

## CHAPTER III.

### ON THE SHAFTS AND TUBE-FITTINGS.

(23.) HAVING now explained the principal parts of the frame-work, I will return to the arrangements of the revolving mechanism.

I have already stated the advantages of mounting these parts for exhibition, as far as possible, upon studs; this, with a little contrivance, may be done to a very great extent. No doubt a long stud is liable to bend, and its diameter being necessarily greater than those of the pivots of an axis or shaft supported at the ends, introduces greater friction. But the forces and resistances of the machines we have to deal with in the Lecture-Room are rarely of sufficient magnitude to occasion inconvenience on this score. Nevertheless there are combinations in which shafts must be employed, and I will now explain the manner in which I have arranged them, in conformity with the system of frame-work.

When the pivots or necks of shafts are sustained by two 'plummer-blocks,' 'pedestals,' or other supports independently attached to the frame of a machine as usual, great inconvenience necessarily arises from the difficulty of fixing these pedestals so that the axes of their holes shall coincide with the direction of the shaft; for as every practical mechanist knows, the holes in the pedestals which receive the pivots or journals may separately fit the latter perfectly, and yet it will be found that when the pedestals are to be screwed to the frame, a great deal of careful fitting and adjustment is required in putting them together; otherwise the direction of their holes will be twisted, so as to set the shaft perfectly fast, and require the insertion of wedges or bits of paste-board, or careful filing of the seats against which they are fixed. Processes of this kind are plainly out of the question in putting lecture-machinery together.

Such shafts as are wanted must therefore be fitted each in its own carriage to which the pedestals or bearing-holes are permanently fixed, so that this carriage may be bolted to the frames already described when the shaft is required to take its place in a train of machinery; or else the pieces which sustain

the ends or necks of the shafts must be so contrived as to obviate the necessity of the above-described troublesome adjustments.

(24.) Fig. 35 represents a cast-iron carriage adapted to our system. It carries a short shaft, 1 inch in diameter, and 5 inches long between the bearings. The latter are fitted with caps, with binding-screws, and oil-ways, so that the shaft is very steadily mounted in the most complete manner. The shaft is not intended to receive revolving pieces between the bearings, and therefore does not require to be dismantled. But the ends upon which the wheels, &c. are to be fixed project, the one 2 inches and the other 3 inches. A flat fillet is filed upon these plain parts, and thus any large wheel or rigger, provided with a binding-screw in its boss, or any other piece similarly fitted with binding-screws, as the handle (fig. 34), or the flanch (fig. 32),<sup>1</sup> may be attached to the shaft. But the toothed-wheels and pulleys described above (Art. 3), which are all bored with an inch hole with key-grooves, do not readily admit of the addition of a binding-screw. For these the 'lengthener' (shown in section, fig. 36) is provided. This is made of iron, and has a socket with a binding-screw by which it can be fixed to the end of the shaft. Its left-hand portion is 1 inch diameter, and has a feather or a pin to suit the key-groove of the wheel, and a screw and nut by which to fix it in its place against the shoulder.

The 'coupler,' fig. 37, is also intended to fix short pieces of inch-shaft to the ends of the carriage shaft, in order to lengthen them, if required, and will also serve to attach disks or other pieces that admit of a short neck or stem of hardwood, 1 inch diameter, being fixed to their backs.<sup>2</sup>

The cast-iron carriage has four bolt-slits, two of which are seen in figure 35. It may either be bolted to the beds, &c., or directly to the stool at any part most convenient. It is strong enough to carry a small fly-wheel of 2 feet diameter, like those employed for five-inch lathes. In this case the carriage may be bolted to one of the top beds of the stool; for example, midway between B and c, fig. 24: the

<sup>1</sup> See Arts. 30, 31, for the description and use of these.

