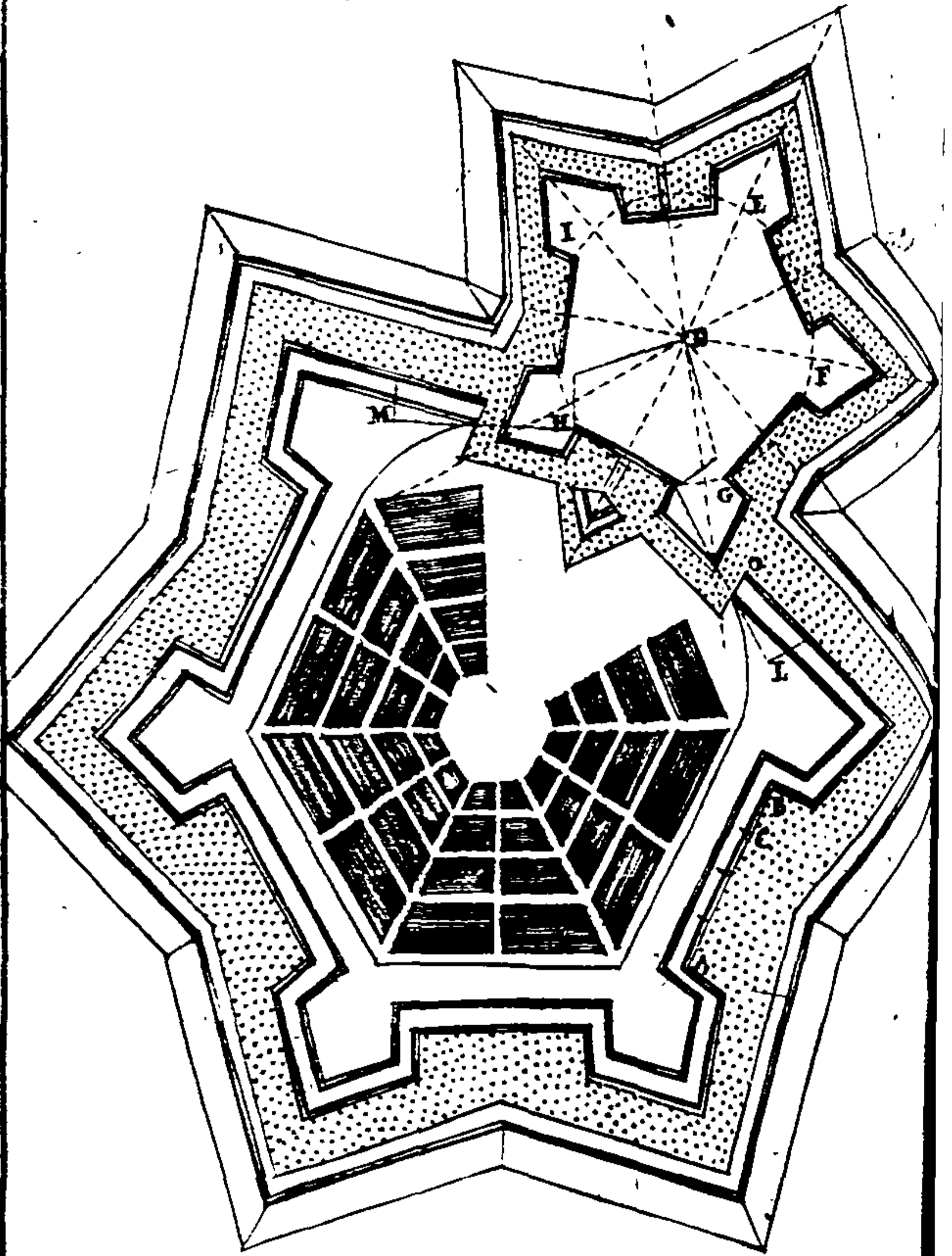


opposite Front A H the Line G F, to the inside of the *Bastion* observing where it cuts C D, as in I, purposely to carry on one fathom from I to L, afterwards draw the Line M L N parallel to F I, the length of which from M to N, must be 11 fathom; That done, make N O parallel to the flank B F, the length of which from N to O must be 4 fathom. Lastly, make O P parallel to F I, and then all the void space B M N O P C shall be the extent of the *Cazemates*, as well of the large *Cazemates*, as those which are more private.

To make the *Shoulder* or *Ear* of the *Bastion*, draw upon the Line of Defence P S 6 fathom from E to I, and upon F G 6 fathom; also from F to V, then joining V and T together, you have the whole *Shoulder* or *Ear* F V T E which must be all one solid piece. For the *Paropet*, of the first *Cazemate*, you must allow within side one *Toise* of height from 3 to 4 in thicknets, with 8 *firing Places* for the planting of so many great *Guns*, observing that the *Paropets* of the *Cazemates*, more especially all that which

Platz II



is next to the *Gorge*, and lies always hid from the *Besiegers*, do not require a length and thickness so precise.

A *Ravelin* is a Bulk of Earth almost like a *Bulwark*, cut off, lying beyond the *Ditch* for the covering of the *Curtain*, *Bridge* or *Gate*, and is surrounded with *Water*, and separated from the *Fortification* by the breadth of the *whole Ditch*; it is raised but a little height above the level of the *Ground*; towards the *Enemy* 'tis built with a *Rampier* and *Breast-work*, but lies open towards the *Fortification*.

PLATE II.

The Raising of Cittadels with five Bastions, which are built upon the Walls of Cities.

WHEN Cities are well peopled, and that the nature of the *Ground* will suffer it, 'tis usual to lay the *Cittadels* towards the *open Field*, to

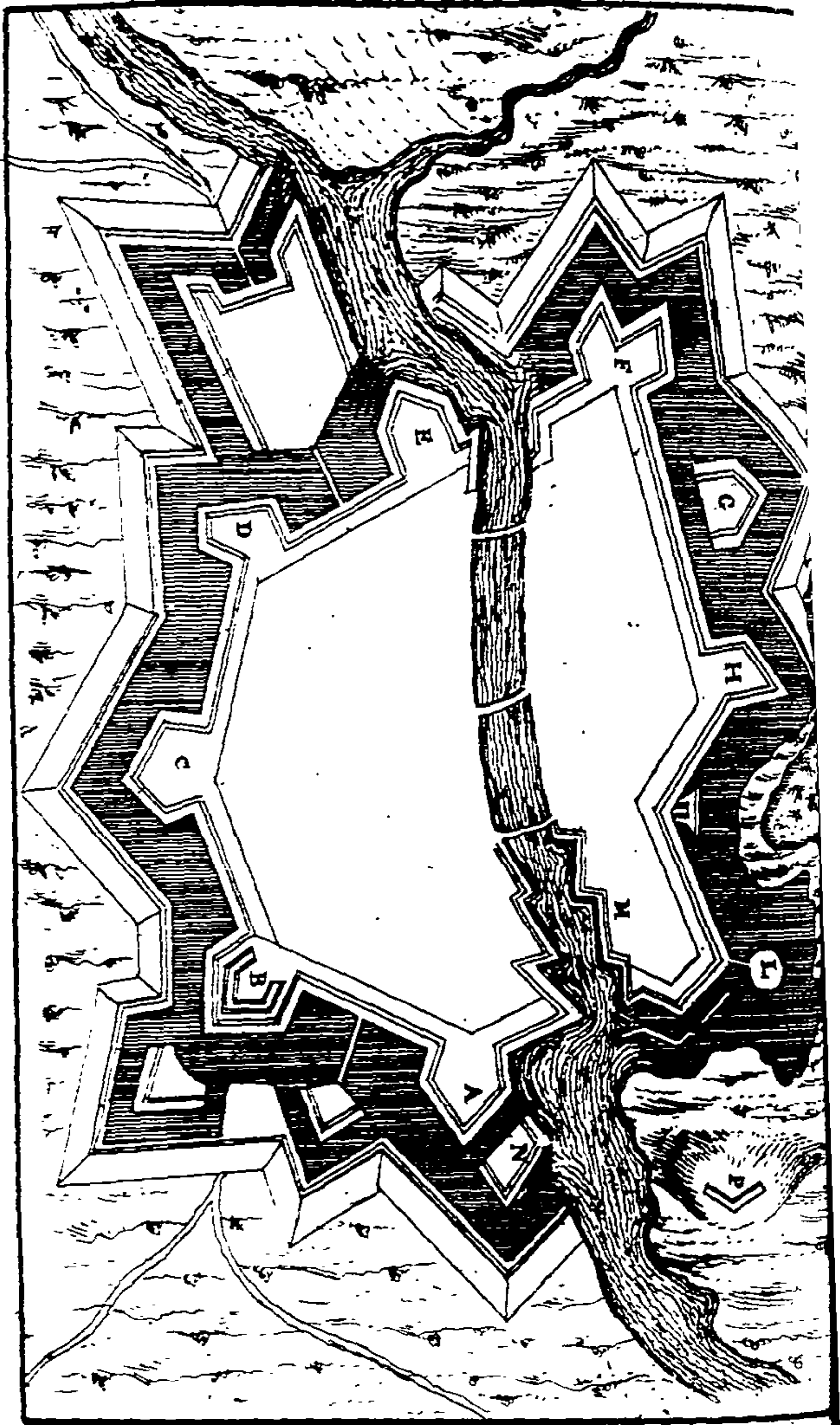
prevent the ruining of the *Buildings* of the place; so then after you have agreed upon the number of *Bastions*, as here for Example upon five to make a *Pentagon*.

Divide one *Courtain* of the City A B, into 4 equal parts, of which A C comprehends three. This *Overture* being designed at the Point of the bastion D, draw the *Circumference* E F H G F that you may have the five sides of the *Polygon* E I I H H G G F, and F E putting the Point E directly where the *Circumference* cuts the *Center-line* of the place, which passes through the Point D. This will produce two *Bastions* on the City side, and three towards the *open Field*.

This *Cittadel* will be finished after the *Ramperts*, *Paropets*, *Motes*, *Covert-ways*, and their *sloping Paropets* are compleated, as also a *Ravelin* just before the Gate.

OBSERVATION.

