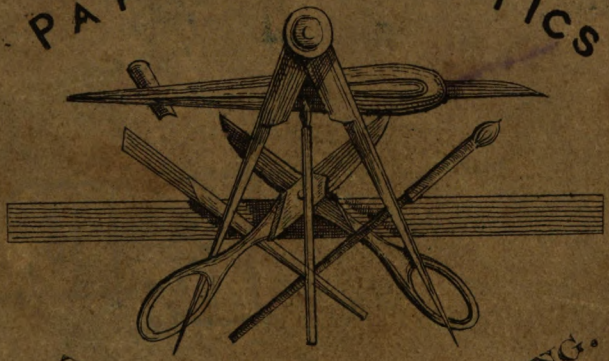
PAPYRO PLASTICS



OR

THE ART OF MODELLING IN PAPER.

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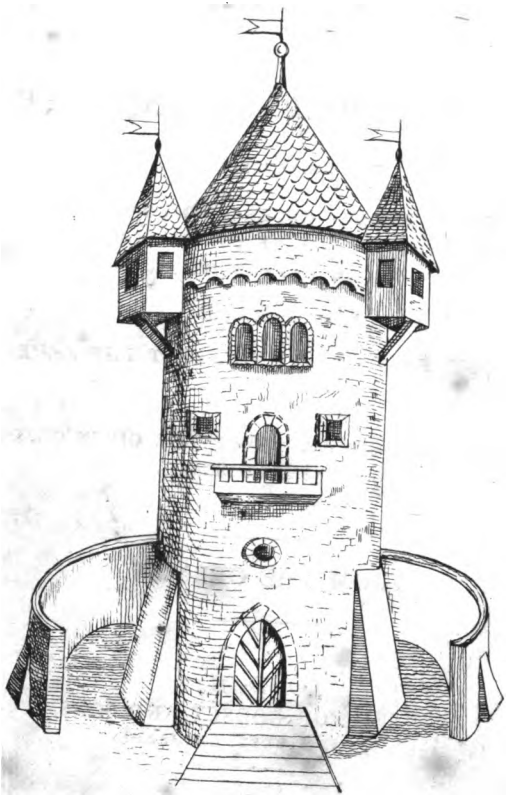
PAPYRO-PLASTICS.



PAPYRO-PLASTICS,

OR THE

ART OF MODELLING IN PAPER;

WITH AMPLE DIRECTIONS

TO DRAW WITH A RULER AND COMPASS THE FLAT PAPER FIGURE OF THE OBJECT TO BE REPRESENTED;

AND AFTERWARDS

TO CUT, FOLD, JOIN, AND PAINT THE SAME,

SO AS TO FORM

A NEAT REPRESENTATION OF THE GIVEN OBJECT ON A SMALL SCALE.

FROM THE GERMAN.

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PREFACE.

ON submitting to an enlightened Public a new, elegant and instructive amusement for Children, we have first to account for its name. We are aware that the term *Plastics* is generally confined to the modelling of sculptors and statuaries in gypsum, clay, wax, &c. But as the art of making cork models of architectural monuments on a small scale, has obtained on the continent the appellation of *Phelloplastics*, from the Greek word φελλος, cork; we think ourselves warranted by this analogy in denominating the art of modelling in paper *Papyroplastics*.

This ingenious art is calculated to introduce children to the most common and practical applications of geometry, in a way which occupies their hands, and thus enforces their attention, without any particular effort of their thinking powers. By a law of our nature, our curiosity, in our earlier years, is preferably directed to palpable objects. Abstraction is an exertion of the mind, which is irksome even to a great many grown up persons; and children can hardly be induced to exercise it, because they cannot form an idea of the advantages resulting from that faculty. This love of reality is likewise the characteristic of the infancy of nations. The Greeks had clever statuaries long before they had able painters. The sculptor represents the object as it is, with all

its angles and rotundities; his works are real representations, they may be touched and handled, whilst those of the painter are mere illusions, which vanish as it were at the touch. Complete figures, by which both the senses of seeing and feeling are gratified, satisfy the infant mind better than bare outlines; and the study of mathematics is likely to be prosecuted with more ardour after young persons have previously amused themselves with converting quadrangles and parallelograms into tables, chairs, houses, churches, bridges, and ships.

But, independently of the mathematical studies for which it prepares the youthful mind, Papyroplastics, or the art of modelling in paper, has the additional advantage of teaching manual dexterity, the knowledge of

proportions, a taste for the arts of design, and, above all, of affording a salutary antidote to that listless indolence, that pernicious love of cards, or that rage of reading any book at random, which are unfortunately tolerated in many respectable families during the long winter evenings, and which are alike unfavourable to the comfort and to the best interests of young persons, and greatly tend to obstruct them on their road to duty and happiness.

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CHAPTER I.

PRELIMINARY REQUISITES AND DIRECTIONS.

TO make neat representations in paper of any given object on a small scale, is an occupation as agreeable as useful. It consists chiefly in drawing, cutting, folding, joining and painting.

1. The *drawing* regulates the cutting and folding. It is most easily performed by means of a pair of compasses, a common brass ruler, and a ruler in the shape of a triangle, a representation of which is given, No 10 on the 10th Plate.

See also the Second Chapter on the previous Exercises in Drawing.

2. The *cutting* is performed either with scissars or with a penknife. When the latter is used, the paper should he laid on a small board of soft wood; and whether the paper be cut with scissars or with a penknife, margins must be left on the cut paper figures for the purpose of glueing them together.

3. In *folding*, particular attention is to be paid to its being done in a straight line.

4. The *joining* may be effected with glue, gum arabic, paste, or wafers, the latter being easily converted into a kind of paste when properly wetted. Care however must be had to glue only the edges or margins left for that purpose in each cut paper figure; and in some cases recourse must be had to cording or fastening with small slips of tin, until the parts glued be properly joined and perfectly dry.

5. Of the articles used for joining, the glue must be in such a state of thickness as to be like the white of an egg, or pretty thick oil, when suf-

fered to drop from the vessel in which it is made: the gum arabic is to be dissolved in water so as to have the same consistency with glue, and should it prove too thin, it may be thickened with a little chalk; paste is best when made of starch or fine wheat flour; it is much cleaner than glue, but any brush or stick left in it, will cause it to ferment and render it too watery.

6. The *painting* is performed in the usual way with different colours or mixtures of colours, and with brushes proportioned to the size of the cut paper figures to which the painting is to be applied.

But every thing depends on the goodness of the paper, which should be strong, stiff, and very smooth. Music paper, or drawing paper, Bristol board of the middle size, is the best. A thinner sort of paper may be employed, whenever it is to be used double; and in this case, both sheets of paper are to be done over on one side with glue or paste, but one of them so sparingly as

only to become moist; they then should quickly be laid one upon the other, covered with a dry sheet of paper, smoothed in an uniform direction on a hard, even surface, and pressed between two boards or in an old book until they are perfectly dry.

Lastly, objects ought not to be represented on too large or on too small a scale. In the former case, or when the objects are complicated and composed of too many parts, the surface of the paper seldom proves sufficiently stretched and even, and both the beauty and durability of the model are impaired. And when the scale is too small, it frequently occasions a waste of time and labour, and too diminutive models rarely succeed after all.

Neither should such objects be attempted which cannot well be represented in paper. A certain facility in modelling easy objects must have been previously acquired, before one may venture upon more difficult ones. The models

mentioned in the following Directions should not be altered, nor should new ones be undertaken, but after they have been repeatedly and successfully executed. The transition from what is easy to what is more difficult, is as indispensable here as in many other cases.

CHAPTER II.

PREVIOUS EXERCISES IN DRAWING WITH COMPASSES AND A RULER.

The tenth and eleventh plate refer to these previous exercises. The points, lines, and surfaces are designated by letters.

I. *To draw a right or straight line.*

Have a very sharp pointed black lead pencil, and keep uniformly close to the ruler in drawing the line, taking care to have it very fine and almost imperceptible, for a line is that which has length without breadth.

II. *To take the length of a line with the compasses.*

The compasses must be opened so wide that the ends touch exactly the two extremes or the beginning and terminating point of a line; for the

place where a line commences or ends, or where a line passes through, or, as it is called, intersects another, is a point.

III. *To take the length of a pretty long line in order to make another exactly similar, as for instance of a line longer than a sheet in quarto.*

The given line is divided with dots into several optional parts, which are measured in regular succession with the compasses.

IV. *To mark the exact division of a given line on another line.*

Whenever the given line is not very long, as for instance, this line b——c——d——f——g, this is most accurately done by measuring not the intermediate successive lengths, but the widths *bc*, *bd*, *bf*, or *fg*, *dg*, *cg*, beginning always with *b* or *g*.

But when the line is of considerable length, a common ruler or a straight slip of paper may be

held against it, and the divisions may be noted on the same. This may also be done with regard to the preceding art. III.

V. *To give the distance of a point from an opposite line, as, for instance, the distance of the point b from the line c d.* (See No. 1 of the 10th plate.)

One end of a pair of compasses, that have been previously opened nearly as wide as is the distance of the point *b* from the line *c d*, is placed on this point *b*, and the other end is carried so near the line that an arch is described, which, as may be seen here, is close to the line, yet does not intersect, but only touches it. In this case the distance is given by the width between the two ends of the compasses.

VI. *To divide a given line into two equal parts with the compasses, as, for instance, the line f g* (No. 2) or (No. 3).

Open the compasses so that the distance of their

points may conjecturally mark the middle; and examine whether the line be actually divided into two equal parts. If there be any part of the line left, as *f h* (No. 2), one point of the compasses is kept steady on *k*, and the other is carried by guess to the middle of *f h*. Should there still be a remnant, as (No. 3) the distances *l p*, one point of the compasses is kept steady on *n*, and the other is carried to about the middle of *l p* nearer the other point of the compasses.

If on examination the line is not yet divided into two equal parts, the same process must be repeated until the two parts are of equal length.

VII. *To divide a line into more than two equal parts, as, for instance, the line q r* (No. 4), *or the line v w* (No. 5), *into three.*

The process is the same as in art. VI; and if there be any remnant, as *q s* (No. 4), one point of the compasses is kept steady on *t*, and the other is carried further conjecturally to about the

third of $q\,s$. But if the first conjectural third be too large, and a remnant is left beyond the line, as $v\,z$ (No. 5), the points of the compasses, one of which is kept steady on x, must again be brought nearer to each other by about the third part of $v\,z$.

The same is to be observed when the line is to be divided into 4, 5, or more equal parts, with this difference, that whatever remains may always be subdivided; as, for instance, when the question is of six parts, into six. And whenever such parts are many, they may first be divided into a smaller number of parts, and then each part again separately; as, for instance, when the question is of six parts, twice 3 or three times 2 giving six, the given line may be first divided into two parts, and every part again into three; or first into three parts, and every part again into two.

VIII. *To place the length of a given line exactly in the middle of another line, as, for instance, the line b c* (No. 6) *on the line d f.*

The shorter line is placed on the longer one from *d* to *g*, and the remnant *g f* here is divided into two equal parts. Each of these parts is the distance at which the extremes of the shorter line are to be from the extremes of the longer, if the shorter line is to be precisely on the middle of the long one. When therefore the distance is taken from the beginning and terminating point towards the centre of the longer line, the middle space between is the length of the shorter line.

Supposing the line to be placed in the middle be the width of a door, and the longer one be the length of a small building, the door by this process would be placed exactly in the middle of the building.

IX. *To fix a line more than once upon another longer one, so that the intervals be equal; as, for instance, the line h k* (No. 7) *three times on the line l m.*

The shorter line is to be placed upon the longer, either at the beginning or terminating point, as often as required; here, of course, three times. The remnant *n m* is then divided into as many equal parts as the line to be placed upon the other, less one; here therefore into two parts. After which first the shorter line and then the said equal part, as intermediate width, are alternately taken, beginning precisely at one of the extremes of the longer line.

