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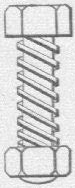

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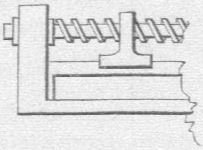

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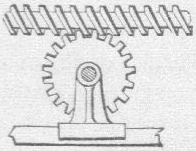

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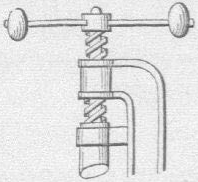

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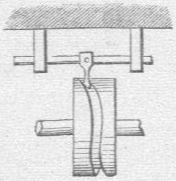

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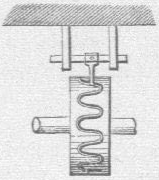

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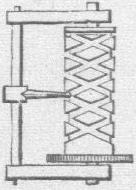

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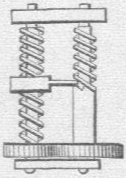

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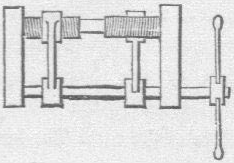

102. Common screw bolt and nut; rectilinear motion obtained from circular motion.

103. Rectilinear motion of slide produced by the rotation of screw.

104. In this, rotary motion is imparted to the wheel by the rotation of the screw, or rectilinear motion of the slide by the rotation of the wheel. Used in screw-cutting and slide-lathes.

105. Screw stamping-press. Rectilinear motion from circular motion.

106 and 107. Uniform reciprocating rectilinear motion, produced by rotary motion of grooved cams.

108. Uniform reciprocating rectilinear motion from uniform rotary motion of a cylinder, in which are cut reverse threads or grooves, which necessarily intersect twice in every revolution. A point inserted in the groove will traverse the cylinder from end to end.

109. The rotation of the screw at the left-hand side produces a uniform rectilinear movement of a cutter which cuts another screw thread. The pitch of the screw to be cut may be varied by changing the sizes of the wheels at the end of the frame.

110. Uniform circular into uniform rectilinear motion; used in spooling-frames for leading or guiding the thread on to the spools. The roller is divided into two parts, each having a fine screw thread cut upon it, one a right and the other a left hand screw. The spindle parallel with the roller has arms which carry two half-nuts, fitted to the screws, one over and the other under the roller. When one half-nut is in, the other is out of gear. By pressing the lever to the right or left, the rod is made to traverse in either direction.

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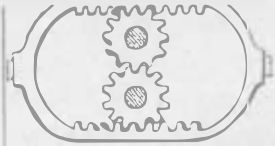

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111. Micrometer screw. Great power can be obtained by this device. The threads are made of different pitch and run in different directions, consequently a die or nut fitted to the inner and smaller screw would traverse only the length of the difference between the pitches for every revolution of the outside hollow screw in a nut.

112. Persian drill. The stock of the drill has a very quick thread cut upon it and revolves freely, supported by the head at the top, which rests against the body. The button or nut shown on the middle of the screw is held firm in the hand, and pulled quickly up and down the stock, thus causing it to revolve to the right and left alternately.

113. Circular into rectilinear motion, or *vice versa*, by means of rack and pinion.

114. Uniform circular motion into reciprocating rectilinear motion, by means of mutilated pinion, which drives alternately the top and bottom rack.

115. Rotary motion of the toothed wheels produces rectilinear motion of the double rack and gives equal force and velocity to each side, both wheels being of equal size.

116. A substitute for the crank. Reciprocating rectilinear motion of the frame carrying the double rack produces a uniform rotary motion of the pinion-shaft. A separate pinion is used for each rack, the two racks being in different planes. Both pinions are loose on the shaft. A ratchet-wheel is fast on the shaft outside of each pinion, and a pawl attached to the pinion to engage in it, one ratchet-wheel having its teeth set in one direction and the other having its teeth set in the opposite direction. When the racks move one way, one pinion turns the shaft by means of its pawl and ratchet; and when the racks move the opposite way, the other pinion acts in the same way, one pinion always turning loosely on the shaft.

117. A cam acting between two friction-rollers in a yoke. Has been used to give the movement to the valve of a steam engine.

118. A mode of doubling the length of stroke of a piston-rod, or the throw of a crank. A pinion revolving on a spindle attached to the connecting-rod or pitman is in gear with a fixed rack. Another rack carried by a guide-rod above, and in gear with the opposite side of the pinion, is free to traverse backward and forward. Now, as the connecting-rod communicates to the pinion a the full length of stroke, it would cause the top rack to traverse the same distance, if the bottom rack was alike movable; but as the latter is fixed, the pinion is made to rotate, and consequently the top rack travels double the distance.

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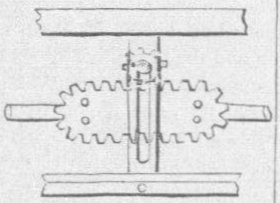

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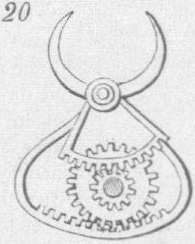

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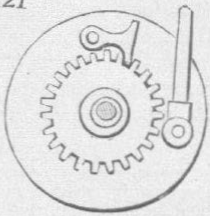

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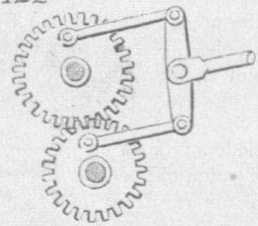

