CHAPTER II.

ON THE FRAME-WORK AND GUIDE-PULLEYS.

(8.) It will in the next place be convenient to show the nature of the frame-work by which the socket-studs described in the last chapter can be fixed in their proper relative positions, so as to cause the wheels, pulleys, or other pieces which revolve upon them, to gear properly together and form machines.

In arranging the parts of mechanism, it will be found that their axes of rotation may be required to be fixed in every possible position, whether horizontal, vertical, or inclined at any intermediate angle. Accordingly, when our rotating pieces have been mounted on stud-sockets, we must provide the means of fixing their studs in any of these positions, as the case may require, and also at the proper distances.

The most obvious way is to make a wooden frame for each especial machine, and to bore holes in the frame for the reception of the studs; care being taken to design the frame so that the rails of which it is composed shall present themselves at the proper angles and distances to receive the holes.[1]

This method I adopt when the machine in question is frequently wanted for use, or when its construction is so complex that the putting together of its frame by the more general system about to be described would consume too much time, and require too many pieces, to make the attempt worth while.

But even this simple method has a great advantage over ordinary models; for after the machine has been exhibited, the stud-sockets, wheels, and other parts of general use, can be removed, leaving the *peculiar*[2] parts by which most machines are characterized, and which may remain undisturbed, upon the frame-

[1] See Art. 43, and fig. 43, Plate II., for an example.

[2] Throughout this Essay I use the epithet *peculiar* to characterize all pieces and frames which are constructed for one object or model only, in contradistinction to those pieces or frames which are shaped to adapt themselves to a great many objects or models in turn.

work; and if the holes for the studs are carefully made, these, with their wheels, can be readily replaced when the machine is again required. But the quantity of such frames, if they were employed for every machine, would lead to serious inconvenience from their bulk, and they will be found perfectly unnecessary for the greater number of cases. In many examples, machines may be contrived in which the complex parts may be thus mounted in a small peculiar frame, and the simpler portions, together with this peculiar frame, be fixed upon a frame built up upon the general system. Thus we obtain a machine which, when put together for use, is large, and its acting parts spread forth so as to be distinctly visible to an audience; but which admits of being separated so that its peculiar frame and pieces may be stowed away for the next year's Lecture, while its general parts are available during the entire Course, as required.

(9.) The advantages of mounting the revolving pieces upon studs are various. When wheels are fixed to axes that are supported at or near each end, the frame-work becomes more complex; and if the wheels or any other parts lie between the two halves of the frame, they are liable to be concealed thereby. But when stud-sockets are used, the supporting piece of the frame is wholly behind or beneath, and thus leaves the revolving piece fully exposed to view; and the latter can also be readily taken off and replaced, if required in the course of the explanation. Again, the steadiness of rotation depends wholly upon the stud and its socket, and not at all upon the frame; and the stud-socket, which requires good workmanship, will serve for many machines, but the frame may be a mere deal board with holes in it, or other simple form, which, being of comparatively small cost, may be cut up or altered at pleasure.

(10.) I will now proceed to a system of framing which is built up of parts capable of being combined in various ways, so as to make frames for the support of the studs and other pieces in any relative position at pleasure. This may be called the *general system* of framing, in opposition to the *especial frames* above described. In the first place, for the purpose of carrying the studs firmly, and of readily fixing them in the various relative positions required, cast-iron *brackets* of six different forms are provided. These are all shown in Plate I., and are there indicated respectively as No. 1, No. 2, and so on. They will also be described in the following pages as Bracket No. 1, Bracket No. 2, &c.

