subject, in which as usual, the same letters of reference are respectively affixed to the same parts.

The mechanism shewn in our figure S 8, Plate 11, also applies directly to the general solution of this problem, without the necessity of a counterpoising weight; thus, let A B and C D represent two axes, each of which carries a pulley, a of one of them, a′ of the other; and also a toothed wheel on each, b and b′. An endless rope or band presses crosswise over the pullies a and a′, and produces their simultaneous circular motion, in opposite directions. Let E F represent another axis carrying a toothed wheel c, this axis is at liberty to alter its distance from the axes A B and C D, or to move between them approaching one of them, while it recedes from the other, its pivots being let into the oblong aperture d d′; it thus operates to carry the wheel c into working contact with the wheels b and b′ alternately, and so to convert the direct circular motion of the axes A B and C D into alternate circular motion.

An attentive inspection of the several figures of this subject, with reference to the description already given in our article S 8 will give a complete idea of this mechanism. In the two upper figures of K 9′, or the plans, the curves e f g h, e′ f′ g′ h′ will be observed; each of which is composed of two parts, the first portion of each is circular and they are respectively marked e f g, and e′ f′ g′; these portions support the axis E F alternately in its bearings towards C D and A B, the other portions g h and g′ h′ operate to communicate the shifting movement to the axis E F.

SECTION X.

To convert direct circular motion, of uniform velocity, or which varies by a given law, into that of a curve of given species, direct and continuous, of velocity similar to that of the moving power, either equable, or variable by a given law, and in the same or in different planes of direction.

A 10. Plate 8.

First general Solution of the Problem.

Let F represent the given curve; and let it be required to trace or describe it

mechanically by a pencil or other instrument upon the surface P Q by means of the direct circular motion of the wheel D. For this purpose three wheels A, B, C must be taken of suitable diameter, and arranged as shewn in the figure, and which shall receive their motion through the operation, and by their connection with the wheel D; m n, p q are two rulers or bars, which are at liberty to traverse to and fro in the clips or directing grooves a, b, c, d. They are terminated in m and q by two rulers or bars r s, t u, each having a straight groove or channel cut through it. The pencil or instrument with which the curve is to be traced is to be fixed at the point of intersection of these two grooves. A certain number of points are assumed at pleasure upon the given curve, and the number of them for the reasons explained in the article A 7, should be encreased at those points of the curve at which the most abrupt changes of direction take place. The proper curves thus obtained must be traced, and placed on the surfaces A and C in relief, and so arranged that the extremities n and p of the tracing points shall be pressed into constant contact with them by means of springs or other suitable contrivances; and the points of intersection of the grooves or the positions of the pencil, will then traverse the previously determined points.

From this mechanism might easily be devised a mechanical method of explaining the laws of the resolution of forces, and the motion of projectiles in a resisting medium or otherwise; if such methods might be considered of sufficient importance to warrant our thus encreasing the number of our scientific apparatus and instruments, which it must be confessed seem already to be more numerous than the legitimate purposes of science properly require.

B 10.

The general solution which we have given of this problem in the preceding article, is the only solution which accords with the plan of our analytical table, in which the principal object is to shew the transformation of one movement to another. But in the practical arts, it is essential not merely that the desired result be produced, but that it should unite simplicity of arrangement, with a facility of construction, and which shall be effective and suited to the habits and

comprehension of workmen. For the due performance of these conditions, the movements should be judiciously arranged with respect to the different parts of the machine, and as the distribution of parts will be arbitrary, the same end may therefore be produced in various different ways. It is the business of an accomplished mechanist to calculate all the practicable combinations which may be made with the component parts of a given machine, and the required number of movements, and to adopt the most simple and effective.

The object of the problem we are now considering, is not so much to produce the curvilinear motion of a given point, or tool of any description, as to describe that curve on a given plane surface. To this end, the surface P Q is attached to the extremity of the arm p q; this surface, which was previously fixed, will thereby receive an alternate rectilinear motion; having fixed the pencil or cutting tool to the end m of the other arm m n, corresponding curves will be traced on the surfaces A and C, and a machine will thus be obtained which we consider to possess much novelty and usefulness.

Second general Solution of the Problem.