Remember that you are always to throw down the Defences of the City on the *City side*, to the end that if the inhabitants should happen to *revolt*, or the
Enemy



Enemy to become Masters of it, they may not be able to make *any advantage* of their own *Fortifications*, especially the flanks L and M, which must be ruin'd, continuing their Faces in a *Right Line*, and sloping down the *Ramperts* to the Mote of the Cittadel, to the end she may be able to command the whole City.

Observe moreover, That there may be a *great space* between the Mote of the Cittadel, and the Houses of the City; for this space is of *great importance* to prevent any designs which the *Citizens* may have upon the *Cittadel*, as not able to approach undiscovered, or *without entrenching* themselves.

PLATE III.

Of Irregular Fortifications.

SINCE most Cities are of an irregular Figure, 'tis evident, *what great use*, or rather *necessity*, there is of this part.

part. I shall comprehend all the matter briefly, but plainly in the following *Heads*.

First, Such *Figures* as have not their Sides and Angles equal to one another, are called Irregular.

Now forasmuch as the Forms of Towns are so various and subject to so many Cases, their *Fortification* cannot be comprehended under certain Rules, neither can the Principles of *Regular Fortification* be exactly observed here; It is therefore requisite that the *Engineer* make a Map or Draught of the whole, with all the *ways, Passages, Rivers, Pools, Enclosures*, and all other *matters* fit to be known, and then consider what Designs and Works he shall think most fit and proper for the place. To this end let him know,

1. The same Laws and Maxims for Regular Fortifications, stand and be in force, as for the *Irregular*; and that the nearer an *Irregular Figure* comes to a Regular, the *stronger* and *better* it is.

2. That none of the *inward Angles* of his *Figure* be less than 90 degrees; if less, then

then they must be changed by making the *Point*, the outward *Point* of a Bastion.

3. That the Angles of the Bastion be not less than 60 degrees.

4. That the Line of Defence, or side of an *Irregular Figure*, must not be more than *Musquet-shot*.

5. The Sides of an *Irregular Figure*, which is too long for two Bastions, and too short for three, may be fortified with two great *Bulwarks*.

6. When the side is above 70 Rod, there may be a Ravelin erected between the two Bulwarks, or a flat Bulwark built between.

7. When an Angle of the Figure is between 80 or 90 degrees, it ought to be fortified with a *Horn-work*.

8. All the differences between *Regular* and *Irregular Fortifications*, consists in the rectifying the *Sides* that are too short or too long, and altering the Angles that are too little, by cutting off from the length, what is too much, or adding to it, what is necessary, to make them in their *just* and *true proportions*, as in the *Regular*.

More

More Rules might be given, but there being so *much variety* in this sort of *Fortifications*, the Engineer must practise by himself, by drawing several *Plats* of *Irregular Places*, and fortifie them. And he should also peruse all the Books he can get of this Subject, as *Marolos*, *F. Bach*, *Dogen*, *Dilichius*, *Travax de Mars*, &c. where he will find variety of *Examples* which will help to inform his Fancy, and rectifie his Judgment.

For the Raising the *Ramparts*, *Parapets* and other *Works*, you must observe the same *Rules*, and proceed in the same *Method* as in *Regular*, and no otherwise.

A Is a *Regular Bastion*, and here I shall give one *Rule* to find the *Capital Line* in all irregular Angles, *viz.* At the end of each *Courtain*, as at e d, cross an Arch at c and f, and draw the line c a, which shall be the *Capital Line*, which may be about 243 Feet, a little more or less, and the *Gorges* may be one hundred forty five or 150, Feet, or thereabouts.

B. Is a *double Bastion*, that is, upon the Plane of the great *Bastion*, another *Bast.* is built up it higher: This hath the use of a *Cavalier*,
and

and overlooks the *Campagne*; there may be about 12 or 18 feet left between the *Paropet* of the *lower Bastion*, and the foot of the *higher Bastion*.

C. Is a *Bastion composed*, that is, when the two *interior Polygons* are much unequal, then the *Gorges* will be unequal.

D. Is a *Bastion deformed*, that is, if one of the *interior Polygons* be so short that it can have no *Demigorge*.

E. Is a *Plat Bastion*, that is, if the distance from the Points of the *interior Polygon* be double to the usual length.

F. Is a *forked Bastion*, cut off with a *Tenaile*, that is, if the Angle of the Figure be less than 90 degrees; and because of *water*, or some other *Accident*, it cannot be *changed*, then you may cut off the Angle, and joyn it with a *Tenaile*.

G. Is a *Bastion cut off*, that is, separated from the *Rampire*, so that its *Gorges* are in a *Right Line* with the two Points of the flanks H F.

H. Is a *Demi Bastion*, that is, such as have their *Gorge* and *Capital* equal, and its flank half of the *Gorge*.

I. Is a *Platform* upon an *inward Angle*,
for

for the placing of *great Guns* to scour the *Ditch*.

L. Is a *Mount upon Files* for a *Corps de Guard*, with a *Paropet*, like that of the *Outworks*, *Cannon-proof*, necessary to hinder the *Under-surprises* when the *Mote* is frozen.

M. Is an *indented Line*, often used upon the *Bank* of the *Counter-scarp*, or upon a *River*.

N. Is a *Counter-Guard*, or *Demi-Bstion*, built in some watry place before the main *Bastion*.

O. Is a *Scillen*, or a *Tenail* with a *Breast-work* placed in the *Mote*, called also a *Counter-guard*.

P. Is a *Bonnet*, that is, an advanced *Work*, like a *Ravelin*, sometimes placed on high *Ground*, sometimes on low.

Plate IV.

For the Constitution and Ground-lines of a Fortification, some things ought to be known for given; The things here, said to be given, are those *Data's*, which a skilful or experienced Engineer knows to agree best with the *Rules* or *Maxims* before mentioned; and from these *Data's* once ordered, the rest of the Parts, in proportion, follow sure and determined, according to the Reason of things given; for which use the Two following Tables are made, by which may be laid down any *Fortification* required: The proportion of the *Lines*, serving for any *forms*, the quantity only for the *Royal*; the *Numbers* are *Rhynland Rods*, and *Centesmes* of a Rod of 12 Feet.

First

	Semi-diameter.		Polygon Inter.		Gorge.		Capital.		Flank.		Second Flank.		Courin.		Face.	
IV	42	76	60	57	12	24	15	83	7	74	08	94	36	00	24	00
V	52	34	61	54	12	77	17	33	9	09	13	10	36	00	24	00
VI	62	39	62	39	13	19	18	71	10	07	14	02	36	00	24	00
VII	72	68	63	07	13	53	20	03	10	83	13	89	36	00	24	00
VIII	83	15	63	64	13	82	21	29	11	44	13	27	36	00	24	00
IX	83	70	64	10	14	05	22	99	11	61	12	41	36	00	24	00
X	103	38	63	89	13	94	24	07	12	00	12	41	36	00	24	00
XI	114	14	64	33	14	16	24	49	12	00	14	02	36	00	24	00
XII	124	77	64	39	14	29	24	85	12	00	14	22	36	00	24	00

Second Table for the Lines.

	Semi-diameter.		Polygon Inter.		Gorge.		Capital.		Flank.		Second Flank.		Courin.		Face.	
V	38	14	53	94	8	9	20	01	8	00	06	14	36	00	24	00
V	48	8	56	53	10	26	21	03	9	00	10	58	36	00	24	00
VI	59	19	58	19	11	8	22	15	0	00	11	86	36	00	24	00
VII	68	47	59	42	11	71	23	31	11	00	12	03	36	00	24	00
VIII	78	60	60	31	12	16	24	48	12	00	11	67	36	00	24	00
IX	90	31	61	77	12	89	24	64	12	00	12	95	36	00	24	00
X	101	84	62	94	13	47	24	66	12	00	13	90	36	00	24	00
XI	113	38	63	90	13	95	24	76	12	00	14	63	36	00	24	00
XII	124	77	62	59	14	29	24	85	12	00	15	22	36	00	24	00

(145)

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For the Angles first Table.

	Angle of the Centre.			Angle of the Figure.			Angle of the Bulmarks.			Angle C F A			Angle A C F		
IV	90			98			65			12		30	77		30
V	72			108			72			17		00	73		
VI	60			120			80			20		00	70		
VII	51	25	43	128	34	37	84	17	03	22	8	34	67	51	26
VIII	45			135			87		30	23	45		66	15	
IX	40			140			90		00	25			65		
X	36			144			90		00	27			63		
XI	32	13	38	147	16	22	90		00	28	18	11	61	12	12
XII	30			150			90		00	30			60		

For the Angles second Table.

	Angle of the Centre.			Angle of the Figure.			Angle of the Bulmark.			Angle C F A			Angle A C F		
IV	90			90			60			15			75		00
V	72			108			69			19		30	70		30
VI	60			120			75			22		30	67		30
VII	51	25	43	128	34	17	79	17	09	24	38	34	65	21	26
VIII	45			135			82		30	26		15	63		45
IX	40			140			85			27		30	62		30
X	36			144			87			28		30	61		30
XI	32	43	38	147	16	22	88	28	11	28	18	11	60	12	12

How to Delineate any Fort, according to the Proportions in these Tables.

1. To make a *Square Figure*, a *Pentagon*, *Hexagon*, *Heptagon*, &c. Having no *Scale* or *Sector*, then you may make a *Scale* large or small, as you design to make your *Polygon*; dividing it into ten equal Parts, and every 10th. into ten, then the *Scale* will be divided into 100 equal parts, then supposing each part subdivided into 10, so the *Scale* will be 1000. *Plate 4. Fig. 1.*

2. To delineate a great *Royal*, according to the proportions in the first *Table*, take out of that *Table* the *Semidiameter*, or *Radius*, of that *Polygon*, which you intend to draw; (for Example, an *Hexagon*;) which is in the *Table*, 62. 39. that is, 62 *Rods*, 3 *Foot*, and 9 *tenths* of a *Foot*, or 62 *Rods*, and 39 *Centesmes* of a *Rod*, which take off from the *Scale*, and describe a *Circle*, as 1, 2, 3, 4, 5, 6. as in *Fig. 2. Plate the 4th.*

3. Take off the *Scale* the length of the interior *Polygon*, 62. 39. or side of the
Figure,

Figure, which the *Table* shews that distance, apply it to the *Circumference*, 4, 5, 6, 7, 8 or 9 times, as the *Polygon* is that you intend to draw, which is 6 times in the *Hexagon*; draw the blind lines from the *Centre*, and through the several *Divisions* 1, 2, 3, 4, 5, 6, and Line from 1 to 2, and from 2 to 3, and from 3 to 4, and from 4 to 5, and from 5 to 6.