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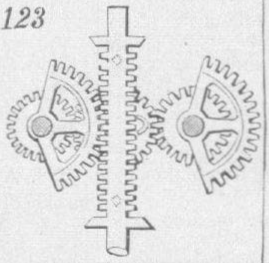

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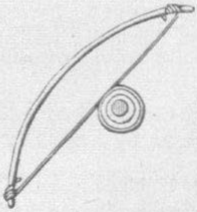

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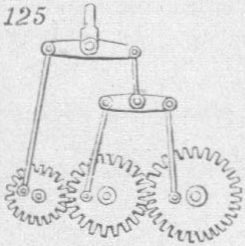

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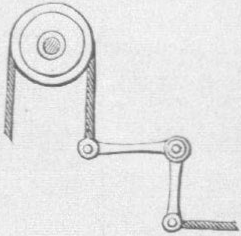

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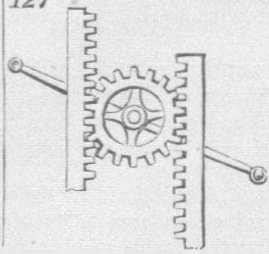

119. Reciprocating rectilinear motion of the bar carrying the oblong endless rack, produced by the uniform rotary motion of the pinion working alternately above and below the rack. The shaft of the pinion moves up and down in, and is guided by, the slotted bar.

120. Each jaw is attached to one of the two segments, one of which has teeth outside and the other teeth inside. On turning the shaft carrying the two pinions, one of which gears with one and the other with the other segment, the jaws are brought together with great force.

121. Alternating rectilinear motion of the rod attached to the disk-wheel produces an intermittent rotary motion of the cog-wheel by means of the click attached to the disk-wheel. This motion, which is reversible by throwing over the click, is used for the feed of planing machines and other tools.

122. The rotation of the two spur-gears, with crank-wrists attached, produces a variable alternating traverse of the horizontal bar.

123. Intended as a substitute for the crank. Reciprocating rectilinear motion of the double rack gives a continuous rotary motion to the center gear. The teeth on the rack act upon those of the two semicircular toothed sectors, and the spur-gears attached to the sectors operate upon the center gear. The two stops on the rack shown by dotted lines are caught by the curved piece on the center gear, and lead the toothed sectors alternately into gear with the double rack.

124. Fiddle drill. Reciprocating rectilinear motion of the bow, the string of which passes around the pulley on the spindle carrying the drill, producing alternating rotary motion of the drill.

125. A modification of the motion shown in 122, but of a more complex character.

126. A bell-crank lever, used for changing the direction of any force.

127. Motion used in air-pumps. On vibrating the lever fixed on the same shaft with the spur-gear, reciprocating rectilinear motion is imparted to the racks on each side, which are attached to the pistons of two pumps, one rack always ascending while the other is descending.

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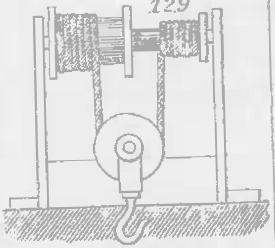

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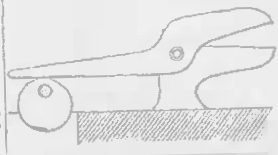

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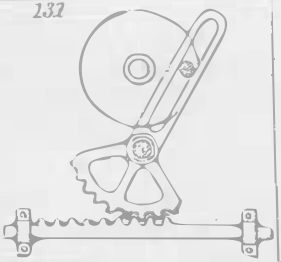

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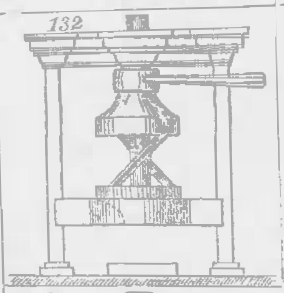

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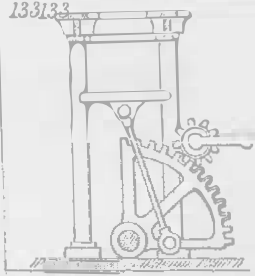

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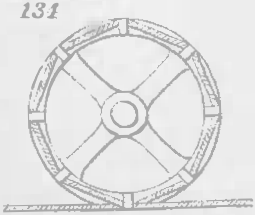

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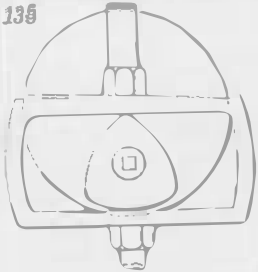

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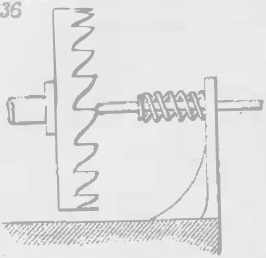


128. A continuous rotary motion of the shaft carrying the three wipers produces a reciprocating rectilinear motion of the rectangular frame. The shaft must revolve in the direction of the arrow for the parts to be in the position represented.

129. Chinese windlass. This embraces the same principles as the micrometer screw 111. The movement of the pulley in every revolution of the windlass is equal to half the difference between the larger and smaller circumferences of the windlass barrel.

130. Shears for cutting iron plates, etc. The jaws are opened by the weight of the long arm of the upper one, and closed by the rotation of the cam.

131. On rotating the disk carrying the crank-pin working in the slotted arm, reciprocating rectilinear motion is imparted to the rack at the bottom by the vibration of the toothed sector.