The principal points of a given curve may also be governed by angular co-ordinates. These curves are of two descriptions:—1. Continuous or returning curves, in the interior of which a point may be determined—such as that all right lines passing through it, shall pass through but two points in that curve. 2. Similar curves in the interior of which no point can be assumed which possesses that property.

The curves of the first-mentioned description may be easily described by a direct circular motion, thus: Let A B D, (figure α, plate 10.) represent the given curve, and let any point C be taken within it for the centre of rotation of the circular movement of the bar P Q, which revolves in the same direction, while the bar T O slides upon PQ. During the motion of the point O over the given curve, the end T traces another a b d, and reciprocally, the assumed length of the bar O T being arbitrary, the bar O T′, might have been taken instead of it, in which case the curve a′ b′ d′ would have been produced, answering the proposed conditions of the problem.

The curves of the second description involve some difficulty. Let A, B, D, (figure β, plate 10.) represent the given curve: there does not appear on the

first consideration any general solution of this problem, in whatever position the point C may be assumed; for the circular movement of the bar P Q being direct, while the bar OT follows its direction the solution of this problem thus becomes impossible; a little further consideration however will indicate the method of proceeding.

Suppose that the line O T (figure 3, plate 10.) instead of being placed in the direction P Q, shall make a constant angle with it as C O T; if during the passage of the arm P Q to the position P′ Q′, the point O approaches the centre and arrives at O′, the point T will pass to T′, having experienced a retrograde movement relatively to the movement of P Q. This will sufficiently point out the practicability of a general solution of the problem.

A detail of all the operations connected with this subject, would lead us into considerations essentially distinct from the general object of our work. We shall therefore pass on to our usual descriptive mode of explaining the practical applications of the problem.

Having shewn the methods of tracing curves formed by a circular, and an alternate rectilinear motion, we will now suppose the surface on which the curve is to be traced, to have a circular movement while the line T O has an alternate rectilinear motion, so that the whole line, or only the point O of it shall be constantly found in the direction of a radius of the circle described by a given point of the revolving surface.

In this point of view, we find this problem give rise to a practical art of great elegance and utility, viz.—The branch of ornamental turning, which is termed —rose engine turning. Much practical information in this art may be obtained from " le Manuel des tourneur de Bergeron," and the French " Encyclopédie."

In the Memoirs of the French Academy of Sciences for the year 1734 we find two Memoirs on this subject by M. de la Condamine; the first given at page 216, is entitled " Recherches sur le tour; Description et usage d'une Machine qui imite le Mouvement du tour*.

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* M. de la Condamine in his second Memoir, gives the solution of some problems analogous to those general ones whose solution we have here pointed out; he however considers them in a different point of view.

We have introduced the simple method shewn at C 10 of our plate 8, as an effective substitute for M de la Condamine's machine. It is composed of an auxiliary wheel A, which drives two other wheels B and C, which in the latter are placed on the same axis. The rosette D is affixed to the first wheel B; the pin m n, which is attached to the sliding bar P Q, presses upon its edge by means of a spring a b acting on the end p of the bar. At the point q of the moveable arm p q is set a point or pencil which may be placed at pleasure in any part of a circle of paper placed on the surface C.

The practical use of this machine is, as M. de la Condamine observes, to determine the variety of figures which may be described by the tool, from the same rosette, a matter extremely easy to accomplish. We shall refer to his memoir for a detailed account of the various forms to be obtained by changing the rosette, or varying the position of the tool or pencil.

In actual practice, those rosettes will be found most commodious, the lines of which form the most obtuse angles; the motion of the pin m n is thus rendered more uniformly steady.

M. de la Condamine observes, that the second practical use of the machine, is to determine the proper species of rosette suitable to any given design.

He says, " Having properly determined the place of the tracing point, " and secured it in the required position, it only remains to set it by hand " to the design for which the rosette is required; and the other extremity of the " bar which in the common use of the machine, is pressed upon the edge of the " rosette, will trace the rosette required. For the present purpose therefore, a " plane surface of paper or pasteboard is substituted on the wheel B for the " model of the rosette before placed there, and the end m of the point m n, " which in the former case applied itself on the outline of the rosette, will now " carry a pencil which will describe the outline of the figure required."

D 10.

The second memoir of M. de la Condamine, page 303, of the Memoirs of the Academy, is entitled—" Recherches sur le tour, second memoire. Examen de