And the same manner of proceeding takes place when the line is to be taken four, five, six times, or more.

X. *To place a line several times upon a longer one, and so that there be not only equal intervals, but that the line be at an equal distance from both extremes of the greater line; as, for instance, the line p q* (No. 8) *three times on the line r s.*

The shorter line *p q*, as in the preceding case, is to be placed on the longer one *r s* three times from *r* to *s*: the remnant *t s* is then divided into as many equal parts as the shorter line is to be placed on the longer, and one more: consequently here into four parts. Each of these four parts is the required distance, and at the same time the intermediate width.

It is in this way that doors or windows are distributed in a building.

XI. *To make two lines meet exactly like two others, as, for instances, omitting the dotted arches* (No. 9) *the lines z q and z b, like the lines v w and v x.*

Draw the line *z c*, if it be not already drawn, and with an uniform opening of the compasses describe from the points where they are to meet, as here from *v* and *z*, two small arches; take the length of the arch between the aforesaid lines, viz.; *x w*, from *c* to *b*, and draw a line from *z* to *b*, and it will meet the line *z c*, as required.

Such a meeting of two lines in one point is called an angle. Whenever a line meets another without having any inclination when prolonged, it is a right angle, and the line itself in this case is said to be standing right angularly, or perpendicularly, or straight upon the other.

When the lines are more inclined to one another than the quantity of a right angle, it is

called an acute angle; but when they are less inclined to one another than a right angle, it is an obtuse angle. Whenever a line is not perpendicular upon another, it is inclined.

To describe an arch from a given point, place one end of the compasses on that point, and describe the arch with the other end.

XII. *To draw a perpendicular line upon another, as, for instance, the line g f upon the line d f* (No. 10).

This is best done with a triangular ruler. Put the common ruler against the line on which the other line is to be placed, as here the line *d f*; and bring upon this ruler one of the short sides of the triangular ruler on the point of concourse; then holding both rulers firm one against the other, draw the required line along the other short side of the triangular ruler.

And to try this ruler, draw in the aforesaid

manner a right angular line upon another, and holding the common ruler firmly, turn the triangular ruler upon the right angular line just drawn, and move it on the common ruler exactly against this line. If the edge of the ruler and the line meet again accurately, the triangular ruler is correct.

XIII. *To draw from a point above a given line another right angular line without the triangular ruler, as, for instance, from the point h* (No. 11) *a line upon the line k l.*

Describe from the point *h* small arches intersecting the line *k l*, and from these two other arches intersecting each other, as here at *m*. Then placing the ruler against the points *h* and *m*, draw a line up to the line *k l*, and the other will be standing at right angles upon this.

And when small arches like those (No. 11)

are described, both above and under a line from two intersecting points of the same; and when the said line is intersected by placing the ruler on the two points where the arches meet, that line will be divided exactly into two equal parts.

XIV. *To draw, but without the triangular ruler, another line at right angles, on a given point of a line, as, for instance, the line r n on the point n of the line p q* (No. 12).

Place one end of the compasses on the given point *n*, and describe with the other small arches intersecting the line, as here at *p* and *q*. Describe again small arches from these points *p* and *q*, intersecting each other above the line, as here at *r*, and then draw the required line by holding the common ruler against the points *r* and *n*.

XV. *To draw, without the triangular ruler, another line at right angles at the end of a given line, as, for instance, the line h upon the line f* (No. 20. Plate XI.).

The point *f* is optional; but describe from this point *f* and the terminating point of the line, two arches intersecting each other as here at *g*. Afterwards draw a line through the points *f* and *g*, making *g h* equal to *g f*, and then draw a line from the point *h* to the aforesaid terminating point.

XVI. *To divide an angle into several equal parts, as, for instance, the angle t s v* (No. 13) *into four equal parts.*

Describe with the compasses, from the angular point *s*, an arch intersecting both the lines that inclose the angle or its sides, as here at *t* and *v*. Afterwards divide the length of the arch between the two lines of that angle into as many

equal parts as the angle is to be divided, in this case of course into four; and then draw lines through these points of subdivision up to the angular point *s*.

The larger or smaller the arch *t v* is, in case of similar distances, as *s v*, which however may be more or less considerable, the larger or smaller is the angle itself. The length of the lines has no effect on the magnitude of the angle, which varies only according to the inclination of the lines towards each other.

XVII. *To draw a line to be every where equidistant from another, or parallel to another line; as, for instance, the line w x* (No. 14) *parallel to the line z b.*

Take between the compasses the whole interval of the given line, as here *z b*, and from one extremity, as the centre, describe, as far off as the two lines are to be from each other, small arches, and placing the ruler upon the upper extremity of

these arches, draw a line which is barely to touch the two arches.

Equidistant or parallel lines may be seen, for instance, in the side walls of houses, in doors, windows, and other objects.

XVIII. *Another way of drawing one line parallel to another; as, for instance, the line c d to the line f g* (No. 15).

Draw on the given line, *f g*, if possible at a good distance, two lines at right angles and of the same length, and through the extremities of those perpendiculars draw another straight line. This will be parallel to the given line.

When several lines are required to stand perpendicularly upon another, and consequently parallel to one another, the shortest way is to put the triangular ruler against the common ruler, and to keep it firm against it.

XIX. *To draw through a given point opposite to a given line another line parallel to this line, as, for instance, the line h k parallel to the line l m through the point h* (No. 16).

Seek, by means of art. V., the distance of the point *h* from the line *l m*; place one end of the compasses on this line *l m* very far from *h*, and describe a small arch opposite to this point. Afterwards put the common ruler against this arch and the aforesaid point *h*, and draw the intended line.

XX. *To take the distance of two parallel lines.*

Proceed, either according to art. V., selecting at pleasure a point on one of the two lines, and describe from this point an arch which closely touches the other line. The opening of the compasses is, in that case, the required distance.

Or, put the ruler against one of the two lines, and draw (which is most readily done with the

triangular ruler) a line at right angles upon it, so as to intersect the other of the two given lines. The length of this right angular line drawn between the two parallel lines is, in this case, the required distance.

This process determines the length or breadth of objects inclosed within parallel lines, as, for instance, of doors, windows, and such like. With regard to diminutive objects, only the aforesaid arch or the right angular line is to be attended to.

XXI. *To make three given lines meet at their extremities, or to form a figure with them; as, for instance, the lines n, p, q* (No. 17).

Draw, as here *r s*, a line as long as one of the three given lines, for ex. *n*; then from both extremities of the line *n* describe, with the length of the other two, arches intersecting each other, as in *r* and *s*; and draw two lines from the said extremities to the point of intersection. The figure

may also be begun with either of the other given lines, instead of the line *n*.

A figure is a space completely bounded by lines; an angle therefore, as for instance that at No. 11, is not yet a figure. But any figure inclosed within three lines is called a triangle.

XXII. *To describe an equilateral Triangle, viz. one whose sides are all equal, as, for instance, that* (No. 18) *with the given line t s.*

Describe over the line *w x*, which is drawn as long as *t v*, from their terminating points *w* and *x*, small arches, and from the points where they intersect each other, draw lines to the points *w* and *x*.

XXIII. *To describe an Isosceles Triangle, viz. one of which two sides only are equal; as, for instance, the Triangle* (No. 19) *with the given lines p and q.*

Draw the line z equal to the line q; with the length of the line p describe from both extremities of the line z two small arches intersecting each other opposite to it, and draw lines from their common intersection to the extremities of the line z.

XXIV. *To describe a Scalene Triangle, viz. one of which all the three sides are unequal; as, for instance, the Triangle* (No. 17) *with the given lines n, p, q.*

The process is the same as in art. XXI.

XXV. *To describe a Right-angled Triangle, viz. one which has one right angle.*

Draw according to art. XII. two lines to meet

at right angles; and when there are two given lines, make them of equal length with the other two, from the point where the former meet. Afterwards draw the inclined line.

XXVI. *To describe any proposed Triangle accurately.*

Consider the sides of the proposed Triangle as given lines, and proceed,

When the triangle is equilateral, according to art. XXII.

When it is an Isosceles, according to art. XXIII.

When it is a Scalene, according to art. XXIV.

And when it is a right-angled Triangle, according to art. XXV.

XXVII. *To make four Lines meet at their Extremities, as, for instance, those* No. 23.

Let the four given lines be, two of them each

equal to *f*, and two each equal to *g*. Make two of them meet in any optional angle, viz. make an angle and its two sides equal to the two given lines, as here the line *b* equal to the line *g*, and the line *c* equal to the line *f*. Afterwards with the length of the other two lines describe, from the terminating points of the lines *b* and *c* which do not meet, two arches, as here at *d*, and then draw two lines from the point where the two arches intersect each other.

All quadrangular figures vary according as the lines are varied, and according as the angles are greater or less.

XXVIII. *To draw a Quadrangle, viz. a Square whose sides are all equal and its angles all right ones; as, for instance, the Figure* No. 20.

Let *n* over No. 17 be the given line. Draw the line *f* equal to the line *n*; place upon it, according to art. XV. or using the triangular ruler, a line at right angles, and make this also equal in

length to the line *n*, from the point where it meets the line *f*. Afterwards with the line *f* or *n* describe, from the terminating points of the lines *f* and *h* where they do not meet, two arches intersecting each other; and then draw the other two remaining lines.

XXIX. *To draw a Rhombus, viz. a Square, whose sides are all equal, but its angles not right; as, for instance, the Figure* No. 21.

Let the line *k* be the given line. Make two lines meet at a given or optional angle, and proceed as before with the quadrangle.

XXX. *To draw a Rectangle or Oblong, viz. a Quadrangular figure whose opposite sides only are equal, and yet the angles all right ones; as, for instance, the Figure* No. 22.

Let *f* and *g* be the given lines. Draw two lines to meet at right angles, make them of equal length with the two given ones from the point where they meet, and proceed as in art. XXVII.

XXXI. *To draw a Rhomboïd, viz. a Quadrangular figure of which the opposite sides only are equal and the angles not right; as, for instance, the Figure* No. 23.

Let *f* and *g* again be the given lines; and excepting the right angle, instead of which another angle must be formed, the process is the same as with the rectangle in art. XXX. or art. XXVII.

A quadrangle, a rhombus, a rectangle and a rhomboïd have also the common denomination of *Parallelograms*; and the line which joins the two opposite angles of a four-sided figure is called a *Diagonal.*

XXXII. *To draw a Trapezium, viz. a Quadrilateral figure of unequal sides, two of which however are parallel; as, for instance, the Figure* No. 24.

Let *f* and *g* (No. 22) be the given lines. Place the shorter line exactly on the middle of the longer one, according to art. VIII. After-

wards draw on that point, as here at *h* and *k*, lines at right angles; make each from the greater line equal to the distance at which the short line is to be, and join the two points with a line. Then draw the two inclined lines.

Whenever, in any four-sided figure of unequal sides, these sides are all unequal, such a figure is usually called a Trapezoïd.

XXXIII. *To draw an irregular Polygon, viz. a Figure of more than four unequal sides; as, for instance, the irregular Pentagon* (No. 25).

Draw the lines and angles in proper succession, viz. First draw a line of the given length, form at its extremity one of the angles, make its yet undetermined side equal to that of another of the given lines, and form again at its extremity one of the given angles, and so on.

To copy such a drawn polygon accurately, it must be divided into Triangles, such as those

marked with dots (No. 25), and these Triangles must be copied in regular succession.

