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 la nature des courbes qui peuvent se tracer par les mouvemens du tour." He gives the solutions of the two following problems.

Problem 1.—The outline of any rosette being given, with the respective positions of the centres of the tracing point, and the cutting tool, in the same plane, to determine on that plane every point of the corresponding design.

2.—Any design or outline being given, with the position of the centres of the tracing point or of the cutting tool, to determine on the same plane, the outline of a corresponding rosette.

The solution of these problems is so simple, that we do not consider it necessary to enter into any detailed explanation of them. For further particulars on the subject, the memoir itself may be consulted.

M. de la Condamine afterwards gives the description of the instrument shewn at D 10, which, he observes, affords a ready and correct mode of determining at once, and of describing by a direct motion, rosettes for the production of every possible outline of a given design ; or reciprocally, to trace every possible design to be obtained from any given rosette, and this without the necessity of wrought models, as in the machine described in the first memoir.—A B C D is a bar or rule of three inches in length, having a longitudinal groove; the portion A B is perforated with several screw apertures, in any of which the point B may be screwed so as to vary its distance from the end A as may be required; the bar A B C D is held or supported by the clips E G of a second bar, which is also perforated with a longitudinal groove; the first bar has a sliding motion through the second, which carries a small hollow spring cylinder or barrel L, the action of which tends constantly to draw the longer bar in the direction D A, being attached to it by the band D; the lower bar also carries a second point N, which consequently tends continually towards the centre P, by the action of the spring; the centre is determined by a third point P, which passes through both bars, and is fixed to the lower bar E G, at any required point, by the nut z. The instrument is applied in the following manner :

Let the outline of the profile head at T, be the figure for which a suitable rosette is required ; having first cut this profile accurately in thick pasteboard, it is glued or otherwise firmly attached to a second surface of the same material

RS, a point T is assumed at pleasure for a centre, within the outline of the subject; the two cards are then perforated in the point T, and they are together fastened down on a plane surface, passing the point P through the perforation; after which the point N is placed in contact with any part of the outline; the whole instrument is then turned by hand on its centre of rotation P, keeping the point N in constant contact with the outline of the subject, or in some cases, it may be preferable to turn the pasteboard on its centre of rotation with one hand, while the instrument is held firm with the other, attention being paid at the same time to the accurate and uniform contact of the point N with the contour of the subject.

In both these cases, the point B bearing on the surface of the large pasteboard RS will describe the line VX, which is the contour of the required rosette; the point N drawn continually towards the centre P by the action of the spring L, and its progress in that direction restrained by the relief or thickness of the subject, will follow its outline with great facility and correctness so long as it does not lie in the direction of a right line drawn from the centre, which must be attended to, and avoided as much as possible in determining the point within the figure for the centre of rotation of the instrument. If in any instance this cannot be entirely avoided, as in the present subject where the lines which depict the lower portions of the nose and the chin lie in the objected direction, and that therefore the tracing point N cannot have its requisite bearing on the edge of the subject, but slides upon it, the action must be carefully assisted by the hand; this inconvenience may also be avoided in a great degree by turning the surface in an opposite direction*. Thus, in this instance the tracing point will not move up from the nostril of the figure towards the extremity of the nose, without the assistance of the hand, but will by the last-mentioned method slide

* The author's directions in these respects should however be followed with considerable caution: it appears to us, that under the circumstances stated, the requisite assistance cannot be supplied either by the manual adjustment, or the reversed rotation he recommends, but that the required correction must be sought by placing the point B out of the direction AD in a suitable manner, so as to avoid the obstacles in question; which may generally be accomplished with practice and attention.

easily over that portion of the outline, and will be drawn back again by the action of the spring. It must be observed, that in changing the centre P, or separating the two points B and N in a greater or less degree, different outlines will be produced, of which those will be chosen for the model which have the most easy and flowing curvature, and which are the most practicable in the subsequent operation of turning. It will be proper to verify this process of production of the curve, before it is cut, by a process of reversal, that is to say, by carrying a tracing point round the curve produced, and observing if the point N correctly retraces the original outline of the subject.

In this instrument we have supposed the tracer, the centre, and the cutting tool to be situated in a right line, that arrangement being at once the most simple and the most commodious in practice. The effect of oblique positions may be easily obtained, by affixing a small arm moveable on a stud or centre pin at the extremity A of the bar A D, to set the point B which describes the curve of the rosette out of the alignment with the centre of the point which traces the subject, and to set it at any required angle with that alignment.

