rectilinear, afford an approximating solution of the problem. They are sometimes adopted in the construction of steam engines.

In the figure S 7′, n m is the crank of an axle n, which receives its circular motion from the first mover, D is a bar attached to the extremity p of the piston rod of a pump, and which will then traverse on the line b b a distance which approximates to twice that of the crank arm n m. The lengths of the arms B and C, and the position of the centre of rotation F, is arbitrary. The bar C is placed in the three positions F t, F q, and F r, which it will occupy at the middle and the extremities of the course described by the point d of the arm D; this will determine q, r, and s for the points of opposition which the other end of the bar B will have at the same time; if a circle be described through these points, its radius will be the length of the arm A, and its centre, the point of rotation. A few repeated trials will be found to afford results sufficiently accurate for practice.

In the figure T 7′ are also given the lengths of the arms E I H, and the point of rotation F; the points n, m, and r are determined as in the last example; and the radius and centre of the circle which passes through them, respectively give the length of the arm L, and the situation of K its centre of rotation.

SECTION. VIII.

To convert a given direct and equable circular motion, or the velocity of which varies by a given law, into direct 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 planes.

A 8.

THE two toothed wheels A and B act on each other in the usual manner; the direct circular motion of the one, is communicated to the other, which is situated in the same plane, but the direction of the communicated motion is of course in this instance, contrary to that of the mover; if a motion be required in the same direction, a third wheel C must be added to the arrangement: the ratio of the velocities will be determined by that of the diameters. If n be supposed to represent the radius of the wheel A, and n′ that of the wheel B, and if n and n′ are whole and prime numbers, the two wheels A and B will after certain revolutions, resume the same relative positions, if the number of revolutions of the wheel A be equal to n′, and those of the wheel B be equal to n. A very ingenious and practical application of this property of circles of unequal radii has been made by M. Breguet, the younger, in the construction of watches, in the following manner:—the fusee is laid aside in this description of watches, and the barrel or cylinder A, (see figure 5, plate 12.) which encloses the spring, has a toothed wheel α β, by which the action of the spring is transmitted to the pinion of the first wheel in the train; the spring is attached by one of its extremities to the axis r d, and by the other to the interior concave surface of the barrel; the length of the spring is such that supposing it entirely released, the axis r d may make twelve revolutions to bring it up to its maximum of tension; in general, the mean tension of the spring is that which is employed, that is to say, the tension produced by four mean revolutions of the axis; the ratchet wheel λ is applied to prevent the arbor from turning in the contrary direction to that in which the barrel is impelled by the spring; and finally, the advantage of suppressing the fusee results from the principle of the escapement itself: the inequality of the action of the spring being compensated by the unequal action exerted on the escapement during its repose. This being understood, the inventor has set a toothed wheel B upon the axis rd, acting on a second wheel C, which is fitted easily upon a cylindrical stud or pin which stands upon the upper face of the barrel, a broad and flat-headed screw is tapped into the upper end of the cylindrical pin, and thus secures the wheel C; the diameters of the wheels B and C, are respectively as five and four, the wheel B must therefore make four revolutions, and the wheel C five revolutions, in order that the same teeth of those wheels shall be in contact and their positions be relatively the same as at the commencement of the movemeut; if the wheel B does not move, which is the case when the barrel is in action, the wheel C will make four revolutions about the wheel B, in order to arrive at its point of commencement: it will in that course have made five revolutions about its own axis, and the same teeth will again be brought into contact with each other. Now if the spring contained in the barrel is compleatly relaxed, and that we cause the axis d r, and consequently the wheel B to make eight revolutions in the direction indicated by the dart in the figure, we shall then obtain the maximum action of the spring; it will act to impede any farther revolution of the axis r d; we will suppose the lower figure represented in the plate to exhibit in plano, the relative position of the wheels B and C at that moment; if the distance d e be divided into two equal parts in i, and the semicircle d f e be described on that point, it is evident that in order to produce the intended effect to the greatest possible advantage, the stops should fall into contact in some part of the semicircle d f e; but when the motion of the wheel B ceases, the wheel C is made to commence its motion by the action of the barrel, and imagining the diameters of C and B to be respectively represented by n′ and n, C cannot return to its first position after n′ revolutions about B, because it will previously fall in contact with the stops, in whatever part of the semicircular arc the point of contact may be determined; but it will meet them under different angles: this therefore does not produce the end required. It is a necessary condition that the stops shall fall in contact at right angles before the wheel C shall have compleated the number of revolutions represented by n′, about the wheel B. Let f be the required position—it is necessary that the arc a b should be equal to the arc a c, for if the barrel be turned in the contrary direction to that indicated by the dart, the point b will fall in contact with the point C, and when the centre e of the wheel C arrives at g, the angle d e f will equal the angle d g f; and consequently the conditions will be answered: a l is the fourth part of the periphery of B, and a k is the fourth part of the periphery of C; we have therefore