XXXIV. *To draw a regular Polygon, viz. a Figure of more than four sides, which, as well as the angles, are all equal; as, for instance, the Pentagon* (No. 26).

The easiest way, when no importance is attached to the sides being of more or less considerable length, is to describe a circle, to divide this circle into as many equal parts as there are sides required, or as the Polygon is to have angles, and afterwards to join these points of division by straight lines.

A circular line, which is also called a periphery or circumference, is such only when in whatever part of this line we suppose a point, that point is every where at the same distance from a point in its middle. This latter point is called the centre. The distance of the centre from the circumference

is called the Radius; the distance of any point of the circumference to another point in the same, in the direction through the centre, is called the Diameter; but if the direction be not to the centre, it is called a Subtense or Chord.

XXXV. *To draw a circular Arch through three given Points which are not in a straight Line; as, for instance, through the Points l, m, n* (No. 27).

Describe from *l* and *m*, with the same opening of the compasses, small arches intersecting each other, as here at *k* and *p*, and likewise from the points *m* and *n* similar arches intersecting each other, as here at *q* and *r*. Afterwards draw through these points of intersection *k*, *r* and *q*, *r* two lines, and the point where these lines intersect each other is the centre for the circular arch.

The same process takes place when in a circular arch the point, from which the arch itself

has been described, is to be found, viz. by supposing three optional points on the same.

XXXVI. *To draw a regular Polygon upon a given Line; as, for instance, the Pentagon* (No. 26).

Let *s t* be the given line. Draw upon it, as here at *t*, a line at right angles, and describe with its length the circular arch *s t*. Then divide the length of this arch between the right angle, as here *s v*, into as many equal parts as the figure is to have angles, here therefore into 5; take whatever polygon it may be, the width, as here from *v* to the point where there are still four parts remaining, and carry it, as here from *v* to *w*, further upon the arch. Then seek in *s t* and *w* for a point on which to rest the end of the compasses in order to describe the curve line which goes through the points *s*, *t*, *w*, and place the line *s t* upon it, after having actually drawn the curve line. The rest is easy.

The width which is to be added to the divided arch consists, consequently, of the parts made, in the pentagon of one, in the hexagon of two, in the heptagon of three parts, and so on, so that there be always four parts left remaining.

XXXVII. *To draw an Elliptical Circumference, such, for instance, as that* No. 28.

Draw a line, and placing the compasses on it describe two arches, each of which passes through the centre of the other. Afterwards with the length *x z* describe, upon and under that line, two equilateral triangles, and lengthen, as may plainly be seen here, the sides of these triangles; this gives the limit of the arches required to round it, whose centres are in the angular points of the triangles above and under No. 26.

XXXVIII. ***To divide a Line into equal parts, so that there shall be left a certain length; as, for instance, the Line b*** **(No. 29)** ***into two equal parts and two thirds of such a second part.***

Draw any line at option, somewhat longer however than that which is to be divided; open the compasses so wide that, as there are to be two equal parts, this width may be carried twice upon the line, as is actually done here at *b*. Afterwards, to get at the two thirds, divide one of the aforesaid two parts into 3 equal parts, and add two of them to the former two parts. Then, with the whole length, as has been done here, describe an equilateral triangle, take with the compasses the terminating points of the given line, and carry the length of this line, as here from *c* to *d* and from *c* to *f*. Lastly, draw the line, as here *d f*, and intersect it by placing the ruler against the point *c* and against the dividing points of the

line under *d*; thus this line, which is equal to the given line, will be divided as required.

The same process may take place whenever a line is to be divided into a certain number of equal parts without any addition. But with regard to this addition itself, it may be observed that one of the greater parts is always divided into as many equal parts as the number last mentioned in the addition; for instance, with three fifths into five; and as many parts are always to be added as mentioned by the number which is first uttered, for instance with three fifths three.

XXXIX. *To make a Straight Line as long as a Curve Line.*

Divide the curve line with dots into parts, the terminating points of which are pretty near each other, and carry these parts upon the straight line in the same order in which they follow each other.

The smaller the parts on the curve line, the

more accurate is the process ; only they must not be made over small.

XL. *To describe a Curve Line, of the same length as another Curve Line.*

The process is the same as in the preceding case.

CHAPTER III.

MODELLING WITH CUT PAPER FIGURES.

Preliminary Observations.

1. The proportions here given refer only to the objects represented on the plates. They are of indispensable necessity, and carefully to be attended to until the capacity to determine them has been acquired.

2. Whenever height, length and breadth are stated in general, these dimensions are to be understood of the main parts of the given object. When the dimensions of the smaller parts are meant, those parts are expressly mentioned.

3. Care must be had to have a distinct notion of the sides within which the object to be repre-

sented is inclosed. This is the main point. And before you begin to draw, consider how much paper is required, and how it is best made use of.

4. The dotted lines always direct the folding, but they must not be dotted on your own drawing. If you wish particularly to mark them, they may be drawn finer than the others, or distinguished by little strokes.

5. Begin with making the given models with white paper only, and as simple at first as possible, leaving out small and less necessary parts. Adhere at first to the size here stated, and compare your own flat paper figure with the one here given.

6. Be not over hasty. Read only as much of the directions at once as may be performed in a little time, and endeavour to imitate directly whatever you apprehend clearly.

7. But should you not succeed at once, be not deterred; try once more with greater attention,

seek for the cause of your failure, and avoid the mistake into which you had been betrayed. Repeated attempts are sure to be crowned with success.

A Die. Plate. 1.

With the flat paper figure *b c*. Plate 12.

Proportions.

The Die is inclosed within six quadrangular sides, consequently it is as high as it is long and broad.

Drawing.

1. Draw the line *b c*; mark off from *b* to *c* three times one of the sides of the Die; place on the two middle points two lines at right angles and produce them downwards.

2. Draw from the points *b* and *c* two straight lines at right angles; make them from *b* and *c* as long as one of the sides of the Die; and join

them by a line, so that you obtain, as here, three quadrangles.

3. Afterwards draw, which now will be very easy, the three remaining quadrangles, and leave in the proper places the edges or margins requisite for joining.

Construction.

Cut out the flat paper figure. If the paper be large, do it first conjecturally, but afterwards very accurately. Both are easy. You need only observe the lines which here are drawn through and not dotted on purpose. Care must be had not to miss any of the main surfaces nor any of the edges left for joining. The latter may even be left pretty large. Afterwards proceed to the folding. This too is not difficult. You are guided by the dotted lines by which it is clearly pointed out. You then clip the edges for joining, if needful, a little, and examine whether all the parts will form a correct whole. The points

d, *c* and *f*, for instance, must meet exactly. When this is the case, the edges are done over with glue or paste, and joined in such a manner as not to be perceptible on the outside.

A Chair. Plate 1.

With the flat paper figure over *g h*. Plate 12.

Proportions.

Without the back, as high as large and broad. The back itself as broad as high. But the seat is somewhat narrower than long. On considering the flat paper figure attentively, you find over *g h* three quadrangles for the feet, a rectangle over the middle one for the seat, and over this seat another quadrangle for the back.

If the seat is to be a little narrower behind, and the back consequently a little less broad, the former is not a quadrangle but a trapezium.

The thickness of the feet in the upper parts is about one sixth of their height; but in the lower

parts only half of a sixth of their height. The thickness of the seat is about the fifth of its length. Several parts of the back, in front and on the side below, are as thick as the upper parts of the feet; and the back on the side above is as thick as the lower parts of the feet. The upper cross piece of the back is as high as the seat is thick in front.

Drawing.

1. Draw the line *g h*: erect upon it three successive times the front line of the seat, and place on the points right angular lines, the two exterior ones about as long as the breadth of the seat; but the two middle ones a little more than three times as long as that breadth.

2. Take the height of the seat from *g* to *k*, and from *h* to *l*, and drawing the line *l k* determine the three adjoining quadrangles. Afterwards draw, which will now be very easy, the middle rectangle and the upper quadrangle. The for-

mer is lower than the quadrangle by the thickness of the lower side of the back.

3. Draw under the line *l k* a line parallel to it at a distance equal to the thickness of the seat, and extend upon it the thickness of the upper parts of the feet to the right and left of the lines right angularly drawn upon *g h*. Then in the same manner mark off upon the line *g h* the lower thickness of the feet, and draw the inclined lines by which the feet are distinguished.

4. Having attended to the given proportions and first drawn parallel lines, delineate the open work of the back, and, as here, its lateral breadth. Lastly, mind the margins for joining.

Construction.

After the flat paper figure has been cut out in the rough, fold it so that the sides not marked come to lie one upon the other, excepting however the back, the marked side of which comes to lie upon the marked side of the seat.

The figure then is cut out more accurately, so that the feet stand free; the open work of the back appears, and margins of proper breadth are left for joining.

If the parts now meet exactly, as for instance the point *l* the point *m*, proceed to glueing so that the margins be not visible on the outside. The back must be a little inclined.

Observatiǒns.

Should coloured paper be preferred, brown, spotted, or streaked like wood, will be most suitable.

If the upper cross piece of the back is to project a little sideways as on the chair in the first Plate, or as it is to the right of *d*, draw and cut out separately a narrow rectangle like that at *t*, and fix it properly. It may be clipped after it has been joined.

A Table. Plate 1.

With the flat paper figure over *n p*. Plate 12.

Proportions.

Two thirds as broad as long, that is to say, if you allow two parts to the breadth, the length must have three. The height is a little more than the breadth. If this height is to be proportioned to the chair, half of the height of this may be added. The upper cross ledge of the plinth has nearly a fourth of the height of the plinth itself. The lower ledge is half as much raised from the bottom.

The breadth of the upper parts of the feet is about an eighth of their height up to the upper cross ledge; lower down they are less thick. The drawer has half the height of the cross-ledge, and its ngth is double its breadth. The table board projects on all the four sides half the height of the upper cross ledge.

Drawing.

1. Draw the line *n p*; take upon it from *n*, first the length of the pedestal, then its breadth, then again the length, and once more the breadth, and erect at these points perpendicular lines as long, or even a little longer, as the pedestal is to be high.

2. Make the line *n q* and *p r* of the height of the pedestal; draw the line *q r*, and under it parallel to it at the proper distance another for the upper cross-ledge. Afterwards draw the feet, as before for those of the chair.

3. Determine by taking correctly *n* and *p* the lower cross-ledge, and observe the margins for joining.

4. Draw the rectangle for the table board with small margins at the four sides, either for joining or to represent the thickness of the table board.

5. Draw as at *s* and *t* the pieces requisite for the drawer. The part *t* is fixed to it in front.

Construction.

After having made a die or a chair, it is easy to cut and fold the flat paper figures of a table. The feet may be cut out after the folding.

If the edges correspond exactly, join first the parts of the pedestal. The point *q* must here correspond with the point *r*. Afterwards fasten the pedestal to the board, so that the latter projects.

And, in order that the drawer may not sink behind on being put into the table, fasten at the upper part of the plinth, a small slip of paper on which the drawer may rest. A little grain of seed put in front in the middle will serve as a knob for pulling.

Observations.

If coloured paper be employed, brown of the

colour of wood is the most suitable. The table board may be of a different colour; you may, for instance, give it the appearance of being covered with oil cloth. Should the making of a separate drawer give too much trouble, a slip of paper, like that at *t*, upon the upper cross ledge, may supply its place.

A Chest of Drawers. Plate 1.

With a flat paper figure like that of the Table, only that the feet are very short, and that there are several drawers.

Proportions.

Two thirds as broad as long, and nearly as high as broad. The top projects but little. The height of the drawers is according as there are two, three or four of them. The height of the feet is about a seventh of the height of the chest of drawers.

Drawing.