4. Take off from the *Scale*, the *Capital Line*, 18. 73. as in the *Table*, and set it off at all the *Angles* of the *Ground-Plot*, viz. from 1 to 2, and from 2 to 3, &c.

5. Take the length of the *Gorge*, 13. 79. from the *Table* upon your *Scale*, and set it off from 1 to 7, and from 6 to 7; and on the two *points* 7 and 7, raise perpendicular *Lines*, as 7, 8. and 7, 8.

6. Take off from the *Table*, the length of the *Flank*, viz. 10. 07. upon your *Scale*, and set it off from 7 to 8.

7: Draw the *Face* from the uppermost
 L 2 part

part of the *Capital Line* d. to the uttermost part of the *Flank* 8. and so for the rest of the *Lines*, they are easily set off, and transferred from these, and so the Draught is finished.

Thus you may by these *Tables*, with a *Scale* of equal parts, delineate any regular *Figure*, two several ways, according to the first or second *Table*, and by the *Rule of Three*; these *Tables* may serve for any Proportions.

But these *Data's* may be varied without prejudice to the Maxims of *Fortification*, and the Constitution of the *Ground-lines* will be various, according to the Experience and Opinions of several *Engeniers*: Therefore I shall shew the Constitution, and making the principal *Ground-lines* of any *Fortification*, in several ways, used by other more famous and modern Authors.

And First, of the *Dutch* or *German* ways, who, although they have filled the World full of Books, of several ways
of

of *Fortification*, yet *Maralois*, *Fritach*, *Goldman*, and *Dogen*, all agree, to make the *Courtain* 36 *Perches*, or 432 *Rhinland feet*; the *Face* 24 *Perches* or 288 of the afore-said *Feet*, so that the proportion of the *Courtain*, to the *Face*, is as 3 to 2 the *Angle* forming the *Flank*, is always 40 *Degrees*; the *Angle* of the *Bulwark* is half the *Angle* of the *Figure*, increased with 15 *Degrees*; *Goldman*, *Maralois*, and *Fritach*, agree in the *Angle* of the *Bulwark*; but *Dogen* makes the *Angle* of the *Bulwark*, equal to 4 of the *Angle* of the *Figure*; so that all the *Data's* are very near the same, with those the *Author* hath laid down before.

For *English Authors*, I shall only mention *Mr. Norwood*, who in his *Maxims* differs very little from our *Author*; the *Dutch Fortifications* being then most used. And *Sir Jonas Moor*, who was an able *Mathematician*, and well experienc'd in this *Art*; after he had shewed the several ways of all *Modern Engeniers*, saith, That the interior *Polygon* is most agreeable to *Practice*, being 1000. to take 333 *Feet*, for the *Capital* 200, for the *Gorge* and *Flank*, and 600 for the *Cour-*

tain, so that he agrees with *Manassen Mallet*, Author of *Travaux de Mars*; and, for a general Rule, take, saith he, $\frac{1}{3}$ of the interior *Polygon*, for the *Capital* $\frac{1}{5}$ of it, for the *Gorge* and *Flank*, where there is no second *Flank*, and where the *Flank* and *Capital* stand at *Right Angles*.

The Emperor, *Ferdinand III.* sets down (as *Schotus* that learned Jesuit saith) an Universal way to lay down the *Lines* of any *Fort*, viz. to divide the interior *Polygon* into 22 parts; of these, take 5 for the *Gorge*, 8 for the *Capital*, and 4 for the *Flank*; or supposing the *Polygon* to be divided into 1000, the *Capital* is 363, the *Gorge* 227, the *Flank* 181, this proportion is good, and for such as are not well skilled in *Trigonometry*, may very well be used.

Of the Italian Fortifications.

First, of Signior *Pietro Sardi*, who makes the interior *Polygon* 800 *Venetian Feet*, his *Gorges* and *Flanks* 150, and determines the *Face* of the *Bastion*, by the

L 3

Line

Line of Defence, raising which in a *Square* or *Pentagon*, falls upon the 10th. part of the *Courtain*; in a *Hexagon*, on the 4th. part; in a *Heptagon*, *Octagon*, *Enneagon*, on the 3d. part, in all above on the half, to lay this down: suppose an *Hexagon*, whose interior *Polygon* is 1000, then 187 will be the proportion for the *Gorges* and *Flanks* which prick off, from 4 to 7, and from 5 to 7, and raising a *Perpendicular* at 7, set off the same distance, from 7 to 8, for the *Flanks*; then for the *Face a. d.* divide the *Courtain* 7, 7, into 4 parts, and set off $\frac{1}{4}$ from 7 to *e.* then lay a *Ruler* from *e.* to *b.* and draw *a, b.* for the *Face*; but had it been *Square* or *Pentagon*, then 7 *c.* had been $\frac{1}{2}$ of the *Courtain*, if it had been an *Heptagon*, *Octagon*, *Enneagon*, then 7, *e.* had been $\frac{1}{3}$ of the *Courtain*, if above $\frac{1}{3}$ from the opposite *Flank.*

2. *Tensini*, in small Forts above the *Pentagon* makes the *Gorge* and *Flank* equal, and both a 7th. part of the *interior Polygon*, and the *Face* in all *Figures* one 3d. of the said *Polygon*. To draw this: Suppose a *Hexagon* whose *interior Polygon* 5, 6. is divided into 1000. the *Gorge* and *Flank* will be as in the *Table* 143. the 7th. part, which set off from 5 to 7. and from 6 to 7. and raising 7, 8. at *Right Angles*, set the same distance from 7 to 8. then take $\frac{1}{3}$ part of *p. p.* and setting one foot of the *Compasses* in 8. cross the *Capital Line* in *d.* and draw 8 *d.* which do to every *Bastion*, till all be finished.

Of the French Fortifications.

The chief of these are *M. de la Mont*, and *Manasson Mallet*, both these divide the *interior Polygon* into 5 parts, and take one for the *Gorge*, and also divide the *interior Polygon* into 3 parts, and take one for the *Capital Line*; only *De la Mont* takes 4 of the *Courtain* for the *Flank*,
and

and *M. Mallet* makes the *Angle* of the *Flank* and *Courtain* to be 98 degrees, (leaving no second *Flank*,) and so lays the *Courtain* more open for use, and yet not so much as to the subject it to ruine of the *Besiegers*.

I must not forget *D. Ville*, and *Fur-
neiers*, who divide the *interior Polygon* into 6 parts, one for the *Demigorge* and *Flank*, both being equal, and at *Right Angles*, if the *inferior Polygon* be 1000, the *Gorges* and *Flanks* will be 166.

By.

By this *Table* following may be laid down any *Fortification*, according to these *Authors*.

	Capit.	Gorge	Flank	Courtain
<i>Fritach.</i>	400	220	200	560
<i>Dogen.</i>	351	167	200	666
<i>Emperor.</i>	363	227	181	546
<i>P. Sardi.</i>		187	187	626
<i>Tensini.</i>		143	143	714
<i>G. Maris.</i>		135	138	750
<i>De la mont.</i>	333	200	150	600
<i>Manesson.</i>	333	200	200	600
<i>Fren. Conquest.</i>		200	240	600
<i>Furner, &c.</i>	228	166	166	666

In this *Table* you have the *Proportions* for the *Capital*, *Gorge*, *Flank*, and *Courtain*, supposing the length of the *interior Polygon* 1000. *English Feet*, according to these several *Authors*. But if the *interior Polygon* be less than a 1000, the *Proportion* in this and the former *Tables* may be reduced to any other *Polygon* required,

required, by multiplying the length given by any of those *Numbers*, and cutting of the 3 last places. *Example.* A *Polygon* given is 750, what shall be the length of the *Capital*, *Gorge*, *Flank*, and *Courtain*, according to any of the aforesaid Authors. For *Example*, to *De la Moire*, multiply 750 by 333, gives 249 Feet for the *Capital*, so for the *Gorge*, then multiply 750 by 200. and there is 150, for the *Gorge*, then multiply 750 by 150, and there will be 112 for the *Flank*; and after the same manner 450 for the *Courtain*. And thus you may proportion any of these Authors to any *interior Polygon*, which must not exceed 800, nor be less than 500, for if less, your *Fort* will be fit only for *Cittadels*, or *Field-works*, but if more than 800 Foot, too big for a *Fort-Royal*, and must be well stored with *great Guns*.

I shall mention only *Count Pagan's* way which was one much approved of here in *England*; he was indeed a great *Mathematician*, and well experienced by many *Campaignes* and *seiges*, he works
by

by the exterior Polygon, and his chief Proportions are in the following Table.

Exterior Polyg.	1200	1080	1000	960	820	720	600
the half.	600	540	500	480	410	360	300
Length of the Curtain.	425	364	334	30	375	234	164
	212½	182	167	152	137½	117	82
Length of the Per- pendicular.	} 180 180 180 180 150 144 138						
Length of the Face.	} 364 336 308 288 242 222 200						
Complem. of the Line of Defence	} 222 192 162 162 162 90						

To draw a Fort after this way, draw the exterior Polygon C. D. divide it into two equal parts at E. which suppose 600 each, and raise the Perpendicular E. L. upon which set off the length of the Perpendicular in the Table, videlicet. 180. which will terminate in the Point F. then from either Point D. and C. draw Lines to F. videlicet. C. F. and D. F. then look in the Table for the length of the Face, viz. 364. which set off from C. to I. and from D. to K. then (measure out the length of the Curtain, viz. 212½ from L. to H. and G.

or else) take out the Compl. of the *Line of Defence*, viz. 217. and set it off from F. to H. and from F. to I. then from H. and I. and from G. K. draw the *Flank*. Thus following the same Method, from each *Base* or *exterior Polygon*, you may draw any *Fortification*; but to fortifie a *Square*, the *Proportions* must be altered thus:

<i>Base or exterior Polygon</i> ..	600	550	640	520
<i>Perpendicular</i> —————	161	146	173	137
<i>Face</i> —————	364	326	384	296
<i>Compl</i> —————	222	211½	243	211½

And may be drawn by the foremen-
tioned Directions.