Each bracket has a *head* A (see No. 1), bored with a hole $\frac{5}{8}$ inch diameter, and thus fitted to receive the screw (E, fig. 8) of any of the studs, which, as already mentioned, are of the above diameter at the shoulder; also a *sole* B, in the middle of which is a slit, full $\frac{3}{8}$ inch wide (or rather $\frac{1}{2}$ inch), to receive the bolt or bolts by which the bracket is attached to the wooden or iron frame-work.[1]

The brackets differ from each other, as well in the direction in which the stud is fixed with respect to the sole as in the height of the stud above it. In No. 1, No. 2, and No. 3, the stud stands parallel to the slit of the sole, and its axis is at heights of 8, 5, and $1\frac{1}{2}$ inches respectively above the lower surface. In No. 4 and No. 5 the stud stands also parallel to the plane of the sole, but is at right angles to the direction of its slit, and at heights of 5 and $1\frac{1}{2}$ inches respectively. In No. 6 the stud stands perpendicularly to the plane of the sole.[2]

In each of these forms the stud may be fixed with its shoulder either on one side or other of the head of the bracket.

The higher brackets (Nos. 1, 2, and 4) are also provided with bolt-slits in the upright face, for the convenience of fixing other pieces, as will presently appear.

(11.) The brackets are fitted up for use, as follows, by fixing them to wooden or iron stands or frames. For the purpose of uniting the brackets to these frames, as well as the parts of the frames to each other, I employ bolts of the kind termed *coach-bolts.* These have a circular and convex head, below which the shank is made square for a short distance, and then continued as a strong screw with a square nut. The shank is $\frac{5}{8}$ inch square, and the slits in the brackets are adapted to receive it: a washer must be placed under the nut, and if the head of the bolt bears against a wooden frame, another large washer must be also placed under this head, but is unnecessary if the head bear upon the sole of the bracket. A key or spanner must be provided, to screw up the nuts. Thumb-screws, or fly-nuts, as they are called, may be employed,[3] but I greatly prefer the plain nut for its simplicity and firmness, and because it looks neater and more engine-like, and is besides cheaper, as the coach-bolts can be had ready-

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[1] A mathematician will perceive that I have so designed these brackets, that supposing their soles to be fixed on a plane horizontal or vertical surface, with the slits parallel to each other, the different forms give the power of placing the studs parallel to the three axes of co-ordinates.

[2] The dimensions of the brackets are,—sole, $6'' \times 2\frac{1}{2}''$; diameter of head, $1\frac{1}{2}$ inch; thickness of head, $\frac{9}{10}$ inch; thickness of sole, $\frac{5}{8}$ inch; thickness of upright, $\frac{1}{2}$ inch. The patterns of these brackets and of the rectangle (Art. 15) are in the hands of Messrs. Holtzapffel, 127, Long Acre.

[3] Bolts with fly-nuts are employed in fig. 45, Plate III. (Art. 45,) to fasten the two No. 3 brackets to the bridge. But the position of these brackets, from the nature of the apparatus, may require to be changed, to adjust their distance for different proportions of the curves; and whenever such adjustments are required, fly-nuts are of course convenient and appropriate.

made in the shops. An assortment must be kept of various lengths, which I will indicate as their uses occur.[1]

(12.) The wooden frames which constitute the bases of the machinery are of various kinds, but all constructed on the principle of providing a number of slits, $\frac{3}{8}$ inch wide, for the reception of the bolts by which the soles of the brackets are attached to them. Fig. 16 (Plate II.), which I term a *slit table*, is the simplest form: it consists of four bars of deal, each 2 feet long, $1\frac{1}{4}$ inch broad on the upper face, and $2\frac{1}{2}$ inches deep, arranged so as to leave a space of full $\frac{3}{8}$ inch between each. It is supported on two feet, so as to raise the bars a convenient height, for access to the nuts below, and allow room for overhanging wheels, &c. Each foot is, as the drawing shows, notched on the upper edge to keep the bars in their places, and united to them by a single bolt, which passes through the whole. Thus we have a table about $6\frac{1}{2}$ inches wide and 2 feet long, upon which the brackets may be set so as to bring their studs into any required relative position; and the soles of the brackets being laid transversely to the slits, the slit of the sole is sure to intersect one or more of the slits in the table, so as to allow a bolt, or two if required, to be passed through and secured, the nut being placed upwards or downwards, as convenience may dictate. The 'slit table' is shown in use in fig. 42 (described below in Art. 42).