$$a\,h = a\,k = a\,l\,\frac{n'}{n},$$

and if we make $a\,h = a\,l\,\frac{n}{n}$, and draw through the point h the line d g equal to d e, and from the point d draw the line d f perpendicular to g e, the intersection of that perpendicular gives the position of the point f, in which the stops p and q must be in contact whatever be the ratio of the diameters of the wheels B and C; in this instance we shall have $a\,h = a\,l\,\frac{4}{5}$, or the angle g d e = 72 degrees. The position of the point f being thus determined the two stops p and q will be placed as in the figure. The centre of the wheel C will arrive at the point g before it will have completed the number of revolutions represented by n', and the action of the watch will be stopped: in order to wind it up, the wheel B must be turned in the direction indicated by the dart; the wheel C will revolve on its axis in the contrary direction, and the stop p will be checked by q, as at the commencement of the action.

In watches of this description there is no exterior indication by which the state of the spring may be known, and they are consequently much exposed to the inconvenience of being unexpectedly stopped, as well as improperly wound up. M. Breguet, the elder, has contrived the following method of exhibiting the required indication:—A screw m n is cut upon the axis r d, and the broad nut s t with bevelled edges, is fitted upon it, one or more arms u project from the upper surface of the barrel, passing through the nut s t and allowing it a free vertical motion. Now when the watch is wound up, the screw is turned, but is not at liberty to alter its vertical position, and since the nut s t cannot revolve horizontally on account of the arms u, which pass through and hold it, it will be compelled to rise vertically, that is to say, on the axis r d, as we have already shewn in our explanation of the action of the nut and screw in the article C 3; but while the watch is in action it is the nut which turns, and it then traverses the same space in an opposite direction; from this there results an alternate rectilinear motion, which is then converted into alternate circular motion by the application of a bent lever a', b', c', d', whose arms are placed at right angles to each other; the smaller arm c' d' of this lever rests upon the bevelled edge of the nut s t; and the longer arm a' b' carries to the exterior of the watch an accurate indication of the state of tension of the spring; and this is exhibited on the dial plate by an arc of suitable dimensions.

If the three wheels A, B, and C are of the same diameter, during the time in which A makes one revolution in the direction pointed out by the dart, the second wheel B will make one revolution in the opposite direction, and the third wheel C will also make one revolution, but in the same direction.

We will now suppose the wheel A to be fixed, and the wheels B and C to be attached to the wheel A by a bar or arm—it is evident that if the arm be made to turn about the centre of the wheel A, when it has completed one revolution, the two wheels B and C, will also have made one revolution, as in the preceding case with respect to the wheel A; for the relative effect will be the same, whether the first wheel A makes one revolution on its axis, or the second and third wheels make a revolution on that point; but in the second case the wheels B and C will participate in the rotatory motion of the arm, an effect which does not take place in the first case. It follows that the wheel B, whose rotation on its axis takes place in the same direction as that of the arm, will have made two turns or revolutions with respect to the distance, but the rotatory movement of the wheel C about its axis is made in an opposite direction; and consequently by the operation of the moveable arm, it will have traversed the circle which the arm describes in its motion about the axis of the wheel A; but it has no movement of rotation on its own axis, and consequently any lines which may be described on its surface in whatever position or direction, will preserve a constant parallelism among themselves.

