ſupputations, many pleaſant propoſitions in this manner.

Firſt, if you imagine there were a hole through the earth, and that a Milſtone ſhould be let fall down into this hole, and to move a mile in each minute of time, it would be more than two dayes and a halfe before it would come to the Centre, and being there it would hang in the aire.

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

Thirdly, the Moone runnes a greater compaſſe each houre, than if in the ſame time ſhe ſhould runne twice the Circumference of the whole earth.

Fourthly, admit it be ſuppoſed that one
ſhould

ſhould go 20 miles in aſcending towards the heavens every day, he ſhould be above 15 years before he could attaine to the Orbe of the Moone.

Fifthly, the Sunne makes a greater way in one day than the Moone doth in 20 dayes, becauſe that the Orbe of the Sunnes circumference is at the leaſt 20 times greater than the Orbe of the Moone.

Sixthly, if a Milſtone ſhould deſcend from the place of the Sunne a thouſand miles every houre, (which is above 15 miles in a minute, farre beyond the proportion of motion) it would be above 163 dayes before it would fall downe to the earth.

Seventhly, the Sunne 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 winde that moves with ſuch quickneſſe.

Eightly, it is of a farre higher nature to conſider the exceeding and unmoveable quickneſſe of the ſtarry firmament, for a ſtarre being in the *Æquator*, (which is juſt between the Poles of the world) makes 12598666 miles in one houre which is two hundred, nine thouſand nine hundred and ſeventy foure miles in one minute of time: & if a Horſeman ſhould ride every day 40 miles, he could not ride ſuch a compaſſe in a thouſand yeares as the ſtarry firmament moves in one houre, which is more than if one ſhould

ſhould move about the earth a thouſand times in one houre, and quicker than poſſible thought can be imagined: and if a ſtarre ſhould flye in the aire about the earth with ſuch a prodigious quickneſſe, it would burne 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 finde the Biſſextile yeare, the Dominicall letter, and the letters of the moneth.

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 Leape-yeare, and that which remaines of the diviſion ſhewes the leap-yeare, as if one remaine, it ſhewes that it is the firſt yeare ſince the Biſſextile or Leap-year, if two, it is the ſecond year &c. and if nothing remaine, then it is the Biſſextile or Leap-yeare, and the Quotient ſhews you how many Biſſextiles or Leap-yeares there are conteined in ſo many yeares.

To

To finde 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 Sunne or whole revolution of the Dominicall letters) and that which remaines 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 it sheweth the yeare which is present, and the words of the verse shew the *Dominicall letter*.

Example.

DIvide 123 by 28 for the yeare (and so of other yeares) 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 *Dominicall letter* for each moneth, account from *January* unto the moneth required, including *January*, and if there be 8, 9, 7, or 5, you must begin upon the end of the finger from the thumbe and account, *Adam degebat, &c.* as many words as there are moneths, for then one shall have the letter which begins the moneth; then to know what day of the moneth it is, see how many times 7 is comprehended in the number of dayes, and take the rest, suppose 4, account upon the first finger within & without by the joynts,

unto

unto the number of 4, which ends 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 yeare, the Dominicall letter, the letter which begins the Moneth, and all the dayes of the Moneth.

PROBLEM. XCIII.

To finde the New and Full Moone in each Moneth:

ADde to tne Epact for the yeare, the Moneth from March, then subtract that surplus from 30, and the rest is the day of the Moneth that it vvill be New Moone, and adding unto it 14, you shall have that Full Moone.

Note

THat the Epact is made alwayes by adding 11 unto 30, and if it passe 30, subtract 30, and adde 11 to the remainder, and so *ad infinitum*: as if the Epact were 12, adde 11 to it makes 23 for the Epact next year, to vvhich adde 11 makes 34, subtract 30, rests 4 the Epact for the yeare after, and 15 for the yeare follovving that, and 26 for the next, and 7 for the next, &c.

PROB-

PROBLEM. XCIV.

To finde the Latitude of a Countrey.

THose that dwell between the North-Pole and the *Tropicke* 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 sunnes distance by instrumentall observation from the zenith at noone, and adde the declination of the sun for that day to it: so the Aggragate sheweth such is the Latitude, or Poles height of that Countrey. Now the declination of the sunne 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 sunnes declination for that day must be taken out of the distance of the sunne from the zenith at noone: so shall you have the Latitude, as before.

PREOLEM XCV.

Of the Climates of countreys, and to finde in what Climate any countrey is under.

CLimates as they are taken Geographically signifie nothing else but when the length

of the longeſt day of any place, is half an houre longer, or ſhorter than it is in another place (and ſo of the ſhorteſt day)and this account to begin from the Equinoctiall Circle, ſeeing all Countreys under it have the ſhorteſt and longeſt day that can be but 12 houres; But all other Countreys that are from the Equinoctiall 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 Equinoctiall to either of the Poles Circles,(which are in the Latitude of *66* degr. 30 m.) between each of which Polar Circles and the Equinoctial Circle there is accounted 24 Climates,which differ one from another by halfe an hours time:then from each Polar Circle, to each Pole there are reckoned *6*.other Climates which differ one from another by a moneths time : ſo the whole earth is divided into *60* Climates, 30 being allotted to the Northerne Hemiſphere, and 30: to the Southerne Hemiſpheare. And here note, that though theſe Climats which are betweene the Equinoctiall and the Polar Circles are equall one unto the other in reſpect of time , to wit , by halfe an houre ; yet the Latitude, breadth , or internall , conteined between Climate and Climate , is not equall: and by how much any Climate is farther from the Equinoctiall than another Climate, by ſo much the leſſer is the intervall between that Climate and the next:ſo thoſe that are neareſt the Equinoctial are larg-,
eſt

eſt, and thoſe which are fartheſt off moſt contracted: and to finde what Climate any Countrey is under : ſubtract the length of an Equinoctiall day, to wit, 12 houres from the length of the longeſt day of that Countrey ; the remainder being doubled ſhews the Climate : So at *London* the longeſt day is neare 16 houres and a halfe; 12 taken from it there remaines 4 houres and a halfe , which doubled makes 9 halfe houres, that is , 9 Climates ; ſo *London* is in the 9 climate.

Problem. XCVI.

Of Longitude and Latitude of the Earth and of the Starres.

Longitude of a Countrey, or place, is an arcke of the *Æquator* conteined 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 Terreſtriall Globe or Mappe, 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 neare the *Azores*. But why it was firſt placed by *Ptolomy* at the *Canary Iſlands*, were becauſe that in his time theſe Iſlands were the fartheſt weſterne parts of the world that vvas then diſcovered. And vvhy it reteines his place novv at Saint *Michaels* neare the

Azores, is that becauſe of many accurate obſervations made of late by many expert Navigators and Mathematicians, they ha e 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 Eaſtwards, is from the motion of the Sunne Eaſtward, or that *Ptolomy* and others did hold it more convenient to begin from the Weſterne part of the world and ſo account the Longitude Eaſtward from Countrey to Countrey that was then knowne; till they came to the Eaſterne part of *Aſia*, rather than to make a beginning upon that which was unknowne: and having made up their account of reckoning the Longitude from the Weſterne part to the Eaſtern part of the world knowne, they ſuppoſed the reſt to be all ſea, which ſince their deaths hath been found almoſt to be another habitable world.

To finde 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 Equinoctiall that degree is the Longitude of that Place: if it be in a Mappe, then mark what Meridian paſſeth over it, ſo have you the Longitude thereof, if no Meridian paſſe over it, then take a paire of Compaſſes, and meaſure the diſtance betweene the Place and the next Meridian, and apply it

to

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 Equinoctiall, or it is an Arke of the Meridian conteined between the Zenith of the place and the *Æquator*; which is two-fold, *viz.* either North-Latitude or South-Latitude, either of which extendeth from the Equinoctiall to either Pole, so the greatest Latitude that can be is but 90 degrees: if any Northern Countrey have the Artick Circle verticall, 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 houres, if the Countrey have lesse Latitude than 66. degrees 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 dayes, and if the Countrey be under the Pole, the Sun will make a Circular motion above the Earth, and be visible for a half yeare: so under the Pole there will be but one day, and one night in the whole yeare.

To finde the latitude of Countreys.

IF it be upon a Globe, bring the place to the Brasen Meridian, and the number of degrees which it meeteth therewith, is the Latitude of the place. Or with a paire of Compasses take the distance between the Countrey and the Equinoctiall, which applied unto the Equinoctiall will shew the Latitude of that Countrey; which is equall to the Poles height; if it be upon a Mappe. 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 betweene the place and the next parallel, which applied to the divided Meridian from that parallel will shew the Latitude of that place.

To finde the distance of places.

IF it be upon a Globe: then with a paire of *Compasses* take the distance betweene 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 Mappe (according to *Wrights* projection)

ection) take the distance with a paire of *Compasses* between the two places, and apply this distance to the divided Meridian on the Mappe right against the two places; so as many degrees as is conteined 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 the Longitude, Latitude, Declination, and distance of the Starres.

THe Declination of a starre is the nearest distance of a Star from the *Æquator*; the Latitude of a Starre is the nearest distance of a Sarre from the *Ecliptick*: the Longitude of a Starre is an Ark of the *Ecliptick* conteined between the beginning of *Aries*, and the Circle of the Starres Latitude, which is a circle drawne from the Pole of the *Ecliptick* unto the starre, and so to the *Ecliptick* The distance between two Sarres in Heaven is taken by a *Crosse-staffe* or other Instrument, and upon a Globe it is done by taking between the feet of the *Compasses* the two Starres, and applying it to the *Æquator*, so have you the distance betweene those two starres.