Hd

Having now set down the several ways for laying down the Fundamental Ground-line, from the most considerable Engeniers of this Age. I shall here show how to draw out Mechanically, in the Field, any Regular or Irregular Fortification, either from the Exterior or Interior Polygon, according to Count Pagan.

And first, from a *Pentagon* to a straight *Line* from the *exterior Polygon*.

The *Base*, or *exterior Polygon* *a. c.* given, divide as in *Plate the 4th.* into equal parts in the *Point b.* from the *Point b.* raise the *Perpendicular c. b.* of a sufficient length, then divide *a. b.* the half *Base* into 3. 6. or 9. equal parts, and take thereof $\frac{1}{3}$ for the *Perpendicular b. d.* so is *d.* a *Point*, through which draw the *Line a. d.* and *d. c.* which done,

divide the *Perpendicular* *b.d.* into 8 equal parts, and make *d. h*, and *d. f.* equal to 9 of those parts. then from the points *b.* and *f.* let fall the *Perpendiculars* *b. g.* and *f. p.* till they cut the *Lines* *a. f.* and *c. b.* in the *Points* *g.* and *p.* then join the *Points* *a. g. b.* and *f. p. c.* and so you have *a. g.* and *c. p.* for the two *Faces* *g. b.* and *f. p.* for the two *Flanks*, and *b. f.* for the *Courtain* of the *Fortification*, *Plate 4. Fig. 3.*

From a Square to a Pentagon.

The Method of this is the same as the former, only instead of dividing the half *Base* *a. c.* into 3. 6. or 9. and taking the $\frac{1}{3}$ thereof for the *Perpendicular*, you must here divide the half *Base* *a. c.* into 15 or 30 *lengths*, and set off 4 or 8 for the *Perpendicular* *d. b.* and instead of dividing the *Perpendicular* *d. b.* into 8. you are to divide it into 5, and of these parts, you are to set off 7 upon both the *Lines* *d. f.* and *d. h.* and this is all the difference.

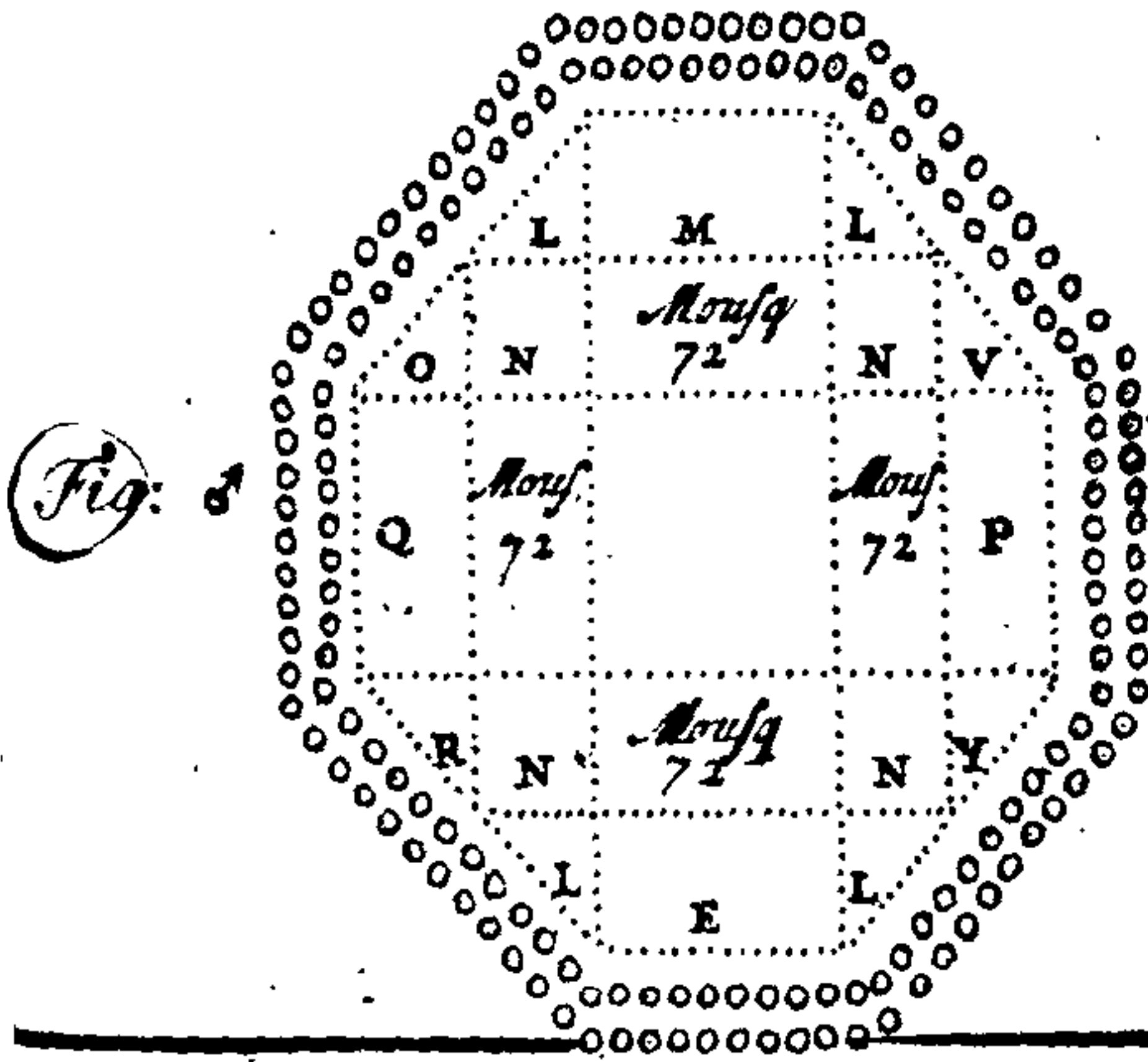
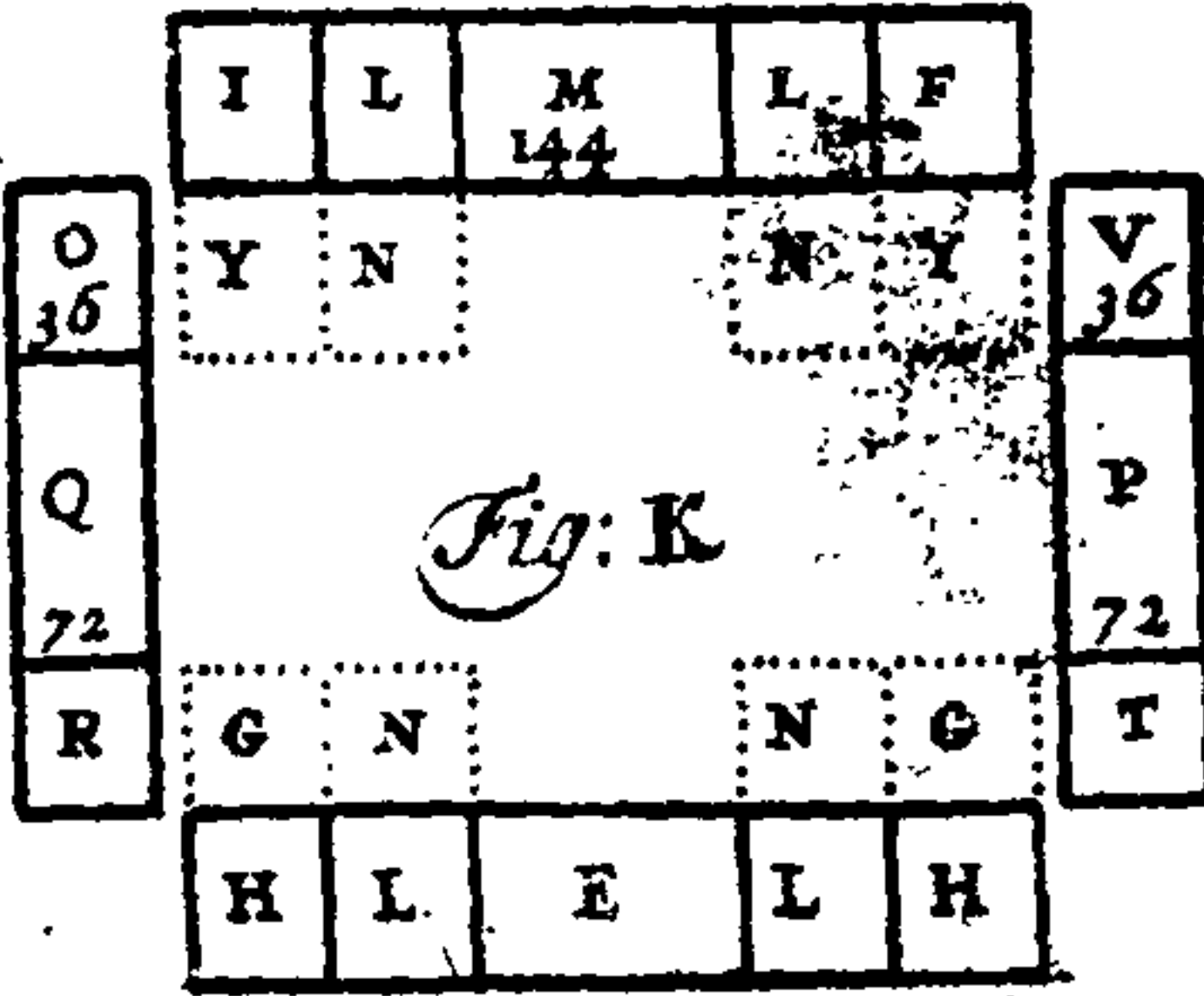
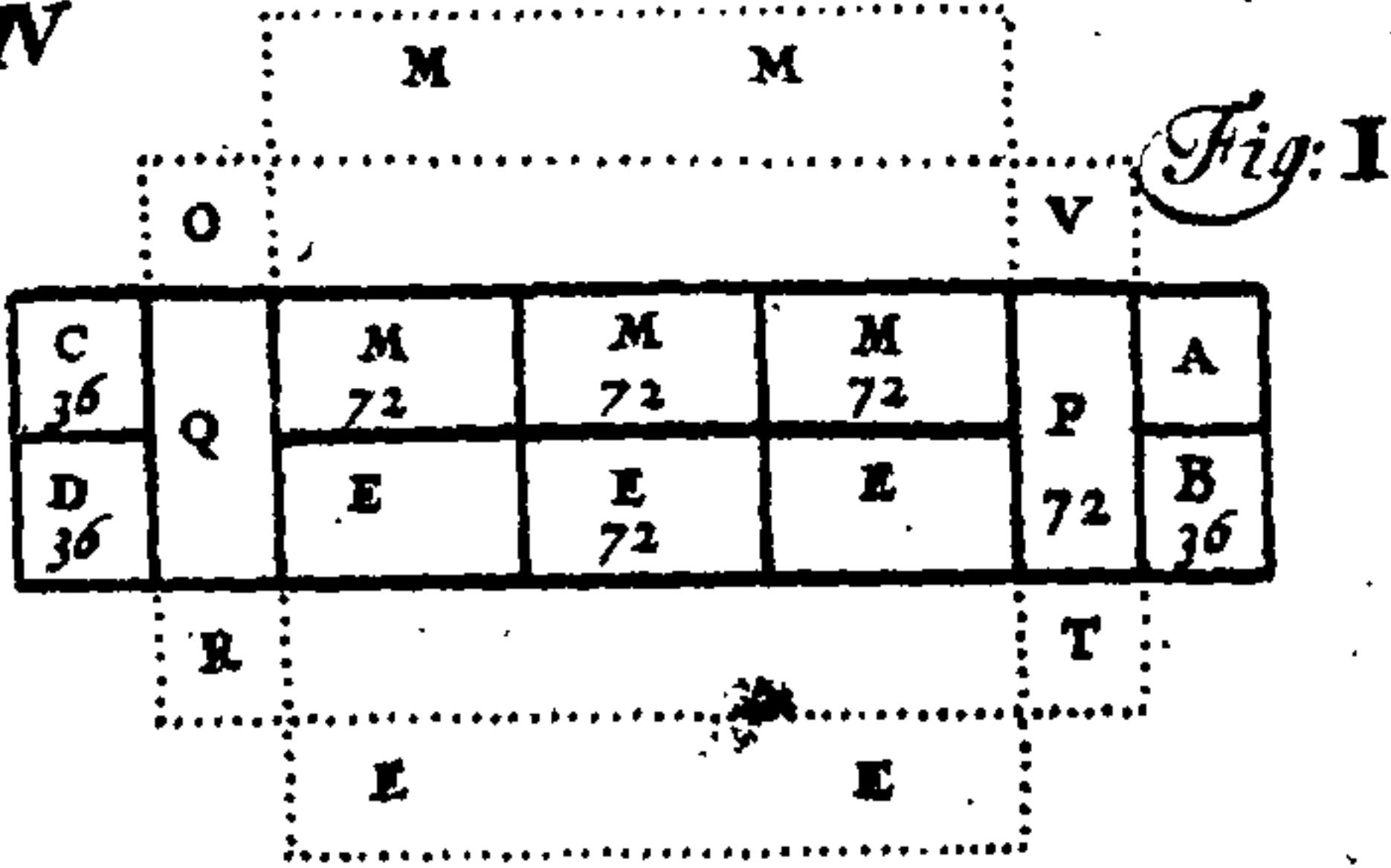
Or

