the tangential acceleration is $r\alpha = \frac{5}{12} \times 7 = 5.8$ ft. per sec. per sec., which is very small compared with 458 ft. per sec. per sec., so that on any ordinary drawing the point P'' would be very close to P. Thus without serious error $r\alpha$ may be neglected compared with $r\omega^2$ and thus we may take P''at P in the case of the steam engine.

With the foregoing modification for the steam engine, the complete acceleration diagram is shown at Fig. 142, the length PA representing $\frac{b'^2}{b}$, AQ'' being normal to b, thus $P''Q''$ is the acceleration diagram for the connecting rod and OQ'' resents the acceleration of the piston on the scale — ω^2 to 1. T cases are shown (a) for the ordinary construction and (b) for the off-set cylinder. The acceleration of any such point as G is found by finding G'', making the line GG'' parallel to QQ'', the accelerations then is $G''O \,.\, \omega^2$. Dealing only with the case shown in figure (a) it is seen that when the crank is vertical, b' is zero, and hence A is at P, or Q'' lies to the left of O, so that the piston is being retarded. The numerical value of the acceleration may be found in this case by remembering that $Q''Q$ may be taken as the diameter of a circle which will pass through P and hence $Q''O \,.OQ = OP^2$ or $OQ'' = \frac{OP^2}{OQ} = \frac{a^2}{\sqrt{b^2-a^2}}$ so that the acceleration of the piston is $OQ'' \,.\, \omega^2 = \frac{a^2}{\sqrt{b^2-a^2}}\omega^2$

At both the head and crank ends $b' = a$ hence $P''A = \frac{b'^2}{b} = \frac{a^2}{b}$, so that for the head end $Q''O = a + \frac{a^2}{b}$ and the piston has its maximum acceleration at this point, which is $\left(a + \frac{a^2}{b}\right)\omega^2$ toward O, while for the crank end $Q''O = a - \frac{a^2}{b}$ and the acceleration is $\left(a - \frac{a^2}{b}\right)\omega^2$ toward O, so that the piston is being retarded.

Example: Let an engine with 7 in. stroke and a connecting rod 18 in. long run at 525 revs. per min. Then $a = \frac{3\frac{1}{2}}{12} = .29$ ft., $b = \frac{18}{12} = 1.5$ ft. and $\omega = 55$ radians per sec.