difference of the circumferences of the two portions A and E of the roller; and it will also be evident that the difference may be made small at pleasure.

The description of a double capstern, produced by an application of this principle will be found in vol. xix, page 305 of Les Annales des Arts et Manufactures.

SECTION IV.

To convert a given direct and equable rectilinear motion, or the velocity of which varies by a given law, into alternate circular motion of velocity similar to that of the moving power, either equable or variable by a given law; and in the same, or in different directions.

(A 4.)

IF direct rectilinear motion be converted into direct circular motion by any of the arrangements pointed out in Section 3rd, all the examples shewn in Section 9 will apply to this section.

(B 4.)

It has been proposed by M. Perrault, of the Royal Academy of Sciences (Recueil des Machines approuvées par l'Académie des Sciences, Vol. i. Nos. 9 and 10,) to apply the fall of water as a mover for a pendulum clock. Without pledging our judgement as to the usefulness or merit of his machine, we shall explain the organization he has adopted for converting the rectilinear direction of the moving power into an alternate circular motion.

Water is made to fall, as at c in the figure, into the vessel d, which is constructed to turn or swing on an axis m, and is divided in the middle into two eqnal parts by a partition. When the base of this vessel is in an horizontal position, the water falls so as to divide itself equally by the partition before mentioned, and in any inclined position the whole quantity of falling water will be received by that side of the vessel which is elevated. In the position shewn by the figure, this entire quantity is received by the side b of the vessel; when that side of the vessel becomes full, it turns on its axis in the direction of that side, and descends till it reaches and rests on the stop or support f, pouring out, by this change of position, the quantity of water which produced the motion. The opposite side fills in its turn, and brings the vessel into its first position, resting on the support g; and the operation is repeated.

(C 4.)

Problem.—*To convert alternate circular motion into direct rectilinear motion.*

Let A B of this figure be a lever turning about on an axis C, and F G an upright bar, which is at liberty to rise and fall easily; and having a strait ratchet on each of its longitudinal edges. D E, D E are two small levers turning on pivots at D and D, and have their other extremities E E, turned so as to engage in the teeth of the ratchet already mentioned. The alternate circular motion of the lever A B will operate to raise the bar F G. M. Perrault, of the Royal Academy of Sciences, has applied a piece of mechanism of much similitude to this, to the construction of an engine for raising heavy weights. It will be found in the Recueil des Machines approuvées par l'Academie, Vol. i. No. 1.

(D 4.)

A boat at anchor in the middle of a river, if held by a cable of sufficient length, will move alternately from one bank of the river to the other, by means of its rudder: furnishing an instance of alternate circular motion from direct rectilinear: this is a well known contrivance, and is of frequent application.

(E 4.)

A sector of a circle surmounted with a sail, forming together a combination, the centre of gravity of which shall be situated considerably below the centre of oscillation, by means of the application of a counterpoising weight, will swing to and fro continually, with an alternate circular motion produced from the impulsion of the wind upon the sail: this mode of applying the direct action of the wind has been often proposed, and many models constructed on this principle may be found in the Conservatory of Machines of Paris; and in the work of M. Alexander Bailey, which includes the description of machines presented to the Society for the Encouragement of Arts and Manufactures of London: the application of this contrivance as a first mover to an hydraulic machine by M. Merryman, will be found in vol. i. page 154.

All machines which are applied to the purposes of raising water by means of an oscillatory or alternate circular motion, communicated to the machine by any power whatever, and which is applied to them exteriorily, as are those for instance which are described in the Journal des Mines, No. 66, may be placed in this fourth class.

The Bulletin de la Société d'Encouragement, for August, 1811, No. 86, contains a description of a machine termed an Hydraulic Pendulum, by its inventor M. Boitias. M. Molard, in a report upon this machine, made by him to the Society in December 1808, and which is contained in the 54th Number of the work above mentioned, makes the following observation:—" With respect to the hydraulic pendulum, this machine must not be confounded with a contrivance under the same name, described by Belidor, for the purpose of raising water. It is a simple pendulum which receives its oscillatory movement by means of the current of a river, and with the additional aid of a counterpoising weight.

To produce this effect, the author has placed a float board of considerable size, and mounted on a supporting pivot, at the lower extremity of the pendulum; it alternately assumes the vertical and horizontal position. In the first it dips into the current and obeys its pressure; in the second it obeys the effect of the counterpoising weight, which brings it back to the position from which it set out, in order to commence another oscillation."

SECTION V.

To convert a given direct and equable rectilinear motion, or the velocity of which varies by a given law, into a direct curvlinear motion of velocity similar to that of the moving power, either equable, or variable by a given law, and in the same, or in different directions.

DIRECT rectilinear motion may be converted into direct circular motion by the methods exhibited in Section III.; and the arrangements shewn in Section X. will afford examples of the required conversion.

SECTION VI.

To convert a given direct, and equable rectilinear motion, or the velocity of which varies by a given law, into an alternate curvlinear motion, of velocity similar to that of the moving power, either equable or variable by a given law, and in the same, or in different directions.

DIRECT rectilinear motions may be converted into direct circular motions by any of the arrangements exhibited in Section III.; and then the examples of Section II. will afford instances of the required conversion.

SECTION VII.

To convert direct circular and equable circular motion, or the velocity of which varies by a given law, into alternate rectilinear motion of velocity similar to that of the moving power either equable, or variable by a given law, and in the same, or in different directions.

(A. 7.)

LET A B D E, plate 2, be a wheel which is at liberty to revolve on its axis in the direction indicated by the letters A B D E with an uniform velocity;

m n is an index which is obliged to observe the same direction, while the extremity m follows the figure of a curve drawn on the surface of the wheel; the other extremity n, is also required to make a determined number of back and forward motions of given extent; and returning with each revolution of the wheel to the same point from which the motion commenced, and this with a velocity either uniform, or which varies by a given law, or which is even entirely arbitrary.

If the ratio of the velocities be uniform, or if they follow given laws, the curves which will be thus described will be determinate and easy of construction. On this subject a memoir of M. Deparcieux may be consulted on the mechanical methods of describing those curves which occur in the construction of machines intended to move levers or balance wheels. It is printed in the memoirs of the Royal Academy of Sciences for 1747.

If the ratio of the velocities be arbitrary, a solution of the problem may be afforded by a great variety of curves; and by rectilinear polygons as well as by curved. Rectilinear polygons afford angles too acute—curvlinear ones are therefore to be preferred.

The application of this problem is of considerable use in the art of turning.

(B 7.)

This is a particular case of the subject of the last problem, in which at each revolution of the wheel we obtain but a single alternate stroke, aud that an uniform motion. The curve being proportional and all its diameters equal, that circumstance is rendered advantageously available by subjecting the motion of the rule or bar a b, to the curve, by means of two metal pins n m, which are fitted with friction rollers, against which the curve acts through its whole course.

The pieces which carry the threads in the bobbins of the silk-throwing machine of M. Vaucanson, are put in motion by an application of this curve. It is also used in different hydraulic engines to afford an uniform motion to the pistons of pumps.

In the 23rd number of Les Annales des Arts et Manufactures, we find the description of a new spinning-wheel by Mr. Antis, an Englishman, for which the Society for the Encouragement of Arts, &c. of London awarded a premium to that gentleman.

C 7. Plan and Elevation.

Let A B C in the plan of the figure represent a plate of metal, through the thickness of which are cut the grooves or channels ab, cd, &c.: behind the plate A B C, and close to it, let us suppose a second plate N M (shewn in the elevation or upper figure); in this plate is cut, also through its thickness, the spiral channel indicated in the plan of the figure by the double dotted line, and described on the same principles as the curve of the preceding figure B 7: it is evident that if the small cylindrical pins r s pass through the intersections which the spiral will form with the channels ab, cd, &c. and the hinder plate be made to move, all the cylindrical pins will approach to, or recede from the centre by an equal distance. Now if the bent arms s n be added to those cylindrical pins forming radii to the circle, and their lengths be such that their extremities n shall terminate in the circumference of a circle concentric to the plate; it is evident that these extremities n of the arms, will in every position, whether advancing to, or receding from the centre, also be situated in the circumference of a circle concentric to the same circle. Two pieces of mechanism similar to this may be arranged one over the other, as is shewn in the elevation of the figure; and the extremities n of the bent arms may be connected so as to compose a kind of cylinder whose diameter may be encreased or diminished at pleasure by the rotatory motion of the spiral plates before described. This ingenious arrangement is adopted in England, in the construction of lathes, and in other machines in which it is occasionally required to alter the relation which the moving power bears to the resistance, and where it is necessary to effect this with quickness and facility. Other applications of this contrivance may be found in the Repertory of Arts and Manufactures, vol. xvii.; which contains the specification of a patent obtained by R. Brayshay—" for a machine for the purpose of gaining an increased speed and power to all mechanical operation by land and water:" dated October 30th 1801; and No. lxxi of Les Annales des Arts, &c. by R O'Reilly.

(D 7.)

The wheel A B (of which the figure shews a side elevation) has its periphery formed into teeth of any figure at pleasure: the arm a b is made to press constantly upon the teeth of the wheel by means either of a spring or the application of a weight, and is at liberty to slide through the pieces c anded, while it preserves its perpendicular position with the plane of the wheel. If the wheel be turned, it will communicate to the arm ab, an alternate rectilinear motion,.which may be varied to suit the required purpose. It will not be difficult to determine the figure of the teeth upon the principles spoken of under the article (A 7).

A very ingenious application of this motion has been made by M. Zureda in his carding machine. The same motion has also been latterly applied to a machine for the manufacture of fishing lines.