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 certaine dayes travell the one lived more dayes than the other, notwithstanding they dyed together in one and the same moment also?

THis is easie to be answered: let one of them travell toward the West and the other towards the East: then that which goes towards the West followeth the Sunne: and therefore shall have the day somewhat longer than if there had been no travell made, and that which goes East by going against the Sunne, shall have the day shorter, and so in respect of travell though they dye at one and the selfe same houre 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 Sabath 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 travell upon the Saturday, the Christian going West, and the Saracen Eastwards, shall compasse the Globe

Globe of the earth, thus the Christian at the conclusion shall gaine a day, and the Saracen shall lose a day, and so meet with the Jew every one upon his owne Sabbath.

Certaine fine observations.

1 Under the Equinoctiall 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 verticall.

2 In these Countreys which are without the Tropicall Circles, the Sunne comes East and West every day for a halfe yeare, but being under the Equinoctiall the Sun is never East, nor West but twice in the yeare, to wit, the 10. of *March* and the 13 of September.

3 If a ship be in the Latitude of 23 gr. 30 m. that is, if it have either of the Tropicks verticall: then at what time the Sunnes Altitude is equall to his distance from any of the Equinoctiall points, then the Sunne is due East or West.

4 If a ship be betweene the Equinoctiall and either of the Tropicks, the Sunne will come twice to one point of the compasse in the forenoone, that is, in one and the same position.

5 Vnder the Equinoctiall neare *Guinea* there is but two sorts of windes all the year, 6 moneths a Northerly winde, and 6 moneths a Southerly winde, and the flux of the Sea is accordingly.

6 If two ships under the *Equinoctiall* be 100. leagues asunder, and should saye Northerly untill

untill they were come under the Articke circle, they should then be but 50 leagues asunder.

7 Those which have the Artick circle, verticall: when the Sunne is in the Tropick of *Cancer*, the Sun setteth not, but toucheth the western part of the Horizon.

8 If the complement of the Sunnes height at noon be found equall to the Sunnes Declination for that day, then the *Equinoctiall* is verticall: or a shippe making such an observation, the *Equinoctiall* is in the *Zenith*, or direct over them, by which Navigators know when they crosse the line, in their travels to the Indies, or other parts.

9 The Sunne being in the *Equinoctiall*, the extremity of the stile in any Sunne-dyall upon a plaine, maketh a right line, otherwise it is *Eclipticall*, *Hyperbolicall*, &c.

10 When the shadow of a man, or other thing upon a *Horizontall* plaine is equall unto it in length, then is the *Sunne* in the middle point between the Horizon and the *Zenith*, that is, 45 degrees high.

PROBLEM. XCVII.

To make a Triangle that shall have three right Angles.

OPen the *Copasses* at pleasure: and upon *A*, describe an Arke *B C*. then at the same opening, place one of the feet in *B*, and describe the

the Ark *A C*. Lastly, place one of the feet of the *Compasses* in *C*. and describe the Arke *A B*. so shall you have the sphericall *Æquilaterall Triangle A B C*, right angled at *A*, at *B*, and at *C*. that is, each angle comprehended 90. degrees: which can never be in any plaine Triangle, whether it be *Equilaterall, Isocelse, scaleve, Orthogonall*, or *Opigonall*.

Problem. XCVIII.

To divide a line in as many equall parts as one will, without compasses, or without seeing of it.

THis Proposition hath a fallacie in it; & cannot be practised but upon a *Maincordion*: for the Mathematicall line which proceeds from the flux of a point, cannot be divided in that wise: 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 untill you found a third in musick: if you would have the fourth part of the line, then

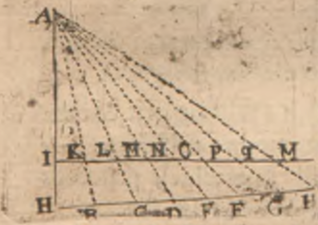
then finde the fourth sound, a fifth, &c. so shall you have the answer.

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 & the same plaine, held in great account amongst the Ancients, and it is drawne 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, *I M.* transferre *I H. viz. K B. L C. O D. P E. Q F. M G.*



then from those points draw the line *H B. C D. E. F. G.* which will not meet with the line *I M.* and yet incline nearer and nearer unto it.

PROB:

PROBLEM. C.

To observe the variation of the compasses, or needle in any places.

First describe a Circle upon a plaine, so that the Sun may shine on it both before noone and afternoone. in the centre of which Circle place a *Gnomon* or *wire* perpendicular as *A B*, and an houre before noone marke the extremitie of the shadow of *A B*, which suppose it be at *C*. describe a Circle at that semidiamiter *C D F*. then after noone mark when the top of the shadow of *A B*. toucheth the Circle, which admit in *D*; divide the distance *C D* into two equall parts, which suppose at *E*. draw the ine *E A F*. which is the Meridian line, or line of *North & South*: now if the Arke of the Circle *C D* be divided into degrees. place a Needle *G H*, upon a plaine set up in the Centre, and marke how many degrees the point of the Needle *G*, is from *E*. so much doth the Needle vary from the North in that place.

PROB.

Probleм. CI.

How to finde at any time which way the wind is in ones Chamber, without going abroad?

Vpon the Plancking or floore of a Chamber, Parlor, or Hall, that you intend to have this device, let there come downe from the top of the house a hollow post, in which place an Iron rod that it ascend above the house 10, or 6 foot with a vane or a 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, turne this Dart which is within: about which upon the plaister must be described a Circle divided into the 32 points of the Mariners Compasse pointed and distinguished to that end, then may it be marked by placi to Compasse 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 comming into this Roome, you have nothing to do but to look up to the Dart, which will point you out what way the winde bloweth at that instant.

Prob-

PROBLEM. CII.

How to draw a parallel sphericall 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 seene nor where the Compasses were placed, will seeme very strange how possibly it could be drawne with such exactnes, 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.

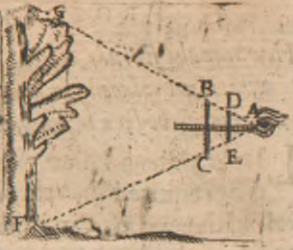
THe way of this is easie: for having ones hat upon his head, come neare to the bank of the River, and holding your head upright (which may be by putting a small stick to some one of your buttons to prop up the chin) pluck downe the brim or edge of your hat untill you may but see the other side of the water, then turne about the body in the same posture that it was before towards some plaine, and marke where the sight by the brimme of the hat glaunceth on the ground; for the distance from that place to your standing, is the breadth of the River required.

Problem. CIIII.

How to measure a height with two strawes or two small stickes.

TAke two strawes or two stickes which are one as long as another, and place them at right Angles one to the other, as *A B.* and *AC.* then holding *AB.* 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

ward untill 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 equall to the height thereof above the levell of the eye: to which if you adde your ovvne height you have the whole height.



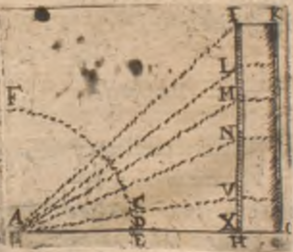
Otherwise.

TAke an ordinary square wch Carpenters or other workemen use, as *H K L*. and placing *H*. to the eye so that *H K* be levell, go back or come nearer untill that by it you may see the top *M*. for then the distance from you to the height is equall to the height.

PROBLEM. CV.

How to make statues, letters, bowles, or other things which are placed in the side of a high building, to be seen below of an equall bignesse.

LEt *B C.* be a Pillar 7 yards high, and let it be required that three yards above the levell of the eye *A, viz.* at *B.* be placed a Globe, and 9 yards above *B.* be placed another, & 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 appeare to be of one and the same Magnitude: It is thus done, first draw a line as *A K.* and upon *K.* erect a perpendicular *K X.* divide this line into 27 parts, and according to *A K.* describe an Arke *K Y.* then from *K.* in the perpendicular *K X,* account 3. parts, *viz.* at *L,* which shall represent the former three yardes, 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 Arke *V K.* in *N* then from *K.* in the perpendicular account 9 yards, which admit at *T.* draw *T A,* cutting *Y K.* in *O* transferre the Arke *M N,* from



A

A to *P*. and draw *A P*. which will cut the perpendicular in *V*. so a line drawne from the middle of *V F*. unto the visuall lines *A I*, and *A V*, 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 Arke *M N*, and transferre it from *Q* to *R* and draw *A R* which will cut the perpendicular in *X* so the line which passeth by the meddle of *X W*. perpendicular to the visuall 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, & the foulding 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 a bove the eye.

PROBLEM. CVI.

How to disguise or disfigure an Image, as a head, an arme, a whole body, &c. so that it hath no proportion, the eares to become long: the nose as that of a swan, the mouth as a coaches entrance, &c. yet the eye placed at a certaine point will be seen in a direct & exact proportion.

I Will not strive to set a Geometricall figure here, for feare it may seeme too difficult to understand,

derſtand, but I will indeavour 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 Bookes of Paper, where you deſire to have the figure diſguiſed in ſuch ſort that the height paſſe athwart the hole of the Picture: then will it carry all the forme of the Picture upon the Paper, but with deformity; follow theſe tracts and marke out the light with a Coles black head or Ink: and you have your deſire.