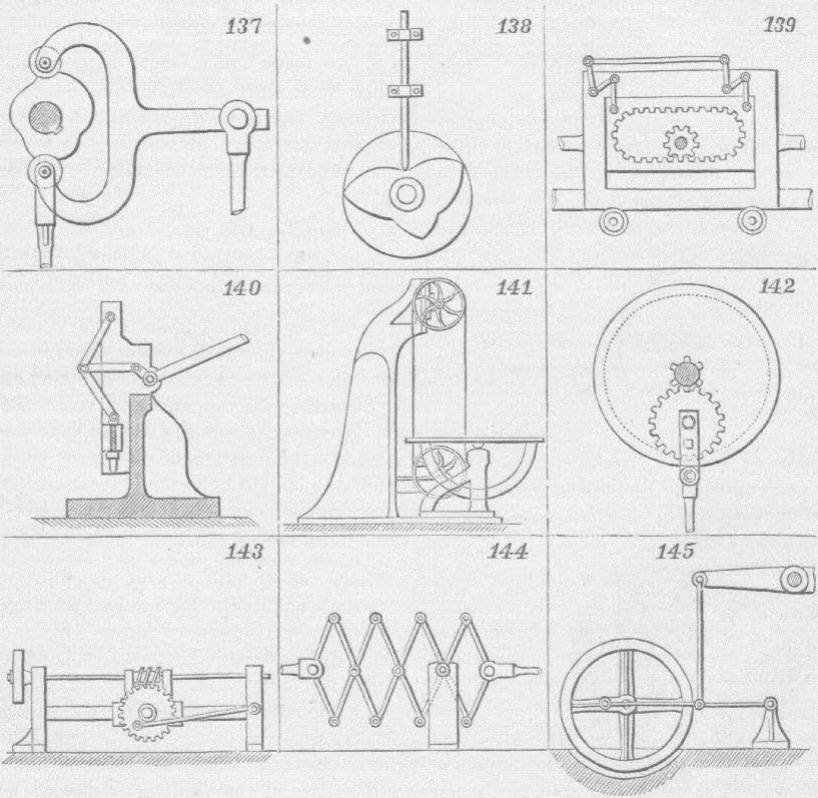
132. This is a motion which has been used in presses to produce the necessary pressure upon the platen. Horizontal motion is given to the arm of the lever which turns the upper disk. Between the top and bottom disks are two bars which enter holes in the disks. These bars are in oblique positions, as shown in the drawing, when the press is not in operation; but when the top disk is made to rotate, the bars move toward perpendicular positions and force the lower disk down. The top disk must be firmly secured in a stationary position, except as to its revolution.

133. A simple press motion is given through the hand-crank on the pinion-shaft; the pinion communicating motion to the toothed sector, which acts upon the platen, by means of the rod which connects it therewith.

134. Uniform circular motion into rectilinear by means of a rope or band, which is wound once or more times around the drum.

135. Modification of the triangular eccentric 91, used on the steam engine in the Paris Mint. The circular disk behind carries the triangular tappet, which communicates an alternate rectilinear motion to the valve-rod. The valve is at rest at the completion of each stroke for an instant, and is pushed quickly across the steam-ports to the end of the next.

136. A cam-wheel — of which a side view is shown — has its rim formed into teeth, or made of any profile form desired. The rod to the right is made to press constantly against the teeth or edge of the rim. On turning the wheel, alternate rectilinear motion is communicated to the rod. The character of this motion may be varied by altering the shape of the teeth or profile of the edge of the rim of the wheel.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137. Expansion eccentric used in France to work the slide-valve of a steam engine. The eccentric is fixed on the crank-shaft, and communicates motion to the forked vibrating arm to the bottom of which the valve-rod is attached.

138. On turning the cam at the bottom a variable alternating rectilinear motion is imparted to the rod resting on it.

139. The internal rack, carried by the rectangular frame, is free to slide up and down within it for a certain distance, so that the pinion can gear with either side of the rack. Continuous circular motion of the pinion is made to produce reciprocating rectilinear motion of rectangular frame.

140. The toggle-joint arranged for a punching machine. Lever at the right is made to operate upon the joint of the toggle by means of the horizontal connecting-link.

141. Endless-band saw. Continuous rotary motion of the pulleys is made to produce continuous rectilinear motion of the straight parts of the saw.

142. Movement used for varying the length of the traversing guide-bar which, in silk machinery, guides the silk on to spools or bobbins. The spur-gear, turning freely on its center, is carried round by the larger circular disk, which turns on a fixed central stud, which has a pinion fast on its end. Upon the spur-gear is bolted a small crank, to which is jointed a connecting-rod attached to traversing guide-bar. On turning the disk, the spur-gear is made to rotate partly upon its center by means of the fixed pinion, and consequently brings crank nearer to center of disk. If the rotation of disk was continued, the spur-gear would make an entire revolution. During half a revolution the traverse would have been shortened a certain amount at every revolution of disk, according to the size of spur-gear; and during the other half it would have gradually lengthened in the same ratio.

143. Circular motion into alternate rectilinear motion. Motion is transmitted through pulley at the left upon the worm-shaft. Worm slides upon shaft, but is made to turn with it by means of a groove cut in shaft, and a key in hub of worm. Worm is carried by a small traversing-frame, which slides upon a horizontal bar of the fixed frame, and the traversing-frame also carries the toothed wheel into which the worm gears. One end of a connecting-rod is attached to fixed frame at the right and the other end to a wrist secured in toothed wheel. On turning worm-shaft, rotary motion is transmitted by worm to wheel, which, as it revolves, is forced by connecting-rod to make an alternating traverse motion.