Leupold, in his work "Theatrum Machinarum Hydraulicarum, vol. ii. p. 36. fig. 3, shews an application of this contrivance to a motion for pump pistons. The vertical axis of an horizontal hydraulic wheel carries another horizontal wheel, on the upper side of which are arranged seven inclined planes, forming a kind of ratchet wheel, having the spaces or intervals between the teeth nearly equal to the base of the inclined planes which compose the wheel; the piston rods of the pump are fitted with projecting pieces which rest on the wheel by friction rollers; so that at each revolution of the first wheel or mover, the pump pistons make seven ascending, and seven descending strokes, or seven alternate rectilinear motions.

(E 7.)

The circle A of this figure has a motion on its axis, and a projecting point or pin fixed on its face passes through the groove n m of the lever P Q, whose centre of motion is at R. It will result from this arrangement that the direct and uniform circular motion of the wheel A will be converted into an alternate circular motion; and the two extremities of the lever P Q will traverse with unequal velocities, and the machine will belong to the class of the ninth section. But if a portion of a toothed wheel be set on the extremity P of the lever which shall act in the rack-bar NM, an alternate rectilinear motion of unequal velocity will be obtained, and which will belong to the arrangement of Section VII.

By means of the simple fixed pulley G, and the rope QGH fixed at Q andr sustaining the weight H we also obtain an alternate rectilinear motion of unequal velocity.

Another alternate rectilinear motion of unequal velocity will also be obtained by placing a pin or small cylinder at the intersection of the groove pq of the lever PQ, with a groove st described in the fixed bar Xy, the cylinder so placed will have the required motion.

Les Annales des Arts et Manufactures, vol. xv, page 119, contains an application ofr this motion to an improved machine for cutting the teeth of wheels.

(F 7.)

PLAN AND ELEVATION.

A is a wheel of which a portion only is toothed, and which turns constantly in the same direction on a fixed centre; BC is a chase frame, the two inner and opposite sides of which are formed into racks. To the ends of this frame are firmly attached the bars BS CT, which are at liberty to move to and fro within the clips pq, nm; the frame with its two bars, which may thus be considered as one piece, thus acquire an alternate rectilinear motion by conversion, from the direct circular motion of the wheel A. The frame which contains the two racks might also be applied to a bar, by a simple change of construction.

If the teeth of the wheel were infinitely small, they ought to occupy one half of its periphery and the remainder be left plain. The length of the two racks will be equal to half the periphery of the moving wheel, and their extremities will be at equal distances from the short sides or ends of the frame :r but when the teeth of the wheel are of larger size, which must always be the case in practice, the toothed portion of the wheel must be less than half its periphery; the racks will be equal in length to the toothed portion of the wheel, and they will terminate at unequal distances frm the ends of the frame. The number of teeth for the wheel is arbitrary, but great mechanical precision is required in the practical execution of this machine.

The teeth of the wheel and of the racks will be described with sufficient facility by reference to the instructions for that process given by M. Camus, in the second volume of his "Course de Mathematiques" *.

When the portion of the wheel to be formed into teeth is determined on, and thence the length of the rack, and the situation of one of them, that situation of the other which shall afford the maximum effect in the entire machine may be easily determined by trial: the theoretical discussion would lead us from our view of the subject without affording adequate advantage.

Applications of this motion to the alternations of pump pistons may be found in the description of M. Augur's pumps, (Machines approuvées par l'Academie des Sciences de Paris, Vol. iv, No. 223).

Examples of the conversion of a direct circular motion, into an alternate rectilinear motion, by means of a wheel of which only a part is indented, and one or two racks; and also of the conversion of direct circular into alternate circular motion, may be found in the Repertory of Arts and Manufactures, London, Vol. xii. page 145; in Berthelot's work—Mécanique appliquée aux Arts, aux manufactures, à l'agriculture, à la guerre, vol. i. page 79; Moulin à pédale vol. ii. page 36; Machine à manége pour scier la pierre, vol. ii, page 40; Scie à débater le bois.

In the 1st volume of a work by J. Leupold, printed at Leipsic in 1724, entitled Theatrum Machinarum generale, chap. 12, the author undertakes to shew five different methods of converting direct circular motion into alternate rectilinear. The first of these methods which he shews in plate 25, figure 1 of his work, corresponds with our arrangement (F 7). This second method, plate 25, figure 2, is actually the same: the only observable difference is that the bar represented by T S in our figure (F 7) is vertical, and that the two racks instead of being toothed, are formed of a series of small horizontal cylinders similar to those which are used as trundles in the lanterns of mill-work; the motion of the bar TS is applied

* Further information on the subject may likewise be found in "L'Essai sur l'Horlogerie," by F. Berthoud, Paris 1786, vol. ii, page 13; the 4th volume of the French Encyclopédie, article "Dent"; and the Dissertations of M. de la Lande, in "Le Traité d'Horlogerie de M. Le Paute.

to the piston of a pump: this application had already been made by Ramelli. The third method (figure 3, plate 25), does not materially differ from the preceding: it is in substance a lantern pinion, which is partly fitted with trundles, instead of a wheel partly indented, and the teeth of the rack are rounded. The fourth method (fig. 4) is composed of two vertical racks, having their flat sides placed parallel to each other, and their racked edges lying in the same direction. The upper extremities of these racks are attached to the ends of a rope which passes over a simple fixed pulley; the racks being thus suspended, it follows that whenever one of them is made to ascend, the other will descend by its own weight; an horizontal spindle is placed across the front edges of the racks, and two lantern pinions partially fitted with trundles are set on it so as to act on the racks; their positions are so adjusted in the first instance, that when the trundles of one of them act on the corresponding rack and cause it to ascend, the blank space of the other pinion is opposite to the other rack, which is therefore at liberty to descend. The author applies this mechanism to the movement of pump pistons in his work entitled, "Theatres des Machines Hydranliques," printed in 1724, vol. 2, plate 40, fig. 8. In his fifth and last method, the author converts the direct circular motion into alternate circular, by our arrangement R 9, plate 7, in which B and C are two pinions, and A a wheel partly indented. He again converts the alternate circular motion of the bar d e of our figure, into an alternate circular motion by our arrangement (D 8), plate 5: for this purpose he places an endless screw on the horizontal bar d e, which works in the segment of a wheel; the extremities of the segment are continued horizontally, and carry the piston rods of two pumps. The description we have here given will shew that the five supposed methods of the anthor are reduced to one, the arrangement of which admits of but little modification.

By laying aside one of the two racks, and introducing an entire toothed wheel, the alternate circular motion may be converted into an alternate rectilinear motion, as will be shewn in our figure (M 17). This arrangement had long been applied in the process of coining—for milling the edges of the pieces under operation, but its use has since been discontinued.

A very simple and ingenious method of avoiding the loss of time which would take place in this piece of mechanism at each change of direction of its motion, was invented by M. Duinet. An additional tooth marked a, in the figure (F 7) is set on the wheel A, but below the level of the other teeth of that wheel. An additional tooth is also set on each rack, and in the same plane or level with the additional tooth of the wheel. The action of the tooth a, upon the additional teeth of the racks operates to continue the motion of the bar T S during the interval which elapses between the action of the wheel ceasing on one rack, and its commencement on the other.

In Bockler's work, already mentioned in speaking of our figure (E 3,) we find the direct circular motion of a vertical spindle converted into an horizontal and alternate rectilinear motion by the arrangement we have described in our account of F 7. A vertical spindle carries an horizontal lantern pinion, the trundles of which work into two rows of pins arranged upon the inner edges of a frame, which is thus substituted for the racked frame of our figure. In Bockler's machine it may be observed by figure 71, that each rack is terminated at the opposite ends by a pin somewhat longer than the rest: this is evidently intended to correct the loss of time incidental to the changes of direction. The author then convertsrthe horizontal alternate circular motion into the vertical and alternate rectilinear motion, required for working pump pistons, by an intermediate alternate circular motion, which he effects by a contrivance similar to our figure N 7, plate 3: thus---To the end of the piston rod he fixes a bar which extends to the edge of a cylinder or horizontal circle, whose axis is perpendicular to the vertical plane passing through the piston rod, and the spindle of the frame; another bar is placed from one end of the frame to a point upon the edge of the cylinder 90 degrees distant from the attaching point of the bar first mentioned. These bars turn freely at their ends, as the bar n m in our figure N 7. This mechanism resembles that in common use in bell-hanging, for transferring alternate rectilinear motion from one apartment to another. He also shows other applications of the same arrangement.

G 7. Plan and Elevation. Plate 3.

In this arrangement the frame containing the racks is made somewhat larger than that of the preceding article, by having the racks themselves longer, so as to meet at the ends, where they continue in a semicircular form, and the small wheel or pinion is completely toothed. It has been found necessary to allow a small lateral motion to the rack-frame, which is given at the end of each alternation by means of two cross pieces ab, cd, in order to facilitate the change of direction of the rack. In general however, this motion involves considerable difficulty in the practical execution; and it appears but little adapted to produce any important effect.

In a report made by Messrs. Prony and Mollard, upon the methods proposed to replace the hydraulic machine of Marly, we find a machine projected by M. White, in which this motion is introduced.

In Bockler's work—Theatrum Machinarum novum, &c. the same mechanism is applied to convert the direct circular motion of an horizontal spindle into an alternate and vertical rectilinear motion for pump pistonsr. Bockler's contrivance for equalizing the motion of the rack-frame does not appear of sufficient merit to recommend it to notice; but in the course of this work we shall introduce a variety of methods for that purpose.

H 7. Plan and Elevation.