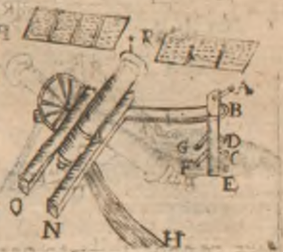
To finde now the point where the eye muſt ſee it in his naturall forme: it is accuſtomed according to the order of Perſpective, to place this point in the line drawne in height, equall to the largeneſſe of the narroweſt ſide of the deformed ſquare, and it is by this way that it is performed.

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 wheele *L*, the axletree *P B*. upon which the *Cannon* is placed, at which

which end towards *B*, is placed a pillar *A E* supported with props *D*, *C*, *E*, *F*, *G*. about which the Axeltree turneth: now the *Cannon* being to shoot, it retires to *H*, which cannot be directly because of the Axletree, but it make a segment of a circle, and hides himselfe behind the wal *Q R*,

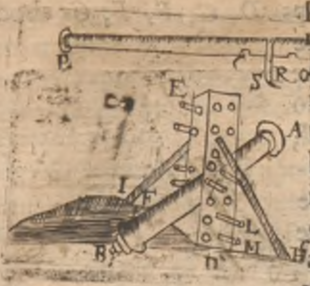


and so preserves it selfe from the Enemies battery, by which meanes one may avoid many inconveniences which might arise: and moreover, one man may more easily replace it againe for another shot by help of poles tyed to the wall, or other help which may multiply the strength.

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 *C D*, and *E F*: & let *L*, and *M*, be the two barres of Iron which passeth through the holes *G H*, and *F*; *K*, the



two supports, or props, *A B* the Cannon, *O P*, the Lever, *R S*, the two notches in the Lever, and *Q*, the hooke where the burthen or Cannon is tyed to. The rest of the operation is facill, that the youngest schollers or learners cannot faile to performe it: to teach *Minerva* were in vaine, and it were to Mathematicians injury in the succeeding Ages.

PROBLEM. CIX.

How to make a Clock with one onely Wheele.

MAke the body of an ordinary Dyall, and divide the houre in the Circle into 12. parts: make a great wheele in height above the Axletree, to the which you shall place the cord of your counterpoize, so that it may descend, that in 12 houres

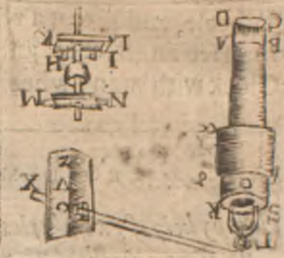
houres of time your *Index* or *Needle* may make one revolution, which may be knowne by a watch which you may have by you: then put a balance which may ſtop the courſe of the Wheele, and give it a regular motion, and you ſhall ſee an effect as juſt from this as from a Clock with many wheeles.

PROBLEM. CX.

How by help of two wheeles to make a Childe to draw up alone a hogſhead of water at a time: and being drawne up ſhall caſt out it ſelfe into another veſſell as one would have it.

LEt *R* be the *Pit* from whence water is to be drawne, *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 wheele *S F*, which wheele hath divers forkes of Iron made at *G*, equally faſtened at the wheele; let *I*, be a Card, which is drawne by *K* , to make the wheele *S*, to turne, vvhich vvheele *S*, beares proportion to the vvheele *T*, as 8 to 2. let *N* be a Chaine of Iron to vvhich is tyed the veſſel *O*, and the other vvhich is in the Pit; *E F* is a piece of vvood vvhich hath a morteſin 1, and 2, by vvhich the Cord *I*, paſſeth, tyed at the vvall, as *K H*, and the other piece of timber of the little vvheele as *M*, mortiſed in likevviſe for the chaine

chaine to passe through: draw the *Cord I*, by *K*, and the wheele will turne, & so consequently the wheele *T*, which will cause the vessell *O* to raise; which being empty, draw the cord againe by *Y*, and the other vessell which is in the pit will come out by the same reason. This is an invention which will save labour if practised; but here is to be



noted that the pit must be large enough, to the end that it conteine two great vessels to passe up and downe one by another.

PROBLEM. CXI.

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

TAke two Pullies *A*, & *D*, unto that of *A*, let there be fastened a *Cramp* of Iron as *B*; and at *D*, let there be fastened a staffe of a foot and a halfe long as *F*, then the Pully *A*: place a hand of Iron, as *E*, to which tie a cord of an halfe inch thick (which may be of silk because it is for the pocket:) then strive to make fast the

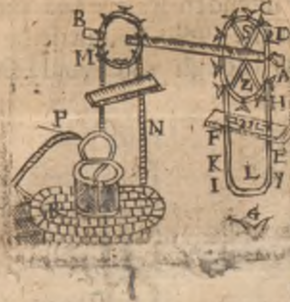
Pully

Pully *A*, by the help of the *Crampe* of Iron *B*, to the place that you intend to ſcale; and the ſtaffe *F*, being tyed at the Pully *D*, put it betvveen your legges as though you vvould ſit upon it: then holding the *Cord* C in your hand, you may guide your ſelfe to the place required: vvhich may be made more facill by the multiplying of Pullies. This ſecret is moſt excellent in Warre, and for lovers, its ſupportableneſſe avoids ſuſpition.

Problem. CXII.

How to make a Pumpe whoſe ſtrength is marvelous 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 two or three foot high, and broader according to diſcretion: the reſt of the *Caſe* or concavity let be *O*: let the ſucker of the Pumpe vvhich is made, be juſt for the *Caſe* or *Pumpes* head $\alpha \beta \gamma \delta$, & may be made of vvood or braſſe of 4 inches thick, having a hole at *E*, vvhich deſcending



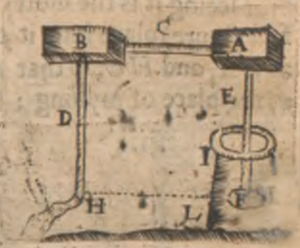
scending raiseth up the cover P, by which issueth forth the water, & ascending or raising up it shuts it or makes it close: *R S*, is the handle of the sucker tyed to the handle *T X*, which works in the post *V Z*. Let *A, B,C,D*, be a piece of Brasse, *G* the piece which enters into the hole to *F*, to keep out the Aire. *H,I,K,L*, the piece tyed at the funnell or pipe: in which playes the Iron rod or axis *G*, so that it passe through the other piece *M N*, which is tyed with the end of the pipe of Brasse.

Note, that the lower end of the Cisterne ought to be rested upon a Gridiron or Iron Grate, which may be tyed in the pit, by which means lifting up and putting downe the handle, you may draw ten times more water than otherwise you could.

Problem. CXIII.

How by meanes of a Cisterne, to make Water of a Pit continually to ascend without strength, or the assistance of any other Pumpe.

Let *I L*, be the Pit where one would cause water to ascend continually to each office of 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 aire 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 Ciſterne as *B*, which may be communicative to *A*, by helpe of the pipe *G*, from vvhich Ciſtern *B*, may iſſue the vvater of pipe *D*, vvhich may deſceud to *H*, vvhich is a little belovv the levell of the vvater of the pit as much as is *G H.* to the end of vvhich



ſhall be ſoldered cloſe a Cock vvhich ſhall caſt out the vvater by *K H.* Novv to make uſe of it, let *B* be filled full of vvater, and vvhen you vvould have it run turne the Cock, for then the vvater in *B*, vvill deſcend by *K.* and for feare that there ſhould be vacuity, nature vvhich abhors it, vvill labour to furniſh and ſupply that emptineſſe out of the ſpring *F*, and that the *P*it dry not, the Pipe ought to be ſmall of an indifferent capacity according to the greatneſſe or ſmalneſſe of the ſpring.

PROB.

PROBLEM. CXIIII.

How out of a fountaine to cast the water very high: different from a Probleme formerly delivered.

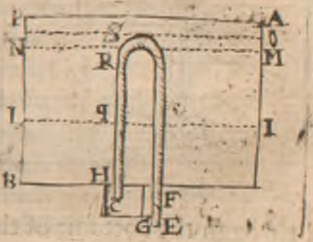
LEt the fountaine be *B D*, of a round forme (seeing it is the most capable and most perfect figure) place into it two pipes conjoyned as *E A*, and *H C*, so that no Aire may enter in at the place of joyning: let each of the Pipes have a cock *G*, & *L*. the cocke at *G*, being closed, open that at *I*, & so with a squirt force the water through the hole at *H*, then close the Cocke at *A*, & draw out the squirt, and open the cock at *G*.

the Aire being before rarified will extend his dimensions, and force the water with such violence, that it will amount 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 Aire approacheth to his naturall place, so the force will diminish.

Problem. CXV.

How to empty the water of a Cisterne by a Pipe which shall have a motion of it selfe.

LEt *A B*, be the vessell; *C D E*, the Pipe: *H G*, a little vessell 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 bottome of the vessell at *F*, then as the vessell filleth so will the Pipe, and when the vessell, shall be full as farre as *P O*, the Pipe will begin to runne at *E*, of his owne accord, and never cease untill the vessell be wholly empty.