In a descriptive work entitled " Traité des Instrumens de Mathématiques et Méchaniques," by Jaques de Besson, printed at Lyons in 1579 in folio, page 172, we find accounts of several constructions of compasses for describing rectilinear, curvilinear, elliptical, and spiral figures. The construction of all these instruments is founded on the principle of setting a rosette on one of the legs of a pair of plain compasses, which remains fixed, while the other is at liberty to make its rotation with the tracing point: all which methods may be considered as in fact so many varieties of the simple turning engine. One of these may be particularly remarked for its simplicity of construction, in which, instead of an elliptical rosette, a moveable circle is so adapted that its inclination may be altered at pleasure, and it is also capable of describing any required ellipsis with the same rosette.

In Vol. VII, No. 455 of " Machines appronvées par l'Academie Royale des Sciences," we find the description of a pair of compasses for describing spiral lines, by M. de Thiliéres. It is observed at the close of the memoir, that the second addition of the inventor was detailed in a memoir transmitted to the Academy in August 1745 for a note in the history of 1742.

The little instrument for describing ellipses shewn at Figure 8, Plate 12, is remarkable for its extreme simplicity.

A circular plate either of metal, wood, or any material of sufficient firmness of texture, and of any diameter, has two grooves n n and m m, formed on its surface at right angles to each other, the grooves are of dove-tail construction, and two sliding pieces B and C of corresponding form are placed in them one in each, and are at liberty to move back and forward in them, with a small degree of friction; from the upper side of each of these pieces there projects a small point or cylinder, these points fit into cylindrical holes drilled in the under side of the ruler or bar BD, one of them at the extremity B, the other at some distance from the first, along the bar. A pencil or point of any sort, is then held firmly to any part of the bar, and the bar being turned about on the two centres of rotation, which are thus both in motion at once, the pencil will describe an ellipse, the excentricity of which may be varied at pleasure.

Descriptions of two ellipsographs of much merit are given in the Bulletin de la Societé d'Encouragement, Vol. xvi, for 1817, page 13; and a description of an ellipsograph by Mr. William Cubitt, will be found in the Transactious of the Society of Arts, &c. of London, Vol. xxxiv. for 1817, page 131.

E 10. Plate 8.

Let A, N, B, C, represent a train of toothed wheels, whose diameters are respectively as the numbers 2, 1, 2 and 4; let a′ b′ represeut a bar, whose extremity a′ may be successively fixed to the points 0, I and 2 of the wheel A, and adjusted also to contact with the points a c of N, 0 and I of B. These points being so placed that they may be in a right line in one position of the train, every point of the bar a′ b′ will move in one curve themselves, and will describe another on the revolving surface below it.

These curves assume forms which merit an attentive consideration, and are of much importance in the arts. It will be evident that they may be produced in an infinite variety, by the various combinations which may be made from the original places of the points 0, 1 and 2 of the wheel A, a, c of the wheel N, 0 and I of the wheel B, and other points taken out of the direction of the bar a′ b′.

The ratio of the diameters of the wheels, and the number of them will also give rise to new varieties in the character of the curves. This machine will be considered as a contrivance which may be usefully adopted under particular circumstances, but the curves it produces may also be described by the preceding movements A 10, B 10, C 10, D 10.

F 10.

Problem.—To describe a continuous spiral on the convex surface of a given cylinder.

It will be recollected that this is in fact the process of describing the helix of a screw of a given diameter.

Let AB represent a fixed axis; to which is firmly attached the cylinder C, on the convex surface of which it is required to describe the spiral: and the toothed wheel D. M L K N is a frame having a rotatory motion on the fixed axis A B; between the arms L M, K N, is fixed the axis F G, which has a movement of rotation on itself, and carries a toothed wheel E, which drives the wheel D; and also a male screw H I with its nut P: the nut carries an arm O P at right angles to the axis of the screw; the extremity O of this arm moves in a groove which extends longitudinally through the extent of the bar L K of the frame, and at the other extremity carries a pencil, or cutting tool.

Method of using the Machine.

Let the radius of the wheel E be called α, that of the wheel D be called β, and the thread of the screw cut on the cylinder H I be called δ. If now the frame M L K N be made to describe one revolution about the axis A B, the wheel E and consequently the cylinder H I will in the same time describe a portion of one revolution about the axis F G equal to $\frac{\beta}{\alpha}$, and the pencil, or cutting tool, will in the same time traverse a distance equal to $\frac{\delta\beta}{\alpha}$, which will represent the quantity measuring the thread of the required screw, or the quantity of one revolution of the helix to be described on the cylinder C. The value of this quantity will of course be variable at pleasure, by suitable alterations in the relation of α to β, or that of δ, by the introduction of different guiding screws.