This is a modification of the motion shewn in F 7. In this machine the number of teeth in each rack is reduced to one, and those of the wheel are entirely superseded; they are replaced by projecting arms, each having a small friction roller at its outer extremity. It will be readily observed that this strait figure of the teeth of the racks will occasion an irregularity in the rate of their alternate movements; but the law of this velocity may either be varied at pleasure, or rendered uniform. by making the teeth of a suitable figure.

The construction of this machine is to be preferred to that of F 7: for all arrangements which are exposed to violent action, and to which small teeth of the usual form and dimensions would not offer sufficient resistance. The engine in this form will be less costly in its original construction, and will be made with greater facility: incidental repairs will also be more easily made.

In the first volume of "Machines approuvées par l'Académie des Sciences", we find this movement applied to the construction of a machine for sawing stone, &c.; and another application of it in the "Traité de la Gravure à l'eau forte" of the old Encyclopedia.

I 7.

In this figure A represents a wheel which turns on its axis; n and m two clips between which slides the bar P Q, with the attached cross-bar R S; s is a pivot which is allowed to pass through the groove p q. The circular motion of the wheel A will under this arrangement produce an alternate motion to the bar P Q.

This alternate rectilinear motion is very slow at its commencement, but is accelerated as it approaches the middle of each alternation: it is evidently extremely simple and easy of construction. This is also a modification of the arrangement shewn at F 7.

In the first volume of "Machines approuvées par l'Academie des Sciences", this contrivance is applied to the construction of a machine for sawing marble. It is used in the ribbon weaving machine, to give the stroke for throwing the shuttle; and is also sometimes used in domestic economy, in a machine for churning.

In the eighth volume of the Repertory of Arts and Manufactures, we find this movement adopted by Mr. Bunting, in his calendering engine. His first mover is a horse, which is applied to turn a vertical spindle; at the upper extremity of this is a pinion which drives an horizontal wheel. The direct circular motion of this wheel is converted into an alternate rectilinear motion by the means already described; the height of the arm which receives this motion being inconvenient, the author transfers his alternate rectilinear motion to another arm lying in a parallel direction to the first, and at the required height, by means of an intermediate alternate circular motion E 17. The polisher of his machine is fixed to this second arm.

(K 7.)

The alternate rectilinear motion of the bar P Q R S, figure I 7, may be readily equalized by substituting a groove of the curve represented at p q in the figure, for the strait groove pq, of the figure I 7.

The method of describing this curve is very simplei: the distance C s is divided into a certain number of equal parts, as for example six, s1, 12, 23, 34, 45, 5Ci; aud the quadrant s D is to be divided into a like number of equal parts. It is evident that the conditions of the problem will be obtained if that point of the bar PQ which corresponds with the point s of the figure be made to coincide with the divisions 1, 2, 3, &c. of the radius s C, at the same time that the pivot s itself shall coincide with the corresponding divisions 1, 2, 3, &c. of the arc s D ; it will be necessary therefore to determine the position of the points 1, 2, 3, &c. of the curve p s q, so that each shall be placed with relation to the point s, as the corresponding points of the arc s D, are placed with relation to the points of the same name in the radius s C, which will not be found difficult. The same process will be followed for each of the three remaining quadrants of the circle.

L 7.

In this figure a b is a vertical bar, which slides between the two rings n m ; a pestle is fixed on its lower end b, on one side of the bar is fixed a rack in which works the indented portion of the wheel A, the remaining part of which is without teeth. When the plain portion of the wheel is opposite to the rack of the bar, the pestle P will fall by its own weight upon the body M : but if the wheel be made to turn in the direction of the dart in the figure, when the teeth arrive at the rack, and begin to act, the pestle will be gradually elevated ; but will fall again when the plain portion of the wheel again arrives at the rack, and this alternate motion will be continued with the action of the wheel. This is another direct instance of the arrangement F 7. It is in frequent use for machines for the purpose of bruising and pounding hard substances.

If for the rack and bar were substituted a toothed wheel which should turn in the same direction as the pinion A, either by a weight P, attached to a rope, which shouldi be wound on its axle, or by a spiral spring : the direct circular motion of A would be converted into an alternate circular motion, and the arrangement would be classed in Section 9.

This mechanism was applied to work the pistons of two pumps by De Caus, an architect and engineer, and is described by him, in a work entitled "A new invention for raising water above the level of its source, by means of certain hydraulic machines." London, 1644.

The author caused a vertical wheel having half its periphery indented, to turn by the immediate action of a moving power, and on the right and left of this wheel he placed two others of equal diameter, and which he supposed to be partially indented, but which might also be completely indented, according to the construction described in our last article ; he communicated each of the piston rods of the two pumps with one of these wheels by means of a rope attached to the end of the piston rod, aud by its other extremity winding about the cylinder or spindle of the wheel; the rope was so wound on the spindle that the piston acted by its weight to turn the wheel in the direction which converted the direct circular motion of the moving power, into the alternate circular motion of the lateral wheels ; and consequently the pistons received their required alternate rectilinear motion ; one of them ascending while the other descended by the action of its own weight. The author in order to facilitate the descent of the piston, caused a rope to pass over a simple fixed pulley placed over the middle wheel, and afterwards to wind itself about the axis of the two lateral wheels, and in the same direction with the corresponding ropes of the piston rods ; so that when one of the pistons was raised, a parte of the action of the moving power wase at the same time employed to assist the descent of the other ; the wheel being turned in the proper direction, the piston had to overcome a resistance at least equal to the inertia of the wheel, with its friction, and the rigidity of the rope, and in short, a resistance equal to the power required to set the wheel in motion.

M 7.

This is a modification of the mechanism of the preceding article. The teeth of the rack are reduced to a single one, and the wheel is fitted with cams or curved projecting pieces, the curvature of which is such that the resistance becomes uniforme The construction of these curved pieces is simple; a description of them will be found in the memoir of M. Deparcieux, which we have before spoken of under the article A 7. This contrivance is applied to the same practical uses as that of the preceding article.

N 7.

The circular motion of the wheel A communicates by the intermediate operation of the bar n m, an alternate rectilinear motion to the bar p q, which is allowed to slide between two clips, one of which is shown in the figure at t. If the wheel A be used as a fly wheel, the motions will be reciprocale

The length of the alternate rectilinear stroke made by the rod p q will be more or less, in proportion as the point of rotation m, is more or less distant from the centre of the wheel A.

If the bar p q be taken away, and the bar n m be made to pass through a circular opening which we will suppose to be made in the clip t, the bar n m will then have a compound alternate motion, similar to that of the bar E F G, in our figure L 10. Plate 8. In the first volume of Bailey's description of Machines, in folio, we find an account of a silk reel used in Italy; in which the guides receive their alternate and horizontal motion by an application of this contrivance; the point marked m in our figure is supported by a frame which slides in a groove, upon the surface of the wheel A; so that it may be shifted with facility to any required distance from the centre. The wheel A is placed in an horizontal position, and receives its rotative motion by means of an endless band, the constant and equal tension of which is preserved by providing the wheel A with an horizontal adjustment; the wheel is carried by a bar of wood having a sliding motion in a vertical piece which supports the wholeę a suspended weight acts constantly to draw the wheel A from that which is set on the spindle of the reel.

(O 7.)

A B in this figure represents a cylinder having a rotatory motion on its axis; on the surface are cut two spiral channels or grooves similar to those of a screw, their paths round the cylinder are cut in opposite directions, so that they intersect twice in each revolution, and join or run into each other at each end of the cylinder; C is a projecting piece accurately fitted to the spiral grooves and is attached to the arm C D, which passes through a longitudinal groove or passage cut in the fixed cross-frame E F. Under this arrangement the rotatory motion of the cylinder will produce the alternate motion of the piece C, by passing alternately from the first or direct spiral groove, to the second or reversed one. This motion is extremely ingenious, and is capable of extensive application; it was communicated to us by the inventor M. Zureda, a Spanish mechanist of great professional merit.

P 7.

A B is a cross frame in which a mortice p q is cut, and in this the spindle of the pinion n is at liberty to move freely. C D is a bar the periphery of which is formed into a continued rack and is driven by the pinion, it is attached to the bar or piece which is to receive the alternate rectilinear motion, and the latter is made to slide through the clips a and b. When the racked bar C D is carried by the action of the pinion to the extent of either of its sides, the check-pieces α and β act on the springs r s, u t, which oblige it to return by its other side.

This movement is difficult of construction: it has been suggested as applicable to machinery for cutting the tops of piles, but as the teeth of the pinion cannot be made of sufficient strength for any engine in which great power is required, we do not consider it proper for such purposes.

Q 7. Plan and side Elevation.

A B C, in the plan of this figure, represents a flat circular ring, the inner edge of which is toothed; D is a toothed wheel which works into the wheel A B C: its diameter is equal to the radius of that wheel. The bent axle n m p q, revolves on the centre of A B C; its extremity n supports the wheel D by its centre, while its other extremity p forms a handle, to which the moving power is applied to produce the rotation of D; while this wheel revolves on its centre, and traverses the toothed inner edge of A B C, each point of its periphery will describe a diameter of that wheel. The demonstration of this theorem is given by De la Hire, in his Traité des Epycicloides, et de leur usages dans la Mécanique. Mém. de l'Acad. Vol. ix. page 389.

A model of this movement was presented at a late exhibition of productions of the National Industry, by M. White.e His description of it may be seen in les Annales des Arts, vol. xix.

R 7.

Two toothed wheels A and B, arranged as they are shewn in this figure, will produce an alternate motion, of which the alternations, their extent and velocity, may be infinitely varied, either by altering the ratio of their diameters, or the proportions and arrangement of their several parts. These motions may, however, be accurately produced by the arrangement shewn in the figure A 7.