The mode of arranging a simple train of wheelwork, consisting of wheels and pinions with parallel axes, will be understood from the following diagram, in which A, B, C, are the wheels, *a*, *b*, *c*, the pinions with which they respec-

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[1] Bolts unite pieces more firmly than the clamps which are most commonly resorted to for apparatus; but bolts require holes or slits to be provided in the pieces which they must necessarily pass through. On the contrary, clamps unite pieces that are not so pierced. Occasionally, therefore, clamps must be employed. Fig. 7 represents a form that I have adopted, which has the advantage of not bruising the pieces to which it is applied. It consists of an L-shaped piece (D), the long leg of which is formed into a strong screw, and provided with a large fly-nut. The nut acts upon another L-shaped piece (K M), which has a hole through which the screw passes *freely*, so as to allow this piece to take its bearing firmly by the leg M upon the thing to be clamped, and by the other leg K upon the back of the first piece H. I employ two sizes of these clamps, differing only in the extent to which the jaws D M may be opened. The jaws and flat part of the backs are $\frac{1}{4}$ inch thick and $\frac{5}{8}$ inch wide; screw about $\frac{4}{10}$ inch diameter. The range of motion is of course determined by the length of the plain part and of the screw. In the smaller size the opening of the jaws ranges from $1\frac{1}{2}$ to 3 inches, and in the larger from 3 to 6 inches. The inside length of the jaw H is 2 inches. A diminutive form of this clamp is also very useful for clamping pasteboards to thin frame-work, or drawing-paper on drawing-boards. Its opening ranges from $\frac{1}{2}$ to 1 inch. It is $\frac{1}{10}$ inch thick and $\frac{4}{10}$ inch wide, and the inside length of H is $\frac{4}{10}$ inch. Besides the plain coach-bolts, hook-bolts and T-bolts are sometimes required, as well as a few fly-nutted bolts. (See Arts. 32 and 46, and figs. 48, 49, Plate III.)

tively gear; the wheel and pinion that occupy the same stud-socket being set in the same horizontal line, and the characters =o indicating the place of the bracket-sole and head respectively. The diagram thus represents a plan of the relative positions of the mechanism upon the slit table.

The 1st stud carries a pinion *a*, which gears into a great wheel A, fixed on the 2nd stud; and as the pinion and the wheel should be set close to the shoulders of their respective stud-sockets, the two brackets will stand with their faces in the same line. But the pinion *b*, in front of it, gears with the great wheel B, which is close to the shoulder of the 3rd socket, and thus the 3rd bracket will be set a little in advance of the 2nd bracket. Similarly the 4th bracket will be a little in advance of the 3rd, and thus all the brackets, except the first, will be set in a slanting direction. Their great wheels will be as close as possible to the head of the bracket, thus laying the least strain upon the stud; and as each stud is mounted upon an independent bracket, it can be shifted about and set in any relative position to the others that will best suit the pitching of the wheels, or the nature and thickness of any other revolving pieces that may also be mounted upon the stud-sockets. As the wheels are all placed behind the pinions, they do not conceal them.

1st stud =o *a*
2nd stud =o A *b*
3rd stud =o B *c*
4th stud =o C

(13.) The choice of heights at which the studs may be fixed, given by the different forms of the brackets, is not always sufficient to suit all arrangements; therefore an assortment of wooden blocks is required, termed *sole-blocks* (fig. 17). These are of various thicknesses, and their breadth, width, and slit correspond exactly to those of the bracket-soles. Thus the height of every bracket may be adjusted as required.[1]

[1] The thicknesses provided should be $\frac{1}{4}''$, $\frac{1}{2}''$, $\frac{3}{4}''$, 1", 2", 3", and 4". In practice, it will be rarely found necessary to employ sole-blocks; the choice of heights given by the brackets and adjustable frame-work is usually sufficient, as the smaller adjustments required for pitching toothed-wheels or for stretching bands can all be effected by the changes of horizontal position which the nature of the frame-work admits of almost indefinitely.