It has already been noticed (in our article C 3) that, when the nut is fixed, and the screw is made to revolve, the movement will be compounded of a rotatory motion and one of conversion. This compound movement is precisely that which is required for tracing this helical line; and it consequently affords the solution of the stated problem. The movement has been frequently applied in the construction of pendulum clocks and clepsydræ, and of hygrometers. In these several machines or instruments the helical line is described on the convex surface of a cylindrical column, and so becomes the scale on which the progress of its action is indicated.

An hygrometer on this construction is described in Leupold's "Théatre universel de la Statique," 1726, plate 16.

In this instrument of Leupold's the hygrometric action is supposed to be immediately directed against a small rack ab, (see our plate 12, figure 9) thus producing in it an alternate rectilinear motion of small extent; the axle A carries a toothed wheel B, and a pinion C; it is so arranged that the pinion is driven by the action of the rack, whose alternate rectilinear motion is thus converted into alternate circular; the sensible effect of this motion will be encreased as the diameter of the wheel B exceeds that of the pinion C. The axis n m carries the horizontal circular plate pq, which indicates by its index s the hygrometric gradations of the instrument, or the hour, on a properly divided helical line which may be traced upon the convex surface of the cylindrical column. The axis nm is composed of two portions essentially distinct: one of them n r is a male screw working in the fixed nut F; the other r m is a square bar which slides with some degree of friction in a socket or aperture of the same form, in the centre of the toothed wheel t u; this wheel is driven by the wheel B; it is supported by the flanch piece xx, which rests on the cross framing D E. The alternate circular movement of the wheel B will be transmitted to the wheel t u; and the motion of the axis n m, and the index s, will consequently be a compound alternate motion, as the subject requires.

G 10. Plate 8.

This figure consists of a plan, and a side elevation in distinct arrangement, with the same letters of reference as usual.

When a spiral is required to give a traversing motion to a point, it is generally for the purpose of describing a curve on the exterior or convex surface of a cylinder. In these cases, as we have shewn in the article B 10, the arrangement is much simplified by dividing the movement, or converting it into a circular and a rectilinear motion. A rectilinear movement of conversion may be given to the cylinder on which the spiral is to be described, in the direction of its axis, while the point or tracing tool moves round it; or the cylinder may have a movement of rotation on its axis, while the tracing tool traverses in a line parallel to the axis of the cylinder. The latter method is more generally convenient, and is therefore adopted in the machinery used for cutting screws of large dimensions. An engine upon this plan has been erected at Chaillot, and another by Salencuve.

The following description will explain the elementary construction of this useful engine. F G in the figure represents the cylinder, by whose action the rectilinear motion is produced, and communicates it to the tracing tool by means of its nut P; it has a rotatory motion on its axis, and is secured in its position by the collars H and I. E is a toothed wheel set upon the upper extremity of the guiding cylinder F G, and C is the cylinder on which the required screw is to be cut; it is mounted upon centres, and a toothed wheel D is fixed on its upper extremity; the cylinders C and F G must be set perfectly parallel to each other. A is a third or auxiliary wheel which drives the wheels D and E; the wheel A must be capable of adjustment, so as to accommodate itself to any required change of the wheel D, for the purpose of varying the relation between the radii of the wheels D and E. If the difference between these should be so considerable as that the fixed distance of the two cylinders prevents its being effected by the wheels D and E themselves, and circumstances should also render it impossible to change the guiding cylinder, the difficulty will be obviated by removing the wheel A, and substituting another wheel with a suitable pinion.

H 10.

The machine represented in this figure exhibits a method of superseding the guiding cylinder or screw of the last figure. A rack is here substituted, the rectilinear movement of which is produced by that of the cylinder on which the required screw or spiral is to be cut. The practical result will be the same as under the last arraugement, but the machine will probably not unite all the advantages of the former. We give this example however principally to cultivate the habit of considering every practicable combination, previous to a final determination upon any.

The required rectilinear movement may also be communicated to the tracing tool by means of an inclined plane, as we have shewn in our figure H 1, plate 1. By an arrangement of this sort, the effect of every possible variety of screw may be obtained simply by varying the inclination of the guiding plane. This machinery will not be found suitable to the scale of dimensions required for cutting screws of large dimensions; but for screws of ordinary size, it may be applied with great facility, and will be found perfectly practicable.