144. A system of crossed levers, termed "Lazy Tongs." A short alternating rectilinear motion of rod at the right will give a similar but much greater motion to rod at the left. It is frequently used in children's toys. It has been applied in France to a machine for raising sunken vessels; also applied to ships' pumps, three-quarters of a century ago.

145. Reciprocating curvilinear motion of the beam gives a continuous rotary motion to the crank and fly-wheel. The small standard at the left, to which is attached one end of the lever with which the beam is connected by the connecting-rod, has a horizontal reciprocating rectilinear movement.

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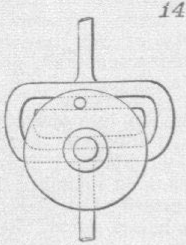

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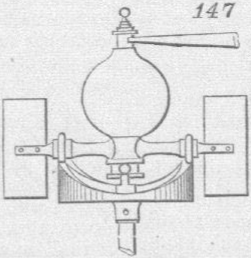

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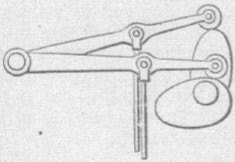

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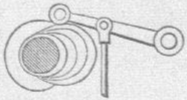

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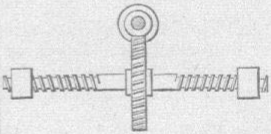

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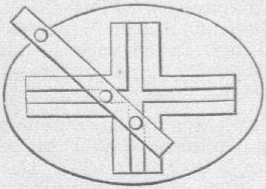

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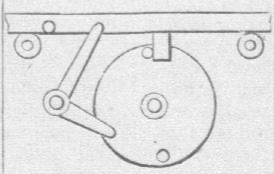

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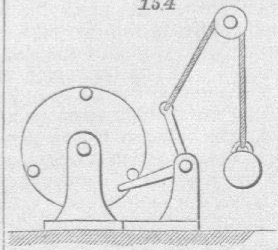


146. Continuous rotary motion of the disk produces reciprocating rectilinear motion of the yoke-bar, by means of the wrist or crank-pin on the disk working in the groove of the yoke. The groove may be so shaped as to obtain a uniform reciprocating rectilinear motion.

147. Steam engine governor. The operation is as follows:— On engine starting the spindle revolves and carries round the cross-head to which fans are attached, and on which are also fitted two friction-rollers which bear on two circular inclined planes attached securely to the center shaft, the cross-head being loose on the shaft. The cross-head is made heavy, or has a ball or other weight attached, and is driven by the circular inclined planes. As the speed of the center shaft increases, the resistance of the air to the wings tends to retard the rotation of the cross-head; the friction-rollers therefore run up the inclined planes and raise the cross-head, to the upper part of which is connected a lever operating upon the regulating-valve of the engine.

148. Continuous circular motion of the spur-gears produces alternate circular motion of the crank attached to the larger gear.

149. Uniform circular converted, by the cams acting upon the levers, into alternating rectilinear motions of the attached rods.

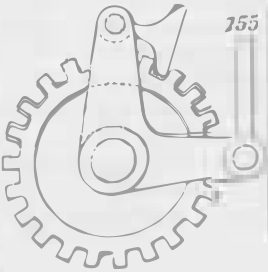
150. A valve motion for working steam expansively. The series of cams of varying throw are movable lengthwise of the shaft so that either may be made to act upon the lever to which the valve-rod is connected. A greater or less movement of the valve is produced, according as a cam of greater or less throw is opposite the lever.

151. Continuous circular into continuous but much slower rectilinear motion. The worm on the upper shaft, acting on the toothed wheel on the screw-shaft, causes the right and left hand screw-threads to move the nuts upon them toward or from each other according to the direction of rotation.

152. An ellipsograph. The traverse bar (shown in an oblique position) carries two studs which slide in the grooves of the cross-piece. By turning the traverse bar an attached pencil is made to describe an ellipse by the rectilinear movement of the studs in the grooves.

153. Circular motion into alternating rectilinear motion. The studs on the rotating disk strike the projection on the under side of the horizontal bar, moving it one direction. The return motion is given by means of the bell-crank or elbow-lever, one arm of which is operated upon by the next stud, and the other strikes the stud on the front of the horizontal bar.

154. Circular motion into alternating rectilinear motion, by the action of the studs on the rotary disk upon one end of the bell-crank, the other end of which has attached to it a weighted cord passing over a pulley.



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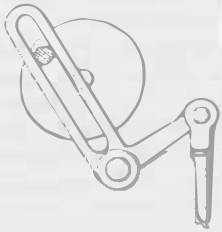

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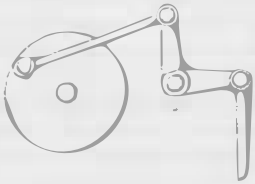

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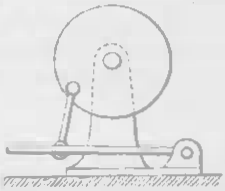

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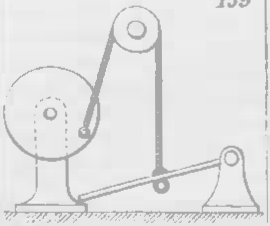

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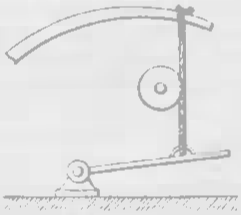

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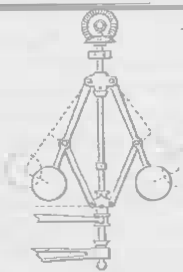

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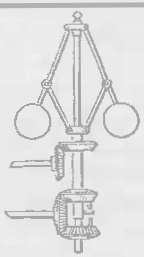

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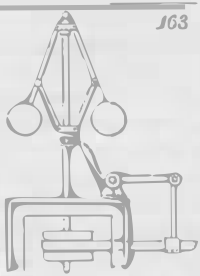


163

155. Reciprocating rectilinear motion into intermittent circular motion by means of the pawl attached to the elbow-lever, and operating in the toothed wheel. Motion is given to the wheel in either direction according to the side on which the pawl works. This is used in giving the feed-motion to planing machines and other tools.