Preolem 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 Brasse, Lead, or of other matter of equal substance as are the two vessels *A B*, and *B D*, & let them be joyned together by the two Pillars *M N*, & *E F*: then let there be a pipe *H G*. which may passe through the cover of the vessell *C D*, and passe through *A B*, into *G*, making a little bunch or rising in the cover of the vessell *A B*, so that the pipe touch it not at the bottome: then

then let there be soldered fast another Pipe *I L*, which may be separated from the bottome of the vessell, and may have his bunchie swelling as the former without touching the bottome: as is represented in *L*, and passing through the bottome of *A B*, may be continued unto *I*, that

is to say, to make an opening to the cover of the vessell *A B*, & let it have a little mouth as a Trumpet: to that end to receive the water. Then there must further be added a very smal Pipe which may passe through the bottome of the vessell *A B*, 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 bottome: let there be further made to this lesser vessell an edge in forme of a Basin to receive the water, which being done poure water into the Pipe *I L*, untill the vessell *C D*, be full, then turne the whole Machine upside downe that the vessell *C D*, may be uppermost, and *A B*, undermost; so by helpe of the pipe *G H*, the water of the vessell *C D*, will runne 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 boyling fountaine, in the forme of a threed very pleasant to behold.

PROB.

Problem. CXVIII.

How to practise excellently the reanimation of simples, in case the plants may not be transported to be replanted by reason of distance of places.

TAke what simple you please, burne it and take the ashes of it, and let it be calcinated two houres between two Creusets wel 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 boyled in some vessel, untill it be all consumed: then there will remaine a salt at the bottome, which you shall afterwards sowe in good Ground wel prepared: such as the Theatre of husbandry sheweth, and you shall have your desire.

Problem. CVIII.

How to make an infalliable perpetuall motion.

MIxe 5. or 6. ounces of ☿ with is equall weight of ♃, grinde it together with 10. or 12 ounces of sublimate dissolved in a celler upon a Marble the space of foure dayes, and it will become like Oile, Olive, which distill with fire of chaffe or driving fire, and it will

sublime

ſubſime dry ſubſtance, then put water upon the earth (in forme of Lye) which will be at the bottom of the Limbeck, and diſſolve that which you can; filter it, then diſtill it, and there will be produced very ſubtill Antomes, which put into a 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 halfe an ounce of fine ſilver refined in a Cappell: then take an ounce of *Aqua fortis*, and two drams of Quick-ſilver: which put in it, and mixe theſe two diſſolved things together, then caſt it into a Viall of halfe 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 haire 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 haire, for feare of touching the fleſh: for this compoſition is very Corroſive or ſearching, that as ſoone as it toucheth the fleſh it raiſeth bliſters, and bladders very painfull.

PROBLEM. CXX.

How to make the representation of the great world?

DRaw ſalt Niter out of ſalt Earth which is found along the Rivers ſide, and at the foot of Mountaines, where eſpecially are Minerals of Gold and Silver: mix that Niter well cleanſed with ♃, then calcinate it hermetically; then put it in a Limbeck and let the receiver be of Glaſſe, well luted, and alwayes in which let there be placed leaves of Gold at the bottome, then put fire under the Limbeck untill vapours ariſe which will cleave unto the Gold; augment your fire untill there aſcend no more, then take away your receiver and cloſe it

hermetically, and make a Lampe fire under it untill you may ſee preſented in it that which nature affords us: as *Flowers*, *Trees*, *Fruits*, *Fountaines*, *Sunne*, *Moone*, *Starres*, *&c.* Behold here the forme of the Limbeck, and the receiver: *A* repreſents the Limbeck, *B* ſtands for the receiver.

Problem. CXXI.

How to make a Cone, or a Pyramidall body move upon a Table without ſprings or other Artificiall meanes: ſo that it ſhall move by the edge of the Table without falling?

THis propoſition is not ſo thornie and ſubtile as it ſeemes to be, for putting under a Cone of paper a Beetle or ſuch like creature, you ſhall have pleaſure with aſtoniſhment & admiration to thoſe which are ignorant in the cauſe: for this animall will ſtrive alwayes to free herſelf from the captivity in which ſhe is in by the impriſonment of the *Cone*: for comming neere the edge of the Table ſhe will returne to the other ſide for feare of falling.

Problem CXXII.

To cleave an Anvill with the blow of a Piſtoll.

THis is proper to a Warrier, and to performe it, let the Anvill be heated red hot as one

can

can possible, in such sort that all the solidity of the body be softned by the fire: then charge the Pistoll 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-bowe, in the space of riding 5 or 6 miles?

HAving made it ready and larded it, stuffe it with Butter; then heat a piece of steele 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 that *Count Mansfield* served himselfe with no others, but such as were made ready in this kinde, for that it loseth none of its substance, and it is dressed very equally.

PROBLEM. CXXIV.

How to make a Candle burne and continue three times as long as otherwise it would?

VNto the end of a Candle half burned stick a farthing lesse or more, to make it hang perpendicular in a vessel of water, so that it swimme above the water; then light it, and it will susteine it self & float in this manner; and being placed into a fountaine, pond, or lake that runnes slowly, where many people assemble, it will cause an extreme feare to those which come therein in the night, knowing not what it is.

Problem. CXXV.

How out of a quantitie of wine to extract that which is most windy and evill, that it hurt not a sick Person?

TAke two vials in such sort that they be of like greatnesse 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 be uppermost, now because the water is heavier than the wine, it will descend into the other Viall, and the wine which is lowest, because it is highest will ascend above to supply the place of the water, and so there will be a mutuall interchange of liquids, and by this penetration the wine wil 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 animall or forme, 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 smal, 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 wil blow out the Candle immediatly, and going to the other Image (before the match of the Candle be out) touch the sulphur with it and say, Light the Candle, & it will immediatly be lighted, which will cause an admiration to those which see the action, if it be wel done vvith a secret dexterity.

PROBLEM. XXVII.

How to keepe wine fresh as if it were in a celler though it were in the heat of Summer, and without Ice or snow, yea though it were carried at a saddles bow, and exposed to the Sun all the day?

SEt your wine in a viall of Glasse; and place it in a Box made of wood, Leather, or such like: about which vial place Salt-peeter, and it will preserve it and keep it very fresh: this experiment is not a little commodious for those which are not neare fresh waters, and whose dwellings are much exposed to the Sunne.

PUOBLEM. CXXVIII.

To make a Cement which indureth or lasteth as marble, which resisteth aire and water without ever disjoyning or uncementing?

TAke a quantity of strong and gluing Morter vvell beaten, mixe vvith this as much nevv slaked Lime, and upon it cast Oile of Olive or Linseed-Oile, and it vvill become hard as Marble being applyed in time.

PROB.

PROBLEM. CXXIX.

How to melt metall very quickly, yea in a shell upon a little fire.

MAke a bed upon a bed of metall with pouder of Sulphur, of Salt-peeter, and saw-dust alike; then put fire to the said pouder with a burning Charcole, and you shall see that the metall will dissolve incontinent and be in a Masse. This secret is most excellent, and hath been practised by the reverend father *Mercenns* of the order of the *Minims.*

PROBLEM. CXXX.

How to make Iron or steele exceeding hard?

QVench 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 *Armorie* in warlike negotiations.

PROB.

PRBOLEM CXXXI.

To preſerve fire as long as you will, imitating the inextinguible fire of Veſtales.

AFter that you have extracted the burning ſpirit of the ſalt of ♃, by the degrees of fire, as is required according to the Art of *Chymiſtrie*, the fire being kindled of it ſelfe, break the Limbeck, and the Irons which are found at the bottome will flame and appeare as burning Coles as ſoone as they feele the aire; which if you promptly incloſe in a viall of Glaſſe, and that you ſtop it exactly with ſome good Lute: or to be more aſſured it may be cloſed up with Hermes wax for feare that the Aire get not in. Then will it keep more than a thouſand yeares(as a man may ſay) yea at the bottome of the Sea; and opening it at the end of the time, as ſoone as it feeles the Aire 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, and full of aſtoniſhment, ſeeing that all kinde of fire laſteth but as long as his matter laſteth, and that there is no matter to be found that will ſo long indure.

Artificiall fire-Workes:

Or the manner of making of *Rockets* and *Balls* of fire, as well for the Water, as for the Aire; with the composition of Starres, 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 lesse sort is very improper to those which are of a more greater forme; for the fire being lighted in a great concave, which is filled with a quick composition, burnes 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 requireth for their charge 10 pound of Powder, as followeth.

For Rockets of one ounce.

Vnto each pound of good musket Powder ſmal beaten, put two ounces of ſmal Cole duſt, and with this compoſition charge the Rocket.

For Rockets of 2 or 3 ounces.

Vnto every foure ounces and a halfe of powder duſt, adde an ounce of Salt-peter, or to every 4 ounces of powder duſt, adde an ounce of Cole duſt.

For Rockets of 4 ounces.

Vnto every pound of Powder duſt adde 4 ounces of Salt peter & one ounce of Cole duſt: but to have it more ſlow, unto every 10. ounces of good duſt powder adde 3 ounces of Salt-peter, and 2 ounces of Cole duſt.

For Rockets of 5 or 6 ounces.

Vnto every pound of Powder duſt, adde 3 ounces and a halfe of Salt peter, and 2 ounces and a halfe of Coleduſt, as alſo an ounce of Sulphur, and an ounce of fyle duſt.

For Rockets of 7 or 8 ounces.

Vnto every pound of Powder duſt adde 4 ounces of Salt peter, and 3 ounces of Sulphur.

