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ABSTRACT

This book is a reproduction of a monograph written in 1906 to advocate the use of curve stitching in the early school years. The book was originally accompanied by a set of punched cards depicting geometric shapes; each card could be used in the construction of many varied designs. The book's preface is written by Mary Boole, to whom the technique is attributed by the author. Both the preface and the text itself praise the use of curve stitching as promoting both aesthetic satisfaction and subconscious awareness of pattern, harmony, and relationships among objects. The importance of using pleasing colors and of allowing the child to work out his own rules for stitching is stressed. Methods of developing the curve of pursuit, the parabola, and other curves are described. Many figures illustrating the principles used and plates displaying complex designs completed by children of various ages are included. (SD)

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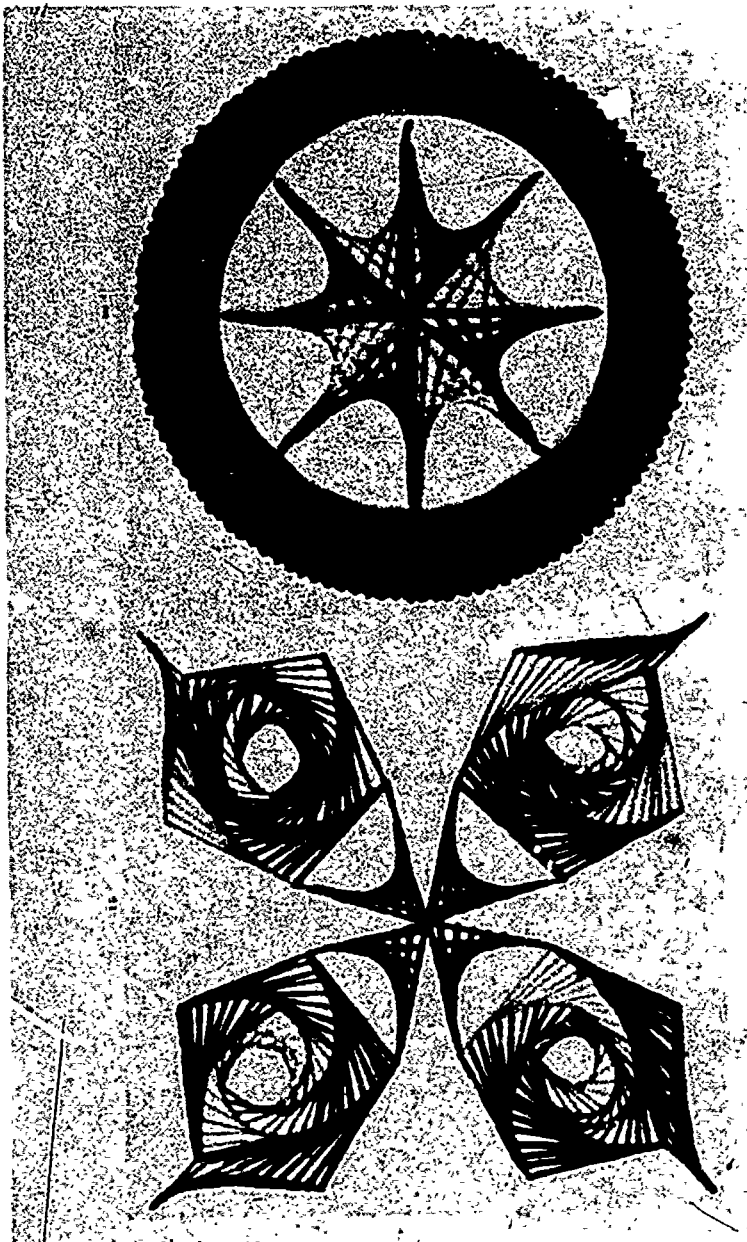


PLATE I.

CLASSICS
IN MATHEMATICS EDUCATION

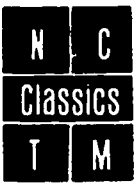
Volume 1: *The Pythagorean Proposition*
by Elisha Scott Loomis

Volume 2: *Number Stories of Long Ago*
by David Eugene Smith

Volume 3: *The Trisection Problem*
by Robert C. Yates

Volume 4: *Curves and Their Properties*
by Robert C. Yates

Volume 5: *A Rhythmic Approach to Mathematics*
by Edith L. Somervell



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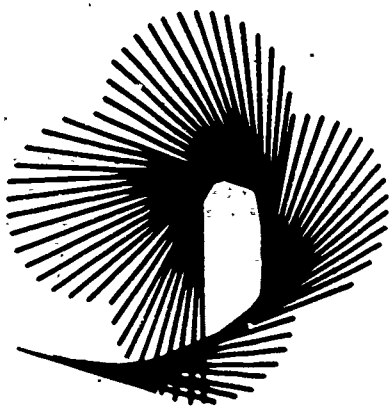

A RHYTHMIC APPROACH TO MATHEMATICS

Edith L. Somervell

With a preface by
Mary Everest Boole

THE NATIONAL COUNCIL OF TEACHERS OF MATHEMATICS

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FOREWORD

Some mathematical works of considerable vintage have a timeless quality about them. Like classics in any field, they still bring joy and guidance to the reader. Books of this kind, when they concern fundamental principles and properties of school mathematics and are no longer readily available, are being sought by the National Council of Teachers of Mathematics, which began publishing a series of such classics in 1968. The present title is the fifth volume in the series.

A Rhythmic Approach to Mathematics was first published in 1906 by George Philip & Son, Ltd., of London, with full-color plates. A photolithoprint reproduction was issued in the 1940s by F. H. Gilson & Co. of Chicago, Illinois, through the efforts and support of Mrs. W. F. Dummer, Miss Laura Christman, and interested groups of teachers. The present reprint edition has been reproduced by photo-offset from a copy of the full-color original publication in the British Library in London. Except for providing new front matter and this Foreword by way of explanation, no attempt has been made to modernize the book in any way. To do so would surely detract from, rather than add to, its value.

Dedicated

TO THOSE
WHO SHALL COME AFTER
IN MEMORY
OF THOSE
WHO HAVE GONE BEFORE.

PREFACE

I HAVE been asked to write a short sketch of the origin and purpose of the method for evoking the geometric instinct described in the following pages.

Somewhere about the year 1735, a boy named Nicholas Antoine Boulanger left school in France with the character of a hopeless dunce, who had never been able to learn any algebra. Before he was forty he was a mathematician of considerable attainments and an engineer employed by the Government to carry out important works; and had become very learned, for that day, in the history of ancient religious customs. He left behind him some unpublished writings, in which he professed to have recovered a very ancient secret method for setting free brain-power and amassing knowledge. The documents were published after his death, and for a time attracted considerable notice. But the French Revolution broke out and distracted public attention from mental science. In England especially people became afraid of French ideas. The stream of thought set flowing by Boulanger and his friends the Encyclopædists passed underground for a time; but it never for an hour ceased to flow steadily on. In the early part of the nineteenth century there was a working shoemaker named John Boole, who kept a French dictionary in the

drawer with his tools, so as to learn the vocabulary while at work. His son George, who had to earn his own living from the age of fifteen and a half, was, at seventeen, struck suddenly with the same idea which had proved so useful to Boulanger. In the course of a few years he became, while still earning his own living, a learned theologian and classic. Later on he gained a European reputation by the originality and power of his methods in mathematical research.

Several of his discoveries proved useful in themselves for purposes connected with statistics, actuarial work, electricity, etc. The brilliancy of the results distracted attention from the method of brain-fertilization which made the attaining of them possible. It seemed hopeless to try to make the method itself intelligible to adults whose minds were already set in a mould inconsistent with the adoption of it. After his death I came to the conclusion that it could be better made intelligible either to children who had not yet formed any mental habits or to adults whose stays of artificial habit had burst in some direction owing to nervous disease. I set to work to invent, as a recreation for nervous invalids, a mode of embroidering in coloured silks which should of itself put the mind through the rhythmic sequence suggested by Boulanger. It soon began to be observed that the work of my pupils, though faulty and deficient in technical skill, had some of the characteristics which distinguish ancient oriental art from all modern imitations, however skilful.

Being now quite satisfied that I was on the right track, I tried to get some children taught the principles of freehand embroidery; but the manipulation of embroidery proved, in the case of little children, so

difficult as to be a serious obstacle. A better method was ready to our hand for setting baby brains swinging in the rhythmic sequence.

Some half-century ago, a youth named Benjamin Betts was employed in a London office in drawing conventionalized patterns of leaves and flowers. As he walked across the park after his work, the plants themselves seemed, he says, to look up at him and reproach him for maligning them. He became disgusted with civilized life and its dishonest conventions, and retired to a Brazilian forest to study philosophy. He bethought him of a system of geometric co-ordinates, founded on the spiral of Archimedes, by which he tried to picture to himself the course of thought checked by obstacles. Thirty years ago a mass of the diagrams produced by Mr. Betts came to England and fell into my hands. Every one who has seen them perceives that they contain some secret of vegetable morphology; but Mr. Betts's system of co-ordinates is complicated, and no one has hitherto been quite able to follow the connexion in his mind between physical and metaphysical pressure.

Eight years ago one of my daughters, who in her childhood had drawn a few of the simpler Betts curves, taught her own little children to ornament Christmas cards with curves produced by the drawing of silk tangents; each such card having on it a single circlogram, parabola, or curve of pursuit. It struck me that the curve of pursuit [1] provides the missing link which had so long been a desideratum; a means of introducing little children to the conception of a connexion between organic

[1] p. 32.

thought-sequence and the evolution of harmonious form. The child draws straight lines which represent to the mind the successive desires and thoughts of animals; which express his own understanding of and sympathy with those desires and thoughts. While he is doing this, a graceful curve, such as he has perhaps never before seen or imagined, grows up under his hands, as if by miracle; he at first hardly realizes how or why it came into being. After a little practice of this kind, the connexion between Laws of thought and Laws of form passes out of the category of things which need to be proved and becomes axiomatic; he knows it, as he knows that things which are equal to the same are equal to each other.

For such a purpose the needle and thread has many advantages over the implements in more ordinary use for curve-drawing. Among them are these :—

It enables a child to get a perfectly uniform line long before he would be able to keep a ruler straight or a pencil sharp; to make a thicker line at pleasure; and to keep the parts of a diagram separate by varying the colour, without the risk of smudging involved in the use of coloured inks or the clumsiness of chalk points.

I gave two or three Christmas cards worked with curves to Mr. Garstang, Mathematical Master at Bedales School, Petersfield, who showed them to Miss Borsche, a Froebel teacher under Mr. Scott, Head Master of a Preparatory School connected with Bedales, suggesting that she might try to invent some method of combining curves. She and her little class devoted only fifty minutes per week during school hours to sewing curves on cards,

but some of the children practised of their own accord at spare moments, and soon began making combinations and suggestions of their own. The experiment was carefully watched, to see whether the children were growing excited, fatigued, or unduly conscious of personal inspiration. But as no symptoms of any such danger showed themselves, the two Head Masters (of Bedales and the Preparatory School) showed their wisdom by giving Miss Borsche a free hand. Some of the work produced was shown by Mr. Garstang in January, 1904, at the house of Dr. Arthur Somervell; and the connexion between harmonograph curves and those produced by Miss Borsche's pupils was pointed out. Mrs. Somervell then began experimenting, with very interesting results. This summer, I have had the great joy of seeing Mrs. Somervell and her children give lessons in the art of Geometric Design to a few children attending the Primary School at Overstrand; and I have now no hesitation in saying that the method carried out by Miss Borsche and Mrs. Somervell, with which they kindly wish to connect my name, is a working possibility as a means of truly national evocation of creative and organizing power.

One of the most pressing hygienic wants of the present age is an inexpensive mode of artistic expression, readily accessible, at any spare moment, to women such as under-servants, general servants, factory hands, and shop assistants, whose daily task it is to subordinate their own sense of what is right or beautiful to the convenience or whims of others. To express their own freaks of fancy freely is with many of such women an overmastering need, a raging thirst, which drives them into much extra-

vagance; and which, unsatisfied, drives not a few into insanity or disease. More than once I have known a woman say, of some very commonplace and imperfect specimen of freehand embroidery, "it is so solemn"; or "it is more fit for a church than a house." For when once colour is set free from connexion with frivolity, fashion and display, the mere fact of revelling at will among "gold and blue and purple and scarlet" puts a woman whose colour-sense is keen back into the atmosphere of the inspired needle-workers who in ancient times embroidered decorations for the Temple "as the Lord gave them skill." It is always a boon to a woman whose working life is monotonous to find herself able to externalize her apparently senseless vagaries without fear of reprimand from her own conscience, or the risk of unintelligent comment from any one else. The boon is doubly great if she can at the same time find herself, as to the form of her work, constantly pulled into line, not with human convention, but with Creative Harmony, not by the word of a possibly mistaken human teacher, but by the infallible guidance of some simple geometric law.

The method here indicated has one great advantage over many kinds of educational reform; it is a thing which women can manage entirely without agitation or public discussion. We need not wait for Acts of Parliament or the permission of School Inspectors. Any lady who will spend a few hours in practising on the lines laid down by Mrs. Somervell will then be able to teach village children in play, during the holidays. The materials are cheap, the apparatus simple, and the work interesting to nearly all children. Moreover, the lessons

can be given in the open air, without desks or chairs. Little teachers and little pupils, sitting in a ring together on the ground, with a good selection of coloured cottons on the grass at their feet, all the young eyes glowing with eager curiosity to see what pattern will come out next, form a picture very pleasant to contemplate.

MARY EVEREST BOOLE.

AUTHOR'S NOTE

It should be clearly understood that the more complicated designs given, are not intended to be copied. The whole value of the curve sewing is in the evolving of original design from a chosen geometrical framework. It is very difficult to copy other people's designs until the work is quite familiar; while an hour or two's practice with needle and thread enables anyone to start making their own designs.

The complicated figures in this book were nearly all invented by children of eleven and twelve, who had had about six months' irregular teaching.

Verbal explanations of how to work the designs represented would have a quite false appearance of being very complicated.

It is pointed out that Figs. VII and XXc represent a design and finished card made entirely by a child of five and a half.

CONTENTS

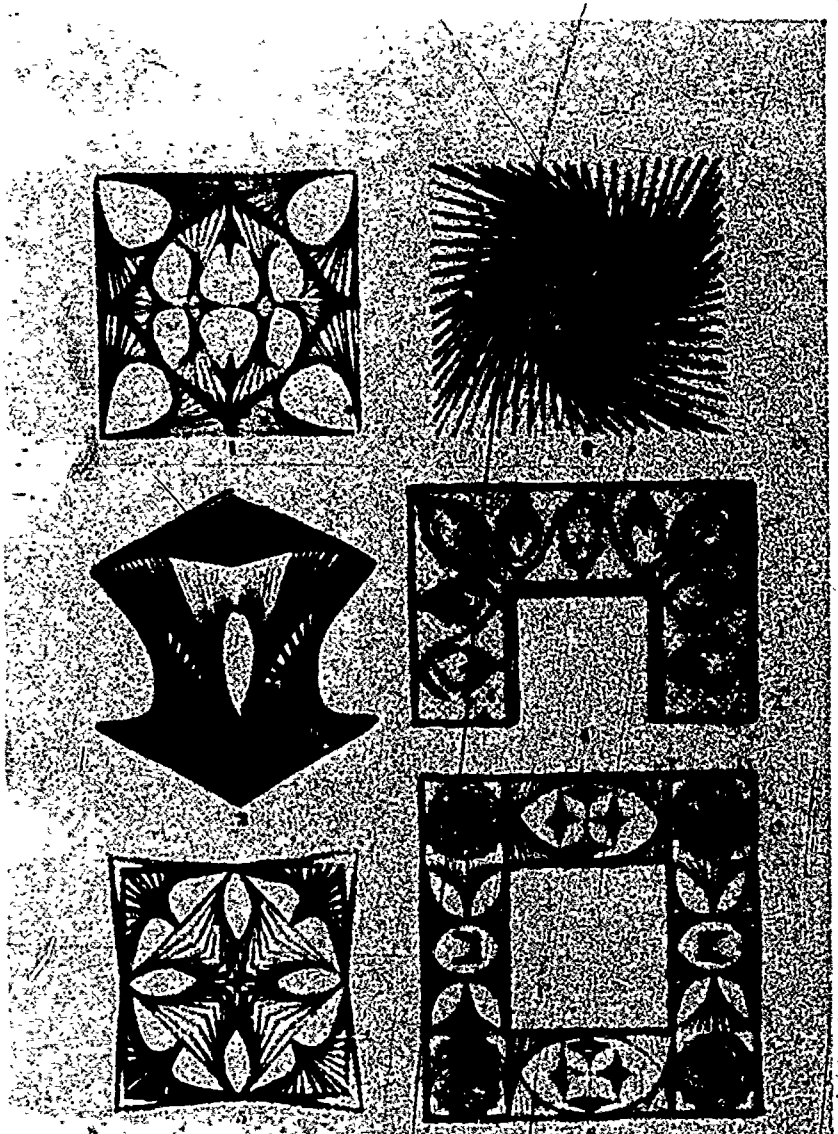


PLATE II.