156. Circular motion into variable alternating rectilinear motion, by the wrist or crank-pin on the rotating disk working in the slot of the bell-crank or elbow-lever.

157. A modification of the movement last described; a connecting-rod being substituted for the slot in the bell-crank.

158. Reciprocating curvilinear motion of the treadle gives a circular motion to the disk. A crank may be substituted for the disk.

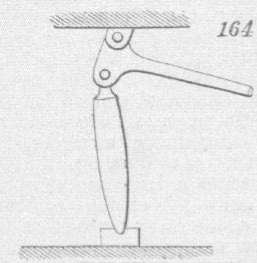
159. A modification of 158, a cord and pulley being substituted for the connecting rod.

160. Alternating curvilinear motion into alternating circular. When the treadle has been depressed, the spring at the top elevates it for the next stroke; the connecting band passes once round the pulley, to which it gives motion.

161. Centrifugal governor for steam engines. The central spindle and attached arms and balls are driven from the engine by the bevel-gears at the top, and the balls fly out from the center by centrifugal force. If the speed of the engine increases, the balls fly out further from the center, and so raise the slideaat the bottom and thereby reduce the opening of the regulating-valve which is connected with said slide. A diminution of speed produces an opposite effect.

162. Water-wheel governor acting on the same principle as 161, but by different means. The governor is driven by the top horizontal shaft and bevel-gears, and the lower gears control the rise and fall of the shuttle or gate over or through which the water flows to the wheel. The action is as follows:—The two bevelgears on the lower part of the center spindle, which are furnished with studs, are fitted loosely to the said spindle and remain at rest so long as the governor has a proper velocity; but immediately that the velocity increases, the balls, flying further out, draw up the pin which is attached to a loose sleeve which slides up and down the spindle, and this pin, coming in contact with the stud on the upper bevel gear, causes that gear to rotate with the spindle and to give motion to the lower horizontal shaft in such a direction as to make it raise the shuttle or gate, and so reduce the quantity of water passing to the wheel. On the contrary, if the speed of the governor decreases below that required, the pin falls and gives motion to the lower bevel-gear, which drives the horizontal shaft in the opposite direction and produces a contrary effect.

163. Another arrangement for a water-wheel governor. In this the governor controls the shuttle or gate by means of the cranked lever, which acts on the strap or belt in the following manner:—The belt runs on one of three pulleys, the middle one of which is loose on the governor spindle and the upper and lower ones fast. When the governor is running at the proper speed the belt is on the loose pulley, as shown; but when the speed increases the belt is thrown on the lower pulley, and thereby caused to act upon suitable gearing for raising the gate or shuttle and decreasing the supply of water. A reduction of the speed of the governor brings the belt on the upper pulley, which acts upon gearing for producing an opposite effect on the shuttle or gate.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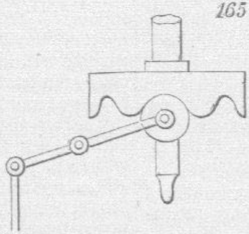
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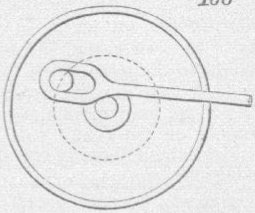
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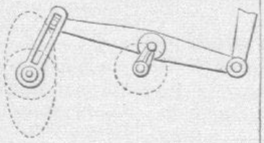
167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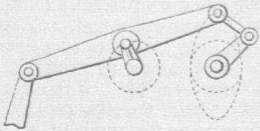
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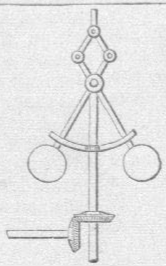
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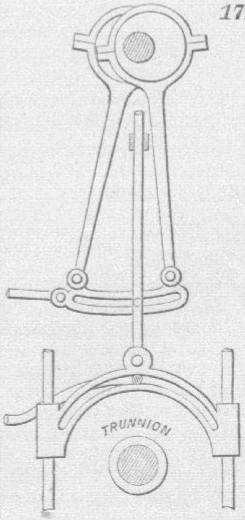


171

164. A knee-lever, differing slightly from the toggle-joint shown in 40. It is often used for presses and stamps, as a great force can be obtained by it. The action is by raising or lowering the horizontal lever.

165. Circular into rectilinear motion. The waved-wheel or cam on the upright shaft communicates a rectilinear motion to the upright bar through the oscillating rod.

166. The rotation of the disk carrying the crank pin gives a to-and-fro motion to the connecting rod, and the slot allows the rod to remain at rest at the termination of each stroke; it has been used in a brick-press, in which the connecting-rod draws a mold backward and forward, and permits it to rest at the termination of each stroke, that the clay may be deposited in it and the brick extracted.