It may at first appear that the different heights of the studs might be adjusted by forming the bracket-head with a slit instead of a hole for the reception of the screw of the stud. But I find that if a stud-screw be inserted in a slit, the last turn of the nut in securing it is sure to disturb it from its position by the wriggling motion which it gives to the screw. The shank of the screw being of course made square (or at least flattened on opposite sides) to fit the slit, must necessarily have a little play to allow of sliding the stud into the required positions, and this play permits sufficient torsion to produce the effect above described, which is exceedingly vexatious. For example, if a toothed-wheel be mounted on a stud, and the stud placed in a

(14.) Slit tables of similar construction to fig. 16 may be made, if required, of different dimensions and numbers of bars; but I find the actual form and dimensions of this example the most convenient; and for machines that require larger or more comprehensive frames, the following more general system is better.

A set of wooden bars is in the first place provided, which are screwed together in pairs, as in fig. 20. The bars of each pair are united by strong screws passing also through small blocks of hardwood (*a* and *b*), which fix the bars at full $\frac{3}{8}$ inch asunder, so as to allow the coach-bolts to pass between them. Such a pair of bars I term a 'bed,' from its similarity to the bed of a lathe, which in like manner consists of two parallel cheeks of wood, between which the bolts pass by which the poppet-heads are secured. The bars of my beds are all of the same depth, namely, $2\frac{1}{2}$ inches, and their breadth varies from $1\frac{1}{8}$ to $1\frac{1}{2}$ inch, according to their length. The beds are of the various lengths of 1′ 6″, 2′, 3′, 4′, 5′, 6′, and 10′.[1] It is convenient to have four or more of the three first lengths and two each of the remainder. I make these beds and frames of deal for cheapness and lightness, but possibly beech or birch might be better, as the repeated screwing and unscrewing of the bolts is apt to indent the soft fibres of the deal. This is diminished by using large washers.

It may sometimes be necessary to employ triple instead of double bars for the beds, in cases where two bolts are required to hold a piece the slit of which lies transverse to the slits of the bed, and which happens to be liable to great strains.

(15.) Fig. 19 represents a cast-iron 'rectangle' employed for supporting and connecting the beds. Its faces are $2\frac{1}{2}$ inches broad (the same as the bracket-soles), their length 6 and 9 inches respectively, and thickness $\frac{5}{8}$ inch. Each face has a bolt-slit, as shown. Three or more pairs of these rectangles should be provided, for they are not only applicable to the support of the beds, as shown in figs. 27 and 39, but are useful in forming stands to which brackets or other pieces may be fixed, and also in constructing other parts of frame-work, as shown in fig. 47 (Art. 46).

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slit in the proper position for pitching with another wheel, this small disturbance of position destroys the pitch. The same effect does not take place when two slit pieces, such as the sole of a bracket and the slit table, are united by a bolt; for the position of the two pieces is secured by the contact of their surfaces, and the wriggling above described only affects the bolt. It will be seen too that the surfaces in contact are much greater than when the shoulder of the stud rests upon the edges of a slit, as in the former case.

[1] In the following descriptions, for conciseness sake, a bed 2 feet long is termed a *two-feet* bed, and so on.

(16.) The beds may be bolted upon a pair of rectangles, or otherwise combined in various ways, so as to form frames suitable for receiving the brackets with their studs, or other pieces of apparatus in every useful position; and they are heavy enough to be very steady on the table. Commonly a single bed of 3 or 4 feet long is sufficient, but in many cases the frame may require two or more beds, sometimes of different lengths, or beds in an upright position.

Various examples of frames, composed of beds and rectangles, are given in the subsequent figures, the machines which they carry being described below. Thus fig. 27 (Art. 52) shows a frame the basis of which is a 3-feet bed, bolted on two rectangles, and the upright faces of the latter serve to support the uprights of a lighter frame for small apparatus.

Fig. 39 (Art. 25) is similarly combined, but the rectangles also carry each a No. 3 bracket on their vertical faces.

