CHAPTER 12

FASTENING, LATCHING, CLAMPING, AND CHUCKING DEVICES

REMOTELY CONTROLLED LATCH

This simple mechanism engages and disengages parallel plates carrying couplings and connectors.

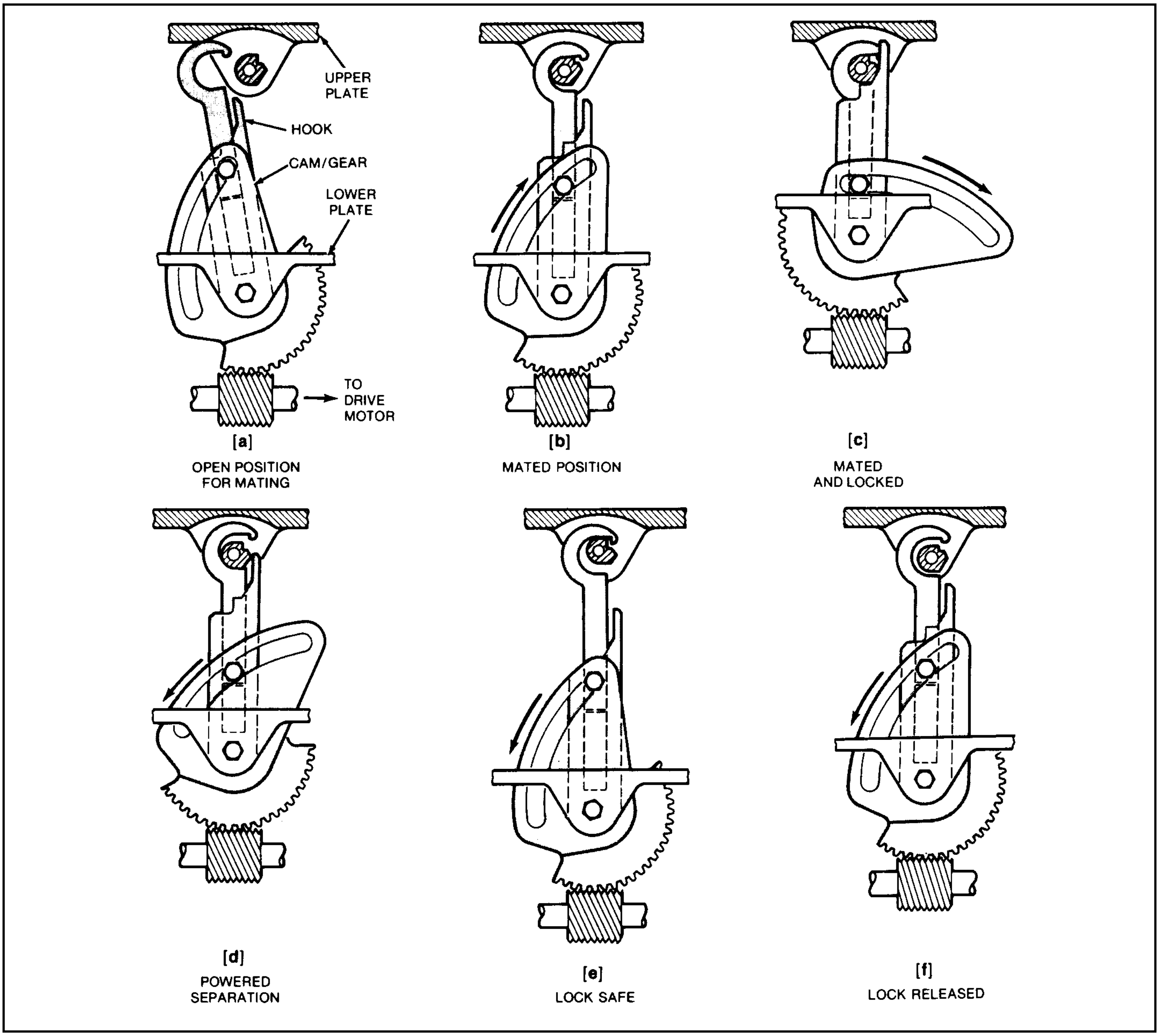


Fig. 1 The latch operation sequence is shown for locking in steps (a) through (c) and for unlocking in steps (d) through (f).

A new latch mates two parallel plates in one continuous motion (see Fig. 1). On the Space Shuttle, the latch connects (and disconnects) plates carrying 20 fluid couplings and electrical connectors. (The coupling/connector receptacles are one plate, and mating plugs are on the other plate). Designed to lock items in place for handling, storage, or processing under remote control, the mechanism also has a fail-safe feature: It does not allow the plates to separate completely unless both are supported. Thus, plates cannot fall apart and injure people or damage equipment.

The mechanism employs four cam/gear assemblies, one at each corner of the lower plate. The gears on each side of the plate face inward to balance the loading and help align the plates. Worm gears on the cam-gear assemblies are connected to a common drive motor.

Figure 1 illustrates the sequence of movements as a pair of plates is latched and unlatched. Initially, the hook is extended and tilted out. The two plates are brought together, and when they are 4.7 in. (11.9 cm) apart, the drive motor is started (a). The worm gear rotates the hook until it closes on a pin on the opposite plate (b). Further rotation of the worm gear shortens the hook extension and raises the lower plate (c). At that point, the couplings and connectors on the two plates are fully engaged and locked.

To disconnect the plates, the worm gear is turned in the opposite direction. This motion lowers the bottom plate and pulls the couplings apart (d). However, if the bottom plate is unsupported, the latch safety feature operates. The hook cannot clear the pin if the lower plate hangs freely (e). If the bottom plate is supported, the hook extension lifts the hook clear of the pin (f) so that the plates are completely separated.

This work was done by Clifford J. Barnett, Paul Castiglione, and Leo R. Coda of Rockwell International Corp. for **Johnson Space Center**.

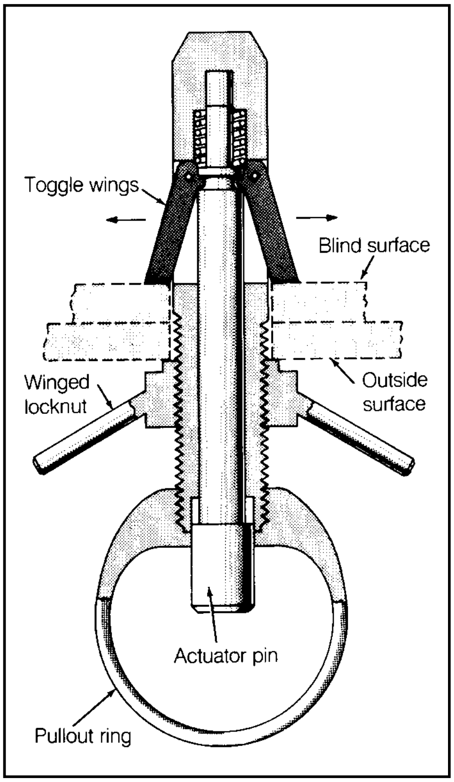
TOGGLE FASTENER INSERTS, LOCKS, AND RELEASES EASILY

A pin-type toggle fastener, invented by C.C. Kubokawa at NASA's Ames Research Center, can be used to fasten plates together, fasten things to walls or decks, or fasten units with surfaces of different curvatured, such as a concave shape to a convex surface.

With actuator pin. The cylindrical body of the fastener has a tapered end for easy entry into the hole; the head is threaded to receive a winged locknut and, if desired, a ring for pulling the fastener out again after release. Slots in the body hold two or more toggle wings that respond to an actuator pin. These wings are extended except when the spring-loaded pin is depressed.

For installation, the actuator pin is depressed, retracting the toggle wings. When the fastener is in place, the pin is released, and the unit is then tightened by screwing the locknut down firmly. This exerts a compressive force on the now-expanded toggle wings. For removal, the locknut is loosened and the pin is again depressed to retract the toggle wings. Meanwhile, the threaded outer end of the cylindrical body functions as a stud to which a suitable pull ring can be screwed to facilitate removal of the fastener.

This invention has been patented by NASA (U.S. Patent No. 3,534,650).



A fastener with controllable toggles can be inserted and locked from only one side.

GRAPPLE FREES LOADS AUTOMATICALLY

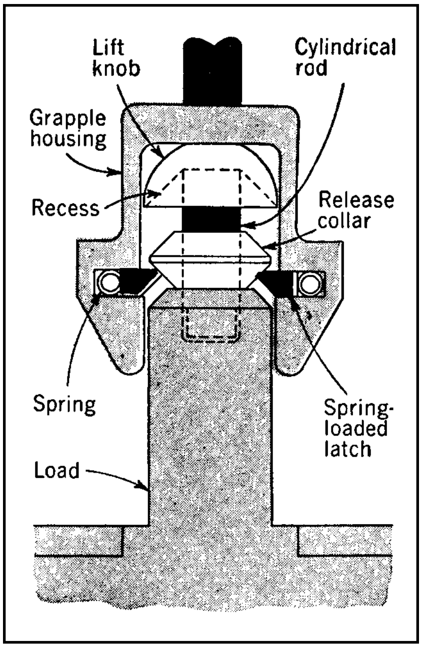
A simple grapple mechanism, designed at Argonne National Laboratory in Illinois, engages and releases loads from overhead cranes automatically. This self-releasing mechanism was developed to remove fuel rods from nuclear reactors. It can perform tasks where human intervention is hazardous or inefficient, such as lowering and releasing loads from helicopters.

The mechanism (see drawing) consists of two pieces: a lift knob secured to the load and a grapple member attached to the crane. The sliding latch-release collar under the lift knob is the design's key feature.

Spring magic. The grapple housing, which has a cylindrical inner surface, contains a machined groove fitted with a garter spring and three metal latches. When the grapple is lowered over the lift knob, these latches recede into the groove as their edges come into contact with the knob. After passing the knob, they spring forward again, locking the grapple to the knob. Now the load can be lifted.

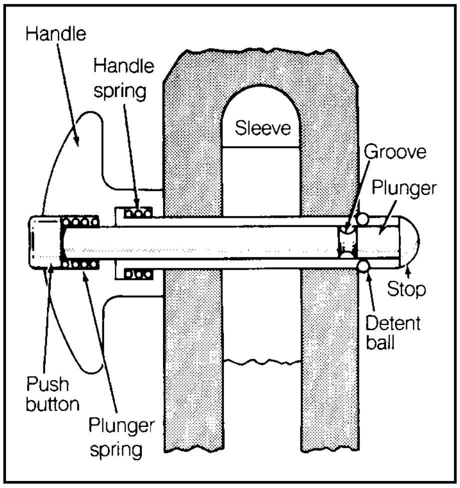
When the load is lowered to the ground again, gravity pull or pressure from above forces the grapple housing down until the latches come into contact with a double cone-shaped release collar. The latches move back into the groove as they pass over the upper cone's surface and move forward again when they slide over the lower cone.

The grapple is then lifted so that the release collar moves up the cylindrical rod until it is housed in a recess in the lift knob. Because the collar can move no farther, the latches are forced by the upward pull to recede again into the groove—allowing the grapple to be lifted free.



A sliding release collar is a key feature of this automatic grapple.

QUICK-RELEASE LOCK PIN HAS A BALL DETENT



A foolproof locking pin releases quickly when the stress on the joint is negligible.

A novel quick-release locking pin has been developed that can be withdrawn to separate the linked members only when stresses on the joint are negligible.

The pin may be the answer to the increasing demand for locking pins and fasteners that will pull out quickly and easily when desired, yet will stay securely in place without chance of unintentional release.

The key to this foolproof pin is a group of detent balls and a matching grooved. The ball must be in the groove whenever the pin is either installed or pulled out of the assembly. This is easy to do during installation, but during removal the load must be off the pin to get the balls to drop into the groove.

How it works. The locking pin was developed by T.E. Othman, E.P. Nelson, and L.J. Zmuda under contract to NASA's Marshall Space Flight Center. It consists of a forward-pointing sleeve with a spring-loaded sliding handle as its rear end, housing a sliding plunger that is pushed backward (to its locking position) by a spring within the handle.

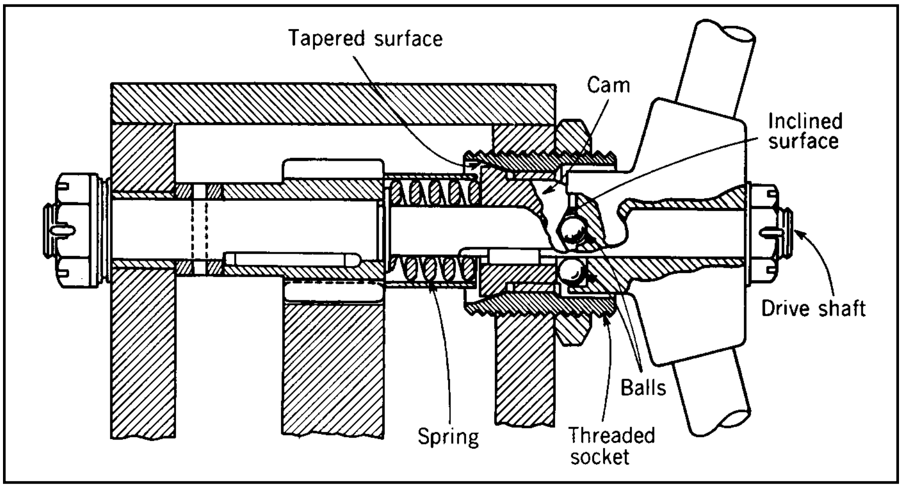
To some extend the plunger can slide forward against the plunger spring, and the handle can slide backward against the handle spring. A groove near the front end of the plunger accommodates the detent balls when the plunger is pushed forward by the compression of its spring. When the plunger is released backward, the balls are forced outward into holes in the sleeve, preventing withdrawal of the pin.