After having drawn the four rectangles, as if it were to be a table, and taken one of them for the sliding in of the drawers, proceed as on the left below Plate 13 over *v*.

1. The distance of the drawers, or rather of the openings for their sliding in, is determined according to the directions in Art. IX. of the previous exercises.

2. Draw, according to the directions given respecting a table, the feet, the top, and the drawers; and attend to the margins for joining.

Construction.

Like that of a table. Instead of real drawers, narrow rectangles may be fixed.

A SENTRY-BOX. Plate 2.

With the flat paper figures over and under *w x*. Plate 13.

Proportions.

As long as broad; but laterally, or from the front to the back, a little more than one third of the height. The door is half as broad as the breadth, and about five times and a half as high as it is broad.

Drawing.

1. Carry upon the previously drawn line *w x* four successive times the length or breadth, and place lines right angularly upon these points. If the height be determined from *w* and *x*, and a line drawn parallel to *w x*, you obtain four similar rectangles.

2. Draw over two of these rectangles equilateral triangles, and deface their lower lines. Afterwards determine, as here, the door and the small windows as well as the margins for joining.

3. Appropriate, as under *x*, the equally divided rectangle to the roof. This rectangle ought to

be somewhat longer than twice a side of the triangles, and a little broader than the sentry-box itself.

Construction.

When the flat paper figure is cut out in the rough, fold it properly, and afterwards cut it out more correctly, as well as the door and windows.

On joining, the edge over *x* must come exactly upon that over *w*, and the sentry-box must be fixed upon the ground. Then the roof is placed upon it; and the whole is joined in such a manner that none of the margins be visible on the outside.

The roof may be painted red, blue, black, or brown, or covered with paper of any of these colours: but it must be done before it is placed upon the box.

Observations.

The size of this sentry-box corresponds with

that of children's pewter or lead soldiers. It may be less. The bottom is in the shape of a quadrangle or rectangle, and may be contrived with very strong paper or thin pasteboard.

The roof may be represented as made of boards, by means of fine wood shavings cut into small pieces of the breadth of a common goose quill, glued cross ways on each side, and projecting a little one over the other. When sufficiently dry, they may be clipped even with scissars; which is far more expeditious than to cut them separately of equal length.

A Thatched House.

With a flat paper figure similar to that of the sentry-box. Plate 13.

Proportions.

The sides double the length but only half the

height of the breadth of the thatched house. The remainder is evident from the

Drawing,

which is exactly like that of the flat paper figure of the sentry-box, only altering the length, breadth and height, making the door somewhat higher, and leaving out the side-windows. The roof and the bottom must, of course, be longer and project a little.

Construction.

It is nearly the same as that of the sentry-box. The roof may be painted, or actually covered with thatch in the following manner: Cut good straw of a fine yellow colour into small pieces somewhat longer than the length of the roof downwards split them, do the hollows over with paste or glue, and fix them one close to the other on the roof, beginning by the gable end, so as to be all

even at the top. When sufficiently dry, clip them equal with a pair of scissars, and observe that they project a little. Lay also some straw cross ways at the top. See Plate 4, above to the left.

A Pigeon-house.

With the flat paper figures Plate 14, and under *K* Plate 15.

Proportions.

The bottom and side-walls are five equal quadrangles. The roof consists of four equilateral triangles. The door is about half as high or as broad as one side of the quadrangles. Each of the four perches is about as long as the door is high, and a fourth as broad.

The pole, which goes below through the bottom of the pigeon-house, is altogether four times as long as the house is broad; its lower end is a little

thicker than the fourth of this breadth, but the upper end not so thick.

The ground of the base is a quadrangle which has double the length or breadth of the pigeon-house; but the sliding ledges are full as long as the building is high without the roof, and about a fourth as broad.

Drawing.

1. The flat paper figure of the building. First draw the line *b c*, and set off on it the breadth of the house four successive times; then draw, as here, five adjoining quadrangles, the undermost of which forms the bottom. After this determine the door and perches as well as the round hole in the bottom for the passage of the pole; the spot for this hole is found by drawing from one angle to the other in the direction of the centre two lines that shall intersect each other. Attend likewise to the margins for joining.

2. The flat paper figure for the base. Having

given to the line *d f* its proper length, draw against and with it a quadrangle and determine its centre by means of two diagonals. Then set off on the middle of each side of the quadrangle the breadth of the sliding ledges, and placing the ruler on the two opposite points, draw lines, and at the same distance two more for the sides of the sliding ledges. Then make these of the requisite length, and observe here and there, as at *g*, the inclined segments and the margin for fixing the sliding ledge on the pole.

3. The flat paper figure for the pole. This consists merely of a slip of paper about as long as the pole is to be high, and in its broadest part a fourth as broad. It is represented on a small scale at *h*.

4. The flat paper figure for the roof. See under *K* Plate 15. Only draw, as here, four adjoining equilateral triangles. But each side of these triangles must be somewhat larger than the breadth of the pigeon-house, else the roof

would not project sufficiently; and the margin for joining must not be omitted.

Construction.

Begin with the flat paper figure of the pigeon-house; after having cut and folded it in the rough, fit the edges *b* and *c* upon each other, and then fix the four walls of the building on its bottom. The margins are all folded inwards: but the upper ones are only a little bent and kept rather erect to facilitate the roofing.

The roof may be painted, or covered cross-ways with wood shavings, like the sentry-box.

Afterwards proceed to the pole and the pedestal. To make the former, roll the aforementioned slip of paper to its proper thickness, beginning at the sharp-pointed end, as here *h* to the left, opposite, and fix it; if you wish to paint it, the most suitable colour is brown.

When the base or pedestal is ready, fix the thicker part of the pole on the middle of the bot-

tom, and on the pole itself the sliding ledges; and afterwards insert the pole through the round hole at the bottom into the pigeon-house.

Observations.

The roof is best painted; the ground itself on which the pigeon-house stands may be painted gray, and covered here and there with moss, particularly where the sliding ledges may happen not to fit exactly.

Instead of making the pole of paper, you may take a young straight twig properly dried and covered with bark. A small pearl of wax or a juniper-berry may serve as a knob on the roof.

AN INK-STAND. Plate 3.

Chiefly with the flat paper figures of the die.

Two dice, like the one on the first Plate, give one the ink-glass, the other the sand-box. Describe therefore on the flat paper figure of each

in the centre of the surface which is to be uppermost, a circle, and this cut out will be the hole of the ink-glass ; pricked through with a fine pin, it will give the holes for the sand to pass through the sand-box. But to find the middle points for the circular line, draw two diagonals on each of the two quadrangles.

A chest, like the table drawer, will serve for the stand itself; only the front ledge must be exactly like the back one. The ink-stand must not be too small, that there may be sufficient room for the ink-glass and sand-box ; the latter may be rendered moveable by means of an uncovered die, into which it might be placed ;, but this is rather difficult and tedious to contrive.

Observations.

The ink-stand may be painted, or made with coloured paper. A grain of seed or a very small wax pearl may be fixed with a little glue or gum against the sand-box to serve as a knob.

A Stove. Plate 3.

With the flat paper figures over *l m* and close to *q*. Plate 15.

Proportions.

This stove, independent of the two supporters, consists of two parts. The lower part is as high as long, but only two thirds as broad. The upper is as high as the lower part, but about a tenth or twelfth less long and broad. The height as well as the breadth of these two parts consequently are determined by the given length.

The height of the two supporters is a fourth of this length. But the hearth-plate on which the lower part of the stove rests, projects but little, say as much as the upper is less broad than the lower part. The door-shaped space in the upper part is a rectangle, which on both sides and at the top recedes about a third of the front breadth of the upper part.

Drawing.

1. Take twice upon the previously drawn line *l m*, as here, the lower length and breadth; erect on these points perpendicular lines, and by determining the height from *l* and *m*, and drawing a line, finish the four lower rectangles.

2. Draw a line parallel to the common or general upper line of these rectangles at a distance equal to what the upper part wants of the length and breadth of the lower one; take, as here at *n p*, the breadth of the upper part exactly in the middle of the lower one, and then draw the rectangles for the upper part in the same way as for the lower one.

3. Draw over the rectangle close to *n p* another rectangle equally broad, but as high as the stove is long at the top, as well as the two rectangles for the door-shaped openings. Afterwards determine also the mouth of the stove, the

round hole for the flue, and the margins for joining.

Determine, as at *q*, the flat paper figure for the supporters, once and once again, afterwards a small rectangle to be rolled up for the flue, and still another rectangle to be folded for the exterior circumference of the mouth of the stove. Draw also the before-mentioned hearth-plate, like the table-board.

Construction.

The flat paper figures are first cut out in the rough, according to the undotted lines, and then folded according to the dotted ones. In joining, the point *l* must lie exactly upon the point *m*, and all the margins are put under and concealed. When the stove is fixed on its plate and provided with the flue and the circumference of the mouth, it is placed on the supporters, and along with these, fastened upon a piece of stiff paper or thin pasteboard in the shape of a rectangle.

The stove may be painted black with fine white cross lines imitating Dutch tiles, and this is best done before joining.

Observations.

The oblong rectangle of thin pasteboard on which the stove is to be fixed, may be folded in such a way that one part represents the floor, and the other the wall of a room, distant one from the other only so as to make a right angle. The stove will then be placed as stoves usually are in Germany.

A Watch-stand. Plate 3.

With a flat paper figure similar to that of the stove.

Proportions.

Distinguish the upper, middle, and lower part. The middle one, as the main part, is as broad as long, but about a fifth of its length higher than long.

The lower part is only a fourth as high as the middle one, and recedes about a third of its height. The upper part is rather sloping, and as high as the lower one.

Drawing.

Excepting the hearth-plate and the two supporters of the stove, the drawing is the same as that of the stove, with this difference only, that what is the lower part of the stove is here still lower, and in the middle one a circle must be described for the dial.

The upper part of this watch-stand must be drawn separately. Describe a circular or curve line like that round the point *r*, Plate 16. Mark off upon it the lower length or breadth of the upper part four successive times, and from these points draw lines towards the centre.

Afterwards draw the lines, like that *s t*, and others parallel to them at the proper distance. Lastly draw, as here, the quadrangle, and mind th margins for joining.

Construction.

Having drawn the dial and the hands on a separate paper, fix it in the interior of the watch-stand, which may be painted black, brown, grey, or spotted, and have additional ornaments made with a pen or pencil.

A Small Staircase. Plate 3.

With the flat paper figures over and under *v w*. Plate 15.

Proportions.

The steps here are the main thing. They are as high as broad, and four times as long. The side pieces are only of such a breadth that the steps do not project.

Drawing.

1. Draw the line *v w* as long as each step, erect straight lines on the points *v* and *w*; and if you

want four steps, set off from *v* and *w*, four times the slope of a step, then once more its breadth and afterwards its upper thickness. This slope is determined as at *x*. viz.; two lines are drawn right-angularly one upon the other; then set off from *x* to *z* the height of the step, and from *x* to *b* its breadth, and afterwards draw the line *z b* as its slope.

2. Join the points just obtained upon the lines over *v* and *w* with cross lines, also dotted here, and then draw by means of parallel lines the breadth and thickness of the side pieces, whose breadth is found by determining, according to Art. V. of the previous Exercises, how far the point *x* is distant from the line *z b*.

3. Determine likewise the slope of the side-pieces at their extremities, as at *w*. The point *d* in the prolongation of the line over *w* is here equidistant from *c* and *w*.

4. Draw three times more such a step separately like the two upper narrow rectangles over

v w, with margins on three sides for joining. Afterwards indicate the supporters or props, as at *f*.

Construction.

Cut the flat paper figure over *v w*, as marked here by the undotted lines, give it the proper breaks for the side pieces and the upper step, afterwards cut and fold the remainder, viz.: the three separate steps and the two supporters.