Fig. 40 (Art. 34) has a bed sustained by two wooden feet, also employed in fig. 41 (Art. 37). These wooden feet, the form of which is sufficiently shown in these figures, are very convenient when a single bed is used as a frame. Each has three bolt-holes to allow of giving different positions to the bed, which, when the machinery hangs over one side of it, as in fig. 41, requires the feet to be longer on that side than on the other.

Lastly, the machine shown in fig. 46 (Plate III.) (Art. 47) is built upon a rectangular frame, made by bolting two beds, one 2 feet and the other 3 feet long, across a pair of 18-inch beds. In this case the rounded heads of the bolts that unite these beds, being downwards, furnish four points upon which the frame rests. The rectangles may also be used, without beds, in combination with each other, or with brackets, to receive stud-sockets, to support models, or in various ways to form the nucleus of the frames of smaller mechanism. When a single bracket or rectangle is sufficient, it should be attached to a small *base-board* (fig. 18). This is a plain board, about 9 inches by 6, with a short bolt inserted in the middle, by which to secure it to the sole of the bracket or rectangle. It serves to give extension to the base of the machine.

(17.) The stands and frames just described are adapted to rest on the lecture table; but larger machines and more extended combinations require to rest on the floor, and for this purpose the beds, rectangles, brackets, and other elements of frame-work, may be attached to the *stool* shown in fig. 24.

This is a strong frame, constructed, like the smaller ones already described, upon the principle of providing slits for the reception of the $\frac{3}{8}$-inch coach-bolts. It consists of two double frames, ABCD, EFGH, connected by two stout rails, I and K, placed near the ground.[1] The halves of each double frame are connected at the upper angles (B, C, F, G) by iron plates, one of which is shown detached from the angle F at fig. 26. This angle shows the appearance of the stool when the plate is removed. In using this stool it is frequently necessary to fix a bed transversely on the upper surface of its top rails; and to allow this to be placed as close to their extremities as possible, the following arrangement is adopted.

Fig. 25 shows one of the bolts furnished with an oblong washer, *k*.[2] One of these bolts is passed through the slit of B C, and another through F G, and both also through the slit of the bed which lies transversely across, the nuts being uppermost. To enable the bed to be shifted, if necessary, close to the angles B and F, grooves are cut in the top of the posts (shown at *a*, near F), of sufficient width and depth to allow the rectangular washer of the bolt-head to be moved close to the iron plate. Without these grooves, it is clear that the washer of the bolt could not be shifted beyond the inner angle of F, and thus the bed could not be fixed close to the extremities B and F of the frame.

Similar grooves (shown at *b*, near F,) are cut vertically, which are employed when a bed is bolted against the vertical faces of the legs. A bed in this position is shown at S, in fig. 47. When a bed is thus bolted to the legs of the stool, the soles of brackets fixed to it become vertical; but this is of no consequence, for the forms of brackets can always be selected so as to place their studs in a horizontal position, if required.[3]

The frame, fig. 23, is employed by bolting its vertical rails against the legs of the stool, for which purpose these rails have two or more holes bored in them, slits being in this case unnecessary, as the slits in the stool-legs furnish the means of fixing the rails at any height required. The rails carry a 3-feet bed, the inner face of which is flush with that of the rails, as shown. Thus the bed may be fixed either below or above the level of the top of the stool at pleasure. A similar bed, with longer vertical rails, may be provided to give the means of raising the bed still higher.

The frame is shown in use in fig. 45, Plate III., where it is bolted to the back of the stool, in order to support a drawing-board in an inclined position. (See

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[1] The frames are 2 feet 6 inches high and 1 foot 9 inches broad, and their outer surfaces 2 feet 6 inches asunder; so that the extreme horizontal dimensions of the stool are 2′ 6″ × 1′ 9″.

[2] $3\frac{1}{2}$ inches long, $1\frac{1}{2}$ broad, and $\frac{1}{8}$ thick, of iron plate.

[3] The same happens when beds or brackets are bolted against the vertical faces of the iron rectangles (fig. 39).