<sup>2</sup> The most complete way of arranging the end of the carriage shaft is to cut a square-threaded screw upon it which does not interfere with its cylindrical form, and therefore allows an inch-bored wheel, or two, to be fitted steadily upon it, and pressed against its shoulder by the nut. There may be a flat place filed upon this screw, which will not disturb its action; or better, a groove sunk in it for the reception of a feather that will thus adapt itself to the key-grooved wheels, and may be removed if it be required to fix a wheel which is simply bored and fitted with a binding side-screw. The square-threaded screw should stop short of the shoulder, to leave a plain part for the binding-screws to act upon, which might otherwise bruise the thread. When a shaft is thus provided with screws and nuts, its shoulders must be both outside, not both together as in the figure. One carriage may be fitted up with this kind of shaft, and another with the plain shaft.

fly-wheel, which must be provided with a strong binding-screw, should be placed on the inner end of the shaft, so as to revolve within the stool. The handle (fig. 34) being then fixed on the outer end of the shaft, will be at a convenient height for the hand, and a useful hand-wheel is thus arranged, by which motion may be given by an assistant to the larger class of machines, which are built upon the stool or fixed on a separate frame; or a treadle may be fixed below, the link of which may act upon a shorter handle-arm. If more convenient, the wheel may revolve outside the stool, and the handle or crank-arm within it.

One or two shafts in carriages of this description are necessary for strong work, and are applicable to all cases in which the limited length of the shaft is no inconvenience. But the most comprehensive method of arranging shafts is that which is described in the next Article.

(25.) The shafts, in this general method, are plain turned iron rods of the several diameters of 1",  $\frac{3}{4}$ ",  $\frac{5}{8}$ ",  $\frac{1}{2}$ ". For simplicity, however, I will at first confine the description of the arrangements and appendages to the  $\frac{3}{4}$ -inch diameter, and apply them to the other diameters afterwards. The lengths of these may be 3', 2', 1', and 7". By way of pedestals to support and guide them in their rotations, I employ pieces termed *tube-fittings*.

The *tube-fitting* (fig. 29) I make of gun-metal or brass, in one piece. It consists of a tube MN, 2 inches in length, bored to fit the  $\frac{3}{4}$ -inch shaft, and  $1\frac{1}{4}$  inch in external diameter. The back of this tube presents a flat surface parallel to the bore, from which projects a stem P,  $\frac{5}{8}$  inch diameter and 2 inches long, having a strong screw upon it, provided with a nut (omitted in the drawing). This stem and nut serve to fix the tube to the heads of the brackets, which, it will be remembered, are bored with a  $\frac{5}{8}$ -inch hole, and the direction of the tube may thus be fixed at any required angle in the plane parallel to the face of the bracket. Also, the bracket can be shifted round the bolt which fixes its sole to the frame, and the axis of this motion is perpendicular to the stem of the tube; so that, by combining the two motions, the tube can be fixed in any required direction.<sup>1</sup>

Fig. 39 is intended to show the manner in which shafts may be mounted upon this system. It represents a frame carrying two shafts, the lower of which (A) is horizontal and parallel to the bed, and the upper (B) inclined both horizontally and vertically. Each shaft is carried by a pair of tube-fittings in brackets. The frame is composed of a 3-foot bed (C) upon rectangles (D, E). The tube-fittings of the lower shaft are carried by No. 3 brackets (F, G), bolted to the upright faces of the rectangles. Thus each tube can swivel about its *vertical* stem and the *horizontal* bolt of the bracket, and the troublesome adjustment described in Article 23 is

<sup>1</sup> See 'Principles of Mechanism,' p. 280.

wholly avoided; for when the shaft is in its place, and the nuts of the stems and bolts moderately fast, the tubes of themselves are compelled to take their places in the line of direction of the shafts, and the nuts may be then screwed fast.

The upper shaft (B) shows how an inclined position may be given. In this instance the higher end of the shaft has its tube-fitting attached to a single No. 1 bracket (κ), and that of the lower end to a No. 3 bracket (η), and these brackets are also so disposed as to place the shaft across the direction of the bed horizontally. In similar ways any required angular position may be given to a shaft with respect to the frame, and the tube-fittings will always accommodate themselves to the line of the shaft, as above explained.<sup>1</sup>

In selecting the proper brackets for any required position, it must be remembered that the adjustability of the *tube to the line of the shaft* depends upon the former having two axes of adjustment (namely, its stem and the bolt which fixes the bracket-sole), which must not be parallel to each other, neither must the shaft be parallel to the bolt.