To install the pin, the plunger is pressed forward so that the balls fall into their groove and the pin is pushed into the hole. When the plunger is released, the balls lock the sleeve against accidental withdrawal.

To withdraw the pin, the plunger is pressed forward to accommodate the locking balls, and at the same time the handle is pulled backward. If the loading on the pin is negligible, the pin is withdrawn from the joint; if it is considerable, the handle spring is compressed and the plunger is forced backward by the handle so the balls will return to their locking position.

The allowable amount of stress on the joint that will permit its removal can be varied by adjusting the pressure required for compressing the handle spring. If the stresses on the joint are too great or the pin to be withdrawn in the normal manner, hammering on the forward end of the plunger simply ensures that the plunger remains in its rearward position, with the locking balls preventing the withdrawal of the pin. A stop on its forward end prevents the plunger from being driven backward.

AUTOMATIC BRAKE LOCKS HOIST WHEN DRIVING TORQUE CEASES



When torque is removed, the cam is forced into the tapered surface for brake action.

A brake mechanism attached to a chain hoist is helping engineers lift and align equipment accurately by automatically locking it in position when the driving torque is removed from the hoist.

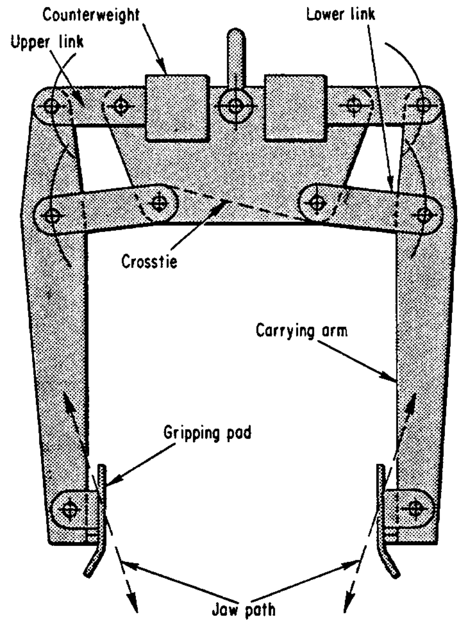
According to the designer, Joseph Pizzo, the brake could also be used on wheeled equipment operating on slopes, to act as an auxiliary brake system.

How it works. When torque is applied to the driveshaft (as shown in the figure), four steel balls try to move up the inclined surfaces of the cam. Although called a cam by the designer, it is really a concentric collar with a cam-like surface on one of its end faces. Because the balls are contained by four cups in the hub, the cam is forced to move forward axially to the left. Because the cam moves away from the tapered surface, the cam and the driveshaft that is keyed to it are now free to rotate.

If the torque is removed, a spring resting against the cam and the driveshaft gear forces the cam back into the tapered surface of the threaded socket for instant braking.

Although this brake mechanism (which can rotate in either direction) was designed for manual operation, the principle can be applied to powered systems.

LIFT-TONG MECHANISM FIRMLY GRIPS OBJECTS



Twin four-bar linkages are the key components in this long mechanism that can grip with a constant weight-to-grip force ratio any object that fits within its grip range. The long mechanism relies on a cross-tie between the two sets of linkages to produce equal and opposite linkage movement. The vertical links have extensions with grip pads mounted at their ends, while the horizontal links are so proportioned that their pads move in an inclined straight-line path. The weight of the load being lifted, therefore, wedges the pads against the load with a force that is proportional to the object's weight and independent of its size.

PERPENDICULAR-FORCE LATCH

The installation and removal of equipment modules are simplified.

A latching mechanism simultaneously applies force in two perpendicular directions to install or remove electronic-equipment modules. The mechanism (see Fig. 1) requires only the simple motion of a handle to push or pull an avionic module to insert or withdraw connectors on its rear face into or from spring-loaded mating connectors on a panel and to force the box downward onto or release the box from a mating cold plate that is part of the panel assembly. The concept is also adaptable to hydraulic, pneumatic, and mechanical systems. Mechanisms of this type can simplify the manual installation and removal of modular equipment where a technician's movement is restricted by protective clothing, as in hazardous environments, or where the installation and removal are to be performed by robots or remote manipulators.

Figure 2 sows an installation sequence. In step 1, the han-

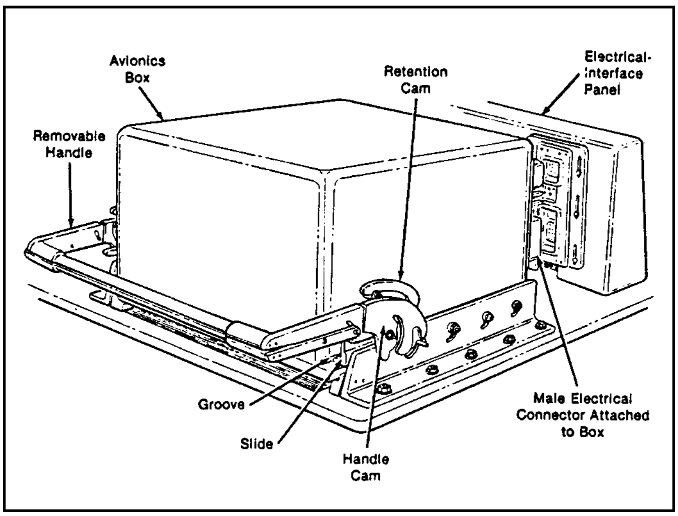


Fig. 1 An avionics box mates with electrical connectors in the rear and is locked in position on the cold plate when it is installed with the latching mechanism.

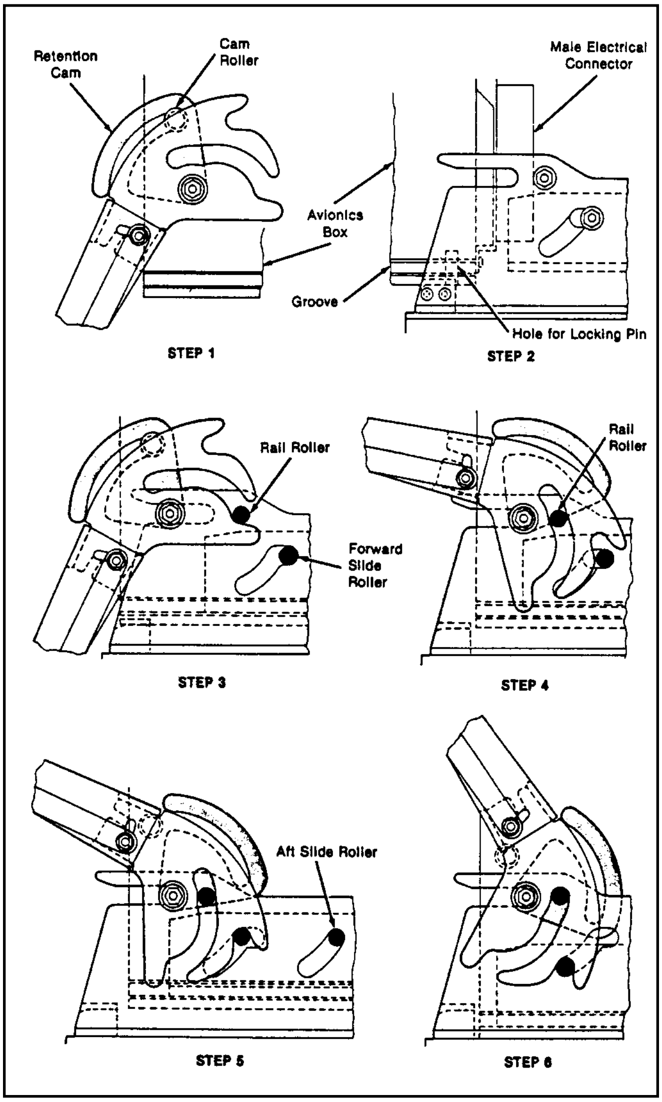


Fig. 2 This installation sequence shows the positions of the handle and retention cams as the box is moved rearward and downward.

dle has been installed on the handle cam and turned downward. In step 2, the technician or robot pushes the box rearward as slides attached to the rails enter grooves near the bottom of the box. In step 3, as the box continues to move to the rear, the handle cam automatically aligns with the slot in the rail and engages the rail roller.

In step 4, the handle is rotated upward 75º, forcing the box rearward to mate with the electrical connectors. In step 5, the handle is pushed upward an additional 15º, locking the handle cam and the slide. In step 6, the handle is rotated an additional 30º, forcing the box and the mating spring-loaded electrical connectors downward so that the box engages the locking pin and becomes clamped to the cold plate. The sequence for removal is identical except that the motions are reversed.

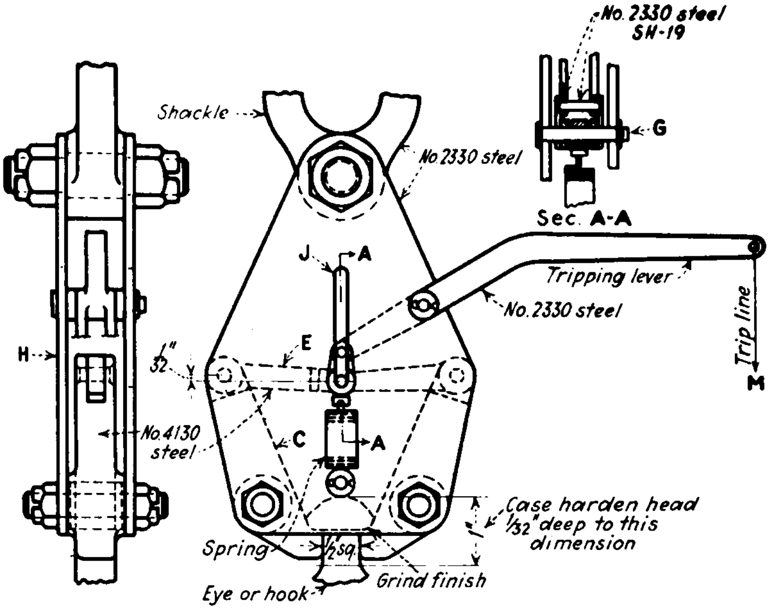
QUICK-RELEASE MECHANISMS

QUICK-RELEASE MECHANISM

Quick release mechanisms have many applications. Although the design shown here operates as a tripping device for a quick-release hook, the mechanical principles involved have many other applications. Fundamentally, it is a toggle-type mechanism with the characteristic that the greater the load the more effective the toggle.

The hook is suspended from the shackle, and the load or work is supported by the latch, which is machined to fit the fingers C. The fingers C are pivoted about a pin. Assembled to the fingers are the arms E, pinned at one end and joined at the other by the sliding pin G. Enclosing the entire unit are the side plates H, containing the slot J for guiding the pin G in a vertical movement when the hook is released. The helical spring returns the arms to the bottom position after they have been released.

To trip the hook, the tripping lever is pulled by the cable M until the arms E pass their horizontal center-line. The toggle effect is then broken, releasing the load.



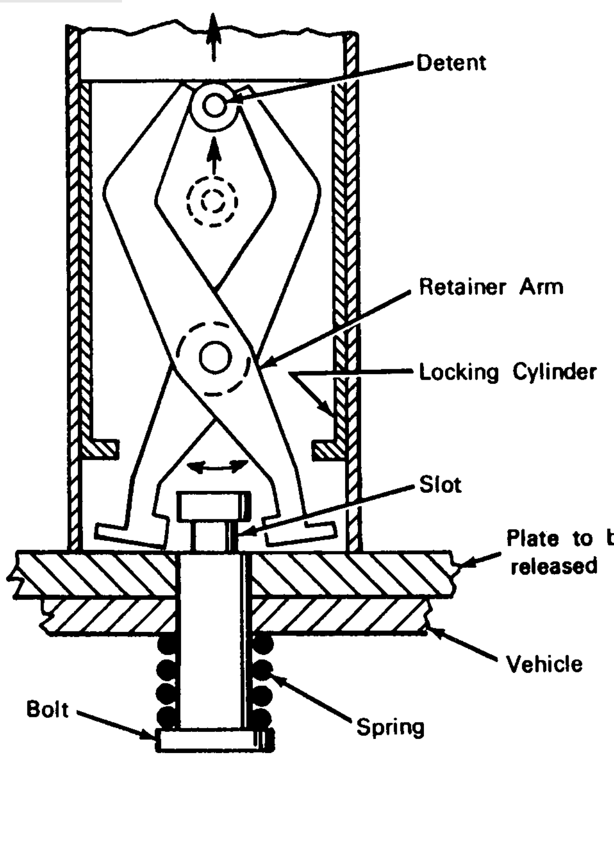
A simple quick-release toggle mechanism was designed for tripping a lifting hook.