CHAPTER I

INTRODUCTION

THE object of the work offered in the series of cards printed to accompany this book and to be used for sewing in schools, kindergartens, and nurseries, is to train in young children certain perceptions, *without the use of any intellectual statements whatever*. These perceptions, if awakened, *without intellectual effort or explanation*, will enable the child—

1. When the actual teaching of mathematics begins, to approach the subject, not as something new, strange, and abstract, but as orderly explanation of experiences long familiar to him, and charged with pleasurable associations.

2. To become aware that there are laws of intimate relation between number, form, movement, and the process of thought.

3. By means of this sense of relation, to grow able to translate readily any of these into terms of any other. There are also important indirect results.

Beautiful curves are produced by a process so simple and automatic that the most inartistic child can succeed in generating beauty by mere conscientious accuracy; and the habit of doing this tends to produce a keen feeling for line. It has also been noticed in some cases, where clean, pure, and strong colour has been used, that a remarkable sensitiveness to colour relation has grown.

The habit which the work has been found to form, even in children of five or six years old, of constantly

inventing patterns suggested by geometrical form, which frequently grow into familiar natural forms, has the effect of keeping them harmlessly happy and busy in a way which satisfies the creative instinct; the bearing of this on the future health of the child can hardly be exaggerated.

It seems necessary to offer a few suggestions and warnings, based on psychological principles of orderly development.

Teachers are earnestly recommended—

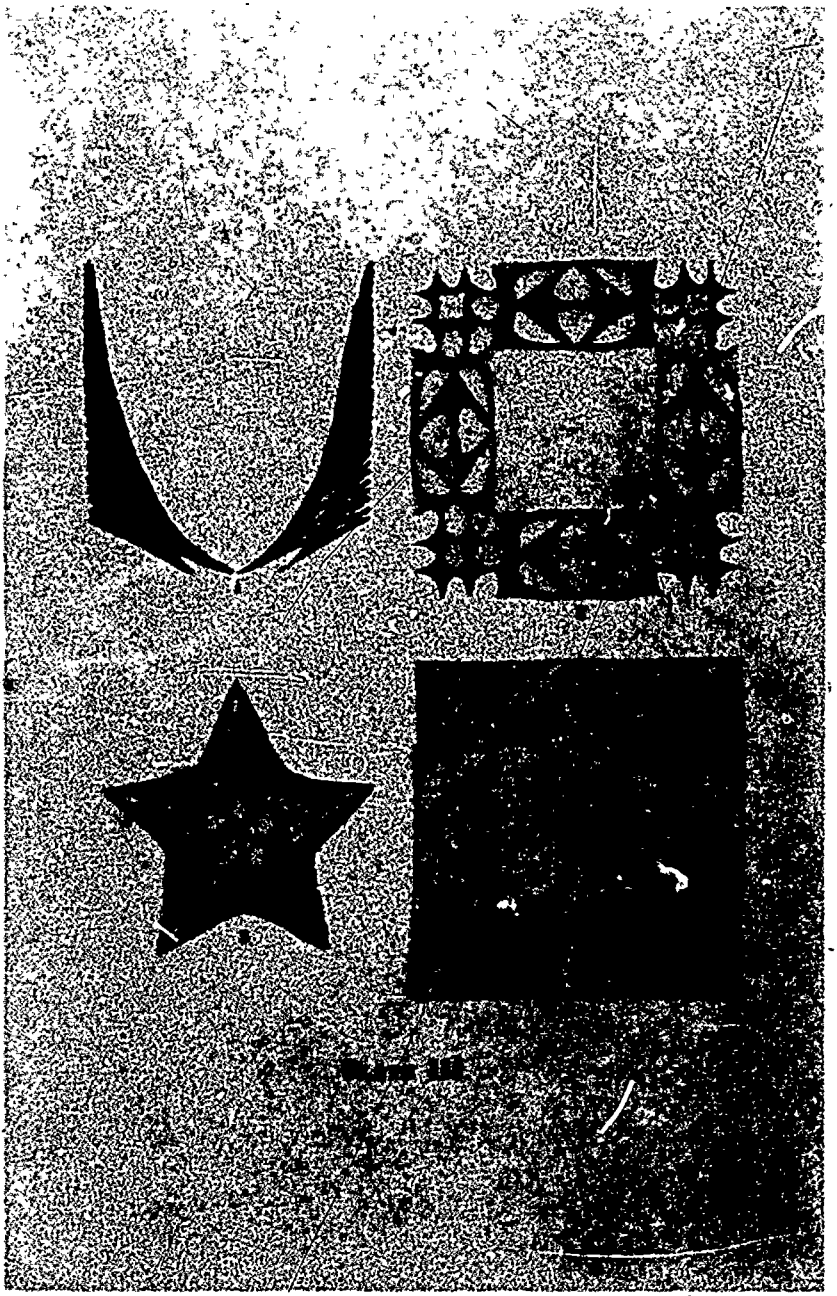
To refrain from explanation of the cards, and from showing the children this teachers' book, giving them an idea of the final result of what they are doing.

To avoid pointing out, even in completed cards, either beauties, or suggestion of nature forms which the child *has not yet noticed for himself*.

To avoid hurrying the completion of any card.

Special notes regarding the use of colour, a most important side of the work, are to be found on page 26.*

Finally, teachers are urged to give the utmost possible freedom to children in suggesting and working out their own ideas, both as to form and colour. Very little ones may be encouraged to show, with a pencil and paper, the kind of design they wish to work; but when they can use pencil, ruler, and compasses, they can themselves invent on a blackboard and work out on graph papers the scheme for the framework, and then stitch it. Very interesting and unexpected results will soon prove to teachers that un-self-conscious power is being evoked, such as is, in the teacher himself, if indeed he possess it, the outcome of intellectual effort and knowledge, far beyond the reach of any small child.



CHAPTER II

PRINCIPLES OF RHYTHMIC TRAINING

CHILDREN who are being rhythmically trained require plenty of leisure. It is of the very essence of such training that a child should be left to brood over—to *feel*—what he is singing, seeing, making, dancing.

Just so far as the formed thoughts of an adult are put into a child's mind in words, or even by conscious "good influence," so far is the formative process, which it is the object of this training to assist, interfered with.

With the majority of children, cheap and rapid results may be easily obtained, based on imitation of action, or on children's amazing facility for thought reading, or imitation of thought.

Much that is called "good influence" is nothing but deliberate encouragement of a child's power of feeling and mimicking thought, and should be avoided by the true teacher, as the climax of moral injury which indulgence in "teachers' lust" may do a pupil.

Strong, highly gifted children are often thus driven into bored acquiescence, or rebellion, taeit or expressed, and it is exactly for such children that rhythmic training is of even more importance than for the more commonplace.

In the work here suggested, much of what, in

ordinary teaching, has to be attempted by the teacher, and is of necessity done irregularly, or badly, happens to be carried out automatically and perfectly, provided it is not interfered with, and above all provided *no moral is ever drawn in words.*

For example, in the drawing lesson the teacher sets a model, either flat or solid, before the children, who copy the curves as well as they can; at first, of course, very badly. This is necessary and valuable experience for learning to draw. But in the hour devoted to rhythmic training, the curve to be produced is not put before the child; something quite different is all that can be seen; he is made to work on that something, in straight lines, according to a set rule, and the curve grows under his hands, an exact replica of what would have resulted had the teacher been working by the same rule, on the same design, always supposing the child has made no careless mistake.

The process in this respect is allied to that of learning arithmetic. In working a sum, it is not sufficient that a child should gradually approximate to the teacher's results. If he has worked his rule accurately, the result is identical. Every child enjoys colour and form more or less, and the race perception of these is far more evolved than that of number. It is, therefore, rather important to introduce into the realm of colour and beauty that sense of the possibility of being kept absolutely right by obedience to inevitable Law, which in European education has been too much relegated to the domain of arithmetic, in itself a rather dull subject to most children. It is desirable to associate, in young children's minds, strict obedience to law with keen enjoyment of that sense of personal power

given by finding an organic form growing under one's touch.

The results obtained by a child, of exquisite curved and flower forms on the "back" of his card, by faithful obedience to a dull little rule in making straight stitches on the "front," is of the nature of a miracle. It should, therefore, be hardly necessary to insist that the less said the better, when the little worker produces anything especially beautiful or unexpected.

One of the most important points in rhythmic training is to introduce a child to any new idea some time before it is proposed to let him work on the idea, and this not only in larger matters, in the way which is embodied in the whole relation between the Boole curve work and mathematics proper, but in small details throughout their schoolroom work.

In the experience of a small group of teachers who are engaged in experimenting in this direction, it has been found better to introduce children to a new subject during the last half of the summer term, or even sooner, giving three or four lessons on it and then dropping it altogether till the following autumn or Christmas.

When it is taken up three or six months later, and regular teaching begun, in a few weeks the children seem to have a grip of the matter, and a capacity for further progress, quite disproportionate to the amount of time and teaching hitherto spent on it. Some assimilative process has gone on unconsciously, which has transmuted the material and formed, as it were, a framework, or pattern, or crystallizing thread, on which the new matter shapes and builds itself. The results of experiments on these lines on a larger scale would be of very great interest.

Should they show results similar to those already obtained, many of the greatest of modern education problems would be on the way to solution.

Were it found possible to rhythm the curriculum to any large extent, taking up first one set of subjects and then another, making cycles of work corresponding to the cycle of the year, the number of subjects taught at any time might be reduced, while nothing essential need be neglected. Many things point to the possibility that such treatment would show far better results than the continuous study of the same set of subjects, besides bringing about a sense of unity in diversity in the child's apprehension. There is even reason, based, as yet, on very limited experiment, to hope that in this way an automatic test may exist, to indicate over-strain before it has reached the very costly stage of injury to health.

The preliminary introduction should of course deal more with the general scope and purpose of the new subject than with any technical detail of drudgery; e.g., if the violin is to be taught, play a good deal to the child, of course, show (not as a "lesson" at all) a violin string vibrating, with bits of paper astride the nodes and between them—the principle of stopping and producing different notes by plucking the strings—the beautiful and ingenious construction; tell stories of the Cremona makers; show (if possible) barbaric stringed instruments in museums, aiming, for the moment, only at rousing a strong desire to know and understand and use the wonderful thing.

To those interested in the principles of rhythmic training it may be well to point out the undesirability of hurrying the synthetic process. As an example, teachers are warned against attempts at imitation

of flower and leaf forms. Some interesting experiments have been made in this direction; but it is felt that in the present state of knowledge on this intricate subject, it is premature to publish results. The forms produced only *look* rather like certain flowers and leaves, which really are *made* by other curves obeying exceedingly complicated laws.

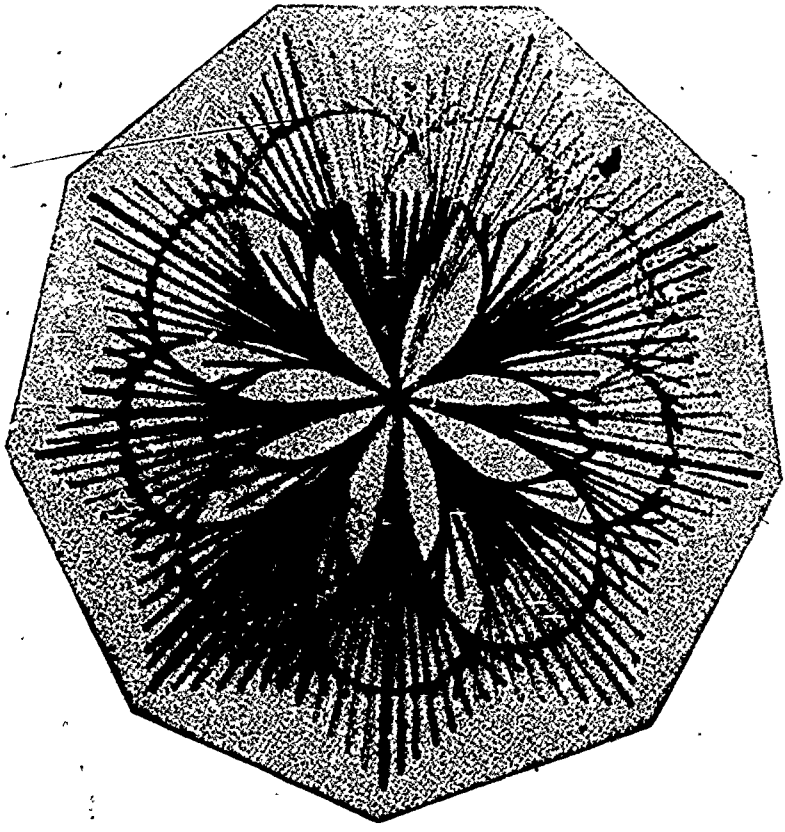
There is some reason to believe that steady use of forms which are evolved from geometric designs, the laws of which are understood, may produce in the children faculty which will give them an intuitive grasp of constructive principles; the children will themselves then evolve *type* forms, at any rate, of vegetable and animal orders of great complexity.[1]

The work, therefore, should always be *from* geometric to flower and leaf forms—never an endeavour on part either of teacher or child to choose flower and leaf forms for which a geometrical framework can be found—thence obtaining an approximate likeness to the curves of the natural growths.

Such pretty-looking things can easily be made in this way that it may prove a temptation to many—but to yield to it is likely to retard the growth of the work, and even to stunt or deform it, both artistically and educationally. The danger would seem to be the same as that which has been so slowly

[1] See No. 7 of Fig. XIX. Series of nine treatments of the pentagon, p. 56. This form, suggesting an orchid, was evolved by a young child (10½ years old), by a "three" treatment of a "five" figure. Botanists will recognize the great interest of this apparent accident. See also Fig. I, p. 24, which, by means of a nonagon, treated with curves of pursuit, evolves the type form of the violaceae.

recognized in the now old-fashioned training of young draughtsmen on so-called conventional design of an inferior order. These designs were not the result of a close and intimate study of geometric laws on one side, and of natural forms and laws on



Nonagon treated with curves of pursuit.

FIG. I.

the other, thus gradually soaking into the young mind a deep perception of the unity of all laws, and giving the synthetic power shown in all great decorative design (as must have been the case with the geometrically trained minds of the great Greek

artists); but were obtained by a facile imitation, or rather caricature, of certain obvious lines and numerical relations in the parts of flowers which were then fitted, with cheap facility, into equally simple and obvious geometrical framework. It was merely another and subtle form of cramming, with the inevitable loss of truth, of real knowledge, and of intellectual rectitude.

This work draws its own morals, and engraves its laws deep down in the hearts and minds of children. To assimilate its teaching they should have abundant time, brooding time, true play-time, not only games and ordered play, supervised and directed by a grown-up—but time when they may do their own will, write, read, draw, dig, romp, sing, or play with toys of their own choice, or thoughts of their own. "Abundant time to dream, to watch the clouds, the wind in the grass, the stars swinging round the heavens, to listen to the music of falling waters and upspringing lark, to grow sensitive in body, soul and spirit, to the secret rhythms of slowly growing things."

The dreams of youth are the stuff which manhood transmutes into thought and action. To many among us it seems that by a reverent standing aside, and abstinence from the natural longing to see results, the way is open to minister to a generation of young men, who shall dream dreams, fulfilling beyond hope the visions of old men, saints and seers, who have gone before.

CHAPTER III

ON COLOUR

WITH regard to colour, for beginners and in very large classes where cheapness of material is essential, [1] Harris's flax threads can be used, or the French D.M.C. mercerized cotton; but the colours in the latter are not quite satisfactory, especially when combined. The flaxes can be ordered as the "Rainbow" colours, and are strongly recommended.

Filoselle silk can be obtained in a fine range of colour, and the use, with older children, of two threads of different colours or shades in the needle enables the workers to produce excellent results. Little children must use a single thread.