The combinations shewn in the figures S 7 and T 7 are of the same nature. An instance of this description of alternate motion may be seen in plate 21, vol. i. of the plates of manufactures of the French Encyclopédie.

U 7. Plan and Elevation.

In the plan of this figure a b c is a flat circular ring, which has a small portion cut away, and which has a continuous series of teeth formed both on its outer and inner edges; the portion of the ring which is cut away is of sufficient width to allow the pinion d to pass freely from the outer edge to the inner, and after having made the circuit of the inner edge, to pass at its opposite extremity again to its outer edge, and the ring is fixed to the circular disk or plate D, which has a motion on its axis.

The pinion D has a motion on its axis, and this bas also a liberty of motion in the groove n m; two springs p and q act alternately on the projecting stops or detents r and s, and so determine the quantity of the alternate circular motion of the disk D; this is a modification of the arrangement shewn in the figure P 7. The alternate circular motion of the disk D is used as an intermediate motion to produce the alternate rectilinear motion of the point F: this is effected by means of an endless rope which passes round the disk, and over the two fixed pullies S and T. This example in strict propriety belongs to Section IX; we introduce it here as a judicious method of using an intermediate motion; and to shew the analogy which exists between this and the subject described in P 7.

It would be difficult in practice to make the pinion d work with equal facility on the interior and exterior edges of the ring on account of the difference in their teeth: this difficulty may however be avoided in a great degree, by placing two pinions d one above the other on the same axis, and making a corresponding separation between the planes of the interior and exterior teeth; so that they shall act only on their respective pinions, as is shewn in the elevation of the figure.

A 7′ Plate 4.

We have here combined two well-known methods of converting direct circular motion into alternate rectilinear motion, by using a bent axle, or a circular plane inclined to its axis of rotation. M. Prony gives a theory of bent-axles in the Journal des Mines.

In the fourth volume, No. 266 of Memoires approuvées par l'Académie, we find an application of this axle to the motion of a piston by M. Lacsson. The author gives a very simple mode of constructing an axle of which the crank may be lengthened or shortened at pleasure.

In Leupold's Theatrum Machinarum Hydraulicarum, vol. ii. pl. 36, fig. 1 & 2; and in Ramelli's work, entitled—Le diverse et artificiose Machine del Capitano Agostino Ramelli, &c. a Parigi, 1588, figure 57.—This method of the inclined circle is applied as a motion for pump pistons. Au hydraulic wheel turns a vertical axle which carries an inclined circular plane; the vertical piston rods have projecting arms with friction rollers, which are supported by the edge of the inclined plane: in this way the circular motion of the vertical axle of the water-wheel produces the required alternate rectilinear movements of the pump pistons. The vertical position of the piston rods is provided for by grooves with friction rollers. A second projecting arm from the piston rod, which applies itself to the under side of the inclined revolving plane, operates to assist the descent of the piston and to equalize the motion.

B 7′.

The large wheel R revolves on its axle, and three rollers m n p, are placed on its surface; a bent lever PGH, the arms of which are set at right angles with each other, carries a roller p at the extremity P of the arm PG, the action of a spring or weight applied to the extremity H of the other arm tends to give the roller p a constant bearing against the rollers m, n, p, which will therefore, by the rotation of the wheel R, act in succession on it and cause the alternate circular motion of H ; this will consequently belong to Section IX. : the alternate circular motion may be converted into alternate rectilinear by means of a fixed pulley f. This motion has been applied by M. Genssane to the construction of a contrivance which he used as a substitute for lever handles. See Machines approuvées par l'Académie des Sciences, Vol. vii. No. 442.

C 7'.

S is a fly-wheel carrying a pinion p ; P and Q are two toothed wheels acting on each other, and P is also driven by the pinion p ; n m, s t, are two lever handles set on the axes of the wheels P and Q ; m f, s g, are two rods both the ends of which have free motion, and they are connected by a cross bar f g with the vertical and larger rod H R, to which they communicate an alternate rectilinear motion during the regular action of the fly-wheel S:—the motion is reciprocal.

The application of this movement may be seen in a memoir on a new steam engine invented by Cartwright, and inserted in the first number of Les Annales des Arts et Manufactures. Two pins might be fixed on the peripheries of the wheels P and Q instead of the lever handles; but they are retained for the greater facility of construction. In No. 25 of the same Journal the Editor proposes a new steam engine, in which he adopts Cartwright's fly-wheel instead of a beam.

D 7'. Plan and side Elevation.

S is a fly-wheel, on one extremity of the axis of which are fixed two ratchet wheels R R ; within these, two toothed wheels are fitted on the same axis, but remain at liberty to turn independently on it. Each of these has a click p, which is placed in the same direction on each, and on the outer face, so that they act upon the ratchets only by turning in opposite directionse; P Q is a large bar which slides between two clips, and dividing itself into two parallel pieces forms a frame furnished on the inner edge of each side with a rack f g and h i; these are not situated in the same plane, the rack f g being a little distance behind the plane of h i, so that h i acts on the wheel M, and f g on N. If we suppose the bar P Q to move from Q towards P, the rack h i will be brought to act on the wheel M by the effect of its click p, and will communicate a rotatory motion to the fly-wheel in the direction shewn by the dart in the figure; the rack f g will at the same time act on the wheel N in the opposite direction; but the click of the ratchet belonging to N does not hold the ratchet during the upward motion of the rack f g; the wheel N will pass round on the axle independently, and will not therefore impede the progress of the fly-wheel in the direction already given it by the action of the wheel M. When the frame returns from P towards Q in its descending stroke, the click of the ratchet belonging to the wheel N is in action, and operates to hold the wheel N, so that the rack f g turns it together with the fly-wheel, in the direction shewn by the dart as before. If one of these wheels M or N, together with its rack were omitted, the direct motion of the fly-wheel would nevertheless continue as in the movement G 9; but as the action of the moving power upon the fly is in that case unequal, the mechanism in the state here described is preferable. No reciprocal action takes place in this instance.

OBSERVATION.

IF a wheel having a constant motion in one direction by the action of any mover, receives another wheel on its axis which is held there by its friction only, being capable of motion on the axis independent of the first, any method which might be invented for alternately attaching and disengaging the first wheel, might also be used either to communicate to the latter the action of the mover, or to withdraw it from such action; in the latter case, it will remain at rest, if by its inertia, or the resistance it is enabled to offer to the second wheel, it could overcome its friction; or it will obey the action of any other power tending

e

to give it motion. It is thus we are enabled to suspend the operation of a machine, without the necessity of interrupting the action of the first mover, or to withdraw it from the action of the original mover, in order to connect it with some other. We find this occur in the action of bells. We shall give an account of some ingenious methods of releasing the ram of the pile driving engine, although we consider the arrangement shewn in the figure 17' as the most simple and effective, and one which may be universally adopted with advantage. We shall however first shew the methods which may be employed, 1st to check the motion of the machine while the action of the mover is suspended, without subjecting it at the same time to any effects of resistance; 2nd, to avoid the accidents which so frequently occur in all machines which are required to produce great power, such for example, as capsterns, presses, the machines used for cleansing harbours, &c. &c. whenever from violent shocks or other causes the resistance causes a retrograde motion upon the mover, and communicates it to the machine, or when the cables, chains, &c. by means of which the action of the machine is transmitted to the resistance, happen to meet with fracture or derangement, and the machinery thereby acquires a greatly accelerated movement in that direction; 3rd, to avoid the vexatious consequences which result from such derangement in any part of the machine, whether from natural obstacles or such as accident or ignorance may occasion, as place the resistance beyond the powers of the machine to overcome.

In order to check the motion or action of the machine, during the suspension of the action of the first mover upon it, without subjecting it at the same time to the effects of the resistance, it is usual to employ a ratchet wheel with a click which puts it in action, while it operates to check the action of the mover in a gradual manner, as is effected in the ordinary methods of working the capstern, &c. &c.*

* In the 14th Report of the Society for the Encouragement of Arts, &c. for 1815, we find the description of a very singular click and ratchet movement, invented by M. Dobo; M. Borgnis, in his work entitled "Traité de la composition des Machines," places it as the 17th variety, 4th species, 1st genus, 2nd class, 5th order—Regulators.

When the resistance is thrown on the mover, the retrograde motion of the machine generally produces so considerable a shock, that the attempt to counteract it by interposing any firm resistance similar to that produced by the common click and ratchet movement, becomes not merely useless, but even dangerous; in such cases, the most proper course, is to effect a gradual weakening of the shock, for which purpose no method can be used which is in our opinion so likely to be effective as the retarding force of friction, applied by a check or curb, either to the axis of rotation, or perhaps more advantageously to the surface of a drum or barrel of considerable size, fixed on that axis. An arrangement of this method is adopted in England for lowering heavy weights from considerable heights to which they have been raised by machinery; this contrivance is curious and judicious; its description is as follows.

Let A Figure 1 of Plate 12, represent a toothed wheel, which is driven by a pinion B immediately connected with the moving power; the weight to be operated upon is suspended at the extremity of the rope D, which passes over the fixed pulley shown in the figure, and returning thence is gathered up on the axis C of the wheel A; t represents one of the pivots of that wheel; the check is composed of the lever m n, moving on its point of rotation or fulcrum q; to the longer arm m q is fixed the pad or cushion p, this presents a concave surface to the axis C, on which it may be pressed by the lever, the counterpoise H serves to raise it from the axis, and the check pin shown at r, stops it at a convenient elevation.

When it is required to release the weight suspended by the rope D, the pinion B must be withdrawn from the wheel A, or thrown out of gear, or it may be detached from the action of the moving power by the method I 7′; the weight will then be rapidly lowered, and when it has arrived within 3 or 4 feet of the ground, where from its accelerated velocity it would be dashed to pieces, the operator presses down the lever by its extremity m, with considerable force and so brings the cushion p to bear on the axis with so much friction as immediately to counteract and check the progress of the falling body.