POSITIVE LOCKING AND QUICK-RELEASE MECHANISM

The object here was to design a simple device that would hold two objects together securely and quickly release them on demand.

One object, such as a plate, is held to another object, such as a vehicle, by a spring-loaded slotted bolt, which is locked in position by two retainer arm. The retainer arms are constrained from movement by a locking cylinder. To release the plate, a detent is actuated to lift the locking cylinder and rotate the retainer arms free from contact with the slotted bolt head. As a result of this action, the spring-loaded bolt is ejected, and the plate is released from the vehicle.

The actuation of the slidable detent can be initiated by a squib, a fluid-pressure device, or a solenoid. The principle of this mechanism can be applied wherever a positive engagement that can be quickly released on demand is required. Some suggested applications for this mechanism are in coupling devices for load-carrying carts or trucks, hooks or pick-up attachments for cranes, and quick-release mechanisms for remotely controlled manipulators.



This quick-release mechanism is shown locking a vehicle and plate.

RING SPRINGS CLAMP PLATFORM ELEVATOR INTO POSITION

A simple yet effective technique keeps a platform elevator locked safely in position without an external clamping force. The platform (see drawing) contains special ring assemblies that grip the four column-shafts with a strong force by the simple physical interaction of two tapered rings.

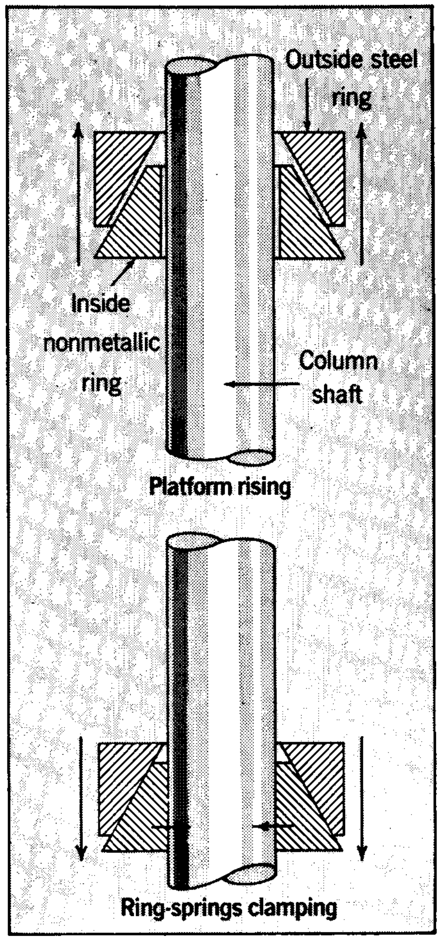
Thus, unlike conventional platform elevators, no outside power supply is required to hold the platform in position. Conventional jacking power is employed, however, in raising the platform from one position to another.

How the rings work. The ring assemblies are larger versions of the ring springs sometimes installed for shock absorption. In this version, the assembly is made up of an inner nonmetallic ring tapering upward and an outer steel ring tapered downward (see drawing).

The outside ring is linked to the platform, and the inside ring is positioned against the circumference of the column shaft. When the platform is raised to the designed height, the jack force is removed, and the full weight of the platform bears downward on the outside ring with a force that, through a wedging action, is transferred into a horizontal inward force of the inside ring.

Thus, the column shaft is gripped tightly by the inside ring; the heavier the platform the larger the gripping force produced.

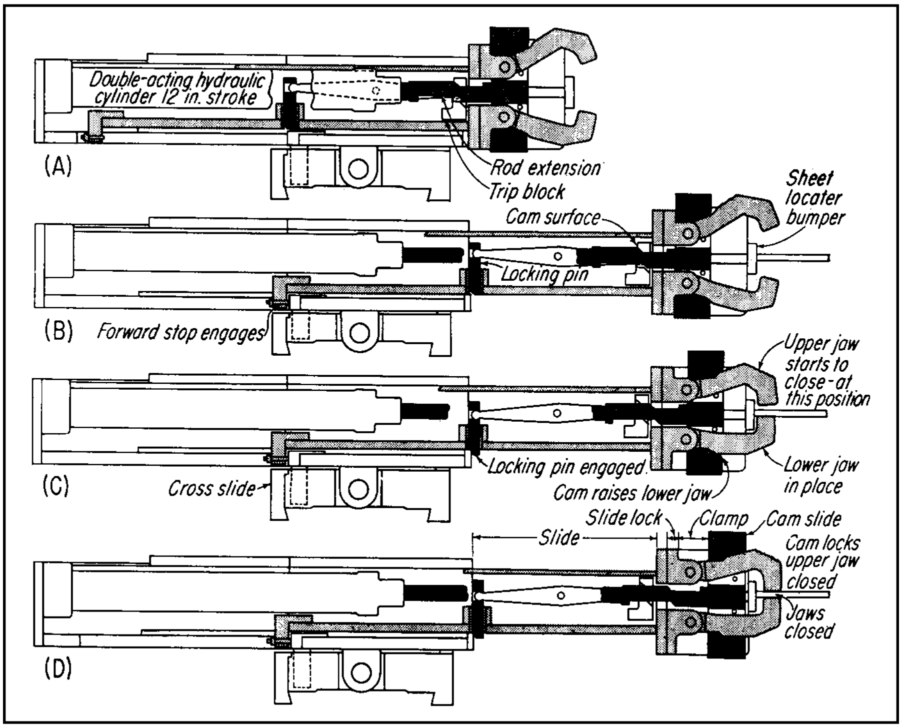
The advantage of the technique is that the shafts do not need notches or threads, and cost is reduced. Moreover, the shafts can be made of reinforced concrete.



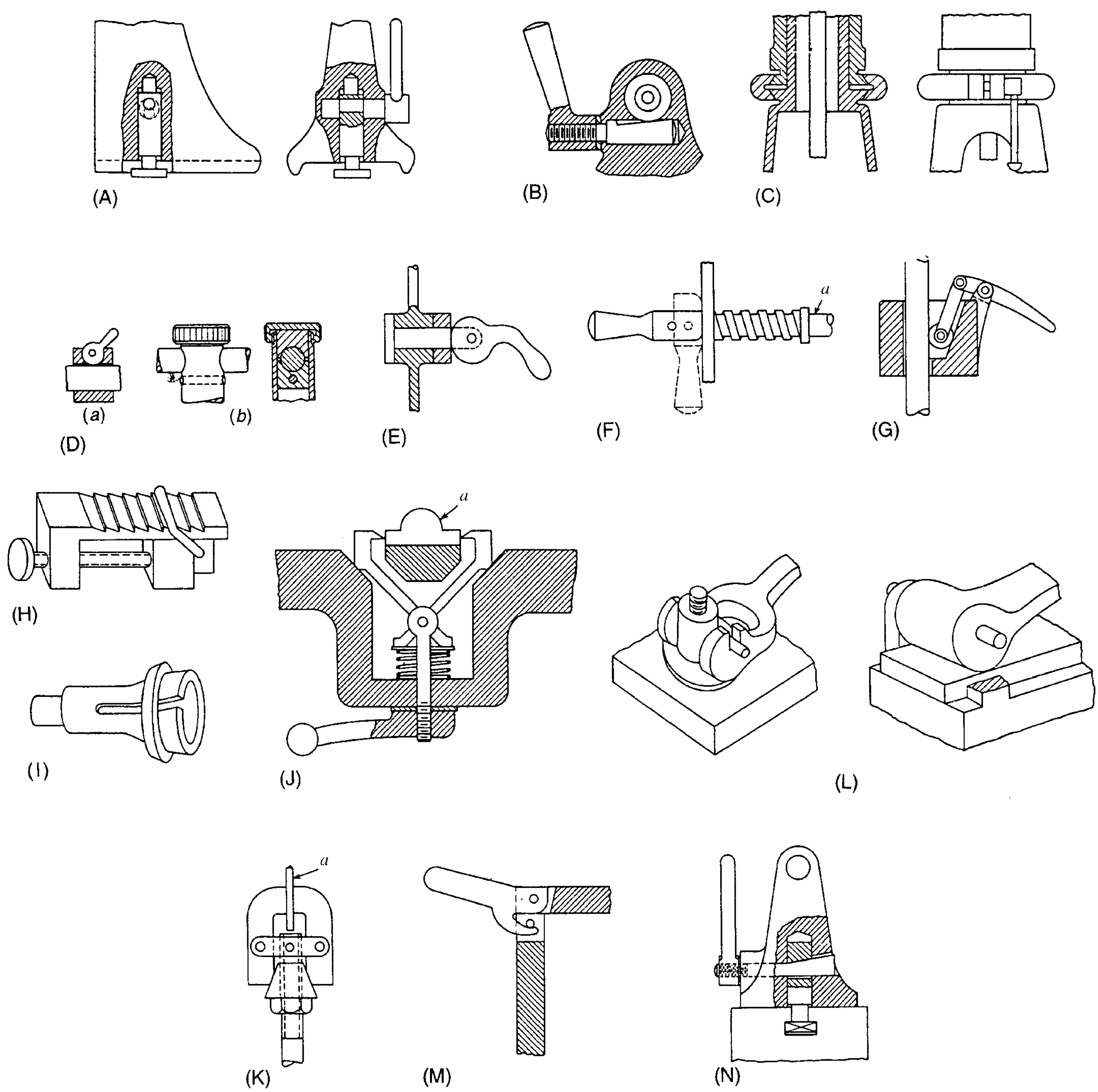
Ring springs unclamp the column as the platform is raised (upper). As soon as the jack power is removed (lower), the column is gripped by the inner ring.

CAMMED JAWS IN HYDRAULIC CYLINDER GRIP SHEETS

A single, double-acting hydraulic cylinder in each work holder clamps and unclamps the work and retracts or advances the jaws as required. With the piston rod fully withdrawn into the hydraulic cylinder (A), the jaws of the holder are retracted and open. When the control valve atop the work holder is actuated, the piston rod moves forward a total of 12 in. The first 10 in. of movement (B) brings the sheet-locater bumper into contact with the work. The cammed surface on the rod extension starts to move the trip block upward, and the locking pin starts to drop into position. The next ¾ in. of piston-rod travel (C) fully engages the work-holder locking pin and brings the lower jaw of the clamp up to the bottom of the work. The work holder slide is now locked between the forward stop and the locking pin. The last 1¼ in. of piston travel (D) clamps the workpiece between the jaws with a pressure of 2500 lbs. No adjustment for work thickness is necessary. A jaws-open limit switch clamps the work holder in position (C) for loading and unloading operations.