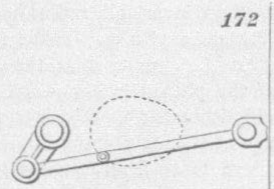
167. A drum or cylinder having an endless spiral groove extending all around it; one half of the groove having its pitch in one, and the other half its pitch in the opposite direction. A stud on a reciprocating rectilinearly moving rod works in the groove, and so converts reciprocating into rotary motion. This has been used as a substitute for the crank in a steam engine.

168. The slotted crank at the left hand of the figure is on the main shaft of an engine, and the pitman which connects it with the reciprocating moving power is furnished with a pin which works in the slot of the crank. Intermediate between the first crank and the moving power is a shaft carrying a second crank, of an invariable radius, connected with the same pitman. While the first crank moves in a circular orbit, the pin at the end of the pitman is compelled to move in an elliptical orbit, thereby increasing the leverage of the main crank at those points which are most favorable for the transmission of power.

169. A modification of 168, in which a link is used to connect the pitman with the main crank, thereby dispensing with the slot in the said crank.

170. Another form of steam engine governor. Instead of the arms being connected with a slide working on a spindle, they cross each other and are elongated upward beyond the top thereof and connected with the valve-rod by two short links.

171. Valve motion and reversing gear used in oscillating marine engines. The two eccentric rods give an oscillating motion to the slotted link which works the curved slide over the trunnion. Within the slot in the curved slide is a pin attached to the arm of a rockshaft which gives motion to the valve. The curve of the slot in the slide is an arc of a circle described from the center of the trunnion, and as it moves with the cylinder it does not interfere with the stroke of the valve. The two eccentrics and link are like those of the link motion used in locomotives.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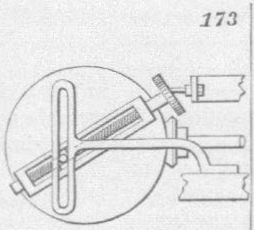
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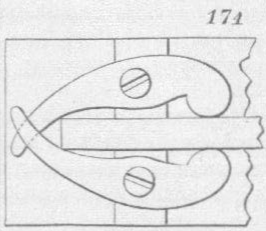
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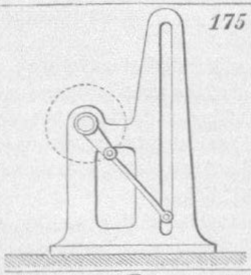
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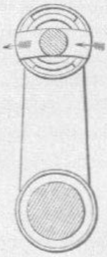
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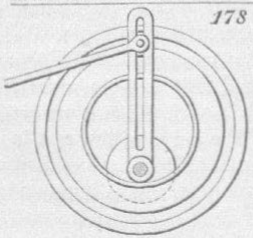
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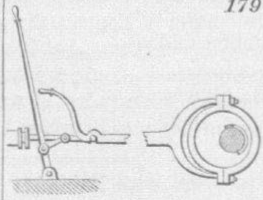
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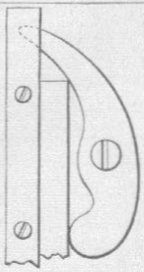

180

172. A mode of obtaining an egg-shaped elliptical movement.

173. A movement used in silk machinery for the same purpose as that described in 142. On the back of a disk or bevel-gear is secured a screw with a tappet-wheel at one extremity. On each revolution of the disk the tappet-wheel comes in contact with a pin or tappet, and thus receives an intermittent rotary movement. A wrist secured to a nut on the screw enters and works in a slotted bar at the end of the rod which guides the silk on the bobbins. Each revolution of the disk varies the length of stroke of the guide-rod, as the tappet-wheel on the end of the screw turns the screw with it, and the position of the nut on the screw is therefore changed.

174. Carpenters' bench-clamp. By pushing the clamp between the jaws they are made to turn on the screws and clamp the sides.

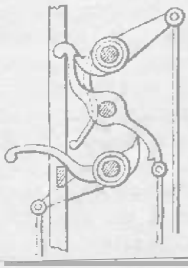
175. A means of giving one complete revolution to the crank of an engine to each stroke of the piston.

176 and 177. Contrivance for uncoupling engines. The wrist which is fixed on one arm of the crank (not shown) will communicate motion to the arm of the crank which is represented, when the ring on the latter has its slot in the position shown in 176. But when the ring is turned to bring the slot in the position shown in 177, the wrist passes through the slot without turning the crank to which said ring is attached.

178. Contrivance for varying the speed of the slide carrying the cutting tool in slotting and shaping machines, etc. The driving-shaft works through an opening in a fixed disk, in which is a circular slot. At the end of the said shaft is a slotted crank. A slide fits in the slot of the crank and in the circular slot; and to the outward extremity of this slide is attached the connecting-rod which works the slide carrying the cutting tool. When the driving-shaft rotates the crank is carried round, and the slide carrying the end of the connecting-rod is guided by the circular slot, which is placed eccentrically to the shaft; therefore, as the slide approaches the bottom, the length of the crank is shortened and the speed of the connecting-rod is diminished.

179. Reversing-gear for a single engine. On raising the eccentric-rod the valve-spindle is released. The engine can then be reversed by working the upright lever, after which the eccentric-rod is let down again. The eccentric in this case is loose upon the shaft and driven by a projection on the shaft acting upon a nearly semi-circular projection on the side of the eccentric, which permits the eccentric to turn half-way round on the shaft on reversing the valves.