In a work entitled "Traité élémentaire de Minéralogie," by M. Brongniart, vol ii, page 302, we find the description of a drum-wheel, the motion of which may be instantly checked when circumstances require it, whatever may be the effort of the moving powere by means of a curb composed of two stays or clips similar to that already described, and which together form a sort of large nippers, the spreading of the extremities of the arms of these clips or nippers, renders it necessary to place a small capstern in the middle point of their separating distance; this capstern is worked by the operator when he finds occasion to check the action of the machine.

The following description will explain the method of tightening the curb.

Let A, Figure 2, Plate 12, represent the drum-wheel set on the shaft or axis of the machine, this wheel has on one of its ends a ratchet wheel R, and it revolves on its axis in the direction indicated by the dart shewn in the figure; m n is the lever of the curb; p the cushion; c c a click suspended by the rope f, to the extremity b of the lever a b, which moves on the point a, as a fulcrum, and rests by its arm on a small roller which is fixed in the end m of the lever n m; the timber frame F has a projecting point s, which prevents the click from rising or leaving its position, while the spring v acts to press it forward to its operation on the ratchet-wheel, and by its curvature, keeps it up to its proper bearing while it is in action. If the motion of the drum-wheel should be reversed the click will be drawn into immediate action on the ratchet-wheel, the lever n m will operate to press the cushion p on the surface of the drum-wheel, and the motion of the machine will be checked without violent shock, and consequently with the least possible inconvenience.

Let us now suppose the machine to be rapidly drawn in the direction of its motion; and (in order to avoid the unnecessary multiplication of figures) let the drum-wheel A in the same figure be imagined to turn inea contrary direction to that indicated by the dart; it will be necessary to suspend the action of the spring v on the click c c, by means of a pin, so as to allow it liberty of motion, and so that in case of any sudden and extraordinary acceleration, the check pin shall cease to act on the spring, and the action of the machine shall be checked as in the preceding case; for this purpose the regulator N 7' Plate 5, and the motion G 8, of the same plate may be used; the wheel A of this motion represents the drum-wheel A of figure 2, and the spindle of the regulator may be represented by the axis of the wheel B, of the figure G 8, Plate 5, and which should be placed in the upper part of the wheel A, figure 2.

The tension of the rope Q which communicates the action of the mover to the resistance, may also be applied to profitable use, by using it to keep the click c c in its detached situation with respect to the ratchet-wheel; when in the event of the rope breaking, the click will be instantly released from its detached position, and will be submitted to the action of the spring r, which forces the click into action with the ratchet-wheel; the mechanism of this contrivance will be less complicated than that of the preceding article, and its action quicker; it consists simply of a very small cord d d, which is attached by one end to the lower part of the spring r, and by the other end to a small bar g g, which slides between the clips g' g', the bar carries a small roller t, which is so adjusted that the rope Q may press strongly against it, the cord d d is extended between the bar g and the spring, by small rollers, as shewn in the figure; it will be evident that if the rope Q should be broken, the roller t will be instantly released from the pressure which enabled it to hold the click c c from its action, the click will therefore as quickly be forced into immediate operation on the ratchet, and the motion of the machine will be checked.

The machine represented in Figure 3, Plate 12, is much used in the neighbourhood of Paris for the purpose of raising large masses of stone from the quarries. The celebrated machinist, M. Martin, considered that the adoption of this machine would prevent the disastrous accidents to which the workmen in that employment are so much exposed; its construction is thus. A lever p q composed of a stout plank, is suspended on the fixed point a, as a fulcrum; the shaft of the wheel A passes through the plank at the point c, and a counterpoise Q capable of raising the wheel A is suspended at the extremity q; the machine in this state resembles in its general features the common steel-yard, on which the wheel A occupies the place of the mass to be weighed, and in which theeusual moveable weight is superseded by the counterpoise Q; in the arrangement of our machine however, no equilibrium is produced, it being necessary that the counterpoise should exceed the load. BC is a strong upright pillar, and f e an edge piece of timber which has a motion on the point f as a centre, and carries the cushion q; e d is a bar either of wood or metal, having motion on the axis of rotation e and d; n n is the rope by which the masses of stone are brought from the quarry P; r is a ratchet wheel fixed to the axis of the wheel A, and r its click which is attached to the upright pillar B C. It will be evident that an upright piece corresponding with DE must be placed on the opposite side of the wheel A, in order to support the axis of suspension a of the lever pq; and also, that the latter must be forked, and its sides at a sufficient distance to allow a space for the free passage of the wheel A. The mass required to be raised must be attached to one of the ends of the rope n n, and on the first action of the weight upon the wheel A in the direction indicated in the figure by the dart, the short arm of the lever p q will descend, together with the wheel, until the end p of the lever is checked by some firm resisting obstacle, on which it will rest: the cushion p will be raised, and the working of the machine will proceed without any interruption; it may however be suspended at pleasure by means of the ratchet wheel, and whenever the rope n should happen to break, the wheel will instantly be raised by the action of the counterpoise Q, the cnshion q of the curb will descend and apply itself upon the drum wheel, and the shock will be prevented.

In Bailey's work already spoken of under the head E 4, we find in thet first volume page 146, the description of a crane invented by Mr. Pinchbeck. In this machine a curb is brought into actiont for the same purpose, but the mechanism is much too complex for general adoption, even if it were fully equal to the proposed object. The mover which operates to press the curb against the wheel, is the action of large bellows which are worked by machinery.

Whenever the resistance of a machine exceeds a determined limit, the action of the mover may be checked in the following manner:—

In the figure 4, plate 12, the lower or shaded figure represents a longitudinal section of the parts of the arrangement to be described, and the three upper or outline figures, transverse sections of different portions of the same.

Let M be the axis or spindle acted on by the moving power, and N that which is connected with all the other parts of the machinee now it is required that whenever the resistance encountered by the machine exceeds the assigned limits, its safety shall he secured by the facility of checking it without the necessity of interrupting either the action of the moving power, or the connection between the two axes M and N.

A A is a circular plate of iron fixed upon the spindle N: the surface which is turned towards N is flat, but on the opposite side are formed the two projecting rings n n and m m.

B B is a second circular plate of iron—on the side nearest to the plate A is formed a projecting ring p, which fits easily into the cavity formed between the plate A and the piece b; on the opposite side are two projecting pieces a a, intended to act against the projections s s of the piece C; and a strong projecting stud b, which extends beyond the opposite surface, enters the space formed by the ring or circular spring D D; performing the office of the curb.

D D, is a ring or circular spring which clips or holds upon the neck formed by the edge of the plate A and its projecting ring m m; this ring or curb may be closed or tightened at pleasure by means of the key E, (see the upper or outline figures) and consequently will encrease or diminish the friction, according to the required or convenient degree of resistance, in order that the motion of the spindle N shall be stopped while that of M shall remain at liberty to proceed. When the communication between M and N is completed, by means of the piece C which turns with it, and is at liberty to slide in the direction of its axis, (as in the wheel C of the figure I 7′, plate 4.); the projecting teeth ss act on the projections aa, the piece B and the curb are in action, and the whole moves together. When the piece C is withdrawn from the piece B, the connectione of the projections s s and a a ceases; and whatever may be the resistance of N, the action of the moving power on the machine is suspended.

It is evident that if the key E be firmly closed, and the communication between the two axes be completed by advancing the piece C as directed, the axes M and N will act conjointly as if composed of one piece; but if by withdrawing the piece C, we detach them completely, the axis M will in its retiring motion take with it the piece B and the curb DD, but the axis N will remain at rest; therefore if the key E be just closed so much as that the axis N may be at liberty to turn, the object of the arrangement will be accomplished with facility.

A very ingenious and important application of this mechanism has been made by M. Béttancourt in a machine constructed by him for cleansing the harbour of St. Petersburgh.

In our article L 7′, will also be found a method of securing a machine from any hurtful or inconvenient effect of the action of the moving power within certain limits.

E 7′.

A machine for driving piles invented by M. Camus.

The ram A is attached to the extremity of a rope which passes over the pullies B and C, and is afterwards wound on the vertical cylinder D, which with the lever I, compose the principal part of the machine: its action depends on the manner in which this cylinder is arranged and acts with the capstern, of which it forms a part; the capstern and the cylinder are of the same diameter and are set on the same axis; the cylinder should be encircled or bound with an iron strap E F, from which should project two or four points or pins also of iron.

The capstern G supports the lever H I, which carries a curved piece or heel F, which applies one of its ends against the cylinder, and the other end is attached to the capstern by a joint or hinge, so that it may be lowered by pressing upon its extremity I, and raised or kept up to its position by the spring L. Ther machine is put in action by applying the power of men to the horizontal levers O, M, N, P, who by their means turn the capstern G, and also the cylinder D, which is attached to the capstern by the lever F I applied to one of its iron pins; in this manner the rope by which the ram is suspended is wound up on the cylinder, and the ram is raised the height of the upright frame V y. When it has arrived at its greatest height, the man situated at the end of the bar N, presses on the end I of the lever I F and forces it down; the iron pin of the cylinder which was held by the heel F of the lever being thus released, the cylinder is at liberty, and the ram by its gravity rapidly unwinds the rope from its surface and descends; the lever I F is now released from the pressure which held it clear of the cylinder, and the action of the spring L raises it to its former position, the heel F becomes again engaged with one of the pins of the cylinder which is thus again connected with the capstern, and the operation is repeated.