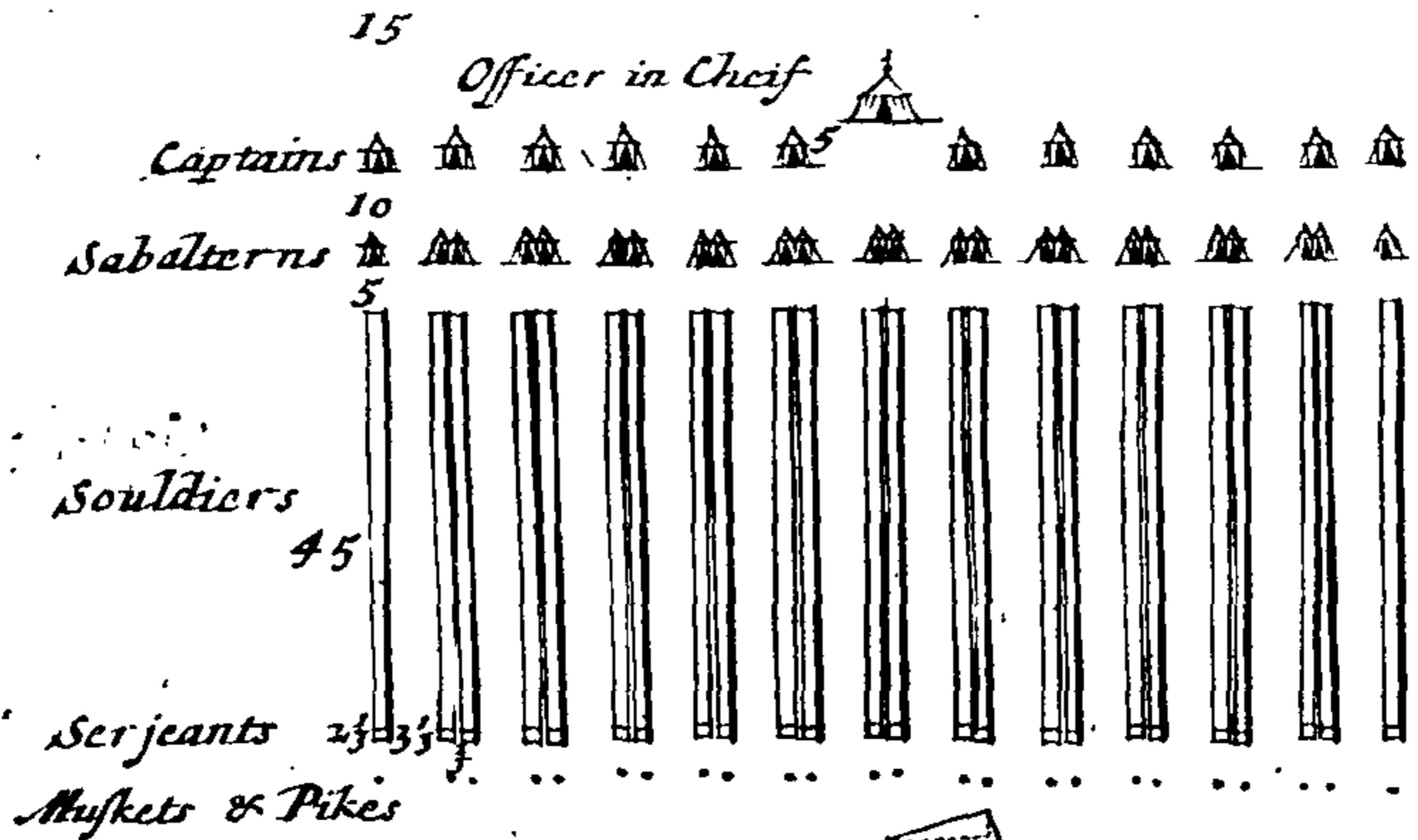
Or note, that having raised your *Perpendicular*, take any measure whatsoever, be it *Pole*, *Staff*, *Line* or *Stake*, and mark out 3. 6. 9. 12. 15. 18. 21. &c. upon the *Line a. c.* to the *Point l.* upon which *Point* erect a *Perpendicular l. k.* equal to $\frac{1}{3}$ of *a. l.* so is *k.* a visual *Point*, through which is to be drawn the *Line a. f.* cutting the *Perpendicular c. e.* in the *Point d.* and *e.* a visual *Point*, through which is to be drawn the *Line c. b.* then proceed as before directed for the *Pentagon*; but for the *Square* instead of marking out 3 *lengths* upon the half *Base*, you must here mark out 15 for the *Line a. l.* and instead of $\frac{1}{3}$ you must allow 4 of those *Parts* for the *Perpendicular k. l.*

To do this by the *interior Polygon*, and that from the *Square* and *Pentagon*, to a *Right Line*, let the *interior Polygon* given be *A. B.* which divide into 12 parts, and make *d. e.* $\frac{1}{12}$ and *a. i.* $\frac{2}{12}$ for a *Square*, and *a. k.* $\frac{3}{12}$ for a *Pentagon*, *p. k. l.* and *p. i. g.* right *Angles*, and proceed as directed before, *Plate the 4th. Fig. 4.*