Of Rockets of 10 or 12 ounces

Vnto the precedent compoſition adde halfe an ounce of Sulphur, and it will be ſufficient.

For Rockets of 14 or 15 ounces.

Vnto every pound of Powder duſt adde 4 ounces of Salt peter, or Cole duſt 2 ¼ ounces of Sulphur

Sulphur and file dust of $1\frac{1}{4}$ ounce.

For Rockets of 1, *pound.*

Vnto every pound of Powder dust adde 3 ounces of Cole dust, and one ounce of Sulphur.

Of Rockets of 2, *pound.*

Vnto every pound of Powder dust adde $9\frac{1}{2}$ ounces of Salt peter, of Cole dust $2\frac{1}{2}$ ounces, filedust $1\frac{5}{8}$ ounce, and of Sulphur $\frac{1}{4}$ of ounce.

For Rockets of 3, *pound.*

Vnto every pound of Salt peter adde 6 ounces of Cole dust, and of Sulpher 4, ounces.

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

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

For Rockets of 8, 9, *or* 10 *pound.*

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

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

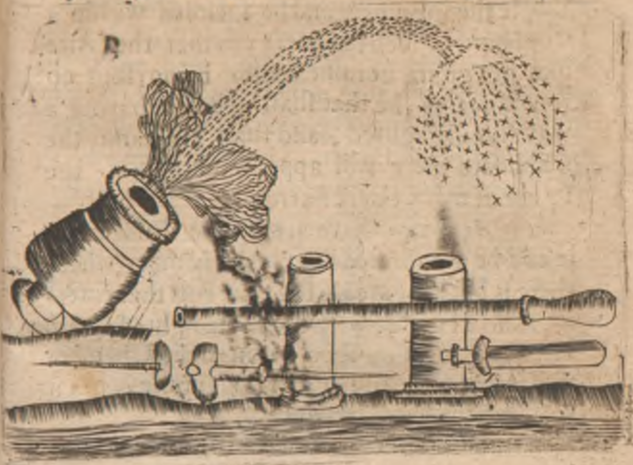
Of the making of Rockets and other Fireworkes.

FOr the making of Rockets of sundry kindes, 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 Raine: the Serpents are made about the bignesse of ones little finger, by rolling a little paper npon 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

graine-Powder or halfe Powder and halfe composition, and tying both ends close, they are finished. The best kinde of starres are made with this mixture following; unto every 4 ounces of Salt-peter, adde 2 ounces of Sulphur

phur, and to it put 1. ounce of Powder-duſt, and of this compoſition make your ſtarres, by putting a little of it within a ſmall quantity 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 drawne a little Primer to make it take fire. Touching the making of the Golden Raine, that is nothing but filling of Quilles with the compoſition of your Rockets ſomewhat hard. Now if the head of a Rocket be loaded with a thouſand of thoſe Quilles, its a goodly ſight to ſee how pleaſantly they ſpread themſelves in the Aire, and come downe like ſtreames of Gold much like the falling downe of Snow being agitated by ſome turbulent winde.

Of recreative fires.

1 PHilostrates saith, that if wine in a platter be placed upon a receiver of burning Coles, to exhale the spirit of it, and be inclosed within a Cupboard or such like place, so that the Aire may not go in, nor out, and so being shut up for 20 yeares, he that shall open it, having a wax Candle lighted, and shall put it into the Cubboard there will appeare unto him the figure of many cleare starres.

2 If *Aquavitæ* have Camphire dissolved in it; and be evaporated in a close Chamber, where there is but a Charcole fire, the first that enters into the Chamber with a Candle lighted, will be extremely astonished, for all the Chamber will seeme to be full of fire very subtile, but it will be of little continuance.

3 Candles which are deceitful are made of halfe powder, covered over with Tallow, and the other halfe is made of cleane Tallow, or Waxe, with an ordinary week; this Candle being lighted, and the upper halfe consumed, the powder will take fire, not without great noise and astonishment to those which are ignorant of the cause.

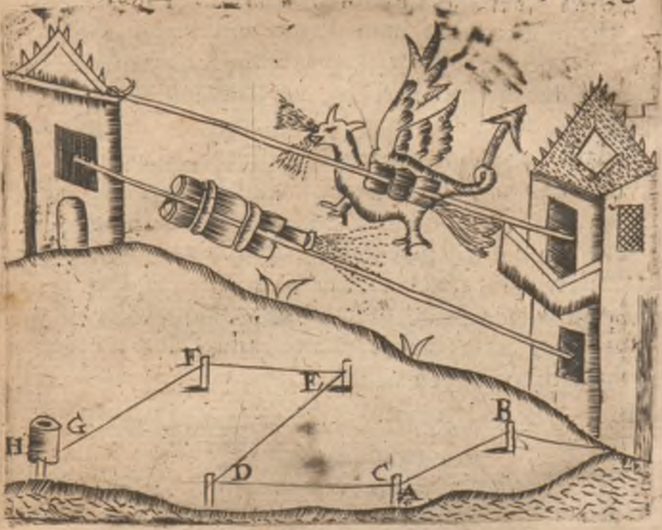
4 A dozen or twenty smal Serpents placed secretly under a Candlestick that is indifferent big, which may have a hole passe through the socket of it to the Candle, through which a piece of primer may be placed, and setting a smal *Candle* in the socket to burne according to

to a time 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 flye here and there, intermixing themſelves, ſometimes in the Aire, 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 Piſtoll; 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 downe, forward and backward.

TAke ſmall Rockets, and place the taile of one to the head of the other upon a Cord according to your fancie, as admit the Cord to be *A B C D E F G.* give fire to the Rocket at *A*, which will flye to *B*, which will come back againe to *A*, and fire another at *C*, that will flie at *D*, which will fire another there, and flie 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 Aire, and upon the ground, and every one will extinguiſh with a report: and here may you note that upon the

Rockets may be placed fierie Dragons, Combatants, or ſuch like to meet one another, having

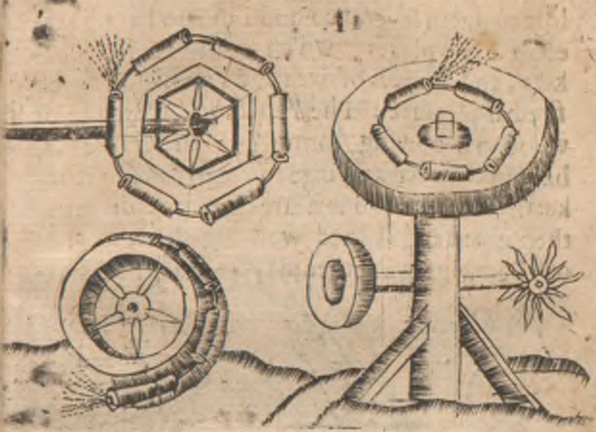


lights placed in the Concavity of their bodies which will give great grace to the action.

How to make Wheels of fire.

TAke a Hoop, and place two Laths acroſſe one the other; upon the croſſing of which make a hole, ſo that it may be placed upon a pin to turne eaſily, as the figure 2. ſheweth upon the ſides of which hoope or round Circle place your Rockets, to which you may place Lances of fire between each Rocket:

Rocket: let this wheele be placed upon a standard as here is represented, and place a 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 immediatly the wheel will begin to move, and represent unto the spectators a Circle of changeable fire, and if pots of fire be tied to it, you will have fine sport in the turning of the wheele and casting out of the Serpents.

Of night-Combatants.

CLubbes, Targets, Faulchons, and Maces charged with severall fires, do make your night-Combatants, or are used to make place amongst a throng of people. The Clubbes at the ends are made like a round Panier with small

ſmall ſticks, filled with little Rockets in a ſpirall forme, glued and ſo placed that they fire but one after another; the Maces are of divers faſhions, ſome made oblong at the end, ſome made of a ſpirall forme, but all made hollow to put in ſeveral compoſition, 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 forme like the figure *A*, having their backes large to receive many Rockets, the head of one neare the neck of another, glued and faſtned well together, ſo that one being ſpent another may be fired. The Tar-

gets, are made of wooden thinne boards, which are channeled in ſpiral lines to containe primer

to

to fire the Rockets one after another, which is all covered with thinne covering of wood, or Pastboard, boared with holes spirally also; which *Rockets* must be glued and made fast to the place of the Channels: Now if two men, the one having a Target in his hand, and the other a Falchon, or Mace of fire, shall begin to fight, it will appeare very pleasant to the Spectators: for by the motion of fighting, the place will seem to be ful of streames of fire: and there may be adjoyned to each Target a Sunne or a burning Comet with Lances of fire, which will make them more beautifull and resplendent in that action.

Of standing Fires.

SVch as are used for recreation, are *Collossus, Statues, Arches, Pyramides, Chariots,*

Chaires

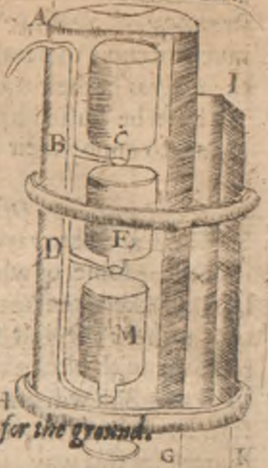
Chaires of triumph and ſuch like, which may be accommodated with Rockets of fire, and beautified with ſundry other artificiall fires, as pots of fire for the Aire which may caſt forth ſeveral figures, Scutchions, Rockets of divers ſorts, Starres, Crownes, Leaters, and ſuch like, the borders of which may be armed with ſundry Lances of fire, of ſmall flying Rockets with reports, flames, of ſmall birds of Cypres, Lanthornes of fire, Candles of divers uſes, and colours in burning and whatſoever the fancie of an ingenious head may allude unto.

