ANALYTICAL ESSAY

ON THE

CONSTRUCTION OF MACHINES.

THE nature of the mechanical movements which occur in the construction of machines, may be classed in three divisions, viz. rectilinear, circular, and those which are regulated by other given curves, and the subjects of either of these classes will again arrange themselves, under the distinct heads of direct and alternate motion.

Fifteen different arrangements may therefore be made of those motions by combining them in pairs, or twenty-one different arrangements, by combining each with each. The object of all mechanical arrangements is either to communicate some of those motions, or, by combining and transposing them to produce any required conversion of them.

The Synoptical table (Plate 13) affords a perspicuous display of the best examples of these several motions. It is composed of twenty-one equal horizontal ranges of square compartments, each of which contains one example; each range is distinguished by numeral figures, and each vertical column by Roman capitals, the intersection of two columns or the situation of any given example is therefore indicated by a letter with an affixed numeral, i e, the distinguishing letter of the vertical column and the numeral of the horizontal range. The open spaces which occur in some parts of the table from the greater abundance of examples in other of the ranges, are evidently unavoidable from the nature of the arrangement, they may however not improperly be considered as

reserved to register those future discoveries and inventions which the researches of practical and scientific men may be expected everywhere to produce.e

In order to confine the table of contents within convenient limits, and avoid the disagreable effect of frequent extensive ranges of open spaces, whenever the number of examples occurring of one class, have exceeded twenty, the remaining subjects have been arranged in a supplementary range, immediately below the first, and distinguished by the same numeral figure with the addition of a line, as in the ninth range, where the supplementary range (which became necessary from the number of examples) is marked 9′; And whenever the conversion of one given movement to another is not immediate, but must be effected by a preparatory conversion to some other movement then a single line of explanatory description is introduced in place of the horizontal range of examples, as in range 2, which should contain examples of alternate rectilinear motion, as produced by conversion from direct rectilinear motion: here the required conversion is not immediate, but is to be effected by the preparatory conversion shewn in the 3rd range, which the line of explanatory description accordingly refers to.

To avoid useless repetition, the 1st compartment of an horizontal range is sometimes occupied by a concise reference to movements which are to be found in other parts of the table, and which might also have been placed in that column, either in the state in which they are found by that reference, or modified by the intervention of another, as in column 4, where direct rectilinear motion is required to be converted into alternate circular motion: here the first compartment of the range informs us that if the given rectilinear motion be first converted into direct circular motion by some of the methods exhibited in the 3rd range, reference from thence to the 9th range will furnish the required conversion.

Each horizontal range of examples, furnishes the subjects of description of a section of the work, in which the object of each combination is explained, with the general solution of the problems analogous to the conversion required; The particular modes of execution with which we are acquainted are shewn by reference to the sources of information, and considerations arc added on

the value of such means, and the various practical applications which may have been made of them.

The subjects of the general table or index plate (Plate 13.) are also drawn to a larger scale, in which each subject has the literal and numeral characters prefixed which point out its situation in the index plate, as for instance, the 1st figure of plate 1, is distinguished in that plate, and referred to from the index plate by the designation B 1, which explains its situation in the index plate to be the intersection of the 1st horizontal range with the vertical column B. Eight of these subjects are arranged in each plate, and each has its respective letters of reference for the description. We have also been obliged to introduce some auxiliary examples in a distinct plate (No. 12.) which do not arrange themselves in the index plate.

SECTION. I.

To convert direct and equable rectilinear motion, or the velocity of which is variable according to a given law, into direct 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 a different direction.

THE only first movers the mechanical action of which can be considered as being direct and rectilinear, are 1st the Air—either by its motion, its gravity, its elasticity, or its rapid expansive force. 2d. Water—either by its motion, its gravity, its re-action, or by the expansive power of steam. And 3d. Gunpowder—either by its explosive force, or its re-action, as in the instance of the common rocket *.