We may here observe that the ram of this engine, and all those which carry the suspending rope with them in their fall, lose a considerable portion of their momentum by that circumstance.

(F 7.)

The upper figure of the view of this machine represents a side elevatione and the lower figure an horizontal plan of the central part of it.

An iron spindle p q, turning constantly in the same direction, is shewn in the side elevatione this is moved either by the power of men whose action is applied to the bars of a capstern, or by any other suitable movere it passes through two drums or cylinders of wood A and B which are not fixed to the spindle, but are fitted easily upon it.

The lower drum or cylinder A rests on the bottom board or floor of the machinee it is formed at its upper part of two rising surfaces a b c, a′ b′ c′, one of them on the exterior of the figure, the other on the interior, each making one turn of its circumference, similar to a hollow screw, or an open aud winding staircase formd of one continuous inclined plane. These surfaces are so arranged that each has its origin a and a′, and also its termination, at the two extremities of the same diameter. This lower drum A has a ratchet wheel r, and a click s (shewn in the lower figure) which acts to prevent the ratchet from turning in the direction of the moving power.

The upper drum B is hollow, and is furnished with two vertical arms or bars n m, each having a small roller at its lower extremity, the length of the bars is equal to the height of the lower drum ; the upper drum is supported by these rollers upon the inclined or spiral surfaces formed on the lower drum, and by which it always preserves an horizontal position. The upper drum also carries a stroug bar of iron terminating at the height of the lower surface, and its outer surface is grooved to receive the suspending rope of the ram.

When the rollers of the arms n m are situated at the commencement of the inclined planes of the lower drum, the upper drum is at its lowest position or point of descent, and if it is then turned in the contrary direction to that which we suppose the moving power to take, that is to say, in the direction c b a, the two rollers will meet the heads of the rising planes and oblige the drum A to turn in the same direction. But if B be made to turn in the direction of the mover, A will remain at rest, and B, turning by means of its rollers upon the inclined planes will be raised to their height.

The iron spindle p q, has a strong cross-piece i i′ also of iron, placed so that it nearly touches the upper part of the cavity of the drum B when it is situated in its lowest position.

This description being clearly understood, the mode of producing an alternate rectilinear motion from the direct circular motion produced by the moving power upon the spindle p q, may he explained in few words. We will suppose 1st the drum B to be placed at its maximum of descent—2nd the cross-bar i i, in contact and ready to act on the upright bar t—3rd the ram M, resting on the head of the pile—and 4th the rope d d′ in a state of tension; the spindle p q will in its own rotatory motion carry with it the drum B; this will raise the ram of the engine to an height equal to the circumference of the drum; the bar t will then pass the cross-bar i i, and the drum B, thus subjected to the effect of the ram M, will turn rapidly in the opposite direction and suffer it to fall. The drum B will consequently have an alternate circular motion while the ram M will have an alternate rectilinear motion, and it will traverse a space equal to the circumference of the drum B.

If all the parts of the machine be supposed in their original positions, and the lower drum A be turned half a revolution, in the opposite direction to that of the mover; in this case, when the upper drum B has also made half a revolution, the ram M will fall; the extent of the circular oscillations of the drum B, and those of the ram will be thereby reduced one half.

This very ingenious mechanism admits of firmness and simplicity of construction, and possesses, as we have shewn, the further advantage of allowing the ramto traverse any required distance from the smallest to a quantity equal to the circumference of the drum B.

G 7′.

This figure includes two views of the machine—one a front, the other a side elevation, the same parts being respectively marked with the same letters of reference.

A B is a spindle which is turned by the moving power always in the same direction ; the wheel C, grooved on the edge, fits easily on the spindle A B so as to be at liberty to revolve with friction, but is not allowed to traverse on the spindle; on one of its faces is fixed a check-pin s ; n m is an elastic bar or arm fixed to the spindle A B ; r is an inclined plane placed a small distance beyond the circle C, and in the same plane ; the rope c t has one end fixed in the grooved edge of the wheel C, and the other is attached to the flail or beater p q, which moves easily on the pivot p.

When the spindle A B revolves, the elastic bar n m meets the check-pin s, and obliges the circle C to revolve, which raises the beater p q: the bar n m also encounters the inclined plane r, and being thus forced from its contiguity to the circle C, suffers the check-pin s to pass; the circle C is immediately subjected to the action of gravity of the beater—which falls—and the process is repeated.

This arrangement, which is in reality but a modification of that shewn in our figure E 7′, has been applied by M. Dubuisson to a machine for beating or pounding plaster: a description may be seen in the " Collection des Machines approuvées par l'Académie des Sciences." Vol. vi. No. 407.

H 7′.

The following description of this machine is extracted from the report made by Messrs. Prony and Molard, upon proposals relative to the re-establishment of the machine of Marly: printed by order of the National Convention at Paris, in the third year of the French Republic.

DESCRIPTION OF WHITE'S MACHINE.

Page 15—The following is a description of the detent wheels: " The piece A is fixed to a spindle which revolves constantly in the same directioni; and the wheel B is fitted on the spindle so as to be capable of being turned upon it with friction, in the contrary direction. This wheel is furnished with a detent C, to which the piece A catches, and thus elevates the chain D, to which one of the pump pistons is attachedi: this continues to rise until the detent C arrives at and presses upon the check-pin E; the piece A is immediately released from the detent, and the piston which is attached to the chain D descends by its gravity, at the same time causing the wheel B to revolve on the spindle in its reverse direction."

I 7'.

A B is a spindle, which we will suppose to revolve constantly in the same direction by the action of any moving power; C is a toothed wheel which is fitted on the spinde A B so as to have the liberty of revolving on it with moderate friction; and a b are two mortice holes to receive the check-pins m and n; D is another circle or wheel also fitted easily on the portion p q of the spindle A B, which instead of being circular as in its other parts, is there made quadrangular. The two check-pins m and n, are fixed on this wheel; and the forked lever f h, is used on the fulcrum r to force it to or from the wheel C, and consequently to place the check-pins m and n into their respective mortice holes, or to withdraw them at pleasure.

Every part of the machine being situated as represented in the figure, it will appear that the wheel C may either remain in a state of rest, during the action of the spindle A B, being prevented from accompanying it in its rotation by some external check: or it may obey the action of another mover which shall urge its rotation in a direction contrary to that of the spindle A B; in short, it may be considered as really independent of the motion of the spindle, except insomuch as it is connected with it by the quantity of friction with which it is fitted to it: but if, by means of the lever f h the wheel D is moved so as to force the check-pins m and n into the mortice holes of C, the latter will necessarily obey the action of the spindle A B, until D, with its pins m and n, are again withdrawn from C, and so on. The action of the spring c is upon the extremity h of the forked lever, tending to withdraw the wheel D from C; the detent st, of which both a plan and profile are shewn in the figure, moves on the axis i, the check e on one side, and the spring k on the other, determine the direction, and limit the extent of its movement; if the forked lever be turned so as to perfect the communication between the wheels C and D, the spring will be checked by the detent. When it is required to detach the machine from the action of the mover, a slight pressure must be made on the extremity t of the detent, the spring c will act on the end h of the lever, the wheel D will be withdrawn, and the required suspension effected.

This mode of checking the action of a machine may be practically applied to several useful purposes, as for example: to stop a mechanical operation at a required time without the necessity of personal attendance, in the working of mills when the operation of grinding is complete; or in the weaving-loom, when the flight of the shuttle is accidentally interrupted.

The first-mentioned of these objects presents no difficulty in the application: it will be merely required to arrange the weight of a repeating watch so as to act on the extremity t of the detent, which may for this purpose be rendered delicately sensible.

In mill work, the machinery may be stopped when the required operation is completed, making use of the last-mentioned contrivance—to call the attention of the operator to the necessary adjustment of the detent.

In the operations of weaving, accidental interruptions of the shuttle are of frequent recurrence, by the breaking of a thread, or other unforeseen circumstances. To prevent the disorder which must otherwise be the consequence of such accidents, the following application of this contrivance is made.—The shuttle frame traverses with an alternate circular movement, (see the Section A, Figure T, in the compartment K 7', pl. 4.) its axis of rotation being in c passing through the lower framing of the loom, the alternate circular motion of the frame should not be equable, its velocity being required to decrease as it approaches the extremity a of the arc a b, described by its motion; we will suppose this extremity of the arc to be on the side nearest to the large roller, and that the decreased velocity at that point is required to allow sufficient time for the shuttle to pass from one side of the frame to the other, according to the width of the loom, and the velocity of the frame is required to be more or less accelerated as it approaches the extremity b of the arc, in order to strike the woof. Let an iron rod extend the whole length of the frame, having a free motion on its axis p, and at each end a bent lever n, p, m, r, which by the action of a spring placed near the middle of the bar, are constantly pressed forward so as to occupy the situations n′ p′ m′ r′; while the shuttle, on arriving at the points which it occupies at each alternation of repose will force them back to their first-described position n, p, m, r, it will be seen that if the shuttle meets with no interruption in its course, but passes freely, the levers n p m r will not meet the obstacles α and β when the frame by its alternate circular motion traverses the arc a b to strike the woof; but, if on the contrary it is interrupted in its passage, the levers which will then assume their second position n′ p′ m′ r′ will first meet the point or object α which receding from its action, will descend, and acting on the extremity t of the detent will effect the separation of the wheels C and D as already described, and they immediately afterward meet the fixed check B; the action of the mover will be detached from the machine, and the frame will consequently not strike the woof, which was the object required.

This motion I 7′ makes an instantaneous communication of the action of the mover to the machine, which is in some cases seriously inconvenient; it may be avoided in a considerable degree by the use of the mechanism Figure 4.