Of Pots of fire for the Aire, which are throwne 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 flow primer or compoſition; then having charged the Trunk *A G*, with the Pots of fire for the Aire at *I G E C*, and make the Trunk *A G*, very faſt unto a Poſt as *I K*, give fire at the top as at *A*, which burning downewards will give fire to *C*, and ſo throw out that Pot in the Aire, vvhich being ſpent, in the meane time the fire vvill burne from *B* to *D*, and ſo fire *E*, and throvv it out alſo into the Ayre, and ſo all the reſt one after another vvill be throvvne out: and if the Pots of fire for the Aire vvhich are caſt out, be filled vvith diverſe Fire-vvorkes, they vvill be ſo much the

more

more pleaſant to the beholders. Theſe Trunks of fire doe greatly adorne a Firevvorke, and may conveniently be placed at each angle of the vvhole vvorke.



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 vvonderfull ſhout amongſt the common people vvch are ſtanders by; for thoſe Pots being filled vvith Balles of fire and flying Serpents for the Aire,

they vvill ſo intermix one vvithin another, in flying here and there a little above the ground, and giving ſuch a volley of reports that the Aire vvill rebound vvith their noiſe, and the vvhole place be filled vvith ſundry

ſtreames

ſtreames of pleaſant fire; which ſerpents will much occupie theſe about the place to defend themſelves in their upper parts, when they will no leſſe be buſied by the balls of fire, which ſeeme to annoy their feet.

Of Balles of fire.

THeſe are very various according to a mans fancy; ſome of which are made with very ſmall Rockets, the head of one tyed 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 rolle 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 ſeverall fires with reports. In the ſecond kind there may be a channell of Iron placed in divers places in ſpirall manner, against which

may be placed as many ſmall petards of paper as poſſible may be, the Channell 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

morter-

morter Peece, or charged on the top of a Rocket: for in its motion it will flye here and there, and give many reports in the Aire: 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, Pagins, Castles,* or such like,

to receive or hold the diversity of Fire workes that may be made within it, in which may play divers fires, Petards, &c. and cast out many simple Granadoes, Balls of fire to burne in the water,

water-Serpents and other things, and often times these boates 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 knowne in respect of the other, and the triumph and victory of the fight gotten.

Of Balles of fire which move upon the water.

These may be made in forme 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 Balles ful of composition for the water which small Balls must be peirced deep and large, and covered with Pitch, except the hole: in which hole must be first placed a little quantitie of grain-Powder; and the rest of the hole filled up with composition; and note further that these Iron Cannons, must

be

be filled with a flow composition; but such which is proper to burne 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 comming to the holes will fire the graine Powder, the which will cause the Balls to separate and fly here and there, sometimes two at a time, sometimes three, sometimes more, which will burne within the water with great astonishment and content to those which see it.

Of Lances of fire.

STanding Lances of fire, are made commonly with hollow wood, to containe sundry Petards, or Rockets, as the figure here sheweth, by which is easie to invent others occording to ones fancy. These Lances have wooden handles, that so they may be fastned at some Post, so that they be not overthrowne in the flying out of the Rockets or Petards: there are lesser sorts of Lances whose cases are of three or foure fouldings of Paper of a foote long, and about the bignesse 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 adde 2 ounces of Salt-Peter, and unto that adde 1

ounce of, Sulphur) it will make a brick fire red before it be halfe 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 Horizontall, or otherwiſe.

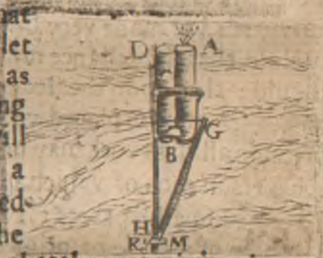
VNto the end of the Rocket place an Arrow which may not be too heavy, but in ſtead of the feathers let that be of thinne white

tinne 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 applyed to warlike affaires.

How

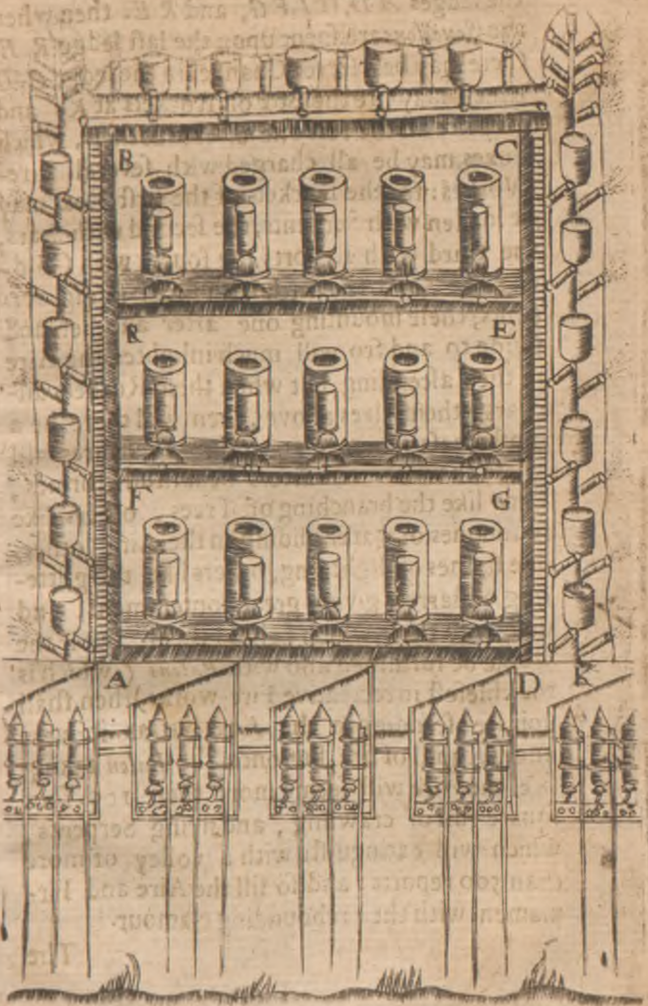
How a Rocket burning in the water for a certaine time, at last shall fly up in the Aire with an exceeding quicknesse.

TO do this, take two Rockets, the one equall to the other, and joyne them one unto another in the middle at *C.* in such sort that the fire may easily passe from one to another: it being thus done, tye 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 lye upright: then take a pack-thread and tye it at *G.* and let it come double about the stick *D M.* at *H.* and at that point hang a Bullet of some weight as *K.* for then giving fire at *A.* it will burne to *B.* by a small serpent filled there and tyed at 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 vvater: and so ascend like a Rocket in the Aire, to the admiration of such as knovv not the secrecie.



Of the framing of the parts of a Fire-Worke, together, that the severall workes m y fire on after another.

CAuse a frame to be made as *A B C D.* of tvvo foot square every vvay, or thereabouts (according to the quantity of your severall vvorkes) then may you at each angle have a great Lance of fire to stand, vvhich may cast out Pots of fire as they consume: upon the ledges *A B. B C.* and *C D.* may be placed small Lances of fire about the number of 30 or 60, some sidevvise, and others upright, betvveen these Lances may be placed Pots of fire sloping outvvards, but made very fast, and covered very close, that they chance not to fire before they should; then upon the ledges *R E. F G. H I.* and *A D* may be placed your soucisons, and behinde all the vvork may be set your Boxes of Rockets, in each of vvhich you may place 6, 9, 12. or 20 small Rockets: Novv give fire at *A.* (by help of a piece of primer going from one Lance to another) all the Lances vvill instantly at once be lighted, and as soone as the Lance at *A* is consumed, it vvill fire the Channell vvhich is made in the ledge of the frame vvhich runnes under the Pots of fire, and as the fire goes along burning, the Pots vvill be cast forth, and so the rank of Pots upon the sides of the frame *A B. B C* and *C D.* being spent, the soucisons vvill begin to play being fiered also by a Channel vvhich runnes under them, upon the


B
C
R
E
F
G
A
D
K

the ledges *A D*, *H I*, *F G*, and *R E*. then when the *Soucisons* are ſpent upon the laſt ledge *R E*. there may be a ſecret Channel in the ledge *C D* which may fire the Box of Rockets at *K*. and may fire all the reſt one after another, which Boxes may be all charged with ſeverall Fire-Workes: for the Rockets of the firſt Box may be loaden with Serpents, the ſecond with Stars, the third with Reports, the fourth with Golden raine, and the fifth with ſmall flying Serpents; theſe mounting one after another and flying to and fro will much inlighten the Aire 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 beautifull formes, ſome like the branching of Trees, others like fountaines of water gliding in the Aire, others like flaſhes of lightning, others like the glittering of ſtarres, giving great contentment, and delight to thoſe which behold them; But if the worke be furniſhed alſo with *Balons* (which is the chiefeſt in recreative Fire-works) then ſhall you ſee aſcending in the Aire but as it were onely a quill of fire, but once the *Balon* taking fire, the Aire will ſeeme 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 Aire and Firmament with their rebounding clamour.