* Examples of the instantaneous expansion of air, by the combustion of gunpowder or other combustible substances, applied as first movers, may be found in the Repertory of Arts and Manufactures, vol. i. p. 154; and in vol. vi. p. 100, a memoir on the subject by Bramah. In the works of Jean de Haute Fenille, printed at Paris 1694, is also a memoir under the title "Pendulle perpetuelle;—la maniere d'elever l'eau par le moyen de la poudre á canon, &c." We find the Academy of Sciences engaged at that time in adapting this power to raising heavy bodies. And the author has proposed an hydraulic telegraph, in which he believes is the earliest idea of communicating the action of a power to

An endless rope, moving about two fixed pullies may exemplify rectilinear motion, which is in fact, but direct motion in a circle whose radius is infinite. The progress of a body in a direct line between two given points, either by its own motive powers, or by the action of any first mover, is a more distinct example of rectilinear motion. The arrangements of the art of marine rigging afford many instances, and all those engines which act by means either of simple or combined pullies.

The arrangement B 1, and C 1, of plate 1, exhibit the most familiar instances of this proposition:—D 1, E 1, F 1, G 1, H1, K 1, are examples of parallel motion.

(A 1.) Index plate. (Plate 13.)

If circular motion be produced from rectilinear by the methods exhibited in the 3rd range, different examples of the required conversion may be found in that range.

(B 1.) (B 1, 2nd figure.) Plan and Elevation—Plate 1.

The points a and b are reciprocally required to traverse the respective spaces a b and c d with the same given velocity.

A general solution of this problem may be afforded by a simple pulley e, (fig. B 1,) or by two such pullies, if the given points are required to move in different planes (B 1. 2nd fig.)

(C 1.)

Problem 2. This is a repetition of the last problem, but with the condition that the distance traversed by c, is less than that of a, in a given ratio. A general solution of this problem is afforded by the combinations of pullies, which are usually adopted for the purposes of lifting heavy masses. These expedients are too well known to need minute explanation, but many examples worthy the attention of mechanics may be found among the machines approved

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great distances by means of long tubes filled with water. A report by Berthollet and Carnot, upon a machine invented by Messrs. Niepce, will be found in the Memoirs of the first class of the Institute for 1817, page 146, these gentlemen term their machine "Pyreolophore," and apply the instantaneous expansion of air by combustion, as a first mover.

Applications of the pressure of water or of the atmosphere, as first movers, may be seen in "Les Annales des Arts et Manufactures," vol. xiii. page 209, by O'Reylli. A description of the engine of Schemnitz; the improvements proposed in it by Boswell; and a description of Goodwyn's machine.

by the Academy of Sciences; in the work of Sabaglia; and in all those authors who have written on the art of rigging maritime vessels.

(D 1.)

Problem.—To move a line continually parallel to itself. This motion is familiar to us in its applications to the common parallel rule used in geometrical drawing*.

(E 1.)

This is another application to a more commodious construction of the parallel rule: some useful applications of it have also been made by M. Ramsden †.

(F 1.)

The foregoing examples are in general not well adapted to works of considerable size, or where great accuracy is required. In our cotton spinning machinery we find however a very elegant and satisfactory specimen of a parallel motion: In this machine a platform which carries the spindles, and is from 18 to 27 feet in length, is required to traverse over a space of about five feet, and to retain in its path an accurate parallelism. The most costly and complicated means had been exhausted to effect this, when it was at length accomplished in a manner at once so simple and correct as exceeded all that could have been expected. In the figures, B represents the carriage or platform running on four wheels a a a a, upon this carriage is plaeed a set of spindles, which receive their rotatory motion by the means shewn at G 8 of the table; d is the point to which the moving power is applied. The required constant parallelism of this machine seems extremely difficult to effect, from its considerable length, it is nevertheless obtained in a very perfect manner, by means of two cords n m p q, and r s t u, the first of these n m p q passes over two pullies s m, and the ends n q, are fixed. The second cord r s t u, also passes over two pullies, placed respectively over those already mentioned, and its ends r and u, are also fixed. It is necessary that the attaching points u q and n r, of the

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* See the work of James Leupold, entitled "Theatre de l'Arithmetique et de la Geometrie," 1727, plate xii. fig. 4.