The extremely simple contrivance of this subject (I 7′) renders it useful in mill work to suspend the action of one of the stones of a mill where several sets of them are worked by one principal wheel, or where direct circular motion is to be converted into alternate circular, as in large flatting-mills, and indeed in almost every machine in which it is occasionally required to check the action of the works without interrupting the action of the moving power.

K 7'.

This is another modification of the preceding arrangement:—AB is a spindle which turns constantly in the same direction by the action of the moving power; the wheel C transfers the rotatory motion to the wheel D, which is fitted by friction only on the spindle E F; a pin e projects from the face of the wheel D, and another projecting pin f is fixed in the spindle E F; the wheel D may be placed within the action of the pin f, or be removed from it by means of the lever P Q; it will be evident by simple inspection of the figure that the action of the spindle E F may be suspended at pleasure by the requisite adjustment of the wheel D with respect to the pin f.

L 7'.

This machine is described in Les Memoires de l'Institut, and in Les Annales des Arts & Manufactures; vol. xix. page 181. It is the invention of M. Prony.

The organization of his machine consists in fact of an extremely ingenious application of the contrivance by which we detach, or communicate at pleasure the action of the moving power, and the axis of a wheel which is fitted on it by its friction, and reciprocally.

A large horizontal wheel A B is turned by the immediate action of the moving power, and drives in contrary directions the two vertical wheels C and D, which are fitted by their friction only upon the horizontal spindle E F; the interior face of each of these wheels has a ratchet wheel n and m: on one of the extremities of this spindle is fixed the wheel or pulley G, npon which is coiled a rope or chain, to each end of which is suspended a bucket, as shewn in the figure.

A frame a a composed of two iron bars, carries two ratchet wheels p and q, one at each of its extremities, and it is at liberty to slide back and forward on the square spindle E F by means of square boxes, which are fitted to, and slide upon it.

It is evident that if the frame a a is pushed towards the end E of the horizontal spindle E F, the ratchet wheels q and n at that end of it, will be placed in action, and the axis E F will then revolve in the same direction as the wheel D, but if the frame a a is pushed towards the end F of the horizontal spindle, the ratchet wheels p and m will be in action, and the axis EF will revolve in the direction of the wheel C, and one of the buckets which are attached to the chain will ascend, while the other will descend. All that now remains is to communicate this alternate movement to the frame a a, so that it shall take place immediately after the rising bucket has emptied itself into the trough ; and so that the chain of the rising vessel shall itself regulate the movement.

The inventor effects this by placing an horizontal spindle S S below E F, and in a direction at right angles to it. This second spindle is of iron, and has an arm x which projects upwards, and into the sliding boxes of the frame a a ; it has also a long upright arm h, which is surmounted by a weight of lead of lenticular form, and below are two flat pieces or feet s and t ; two forked pieces are placed near the extremity of the chain, just above the buckets, so as to act in succession on the two levers M and N. Those levers act upon the feet s and t, elevating them so that the upright bar h declines from a vertical position at the moment when the rising bucket is completely emptied; the weight P then produces a quick oscillatory movement of the spindle S S, and its arm x drives the frame a a towards the end of the machine over which the weight P inclines, and retains its position long enough to produce the operation of the ratchet wheels of that end of the spindle as already described. The spindle E F revolves in the contrary direction, and so on *.

M. Prony has also contrived a very ingenious method of releasing the animal used as the first mover, whenever the resistance is accidentally encreased. The following description of it is inserted in Les Annales des Arts, vol. xix. p. 190.

The traces 1, 1, 1, figure f pass through the apertures 2, 2, in the yokes 4, 4, which are attached to the levers 3, 3, this lever is set in the vertical spindle which gives motion to the machine; the apertures 2, 2, have friction rollers. The

* We find an application of this movement in a machine for rifling gun-barrels, invented by M. Jacquet; a description of which is given in Le Bulletin de la Société d'Encouragement, Sept. 1817.

extremity of each trace terminates in a loop which hangs on a stud or pin, fixed in the roller 5, which is moveable on pivots. A rope is coiled upon this roller which afterwards runs over the pullies 6, 6, 6, and is finally attached to the weight 7.

This weight, which may be varied at pleasure, will therefore regulate the resistance required to be opposed to the effort of the mover: thus—suppose this weight to have been fixed at 20 lbs. and that any obstruction took place in the working-part or wheel-work of the machine, it will follow that, without the assistance of this mechanism, the effort of the animal or mover would cause the derangement or destruction of the machine; but as the effort of the mover necessarily exceeds the regulating weight, the roller 5 will be forced to describe one-fourth of an entire rotation on its axis; the studs or pins of this roller having thus left their former vertical position, the traces which were attached to the roller by them, will be allowed to slip off, the animal or mover will be liberated, and the machinery will suffer no derangement. This method will also be found applicable to the purpose of preventing animals employed as first movers from exerting more than a given quantity of power, which can be determined at pleasure by the previous adjustment of the counterpoising weight 7.

M 7'. Plate 5.

In this figure which is a side elevation of the subject, a b represents a vertical spindle which has a rotation on its axis, by the action of any mover applied at a; its lower pivot rests on a block of wood e, this has two rollers which work in a groove or channel cut in the cross-piece n' m'; by this means the spindle a b is brought into contact with the two vertical wheels F and G alternately, and act upon them by an endless screw h. C and L are two cross pieces which support the spindle ab, at the same time allowing it sufficient space for the vibratory motion given it by the piece e. On this piece may be observed two click pieces a' b', c d turning on the points a' and e, which as well as the two pins or ends b and d which proceed from their extremities, are of sufficient extent to reach the surface of the metal piece u m n. (For a more minute and distinct view of these parts see the separate and enlarged figure m in the margin of the principal figure). This piece has an axis g f, from which at about the middle of its length, proceed at right angles to its direction, the two forked branches i l, which are intended to conduct the ropes which support the buckets; and near the extremity g of the arm f g is fixed an upright arm carrying the weight P; in the cross-piece will be observed two projecting pins x and y, having the quantity of their projection equal to the thickness of the two click-pieces a′ b′, c d; two buckets are attached to the ends of a rope which passes over the cylindrical backs of the toothed wheels F, G, taking one revolution on each. The action of the machine is as follows:—

All the several parts of the machine being in the positions represented in the drawing, the upright arm u, after having pushed the pin a′ towards the left, throws the endless screw h within the action of the toothed-wheel F, and the click piece a′ b′ falling by its own weight, comes in contact with the pin x, and throws the spindle and its endless screw into action with the wheel. When the projecting button s, which is placed a little above the bucket s, enters the forked piece l, the piece u n m is obliged to revolve on its axis; and the arm n, coming into contact with the pin b, disengages the click-piece before it reaches its horizontal positioni: but on the instant of its passing that position, the counterpoising weight P falling on the other side, the arm u presses on the pin c, and drives the vertical spindle within the action of the toothed wheel G, while the click-piece c d descends by its weight into contact with the pin y. The two cylinders on which are placed the wheels F and G, will therefore move in different directions, and the bucket S will descend while the opposite bucket rises, and so on in succession. On the edge of each bucket is a piece of iron which, when the vessel arrives at the proper height, receives a hook which operates to overturn and empty it. This machine is invented by M. Bettancourt.

In a work entitled—Branca (Giovanni) le Machine, volume nuovo e di molto artificio del Signor G. Branca, ingigniero et architeta della santa casa di Loreto. Rome 1629, 4to. (Italian and Latin.) Figure 21. The author shews the application of two vertical face wheels fixed on the same axis, and placed opposite to each other; a horizontal wheel turning constantly in the same direction, is forced into action with the two wheels alternately, by an assistant. Thus communicating an alternate circular motion to the common axis of the two vertical wheels; this method of converting the movement is applied in many different machines.

N 7'.

In this arrangement it will be observed that, in proportion as the rotatory motion of the spindle a b encreases or diminishes, the weights p and q are driven from, or suffered to approach the axis of the spindle by their centrifugal motion, and the cap r, which fits easily on the spindle, rises or falls upon it; the action of a steam valve m, is made to depend on this vertical movement of the cap, and the machine by this means preserves nearly an uniform velocity although the resistance be variable. We have seen this contrivance used with great effect in England in a wind-mill for the purpose of raising the upper mill-stone, when its velocity becomes too great, and to prevent the meal from being improperly heated. The singular ingenuity of this application will render an account of it interesting.

The upper mill-stone A, (figure n 7'.) receives its movement from the upper side, as in the usual construction of wind-mills. The stone is supported by the axis a b which rests on the block C, fixed to the beam D E. Upon the spindle is fixed the cap fg, which carries four arms for the purpose of receiving the stems of four iron balls h, i, k, l, each from four to five pounds weight; from the upper part of the stems four arms descend and support the piece F, which is at liberty to slide easily the entire length of the spindle; a groove is cut on the edge of the piece F, to receive the forked end of the lever d, e, to the other end m of which is suspended one extremity of the beam D E, its other end being supported by the jointed bolt n.

It will be evident that the arrangement of balls, here described, will revolve about the axis, with the motion of the upper mill-stone, and that in proportion as the force of the wind encreases the velocity of the mill, the balls will encrease their divergency from the axis; the piece F will descend, will consequently lower the extremity d of the lever d, e, m, which having the point e for a fulcrum will operate to raise the end E of the beam DE, and consequently the upper mill-stone A.

This mechanism has been applied by M. O'Reilly, in his blowing engine.—Annales des Arts, vol. x. page 26.