When all is properly joined, the stair-case viewed sideways must look as it does on the third Plate.

The steps might also be contrived thus. Determine the height and breadth of the steps four successive times, as under *d*; then fold this flat paper figure in a zigzag, and join it so as to form a whole with the figure over *v w*.

Observations.

On taking twice from *x* the breadth of a step

upon the line close to *b*, and describing an arch as here, you obtain also the slope for two steps, by drawing this sloping line itself. Suppose therefore you had delineated a flight of steps as under *d*, and wished to determine the height of the rectangle over *v w*, the height of two steps would be that of the sloping line, and that of four steps double its height, and so on in proportion.

A Small House with Gable Roof. Plate 4.

With the flat paper figures over *f g* and over *h*. Plate 16.

Proportions.

Only two-thirds as broad as long. The height up to the roof half the length of the building. The gable side of the roof is an equilateral triangle.

The height of the door is double its breadth. The windows in their exterior circumference are quadrangles, a little less in height than the door

is broad. The chimney has half the breadth of the door, and the height and length of a window. The roof and the bottom project a little.

Drawing.

First Case: When the gables at the top are not broken.

1. Draw the line *f g* and take upon it successively the length, the breadth, then again the length and again the breadth of the building; erect on these points lines at right angles, and determine its two long lateral flanks after having first taken from *f* and *g* the height of the building up to the roof.

2. Draw the two equilateral triangles; supplying the lower line in your mind, and then the door and windows, either as here or according to any different plan of your own; and observe the margins for joining.

3. Determine the two conjoint rectangles for the roof, as between *k* and *h*, neglecting the

sloping lines. The length of these rectangles is little more than the length of the building, and the height of each a little more than one of the sloping lines of the gable.

Second Case: When the gables are broken at the top.

1. Draw all as 1 and 2 in the former case, and afterwards shorten every gable side as below *l. m n* is here drawn so that *l m* is equal to *l n*.

2. Determine the bottom and roof; the latter as between *h* and k; it is delineated as at 3 in the first case. Then take from *p* to *q* the shortening of the top, from *p* to *r* and *s* the length *l m* or *l n*, and draw the lines *q r* and *q s*. On describing with *q r* from *q*, and with *m n* from *r*, small arches intersecting each other at *t*, and joining these points with lines, you obtain the equilateral triangle *q r t*. The opposite side is drawn in the same manner, and proper attention paid to the margins for joining.

3. Draw, as under *v*, the flat paper figure for

the chimney, by first taking twice upon one line the breadth and length, and erecting lines at right angles, and afterwards raising to its proper height the line close under *v*. The segments are determined by describing equilateral triangles, the gable side of the roof being such a triangle.

Construction.

After having cut in the rough and folded the flat paper figure of the building, so that the point *f* coincides with the point *g*, fix the roof, then the chimney upon it, and afterwards the bottom. The roof may be painted to represent either tiles or slates.

Observations.

If it be a tiled roof, paint it first red or brown, and then the tiles as below to the right and left on the fourth Plate.

If it be a slated roof, paint it first blue, and then the slates as above to the right and left on the fourth Plate.

Instead of cutting the windows out, they may be painted black, and the sash or casement white.

Instead of cutting the door out and representing it as open, it may be painted as shut. The shutters may be painted in the same way. But both door and shutters may likewise be made with fine wood shavings.

A Cottage.

With a flat paper figure like that of the gable-roofed House.

The proportions and drawing are likewise the same with those of the gable-roofed house.

Construction.

The same as with the aforesaid house; only if the roof is to be thatched, it must be done as to the left at the top, or to the right below, on the fourth Plate. In the former case it is actually covered with thatch, like the thatched house; in the latter it is painted and covered in front of the

gable with wood pieces made of fine wood shavings.

A Barn and Stable.

With flat paper figures like those of the gable-roofed house.

Proportions.

1. The Barn; about two thirds as broad as long. If a cottage be joined to it, the barn, must be longer, broader, and higher than the cottage: the door is as high as broad, and very large.

2. The Stable. Twice as long as broad, but low, and not so high as the cottage, if this be joined to it. The windows as high as broad, and rather small.

Drawing and Construction.

The same as of the cottage. The barn-door may be contrived like the door of the gable-roofed house.

Partition Wall made of Planks or a Palisade. Plate 5.

The flat paper figure is the same as under *w*. Plate 16. But at the top there is a separate slip of paper crossways, to look as in the middle to the right on the fifth Plate. Such a paling or palisade may also be contrived as to the left on this fifth Plate.

A Small House with a Sloping Roof. Plate 4.

With the flat paper figures over *x x*, Plate 16 and over *b c*, Plate 17.

Proportions.

Two-thirds as broad as long. The height up to the roof half the length of the building. The slope of the roof on the narrow side is an equilateral triangle. The height of the door is double

its breadth; every window is two-thirds as broad as high.

Drawing.

The flat paper figure *x z* is only half of the lower part of the house; the other half must be supplied in the mind. The drawing itself is not difficult. First, take twice the length and breadth upon the line *x z*, and its prolongation, and then draw each of the four large rectangles.

To make the roof.

1. Draw the line *b c*, Plate 17, a little longer than the length of the building, that the lower end of the roof may project a little; and mark off exactly in the middle, the length of the top of the roof, according to Art. VIII. of the previous Exercises. Afterwards erect straight lines on the last-mentioned points.

2. Take with the compasses one sloping side of the roof on the broad side of the building, and

about as much in addition as the roof is to project on both sides; and carry this length from the line *b c* to the right-angular lines on the same; draw the line which is parallel to this and the two sloping lines, one of which is *c d*.

3. Having first taken the two right-angular lines upon *b c*, draw once more the trapezium over *b c*, as here; and mark at the same time two margins for joining.

4. Opening the compasses as wide as the breadth of the building, and as much in addition as the roof projects on both sides, describe from *c* a small arch, like that at *f*; then from *d* with the length *c d* another small arch which intersects the former, and draw the lines *c f* and *d f*.

5. Draw another such triangle as *c d f* opposite to it, and the two small flat paper figures for the windows in the roof, according to the directions for the gable elevation of the house on the fifth Plate.

Construction.

The same upon the whole as that of the gable-roofed house, only that the roof here must not be covered with thatch.

A Monument.

Consisting below of a die, and above of a truncated pyramid.

Make the die as that in the first Plate, and the pyramid like the upper part of the watch-stand; only with this difference, that it is to be very high, at least three times higher than the die, which must project a little.

The monument may be painted like stone or marble, and decked with other ornaments; and the ground on which it stands may be covered with a little moss.

A Town House.

Like the house with the gable or sloping roof, only higher; with two or three rows of windows one over the other, and a window over the door

A House with a Gable Elevation in front. Plate 5.

A small part of the flat paper figure is between *g. h.* Plate 18.

Proportions.

Three times as long as broad; only one third as high as broad. The gable elevation in front is about half as long as the whole building, and as high as a fourth of this half. The roof itself is as high as the building up to the roof.

Drawing.

Altering only the length, breadth, and height, it is the same as that of the house with the sloping

roof. The length of the gable elevation must be taken exactly in the middle, according to Art. VIII. of the previous Exercises: but the roof of this elevation is to be drawn like *k l*., Plate 20. This line *k l* is twice as long as one of the sloping lines of the gable elevation; but the right-angular line on its middle is obtained, by supposing, after the roof is fixed, a perpendicular line from the sharp point of the gable elevation to the roof, and taking its length with the compasses.

Construction.

The same with that of the two houses with gable and sloping roof. A few steps may be added to the door in front by removing it a little higher up.

A COURT OR GARDEN GATE. Plate 6.

In the way it is represented here, it is that of a palisade or paling. It is therefore drawn like a

palisade, and may be painted; or if cut out, a slip of paper on which the folding door is painted separately, may be fixed in the opening, or this opening may be left as if the gate were open.

A Bridge. Plate 5.

With the flat paper figure at the top. Plate 18.

Proportions.

Three times as long as broad. The radius of each arch is equal to the length of the bridge. The height of the balustrade is a third of the stated breadth.

Drawing.

After the rectangle under *m n* has been drawn of the length and breadth of the bridge, take with the compasses the length *m n*, and describe from *m* and *n* two small arches which intersect each other, as here at *p*.

Place one point of the compasses on *p*, and de-

scribe with the other not only the arch *m n*, but also the arches parallel to this, which serve to form the balustrade.

The same is done with the similar lower arches, and the two balustrades are then drawn more complete. Describe also the two innermost arches with a radius as long as the straight line between the terminating points of each of these arches.

The upper arch consists of a rectangle, which must be bent, and which is as broad as the bridge, but as long as the arch *m n*. Afterwards determine, according to the last but one of the previous exercises, the length of this rectangle, and mark at each of its sides the margins for joining.

Construction.

On joining, each part, like that over *m n*, comes to stand straight, not sloping, upon the rectangle under *m n*, and the upper part must be fixed in such a manner that there be no margin for joining seen.

Such a bridge looks very neat white; but it may

be painted gray, and the balustrade brown. The upper part of the bridge, or rather the road over it, may be represented as paved or covered with gravel. The paper altogether should be very strong and stiff.

An ancient Tower. Plate 6.

With the flat paper figures which are partly in the middle and partly below on Plate 19.

Proportions.

The tower, which, like its main roof, is round, is up to this roof two times and a half as high as thick, and this roof itself is as high as the tower is thick. The height of the upper ledge close under the roof is an eighth of the height of the tower up to it, and the little turrets lower down are about a half higher. Each roof of these little turrets is one and a half as high as the turret itself is without the roof.

The balcony is about a third as broad as long, half as long as the tower is thick, and half as high as the door behind it. The pillars are a third of the height of the tower without the roof, and a fourth as broad as they are high. Their lower part is about as narrow as half of their lower breadth.

The remaining proportions are easily found.

Drawing.

There is here only part of the flat paper figure of this tower without its roof, close to the line *k l*, which is equal to the requisite height. The exact length of this paper figure should be twelve times a fourth of the thickness of the tower.

The aforementioned ledge, which goes round the top under the roof and is separately joined to it, is a little longer than its *substratum* itself or the circumference of the wall on which it is fixed. It is best determined by compressing the rectangle requisite for the tower.

Other windows and doors besides those marked here must be supplied, and the two doors given here must be placed neither higher nor lower than the balcony and the draw-bridge will allow.

Draw the roof for the tower as under *m*, Plate 19. Take with the compasses the length of one of the sloping lines of the roof up to where it projects over the lower part of the tower, and describe a circular arch; afterwards take upon it twelve times a fourth of the lower width of the roof, and from the two extreme points draw lines towards the centre, or here the point *m*. Mark also the margin for joining.

As for the small turrets, draw the flat paper figure for the lower part as at *n*, Plate 19. And for the roof like that of the pigeon-house, taking care, however, to alter the height.

Draw the flat paper figure for the balcony as at *p*, for the drawbridge as at *q*, and for each pillar as at *r*, Plate 19.

The wall consists in its main parts of a rectangle of about a fifth of the height of the tower without the roof, and of at least ten times its length.

Construction.

After having joined all the parts, and fixed the small turrets, the balcony, and the pillars in their proper places, fasten below at the entrance a narrow rectangular slip of paper, to represent that part of the bridge which may be drawn up.

The wall is best made of thick pasteboard covered with paper, which is neatly clipped and trimmed when dry. The whole building may be placed on pasteboard, and painted like an old ruin; but the roofs as if they were slated, or still better, green as if they were covered with copper. Doors and windows may be painted instead of being cut out; some moss placed in different parts, and vanes fastened to the tops of the turrets or flags kept flying as here, to render the whole more conformable to reality.