This arrangement is often applied to the mechanism by which we illustrate the constant parallelism of the earth's axis in its motion through the annual orbit.

The machinery generally used in the manufactories of porcelain, for the purposes of pounding the materials, and reducing them to the impalpable state in which they are required for the subsequent processes, consists, as is familiarly known, of a large horizontal wheel, which is turned either by the application of animal labour, or the action of water; this wheel drives four or six pinions, the axes of which descend vertically, and each is immersed in a circular trough or vessel A A A A, (see the plan of fig. 6, plate 12, and the elevation No. 1.); at the bottom of each vessel is fitted a slab of stone which exactly fills the space. A second stone D, is placed upon the first—this is also circular, and its diameter is somewhat more than the radius of the lower stone C; the upper stone D performs the action of a muller: it is fixed on or held to the lower end of the pinion by a cramp-iron e d, b c; plates or slabs of porcelain are sometimes substituted for these stones, in which case the upper plate D is surcharged or loaded with some heavier body. The earths and materials which are to be subjected to the operation of the machine are placed in the troughs, which are then filled up with water, and the process commences: when this arrangement has been some time in use it is found that the stones C and D do not wear uniformly—those parts of each of them which are the most remote from the centre of rotation C are considerably worn down; the acting surfaces therefore will be no longer parallel with each other—the parts f u g m h will leave a cavity: in order to remedy this derangement, in some degree, it is usual to fit the cramp-iron c d b c loosely into the upper stone so as to allow it a little shake or motion, that it may fall to fill up the space occasioned by the wear. This is however but a partial remedy—its operation is to prevent the frequent changing of the stones. The muller or upper stone D can never become equally worn, unless every part of its surface traverses equal spaces in equal times; and this can be accomplished only by such an arrangement for its motion as will cause any lines drawn on its surface to preserve a constant parallelism. The mechanism which is the subject of the present article is strictly applicable to this case: the proper arrangement is shewn in the plan, and the elevation, No. 2, of figure 6, plate 12; the vertical axis passes through the cross piece B B, it is supported by the flanch n n, and terminates in the arm c b, placed at right angles to the upper part. From the centre d of the upper stone, a vertical arm d c projects, and passing through a circular aperture in the arm c b, carries at its upper extremity the toothed wheel e; a short pin f h, projects from the middle of the arm c b, and carries at its upper extremity the toothed wheel h, which is at liberty to turn freely on it; a toothed wheel g is fixed on the under side of the cross piece B B, and the axis a b passes and works freely through its centre. The diameter of the three wheels e, h, and g, are equal.

Another extremely simple and practical method for obtaining the required parallelism is this. (See the plan, and the elevation, No. 3, of pl. 6.) A cylindrical arm d e, projects from the centre of the upper stone D, and passes freely through a circular aperture made in the horizontal arm r b of the vertical axis a b. Another point f, is taken on the face of the upper stone D, in the same direction but of somewhat greater length than c d; from the point f, an arm f g projects and passes freely through a circular aperture in the horizontal arm k i of the axis h i, which is supported by the cross piece B B, it is necessary that the two horizontal arms k i and r b should be of equal length. When the axis a b is turned, the point d of the upper stone describes a circular path on the centre c, the radius of which is equal to the distance d c ; the second point f, on the upper stone, will also describe a circle the radius of which f h is equal to d c ; these radii will be constantly parallel, and every part of the surface of the upper stone will have the required parallel motion.

Either of these methods would produce the equal wear of every part of the stone D, supposing it to be homogenous and that the lower stone was similarly circumstanced, but unfortunately this is not the casee the effects of the trituration upon the surface of C diminish from the centre towards the periphery, its surface will therefore become concave, but the surface of the upper stone will also alter its figure, and will become convex ; we are well persuaded that a considerable advantage would be obtained in the wear of the stones by the adoption of these arrangements.