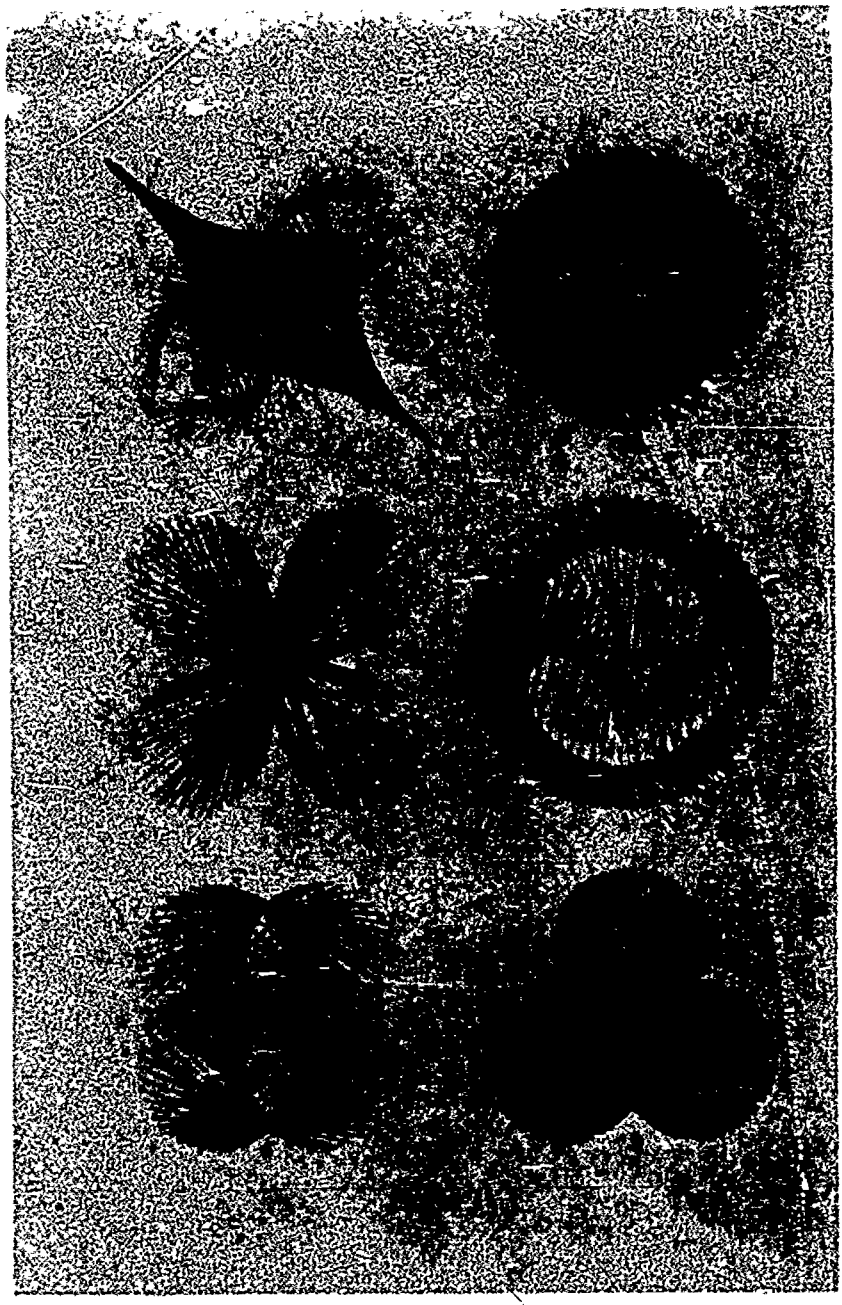
It is suggested that the standard of colour for beginners should be set by the colours of the precious gems, and the rainbow.

By this is meant, not that the colours usually called "ruby red," "emerald green," etc., shall be used, but that some trouble shall be taken to match the gems.

Those who have actually done this are usually surprised to find how different the real colours of the gems are from those conventionally named after them.

The following numbers in Pearsall's washing filoselle have been matched as closely as possible

[1] For particulars of this and other material, see list at end.



with emeralds (pale), rubies (a darker shade of the same range would be satisfactory, but is not at present dyed, except in knitting silk), sapphires, amethysts and topaz. Several shades are given, but all in the same ranges of colour.

Reds	217	
	219	
	220*a*	Matched to a pale ruby.
Blues	20*c*	
	20*g*	Matched to a good sapphire.
Yellow	186*a*	
	186*c*	
	186*h*	
Orange	186*i*	
Purple	240*a*	
	164*a*	
	242*a*	Matched to a reddish amethyst.
Greens	85	
	87	Difficult to match, but fairly near a medium quality emerald.

These silks used either singly or in double threads produce excellent results. The use of "pretty" delicate shades in early stages, to secure effects familiar and pleasing to adults, whose colour sense may not be developed, is much to be deprecated.

It is recommended to let young children use only the darker or medium shades at first.

The gems and the rainbow set the standard in its simplest perfection, and if the children are allowed to use and "play" with these freely, the more subtle and complex combinations suggested by themselves later will have the rightness of fine Oriental work.

Filoselle is a rather troublesome silk to handle; but it has been found by embroiderers that the most satisfactory way is to wind each skein on a card, and

cut from these a length to divide. The remains of the strand can then be drawn with a large crewel needle through a pincushion; the bundle of such remains laid on the table is a valuable help in training the colour sense, and suggesting combinations to the class. A certain quantity gets wasted by entanglement; but this is trifling in cost, and is more than made up for by the suggestiveness of the mass of colour. The so-called "art" colours, such as "peacock" blue, "olive" green, "terra-cotta," etc., are most injurious to a right development of colour sense. They are an attempt to produce ready-made, in a solid mass, some of the most subtle effects of nature and of highly developed Art. Such effects are never obtained by a solid mass of one colour—but by a varied surface, very finely broken-up, of two, three, or more shades and colours, so arranged as to give to the eye the feeling of one particular shade. Often, as in mosaic, feathers, or the colour of vegetation, they depend for their effect on the *texture* of the surface, and on the way such texture catches and breaks up the light, and cannot possibly be repeated truthfully in another material, in a flat mass of colour.

It is well to get children to experiment largely in the great variety of effects they can get by mixed threads of purple and blue, blue and green, green and red, green and purple, red and blue, yellow and green, yellow and blue, yellow and purple, yellow and red, before adding much to the first set—and then to add nothing which will not mix well with the masses of all the rest.

It should be made an absolute rule, when once the colour range has been chosen, to allow the children to select quite freely for their own work, and never

to guide and suggest or to criticize their combinations, however crude. Should a child make a very ugly choice, let him finish the card, and then a few weeks later look at it again, and see if he has any criticism to make. There is interest and instruction to be found in watching the developing colour sense astonishing to those who have not experimented in this direction. Most adults have not developed this freely, and are more or less tied up by conventional rules, or degraded taste produced by early familiarity with bad colour, and the children's combinations are freer, bolder, and more right than those which ordinary adults would venture on.

CHAPTER IV

THE USE OF THE CARDS

It remains now only to make a few remarks on the best way of using the cards.[1] The first few cards, with lettering, are meant to be used for sewing on, directly. This may, of course, be done with any of the cards. But a better effect is produced by the more economical method explained on the envelope containing the cards. Paper clips can be used for attaching the pattern card to the blank one. This is far the neatest way of working, and has the great educational advantage of obliging children mentally to reconstruct their geometrical framework when looking at finished cards of their own, or to find it out in those done by other children. "Graph" paper sheets of the right size for 7 × 7 and 10 × 11 cards are also obtainable; these are suitable for original designing, and can be attached to a blank card in the way suggested. The cards printed with concentric circles and various polygons make a good basis for original designing.

A couple of specimen lessons showing the principles of the work are added, and some remarks on the experience of the few teachers who have as yet used this method

[1] See list at end.

THE PARABOLA AND THE CURVE OF PURSUIT

Though the Parabola is the curve which children should first sew on the cards, and in the case of small children the only one they can conveniently use for some time, it seems best, after much thought and some experience, to recommend teachers to face an apparent intellectual confusion by first introducing to children the curve of pursuit. The reason of this is that a clearer and more complete subconscious impression of the principles involved may be made, introducing at once the idea that the laws of curve formation do not deal only with happenings among inanimate things and forces, but are a notation of laws of thought sequence. The first lesson may therefore be given by the "dog-path" story, as explained in Mrs. Boole's *Lectures on the Logic of Arithmetic* (Clarendon Press 2*s*.), and here repeated in slightly different form.

Fig. II. This lesson should be given on a blackboard, or with a pencil and paper. R represents a rabbit feeding at some distance from his burrow B. D is a dog who catches sight of the rabbit. These three points are all that should appear upon the board at first.

Question. "What does the dog wish to do when he first sees the rabbit?" (To kill the rabbit.)

Q. "Where then does he wish to be?" (At *R* killing the rabbit). Draw a line *D R* representing this wish. Determine the length of each jump of dog, and of rabbit *R* to r_1, *D* to d_1.

Q. "What does he *do*?" (Begins running along). Then draw from the children the *wish* of the rabbit when it catches sight of the dog. (To be

safe in the burrow *B*). The *action* of the rabbit. (To run from *D* to d_1). But while the rabbit runs to D_1 the dog, running from *R* to r_1, sees the rabbit is no longer at r_1, so having got as far as d_1 he changes his wish, and instead of wishing to be at r_1, wishes to be at r_2, and so on.

Make the children indicate several changes of the dog's desire, and the constant coincidence of desire and action on the part of the rabbit; see that they

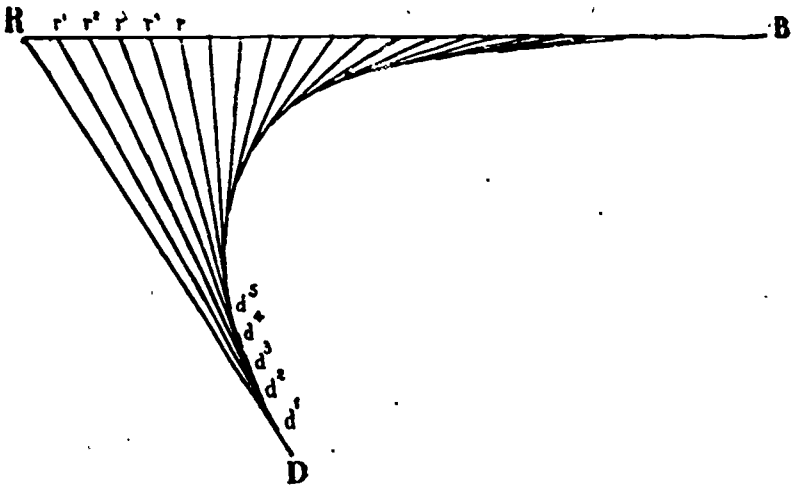


FIG. II.

can clearly point out on the board straight lines which represent the dog's *wishes*, and the curve which represents his *actions*. Draw from them the reason these do not coincide, as in the rabbit's case (because they are perpetually modified by the rabbit's actions).

Q. "What sort of lines have you drawn on the blackboard?" (Straight lines.)

Q. "What sort of line is *D*, d_1, d_2, d_3, etc.? (A curve.)

Q. "Who made the curve?" Leave this question as a suggestion unanswered. If possible, allow two small children to act dog and rabbit, that the class may see that the pursuing child does actually make a curve like that on the board. If this is done in the playground a little bag of rice or dry sand tied to the child and trailing behind him will show the curve more clearly.

Second Lesson

Try to draw from the children whether they know of any other curves *making themselves* (not fixed curves), or curves that they themselves make with anything else they do besides running. Lead them to speak of ball-play. Throw a ball[1] up from one hand to the other; or let two children do it at varying distances from one another.

Q. "What makes the ball go up?" (The impetus given by the throw.)

Q. "What makes the ball come down?" (The earth pulling it down.)

Q. "Are you really sure that the earth pulls things down? How are you sure? Can you feel it pulling things down?" Endeavour to make them *feel* the pull on their own hands of light and heavy

[1] Teachers who are well used to playing with balls can demonstrate the identity of the parabola with the curve of a rising and falling ball, by drawing a parabola on a blackboard and throwing a white ball close against the board at such an angle and with such an impetus that the children can *see* the ball taking the same curve as that drawn on the board.

To do this really well will probably be very much easier to men than to women teachers, and is an experiment which is better not ventured upon without certainty of success.

things, and the pull on themselves when they jump. Would they like to make this same curve that a ball makes when it is thrown up and drawn down again, so that they can keep it and look at it and take it home? Cards 1, 2 and 3, Series I, may be given out for them to sew. Avoid giving the same card to the whole class. Let the children thoroughly realize that the direction in which the stitches are set are

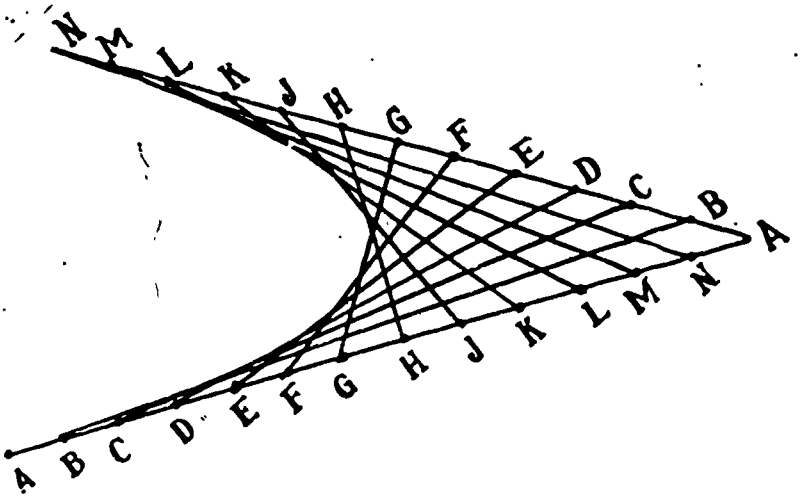


FIG. III.

opposite directions on the two lines making the angle.

Fig. III. A on one line is close to the angle, and A on the other line is as far away as it can be. (Supposing the angle to be London, one line is like a train coming to London, and the other line is like a train going from London. The holes are like stations on the way.) When the card has been worked, A to A, B to B, etc., point out that the children all sewed straight stitches. Suggest again, as in Lesson

I, "Who made the curve?" Do not offer any solution. From this point onwards the children may go on sewing the cards in Set I, gradually learning the rules for the sewing.

1. Make up your mind in which directions you wish the stitches to go on the two lines. Lightly pencil the directions with arrows.

2. From the first hole on one line put your needle into the first hole going in the opposite direction on the other line.

3. On the "wrong" or "pattern" or "ugly" or "front" side always put your needle into the next hole, and put on this side all knots and finishings.

4. On the "beautiful" or "curve" side, or "the back," put your needle into the hole next to the last long stitch which you made.

Get the children gradually to understand these rules as they work, pointing out which one has been broken when a mistake has been made.

Wherever it is possible, allow the children to combine angles and draw their own designs—either roughly, freehand, or on a blackboard, or on chequered paper, according to age and ability.

It is, of course, most desirable, where possible, to teach geometrical drawing to children alongside of this curve work.

It is very important to encourage perpetually inversions of design. Cards 11 and 12, Series I, are good specimens of this. It is useful to let children cut up a printed design and put it together again, inverting all angles as in Kindergarten paper folding and cutting. As much freedom as possible in putting original designs upon the cards should be encouraged, e.g., placing the design *not* straight or symmetrically with the edges of the card. Chil-

dren should occasionally be encouraged to sew on quite irregular figures, of which Fig. IV is an instance.

In the opinion of one mathematical teacher of exceptional ability, this possibility for young children of inverting geometrical figures freely is one of the most useful features in the Boole curve work.

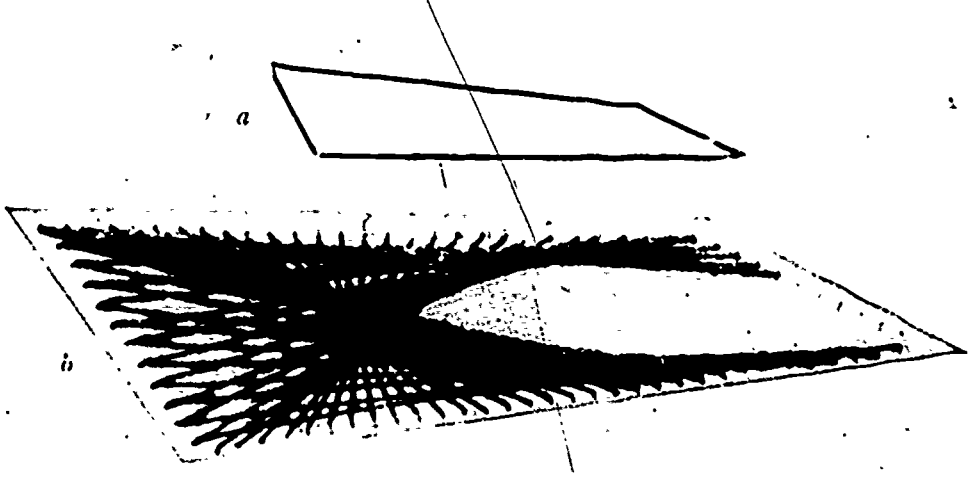


FIG. IV.

THE CURVE OF PURSUIT

This is the curve given first of all—in the dog and rabbit story (p. 32). When children are old enough to measure distances carefully, and have had a thorough drilling in working parabolas on every kind of angle, they can learn to *work* this curve in the same way.

