

TOGGLE MECHANISMS

BY GEOMETER

Two exclusive characteristics result in wide employment of the toggle mechanism both in major machine assemblies and in minor mechanical details. They are its ability to apply high pressure, and its over-centre, self-locking action.

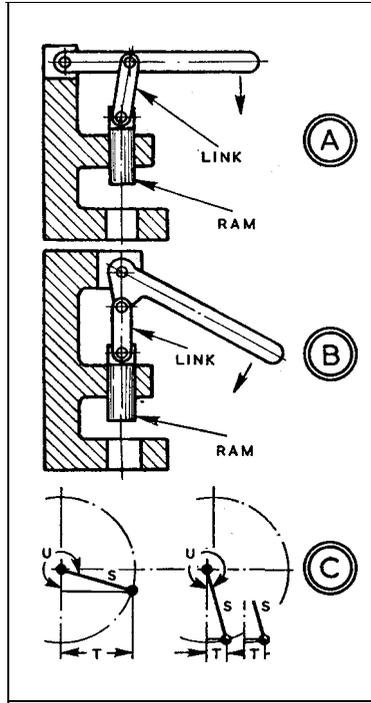
No other such simple mechanism possesses these characteristics. Hence its use for certain production presses and pre-selective gearboxes on cars; for time-saving tools like self-locking pliers and valve spring compressors; and for such things as clips on covers of vacuum cleaners, and stoppers on bottles of soft drinks.

The difference between a toggle mechanism and an ordinary link mechanism is that the former can, as required, approach close to the centre or pass over it. In so doing, a large multiplication of force is obtained—often equal to that of a screw—but more speedily, and with less friction and no torsion. The difference may be seen by reference to *A* and *B*, which show possible layouts of a simple hand-press.

With the arrangement at *A*, the multiplication of force is roughly in simple proportion as the total length of the lever divided by the length from the pivot to the point of attachment of the link. The multiplication is about three times, which means that 10 lb. on the lever gives 30 lb. on the ram.

With the arrangement at *B*, however, when the centres are approaching to a common line, multiplication increases rapidly. By approximation, at an angle of 19 deg., it is three times; at 9 deg. six times; at 4 deg. 14 times; at 1 deg. 57 times; and at 6 minutes 573 times. Even allowing for the length and angle of the link, such multiplications are inherent in the toggle mechanism, and are not (as for the other example) multiplication represented by the total length of the lever divided by the length from the pivot to the point of attachment of the link. This ratio would represent further multiplication.

Reference to a table of cosecants provides a clue to the inherent multiplication, shown diagrammatically at *C*. When lever *S*—to be forced downwards—is in the horizontal position, *T* is the same length, and angle *U* is 90 deg. Cosecant 90 deg. = 1, so



there is no multiplication, except by extending the end as a simple lever, as at *A*. Initially, as *S* descends, *C* (left), there is little difference between it and *T*, so little multiplication occurs. But near the limit of descent (right), *T* like angle *U* becomes very small, while *S* remains the same. Thus, inherent multiplication increases approximately as given, until at $U = 0$ deg. (cosecant 0 deg.), multiplication is at infinity and beyond the limits of practical mechanics. All in all, a toggle press is clearly most advantageously used near the end of its stroke.

Simple toggle clamps can be arranged as at *D* to pull, or as at *E* to push; and in each case so long as the links pass just over centre, they will lock so that force is needed to draw them back over centre for freeing. For a pull, links can be wire as for holding bottle stoppers; but for a push they must be stiff to resist buckling.

In the pre-selective gearbox employing toggle mechanisms common

troubles result from wrong adjustment. Each intermediate gear has an epicyclic train in a drum which is stopped by a band for operation, and the anchored band is closed by a toggle mechanism, as at *F*.

Having selected the gear, the gear-change pedal is used which allows a spring-loaded busbar *V* to force strut *W*, tilt toggle link *X* on the pull rod, squeeze the band and approach points *Y-Z* into line.

Swing over is stopped by an adjusting screw in the band. If points *Y-Z* are far out of line, the gear may slip with weak toggle action. This is corrected by setting the adjusting screw in, slackening the automatic adjuster on the pull rod, selecting the gear, and pumping the pedal. If the link goes over centre, however, the gear may stick. To correct it the adjusting screw is brought out, the gear selected, and the pedal pumped to take up on the pull rod. While actually adjusting a gear, another gear should always be selected. □

