84. The general problem is, given the throw of the eccentric and the diameter of the shaft upon which it is to be fixed, to make a drawing of the arrangement. In Plate XX., figs. 143 to 145, we have worked out the example, of which the dimensions are given in Art. 82, page 62. Fig. 143 is a front-elevation, fig. 144 is a plan, and fig. 145 is an end-elevation; they are drawn to a scale of $\frac{1}{4}$. Fig. 146 shows a portion of the sheave and the strap with the oil-cup in section; fig. 147 is a plan of the same; scale for both $\frac{1}{2}$. Figs. 148 to 156, Plate XXI., are portions of the figures shown in Plate XX. drawn to a scale of $\frac{1}{2}$.

85. The drawing of the figures in Plates XX. and XXI. is as follows:—Draw the centre lines *ay*, *a'y'*, *bz*, *cx*; let C be the centre of the shaft; from C as a centre with a radius CB (one half the throw), describe a circle BDN, which is the path of the centre of the sheave; through B draw the line *dw*, this will be the centre line of the sheave and the strap. From C and B as centres describe the circles for the shaft, &c.; and from the dimensions given, and from the construction lines shown, proceed to draw the figures. The only special points to be noticed are the intersections of the oil-cup with the strap, of the feathers U with the boss V and with the strap, and of the boss with the strap. These points we will now refer to.

The intersection of the oil-cup with the strap would be a case of the intersection of two cylinders whose axes are at right angles, but not in the same plane, as shown in figs. 143, 146, and 148, but the angle formed by the two cylindrical surfaces, as seen in those figures, is filled-up with a curved surface, and therefore there is no line of intersection to be seen in fig. 150. If the filling-up were omitted, the dotted line 0' 1' 2' 3', fig. 150, would represent a portion of the intersection of the two cylinders. On the right of fig. 150 is shown, by a dotted line 0 to 6, one-half of the *junction* of the curved surface, at the bottom of the oil-cup, with the strap; but there is no line produced, as it is not an *intersection*, because the two surfaces blend into one. However, we require the line to find the intersection of the curved surface with the face of the strap, as shown at 2*h*'4, fig. 148; the outer circle of the strap does not pass over the surface of the cup between 2 and 4, fig. 148, but terminates at these points, and then takes the curved form as shown. The boss V is joined to the strap by a surface similar to the one just described; the feathers U, U, are also connected to the boss and the strap by curved surfaces, and therefore, for the same reason as before, there is no line to be seen; the dotted line on the boss in fig. 148 represents the junction of the two surfaces.

86. We have shown in Plate XXII., figs. 157 to 160, the oil-cup and a portion of the strap drawn full size; the curved surface which connects the two is not of uniform cross-section between 0—6, 0—6', figs. 157, 158, but changes from the form shown at 6' VI' to that at 00'. In fig. 158 the boundary lines of the curved connecting surface are 06'VI'0'0; the plans of 06', 0'VI', are the circles 06, 0VI, respectively. Fig. 160 is a projection of the curved surface 0'VI'0', where it meets the cup, and of 06'0, where it meets the strap; the latter is cut by the faces of the strap *l'm'*, *n'o'*, in the points *b'*, *c'*; an elevation of this intersection is shown at *b'h'c'*, fig. 158; the curve is not quite correct, but it is a good approximation: to draw the curve correctly would require a better knowledge of curved surfaces than we can assume the student at present possesses. If the cross-section of the curved surface was uniform, *b'h'c'* would be obtained by a construction similar to that used to obtain *ab*, fig. 137, Plate XVIII.

87. The drawing of the eccentric-rod requires no special instructions, the forked end is shown in figs. 153 to 155. Fig. 153 is a plan, fig. 152 is an elevation, and fig. 155 is a cross-section, made by the plane SP, of the chamfered portion *pq* between the fork and the cylindrical part K. Fig. 156 is a section of the pin X showing the split-pin Y.

88. Cams.—The motion resulting from the two arrangements just considered is of a certain fixed kind; that is to say, all cranks and ordinary eccentrics produce the same kind of irregular rectilinear motion, which motion cannot be altered, except in the case of *shifting* eccentrics. By the use of cams we can obtain any kind of rectilinear motion we choose, either regular or irregular. They are generally made in the form of discs, or grooves: figs. 161 to 166, Plate XXIII., represent three common forms of cams. Fig. 161 shows one revolution of a *spiral*, which is used as a *base* for the cams shown in the remaining figures. Its construction is as follows:—Describe concentric circles of radii C0, C12 (3" and 6", respectively); divide the distance 0—12 into any convenient number of equal parts divisible by 4, say 12; and divide the circumference of the outer circle into the same number of equal parts; from these points draw radii; make one of them equal to C12, and each of the others in succession less than the preceding by $\frac{1}{12}$ of 0—12, the last one, C0, being in the same radius as C12.

Through the extremities I, II, III, &c., of these radii draw the curve; this is the required spiral. If now the spiral is centred upon C and made to rotate, having its curved surface in contact with a sliding piece at 0, which is free to move in a direction C12, then for equal arcs described by the spiral, the sliding piece will move through equal spaces; for example, if the spiral turns through an angle 2C12 ($\frac{2}{12}$ of a revolution) the sliding piece will move from 0 to 2 ($\frac{2}{12}$ of 0—12), and so on for each fraction of a revolution. The motion of the sliding piece is therefore uniform.

89. The form of cam described above can only be used for motion in one direction; but by using the one shown in fig. 162 we can obtain an alternate motion, which is also uniform. The cam in this example consists of two equal and similar halves, the distance between the two circles being divided into 6 equal parts instead of 12, while the circumference is divided into the same number as in fig. 161; this is usually called the *heart-shaped* cam. Fig. 163 is a cam for producing a regular motion, but the time occupied for the forward and backward motion is not the same, one being performed in $\frac{5}{12}$ and the other in $\frac{7}{12}$ of a revolution. Figs. 161 to 163 are drawn to a scale of $\frac{1}{16}$, figs. 164 to 166 to a scale of $\frac{1}{8}$.

90. The cams in figs. 161 to 163 are supposed to act upon *mathematical points*, which in practice is impossible, we have therefore to assign some size to the point acted upon by the cam; to illustrate this we will take a practical example and work it out. Let it be required to give to a roller A, 2" diameter, attached to a sliding piece, and capable of moving in the direction SP, a regular alternate rectilinear motion of 6", the distance from the centre of the cam to the centre of the roller, when at its greatest distance from C, to be 12". Draw the centre lines *ay*, SP; from C as a centre with a radius of 12", describe a circle cutting SP in A'; from A' along SP towards C set off A'A = 6", the extent of the motion; and from C as a centre with a radius CA' describe a circle; divide its

(To be continued.)