Subsequent to our organization of this improvement in the machinery used in the operation, of pounding or trituration, M. Joseph Zureda has communicated to us an account of his machine for polishing glass plates, established in the imperial manufactory of St. Petersburgh. In this machine the polishers are guided in their motion by a contrivance precisely similar to that we have just describede the arrangement is shewn in figure 7, plate 12, in which a b c d is a bar of iron, supported by five cranks e, e, e, e, e, of equal lengths, and are so arranged as to preserve parallelism among themselves, while the centre crank moves about its own axis by communication with the first mover, which in this machine is an hydraulic wheel. It will be easily conceived that by the action of this movement every part of the bar a, b, c, d, will describe a circle whose radius will be equal to the length of the crank arm. This action allows the weight to be lightened by suspending it by the ropes s s.

The polishing tools f f f operate on the surface of the plates, and their position, or that of the plates are altered at pleasure as the state of the process may require.

B 8. Plate 5.

The same problem is resolved by this arrangement, by means of an endless rope or chain: the movement takes place in the same, or in a different direction, according to the arrangement of the rope on the wheels, whether passing over them without crossing, or being crossed between them.

The length of chains or cords is subject to continual variation from natural causes: the preservation of their uniform tension therefore requires the application of counter-acting weights or springs; but in applying such remedial contrivances, care must be taken that the power shall act in the same direction as the first mover, that is to say, that the tension produced, shall act on the wheel which receives the action of the mover in the same direction as the mover itself; a counterpoising weight may be employed with good effect under such regulation, and may be applied with success to any machine; but if the tension produced by its operation acted in a contrary direction to the motion communicated by the moving power, the effect would be destroyed.

The forms of chains vary according to the purposes to which they are applied; a detached account of several may be seen in the French "Encyclopedie," under the head—Chain-making; and in Les Annales des Arts et Manufactures: No. 41, page 213, we find a description of a chain invented by M. Hancock.

C 8.

In this figure are combined different methods of communicating the motion of wheels in the processes of the arts.

D 8.

This figure shews an endless screw, which transmits its direct circular motion to a wheel. The action of the mover is perpendicular to that of the wheels; the practical applications of this movement are extremely numerous and familiarly known.

E 8.

The silk-mill of Piedmont, presents a remarkable specimen of the application of the endless screw—the screw is in that machine of unusually large diameter. In the figure, A B represents the diameter, and the single thread of which it is composed is divided into six equal parts, which are arranged between the two parallel planes of the figure; these separated portions of the spiral arranged in echelon upon the periphery of the wheel, are represented in the figure by the double curved lines a b, a b, a b, the rotation of the wheel causes them to act in succession on the cylinders H of the machine, by means of the six rollers or teeth d e, d e, &c. fixed on their peripheries.

A detailed description of this machine may be found in La description des arts et Métiers, published by the academy of sciences.

F 8.

The same problem may also be resolved by the means of bevel wheels, represented in the figure by the truncated cones A and B. This mechanism is of frequent application in the arts, the figure shews a familiar instance, in the common carpenter's wimble. The theoretical principle of bevel wheels may be found in M. Hatchette's work entitledé' Traité élementairedes machines."

C 8.

In this figure, A and B are two wheels whose planes are at right angles with each other, they are put in communication by means of an endless rope, which after passing round the horizontal wheel B is conducted by the vertical fixed pulley to the vertical wheel A. The wheel B may have rectilinear motion along the bar a b, revolving on its axis at the same time; in which case the motion should be considered as belonging to Section 17; but if this change of position of B be prevented, it will then arrange itself in this paragraph. This contrivance is adopted in our cotton spinning machinery.

H 8.