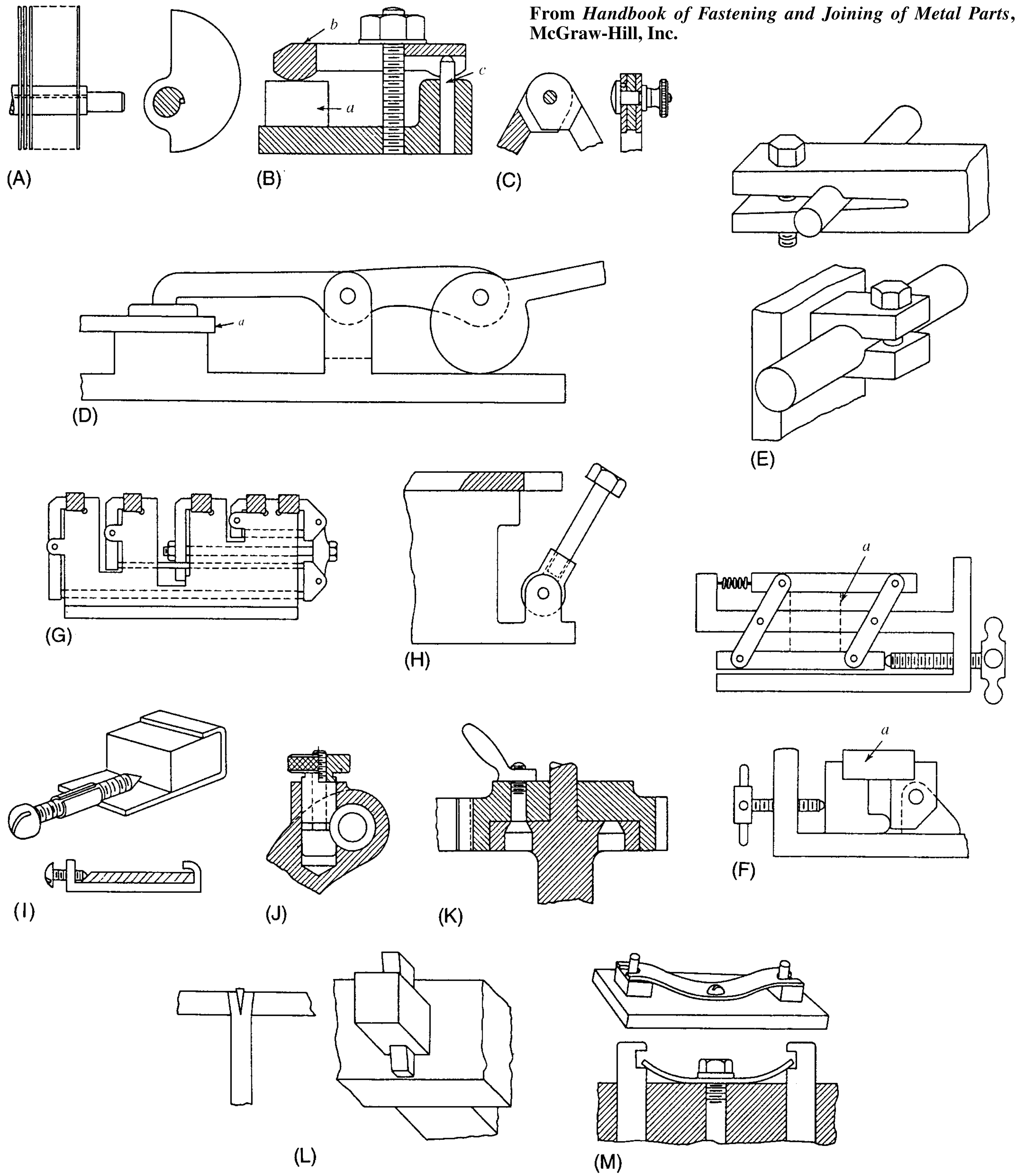


QUICK-ACTING CLAMPS FOR MACHINES AND FIXTURES



(A) An eccentric clamp. (B) A spindle-clamping bolt. (C) A method for clamping a hollow column to a structure. It permits quick rotary adjustment of the column. (D) (a) A cam catch for clamping a rod or rope. (b) A method for fastening a small cylindrical member to a structure with a thumb nut and clamp jaws. It permits quick longitudinal adjustment of a shaft in the structure. (E) A cam catch can lock a wheel or spindle. (F) A spring handle. Movement of the handle in the vertical or horizontal position provides movement at *a*. (G) A roller and inclined slot for locking a rod or rope. (H) A method for clamping a light member to a structure. The serrated edge on the structure permits the rapid accommodation of members with different thicknesses. (I) A spring taper holder with a sliding ring. (J) A special clamp for holding member *a*. (K) The cone, nut, and levers grip member *a*. The grip can have two or more jaws. With only two jaws, the device serves as a small vise. (L) Two different kinds of cam clamps. (M) A cam cover catch. Movement of the handle downward locks the cover tightly. (N) The sliding member is clamped to the slotted structure with a wedge bolt. This permits the rapid adjustment of a member on the structure.

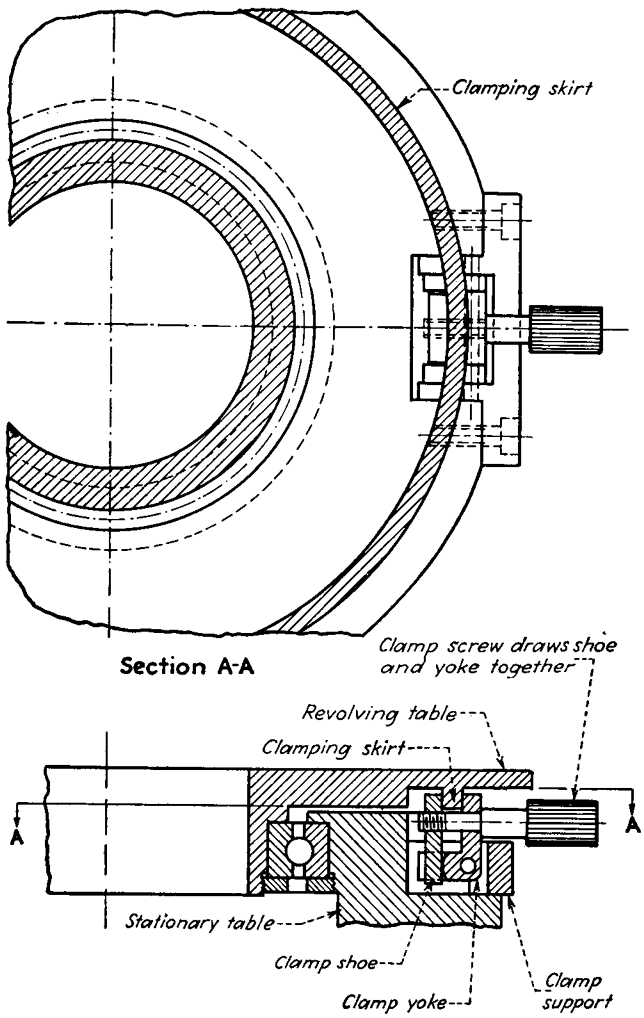
From *Handbook of Fastening and Joining of Metal Parts*, McGraw-Hill, Inc.



(A) A method for fastening capacitor plates to a structure with a circular wedge. Rotation of the plates in a clockwise direction locks the plates to the structure. (B) A method for clamping member *a* with a special clamp. Detail *b* pivots on pin *c.* (C) A method for clamping two movable parts so that they can be held in any angular position with a clamping screw. (D) A cam clamp for clamping member *a.* (E) Two methods for clamping a cylindrical member. (F) Two methods for clamping member *a* with a special clamp. (G) A special clamping device that permits the parallel clamping of five parts by the tightening of one bolt. (H) A method for securing a structure with a bolt and a movable detail that provides a quick method for fastening the cover. (I) A method for quickly securing, adjusting, or releasing the center member. (J) A method for securing a bushing in a structure with a clamp screw and thumb nut. (K) A method for securing an attachment to a structure with a bolt and hand lever used as a nut. (L) A method for fastening a member to a structure with a wedge. (M) Two methods for fastening two members to a structure with a spring and one screw. The members can be removed without loosening the screw.

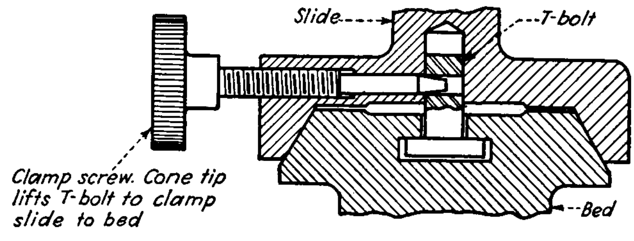
FRICTION CLAMPING DEVICES

Many different devices for gaining mechanical advantage have been used in the design of friction clamps. These clamps can grip moderately large loads with comparatively small smooth surfaces, and the loads can be tightened or released with simple controls. The clamps illustrated here can be tightened or released with screws, levers, toggles, wedges, and combinations of them.

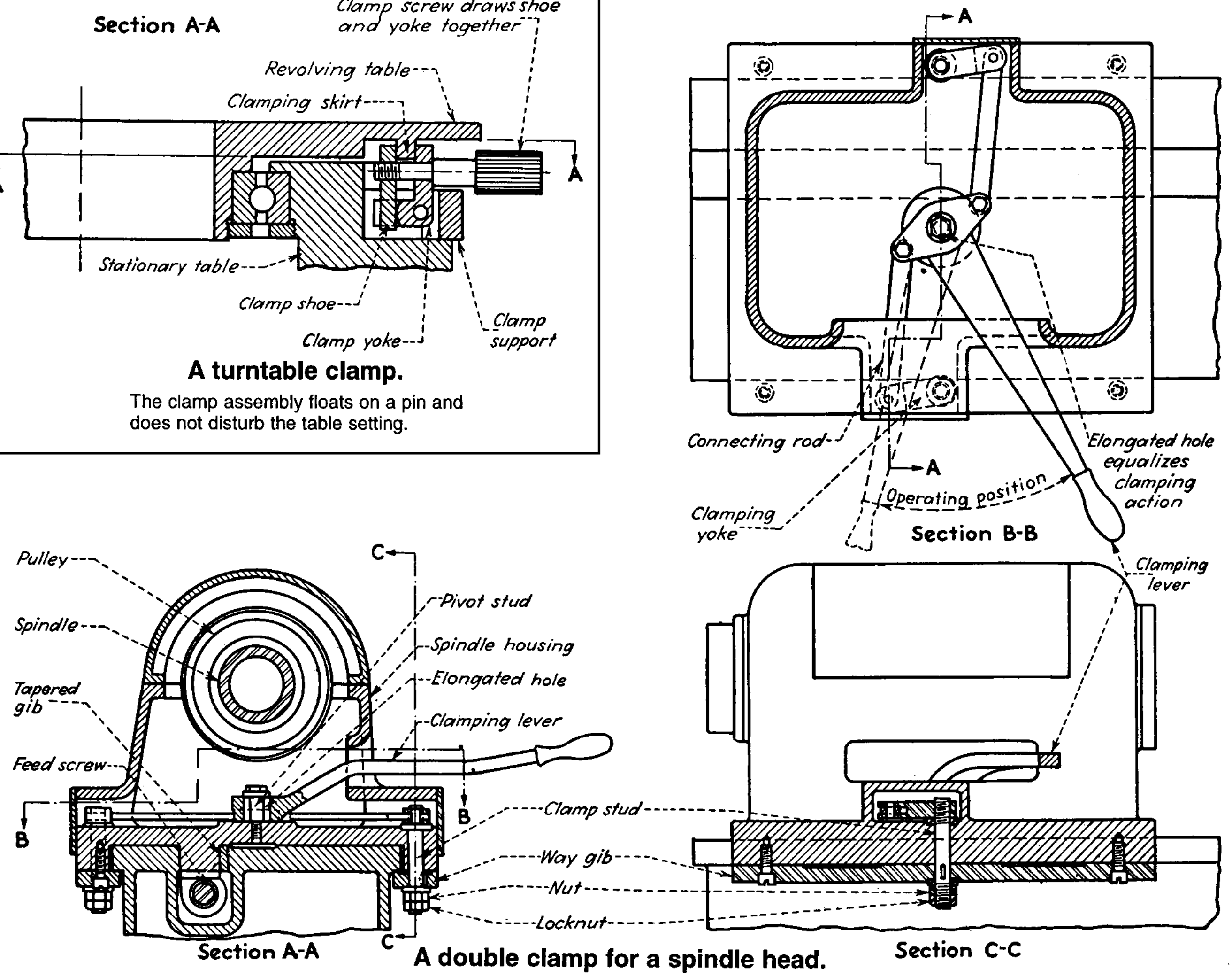


A turntable clamp.

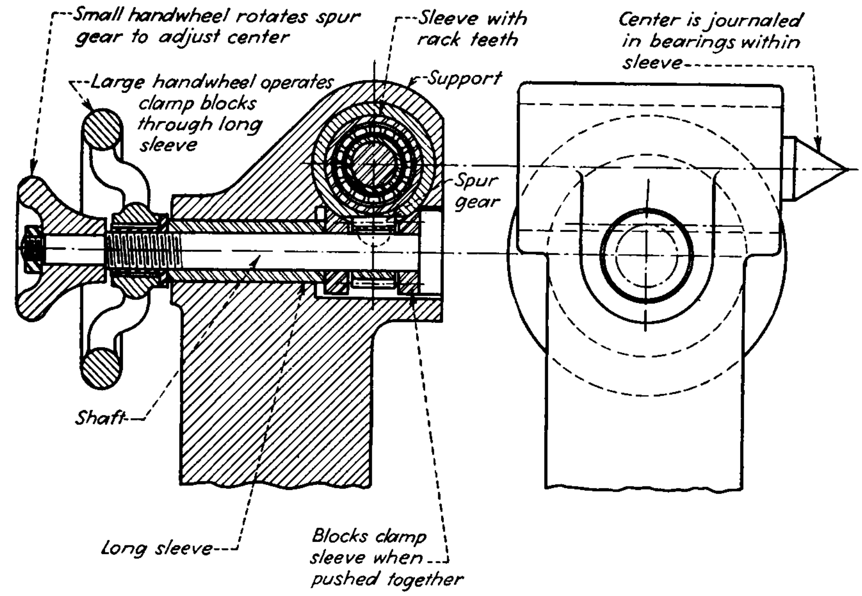
The clamp assembly floats on a pin and does not disturb the table setting.



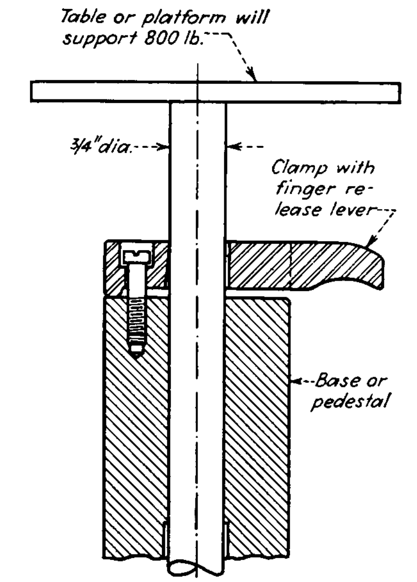
A slide clamp.