A Boat.

With the flat paper figure close to *s t*, Plate 19.

Proportions.

The flat bottom is a rectangle six times as long as high or broad.

Drawing.

1. Draw the rectangle over *s t* six times as long as high or broad; prolong the narrow lateral lines on both sides, and resting one point of the compasses on each of these prolongations, describe, with half the length of the rectangle, arches which meet, as here at *v*.

2. Make the length *s w* equal to the length of the arch *s v*, and do the same with the other three similar lengths; determine also, upon the aforesaid prolonged lines, from the point where they are met by the long lateral lines of the rect-

angle above *s t*, the height of the two sides of the boat, here two thirds of the breadth of the rectangle over *s t*; then draw the remainder as here.

3. Mark the margins for joining, as those of *s w*, and others.

Construction.

The two parts here above and under *w* must first be joined; the point *w* must coincide with the point *x*, and the same is to be observed with the opposite part of the flat paper figure.

When all is dry, the other parts are folded according to the curve lines marked here. The bottom and the side pieces must have the proper bend, as over *s*. For the two benches or seats, which are at a pretty good distance from each other, a small slip of paper is to be folded as under *z*.

Such a boat requires particularly strong paper, and may be painted a brown or gray wood colour.

A Sledge. Plate 7.

With the flat paper figure close to *b d*, Plate 17.

Proportions.

These are given by the following

Drawing.

1. Draw the rectangle *b c* and the similar one over *b d*, each only one third as high or broad as long. With the length *b d*, describe from *f* the two parallel arches, distant from each other about a ninth part of *c d*.

2. Draw the line *g h* and its prolongation about a third equidistant from *c d* from *b d*, and also the two lines *g* to the right, and *h* to the left, in the proportion of two thirds of *c d*.

3. Determine all the rest as is clearly seen here.

Construction.

After having cut out in the rough, and lined the paper if it be too thin or coloured, fold according to the dotted line *b d*, and cut according to the undotted lines, holding the two halves of the paper figure one upon the other. Hence there is no occasion for any further delineation of the rectangle over *b d*. Then open the paper, smooth it and finish the folding; all parts here must be bent towards the point *f*. The body of the sledge is soon formed, and the remainder is easily done. The seat in the sledge may be contrived with a narrow slip of paper.

Observations.

If the rectangle over *b d* be drawn on the opposite side like that under *b d*, the folding according to this line *b d* may be dispensed with. The outer seat may also be made separately, and fixed on the sledge. Indeed with a correct eye such

a sledge may be cut out of a card without any drawing.

A Ship. Plate 7.

The main body is treated like a boat, only the flat paper figure is in one part like that at *g*, Plate 20. There is also a piece like that under *g* requisite for the cabin; and for the covering in of this cabin, a rectangle which is a little longer than the cabin, and as broad as the length of its arch on the top.

How the rudder is to be made of wood and fastened, may be seen at *h*, Plate 20. The mainmast is almost as long as the ship; the second mast a little shorter. Each sail consists of a rectangle, whose breadth is two thirds of its length. It is fastened here and there on the mast.

The main body of such a ship may also be made

at both ends like the boat, only the two arches must in one place be made somewhat longer by opening the compasses a little wider, and the cabin made separately must be placed where the shorter arches begin and do not intersect each other.

In this latter case the rudder consists only of a single crooked piece of wood, somewhat like *k*, Plate 21.

A Church. Plate 8.

With flat paper figures like those of the house with a sloping roof and of the upper part of the pigeon house.

Proportions.

The length almost double that of the breadth; up to the roof as high as broad or rather a little higher. The roof of the church and that of the tower are both of that height. Without the roof the tower has not quite that height.

The large windows are three times as high as broad, but the window over the door is only a little higher than broad. The door is but half as broad as high. The window in the tower is a quadrangle.

Drawing.

Like the house with the sloping roof, only with different proportions. Draw the lower part of the tower as above *l m*, Plate 20. The two segments, to fasten it on the church roof, are found by drawing the narrow side of the church roof separately as at *n*, and placing the lower part of the tower exactly in the middle, as may be seen here close to *n*. Each of the aforesaid segments is a triangle like that at *n*.

The roof of the tower, altering only the height, may be drawn like that of the pigeon house; the triangles are all equilateral.

Construction.

The same as of the house with the sloping roof and of the pigeon house. If, besides the roofs of the church and tower, the lower parts of the church are likewise to be painted, it may be done as marked below to the left or in the middle to the right of the 8th Plate.

A ROUND HUT. Plate 8.

Drawing.

The bottom or ground is a circle described with an opening of the compasses equal to the height of the posts or pillars up to the roof, of which the flat paper figure is to be drawn like that under *m*, Plate 19, but so that the arch here be somewhat longer than the circular line, for the bottom to secure the proper projection of the roof.

The posts or supporters, six or eight in number, must be drawn as at *p* or *q*, Plate 18.

Construction.

When the parts have all been cut and folded, the posts are fixed at equal distances from each other on the circular bottom, and the hut is roofed in. The roof may either be painted or actually covered with thatch, and a little moss may be strewed here and there upon the roof and posts.

A Windmill. Plate 9.

The flat paper figures for the house itself are the same with those of the house with the gable roof. The breadth sideways is a little more than that in front; but the height up to the roof is twice the breadth. The trestle or base on which the mill stands is half as high as the mill. The wings or sails are so long that they almost graze the ground.

On the side opposite to the wings or sails is a door; a small staircase leads to it, the steps of which may be made with a flat paper figure like

that over *p*, Plate 20. The two side pieces and the balustrade may be cut out separately. This staircase is fixed to the long beam with which the wheel of the mill turns on the trestle, as may be seen at *q*, Plate 20.

The skeleton of the wings or sails is partly given below to the left of the 9th Plate; but the rods or bars may also go through the middle of the wings or sails, and a small part of the skeleton will then appear as below to the right of the said plate.

The trestle is contrived with small pieces of wood; but it may likewise be made as the base of the pigeon house. The slope of the wings or sails and their axle-tree are also indicated on the 9th Plate.

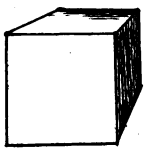
An Arm Chair.

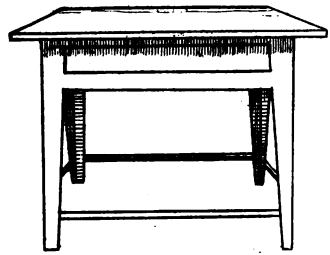
The same flat paper figure as that of a chair; only the three quadrangles one over the other

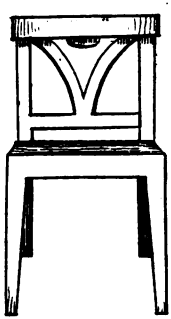
must be made broader, and the two arms must be contrived with the flat paper figure at *r*, Plate 20. The back as well as the seat may be covered with paper of a different colour, to give them the appearance of being stuffed.

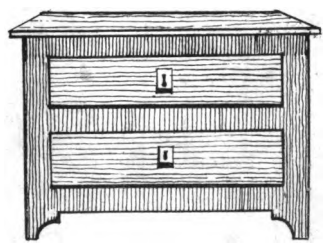
A small Basket.

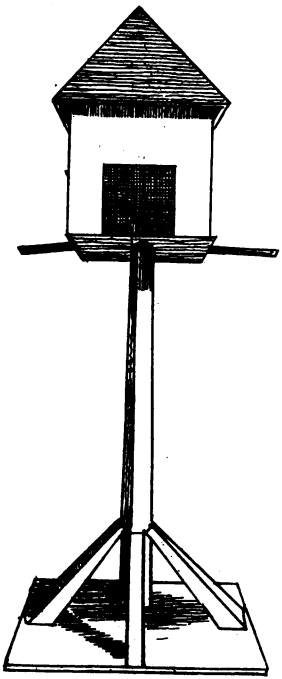
It may be made with a flat paper figure like that under *s* or over *r* on the 16th Plate. The handle may be made separately with a slip of very strong paper.