The difference in working is, of course, that instead of fixing the holes before the work is begun, the holes can be pricked only on the line of the pursued; on the path of the pursuer, each stitch set is the fresh line or tangent, along which the distance must be measured for pricking the intersecting point of the

next tangent. Figs. V and VI show the back and front of a treatment of this curve, invented, explained and worked by a carpenter's daughter,

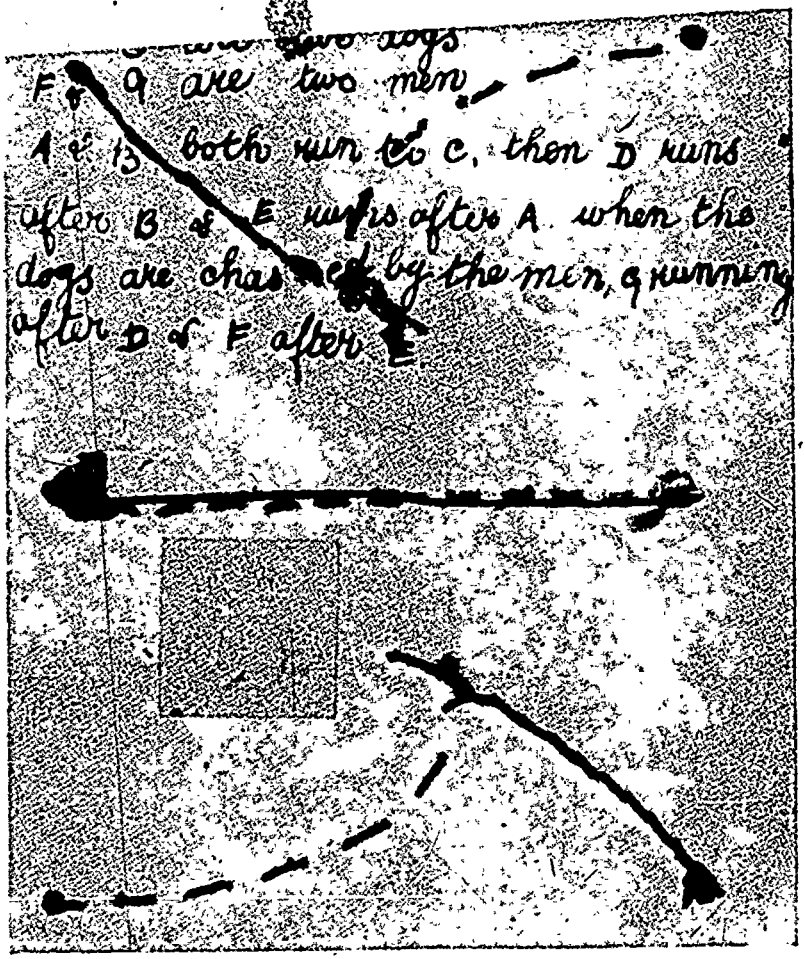


FIG. V.

aged 12, after five lessons given by a child of her own age.

Card No. 10, Series III, may now be given to the children to sew. The dots for holes must be clearly understood by the child to represent the successive

leaps of the rabbit. The length of the leaps of the dog must be fixed, as have been those of the rabbit, and a stitch must be set from *D* to *R*. The needle must be brought up again through the next hole r_1 and the

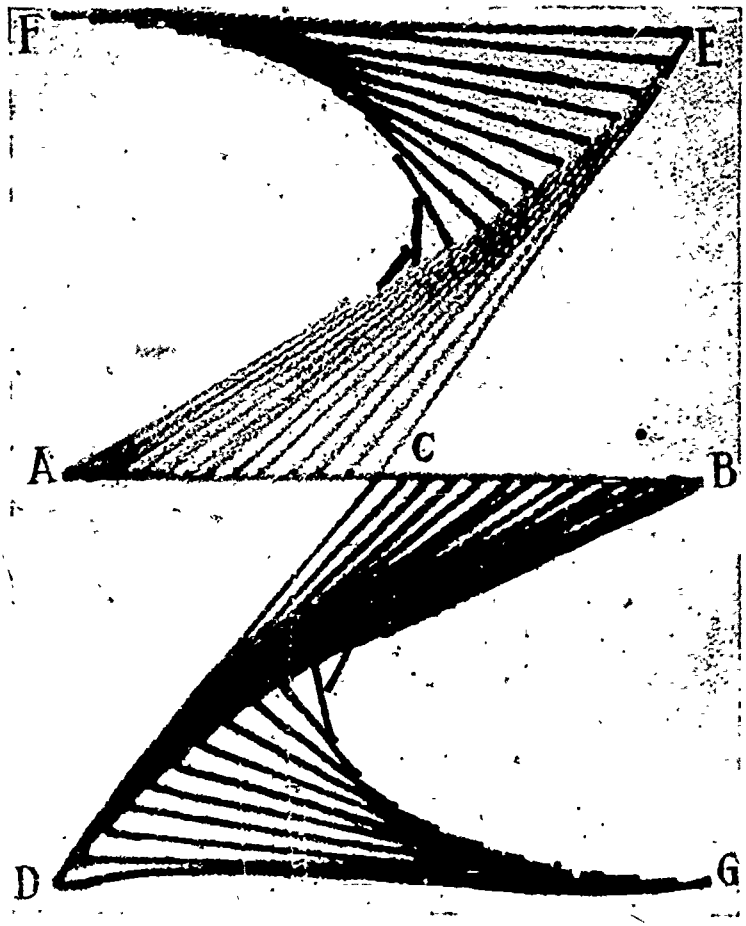


FIG. VI.

stitch drawn tight. Then the needle must be left for a moment, and with dividers or a paper measure a prick must be made on the last stitch *D R*, distant from *D* exactly the length which was decided on for

the dog's jump ; and the needle must be put through this hole making a long stitch from r_1 to d_1.

Again on this stitch the dog's jump must be measured to D_2 and pricked and a stitch brought from d_2 to r_2 and so on.

The whole set of designs to be got from this curve are of course quite different from designs got from the parabola—where exactly the same geometrical frame-work is used—and children are delighted to find this out by working the same designs successively with the two different curves. (See XXII*e*, XXIII*a*, and coloured plates I², II, III, IV¹.

The cards 11 and 12, Series III, show how the idea can be given of using it decoratively.

In allowing a class to work this, each child should be allowed to determine the speeds, and the cards will all be different.

Children sometimes like to make dog or rabbit run quicker half-way through the card—or be "too tired to go so fast"— or remember that the dog is lazy or old. Such fancies should be allowed free play. One little boy of 5½ who was watching the curve being worked insisted that the second thread of silk used should be red instead of yellow—"cos when Jack (the dog) runs he gets so hot—and when I gets hot I gets a red face."

For the reasons indicated on page 19 this kind of thing is on no account to be called nonsense, or discouraged. The aim of all rhythmic training is to get children to *feel* the things through the senses and imagination, which the reason is afterwards to deal with.

It will probably be found that the children will readily enter into the idea of this curve, as it will have been introduced to them long before.

The two curves given in these lessons, the parabola and the curve of pursuit, freely handled in decorative combinations with circles, triangles, squares, oblongs, polygons, etc., will give abundant scope for two or three years' work and play.

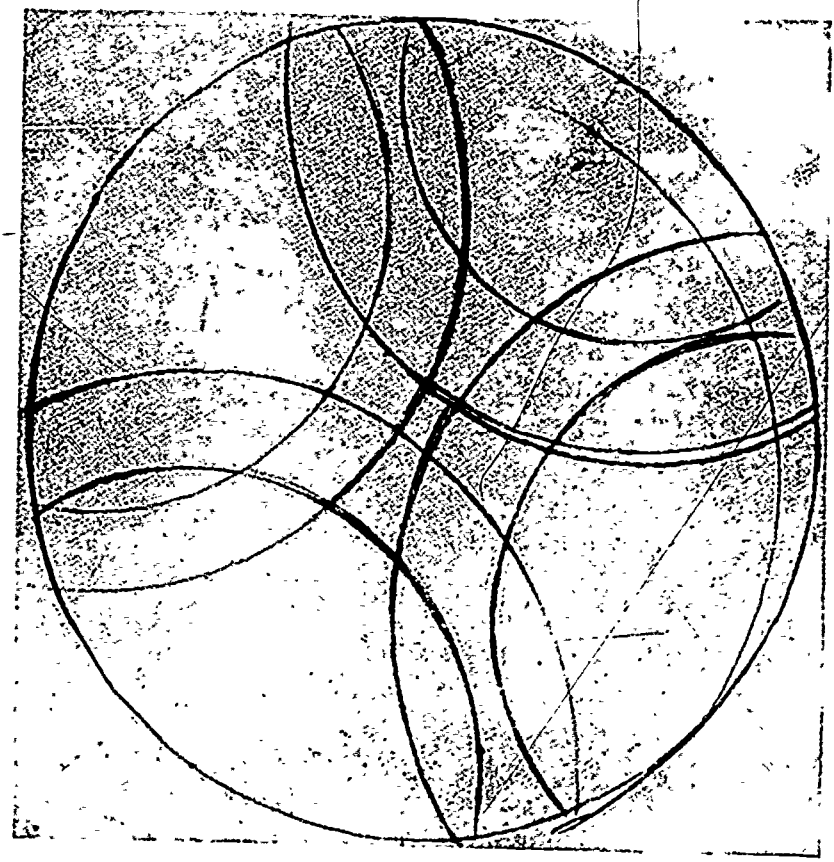


FIG. VII.

Fig. VII is an untouched reproduction from the original design of a child aged 5½. The finished card is reproduced on page 61, Fig XXc, as the child worked it—no mistake corrected.

The children will themselves find many ingenious

and beautiful combinations, and will evolve parts of other curves by the manner of working, as, e.g. XXI, A_2, which is made by arcs of a circle worked against a straight line; this is really quite a different curve. (Fig. XIX *a* and *b*, page 58–60.)

The Circle

Delightful designs can be evolved from circles alone.

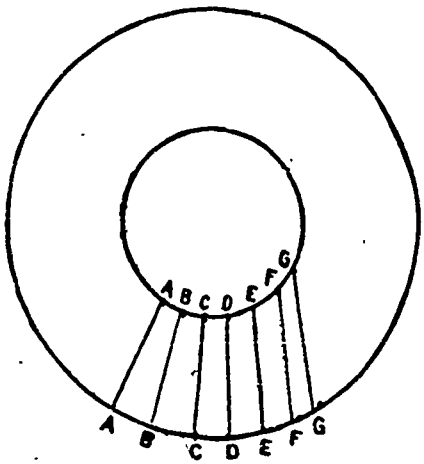


Fig. VIII.

Fig. VIII. Children can produce the caustic curve, which they can look at in a tea-cup, made by refraction of light, by making two concentric circles, and pricking them so that the number of holes on the larger circle is double that on the smaller circle. The child should then join, by a stitch, the outer and inner circles, and go on joining points successively all round. When he has stitched into every hole on the inner circle, he must go straight on in the same direction, round and round, until he finds himself at the place where he is beginning to put stitches into the same two holes that he began with. The pattern is then complete of what he sees in the tea-

cup. The curve is not, however, complete, and it would be well to let him draw the complete curve later. It is not easily done with sewing.

This curve can be varied very largely by varying the radii, and also by varying the number of points on the two circles, producing a series of exceedingly complex curves (evolutes of epitrochoids, etc.). See page 65,[1] Fig. XXIV.

Another treatment of the circle, which delights children, is :—Divide a circle into three, four, six, or eight equal parts ; on each of these arcs prick an equal number of holes ; begin taking stitches from the first hole on one arc to the first hole on the next arc, from the second hole to the second, and so on. Change the colour each time you reach the beginning of a fresh arc, or use two colours alternately. A beautiful ring of colour will appear, varying in width inversely with the number of divisions on the circle, and giving an odd effect of movement. It is best to divide the circle into quarters for young children, when beginning a set of cards like this. No. 10, Series I, is planned to be worked in this way, and the blue and green ring in the coloured plate I_1 illustrates the effect.

The " mystic rose " is very fascinating to children. Take any number of equidistant points on the circumference of a circle, choose a colour, and join one point to every other one ; for the next point take a fresh colour, and do the same thing again, all round. Shell effects are produced when there are

[1] Since these pages were written, some beautiful cards have been worked by inverting the method, and setting the stitches in directions opposite to each other, instead of going round both circles in the same direction. Series VI, for the spiral of Archimedes can be used also for setting out these circles with varying numbers of points.

only two or four points, but when a large number, 18, 36, or more points are used, the whole design forms innumerable exquisite curves by intersection (spirals, etc.), according to the fineness of the thread and the number of points on the circle.[1] Fig. XXIII, *B*, and No. 6, Series III of the cards.

Stitches can be set on circles, divided in this manner, from one point to certain other points, alternately or in any other sequence, each sequence, of course, producing quite different results.

The Tractory

Fig. XXVI, *e* and *f*, page 67, represent decorative designs made by using this curve on a circle. The principle of this curve may be explained to children as follows :—

Fig. IX. A man *a* has an iron rod of the length *a.c.* He walks from *a* to *b*, dragging the rod after him, and continues to walk along *a.b* to *a*1, *a*2, *a*3, etc. The rod is, of course, always of the same length, but the end of it does not take the same line that the man takes. (This can be demonstrated by allowing a child to pick up, and walk away with a long rod, which shall first be placed at an angle to the direction in which the child is to go.) The curve represents a line taken by some particular spot anywhere near the end of the rod. The curve must be worked by measuring each stitch from

[1] In the case of one child of very passionate and impetuous disposition, working this figure seems to have a very soothing effect; the child often resorting to it when "at two" with the world in general, and becoming quite calm and happy after half-an-hour or more on the "mystic rose." Children often seem to have a special fondness for the use of one set of figures or one particular curve, and careful observations relating to this would be of great interest.

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successive points on the man's path to a point on the last stitch, making the distance between these the same as *a.c*, that is, of the determined length of the rod. If no point on the stitch is far

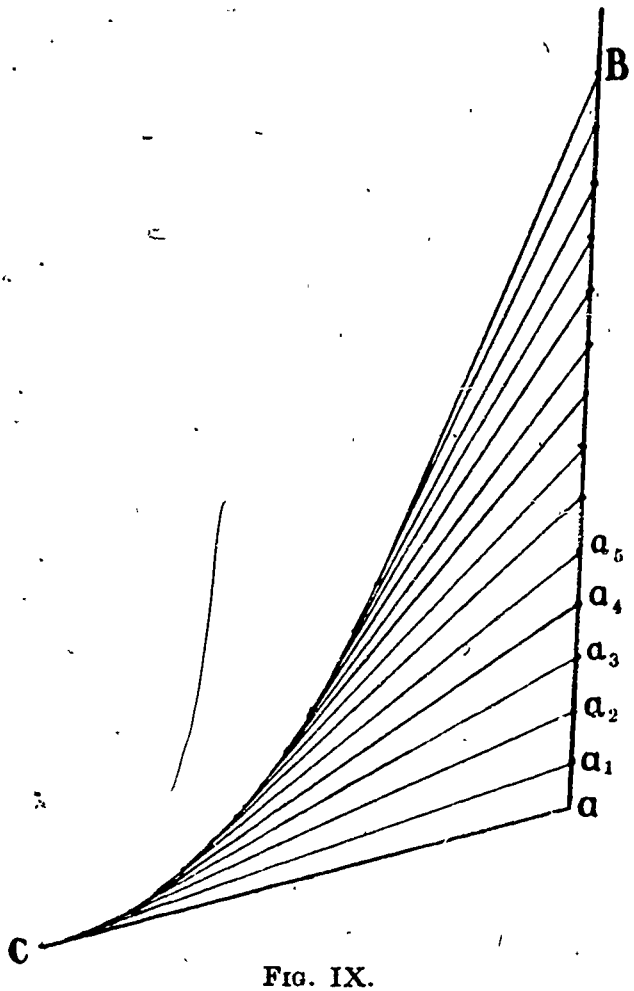

FIG. IX.

enough away the point required will be in the same straight line with the stitch but beyond its end. (See Fig. X.)

When the child understands the law of this curve

he can produce some very interesting results by placing the starting point of the rod at different places :—

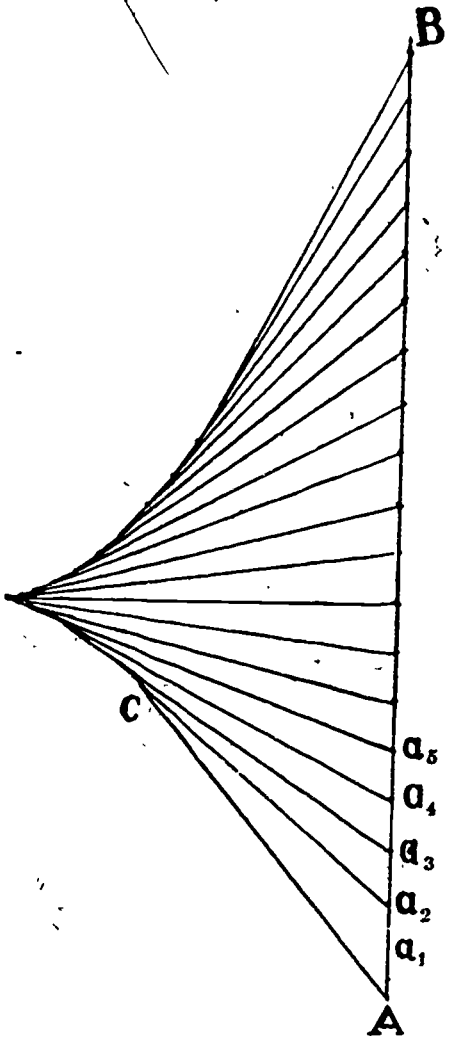

FIG. X.