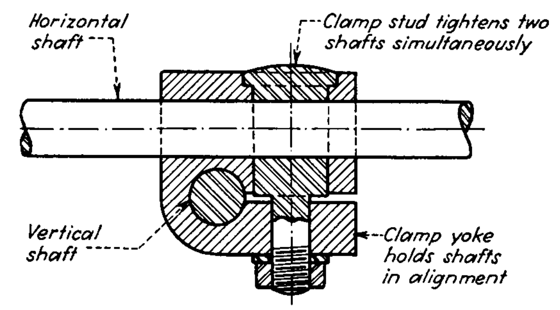
A double clamp for a spindle head.



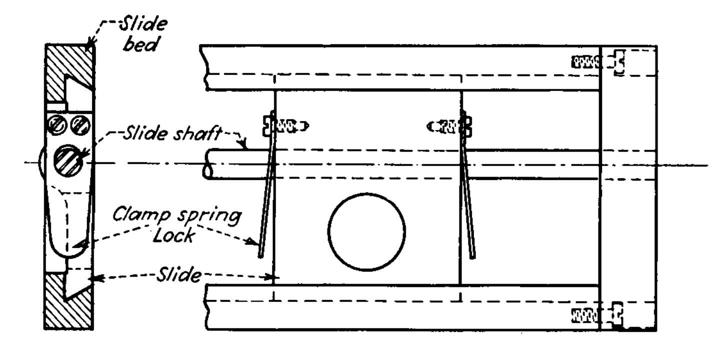
A center-support clamp.



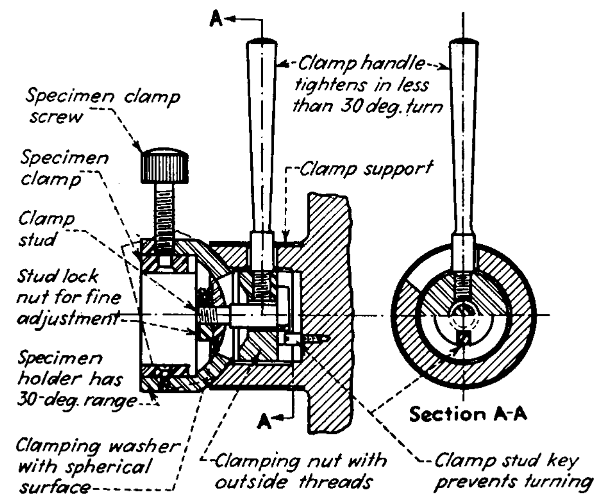
A pedestal clamp.



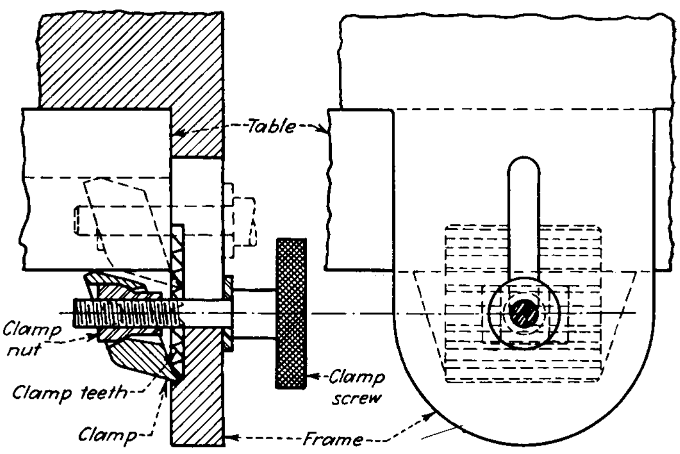
A right-angle clamp.



A slide clamp.



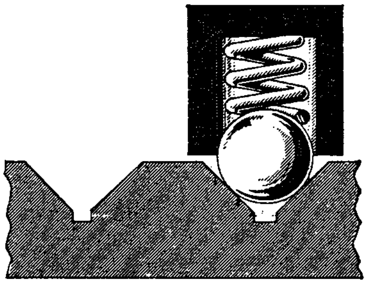
A specimen holder clamp.



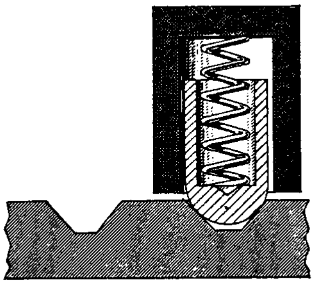
A table clamp.

DETENTS FOR STOPPING MECHANICAL MOVEMENTS

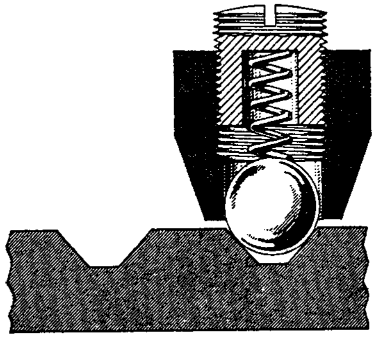
Some of the more robust and practical devices for stopping mechanical movements are illustrated here.



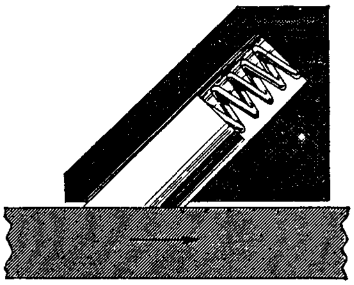
Fixed holding power is constant in both directions.



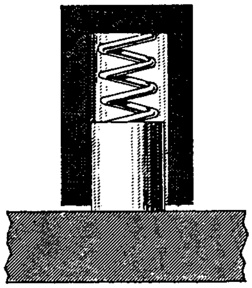
A domed plunger has long life.



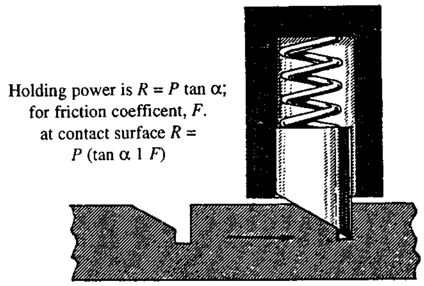
The screw provides adjustable holding.



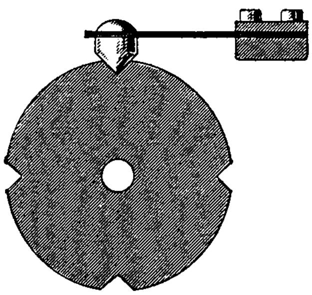
Wedge action locks the movement in the direction of the arrow.



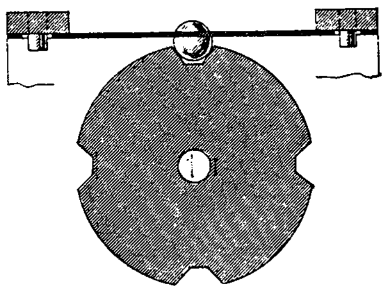
Friction results in holding force.



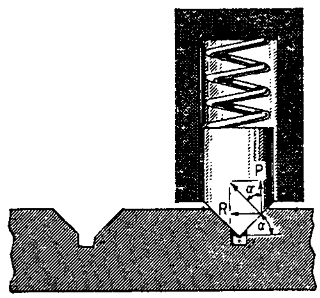
A notch shape dictates the direction of rod motion.



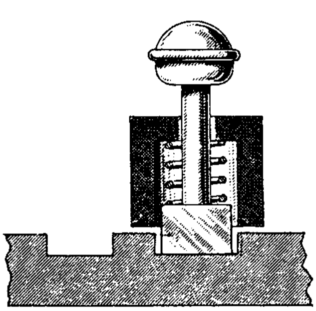
A leaf spring provides limited holding power.



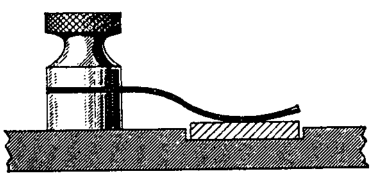
A leaf-spring detent can be removed quickly.



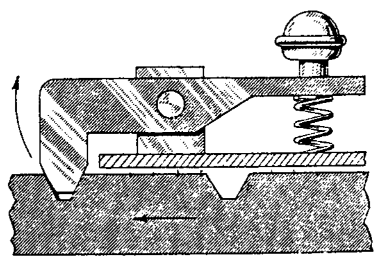
A conical or wedge-ended detent.



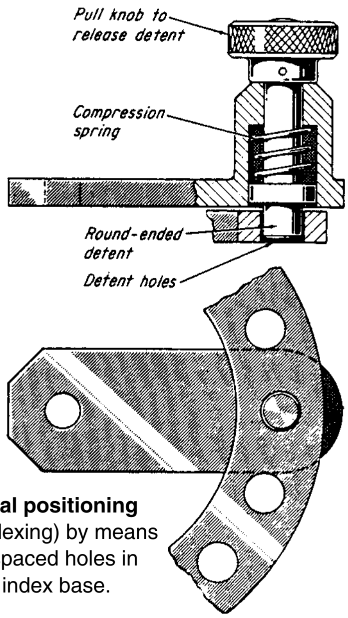
A positive detent has a manual release.



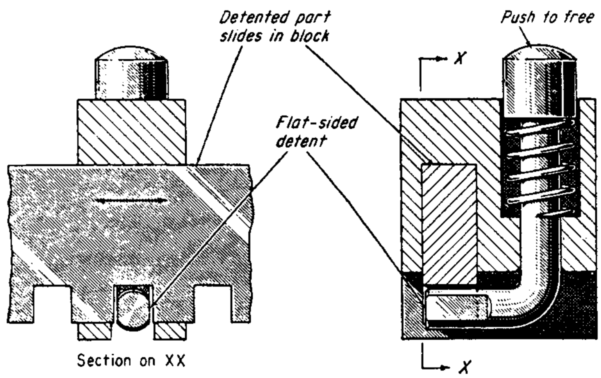
.**A leaf spring** for holding flat pieces.



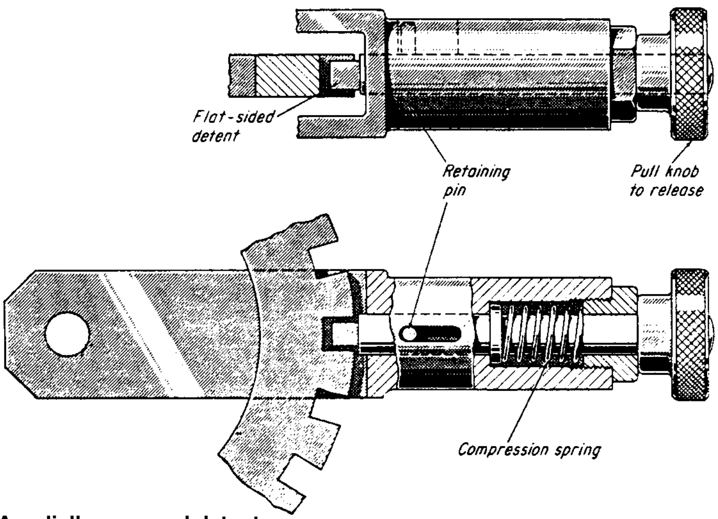
An automatic release occurs in one direction; manual release is needed in the other direction.



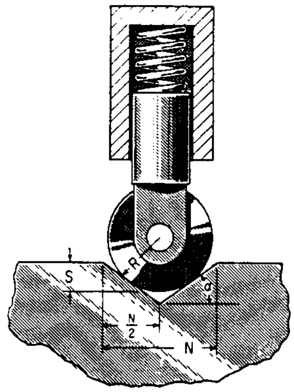
Axial positioning (indexing) by means of spaced holes in the index base.



A positive detent has a push-button release for straight rods.



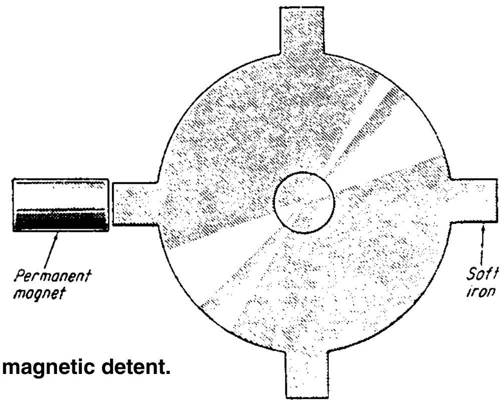
A radially arranged detent holds in slotted index base.