In Bockler's work, already mentioned, under the article E3, figure 19, we find the description of a mill which is put in motion by the action of a horse: in this mill we may observe a piece of mechanism which is used for raising or lowering the upper mill-stone. This mechanism differs from that before described in that the lever d e m, instead of being parallel to the beam DE, is placed perpendicular to it; and that its motion does not depend on the velocity of that of the mill. The author simply suspends a weight to the extremity d of the lever d m, and which he adjusts at pleasure as to its distance from the point of rotation or fulcrum e, (as in the case of the common steelyard) for the purpose of regulating the distance of the mill-stones; but the interval remains uniformly the same so long as the position of the weight remains unaltered. In figure 47 of Bockler's work, he shews an application of the same mechanism to a water-mill.

Ramelli, in his work already mentioned in our Article A 7', figure 120, had before this made a similar application of this mechanism.

O 7'. Plan and Elevation.

The description of a mill which is worked by the operation of the flux and reflux of the tide, invented by Leslie of London, is given in Les Annales des Arts et Manufactures, vol. xxii, page 302. The operation of this mill being simply to convert an alternate rectilinear motion, into a direct circular motion, we shall merely insert its description as it is given in the work mentioned.

Figure 1—Is a horizontal plan or section of the wheel, with its outer cover or case.

Figure 2—Is a vertical section.

a, represents the spindle or shaft of the wheel revolving on a pivot of metal which works in a bed of steel.

b b, are wings of the wheel, a little inclined so as to admit the influx of the water in a spiral direction.

c c, A drum or cylindrical case, within which the wheel revolves, leaving the smallest space possible between the partitions and the wings.

d d d d—A second drum or case of larger diameter, placed above the wheel, and forming an upper structure to the drum cc, with which it is also connected.

e e—moveable shutters, opening on opposite sides: the first, which is on the side in the direction of the current, opens by the pressure of the current, and is stopped at its proper position for that purpose by an upright timber f; the shutter of the opposite side will of course be pressed by the action of the current in the opposite direction, and will therefore be closed by the same action which opened the first. The inverse of this operation will take place, when the water which has risen during the tide of flood or increase, seeks egress at the tide of ebb: the dotted lines of the figure will sufficiently indicate this reverse movement.

Now, let us suppose h h in figure 2, to represent the surface of a river or current which is at the level of the cover of the upper drum or compartment at the ebb-tide, so that there shall be the same quantity of water always acting on the wheel if the surface of the current should happen to be above the upper edge of that compartment, the water which runs above, even if elevated several feet, will not produce any greater effect than when it reaches but to the level of the cover.

Let i i represent the bed of the river, and if it has not sufficient depth, it may be encreased by digging*. The current penetrates the drum by the opening e, causing the latter to rest itself against the check f, by this admission it passes to the lower side of the machine by traversing the spiral wings of the mill, which are thus put in action by the impulsion of the current, and produce a rotatory motion of the vertical spindle; the current having passed through the machine

* We consider this practice as entirely inadmissible—for the resistance which the running water will meet with from that portion of the column which is at rest, will diminish its velocity, or even reduce it altogether.

and reached the bottom, escapes by the opening or shutter k; this is the process during the tide of ebb: on the contrary during the tide of flood, the shutters or openings mentioned, (k and e) will close, and the opposite ones will be opened, by which the water or current will descend as before, and the wheel will continue to turn in the same direction whether the current be that of the ebb or flood tide.

The peculiar advantages of this wheel over those of other contrivances for tide mills are these:—

1st—It is to be preferred for a corn-mill on account of its velocity being more uniform, from the circumstance of its motion being produced by the constant action of the same quantity of water.

2ndly—It has the peculiarity of its motion being produced constantly in the same direction, whether by the flux or reflux, and in a much more simple manner than in other tide-mills.

3rdly—The wheel being horizontal, it is very easy to adapt and fix any required wheel-work upon the spindle, the spindle being easily raised above the surface of the water.

4thly—This wheel has a greater velocity with respect to the velocity of the acting current, than other wheels of the same description; and this circumstance enables us to dismiss all the contrivances practised in the old wheels to counteract or diminish friction.

With respect to the construction, the inventor states that its simplicity is highly favourable to economy in the first cost.

We find descriptions of many different mills which act by the same moving power, in l'Architecture Hydraulique de Belidor.

P. 74. Plan and Elevation.

In the upper figure or elevation, A B represents a fixed vertical axis or pillar of very solid construction: it is surmounted by a toothed wheel C. A hollow cylinder D is placed upon the axis, and rests upon a projecting ledge at its lower part. Four cross-pieces ab, cd, ef, gh, project horizontally from thei cylinder D, and are placed at right angles with each othere at the extremity of each of these cross pieces or arms is suspended a commodious seat or chair, and upon the face of one of the arms (ab) is set a small toothed wheel D' revolving on its axis, and working with the wheel C. The wheel D has a small lever handle E from the upper extremity of which proceed four ropes, each of them passes over a small fixed pulley, and they are fastened at the extremities of their respective arms.

A person seated in one of these four chairs can easily communicate a direct circular motion to the small wheel D', by means of the rope, which passing over the pulley is situated directly in front of the seat, and by applying an alternate rectilinear action to that portion of the ropee* he will be himself carried round with a circular movement which will include the entire moveable part of the arrangement of which he forms a part, and which will thus compose a sort of fly-wheel.

It will always be in his power to vary or modify at pleasure the velocity of this direct circular movement of the machine.

If instead of one person, we suppose two, three, or four persons to be seated in the chairs, it will be necessary for them to apply the action in concert, so that they do not counteract each other.

This ingenious machine was invented by M. Marcel Cardinet, and was secured to him by brevet of invention or patent; his object in the invention was the material improvement of a popular amusement, by dispensing with the manual labour by which the machine was then impelled, and affording the parties themselves the important advantage of regulating their velocity, and of stopping the motion of the machine at their pleasure.

Before this application by M. Cardinet, the same mechanism had heen applied to the construction of a watch by M. Breguet, in which the regulating parts revolved about an axis, under such an arrangement, that the relative positions of all its parts were continually changede and this, as the inventor conceived, afforded an effectual remedy for many serious inconveniencies and imperfections

---

* Similar to the action used in rowing.

of watches of the usual construction. The application of the idea to this practical purpose was worthy the reputation of an artist of his distinguished merit: but certainly the coincidence of invention does not lessen the merit or impeach the ingenuity of M. Cardinet, who, as we fully believe, was unacquainted with M. Breguet's invention; it affords a very remarkable instance of the relation which science establishes among branches of knowledge, where to superficial observers there seems no analogy.

Q 7. Plate II.

Let A represent the plan or upper side of a wheel having a ratchet wheel a b c d on its face of the same diameter; e f and d g are two arms, which are each at liberty to turn freely, by one of their ends on the axis of the wheel A; f g and h g are two other arms forming with e f and d g an irregular quadrilateral figure, of which the angles at f and g are nearly right angles; the several extremities of these arms are united by centre pins upon which they are at liberty to turn freely; h i is an arm connected with the quadrilateral arrangement of bars already described, by its extremity h; the three arms h i, h f, and h g, are also held by a centre pin upon which they have free motion; the arm h i passes through the clips k and l, and is therefore confined in its movements to the direction in which they are placed; the two arms e f and c g carry two click pieces m and n, one of them placed to the right, the other to the left of the figure; these two click pieces are connected with the arms by hinges, and they enter, and are kept to their action in the notches of the ratchet wheel, either by their own weight or by the operation of a spring. If now the arm h i be moved in the direction h i, the click piece m will act upon the ratchet wheel, and cause the wheel A to revolve in the direction indicated by the dart in the figure, while the click-piece n will slide over the teeth of the ratchet wheel; but if the arm h i return from i towards h, the click-piece n will then act, while the other piece m will slide over the ratchet; in each of these cases, the wheel A will revolve in the same direction. The alternate rectilinear motion of the arm h i will thus be converted into the direct circular motion of the wheel A.

R 7'. Plate 11.

Let A represent a wheel from which there projects the six pins 1, 2, 3, 4, 5, 6; and h p a horizontal bar supported by the rollers B and C; the bar h p has a projecting piece DE, the length of which is equal to the distance d e, between the bar h p and half the arc 1, 2, which separates the pins 1 and 2; F G H is a bent lever composed of the two arms F G and G H placed at right angles to each other, this bent lever is at liberty to turn freely on the joint G, the length of the arm G H is equal to the radius of the circle A, the centre point G is situated in a line G K, drawn through the centre K and parallel to the bar h p, and the arm HG tends constantly to descend by its weight; f is a pin or check which is attached to the bar h p, the horizontal distance of this pin upon the bar, from a vertical line drawn through the joint G, is equal to the distance D d. Now, if under these circumstances, the wheel A be made to turn in the direction indicated by the dart in the figure, the pin 1 acting against the projecting piece D E will draw the bar h p from h towards p, while the pin 5 will raise the bent lever F G H; when the pin 1 arrives at the point e, its action on D E will cease: the arm G F of the bent lever F G H is then in a vertical position, and will begin to act on the pin f of the bar hp, which will therefore make a retrogade horizontal motion in the direction p h; when the pin 5 of the wheel A arrives at the position 6, it quits the arm G H of the bent lever, which falling by its weight rests on the pin 4 which is then in the position 5, the pin 6 at this time occupies the position 1, and the same alternated motion is repeated, so that at each entire revolution of the wheel A, the bar h p makes six movements to the right, and six to the left. We find this contrivance adopted in a machine for polishing clock springs, described by M. Thiout, in his Treatise de l'Horlogerie Mécanique et Pratique; printed at Paris 1741. Vol. i. page 85; the same work also contains descriptions of several clock and watch scapements.

S 7' and T 7'. Plate 11.

These two contrivances for converting direct circular motion into alternate