The

The making of which with many other rare and excellent Fire-workes, and other practiſes, not onely for recreation, but alſo for ſervice: you may finde in a book intituled *Artificiall Fire-workes*, made by Mr. *Malthas* (a maſter of his knowledge) and are to be ſold by *VVilliam Leake*, at the Crowne in Fleet-ſtreet, between the two Temple-Gates.

Concluſion.

In this Booke we have nothing omitted what was materiall in the originall, but have abundantly augmented it in ſundry experiments: And though the examinations are not ſo full, and manifold; yet (by way of brevitie) we have expreſſed fully their ſubſtance, to avoid prolixitie, and ſo paſt by things reiterated.

FINIS.

Printed or sold by *William Leak*, at the Crowne in Fleetstreet neere the Temple, *these Books following*.

York's Heraldry, Folio
A Bible of a very fair large Roman letter, 40
Orlando Furioso Folio.
Callis learned Readings on the Stat. 21. *Hen.* 8o. Cap 5 of Sewers
Perkins on the Laws of *England*.
Wilkinsons Office of Sheriffs.
Vade Mecum, of a Justice of Peace.
The book of Fees.
Peasons Law.
Mirrour of Justice.
Topicks in the Laws of *England*.
Sken de significatione Verborum.
Delaman's use of the Horizontal Quadrant.
Wilby's 2d set of Musique, 3 4 5 and 6 Parts.
Corderius in English.
Doctor *Fulk's* Meteors.
Malthus Fire-workes.
Nyes Gunnery & Fire-workes
Cato Major with Annotations, by *Wil. Austin* Esquire.
Mel Helliconium, by *Alex. Rosse*.
Nosce teipsum, by Sr *John Davis*
Animadversions on *Lillies* Grammer.
The History of *Vienna*, & Paris
Lazarillo de Tormes.
Hero and *Leander*, by *G. Chapman* and *Christoph. Marlow*.
Alcilia or *Philotas* loving folly.
Bishop *Andrews* Sermons.
Adams on *Peter*.
Posing of the Accidence.
Amadis de Gaule.
Guillieliam's Heraldry.

Herberts Travels.
Baccas Tales.
Man become guilty, by *John Francis Senalt*, and Englished by *Henry* Earl of Monmouth.
The Ideot in 4 books; the first and second of Wisdom; the third of the Mind; the fourth of Statick Experiments of the Ballance.
The life and Reign of *Hen.* the Eighth, written by the L. *Herbet*
Cornwallis Essays, & Paradoxes.
Clenards greek Grammar 8o
Aula lucis, or the house of light: A discourse written in the year 1651, by *S N.* a modern Speculator.
A Tragedy written by the most learned *Hugo Grotius* called, *Christus Patiense*, and translated into Engl. by *George Sands*
The Mount of Olives: or Sollitary Devotions, by *Henry Vaughan Silurist* VVith an excellent discourse of Man in glory, written by the Reverend *Anselm* Arch Bishop of Canterbury.
The Fort Royall of Holy Scriptures by *I. H.*

PLAYES.

Hen. the Fourth. *Philaster*.
The wedding. The Hollander.
Maids Tragedie. King & no K.
The gratefull Servant.
The strange Discovery.
Othello; the Moor of *Venice*.
The Merchant of *Venice*.

THE DESCRIPTION AND USE OF THE DOVBLE Horizontall Dyall.

WHEREBY NOT ONELY THE Houre of the Day is ſhewn; but alſo the *Meridian Line* is found:

And moſt ASTRONOMICALL Queſtions, which may be done by the GLOBE: are reſolved.

INVENTED AND WRITTEN BY W. O.

Whereunto is added, The Deſcription of the generall HOROLOGICALL RING.

LONDON,
Printed for WILLIAM LEAKE, and are to be ſold at his Shop at the ſigne of the *Crown* in *Fleetſtreet*, between the two *Temple* Gates. 1652.

The deſcription, and uſe of the double *Horizontall Diall.*

THere are upon the Plate two ſeverall **Dyals.** That which is outermoſt, is an ordinary diall,divided into houres and quarters,and every quarter into three parts which are five minutes a piece : ſo that the whole houre is underſtood to contein 60 minutes. And for this dyall the ſhadow of the upper oblique, or ſlanting edge of the ſtyle, or cocke, doth ſerve.

The other diall,which is within, is the *projection of the upper Hemiſphare, upon the plain of the Horizon : the Horizon* it ſelf is underſtood to be the innermoſt circle of the limbe : and is divided on both ſides from the points of *Eaſt* and *Weſt* into degrees, noted with 10.20.30, &c. As far as need requireth : And the center of the Inſtrument is the *Zenith,* or *Verticall point.*

Within the *Horizon* the middle ſtraightline 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 *houre lines*, diſtinguiſhed accordingly by their figures : and are divided into quarters by the ſmaller lines drawn between them : every quarter conteining 15 minutes.

The two arches which croſſe the houre lines, meeting on both ſides in the points of interſection of the ſixe a clocke lines with the Horizon, are the two ſemicircles of the *Ecliptick* or annuall circle of the ſun : the upper of which archesſerveth for the *Summer* halfe yeere ; and the lower for the *Winter* half yeer : and therefore divided into 365 dayes : which are alſo diſtinguiſhed into twelve moneths with longer lines,having their names ſet down : and into tenths and fifts with ſhorter lines : and

and the rest of the dayes with pricks as may plainly be seene in the diall.

And this is for the ready finding out of the *place of the Sun every day*: and also for the shewing of the *Suns yeerely motion*, because by this motion the Sun goeth round about the heavens in the compasse of a yeer, 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 diall, and is therefore called the *Vernall intersection*. Then the *Summer* in that quarter of the *Ecliptick* which begin at the *intersection with the Meridian* in the highest point next the *Zenith*. After that, *Autumne* in that quarter of the *Ecliptick* which beginneth at the *intersection* on the *West* side of the diall, and is therefore called the *Autumnall 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 desides this *yeerely motion, the Sun* hath a *diurnall*, or *daily motion*, whereby it maketh day and night, with all the diversities and inæqualities thereof: which is expressed by those other *circles drawn crosse the houre lines*; the middlemost whereof, being grosser then the rest, meeting with the *Ecliptick* in the points of the *Vernall*, and *Autumnall intersections*, is the *Equinoctiall*: and the rest on both sides of it are called the parallels, *or diurnall arch of the Sun*, the two outermost whereof are the *Tropicks*, because in them the sun hath his furthest *digression* or *Declination* from the *Æquinoctiall*, which is degrees 23½: and thence beginneth againe to return towards the *Equinoctiall*. The upper of the two *Tropicks* in this nor Northerne *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 *Capricorne* ; and the sun being in it, is lowest into the *South*, making the shortest day of winter.

Between the two *Tropicks* and the *Æquinoctiall* , infinite such *parallel circles* are understood to be conteined : for the sun, in what point soever of the *Ecliptick* it is carried, describeth by his *Lation* a circle parallel to the *Æquinoctiall* : 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 yeere in the *Ecliptick* , a proper circle which may be the diurnall *arch of the sun* for that day. For upon the right estimation of that imaginary parallel doth the manifold use of this instument 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 minde thereof , every fift *parallel* is herein made a little grosser then the rest.

For this inner diall 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 yeere both for his annuall and diurnall motion* , may be the first use of this instrument.

II Use. To finde the *declination of the sun* every day.

Looke the day of the moneth proposed in the *Ecliptick*, and mark how many degrees the prick shewing that day, is distant from the *Equinoctiall*, either on the Summer or Winter side, *viz.* North or South.

Example

Example 1. What will the *Declination* of the sun be upon the eleventh day of *August*? look the eleventh day of *August* and you shall finde it in the sixth circle above the *Equinoctiall*: 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 finde it betweene the second and third northern parallels, as it were an half and one fift part of that distance from the second: Reckon therefore four degrees for the two circles; and one degree for the halfe space: So shall the Suns declination be five degrees, and about one fift 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 finde it below the *Equinoctiall* ten parallels, and about one quarter which is 20 degrees and an halfe southward. So much is the declination. And according to these examples judge of all the rest.

III. Use. *To finde the diurnall 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 *Equinoctiall*, which is either one of the circles in the diall, or some-where between two of them. First, therefore seek the day of the moneth; and if it fall upon one of those parallels; that is the circle of the suns course that same day: But if it fall betweene any two of the parallels, imagine in your minde, and estimate with your eye, another parallel through that point betweene 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 11 of August, shal be the very sixt circle above the *Equinoctiall* toward the center.

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 November : shall be an imaginary circle between the tenth and eleventh parallels below the *Equinoctiall*, still keeping one quarter of that space from the tenth.

IIII Use. *To finde 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 marke 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 houre lines which are on both sides of it, by proportioning the distance reasonably, according to 15 minutes for the quarter of the houre, will shew the houre of the suns rising on the *East* side, and the suns setting on the *West* side.

V Use. To know the reason and manner of the *Increasing* and *decreasing* of the *dayes and nights* throughout the whole yeere.