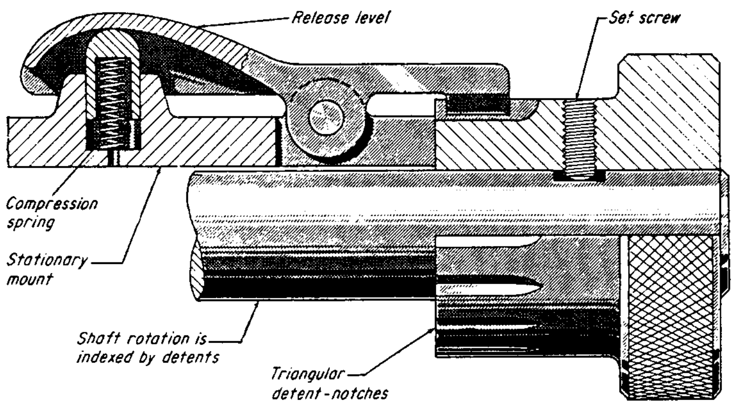
A roller detent positions itself in a notch.

$$\text{Rise, } S = \frac{N \tan a}{2} - R \times \frac{1 - \cos}{\cos a}$$

$$\text{Roller Radius, } R = \left(\frac{N \tan a}{2} - S\right)\left(\frac{\cos a}{1 - \cos a}\right)$$



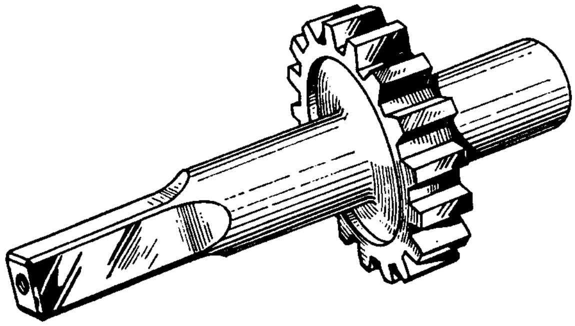
A magnetic detent.



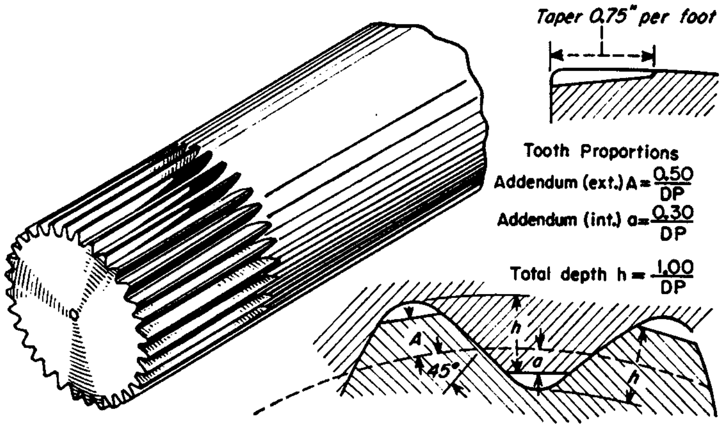
An axial detent for the positioning of the adjustment knob with a manual release.

TEN DIFFERENT SPLINED CONNECTIONS

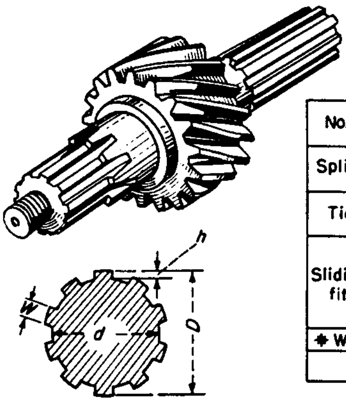
CYLINDRICAL SPLINES



1. SQUARE SPLINES make simple connections. They are used mainly for transmitting light loads, where accurate positioning is not critical. This spline is commonly used on machine tools; a cap screw is required to hold the enveloping member.



2. SERRATIONS of small size are used mostly for transmitting light loads. This shaft forced into a hole of softer material makes an inexpensive connection. Originally straight-sided and limited to small pitches, 45° serrations have been standardized (SAE) with large pitches up to 10 in. dia. For tight fits, the serrations are tapered.



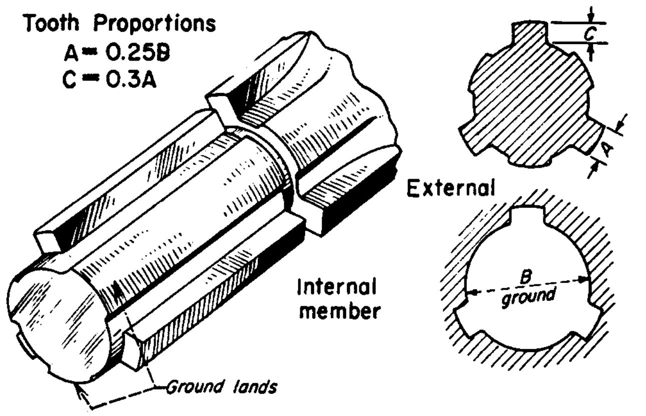
SAE STANDARD SPLINE PROPORTIONS

No. of splines			4	6	10 or 16
Spline width		W	0.241D	0.250D	0.156D*
Tight fit		h	0.075D	0.050D	0.045D
Sliding fit	Unloaded	h	0.125D	0.075D	0.070D
	loaded	h	——	0.100D	0.095D

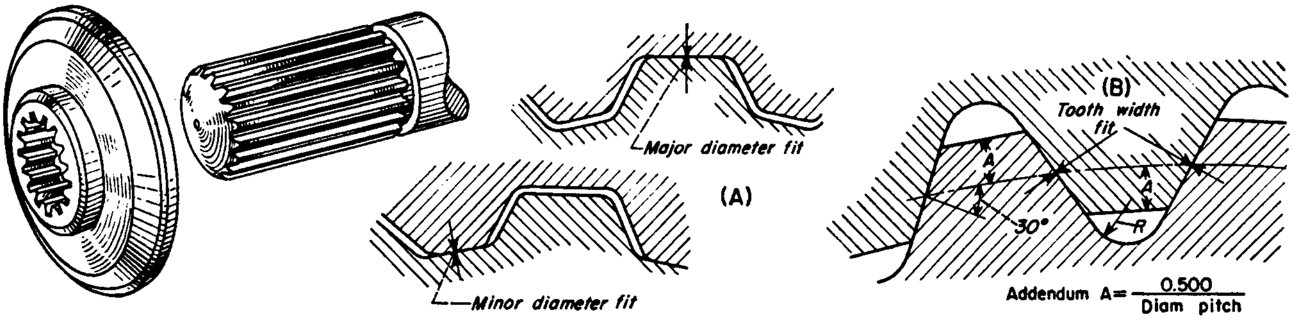
* Width of 16-tooth spline is 0.098D

Root dia, d = D − 2h

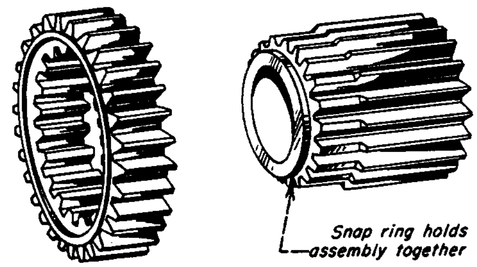
3. STRAIGHT-SIDED splines have been widely used in the automotive field. Such splines are often used for sliding members. The sharp corner at the root limits the torque capacity to pressures of approximately 1,000 psi on the spline projected area. For different applications, tooth height is altered, as shown in the table above.



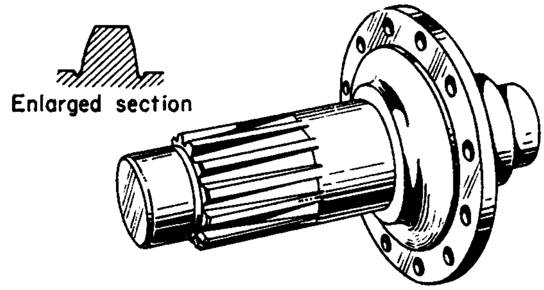
4. MACHINE-TOOL splines have wide gaps between splines to permit accurate cylindrical grinding of the lands—for precise positioning. Internal parts can be ground readily so that they will fit closely with the lands of the external member.



5. INVOLUTE-FORM splines are used where high loads are to be transmitted. Tooth proportions are based on a 30° stub tooth form. (A) Splined members can be positioned either by close fitting major or minor diameters. (B) Use of the tooth width or side positioning has the advantage of a full fillet radius at the roots. Splines can be parallel or helical. Contact stresses of 4,000 psi are used for accurate, hardened splines. The diametral pitch shown is the ratio of teeth to the pitch diameter.

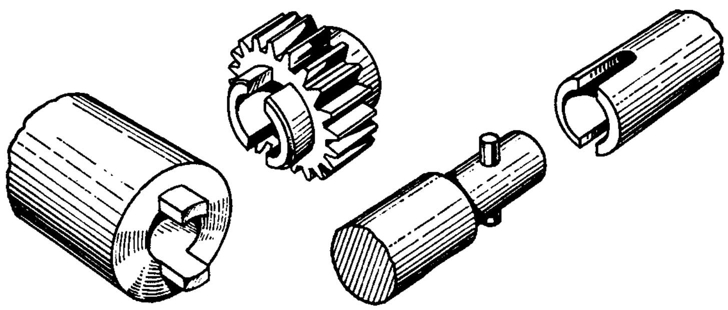


6. SPECIAL INVOLUTE splines are made by using gear tooth proportions. With full depth teeth, greater contact area is possible. A compound pinion is shown made by cropping the smaller pinion teeth and internally splining the larger pinion.

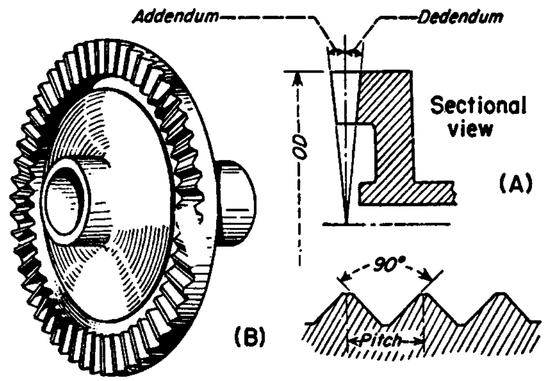


7. TAPER-ROOT splines are for drivers that require positive positioning. This method holds mating parts securely. With a 30° involute stub tooth, this type is stronger than parallel root splines and can be hobbed with a range of tapers.

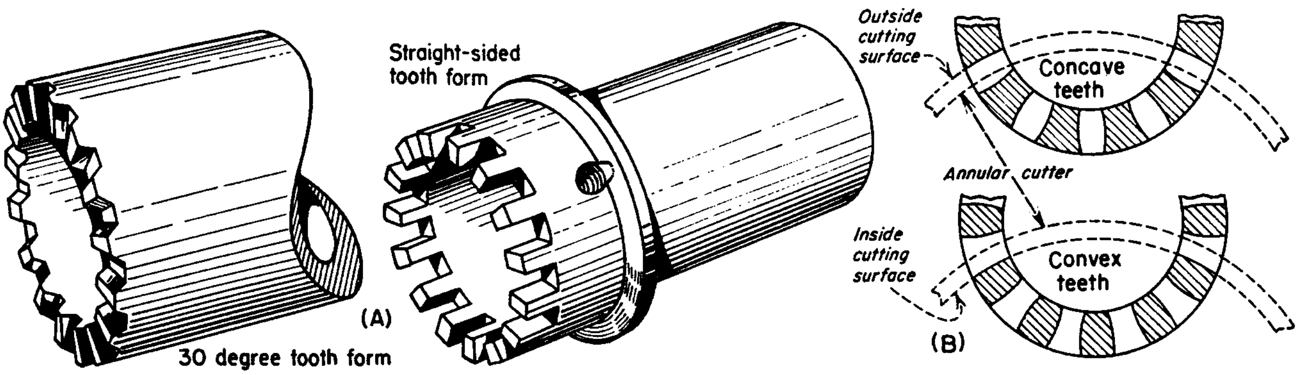
FACE SPLINES



8. MILLED SLOTS in hubs or shafts make inexpensive connections. This spline is limited to moderate loads and requires a locking device to maintain positive engagement. A pin and sleeve method is used for light torques and where accurate positioning is not required.



9. RADIAL SERRATIONS made by milling or shaping the teeth form simple connections. (A) Tooth proportions decrease radially. (B) Teeth can be straight-sided (castellated) or inclined; a 90° angle is common.



10. CURVIC COUPLING teeth are machined by a face-mill cutter. When hardened parts are used that require accurate positioning, the teeth can be ground. (A) This process produces teeth with uniform depth. They can be cut at any pressure angle, although 30° is most common. (B) Due to the cutting action, the shape of the teeth will be concave (hour-glass) on one member and convex on the other—the member with which it will be assembled.