Art. 45.) This stool allows beds of various lengths, from 3 feet upwards, to be bolted on the horizontal surface of its rails or against its legs, in various relative positions: they may also, as required, be fixed either against the inner or outer surfaces. The beds may be bolted vertically against the fronts of the legs, so as to form posts which may similarly be set up against the sides. For the latter purpose the double rails (D, H) at the sides are provided,[1] and the post must be secured to the upper rails by a hook-bolt (shown detached in fig. 48). A bed may also be bolted upon one of the double top rails in their own direction (as at F, fig. 47), instead of lying transversely upon the two double top rails. By these different arrangements, employed singly or in combination, as required, large and substantial frames may be set up, not only for the reception of revolving mechanism, but for the exhibition of numerous other experimental arrangements which are required for the elucidation of mechanical or physical science, and which are frequently omitted on account of the bulk and expense of frame-work when constructed expressly for such purposes. (Two examples of frames thus built upon the stool are given in figs. 45 and 47.) But it will also be seen in these figures, that in many cases the brackets, rectangles, &c. may be bolted to the frame of the stool without the intervention of the beds, or in combination with them, so as to increase the comprehensiveness of the arrangement.

(18.) If a bed like fig. 20, about 6 feet long, be set upright and permanently fixed to a wooden or iron foot, it forms a convenient *post* to which various contrivances may be attached; or two such may be set at a convenient distance on the floor, and one or more long horizontal rails or beds be bolted to them,

[1] The scantlings of the parts of the stool are as follows: The legs and horizontal top rails, $3'' \times 2\frac{1}{8}''$; the bottom front rail, $3''$ wide and $4''$ deep. The double side rails (D, H) are $1\frac{3}{4}''$ thick, being made thinner than the legs into which they are mortised, in order to allow the washers of the bolts to pass behind them. They may be $2\frac{1}{2}''$ deep. The slits of course to be full $\frac{5}{8}''$ wide throughout.

The frame (fig. 23) has its upper bed of the same scantling as fig. 20, and its vertical legs $3''$ thick, to allow their upper ends to pass between the rails of the bed: the lower rail only serves to keep the legs together, and may be slighter.

It is useful to provide a set of single bars of wood, 3 feet long and 3 or 4 inches wide, each with a bolt-hole near each end, countersunk to receive the head of the bolt or nut. These bars being fixed close together across the top rails of the stool, convert it into a table, with this property, that a slit may be had at any part of it by there setting the bars apart, or any *peculiar* bar be inserted in the series, as required. The outer bars must be secured by square-headed bolts like bed-screws, with the heads uppermost, the nuts being of the form of the washer *k*, fig. 25, the place of which they occupy.

so as to constitute a very useful frame for suspending drawings or many kinds of Lecture-Room devices.

(19.) The connexion of lighter pieces than those which are usually carried by the stud-sockets, or than the cast-iron brackets, may be effected by wrought-iron loops, of which I employ the three several forms shown in fig. 22, A, B, C. They are made of $\frac{3}{8}$-inch square iron, the slit being, as before, a full $\frac{3}{8}$ inch wide, or rather, in this case, nearly half inch, as the workmanship may be rough: A is straight and 8 inches long; B and C have upright branches 4 inches long, and differing in this respect from each other,—that a plane passing through the horizontal loop would in B also pass through its upright loop, but in C would be perpendicular to a second plane passing through its upright loop. These loops are useful in a great number of ways,—for carrying light pieces of frame-work and connecting them with the frames already described, supporting the fulcra of levers or clicks, assisting in clamping, and various other purposes that will readily suggest themselves as occasion arises.

(20.) To return to the brackets, which, as I have already stated, are intended to supply the means of fixing the studs in any required angular positions. If the first five forms of bracket be fixed upon a horizontal surface, it is plain that their studs admit of being set in any relative angular positions in the horizontal direction, and that the bracket No. 6 provides for the vertical direction. If any other angular directions be required, they may be obtained by fixing the sole of the bracket to a vertical surface of the frame-work, or by combining the brackets. For example,—let the stud be fixed in the head of bracket No. 3. If this be attached to the vertical face of bracket No. 1 by a bolt passing through the slit of the former and the head of the latter, the stud may be set at any angle in the vertical plane parallel to the face of the latter bracket. Any one of the first five forms carrying a stud may be thus combined together; but it would be useless to combine No. 6 with the others, because its stud (being parallel to the bolt) would remain parallel to the direction of one fixed in the head of the lower bracket: such a combination will, however, sometimes serve to hold a stud over other pieces. In fig. 45, brackets (D, E) are seen in combination, not for the purpose of holding studs, but for fixing a bed in an angular position.