The inclined plane in its application to this purpose may receive its movement either by a rack which works with the pinion D, figure C 10, plate 8, or by the action of a screw placed at right angles to the cylinder on which the required screw is to be cut. Ferdinand Berthoud, in his Essai sur l'horlogerie, Paris, 1786, vol. i. page 150, describes an engine for cutting fusees, in which an inclined plane is used to guide the tracing tool, and is moved by a rack and pinion.

I 10.

The machine here shewn, is a modification of the mechanism described in our article E 10. We extract the following account of it from the work of M. Prony, entitled—Nouvelle Architecture Hydraulique, vol. ii. page 141.

The author says, " We extract the following description of this instrument " from Adams's work on mathematical instruments entitled—Geometrical and " Graphical Essays, &c. London, 1791. The inventor, however, appears to be " Jean Baptiste Suardi, who has himself described it in an Italian work, entitled " Nuovo Istromento per la Descrizione de diverse Curve antiche e moderne, &c.; and he gives it the appellation of—Geometric pen.

" The Geometric pen is represented in an horizontal plan in the figure; it is " fixed upon a table or drawing board by means of the arms A, B and C; the " heads a a of two of these arms revolve on a common axis, so that they may be

" brought into the direction of the third arm at pleasure; and also for the pur-
" pose of rendering the instrument more portable.

" At the lower part of the axis D, which is fixed, and is of one piece with the
" supporting arm C, is fixed a toothed wheel i, which may be changed occasional-
" ly, but when in use, is firmly attached to the axis D and is also immoveable.
" E G is a bar or arm of metal, open, or double horizontally in the greater part
" of its length, its extremity E is held between the piece k, and the wheel i,
" but having free liberty of motion about the axis D. A sliding nut b is ar-
" ranged to slide at pleasure along the opening or groove of the arm E G, and
" can be tightened and fixed at any required point of its length. This nut carries
" a second toothed wheel h, which may be changed when required, and accord-
" ing to the situation of the nut b on the arm, may either act immediately on
" the wheel i, or may receive the movement by an intermediate wheel as is
" shewn in the figure.

"The axis of the toothed wheel h is fixed in a cylindrical stud which is attached
" to a lower clip piece c; a bar f g slides in this clip, and carries a pencil K
" at its extremity, by which the required curve is to be described. The pencil
" is adjustible at pleasure as to its distance from the axis of the wheel h, by
" means of the clip c, in which the arm f g readily moves.

" This arrangement of the instrument being clearly understood, it will be
" evident that if the arm E G be moved about the axis D, the toothed wheel h
" will perform an entire movement of conversion about that axis, and a particular
" movement of rotation about its own axis; the ratio of the angular velo-
" cities of these motions, depends on the intermediate toothed wheels, and the
" relation of the respective numbers of their teeth. The clip piece c, and the pen-
" cil K have also a movement of rotation with the wheel h about its centre, besides
" the general movement about the axis D; and the curve which will be described
" by the pencil K will be determined by the ratio of the angular velocities above-
" mentioned as well as by the relation between the radii D b and bk.

" These relative proportions may be varied at pleasure, either by applying
" different combinations of wheels, or by a different adjustment of the arms E G
" and f g in their respective clip pieces; it is therefore evident that the instrument

" is capable of producing an infinite variety of lines, all of which shall differ from
" circular lines, and which nevertheless will be produced by a combination of
" circular movements. A moderate acquaintance with geometry, will enable
" the reader to practice himself in devising combinations for the production of
" given curves.

" Adams also asserts, that the principle of this machine was applied by Bolton
" and Watt to their improvements of the steam engine; and this has since been
" confirmed."

K 10.

In this figure, A represents a square plate; B a cylinder fixed on its surface; its edge is grooved so as to become a sort of pulley; a b c, d c f, are two ropes or bands which pass round the cylinder B on opposite sides, the terminations of one of those bands are in the points a and d on the left hand bar of the figure; those of the other are in the points c and f on the opposite bar of the figure; the bars to which these bands are thus attached are placed parallel to each other, the points of attachment are certain pins which are set on each bar for that purpose. Now if an alternate rectilinear movement be given to the last mentioned bar, in the direction of its length, the plate A will also assume a similar and corresponding movement, but will at the same time have a rotation on the centre of the cylinder B, every point of the surface of which, except that which marks its centre, will decribe an epicycloidal curve.