Let A B and C D be two parallel axes on each of which is placed three toothed wheels a, b, c, and a′, b′, c′; the wheels a and a′ situated at the opposite extremities of the two axes, are of equal diameter, the wheels c and c′ which are also situated at the opposite extremities of the axes, are of eqnal diameter, b and b′ the middle wheels on each of the axes are also of equal diameter; the wheels of the axis A B are fixed to that axis, but those of the axis C D are fitted so as to be capable of turning with considerable friction, and any one or more of these may be firmly attached to the axis (CD) by the arrangements described in the article I 7′ or K 7′ ; this being understood, it will be evident that we may produce the rotation of the axis C D with the same velocity as that of the axis A B, by throwing the wheel b into action ; its velocity will be greater than that of A B, if the wheel a be placed in action; and if the wheel c is put in action its velocity will be less than that of A B.

I 8.

Let AB, CD and EF represent three parallel axes ; each of which carries two toothed wheels a and b ; we will also suppose the moving power to be applied to the axis AB ; the wheels a b of the axis AB are fixed to that axis ; the wheels of the axes CD and EF are set upon them and are at liberty to revolve with considerable friction, but they may respectively be attached to their axes by the methods I 7′, K 7′ ; the wheels a a a are of equal diameter, and the wheels b b b are also of equal diameter, but the diameters of the latter are double those of the former. This arrangement is capable of four different combinations.

1. If the two wheels b b of the axes C D and E F are placed in action with the small wheel a of the axis A B, the axes C D and E F will revolve in the same direction, aud in a contrary direction to that of the mover, with the same velocity, which will be equal to half that of the mover of the axis A B.

2. If the wheels a and a of the axes C D and E F are placed in action with the wheel b of the axis A B, C D and E F will revolve in the same direction, and with equal velocities, being double that of the mover.

3. If the wheel b of the axis C D be placed in action with the wheel a of the axis a b, and the wheel b of the axis a b with the wheel a of E F, the axes C D and E F will revolve in the same direction, and the velocities of the axes A B, C D, and E F, will be respectively as 2, 1 and 4.

4. If the wheel a of the axis C D be placed in action with the wheel b of the axis A B, and the wheel a of A B with b of E F, the axes C D and E F will revolve in the same direction, and the velocities of A B, C D and E F will be respectively as 2, 4 and 1.

K 8. Plate 6.

To convert direct and uniform circular motion, into variable circular motion, the velocity of which shall vary by a given law.

IN this figure we have a plan and an elevation of the same parts, each part being respectively distinguished by the same letter of reference.

If the axis D be required to perform a certain number of revolutions, as *n*, while another, C, performs one revolution, with variable velocity, it will be evident that any two points of the axes should return to the same positions after the axe D shall have performed the number of revolutions expressed by *n*, or the axis C have performed one revolution. It will follow that these points will traverse equal spaces during *n* revolutions of D, or one revolution of C.

In order to simplify the application, we will suppose the two axes C and D each to perform one revolution in the same time; this example being clearly understood, all others will become perfectly easy of comprehension.

Let P Q, and M N represent the axes of two wheels, a b C, a d D, two toothed segments of unequal radius and equal arcs, and arranged on the level of the line 1, 1; (see the elevation) b′ e f C, and d′ n m D are toothed segments of equal radius and equal arcs, and arranged on the level of the line 2, 2; q C p, q D r are also two toothed segments respectively equal to the segments a D d and a b C, but arranged at the level of the line 3, 3.

It will be seen that by this arrangement the velocities may be varied by fixed intervals and in any required manner, observing that the points a a, are brought into contact, when the axis M N has completed the number of revolutions expressed by *n*.

This piece of mechanism is somewhat difficult of construction, from the interchange of the working parts at each alteration in the velocity, these difficulties may however be practically lessened, by encreasing the number of the teeth in the arcs, in cases where the effective action of the arcs is not produced with sufficient facility and certainty, it may be assisted by applying the additional power of a spring or weight.