1. At right angles to the direction of the man's path.

2. At an obtuse angle to the direction of the man's path.

3. At an acute angle.

In the latter case a cusp is made as the rod goes backwards first, before it appears to begin to follow the man's path. (Fig. X.)

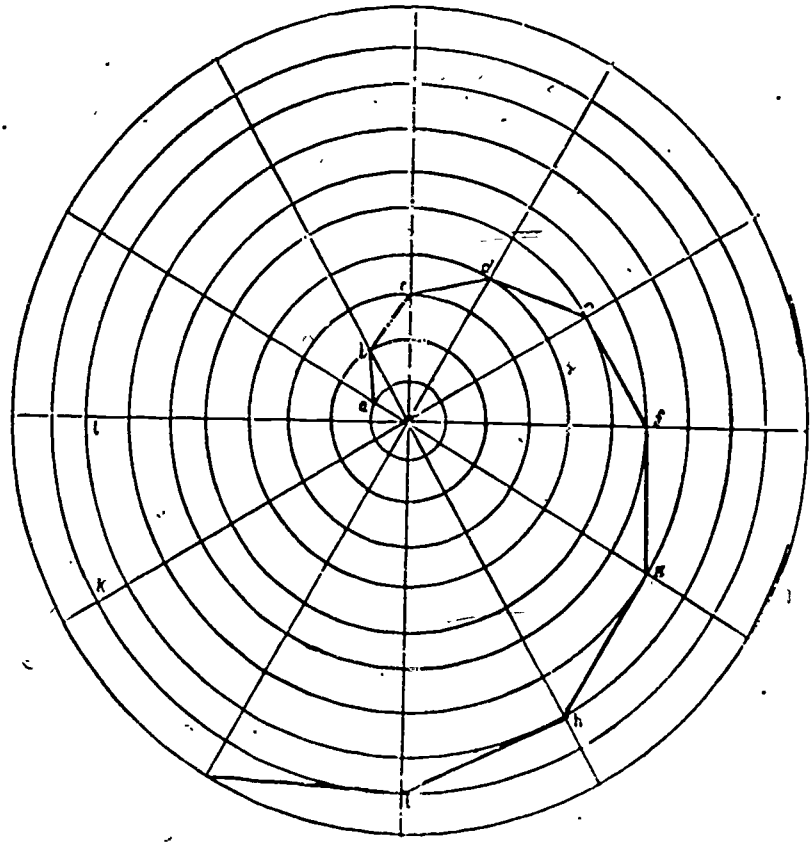

FIG. XI.

THE SPIRAL OF ARCHIMEDES

Fig. XXVI, *a*, *b*, *c* and *d*, illustrate, and the whole packet of Series VI of the cards is provided to facilitate, the use of the Spiral of Archimedes. The principle is shown in Fig. XI, and *a*, *b* and *d*, page 67, are

combinations designed and executed by children under twelve.

The following valuable suggestions are offered by Miss Eleanor Cobham, and the attention of teachers is drawn to the necessity of thus balancing the use of one method against another in giving a real grip of a subject through the sense-perceptions of little children.

"It may be suggested that a little child's mathematical apprehension will be built up on a sounder basis if he practises some other method of getting curves alongside of the tangent method described in this book.

"One of the best ways is to watch a curve grow as the path of a moving point, and to allow it to grow under one's hand as a result of muscular obedience to some constraint, instead of, as in the tangent method, mental obedience to some law.

"The simplest case possible for very young children is that of tracing a circle with a pencil placed within a loop of cotton passed over the head of a pin.

"In this connexion two suggestions may be made. The first is this :—When at a later age the child learns geometrical drawing with compasses and other accurate instruments, he is usually taught in drawing a circle to stop his compasses as soon as the circuit is completed, for the sake of neatness.

"But a little child making his circle round a pin should be allowed to follow the track round and round again and again. He thus gets the feeling of inevitableness which is an important adjunct to the locus idea.

"The second suggestion is as to the value of the chief imperfection in this method of getting a curve.

It often happens that the pencil in the little hand jumps the cotton, and goes off in a straight line. This experience repeated many times in early childhood lays a good foundation for later intellectual conceptions of tangents and tangential motion.

"Later on ellipses, made with two pins, and trifocal and multifocal figures should be followed by curves made with trammels and simple linkages. With this drawing practice should be associated the observation of three-dimensional curves being formed by the path of a glowing point—e.g. by rapidly whirling a joss-stick in a dark room."

Other examples are to be found in Mrs. Boole's *The Preparation of the Child for Science.* (Clarendon Press.)

Many other curves seem to lend themselves for use by children in some such way as those here indicated; but enough has been suggested for several years' school work. It is hoped that later a good deal more material will be available; as also a method for making three-dimensional curves by easy methods.

Meantime the co-operation of mathematicians and teachers is asked, in kindly offering fresh suggestions and giving results of experience. The author would be especially grateful if mathematical teachers would give any hints as to special points to be aimed at, with the object of forming good mental habits, such as that of ready inversion.

In conclusion, the author is very well aware that the method here sketched is only an elementary introduction to the possibilities opened up by the insight of Mrs. Boole, and of her daughter Mrs. Walter Stott. The substitution of the homely

needle and thread for the delicate and difficult instruments of mathematicians, and of geometric and mathematical forms for derived design, has set little children with their abundant leisure and fearless ignorance safely exploring the wonderland of beauty, hitherto reserved for thinkers and mathematicians.

Out of the mouth of babes there is ever much to learn for any who are ready; and familiarity in the concrete, from childhood, with the material of a subject hereafter to be dealt with in the abstract, has been the secret of the success of many a discoverer. What may be the outcome when the young mind is set thus swinging to the pulsing vibrations which we call Music, Colour, Form, Number, throbbing throughout the Universe in minutest flower and crystal underfoot, as in the immeasurable abysses of stellar space?

"It is the primaeval life that . . . wakes now and again, that feels the rhythm of a poem, the pulse of a pattern, the chime of a dancer's feet."

In the beginning when the sun was lit
The maze of things was marshalled to a dance;
Deep in us lie forgotten strains of it
Like obsolete, charmed sleepers of romance.

And we remember, when on thrilling strings
And hollow flutes the heart of midnight burns,
The heritage of splendid moving things
Descends on us, and the old power returns.[1]

[1] *Prolegomena to the Study of Greek Religion.* By Jane Harrison.

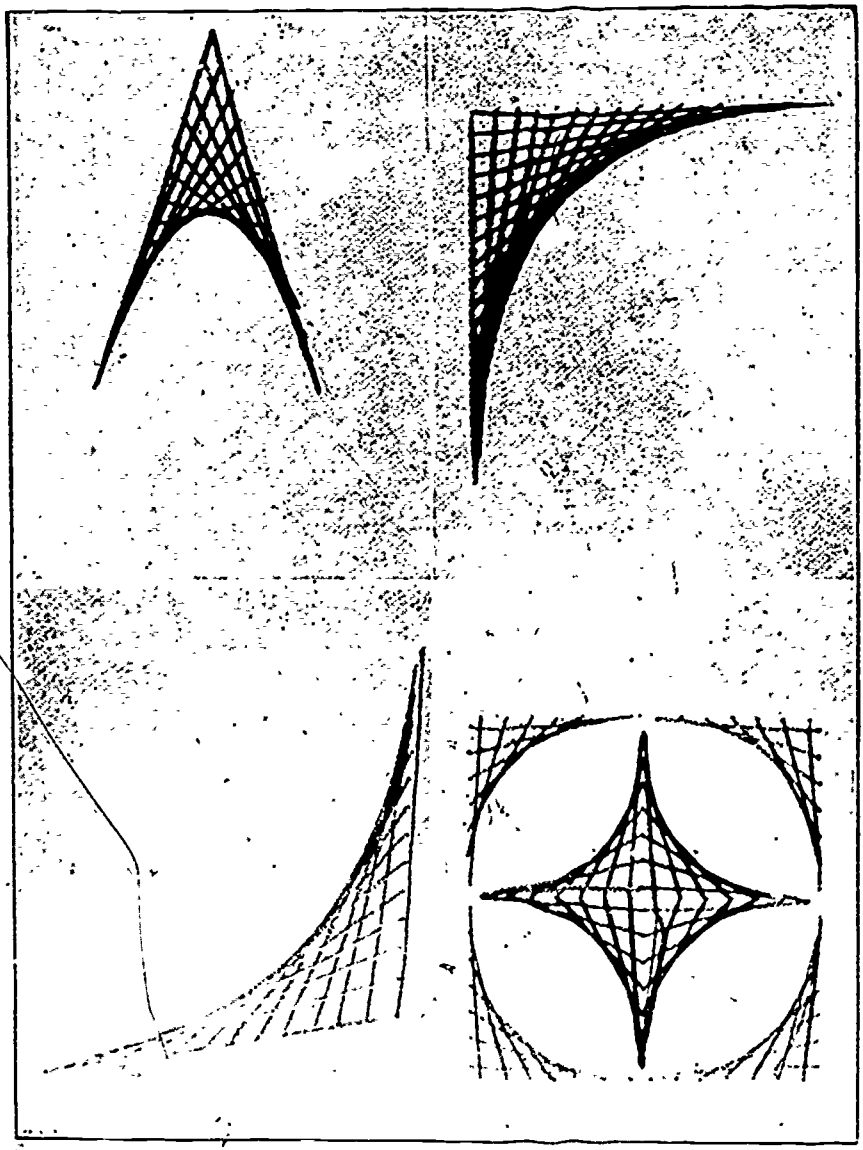

FIG. XII.

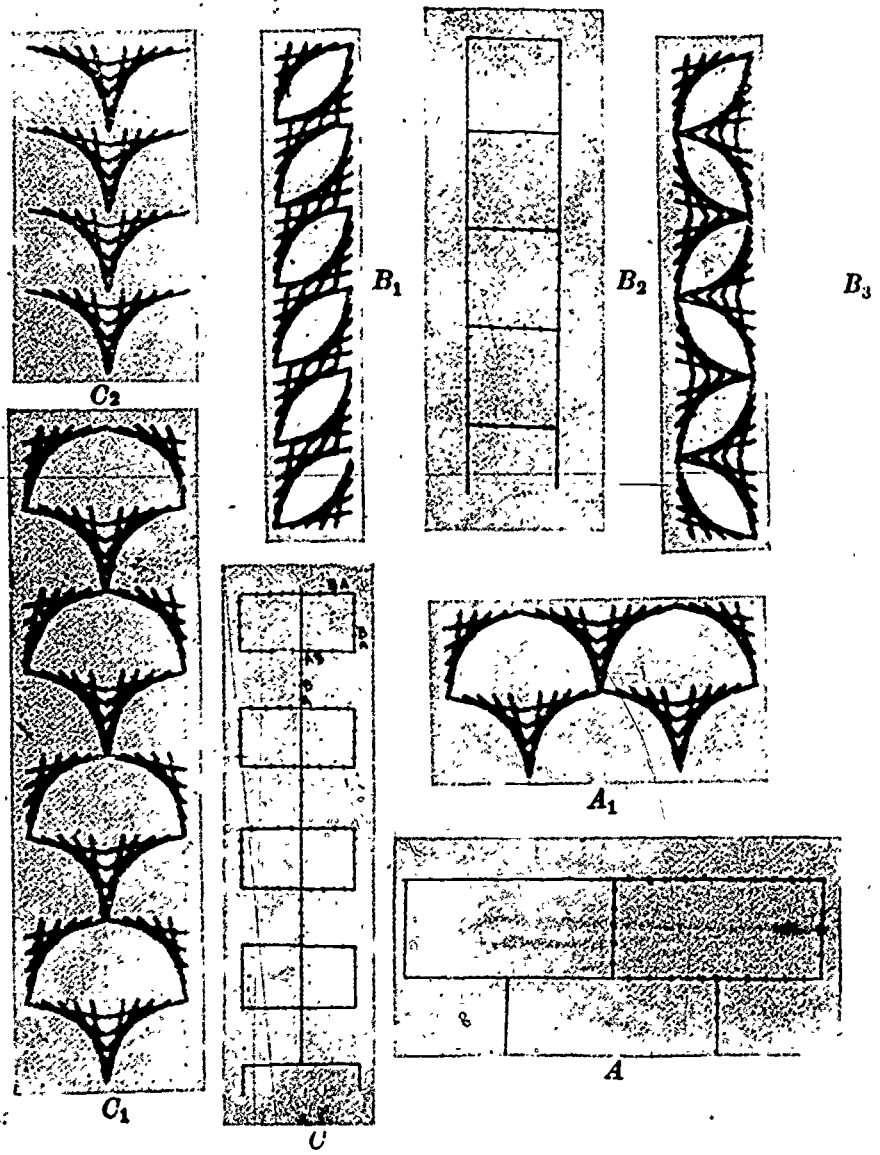

FIG. XIII.—Very simple borders on squares and oblongs. C is the back or frame for C_1 and C_2, A for A_1, B_2 for B_1 and B_3.

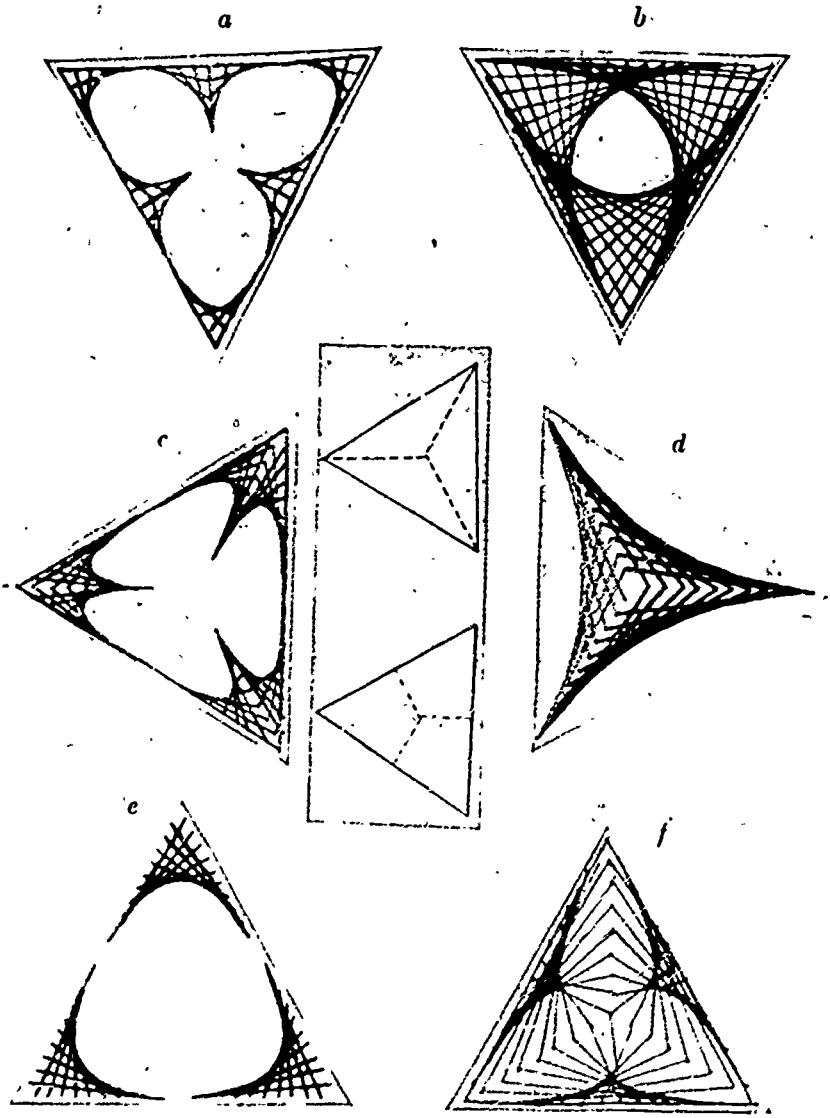

FIG. XIV.—Various treatments of an equilateral triangle, with lines from the centre to the angles or centre of sides.