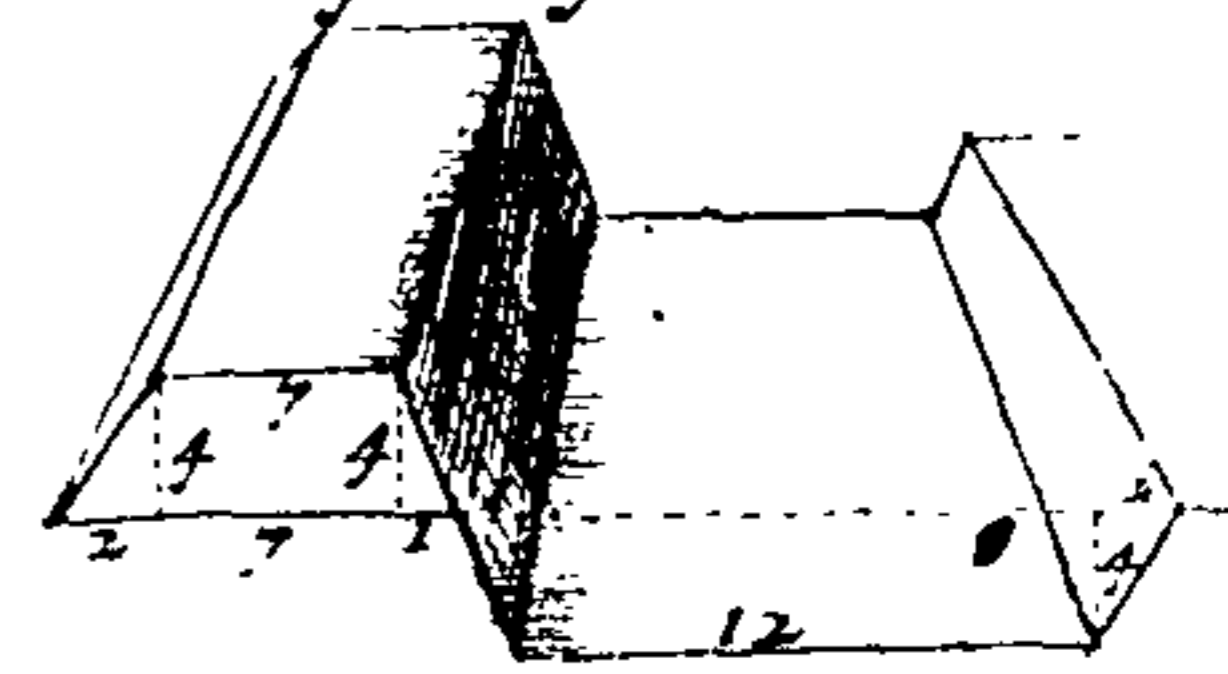
Note

Plate IV

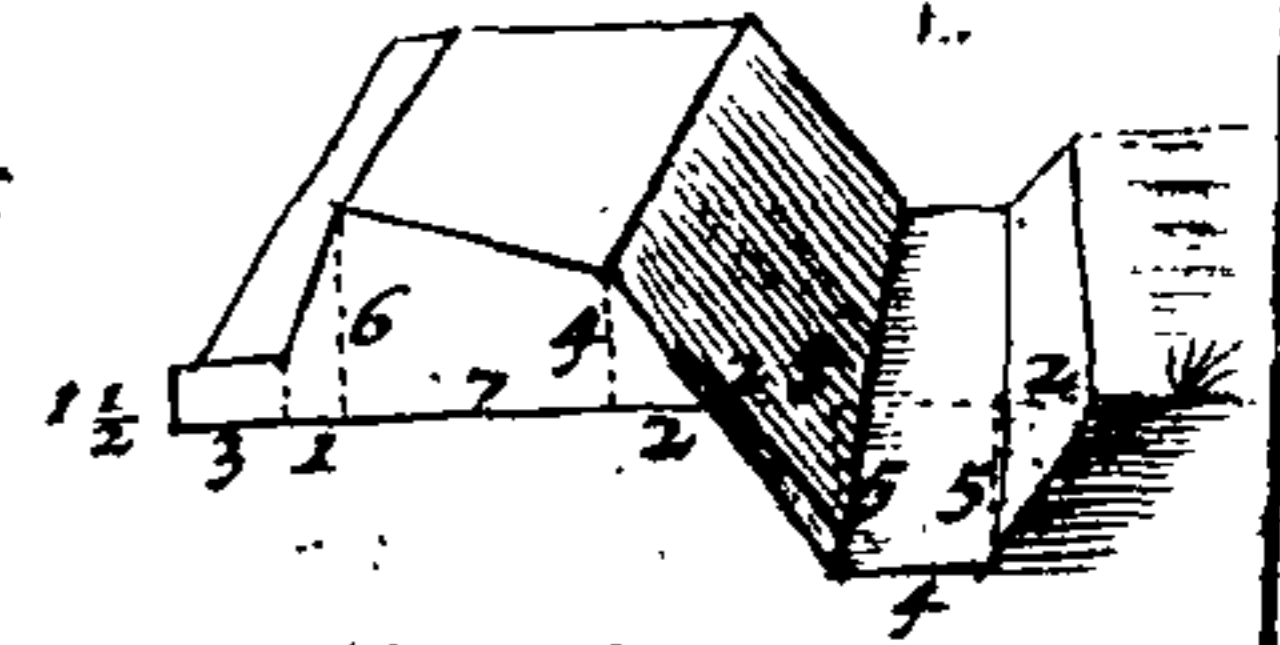




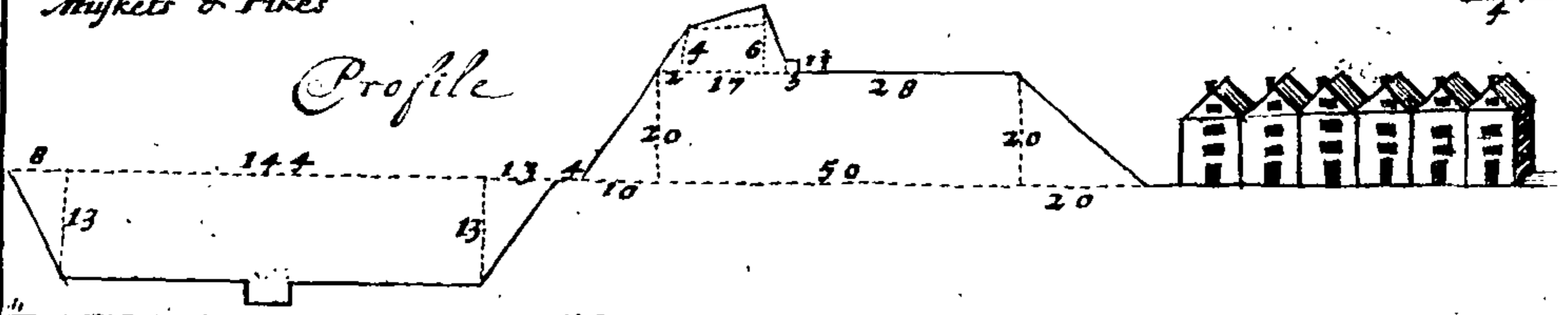
Profile for Trenches

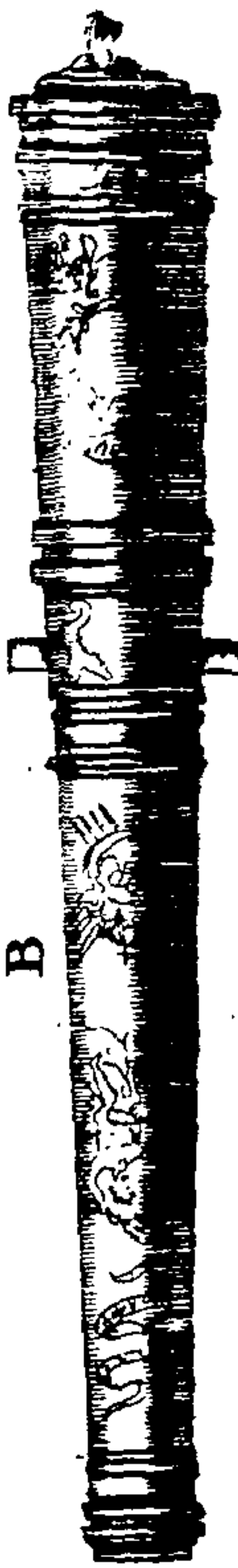
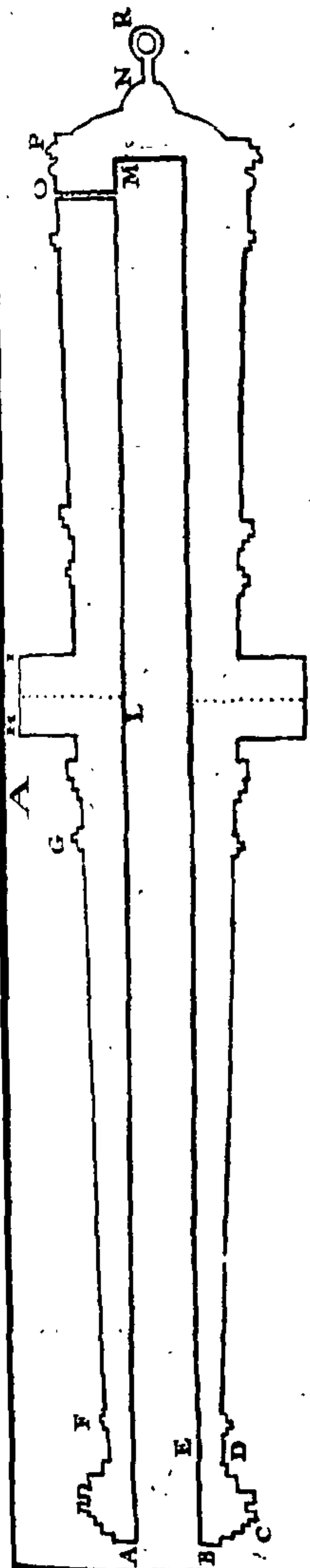