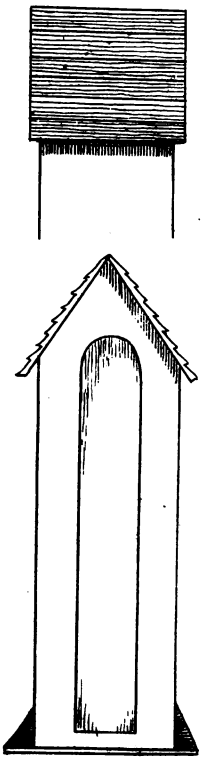


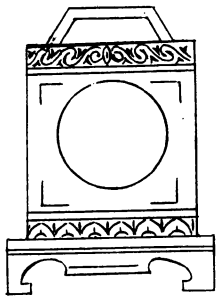


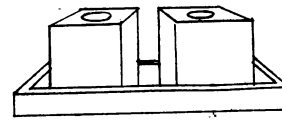


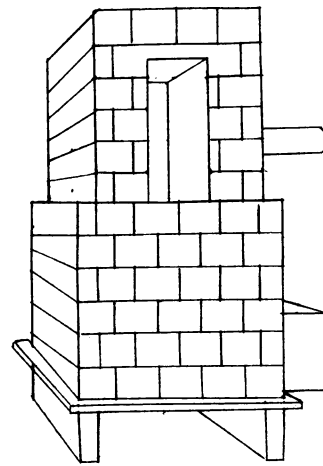


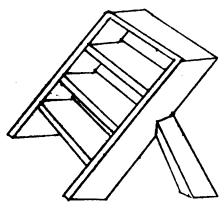


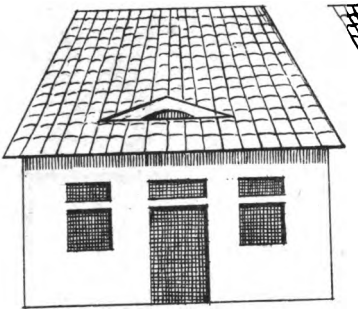


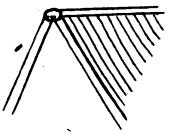


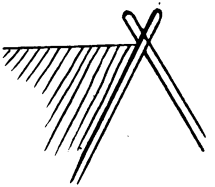


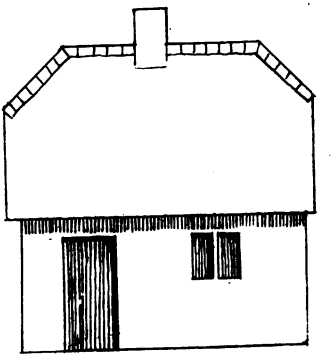


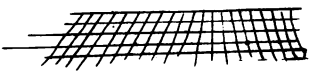


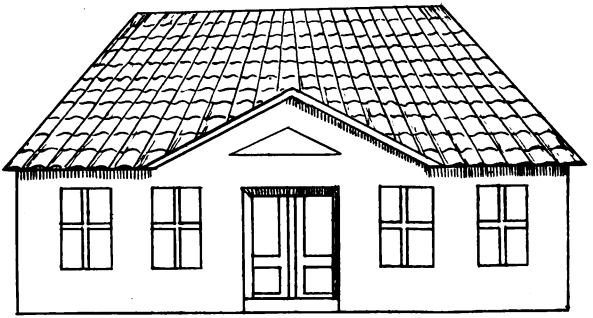


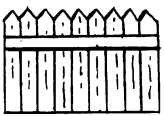


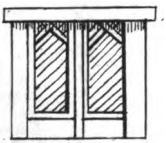


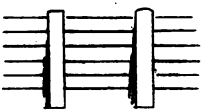


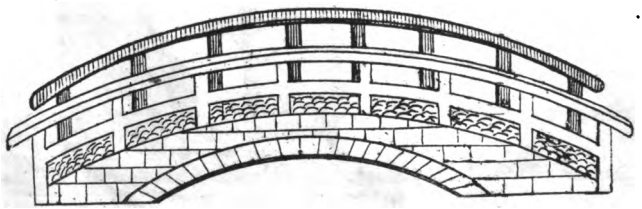


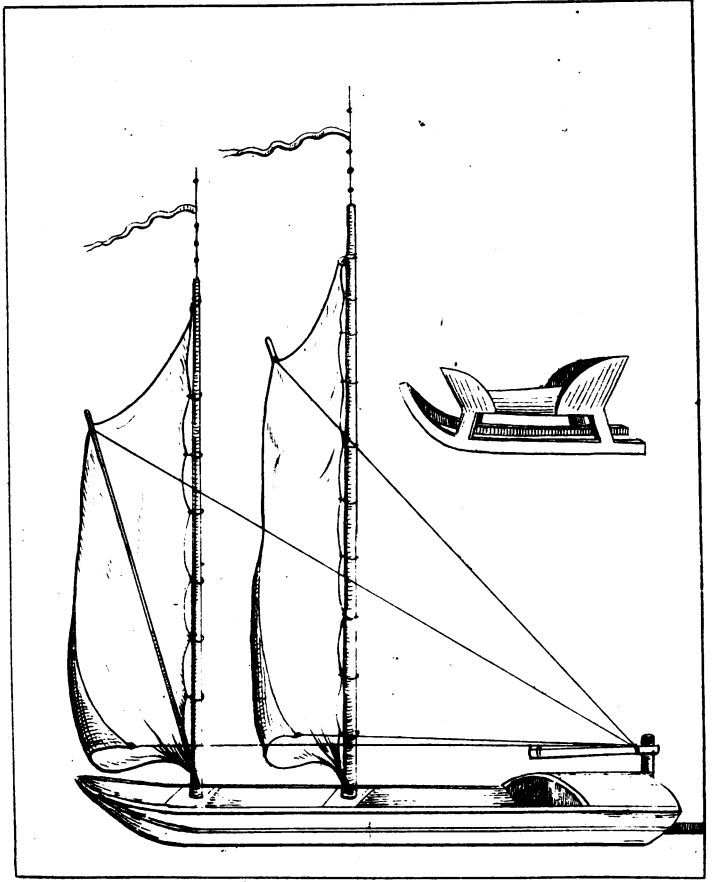


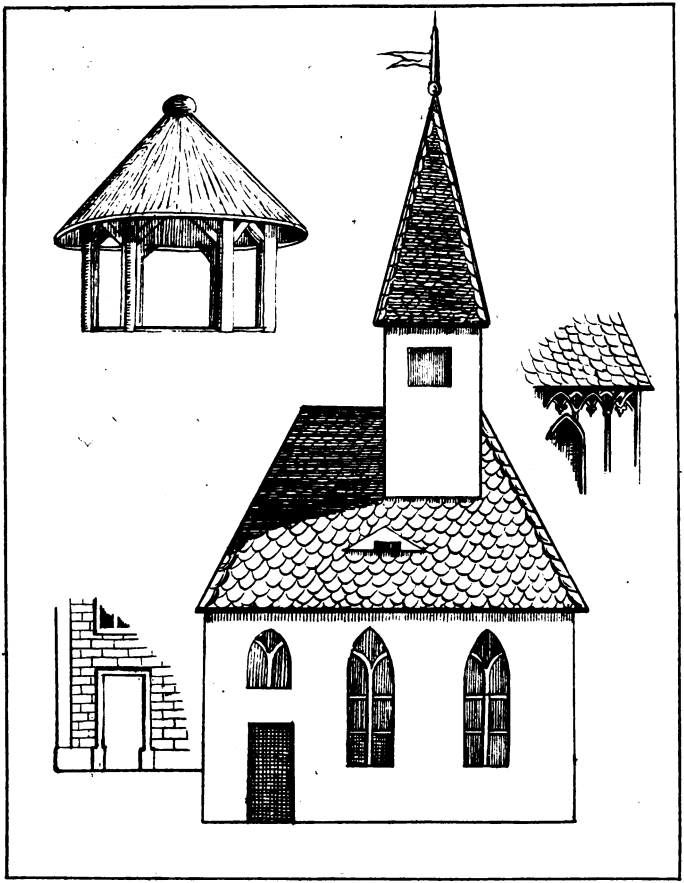


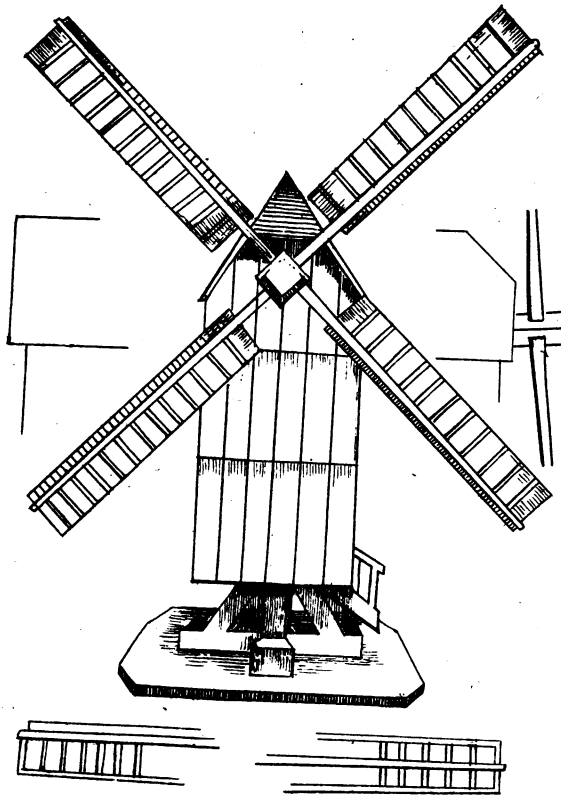


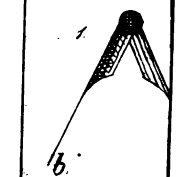


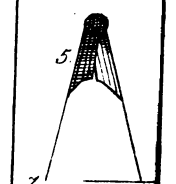


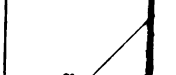


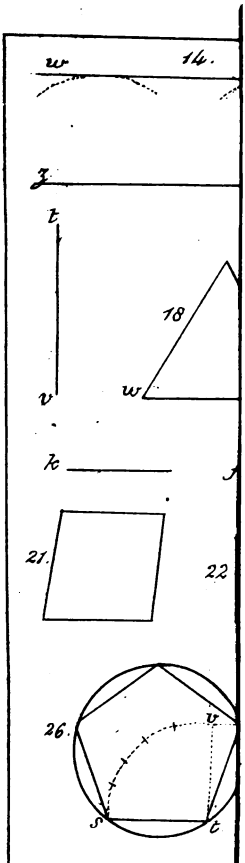












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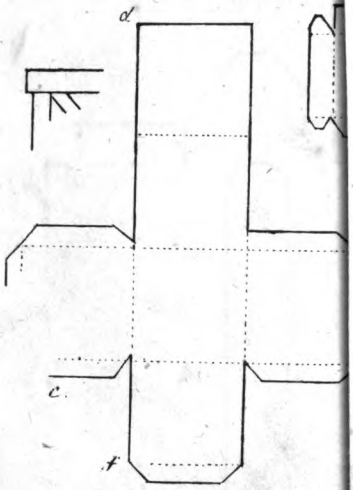