FOURTEEN WAYS TO FASTEN HUBS TO SHAFTS

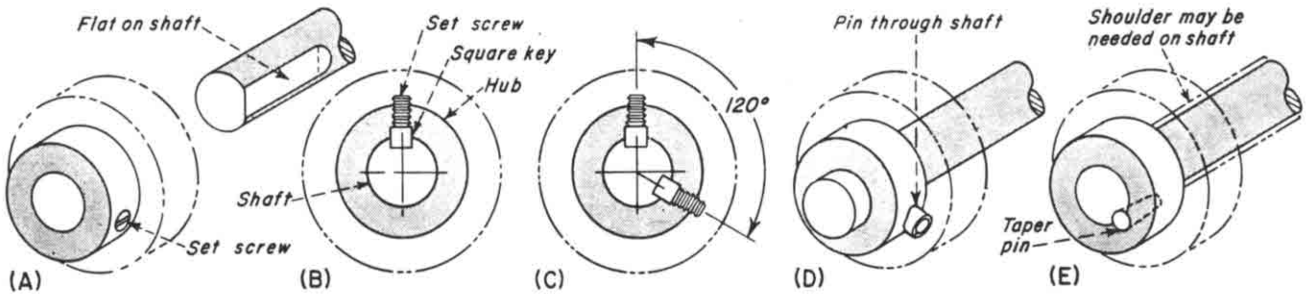


Fig. 1 A cup-point setscrew in hub (A) bears against a flat on a shaft. This fastening is suitable for fractional horsepower drives with low shock loads but is unsuitable when frequent removal and assembly are necessary. The key with setscrew (B) prevents shaft marring from frequent removal and assembly. It can withstand high shock loads. Two keys 120° apart (C) transmit extra heavy loads. Straight or tapered pin (D) prevents end play. For experimental setups an expanding pin is suitable yet easy to remove. Taper pin (E) parallel to shaft might require a shoulder on the shaft. It can be used when a gear or pulley has no hub.

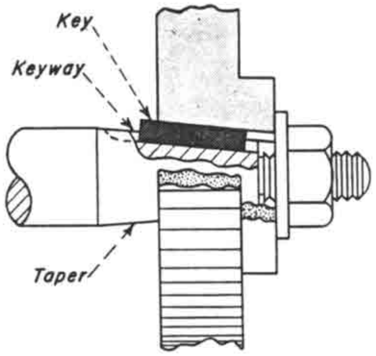


Fig. 2 A tapered shaft with a key and threaded end is a rigid concentric assembly. It is suitable for heavy-duty applications, yet it can be easily disassembled.

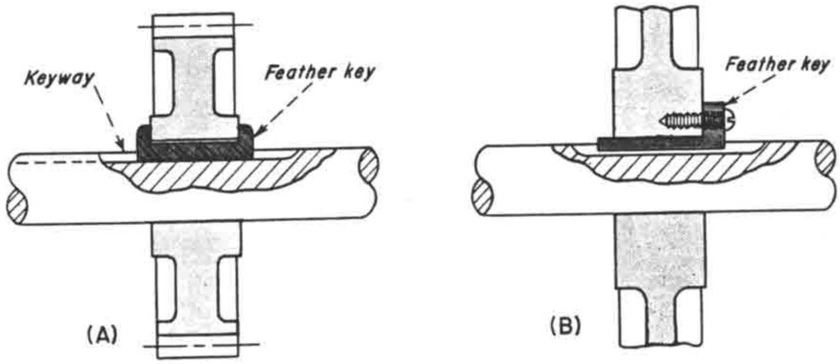


Fig. 3 A feather key (A) allows axial gear movement. A keyway must be milled to the end of the shaft. For a blind keyway (B) the hub and key must be drilled and tapped, but the design allows the gear to be mounted anywhere on the shaft with only a short keyway.

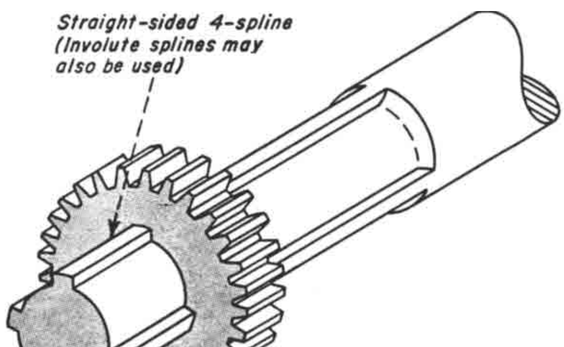


Fig. 4 Splined shafts are frequently used when a gear must slide. Square splines can be ground to close minor diameter gaps, but involute splines are self-centering and stronger. Non-sliding gears can be pinned to the shaft if it is provided with a hub.

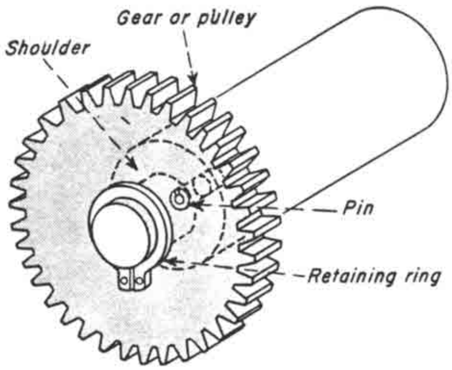


Fig. 5 A retaining ring allows quick gear removal in light-load applications. A shoulder on the shaft is necessary. A shear pin can secure the gear to the shaft if protection against an excessive load is required.

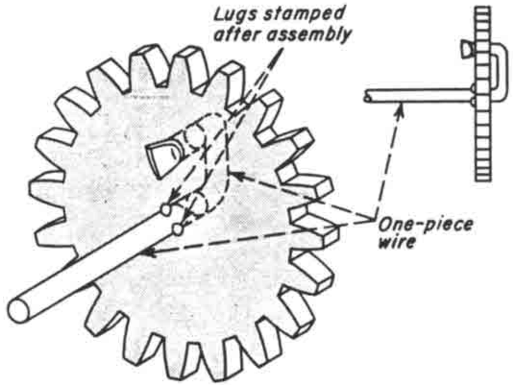


Fig. 6 A stamped gear and formed wire shaft can be used in light-duty application. Lugs stamped on both legs of the wire prevent disassembly. The bend radii of the shaft should be small enough to allow the gear to seat.

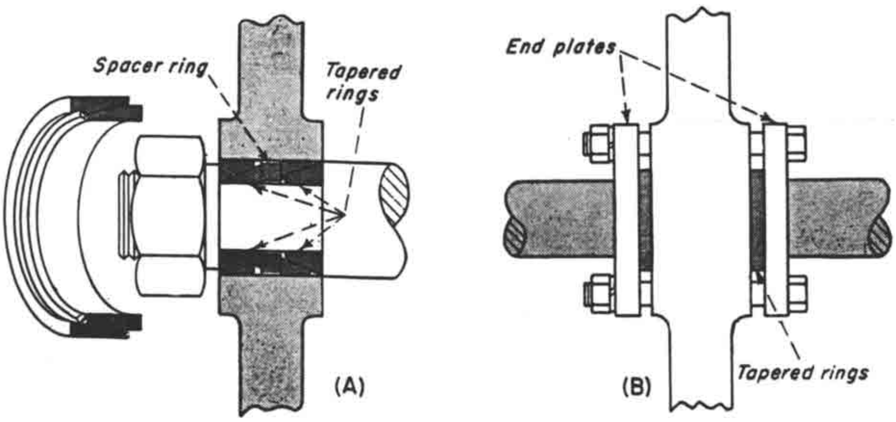


Fig. 7 Interlocking tapered rings hold the hub tightly to the shaft when the nut is tightened. Coarse machining of the hub and shaft does not affect concentricity as in pinned and keyed assemblies. A shoulder is required (A) for end-of-shaft mounting. End plates and four bolts (B) allow the hub to be mounted anywhere on the shaft.

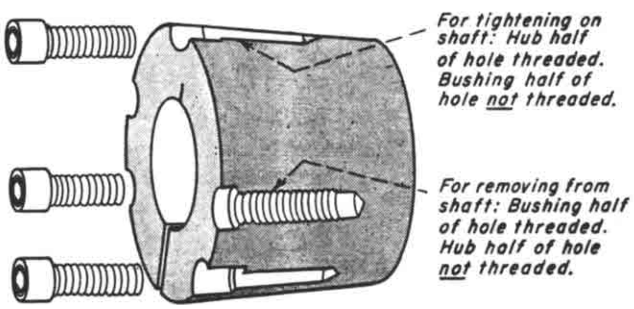


Fig. 8 This split bushing has a tapered outer diameter. Split holes in the bushing align with split holes in the hub. For tightening, the hub half of the hole is tapped, and the bushing half is un-tapped. A screw pulls the bushing into the hub as it is tightened, and it is removed by reversing the procedure.

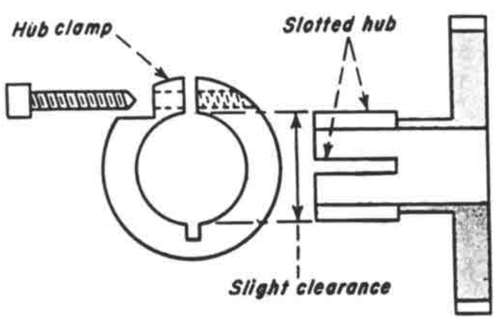


Fig. 9 The split hub of a stock precision gear is clamped onto a shaft with a separate hub clamp. Manufacturers list correctly dimensioned hubs and clamps so that they can be efficiently fastened to a precision-ground shaft.

CLAMPING DEVICES FOR ACCURATELY ALIGNING ADJUSTABLE PARTS

Methods for clamping parts that must be readily movable are as numerous and as varied as the requirements. In many instances, a clamp of any design is satisfactory, provided it has sufficient strength to hold the parts immovable when tightened. However, it is sometimes necessary that the movable part be clamped to maintain accurate alignment with some fixed part. Examples of these clamps are described and illustrated.

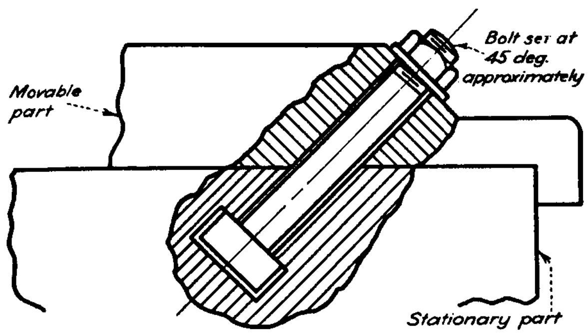


FIG. 1 When a nut is tightened, the flange on the edge of the movable part is drawn against the machined edge of the stationary part. This method is effective, but the removal of the clamped part can be difficult if it is heavy or unbalanced.

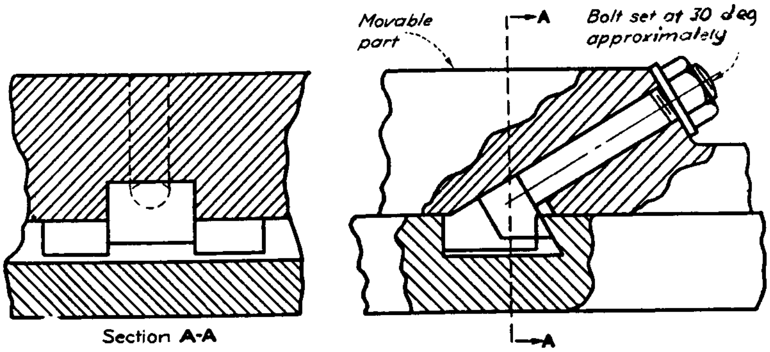


FIG. 2 The lower edged of the bolt head contacts the angular side of locating groove, causing the keys to be held tightly against the opposite side of the groove. This design permits easy removal of the clamped part, but it is effective only if the working pressure is directly downward or in a direction against the perpendicular side of the slot.

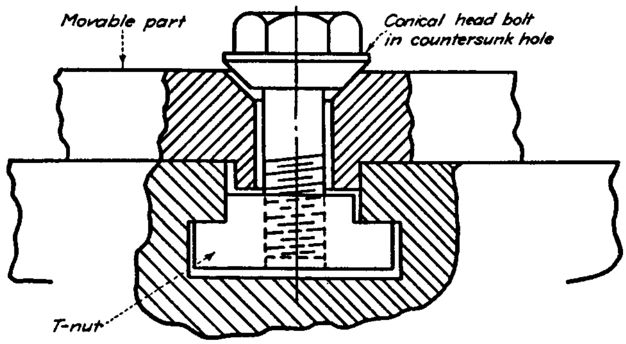


FIG. 3 The movable part is held against one side of the groove while the T-nut is forced against the other side. The removal of the screw permits easy removal of the clamped part. Heavy pressure toward the side of the key out of contact with the slot can permit slight movement due to the springing of the screw.

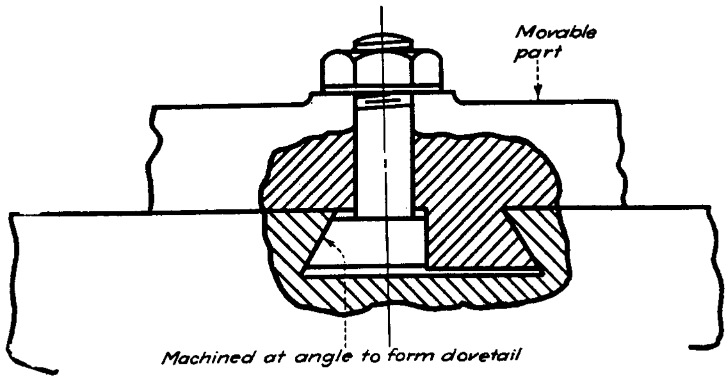


FIG. 4 One side of the bolt is machined at an angle to form a side of the dovetail, which tightens in the groove as the nut is drawn tight. The part must be slid the entire length of the slot for removal.

