CHAPTER IV.

ON THE APPLICATIONS OF THE SYSTEM.

(40.) THE purposes to which I have found my system applicable may be classed under four heads: (1,) the formation of models of the Elementary Combinations described in my work entitled 'Principles of Mechanism,' and other similar ones; (2,) the construction of such machines as I select as examples, either of the principles of mechanism or of the processes employed in manufactures; (3,) the construction and arrangement of apparatus for Experimental Philosophy in general; (4,) the trial of new combinations and original research.

(41.) I will now endeavour to explain more at length, and in order, these several applications of the system; and first, the *Elementary Combinations,* nearly the whole of which I am thus enabled to exhibit; whereas, if each were constructed, as usual in such cases, as a separate model complete on its own foot or stand, the expense and bulk of such a collection would render it impossible.

Many of these combinations consist of pieces of peculiar forms which admit of being made of wood, and in which the axis of motion does not even require a stud-socket. For example, large models to illustrate the forms and action of the teeth of wheels may be cut out of mahogany, with the teeth on a large proportional scale, as in the diagrams given in my work, and such wheels will turn very well upon strong ordinary joiners' screws. In this case I generally mount the two pieces of which such combinations usually consist upon a bar of wood, and fix this bar, when wanted for exhibition, by means of a bolt to one of the posts (Art. 18) or to an iron rectangle (fig. 19), which serves to hold it up or enable it to stand on the table during the explanation.

In other cases a little more building is required; thus, if the action of ratchets, clicks, and detents is to be shown, a cast-iron ratchet-wheel is mounted on a stud-socket, the stud of which is fixed in a hole in a board, on which board is also properly mounted an arm for the clicks, a detent, &c., and the board bolted to the front of an iron rectangle or bracket. Here the rectangle, the ratchet-wheel, and the stud-socket and stud, are general pieces removed after the lecture, to serve for other purposes: the board with its clicks is *peculiar*, and reserved for this purpose alone.

Elementary trains of spur-wheels, of bevels, and mitres, are mounted wholly by means of the general system of parts. Thus, according to the nature of the combination we desire to represent, we must either employ a peculiar construction, frame or pieces, or build it up entirely of the general forms; or, finally, employ such a mixture of the two methods as may suit our convenience.

(42.) Fig. 42 may serve as a specimen of an elementary combination. This is known as Roëmer's wheels, ('Principles of Mechanism,' p. 257,) and was invented by him to effect the varying motion of planetary machines, but will also serve in any case where a rotation of varying velocity is required to be produced from a uniformly revolving shaft. In the figure, the shaft, to which a handle F is attached, is the uniformly revolving shaft, and upon it is fixed a cone A, fluted into sixteen regular and equidistant teeth, like those of an ordinary bevel-wheel, but occupying the surface of a much thicker frustum of the cone than usual. Opposite to this cone is placed, upon a parallel axis, a smooth frustum of another cone B, of the same angle, but set with its smaller end in the reverse direction to the first cone, so that its surface lies parallel to the teeth of the latter, and so close as just to escape contact. Upon the surface of B are planted a series of pins (of brass wire driven into it), and so arranged as to fall in succession between the teeth of A, when the latter is made to revolve. As this series is so placed as to be in some parts at the small end, and at others in the middle or at the large end, the velocity which B receives from A continually varies; for A and B are about the same diameter at the remote ends, and at the other ends the diameter of B is considerably greater than that of A. Thus, when the pins that are engaged in the teeth of A happen to lie opposite its small end, as in the figure, B revolves much more slowly than A. When the pins are opposite the large end, the velocities of the two are nearly equal, and between these two extremes the passage from one velocity to the other may be made gradual or abrupt, according to the path upon which the pins are placed. To mount this apparatus, a *slit table* (fig. 16) is employed for the base. The cone A, made of hardwood, is bored with a $\frac{1}{2}$-inch hole, and is fixed on a $\frac{1}{2}$-inch shaft by pinned rings (fig. 30). The shaft is carried by tube-fittings upon No. 2 brackets (C, D), and the endlong motion of it prevented by the handle F at one end, and by a shaft-ring at the other end. The frustum B is also made of wood, and bored with an inch hole, so as to be mounted on a long stud-socket which is carried by a No. 2 bracket, E.

In this model the only *peculiar parts* are the two cones, every thing else being derived from the general system. I have already described two other specimens of this class; namely, the link-work, fig. 40 (Art. 34), and Ferguson's Paradox, fig. 41 (Art. 37).

(43.) The second purpose to which this system is applied is the construction of models of such machines as I select as exemplifications either of the principles of mechanism or of the processes employed in preparing and working raw material.

A model of a machine is generally constructed for one or other of the following purposes,—to explain the use and contrivance of the machine, or its actual form and construction. If the latter be the object, the model must necessarily resemble the original as nearly as possible, and differ from it only in material or magnitude; as, for example, when a large model is made of a small machine, as a clock scapement, to make its various minute parts more clear; or *vice versâ*, when a small model is made of a large steam engine. When the purpose is to explain and teach the arrangement (or '*packing*') of the different parts, and the form and mode of putting together the frame-work, no deviation from the original, or simplification of it, can be permitted, with this exception, that as the model is not subjected to the strains which the work of the original throws upon its various parts, wood may be used instead of brass or iron.

The case is very different, however, when the object of the model is to explain the motions and mechanism of the original.