The solution of this problem may also be obtained by means of two truncated cones A and B (figure K′ of the same compartment of plate 6) of equal dimensions placed as represented in the figure, at a small distance from each other, with their axes parallel, the lesser diameter of A placed upwards, the lesser diameter of B placed downwards, and the lesser diameter of A, at the same height as the larger diameter of B. On the convex surface of each of these conical frustums is formed an helical groove, one extremity of a rope n m is attached to the larger diameter of B at the point of commencement of the spiral groove of that cone, and after following the entire course of that spiral, it is attached by its other extremity to the corresponding point on the larger diameter of the cone A. It is evident that if A revolves in the proper direction with an uniform velocity, B will revolve also, but with a varying and decreasing velocity, being at first greater than that of A, in the middle part of its course equal to it, and towards the end of its course, as much less than A as it was greater at the commencement: the rope n m, will then be entirely coiled on the surface or groove of A. The movement cannot be continued in the same direction.

If, instead of cutting spiral grooves on the surfaces of the frustums A and B, they were left of their original conical figure, and an endless rope substituted for the rope n m, which shall pass round them, it will be evident that such a cord may be applied to the cones at any required height, without the necessity of altering its length. Suppose this endless rope were first placed on the lower parts of the cones, the uniform rotation of A will communicate a like motion to B, but the velocity of which will be greater than that of A in a known ratio, and this movement may be continued at pleasure ; as the situation of the endless rope is shifted towards the upper part of the frustums, the ratio of the velocities decreases, when it arrives at the middle of the height, the velocities become equal, and increase as it approaches the upper ends. The mechanism is used with great success in England, for the purpose of regulating the velocities of direct circular motion, particularly in the machinery used in the potteries, and manufactories of porcelain. In these arrangements the endless rope is made to traverse on the cones by a rack movement which is placed between them and parallel to their axes, and guides the rope. The contrivance is extremely simple, and produces the required change of velocity in an instantaneous manner.

L 8.

The upper figure in this compartment of the plates represents an elevation of the subject, and the lower a plan; if we suppose the motion of either of the axes M N, P Q of the preceding figure to be equable, the motion of the other may be either retarded or accelerated equably. This has been effected by M. Roëmer of the Royal Academy of Sciences, in the construction of a wheel whose motion exhibits and explains the unequal velocity of planetary motion. See Machines approuvées par l'Académie; vol. i. No. 24.

The inventor proposes a conical pinion cut through its whole length, as represented in the upper figuree its teeth work with those of a conical wheel B, the teeth of which are spirally disposed as a b c in the plan of the figure: the varying form, dimensions, and position of these teeth as they descend the spiral, is of course to be determined by the form, dimensions, &c. of that portion of the pinion with which they are respectively to act.

M 8.

In this figure, the upper is an elevation of the subject, the lower the plan.

Let A represent a drum wheel; B a truncated cone, the surface of which is cut into a spiral path from the base to the summit of the frustum, and a b c is a rope of which the extremity a is attached to the cone; near to its lesser base, the rope is coiled upon the spiral, and its other end is attached to the surface of the drum wheel at C; the equable rotatory motion of the drum will produce a variable rotatory motion of the frustum; and if the frustum be made to revolve with an equable velocity, the rotation of the drum will reciprocally be of variable velocity.

In watch-making, the mover employed is a spring enclosed in the drum A, which is called the barrel or cylinder, the truncated cone B is termed the fusee; the chain, which is attached to the barrel and the fusee, is wound up on the latter, whose property of equalizing the action of the spring is derived from the unequal diameter of its spiral.

Watch-makers are enabled by means of a balance or spring, to suit the fusee to the action of any given spring.