It follows, therefore, that the bracket No. 6 is not applicable to the support of a tube-fitting, because its bolt would be parallel to the stem of the tube. Also, no form of bracket can be applied to the support of a vertical shaft, if its sole be placed horizontally, because thus the bolt and shaft become parallel. Therefore, when it is required to support a vertical shaft by a tube-fitting, the frame must be so arranged as to place the bracket-sole vertically.

(26.) To prevent the endlong motion of the shafts, which are mere plain cylinders unprovided with shoulders or necks, rings must be employed. This device is usual in manufacturing mechanism when a shaft requires to be often taken out for cleaning or adjustment. Two rings, fitting the shaft accurately, and secured upon it by binding-screws, are attached on each side of one or other of the pedestals, or tubes, if the latter be employed; or, if more convenient, they may be fixed either close to the inner sides of the tube, or to the outer sides.<sup>2</sup> It is plain that in either

<sup>1</sup> The tube-fitting was suggested to me by a somewhat similar method of supporting shafts in some machines at Manchester. In these the shaft passed through a short cylindrical tube of metal or hardwood. The tube was inserted in an iron ring which had a tail attached to it, tapped with a screw and nutted. This tail being passed through a slit in the frame-work, and the nut put on and screwed up, the tube was grasped and pressed against the frame, and the slit allowed sufficient play to enable the tube to settle itself in the direction of the shaft, but by no means the universal adjustment afforded by the form I have been led to adopt.

<sup>2</sup>

*a. O. b.*

*c. P. d.*

In this diagram, if the line represent a shaft, and *o p* the place of the tubes, it is clear that we have the choice of four positions for the two rings; namely, (1) at *a b*, (2) at *c d*, (3) at *b c*, (4) at *a d*.

of these four manners the shaft will be free to revolve, but prevented from sliding endlong. If a wheel or other piece be fixed on the shaft close to either tube, it will manifestly render one of the rings unnecessary.

It will be seen that the system of mounting shafts just described is well adapted to our purpose, because it leaves us at liberty to place the bearings at any convenient distance, and to choose any required projection of the free ends of the shaft. A narrow flat fillet may be filed along the shaft, to receive the pressure of the binding-screws by which the rings and the other pieces about to be described are attached to it. This fillet will not impede the rotation of the shaft in the tubes, and it serves to receive the small burrs or bruises which the screws are apt to produce when repeatedly applied, and which would disturb the smoothness of the rotation if allowed to be impressed on the cylindrical surface.

(27.) Some or all of these shafts should have deep conical centre-holes at their ends.<sup>1</sup> This will enable them to be mounted occasionally to run between *centre-points*,—a method which has much less friction than the tube, and is also useful for vertical shafts. In the latter case the lower end of the shaft may rest upon a point, and the upper be supported by a tube-fitting, especially if the upper end be required to run free,—to sustain a disk, for example. (In fig. 47, Plate III., such a vertical shaft is shown at A.)

One or more pairs of pointed centre-screws of steel must be therefore provided, each having two nuts, and the external diameter of the screw being  $\frac{5}{8}$  inch. The screw will thus fit the holes in the heads of the brackets, and may be secured by a nut on each side of the head. This obviates the necessity of tapping the hole to fit the screw. The head of the screw should also have a conical sunk recess to receive the point of a revolving shaft, if required; in which case it must be placed in the bracket so as to present the head to the shaft. A pair of brackets thus provided with centres must be bolted to a bed or to any convenient frame-work, so as to receive the shaft, and the screws may be adjusted by turning the two nuts simultaneously, until the shaft is found to revolve with proper freedom.<sup>2</sup>

(28.) The toothed-wheels, pulleys, &c., which, as above described, are bored with an inch hole, are fixed to the shafts by the intervention of a piece termed an *adapter*, shown in section in fig. 33. This is bored with a  $\frac{3}{4}$ -inch hole to fit the shaft, upon any part of which it can be secured by the binding-screw. Its external diameter is one inch, and it has a shoulder below, through which the binding-screw

<sup>1</sup> If each shaft is turned in a single length between centres in the lathe, the original centre-holes will answer the purpose; but if they are cut from one long rod, the centre-holes must be made afterwards.

<sup>2</sup> In fig. 46 the shaft *n* of the swing-frame is supported by centre-screws of this kind. If it be required to support a shaft which has small pivots at the end, a pair of small tube-fittings may be used.