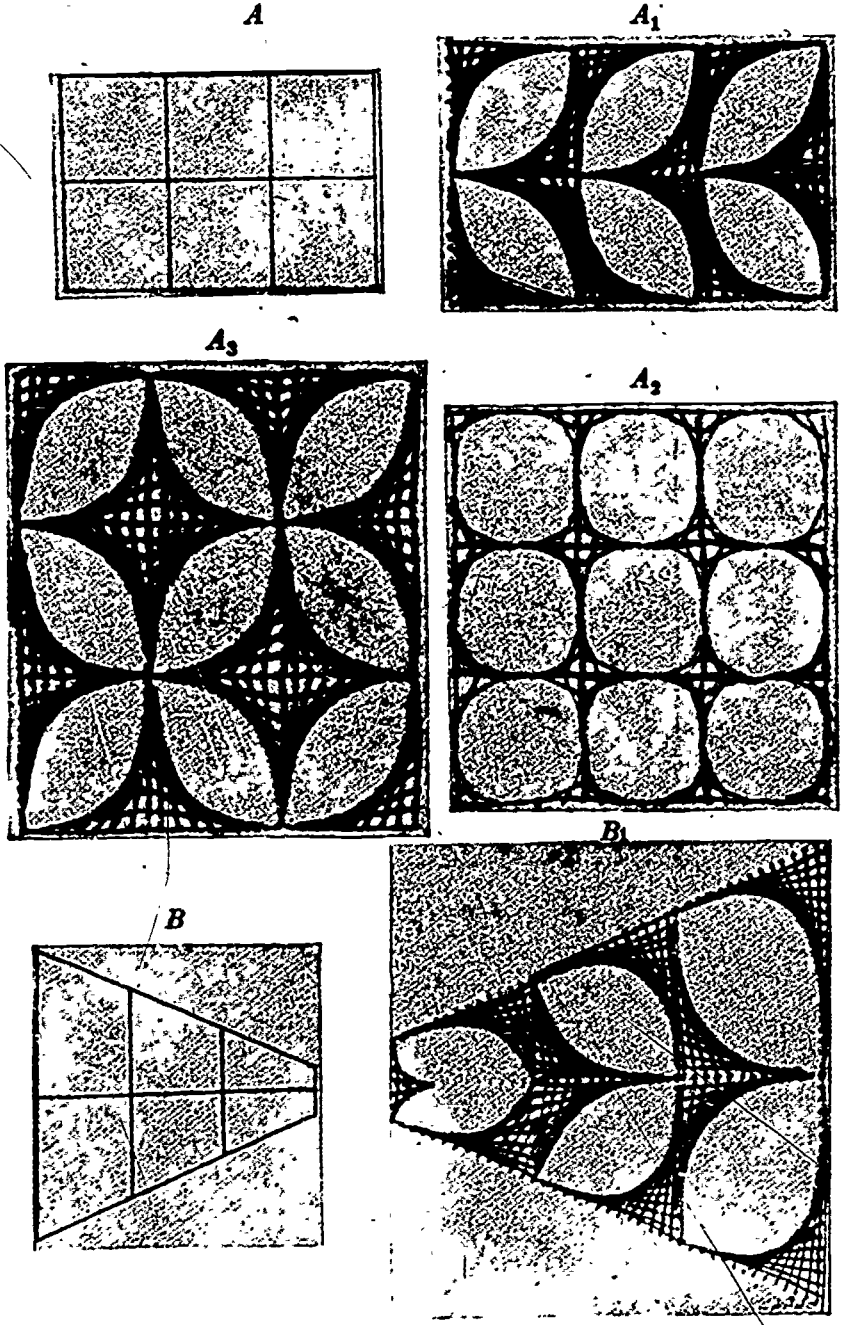

FIG. XV.—A is the framework for A_1, and with three added squares for A_2 and A_3. B is framework for B_1.

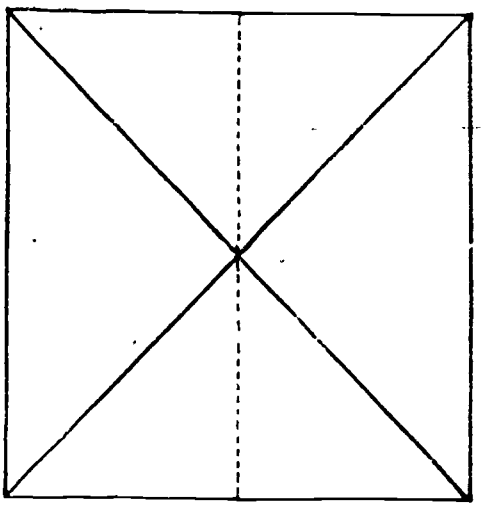

FIG. XVI*a*.

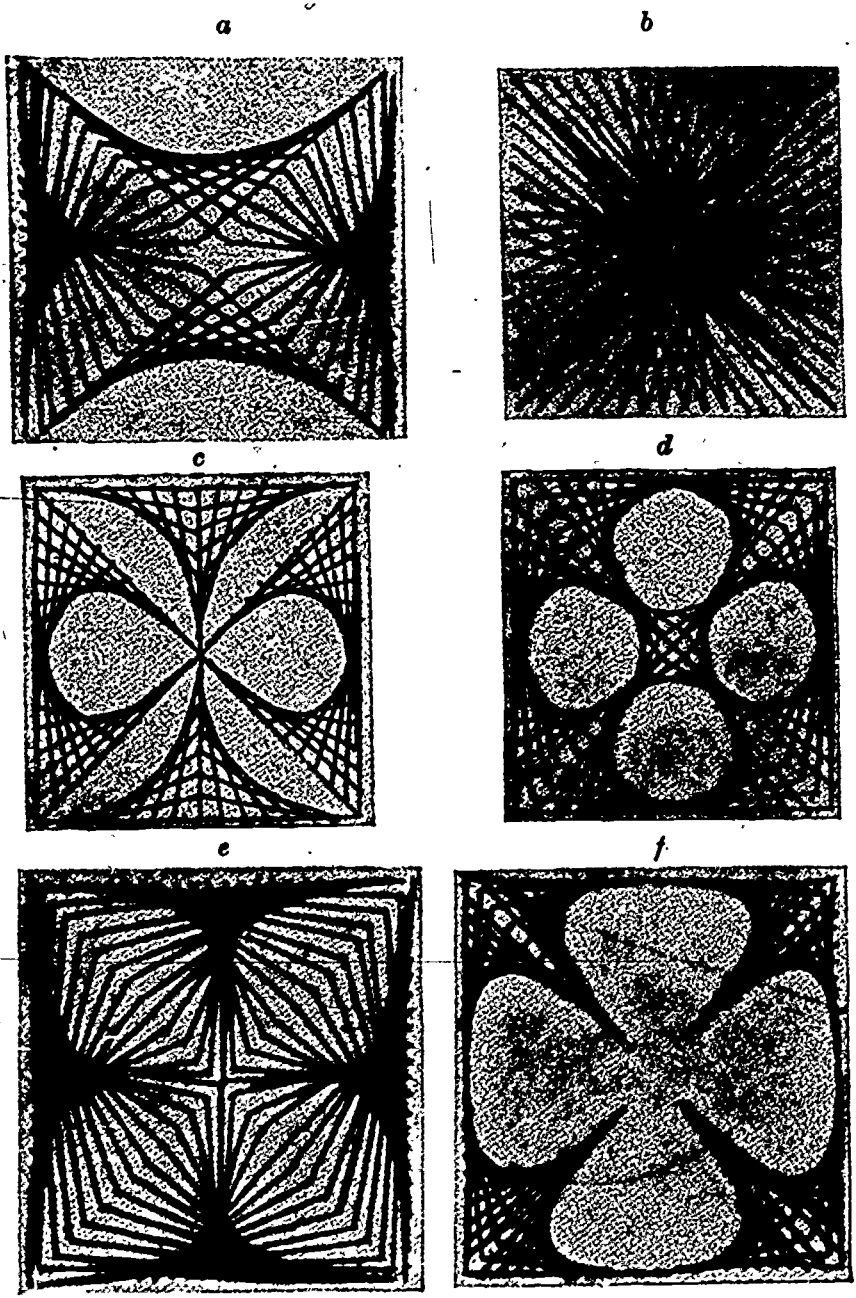

FIG. XVI.—Treatments of a square with diagonals *a*, *b*, *d*, *e* and *f*. *c*. The same with dotted line (Fig. XVI*a*) used as well as the diagonals.

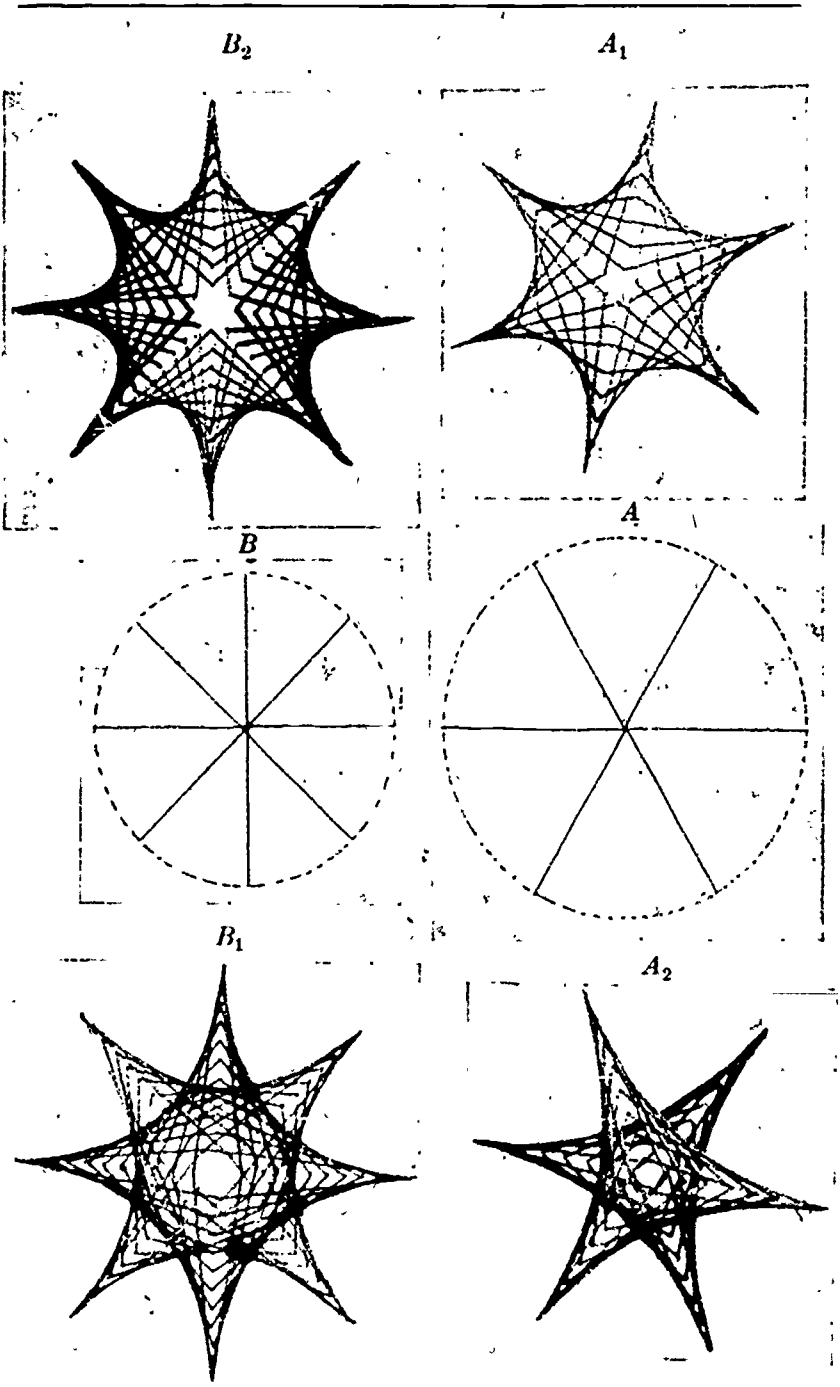

FIG. XVII.

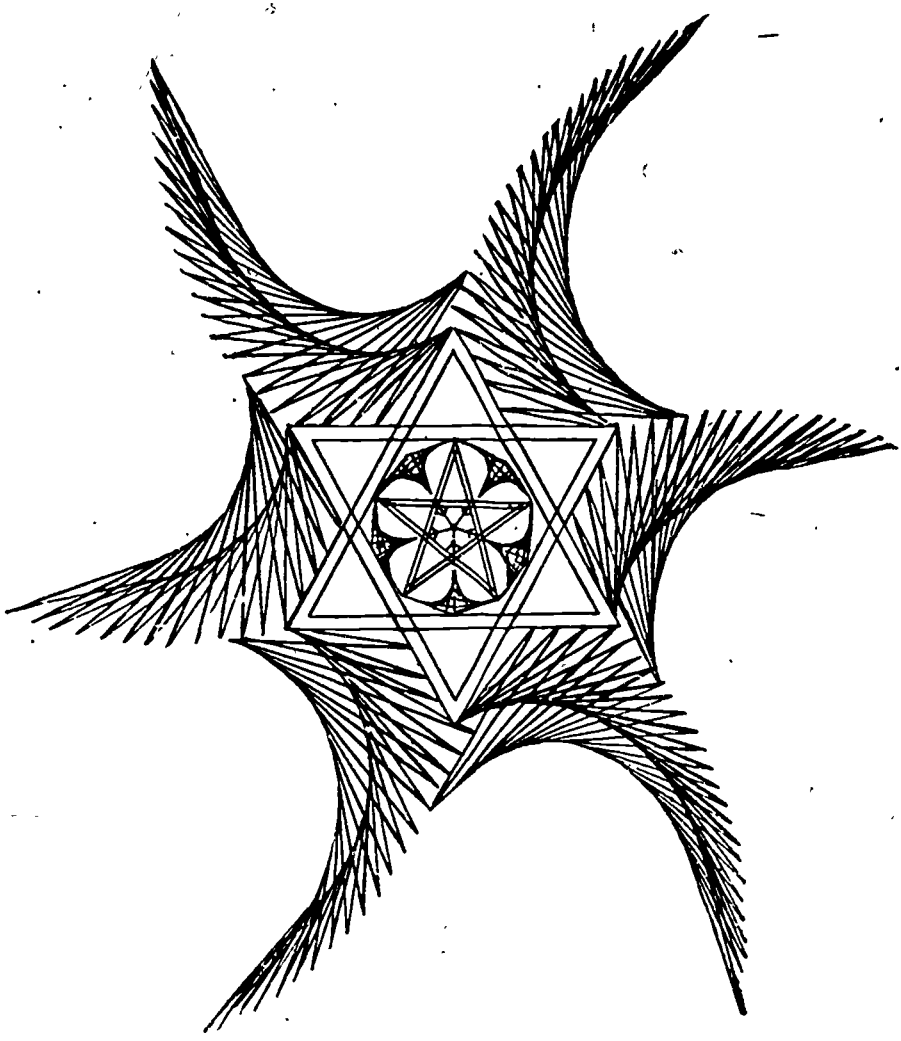

FIG. XVIII.
Design made entirely of straight lines, and ruled with a ruler.

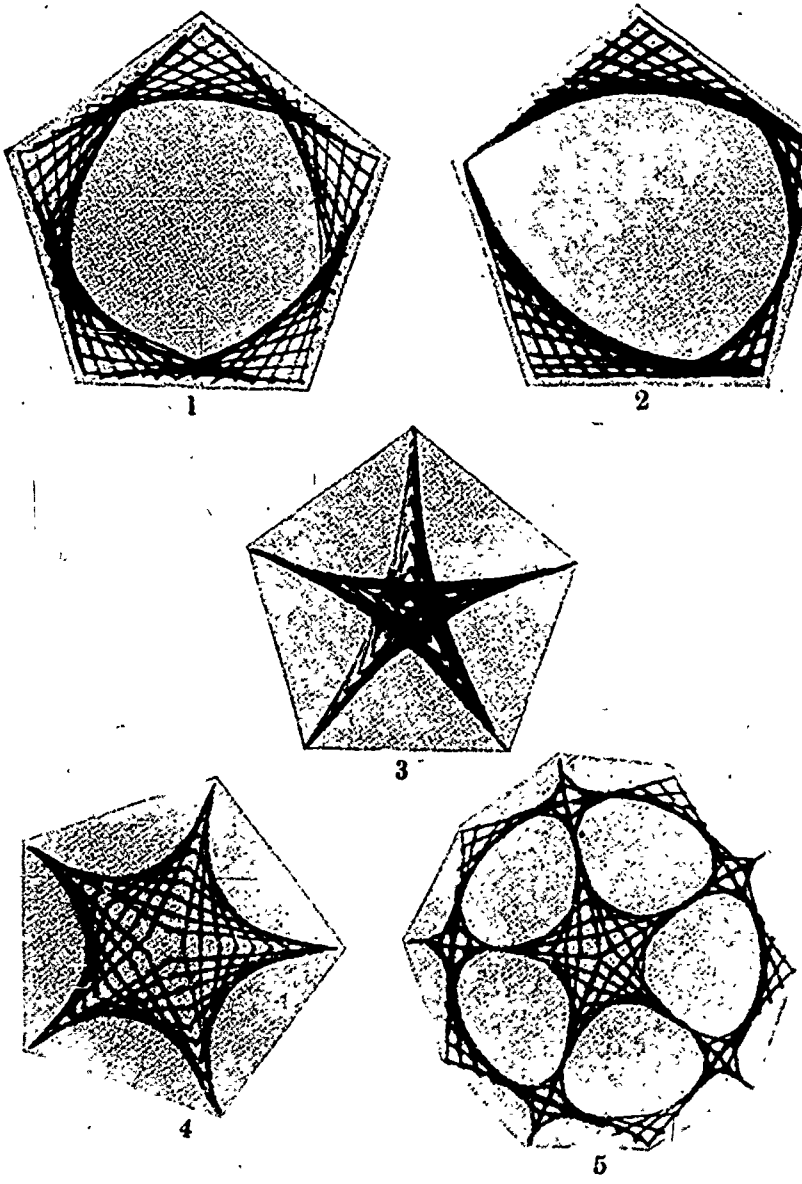

FIG. XIX.