We have seen this contrivance applied to machines for grinding and polishing mirrors.

L 10.

In this figure we have a front, and a side elevation of the subject, with the same corresponding letters of reference.

A B represents a fixed bar, fitted with a line of projecting pins a a, &c.; E D E is a crank movement; C D, a vertical bar whose lower extremity C occupies the space between two of the pins a a of the cross bar A B, while its upper extremity D, which terminates in a ring is attached to the end of the crank arm E D E, so that on the rotation of that axis, the bar C D has a movement compounded of an alternate rectilinear motion, and an alternate circular motion; by this compound motion, every part of the bar C D will describe a curve which assumes the figure of a heart, of different degrees of elongation, the point or most acute portion of which is always in the direction of the fixed bar A B. N is a square plate carrying a ratchet wheel M: this plate may be fixed in any part of the bar CD, and should have a free motion of rotation upon an axis passing through the centre of the ratchet wheel M. E F G H is a claw piece terminating at E in a ring through which the end of the crank axle passes, and previously passing through a ring F which is moveable on its own axis, and is attached to the vertical bar C D, the rotation of the ring F on its axis allows the claw piece to oscillate about E, so that, at each revolution of that axis, the claw piece makes a double oscillation, and its curved termination G H is so formed that, when the extremity D of the vertical bar is at its greatest distance from the pins a a of the horizontal bar A B, the extremity H of the curve G H will have caused a small circular motion of the wheel M on its centre; by its action on the ratchet teeth, and the same effect will be repeated at each successive revolution of the axis E.

This mechanism has been adopted for the purpose of polishing mirrors, a description of the machine is given in Bailey's work, vol. ii, page 142; a model of it may also be seen in the Museum of the Repository of Arts and Trades in Paris.

M 10. Plate 11.

In our article H 10 we have explained that an inclined plane may be applied to give the required motion to the tracing tool in the manufacture of screws of ordinary dimensions; and that the inclined plane might receive its movement either by a rack, or a screw placed at right angles to the cylinder under operation; we referred to Berthoud's description of an engine for cutting fusees to shew the application of the first mentioned of these two methods. We shall now give an example of the second method for screws of small dimensions, such for instance as those usually termed wood screws used in the general operations of carpentry, &c.

A A' is the cylinder on which the required screw is to be cut; it is supported by the two upright pieces or puppets F and G, at the extremity A is set a bevelled toothed wheel C, the moving power used to give the cylinder the necessary rotation, is applied at the extremity A′; the axis B B′ is perpendicular to the cylinder A A′, and is supported by the two upright pieces or puppets H and I, and carries a bevelled toothed wheel D working with the wheel C; the portion g h of the axis B B′ has a screw already formed on its surface. E is a bar of metal on which a sliding piece traverses, carrying the cutting tool M; this bar is either of triangular, or quadrangular form, and is supported by the two puppets F and G. a b c d is a large aud deep mortice formed in the plane on which the supporting pieces or puppets F, G, H and I are placed and supported. e f b d is a bar whose thickness is equal to the depth of the mortice a b c d; it moves within the mortice, and has a free sliding motion through its entire length. The two upright pieces or puppets K and L are placed upon the bar e f b d; the first of these terminates in a cylinder which has a circular aperture through which the axe B B′ passes, and the second of them L, terminates in the nut of the screw g h. At the extremity e f of the bar e f b d is fixed the bar e s i; the bar i k has a motion of rotation about the point i as a centre; it has a longitudinal opening or groove l m, into which passes a small cylinder attached to the sliding piece M. p and q are balls which form the upper terminations of two small cylinders, which project one of them from the bar e f b d, the other from the bar i k; and they have each free motion of rotation on their axes. The portion n o of the arm or rod n r, is cylindrical and passes through the circular aperture of the ball p; it is at liberty to turn freely, but has no sliding motion; the other portion o r, of the same rod n r, has a screw already cut on it, and it passes into its nut which is cut within the ball q.

This description being understood, it will appear that if the cylinder A A′ be made to revolve, the circular motion so produced will be transmitted to the axis B B′, the bar e f b d will be accordingly set in motion, and will carry with it the arm or bar i k. The angle of inclination of this latter may be varied at pleasure by means of the adjustment afforded by the rod n r; it will thus perform the office of an inclined plane, and will effect the guidance of the cutting tool M with the velocity which may be required.