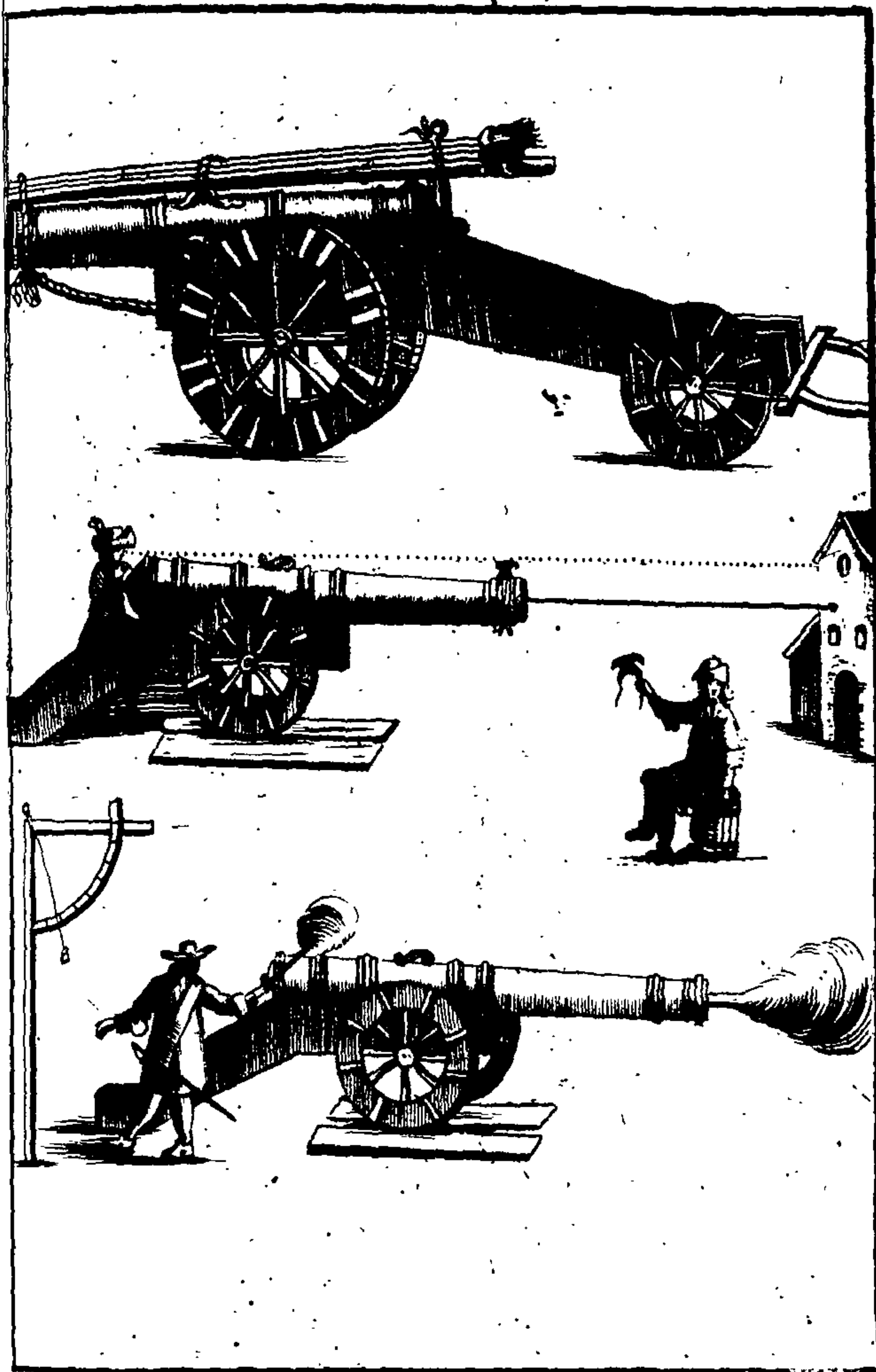
Profile for Redoubts

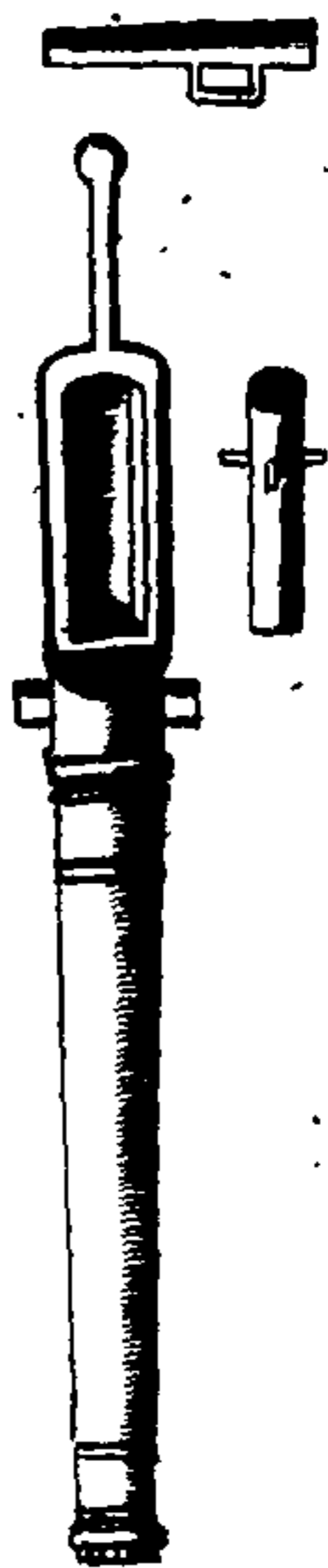
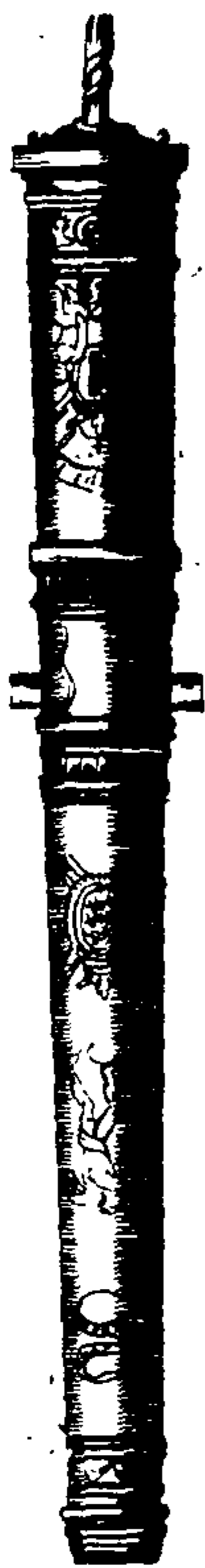


Profile









Note also that the *exterior Polygon* should be about 1150 *Feet* never less than 1024, nor more than 1280, that so the *Line of Defence*, may not be too short, nor longer than a *Musquet-shot*, and that the *Angle* of the *Bastion* be not less than 60 degrees; but where either the *Scitu-ation* of the place; or the old *walls* or *Rampiers* of a *Town* will not admit any such equality either of *Bases* or *Angles*, then the *Engenier* may either open or sharpen his *Angles*, or lengthen or shorten his *Lines* as necessity shall require.

Plate the 5th;

Here not the *Encampment* is figured with *Paces*, and the *Profiles* with *Feet*.

OF
GUNNERY.

Plates IV. V. VI. VII. VIII.

*Of the Names of the Principal Mem-
bers of a Piece of ORDNANCE.*

i. Defn. **A** CANNON is a long round Body, either of *Brass* or *Iron*, formed and made hollow by Art, and proportion, to offend afar off, with a Ball of Iron, Stone, or any artificial Substance, charged with *Gun-Powder* in its charged Cylinder, which being fired, in an instant performs its desired Effect. This Machine was inven-
ted

ted by an *Englishman*, and first put in practice by the *Venetians* against the *Genoveses* at *Chiazza*, Anno 1379.

2. The superficies of the Metal, is the outside, round about the Piece.

3. The Body is the substance of the whole Mass of Metal.

4. The Chase is the concavity of the Piece, in which they put the Charge.

5. the Muzzel is the extremity of the Chase by which you load and unload the Piece.

6. The Calibre is the Diameter of the Muzzel or Mouth.

7. The Touch-hole is that little *Vent*, which passeth from the *Convex Superficies*, to the very Chamber of the Piece, made to give fire to the Powder within; that which encloseth the extremity of the Chase about the Touch-hole, is called the Breech or Coyl.

8. The *Cascabel* is the Pammel at the Breech or Coyl.

The Trunnions are pices of Mettal fixed unto the *exterior superficies* of the Gun, on which he moves in the Carriage.

The Body of the Piece, is that which

is comprehended betwixt the Center of the *Trunnions* and the *Cascable*.

The vacant Cylinder is comprehended betwixt the Center of the *Trunnions* and the *Muzzel*.

The *Frees* or *Muzzel-Ring*, is that thick *Cornish* which incompasseth the *Convex Superficies*, or the Piece.

The *Dispart Line* of the Piece, is the difference betwixt the *Semi-diameter* of the *Muzzel* and *Bate Ring*.

The *Vent* of the Piece is the difference betwixt the *Diameter* of the *Shot*, and the *Mouth* of the Piece.

The *Chamber*, or charged *Cylinder*, is that part of the *Chase* towards the *Touch-hole* equally large, not narrower in one place than in another, and doth contain the *Powder* and *Ball*.

*How to know the different Fortification of
a Piece of Ordnance.*

In fortifying any Piece of *Ordnance*, there are three degrees observed, as first, *Legitimate Pieces*, which are those that
are

are ordinarily fortified; secondly, *Bastard Pieces*, which are such whose Fortification is lessened; thirdly, *Double fortified Pieces*, or extraordinary Pieces.

The Fortification of any Piece of *Ordnance* is accounted by the thickness of the Metal at the *Touch-hole*, *Trunnions*, and at the Muzzle, in proportion to the Diameter of the Bore.

The *Legitimate Pieces*, or the ordinary fortified *Cannons* have $\frac{7}{8}$ at the Touch-hole, $\frac{5}{8}$ at the *Trunnions*, and $\frac{3}{8}$ at the Muzzle, of the thickness of the Bore, in thickness of the Metal. *Bastard Cannons* or lessened *Cannons* have $\frac{3}{4}$ at their Touch-hole, or $\frac{12}{16}$, and $\frac{9}{16}$ at their *Trunnions*, and at their Muzzle: The *Double fortified Cannons* have full one Diameter of the Bore in thickness of the Metal at the Touch-hole, and $\frac{11}{16}$ at the *Trunnions*, and $\frac{7}{8}$ at their Muzzle. Now all double fortified *Culverins*, &c. are $1\frac{1}{8}$ at the Touch hole, $\frac{15}{16}$ at the *Trunnions*, and $\frac{9}{16}$ at the Muzzle, and the *Ordinary fortified Culverins*, are fortified every way as double fortified *Cannons*, and lessened

Culverins as Ordinary Cannons in all respect.

How to know how much Powder is fit for Proof, and what for Service for any Piece of Ordnance.