(21.) These angular positions are seldom required but for bevel-wheels or guide-pulleys. Guide-pulleys are so often wanted, that although they can be mounted very well upon stud-sockets and set in any angular position in the above manner, it is more convenient to fit them to studs of their own. But the most complete guide-pulley is shown in fig. 38 (in the left-hand lower corner of Plate II). This pulley, $4\frac{3}{4}$ inches in diameter, runs upon a stud which is carried by a piece C, tapped to suit the screw of an iron looped piece A B (about a foot long). The latter has a loop, $\frac{3}{8}$ inch wide and 6 inches long, at the end A, for the reception of a coach-bolt: the other end (B) is formed into a screw upon which the piece C is placed, and flanked by a pair of binding-nuts, so as to secure it in any angular position. The loop may be bolted against the face of a bracket (as shown at D), or to any other convenient part of the frame-work, as at R in fig. 47.

By combining the angular motion round the head of the bracket-bolt with the motion about the screw-tail of the loop, the axis of the pulley may be set into any required position, so as to make its plane coincide with the directions of any band which it is required to guide.[1]

When brackets are combined in the way above described, or wrought-iron pieces screwed against them, the gripe of the bolt is much assisted by interposing a thin leaden washer between the two.

(22.) The machines are sometimes required to be set in motion by a hand-wheel at some distance from them. In this case the band may be conveniently guided by the '*tripod-stretcher*,' the construction of which was suggested to me by the late Mr. Holtzapffel, and carried out with some improvements for the purpose of giving motion to a cutting-engine which I contrived in the year 1835.[2] This tripod is a three-legged frame of wrought iron, the lower ends of whose legs are 2 feet apart. They converge upwards and unite at a point 3 feet above the ground, from which point arises a looped upright bar adapted to receive my $\frac{3}{8}$-inch bolts.

Against the vertical side of this bar the loops of two guide-pulley frames, like that represented in fig. 38, can be bolted so as to place their respective pulleys in any required angular position. Two of the legs of the frame terminate below in points; the third is loaded with a heavy adjustable weight, made up of one fixed lump of a hemispherical form which rests on the ground, and of twelve shifting pieces (each $4\frac{1}{2}$ inches diameter and 1 inch thick), made, as usual for adjustable weights, in the form of disks, slit so as to allow them to be placed in any number at pleasure upon the bottom lump. Their whole collective weight is 50 lbs.

When this tripod is set on a floor, the two pointed legs take sufficient hold of the latter to allow the machine to revolve, without slipping, upon the points, and thus to lift the third or weighted leg a few inches above the floor.

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[1] See 'Principles of Mechanism,' p. 177.

[2] The tripod-stretcher and the cutting-engine are manufactured by Messrs. Holtzapffel.

The position of the pulleys and of the whole tripod must be so chosen that the band passing from the great hand-wheel to the machine which is to be driven may be properly guided, and that the weight may be held up by it, as above described. Thus the band will be stretched by the effort of the weight to turn the tripod about the line passing through the points of the two legs that rest on the floor; for as the pulleys are fixed at the top of the machine, and the weight at the lower end of one leg, the rotation of the other legs about their pointed extremities produces a vertical motion of the weight and a nearly horizontal motion of the pulleys. Thus the band is kept tight, for the hand-wheel and the wheel to be driven are usually very nearly at the same level. The convenience of this stretcher is, that it can be set down in any part of the room required, without any previous fixing, and the pulleys will even move sufficiently to accommodate themselves to the band, when the driven wheel is mounted on a travelling carriage so as to shift its position during its action, as, for example, is generally the case in cutting or drilling machinery.