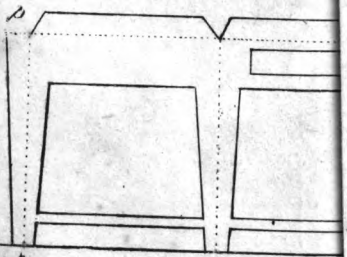

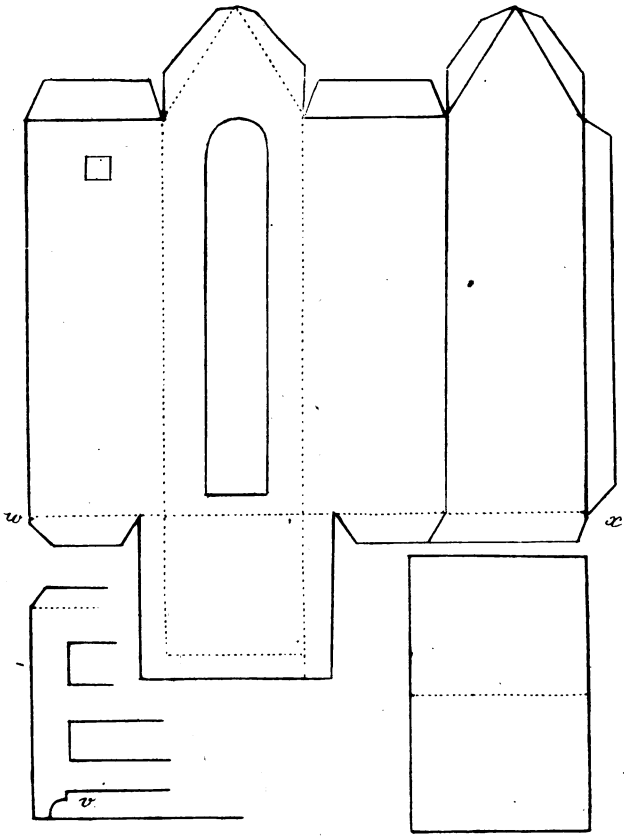

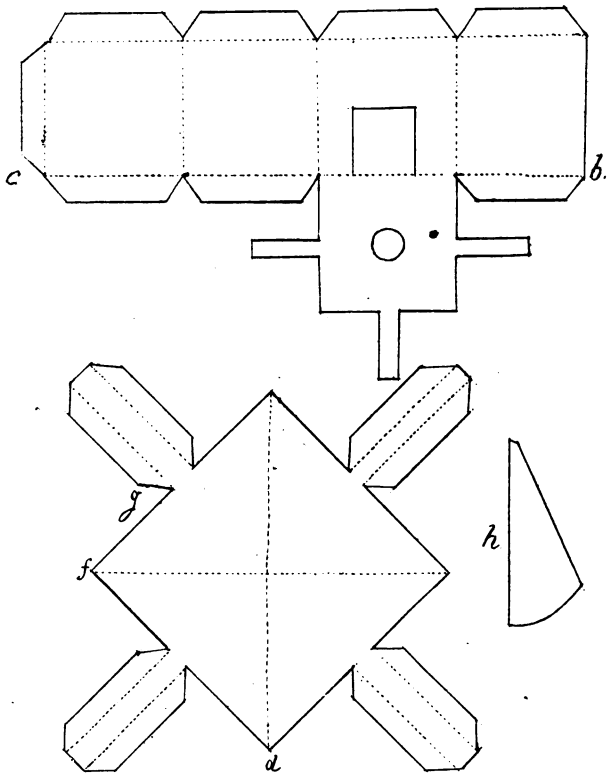

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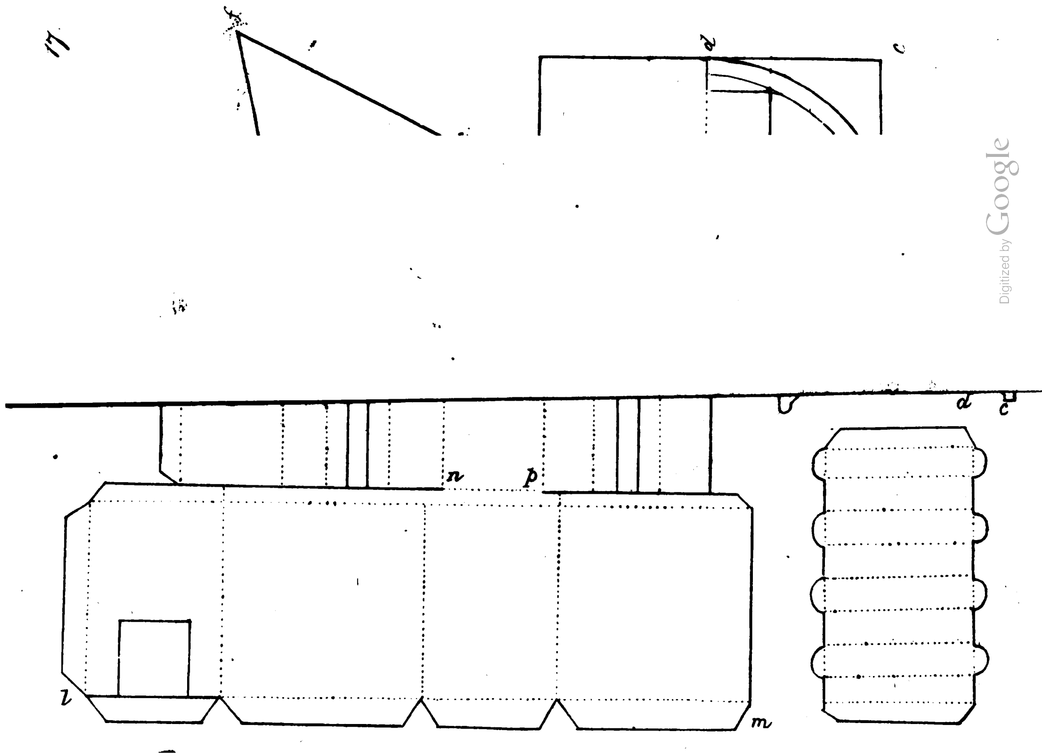

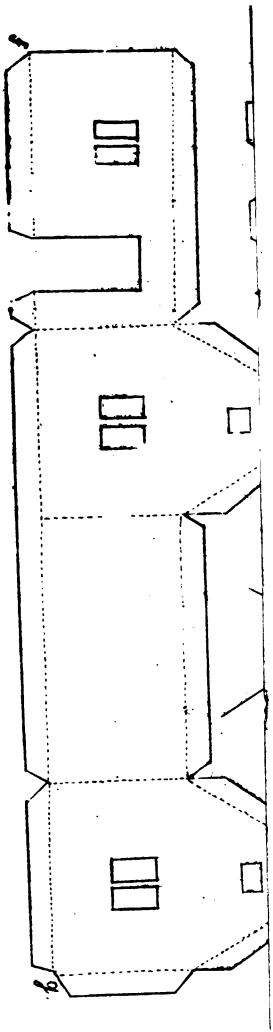

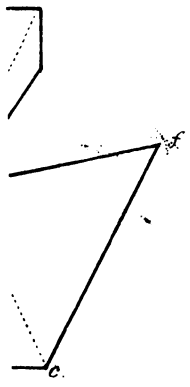

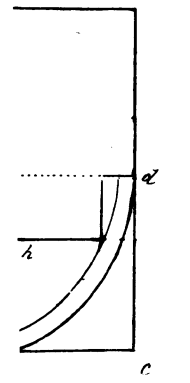

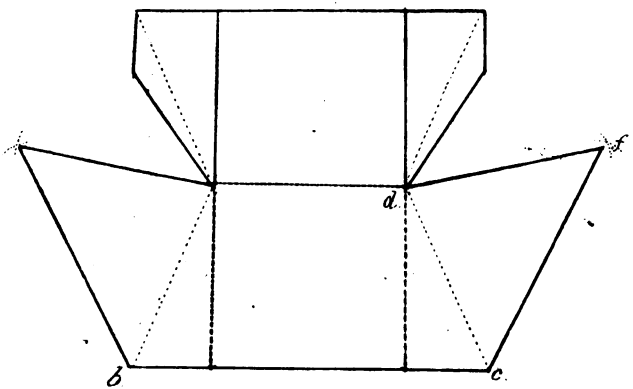

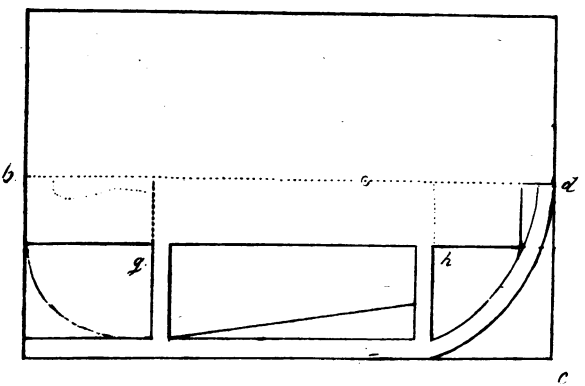

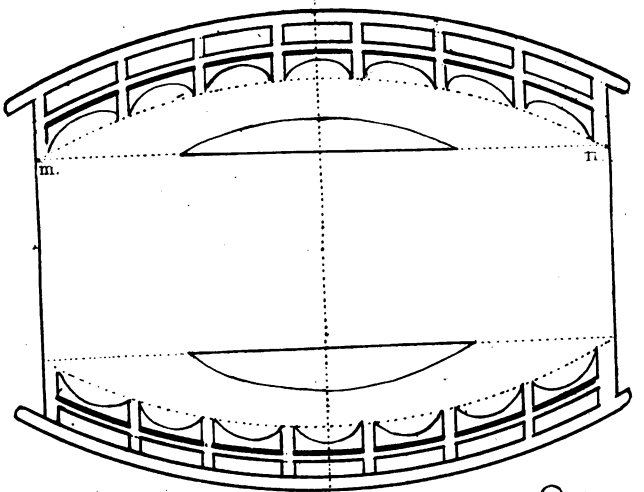

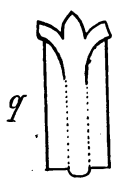

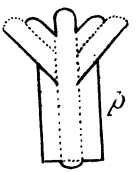

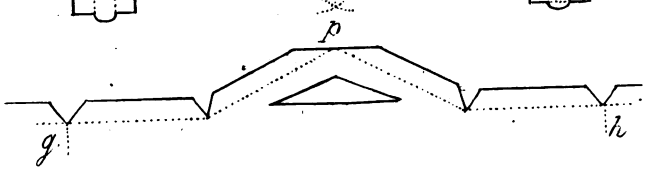

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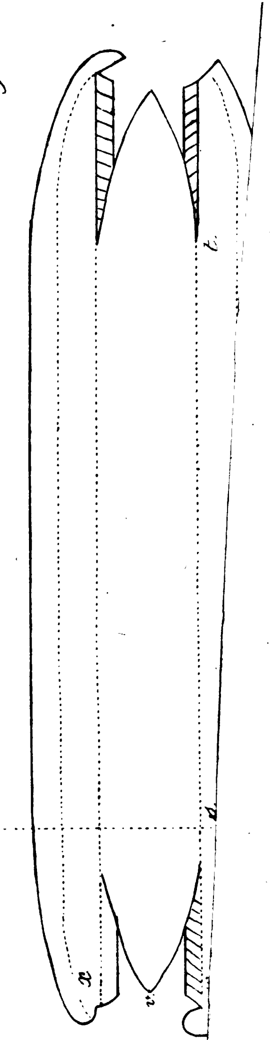

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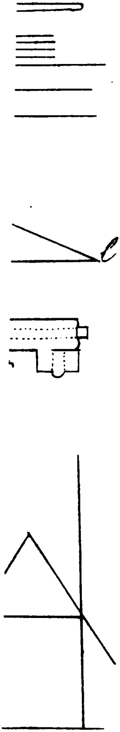

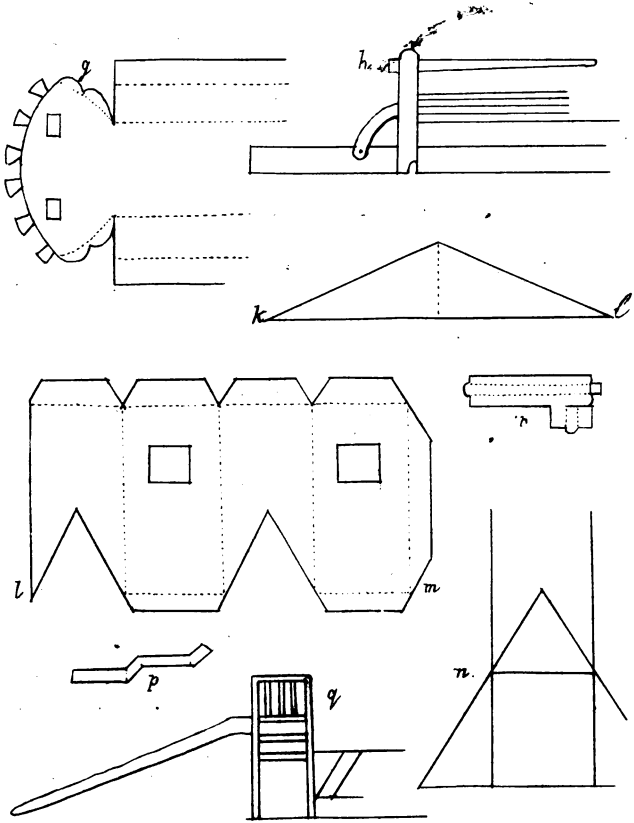

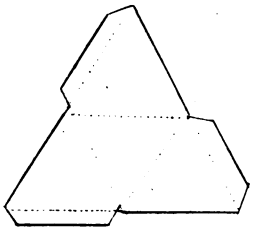

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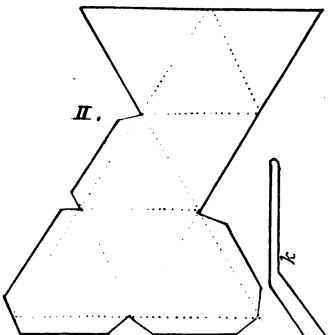

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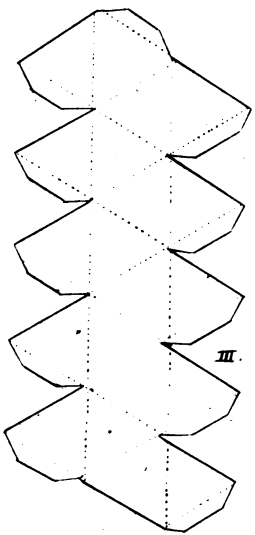

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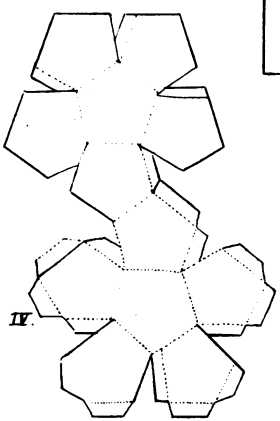

IV.

APPENDIX.

THE flat paper figures of the five regular geometrical bodies. Plate 21.

The flat paper figure I. consists of three adjoining equilateral Triangles, and gives a *Tetrahedron.*

The figure II. consists of eight adjoining equilateral Triangles, and gives an *Octohedron.*

The figure III. consists of twenty adjoining equilateral Triangles, and gives an *Ikosihedron.*

The figure IV. consists of twelve regular Pentagons, and gives a *Dodecahedron.*

The flat paper figure close to *b* on the 10th Plate consists of six adjoining equal quadrangles, and gives the *Die* or *Cube.*

THE END.

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