180. This only differs from 174 in being composed of a single pivoted clamp operating in connection with a fixed side-piece.



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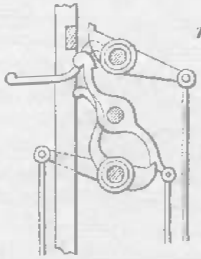

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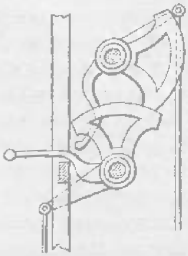

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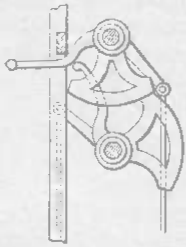

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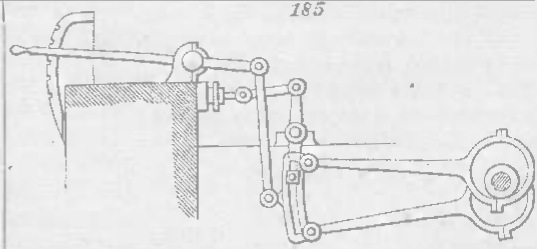

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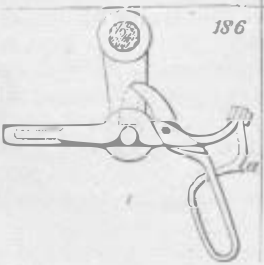

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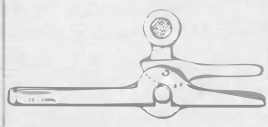

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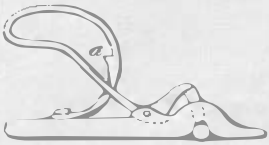


188

181 and 182. Diagonal catch or hand-gear used in large blowing and pumping engines. In 181 the lower steam-valve and upper eduction-valve are open, while the upper steam-valve and lower eduction-valve are shut; consequently the piston will be ascending. In the ascent of the piston-rod the lower handle will be struck by the projecting tappet, and, being raised, will become engaged by the catch and shut the upper eduction and lower steam valves; at the same time, the upper handle being disengaged from the catch, the back weight will pull the handle up and open the upper steam and lower eduction valves, when the piston will consequently descend. 182 represents the position of the catchers and handles when the piston is at the top of the cylinder. In going down, the tappet of the piston-rod strikes the upper handle and throws the catches and handles to the position shown in 181.

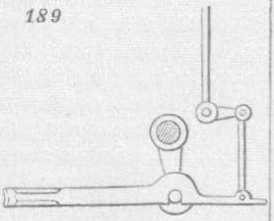
183 and 184 represent a modification of 181 and 182, the diagonal catches being superseded by two quadrants.

185. Link-motion valve-gear of a locomotive. Two eccentrics are used for one valve, one for the forward and the other for the backward movement of the engine. The extremities of the eccentric-rods are jointed to a curved slotted bar, or, as it is termed, a *link*, which can be raised or lowered by an arrangement of levers terminating in a handle as shown. In the slot of the link is a slide and pin connected with an arrangement of levers terminating at the valve-stem. The link, in moving with the action of the eccentrics, carries with it the slide, and thence motion is communicated to the valve. Suppose the link raised so that the slide is in the middle, then the link will oscillate on the pin of the slide, and consequently the valve will be at rest. If the link is moved so that the slide is at one of its extremities, the whole throw of the eccentric connected with that extremity will be given to it, and the valve and steam-ports will be opened to the full, and it will only be toward the end of the stroke that they will be totally shut, consequently the steam will have been admitted to the cylinder during almost the entire length of each stroke. But if the slide is between the middle and the extremity of the slot, as shown in the figure, it receives only a part of the throw of the eccentric, and the steam-ports will only be partially opened, and are quickly closed again, so that the admission of steam ceases some time before the termination of the stroke, and the steam is worked expansively. The nearer the slide is to the middle of the slot the greater will be the expansion, and *vice versa*.

186. Apparatus for disengaging the eccentric-rod from the valve-gear. By pulling up the spring handle below until it catches in the notch, *a*, the pin is disengaged from the gab in the eccentric-rod.

187 and 188. Modifications of 186.

189



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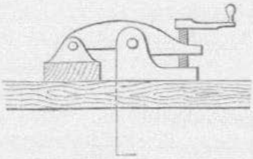

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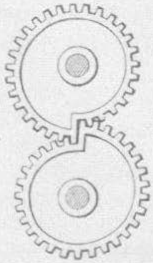

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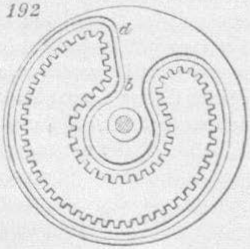

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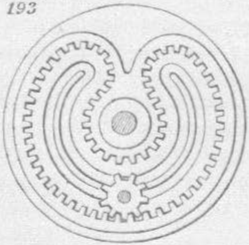

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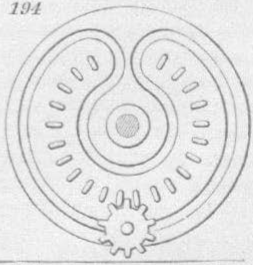

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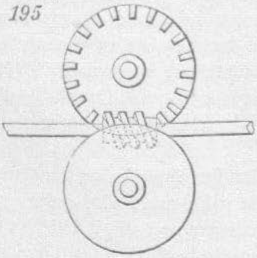

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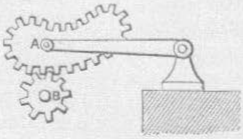

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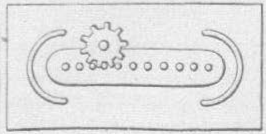


189. Another modification of 186.

190. A screw-clamp. On turning the handle the screw thrusts upward against the holder, which, operating as a lever, holds down the piece of wood or other material placed under it on the other side of its fulcrum.