In the Theatrum Machinarum of Leupold, vol. i, plate 48, we find descriptions of various machines for the purpose of measuring the force of the wind: the first is simply a sail or vertical frame placed upon a carriage—this is placed upon a horizontal plane, at one end of which is an horizontal axis carrying a drum wheel and fusee. A rope attached to the carriage passes over a simple fixed pulley set at one end of the plane, and after making two or three turns on the drum wheel, is attached to it; another rope is attached to that point of the fusee which is nearest to the axis of rotation, and is then stretched by the action of a weight; the whole is then arranged so that the frame or carriage being placed close to the edge of the plane or table, the weight whose action produces the rotation of the axis, shall be in equilibrium with the friction of the carriage with the plane on which it moves. If the apparatus be now placed so that the wind shall act at right angles to the sail the carriage will run the entire length of the plane; but when this movement takes place, the drum makes a rotation on its axis, and the rope, which sustains the weight, is coiled on the fusee, a complete equilibrium will therefore take place, and then the radius of the fusee at that point which is last touched by the rope, will express the force of the wind; all the machines shewn by this author are founded on the same principle.

N 8.

A B represents a fixed beam or plank, having a mortice n m cut through it, and in which is set the axis of a toothed wheel C; a curved spring is applied between the centre of this wheel and the end A of the beam, so as to give it a constant tendency towards the point A; D is au elliptical wheel of which the periphery is toothed. The equable circular motion of C will communicate to the wheel D a circular motion of variable velocity. This method involves tho same practical difficulties noticed in the articles K 8 and L 8; the correct action of these wheels can in strictness only take place when the teeth are supposed to be infinitely small; the teeth of the wheels may however be dispensed with, and an endless rope substituted for them, which has a small degree of elasticity, or which has its tension encreased by means of a weight or spring: paying due attention to the observations made in the article B 8 upon the proper method of applying them.

O 8.

Is an universal joint which is used for the purpose of changing the direction of circular motion: it is frequently applied in the adjustments and motions of astronomical instruments, when it is required to communicate a circular motion to a distant point, and in a new direction.

A very ingenious application of this movement has been made by Messrs. de Bettancourt and Bregnet to their telegraph at those points where the line of communication alters its direction; in a memoir presented to the National Institute, they have shewn that if the rotation of oue of the two axes is equable, that of the other will be variable; and the ratio of the velocities will be the same as that which subsists between the actual subtense of the angles formed on a circle perpendicular to the axis of the first, by radii which divide the circumference into a certain number of equal parts, and the apparent subtense of the same angles, to an observer situated at a great distance, and in a parallel direction to the second axis. An acquaintance with this property is extremely useful in calculating the difference of the resistance which takes place in this movement, and especially when conducted on a large scalee an instance of this occurs in the application of the principles to the purpose of changing the inclination of two Archimedian screws used for draining, and which are worked by the power of wind.

An application of the universal joint has been made to the construction of a flatting engine by M. Droz.

The description of Wright's sowing or dibbling machine, in which this mechanism is employed, may be seen in the Repertory of Arts and Manufactures, vol. xv, page 369.

The reader may also consult Technica curiosa sive Mirabiliæ Artis of Gaspar Scholt, 1664, page 664.

P 8.

Let A B represeut an axis the continuity of which is broken by some impenetrable obstacle, and the separated portions of which are required to make their respective rotatory movements simultaneously, or as if composed of an entire piece. To each separate portion A and B of the axis, is fixed a wheel, as E and F, these are of equal diameter: an entire axis N M, is fixed near A B, parallel to it, and at a distance from it equal to the distance of the wheels E and F; upon this axis are cut the grooves C and D, at right angles to the axis, their distance is eqnal to the distance of the wheels E and F upon the axis A B, two endless ropes or bands pass respectively over the wheels E F, and their corresponding grooves C and D: the two bands must be disposed in the same manner, that is to say, either both direct, or both crossed, so that the motion of M N may be transmitted to A and B in the same direction, which would not be the case if the bands were arranged dissimilarly, the two portions of A and B would then move in opposite directions.

Q 8.