† See the same work, plate xii. fig. 6.

two cords should be so situated as to stretch the cords perfectly parallel to each other, and with equal tension; and the carriage B, should be placed at right angles to them. These arrangements are easily practicable, and the effect is as perfect as can be conceived.

(G 1.)

A solution of this problem will also be obtained by the motion of a ruler a b, which runs on two fluted cylindric wheels or rollers c and d, placed near to its ends. It is necessary that these rollers should be precisely of equal diameter, and be so placed that their faces shall be perfectly parallel. This instrument preserves its parallelism merely by the friction produced by its own weight on the surface on which it rolls: but in the application of this movement to machines of considerable power, as in the instance of that which is used in boring artillery, it is necessary for the rollers to be deeply indented, for the purpose of engaging in hooks, which are fixed to a massive frame. To this ruler is sometimes added a dial, on which its progress is indicated, so that parallel lines may be described at any required distances.

(H 1.)

Let A be a wedge which is at liberty to slide longitudinally between four upright pillars c d e f, while a second wedge B, is so confined to the pillars by projecting pins, or friction rollers, that it is at liberty to move in a vertical direction only. It is evident that if under this arrangement the wedge A receives a motion in the direction f d, the upper wedge will be gradually raised, and the side n m, will move continually parallel to itself: we find this arrangement of wedges frequently applied to useful purposes, among others, to the pedals of musical instruments; but it appears capable of more extensive and useful application. M. De Bettancourt adopted it in England with complete success, for the purpose of raising the lower cylinder of a flatting engine; and he conceives that strait lines might be divided by this means, with as much accuracy as is now obtained with respect to circles by means of the present dividing plate. If we imagine the moving power to act coustantly in the direction f d, of the base a b of the lower wedge, and that an arm or ruler l p, situated at right angles to the inclined plane c b, and having friction rollers at the extremity l, it will rest on the

inclined plane, and the ruler will slide between the two projections o and q. The inclination of the plane being arbitrary, it is evident that a direct rectilinear motion may produce a similar motion in a given angular direction with it, and the velocity of the first will be to that of the second, as radius is to the sine c b a. If the angle c b a be reduced to o, the rule or bar l p, will remain immoveable. This will be the case when the original rectilinear motion is converted into a rectilinear motion at right angles to it. These results are obtained by the help of the second wedge B, as already described; and if a third be added, which shall be attached to the second, both the direction of the movement and the relative velocities may be changed at pleasure. The line c b, may also be curved at pleasure, in which case the direct rectilinear motion will produce an alternate rectilinear motion, and the arrangement would be classed among those of Section II.

(I 1.)

Is the Hydraulic Ram of Montgolfier. A description of this engine may be found in the Repertory of Arts, volume 9; in the Journal de l'Ecole Polytechnique, volume 14; in the Journal des Mines, numbers 48, 64 and 66; in the Journal de Physique of February 1798; in the Bulletin de la Societé d'Encouragement, Number 19; Number 61, of the same work for July 1809, also contains an article on some improvements of the Hydraulic Ram.

A current or fall of water which we have considered as a first mover, acting with an uniform velocity and directly rectilinear, produces an alternate movement in a valve, and with the addition of an air vessel will afford a continued jet of water; and which we have also considered a direct rectilinear motion.

(K 1.)

This is another method of producing a motion which will preserve a constant parallelisme it is frequently used in the drawing instrument familiarly known by the name of parallel ruler, and may be seen in other applications in Leupold's Theatre de l'Arithmetique et de la Geometrie, fig. 5, plate 12. Parallel rulers on this construction are frequently introduced in cases of mathematical drawing instruments.