191. Scroll-gears for obtaining a gradually increasing speed.

192. A variety of what is known as the "mangle-wheel." One variety of this was illustrated by 36. In this one the speed varies in every part of a revolution, the groove, *b*, *d*, in which the pinion-shaft is guided, as well as the series of teeth, being eccentric to the axis of the wheel.

193. Another kind of mangle-wheel with its pinion. With this as well as with that in the preceding figure, although the pinion continues to revolve in one direction, the mangle-wheel will make almost an entire revolution in one direction and the same in an opposite direction; but the revolution of the wheel in one direction will be slower than that in the other, owing to the greater radius of the outer circle of teeth.

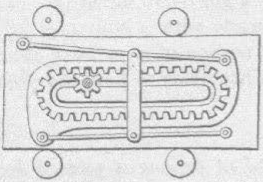
194. Another mangle-wheel. In this the speed is equal in both directions of motion, only one circle of teeth being provided on the wheel. With all of these mangle-wheels the pinion-shaft is guided and the pinion kept in gear by a groove in the wheel. The said shaft is made with a universal joint, which allows a portion of it to have the vibratory motion necessary to keep the pinion in gear.

195. A mode of driving a pair of feed-rolls, the opposite surfaces of which require to move in the same direction. The two wheels are precisely similar, and both gear into the endless screw which is arranged between them. The teeth of one wheel only are visible, those of the other being on the back or side which is concealed from view.

196. The pinion, B, rotates about a fixed axis and gives an irregular vibratory motion to the arm carrying the wheel, A.

197. What is called a "mangle-rack." A continuous rotation of the pinion will give a reciprocating motion to the square frame. The pinion-shaft must be free to rise and fall, to pass round the guides at the ends of the rack. This motion may be modified as follows:—If the square frame be fixed, and the pinion be fixed upon a shaft made with a universal joint, the end of the shaft will describe a line, similar to that shown in the drawing, around the rack.

198



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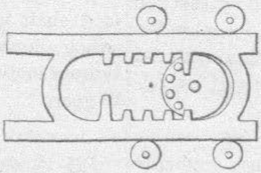

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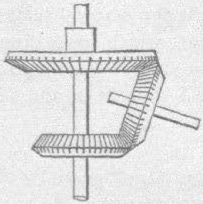

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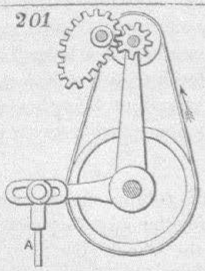

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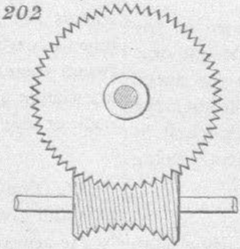

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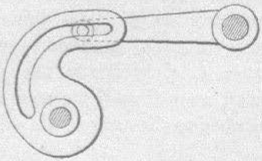

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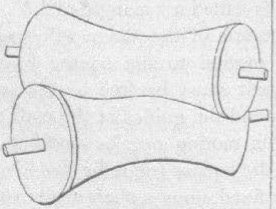

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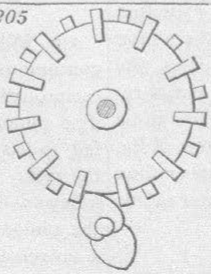

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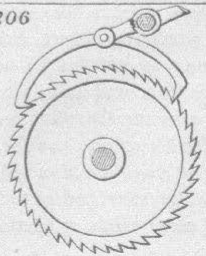

198. A modification of 197. In this the pinion revolves, but does not rise and falle as in the former figure. The portion of the frame carrying the rack is jointed to the main portion of the frame by rods, so that when the pinion arrives at the end it lifts the rack by its own movement, and followse on the other side.

199. Another form of mangle-rack. The lantern-pinion revolves continuously in one direction, and gives reciprocating motion to the square frame, which is guided by rollers or grooves. The pinion has only teeth in less than half of its circumference, so that while it engages one side of the rack, the toothless half is directed against the other. The large tooth at the commencement of each rack is made to insure the teeth of the pinion being properly in gear.

200. A mode of obtaining two different speeds on the same shaft from one driving-wheel.

201. A continual rotation of the pinion (obtained through the irregular shaped geare at the left) gives a variable vibrating movement to thee horizontal arm, and a variable reciprocating movement to the rod, A.

202. Worm or endless screw and worm-wheel. Modification of 30, used when steadiness or great power is required.

203. A regular vibrating movement of the curved slotted arm gives a variable vibration to the straight arm.

204. An illustration of the transmission of rotary motion from one shaft to another, arranged obliquely to it, by means of rolling contact.

205. Represents a wheel driven by a pinion of two teeth. The pinion consists in reality of two cams, which gear with two distinct series of teeth on opposite sides of the wheel, the teeth of one series alternating in position with those of the other.

206. A continuous circular movement of the ratchet-wheel, produced by the vibration of the lever carrying two pawls, one of which engages the ratchet-teeth in rising and the other in falling.