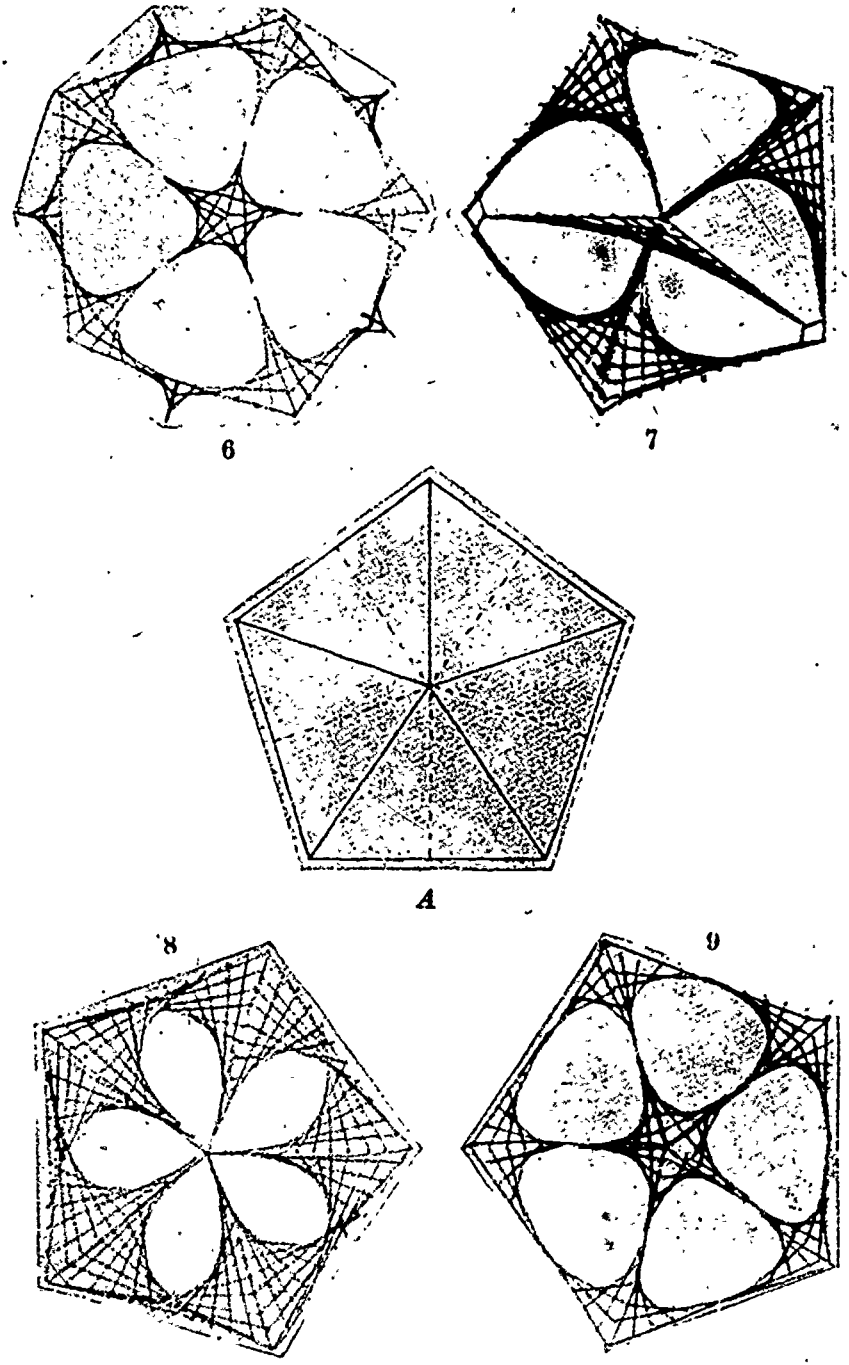

FIG. XIX*a*.—*A* is the framework for all these treatments. In 3 and 4 the outside line is not used; in 1 and 2 the outside line is used.

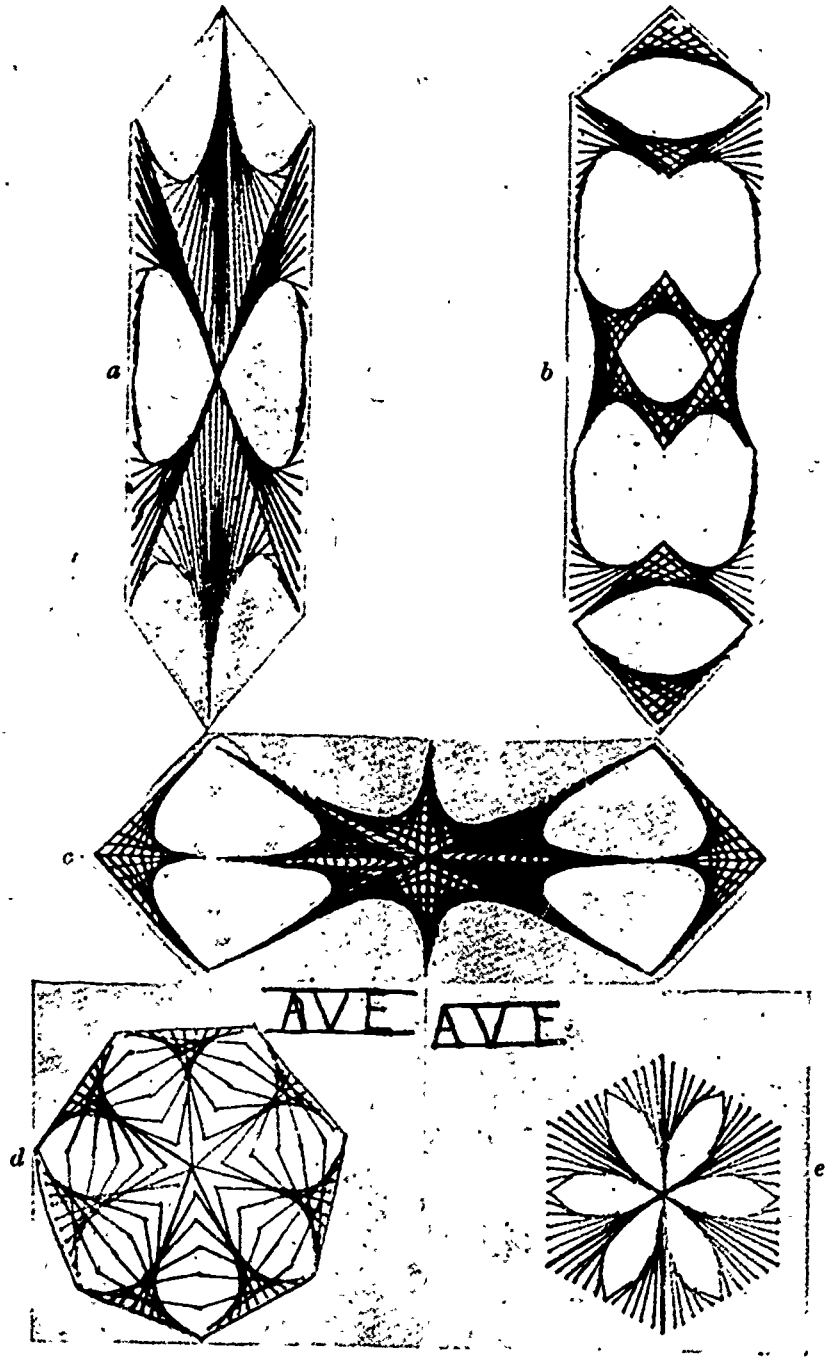

FIG. XIX*b*.—*a*, *b*, *c* are book-markers ; *d* and *e* Christmas cards, all designed and worked by children.

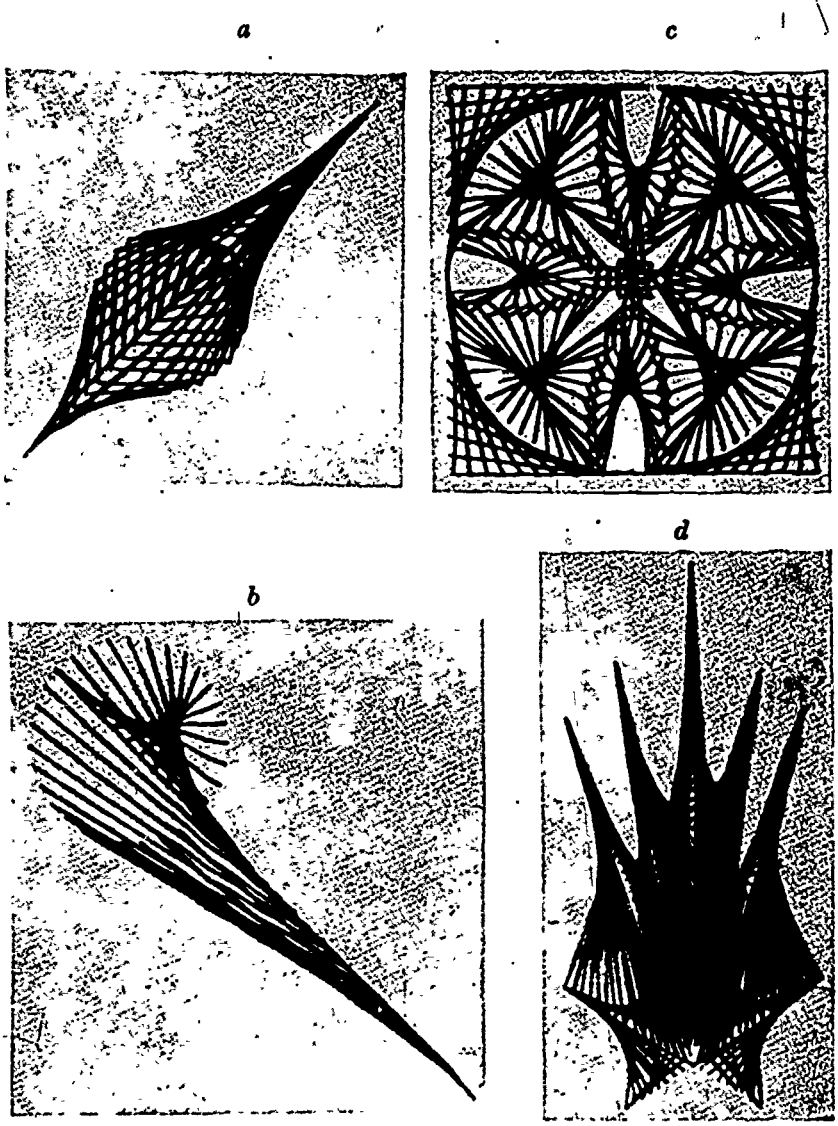

FIG. XX.—*a* and *b* are obtained by a circle bisected by a straight line, and points on both joined. *c* is the working out by a child of five and a half of his own design (Fig. VII.). *d* is a design made by a grown-up person on an ellipse, worked by a child.

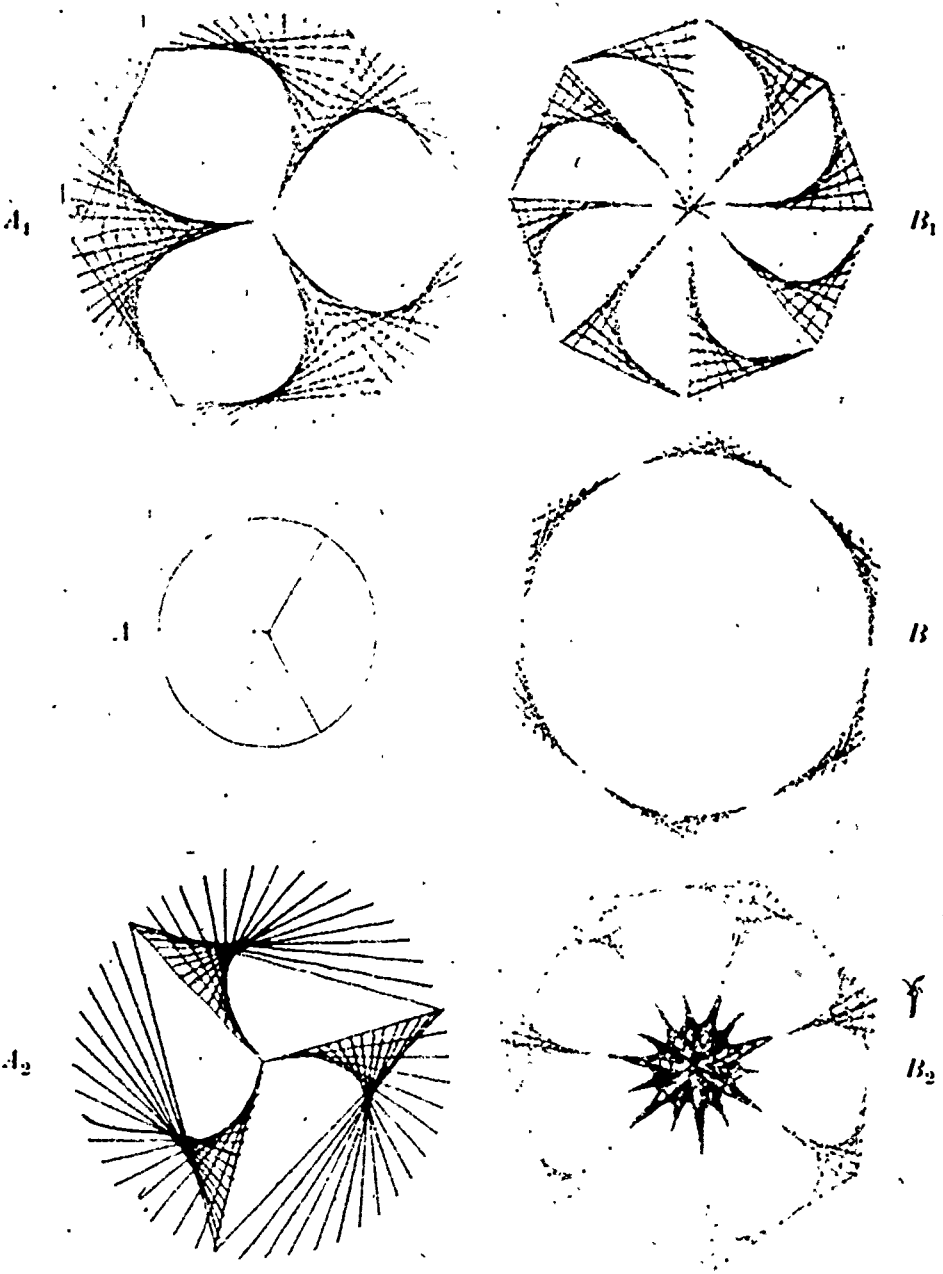

FIG. XXI.—A_1 and A_2 are both worked from A. In A_1 the radius is worked in both directions against $\frac{1}{6}$ of the circumference. In A_2 against $\frac{1}{3}$ in one direction only. B, B_1 and B_2 are three treatments of a hexagon, an octagon and a heptagon respectively. Each figure can be treated in innumerable ways.