Real machines consist of a number of parts of various sizes, packed together in a *cubical form* in a frame-work contrived so as to support the pieces in the best manner, and to reduce the machine to the smallest possible compass consistent with the proper access to the parts for oiling, cleaning, &c. In such machines it is difficult even for an experienced observer to see all the parts, without looking on all sides, or even removing some of them, because they are placed without any reference to the display of their motions, which are often hidden by the frame-work and by other portions of the mechanism.

In preparing a representation of the action of such a machine for the Lecture-Room, it is necessary to alter its arrangement by displaying the parts as much as possible on a *plane* system, instead of a *cubical one*, so that one piece may not conceal another. Instead of ingenious *packing* of the parts, we must have them *unpacked* and laid out, as it were, for inspection, without interfering with their connexion and action. Moreover, the frame-work must be kept out of the way as much as possible. Again, the small parts must be made larger in proportion, to render them visible at a distance, and the larger parts may often be reduced in scale. All this may, by judicious care, be effected without disturbing the connexion of the trains of mechanism, or destroying the individual character of the machine. When a machine contains a repetition of working parts, as in spinning, weaving, &c., a few such parts will do better for our purpose. Two or three *real spindles* set in a frame, with their proper drawing rollers above, may be set in motion by a combination built up of the general pieces above described, and will enable a clearer and better idea to be given of the action of these machines than if the Lecturer was provided with a complete throstle-frame. Many subsidiary contrivances also, which are necessary for adjustments or other secondary objects, and not essential to the primary work of a machine, may be dispensed with in an explanatory model, or explained subsequently by a model made on purpose.

(44.) As an example of the manner in which the parts of a machine may be arranged for Lecture-Room exhibition and explanation, I will take the striking part of a clock on the repeating principle (fig. 43). This model contains so many peculiar parts, and is so complex, that a peculiar frame is provided for it.[1] (The drawing is made to scale.) The frame consists of a base-board with two feet (A, B), and two upright pillars (C and D) of inch deal are attached to the base, as shown in the figure. The left-hand pillar (C) is 8 inches broad and 2 feet 7 inches high, and serves to carry the studs upon which the train of wheel-work is mounted, and also the hammer F, and bell E. The right-hand pillar D, $5\frac{1}{2}$ inches broad and 2 inches higher than the other, carries the snail N, the rack M, and the detent L. This pillar stands 2 inches in advance of the other, and the pieces which it carries are all made of wood and mounted on strong screws, which are quite sufficient for the motion required by these parts, although they would not answer for the wheels, &c. on the other pillar. The snail and the rack have bosses behind, which set them at the proper distances from the pillar; for from the nature of the machine the detent lies behind the rack, and the rack behind the snail. The rack has a projecting knob at the lower extremity, which rests upon the step of the snail when it falls. The detent here is of the simplest construction, consisting merely of an arm turning freely on the screw at the upper end, and having a projecting pin at the lower end, which lies in the teeth of the rack. It is unnecessary to introduce a *lifting-piece* or any other contrivance for the *warning*, because this device is fully explained by a similar large model which I have, of the count-wheel striking train, which it is convenient to exhibit pre-

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[1] See Art. 8.

viously to the present one. Also the snail (N) is so mounted as to turn on its axis by stiff friction, and can therefore be set by hand to the proper positions required for the different hours. The rack (M) turns freely on its centre, and therefore, when the train is discharged by raising the detent (L), it falls on the snail by its own weight.[1]

The train is mounted on three stud-sockets, and is furnished with cast-iron wheels and pinions of the *twelve-pitch* size.[2] The lowest stud-socket carries a wheel of 120 teeth, and a barrel of hardwood, 6 inches in diameter and an inch thick, to the front of which is screwed an annular plate of iron (G), provided with six pins for the hammer-tail.

The hammer (F) turns on a stud which is fixed to a block of sufficient projection to bring the hammer-tail in front of the plate: to the same block are fixed the hammer-springs (not shown in the drawing); the bell (E) is also mounted on a block; a slender cord (P) is coiled round the barrel, to give motion to the train, and passes through a notch in the base-board. The machine, when in use, is set upon a stool or other open-legged frame that will allow the string to hang down, and motion may be given to the machine during the explanation of its action by pulling the string by hand. After the action of the parts has been demonstrated, a weight may be hung to the string, for the purpose of still better showing the effect, by allowing the machine its proper self-action.

It is unnecessary to employ a ratchet for winding up; for by drawing the hammer-tail sideways, so as to clear the plate G, the string may be wound upon the barrel.

The wheel of 120, behind G, gears with a pinion of 20 fixed to the next stud-socket, H. This socket carries in front of the pinion a wheel of 108, and also the gathering pallet and its hook.

It is required that this gathering pallet stand visibly at the end of the socket, and for this purpose it is better to employ a stud-socket of the form fig. 11 or fig. 13, Plate I. (Arts. 6, 7), or to make a stud-socket expressly for the machine in question, in which the pallet and hook are permanently attached to the front of the socket, but from which the wheel and pinion can be removed for other purposes, when the machine is not in use.

The fly K is carried by a third stud at the top of the pillar C, the peculiar

[1] In this description I assume that my reader is already acquainted with the mechanism of the contrivance, the description of which may be found in any treatise on clock-work. My object is only to show the actual construction of the Lecture-Room model.

[2] For simplicity sake, the *teeth* of the wheels are not introduced into the figure.