Practical mechanics employ a variety of methods for regulating the unforeseen inequalities of the moving power, as well as to protect the machinery, and the persons employed in its management from the serious accidents to which they are exposed by abrupt changes in any part of the acting power. The application of the fusee in the construction of the common watch to the purpose of equalizing the action of the spring, is familiarly known, as well as the methods adopted to compensate the variations of length in the pendulum, from the changes of temperature, and to render the vibrations of the balance isochronous: the use of a fan wheel in clock movements to regulate the action of the moving power is also well known, and the adoption of the same mechanism in other machinery. In our article N 7', we have shewn the methods in general use in steam engines for regulating the action of the steam. In machinery where human labour is applied as a first mover, as for instance, in some of those machines which are seen in all ports and harbours, whether for the purpose of cleansing them, or as cranes for raising and lowering considerable weights, in case of the rope breaking the operators would be greatly exposed to danger, but for the expedient usually adopted of a long beam or spring applied as a curb upon the periphery of the wheels; the friction thus produced quickly obviates the danger and inconvenience to be expected from such derangement, and compleatly relieves the operators from apprehension of danger, as has been before noticed page 49.

M. Breguet has adopted a piece of mechanism which he intends to effect an approximating equalization of the action of a first mover in pendulum movements, by encreasing the friction in proportion as the moving power is augmented ; this contrivance we consider to be judiciously applicable to other purposes. It consists of three wheels A B C, which are set upon the plate E E E E′, of two pinions, and an arm D ; the centre of the movement, which is variable at pleasure, is in E′; the arm carries at the point D a pivot of the wheel B, and rests upon a cylindrical portion upon the face of the wheel C.

Suppose the wheel A to be moved in the direction of the dart shewn in the figure, by a variable power, such as that of a spring—the action of the wheel A upon the pinion of B will then be as the power operating upon A ; but as the pinion of B is carried by the piece D, its tendency is in the direction of B, and resting with its end on the cylindrical portion of C, the friction of the latter on its pivot is considerably encreased, which will tend to diminish any excessive action of the wheel C.

R 8.

In this figure we have a plan, and an elevation of the arrangement, in which as usual, the same parts are respectively marked with the same letters of reference.

A and B are two wheels of different diameters, as depicted in the figures: they are each fitted by friction only upon an axis common to both, and which has no rotatory motion ; and they are arranged at a small distance from each other. The wheel A is grooved on the edge for the purpose of receiving an endless rope or band; the wheel B is also grooved on its edge, and has a certain number of projecting pieces on its upper surface which compose a series of other wheels of different diameters, and their edges are also grooved.

Two smaller wheels C, are placed upon an axis situated perpendicular to the surface of the wheels A and B; the diameter of these wheels is equal to the difference of the radius of A and B; and they are so arranged upon the axis that one of them may work with the wheel A, and the other with the wheel B; the combination and the particular arrangements of this wheel-work is arbitrary, and will therefore depend on local circumstances and the judgement of the constructor.

The arm e f terminates in two rings: the common axis of the wheels A and B passes through one of these rings with friction, and the common axes of the wheels C also pass through the other ring in the same manner; the axis of the wheels C is therefore constantly parallel to and equi-distant from the axis of A and B.

D is a cylinder to which the moving power communicates a direct circular motion. Two parallel wheels and endless bands transmit that motion to the wheels A and B, their rotation is in contrary directions, one band passing directly from D, the other being crossed.

S 8. Plate II.

We will now suppose the wheels A and B of the last example, to be of equal diameter; and that for the two wheels C, we substitute a single wheel which is placed at right angles to the faces of A and B; in short, that A B and C are bevel wheels, which are arranged andacombined as in the figure. The wheel C is fitted easily on the axis r s e, and the axis D E passes through r s e by a cylindrical opening for that purpose at s; the wheels A B and C are kept in their respective positions upon their axes by collars, or similar fittings, which prevent them from sliding upon the axes.

The wheel C has two rotatory motions—one about its axis r s, the other about the transverse axis D E.

A ring r u e m, may be attached to the axis r s e, having its plane parallel to to that of the wheels A and B, as in the figure; the exterior edge of the ring may be circular or of any required form, or which circumstances may require,