For *Cannon* take $\frac{4}{5}$ of the weight of their Iron Bullet of good Corn Powder for Proof, and for Service $\frac{2}{3}$ the weight of the Iron Bullet is sufficient, especially for Iron Ordnance, which will not endure so much Powder, as Brass ones will receive by $\frac{1}{4}$ in weight. For *Culverins* allow the whole weight of the Shot for Proof, and $\frac{2}{3}$ for Service. For *Sakers* and *Falcons* take $\frac{4}{5}$ of the weight of the Shot, and for lesser Pieces the whole Weight may be used in Service, until they grow hot; but then there must be some abatement made at discretion, and take $\frac{1}{3}$ of the Weight of their Iron Bullet for Proof.

To know what Bullet is fit to be used in any Piece of Ordnance.

The Bullet must be somewhat less than
the

the Bore of the Gun, that so it may have vent in the Discharge : so Authors affirm, that $\frac{1}{4}$ of an Inch less than the Bore, will serve all Ordnance ; but this vent is too much for a *Falcon*, &c. and too little for a Cannon ; therefore I approve them not, but commend Mr. *Philips's* proportion (set down in his *Mathematical Manual*, page 165) to your Use, which is to divide the Bore of the Gun into 20 equal parts, and let the Diameter of the Bullet be $\frac{19}{20}$ thereof.

Of the Qualification of an able Gunner, and necessary Operations before Shooting, and in Shooting.

A Gunner ought to be a Man of Courage, Experience, and Vigilant ; he ought to have good skill in Arithmetick, to know the extraction of the Roots, &c. He ought to have skill in Geometry, to take heights, distances, &c. to know the Divisions and use of his *Circle*, *Quadrant*, and *Quadret* ; to know how to level and to lay Platforms, and to raise

Batteries. He must know the Names of all sorts of *Ordnance*, their Weight, the height of the Bore, the height and weight of their Shot, the length and breadth of their Ladles, how much Powder to use for Proof and Action; the Shots Level, and the Shots Random; He must know the Names of all the Members of a Piece of Ordnance; he must also know the length, thickness and breadth of all manner of Carriages, and must know all the parts thereof, *viz.* the *Cheeks* or *Sides*, the *Ax-tree*, *Spokes*, *Nave*, *Hoop*, *Transomes*, *Bolts*, *Plates*, *Drawing-Hooks*, the *Clout*, the Hole for the *Linspin*, the *Shafts*, the *Tbill* and *Tbill-Bolt*, the *Forelock* and *Forelock Keys*, *Cap-squares*, the *Forelock pins* and *Chain*, the *Pintle* and *Bolt-hole*, *Fellows*, *Nails*, *Fellow-bars*, *Stirrups*, the *Ruts* of the *wheel*, *Dowledges*, *Bed Conies*, *Leveres*, *Hand-screws*, &c. He must also know how to make his *Ladles*, *Spunges*, *Cartridges*, whether of *Paper*, *Vellum* or *Canvaſs*, and to have by him *Farmers* of all sorts, *Sheep-skins* undrest to make *Spunges*, *Powder*, *Shot*, *Needles*, *Thread*, *Paste* and *Starch*,
Marlin,

Marlin, Twine, Nails, Handspikes, Crows of Iron, Granado-shells, and Materials for Composition, Fasces, Budg-Barrels, Cannon-Basquets, &c. These being general things he is to know, and at all times to have ready by him, and he is more particularly to know these following parts of his Art, as,

How to Tertiate, Quadrate, and to Dispart a Piece of Ordnance.

1. To *Tertiate* a Piece, is to find whether it hath its due thickness at the *Trunnions, Touch-hole* and *Neck*, and if the *Trunnions, Touch-hole* and *Neck* are in its due order, and the *Chase* streight.

2. To *Quadrate* a Piece mounted, is to see whether it be directly placed, and equally poized in the Carriage; which is known by finding in the *Convex Superficies* of the *Base* and *Muzzel-Ring*, the Point which is *Perpendicular*, over the *Soul* of the Piece, which may be found by the *Gunners Instrument*, called a *Level*; an Instrument whose use is so vulgarly

garly known, that it needeth not my Explanation.

3. To *Dispart* a Piece, is to fix, or elevate on the Convex-point of the Muzzle-Ring, a Mark as far distant from the *Cylinder*, or Soul of the Piece, as is the Point of the Base-Ring; to the end, that the *Visail-ray* which passeth by these Marks, may be parallel to the Chase, Soul or *Cylinder* of the Piece. Now the *Dispart*, *i. e.* the difference of the *Semi-diameters* of the *Cornishes*, may be by a pair of *Calliper Compasses* attained, which found, place on the top of the *Cornish Ring*, near the Muzzle, over the middle of the *Inferior Cylinder*.

To know how far any Piece of Ordnance will shoot, &c.

As to the several shootings in *Artillery* Authors differ much in their judgments and Opinions, but they all unanimously agree, that the Ball being shot forth, flies through the Air, with a Violent, Mixt and Natural Motion; describing a *Paraboli- cal line*, in whose beginning and ending,

ding, are lines sensibly streight, and in the middle curved; In the beginning the imprest force driving forward by the Fire, the natural gravity of the Ball doth describe a *Right Line*, called the *Direct Line*, or Ranges of the Balls Circuit.

In the middle that force diminisheth, and the *Natural Gravity* prevaileth, so that it describeth a curved line, called the balls *middle Helical* or *Conical Arch*; In the end, the *Natural Gravity* overcoming the imprest violence, (which becomes altogether weak and faint) describes a new right line, called *the Balls declining line*; in which the Ball tends wards the Center of the Earth, as towards a place natural unto all heavy bodies. See *Figure 92*. These motions are somewhat longer, according as the Piece is mounted from the Level unto the Angle of 45 *deg.* which is called *the Utmost Random*. The Elevation of which, is regulated by the *Gunner's Quadrant*, the use of which Instrument is so generally known, and by so many Authors, fully explained, that I here crave leave
to

to omit it. But take these for general Rules.

That a Shot at Right Angles, strikes more violent and furiously than at Oblique Angles; therefore Gunners use when they are to batter down a Tower, wall, or Earth-work, to shoot point blank at the object, Tire by Tire; by discharging all the Pieces in Battery against the self same object, in the same instant, holding it for a Maxim, that ten Cannons discharged together, do far more Execution, than discharged one after another. Now at Oblique Angles they shoot either Cross-ways, or by rebounding.

2. *That the speediest way to make a Breach into a wall, &c. is by shooting at the Object from two Batteries, which ruins far more speedily than by striking the Object with one Battery at Right Angles, although that one Battery hath as many Cannon as the other two hath.*

3. *That if you were to Batter a flank covered with an Orillion, (which because you cannot possibly Batter it right forward) you must therefore of necessity batter it obliquely, by way of Rebounding, thus: Chule a fit place*

place in the *Courtain* to be your *object*; on which you may play with your *Battery* obliquely, so that by a rebound the shot may leap into the *flanks*, holding for a *Maxim*, in this operation, *That the Angles of Incidence and Reflection are equal.*

Of shooting in Mortar-Pieces.

A *Mortar-Piece* is a short Piece, with which they shoot *Bombs*, *Granado shells*, *Stone-balls &c.* not by a Right Line, but from a Curved, from on high, so that it may fall where it should be desired: Now this Mortar is placed in the Carriage, *Plate VI.*

Bombs are great hollow Balls of Iron or Brass, in which are put fine sifted Gunpowder, which by a Fuse, they proportion to them a due Fire, that so they may break as soon as they fall amongst the Enemies. These Fuses are small Trunks of *Wood*, *Tin* or *Iron*, filled with a prepared *Composition* for that purpose. *Granadoes* are of the same form with *Bombs*, only smaller, and are many times cast by hand, and are made of *Iron*, *Brass*,
Glass.

Glass, or Earth. Now in order to the well shooting in those kind of *Machines* called *Mortars*, 'tis requisite to observe these following Rules: as

1. That before you make a Shot at any place, you find the distance thereof from your *Mortar*.

2. That the Bombs or other Bodies that are to be shot, be of equal weight, otherwise the Shots will fail.

3. That the Carriage in breadth be always on a Level, and without any descent, that so it may not leap or in discharging fail.

4. That the Powder with which the *Mortar* is loaded be always of the same force and weight.

5. That the charge of the *Mortar*, as well in Powder, as in Wadding, be always rammed in with blows equally heavy, and of equal number.

6. That the wads be always either of wood or Tompeons, or else of Oakum, for the strongest drives it farthest.

7. That the Fuses be newly made, in those days that they are to be used, and that they be made of a Composition proportionable to the Range that the Shot shall make in
the

the Air, so that the Bomb may break in the very moment it falls ; which Composition must be such, that though it fall in the Water, yet not to extinguish, but the Bomb there to break.

Now before we proceed any farther, I think it necessary, to shew how to compose your Ingredients for your Fusee.

To make Fusces for Bombs, &c.

The Composition for Bombs must be of a slow motion, that so time enough may be given to throw either Bombs, Granadoes, Fire-Balls, Thundring Barrels, &c. They are compounded of these Ingredients, Thus: Take a pound of Gunpowder, $\frac{1}{2}$ of Sulphur, $\frac{1}{8}$ of Saltpeter, well beaten, dry and sifted separately, then mix it and make up your Fusee hereof. Or, Take Powder of Benjamin and small Coles, all well beaten and mixed together with some Oil of Piter, and so fill the Fusee therewith.

Now the use of Mortar-Pieces, being for the most part to shoot up at Random, therefore the Randoms of these Pieces are very necessary to be known. Therefore

I have hereunto annexed a *Table of Randoms* for the twelve Points of the *Quadrant*, calculated by *Diego Uffano Zutphen*, and to be found in his *Works*, printed 1621.

A Table of Randoms for Mortar Pieces, to the twelve Points of the Gunners Quadrant, calculated by Diego Uffano Zutphen.

583 570 534 468 377 248 100

6 5 4 3 2 1 0

.

6 7 8 6 10 11 12

583 670 534 468 377 248 000

Now suppose the Mortar to be placed at the Pricks in the middle line representeth the several *Randoms*; numbred with the Degrees of the *Quadrant*, forward and backward, unto which the lever?