When the Sun is in the *Equinoctiall*, it riseth and setteth at 6 a clock, for in the instrument the intersection of the *Equinoctiall*, and the *Ecliptick* with the *Horizon* is in the six a clocke 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

before 6 in the morning, and after 6 in the evening: and the *Diurnall arch* greater then 12 houres; and so much more great, the greater the Northerne Declination is. Againe, 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 *Diurnall arch* lesser then 12 houres; and by so much lesser, the greater the Southerne 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 *Equinoctiall* changing the declination, but little altered. As for example, when the sun is neer unto the *Equinoctiall* on both sides, the dayes increase and also decrease suddenly and apace; because in those places the *Ecliptick* inclineth to the *Equinoctiall* in a manner like a streight line, making sensible declination. Again, when the sun is neere his greatest declination, as in the height of Summer, and the depth of Winter, the dayes keep for a good time, as it were, at one stay, because in these places the *Ecliptick* is in a manner parallel to the *Equinoctiall*, the length of the day also is but little, scarce altering the declination: And because in those two times of the yeer, 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 neerer every place is to the *Equinoctiall*, the greater is the diversity of dayes.

Wherefore, we may hereby plainly see that the common received opinion, that in every moneth the dayes doe equally increase, is erroneous.

Also we may see that in parallels equally distant from the *Equinoctiall*, the day on the one side is equall to the night on the other side.

VI. Vse. *To finde 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 III *Vse*) the imaginary 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.*

VII Use. *To finde the length of every day and night.*

Double the houre of the sunnes setting, and you shal have the length of the day; & double the hour of the sunnes rising, and you shal have the length of the night.

VIII Vse. *To finde the true place of the sun upon the dyall, that is, the point of the instrument which answereth to the place of the sun in the heavens at any time, which is the very ground of all the questions following.*

If the dyall be fixed upon a post: Look what a clock it is by the outward dyall, that is, look what houre and part of houre the shadow of the slanting edge of the style sheweth in the outward limbe. Then behold the shadow of the upright edge, and marke what point thereof is upon that very houre and part in the inner dyall among the parallels, that point is the true place of the Sunne at the same instant.

If the dyal be not fixed, and you have a *Meridian line* noted in any window where the Sunne shineth: place the *Meridian* of your dyal upon the *Meridian* line given, so that the top of the stile may point into the north: and so the dyal is as it were fixed, wherefore by the former rule you may finde the place of the Sunne upon it.

If the dyal be not fixed, neither you have a Meridian line, but you know the true houre of the day exactly: hold the dyal even and parallel to the Horizon, moving

it

it till the ſlanting edge of the ſtile caſt his ſhadow juſtly upon the time or houre given; for then the dyal is truly placed, as upon a poſt. Seek therefore what point of the upright ſhadow falleth upon that very houre, 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 moneth in the Ecliptique, finde the ſuns parallel, or diurnall arch for that day, then holding the dyal level to the horizon, move it every way untill the ſlanting ſhadow of the ſtyle in the outward limbe, and the upright ſhadow in the Sunnes diurnal arch, both ſhew the very ſame houre and minute, for that very point of the Sunnes 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 thicknes of the ſtyle, and the bluntneſſe of the angle of the upright edge, the Sun cannot come unto that edge for ſome ſpace before and after noone. And ſo during the time that the Sunne ſhineth not on that upright edge, the place of the Sunne in the dyal cannot be found. Wherefore they that make this kinde of double dyal, are to be careful to file the upright edge of the ſtyle as thinne and ſharpe as poſſible may be.

That which hath here bin taught concerning the finding out the Suns true place in the dyal, ought perfectly to be underſtood, that it may be readily, and dexteriouſly practiſed, for upon the true performance thereof dependeth all that followeth.

IX Vſe. *To finde the houre of the day.*

If the dyal be faſtned upon a poſt, the houre by the outward dyal, or limbe, is known of every one, and the

upright

upright shadow in the Suns parallel, or diurnal arch will also shew the very same houre.

But if the dyall 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 untill the houre shewed in both dialls exactly agreeth, or which is all one, finde out the true place of the Sun upon the dyall, as was taught in the former question, for that point among the houre lines sheweth the houre of the day.

X Vse. *To finde out the Meridian, and other points of the Compasse.*

First, you must seek the true houre of the day (by the last question) for in that situation the Meridian of the dyall 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 compasse.

XI Vse. *To finde out the Azumith of the sun, that is, the distance of the Verticall circle, in which the sun is at that present, from the Meridian.*

Set your diall 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 streight line, till it cutteth the *horizon*: for the degree in which the point of intersection is, shal shew how far the suns *Azumith* is distant from the east and west points, and the complement thereof unto 90; shal give the distance thereof from the meridian.

XII Vse. *To finde 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

Take a board having one ſtreight edg, & a line ſtricken perpendicular upon it; apply the ſtreight edg 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, untill 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 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 finde out the declination of a wall, if the dial be fixed on a poſt not very far from that wall; in this manner. Your board being applyed to the wall, as was ſhewed, hang up a thred with a plummet, ſo that the ſhadow of the thred may upon the board croſſe the perpendicular line: make two pricks in the ſhadow and run inſtantly to the dyal and look the horizontal diſtance of the ſuns Azumith, 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 ſhal from the line through the two pricks meaſure the Horizontal diſtance of the upright ſhadow, or Azumith from the meridian, that way toward which the Meridian is: draw

a line

a line out of the center, to the end of that arch measured: and the angle which this last line maketh with the perpendicular, shall be equall to the declination of the wall.

XIII Vse. *How to place the dyall upon a post without any other direction but it selfe.*

Set the diall upon the post, with the stile into the North, as neere as you can guesse: then move it this way and that way, till the same houre and minute be shewed, both in the outward and inward dials by the severall shadowes, as hath been already taught, for then the diall standeth in its truest situation; wherefore let it be nailed down in that very place.

XIIII Vse. *To finde the height of the sun at high noon every day.*

Seeke out the diurnall Arch or parallel of the suns course for that day, (by *Vse III.*) and with a paire of Compasses, setting one foot in the center, 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 shal therein shew the degree of of the Suns altitude above the the Horizon that day at high noon.

XV *Vse. To finde the height of the sun at any houre or time of the day.*

Seeke out the diurnal Arch, or parallel of the suns course for that day: and marke what point of it is in the very houre and minute proposed. And with a paire of Compasses, setting one foot in the Center, 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

And by this meanes you may finde the height of the Sun above the Horizon at every houre throughout the whole yeere, for the making of rings and cylinders and other instruments which are used to shew the houre of the day.

XVI Vse. *The height of the sun being given, to finde out the houre, or what it is a clocke.*

This is the converse of the former: Seeke therefore in the Semidiameter divided, the height of the sun given. And with a paire of Compasses, setting one foot in the center, and the other at that height, apply the same distance unto the diurnall arch, or parallel of the Sun for that day: for that point of the diurnall arch, upon which that same distance lights, is the true place of the sun upon the dial; and sheweth among the houre lines, the true time of the day.

XVII Use. *Considerations for the use of the instrument in the night.*

In such questions as concerne the night, or the time before sun rising, and after sun setting, the instrument representeth the lower Hemisphære, wherein the *Southerne* pole is elevated. And therefore the parallels which are above the Æquinoctiall toward the center, shall be for the *Southerne*, or winter parallels: and those beneath the Æquinoctiall, for the Northerne 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 Hemisphære.

XVIII Use. *To finde how many degrees the sun is under the Horizon at any time of the night.*

Seeke the Declination of the sun for the day proposed (by *Vse II.*) And 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 houre aud minute proposed: And with a pair of compasses, setting one foot in the center, 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.

XIX Use. *To finde out the length of the Crepusculum, or twylight, every day.*

Seek the declination of the sun for the day proposed (by *Vse II.*) And at the same declination on the contrary side imagine a parallel for the sun that night. And with a paire of compasses setting one foot in the center, and the other at 72 degrees upon the semidiameter divided, apply that same distance, unto the suns nocturnall parallel: for that point of the parallel, upon which that same distance shall light, sheweth among the houre lines, the beginning of the twilight in the morning, or the end of the twilight in the evening.

XX Use. *If the day of the moneth be not known, to finde it out by the dyall.*

For the working of this question, either the diall 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 diall to be justly set either upon the post, or upon the Meridian, Look what a clock it is by the outward diall, and observe what point of the upright shadow falleth upon the very same minute in the inner diall, 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 moneth.

Of

1 *The description of it.*

THis Instrument serveth as a Diall to finde the houre of the day, not in one place onely (as the most part of Dials do) but generally in all Countreys lying North of the *Æquinoctiall*: and therefore I call it the generall 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 *Æquinoctiall*, having in the midst of the inner side or thicknesse, a line round it, which is the true *Æquinoctiall* circle, divided into twice twelue 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 *Æquinoctiall* is hung, is divided into ninety 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 *Equinoctiall*, having his due position. The diameter is broad, and slit in the middle: and about the slit on both sides are the moneths and dayes of the yeer. 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 dayes of the yeer, representeth the *Axis* of the world.

The

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, First, 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.

Secondly, the hole of the sliding plate within the slit, must be brought exactly unto the day of the moneth.

Thirdly, the *Æquinoctiall* is to be drawn out, and by means of the two studs in the *Meridian* staying it, it is to be set perpendicular thereto.

Fourthly, Guesse as neer as you can at the houre, 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 *Æquinoctiall*: for there shall be the houre of the day: And the *Meridan* of the Instrument shall hang directly *North* and *South.*

These Instrumentall Dials are made in brasse by Elias Allen *dwelling over against* St. Clements *Church without Temple Barre, at the signe of the* Horse-shooe *neere* Essex *Gate.*

FINIS.