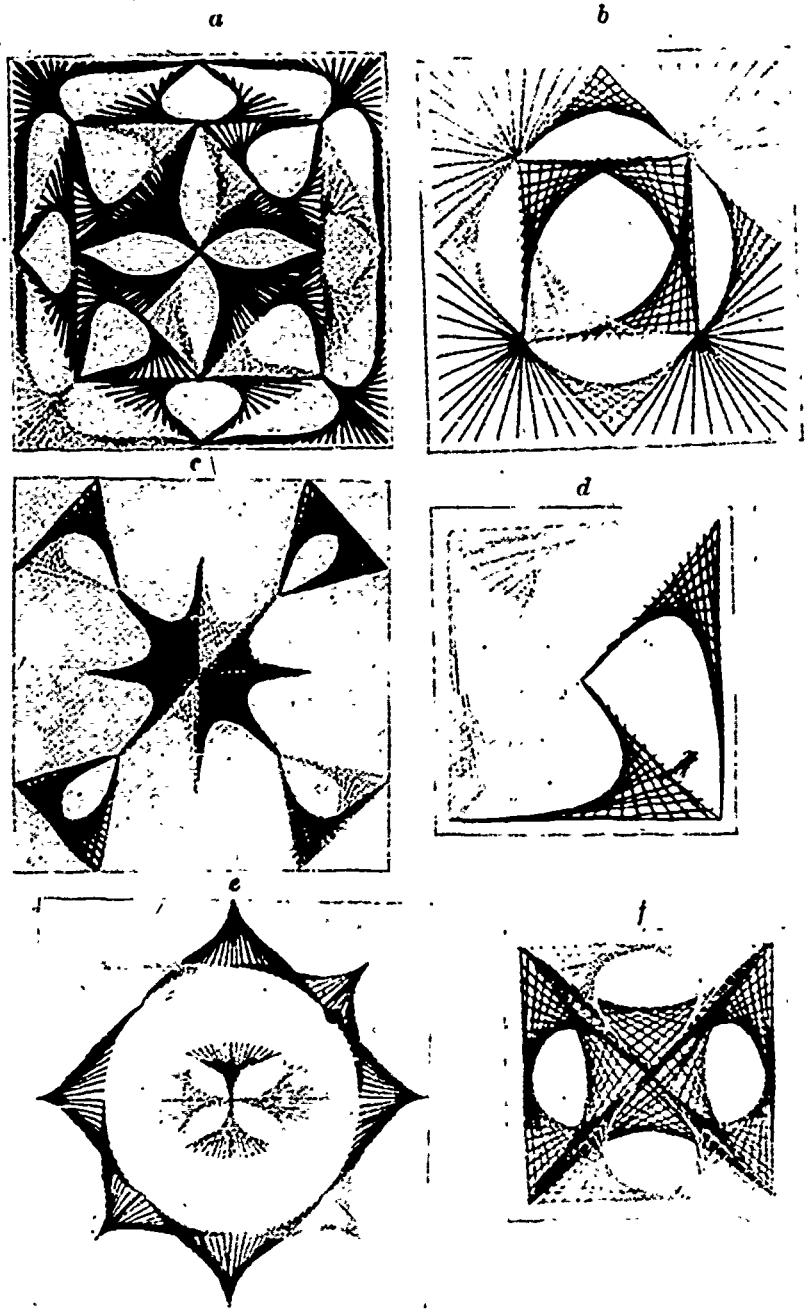

FIG. XXII.—Original designs made and worked at home by village children in Norfolk, after five lessons given by children of their own age (between 9 and 12 years).
a and *c* are treated with the curve of pursuit; *f*, *d* and *e* with the parabola.

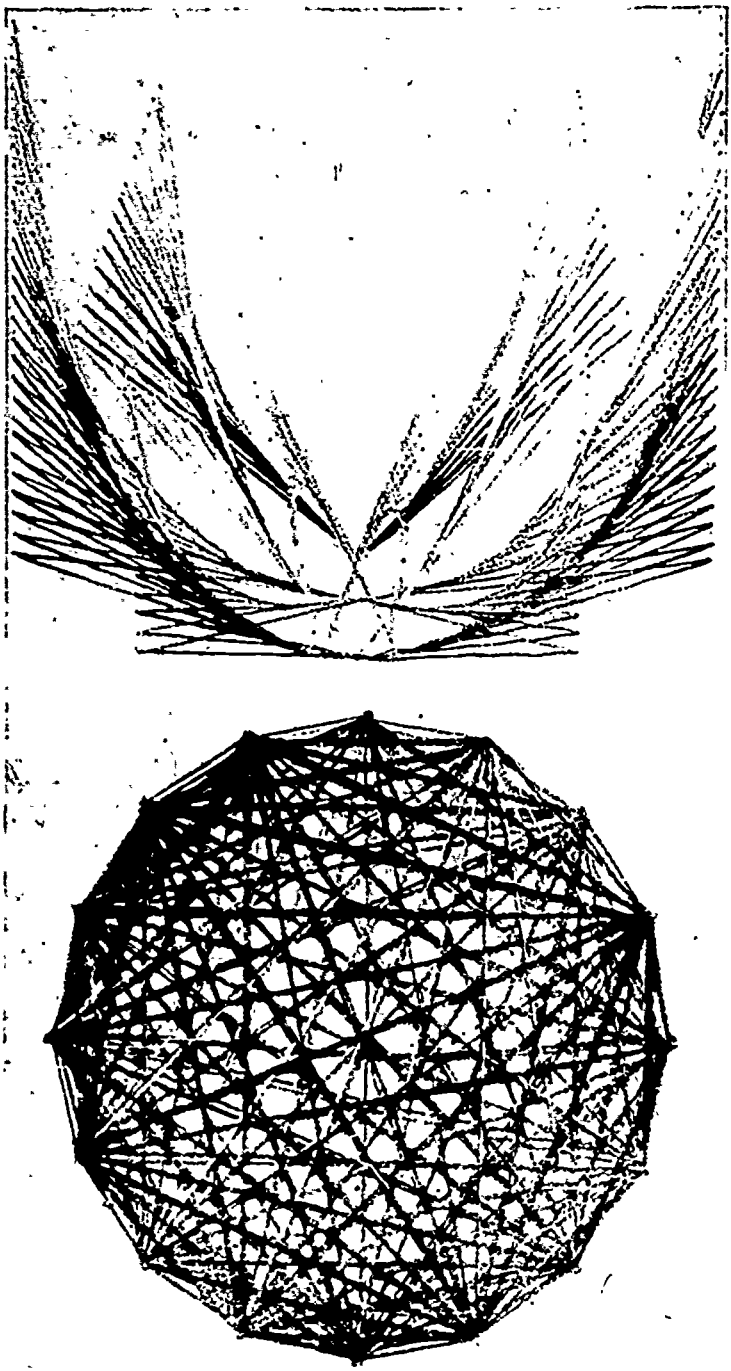

FIG. XXIII.—*A*, Curves of pursuit, 2 pursuers to one pursued in each case. *B*, A "mystic rose" (p. 40).

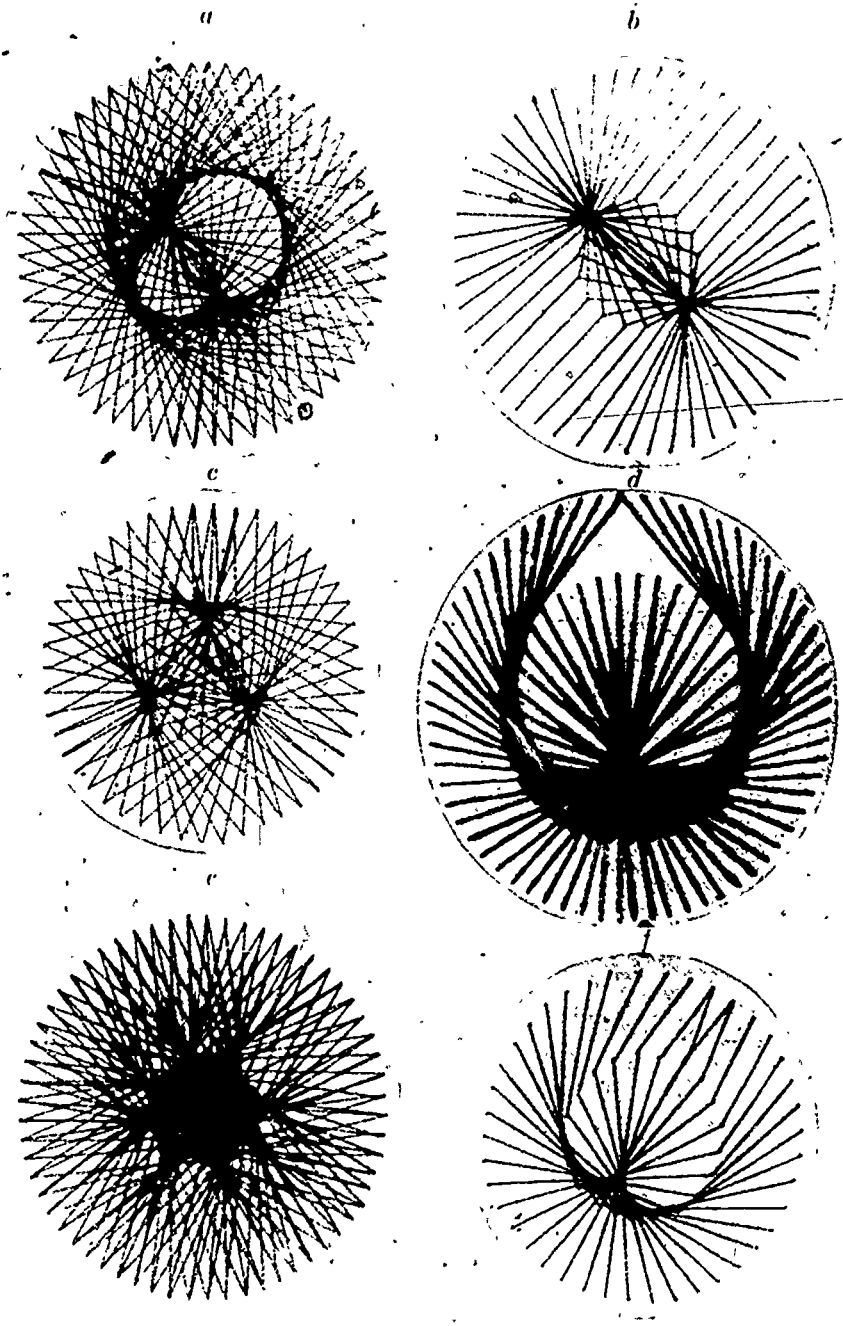

FIG. XXIV.—Figures made by joining successive points on concentric circles. Radius and number of points of circles varying.

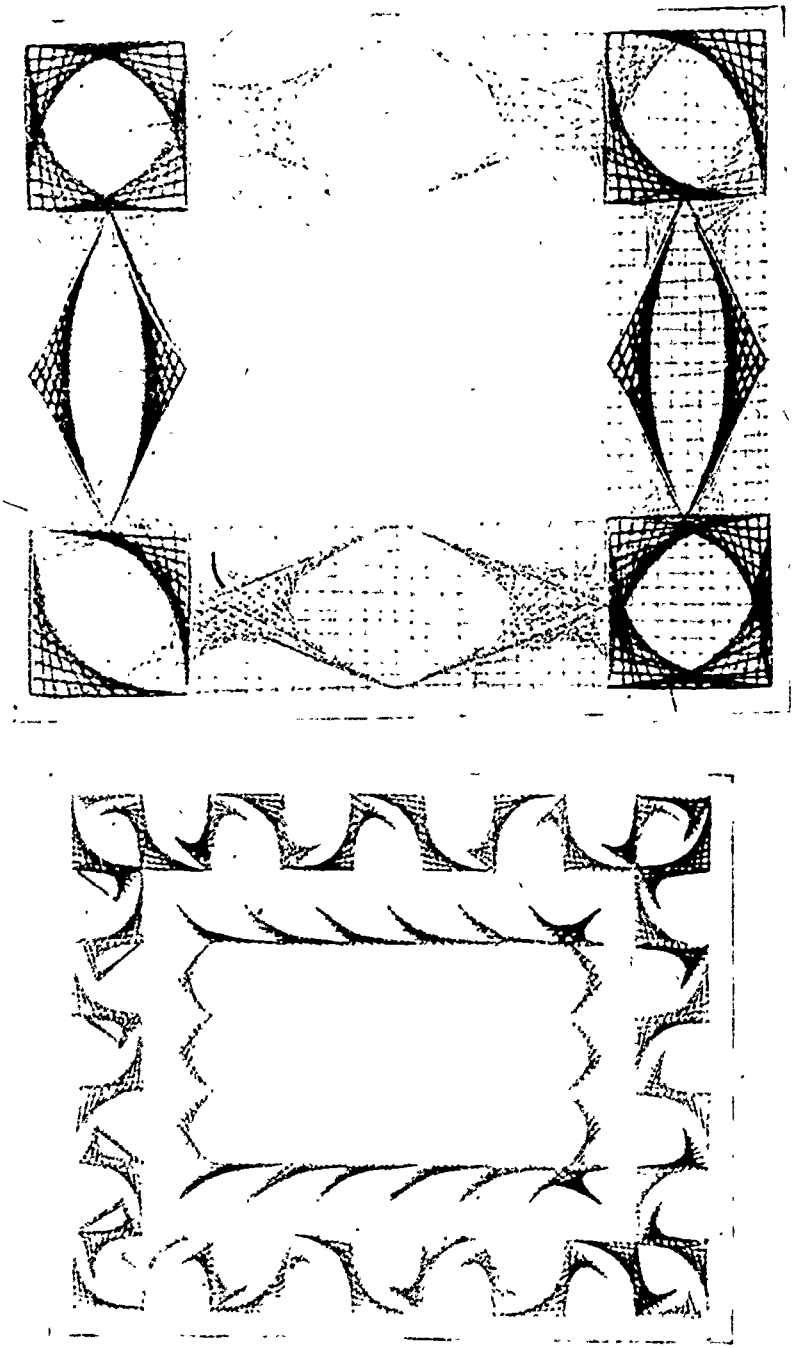

FIG. XXV.—Two photograph frames. Application to decorative purposes of the parabola only.

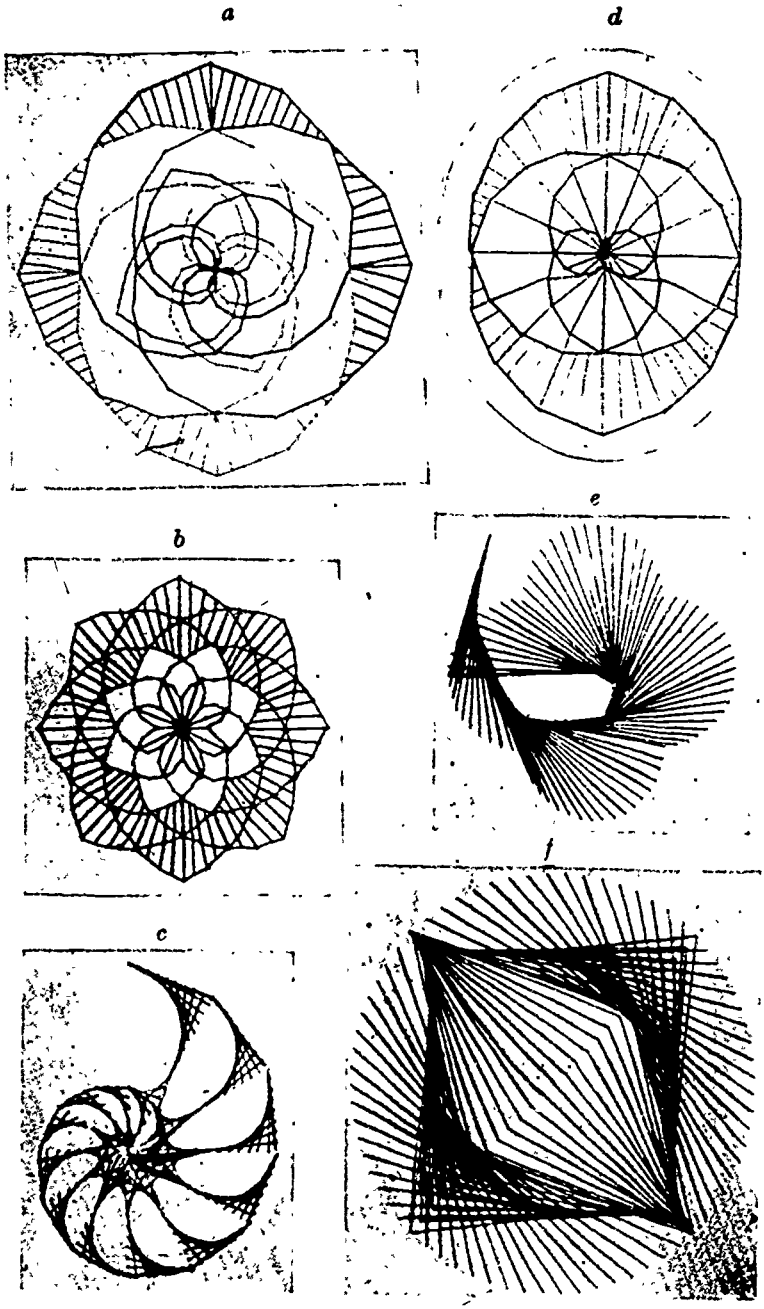

FIG. XXVI.—*a*, *b* and *d* designs on the spiral of Archimedes, designed and worked by children. *c*, The same by an adult, with parabolas drawn by tangents in the angles. *e* and *f*, Decorative applications of the tractory curve drawn by tangents.

ERRATA.

P. 32, commencing at top of page, should read—

"safe in the burrow *B*). The *action* of the rabbit? (To run from *R* to r^1.) But while the rabbit runs to r^1, the dog, running from *D* to d^1, sees the rabbit is no longer at r^1, etc.

P. 23. (Footnote.) For p. 56 read—pp. 58 and 59.