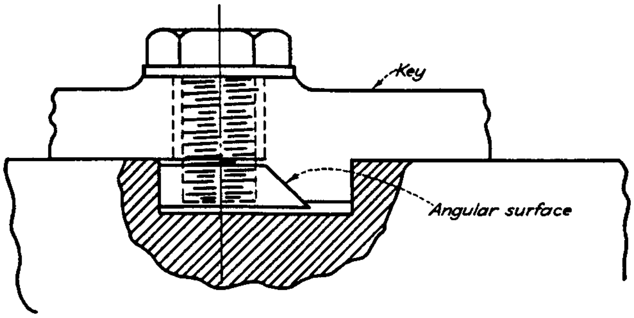


FIG. 5 The angular surface of the nut contacts the angular side of the key, and causes it to move outward against the side of the groove. This exerts a downward pull on the clamped part due to the friction of the nut against the side of a groove as the nut is drawn upward by the screw.

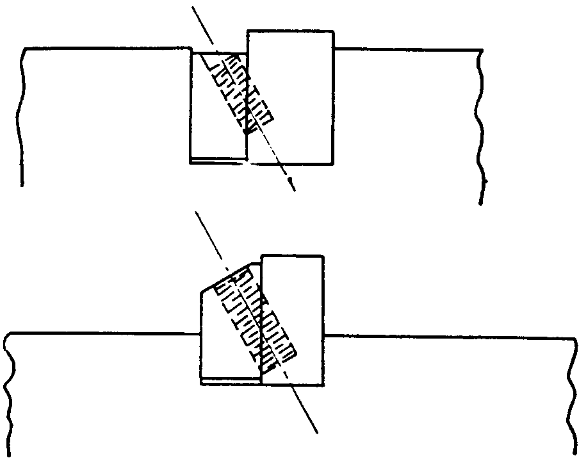


FIG. 6 and 7 These designs differ only in the depth of the grooves. They cannot withstand heavy pressure in an upward direction but have the advantage of being applicable to narrow grooves.

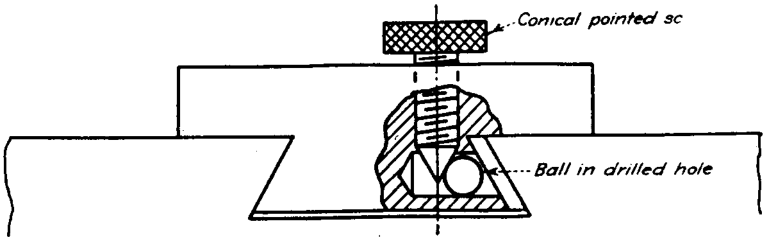


FIG. 8 Screw contact causes the ball to exert an outward pressure against the gib. The gib is loosely pinned to the movable part. This slide can be applied to broad surfaces where it would be impractical to apply adjusting screws through the stationary part.

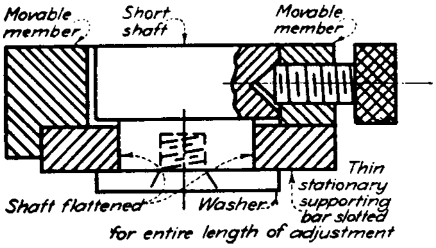


FIG. 9 The movable member is flanged on one side and carries a conical pointed screw on the other side. A short shaft passes through both members and carries a detent slightly out of alignment with the point of the screw. This shaft is flattened on opposite sides where it passes through the stationary member to prevent it from turning when the movable member is removed. A heavy washer is screwed to the under side of the shaft. When the knurled screw is turned inward, the shaft is drawn upward while the movable member is drawn downward and backward against the flange. The shaft is forced forward against the edge of the slot. The upper member can thus be moved and locked in any position. Withdrawing the point of the screw from the detent in the shaft permits the removal of the upper member.

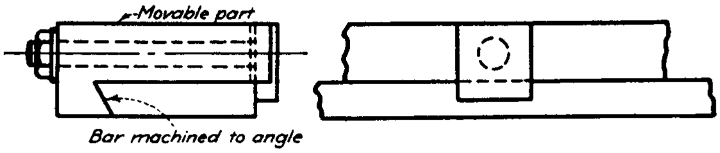


FIG. 10 One edge of a bar is machined at an angle which fits into mating surfaces on the movable part. When the bolt, which passes through the movable part, is drawn tight, the two parts are clamped firmly together.

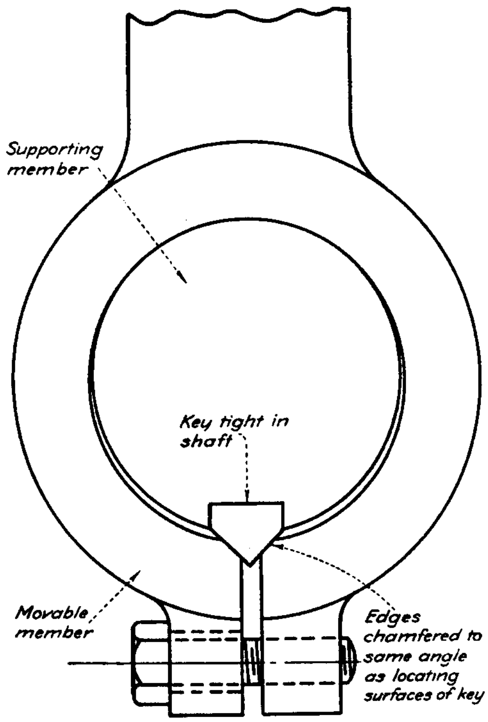
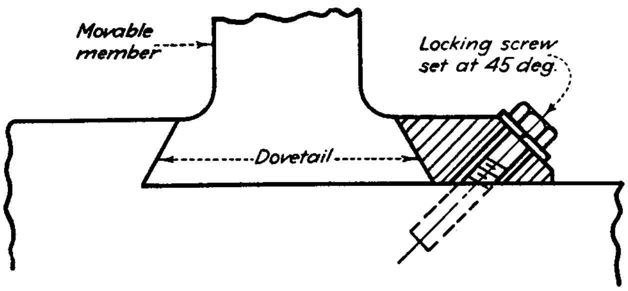


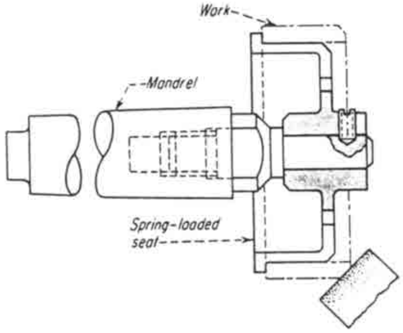
FIG. 11 As the screw is tightened, the chamfered edges of the cut tend to ride outward on the angular surfaces of the key. This draws the movable member tightly against the opposite side of the shaft.

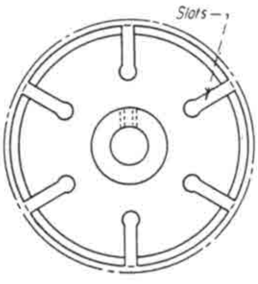
FIG. 12 As the screw is turned, it causes the movable side, which forms one side of the dovetail groove, to move until it clamps tightly on the movable member. The movable side should be as narrow as possible, because there is a tendency for this part to ride up on the angular surface of the clamped part.



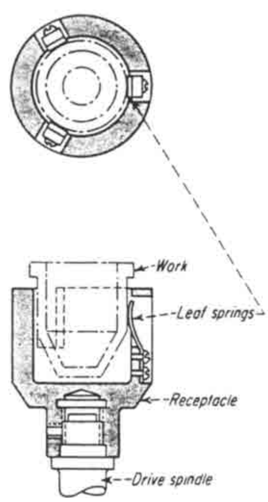
SPRING-LOADED CHUCKS AND HOLDING FIXTURES

Spring-loaded fixtures for holding work can be preferable to other fixtures. Their advantages are shorter setup time and quick workpiece change. Work distortion is reduced because the spring force can be easily and accurately adjusted.

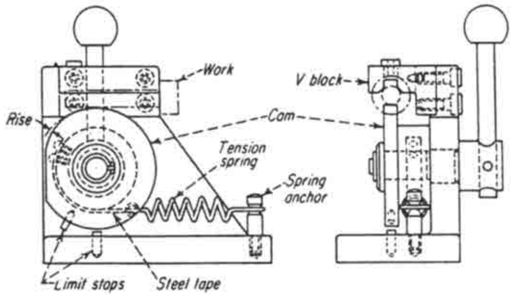




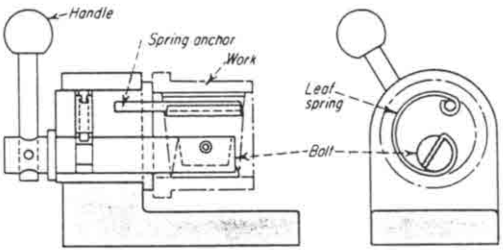
A spring-loaded nest has radial slots extending into its face. These ensure an even grip on the work, which is pushed over the rim. A slight lead on the rim makes mounting work easier. The principal application of this fixture is for ball-bearing race grinding where only light cutting forces are applied.



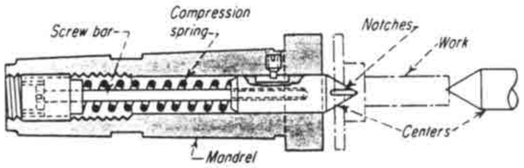
A cupped fixture has three leaf-springs equally spaced in a wall. The work, usually to be lacquered, is inserted into the cup during its rotation. Because the work is placed in the fixture by hand, the spindle is usually friction-driven for safety.



This spring clamp has a cam-and-tension spring that applies a clamping force. A tension spring activates the cam through a steel band. When the handle is released, the cam clamps the work against the V-bar. Two stop-pins limit travel when there is no work in thefixture.



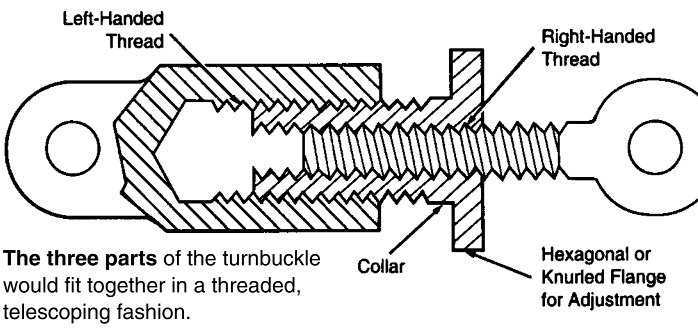
A leaf-spring gripper is used mainly to hold work during assembly. One end of a flat coil-spring is anchored in the housing; the other end is held in a bolt. When the bolt is turned, the spring is tightened, and its outside diameter is decreased. After the work is slid over the spring, the bolt handle is released. The spring then presses against the work, holding it tight.



This lathe center is spring loaded and holds the work with spring pressure alone. Eight sharp-edged notches on the conical surface of the driving center bite into the work and drive it. Its spring tension is adjustable.

SHORT IN-LINE TURNBUCKLE

A short body is achieved without offset.
NASA's Jet Propulsion Laboratory, Pasadena, California



The three parts of the turnbuckle would fit together in a threaded, telescoping fashion.

A proposed turnbuckle would be shorter than conventional turnbuckles and could, therefore, fit in shorter spaces. Its ends would be coaxial. The design is unlike that of other short turnbuckles whose ends and the axes that pass through them are laterally offset.

The turnbuckle would consist of the following parts (see figure):

- An eye on a shank with internal left-handed threads,
- An eye on a shank with external right-handed threads, and
- A flanged collar with left-handed external threads to mate with the shank of the first-mentioned eye, and right-handed internal threads to mate with the shank of the second-mentioned eye. The flange would be knurled or hexagonal so that it could be turned by hand or wrench to adjust the overall length of the turnbuckle.

For fine adjustments of length, the collar could be made with only right-handed threads and different pitches inside and out. (Of course, the threads on the mating shanks of the eyes would be made to match the threads on the collar.) For example, with a right-handed external thread of 28 per in. (pitch ≈ 0.91 mm) and a right-handed internal thread of 32 per in. (pitch ≈ 0.79 mm) , one turn of the collar would change the length approximately 0.0045 in. (about 0.11 mm).

This work was done by Earl Collins and Malcolm MacMartin of Caltech for **NASA's Jet Propulsion Laboratory.**

ACTUATOR EXERTS TENSILE OR COMPRESSIVE AXIAL LOAD

A shearpin limits the load.
Marshall Space Flight Center, Alabama

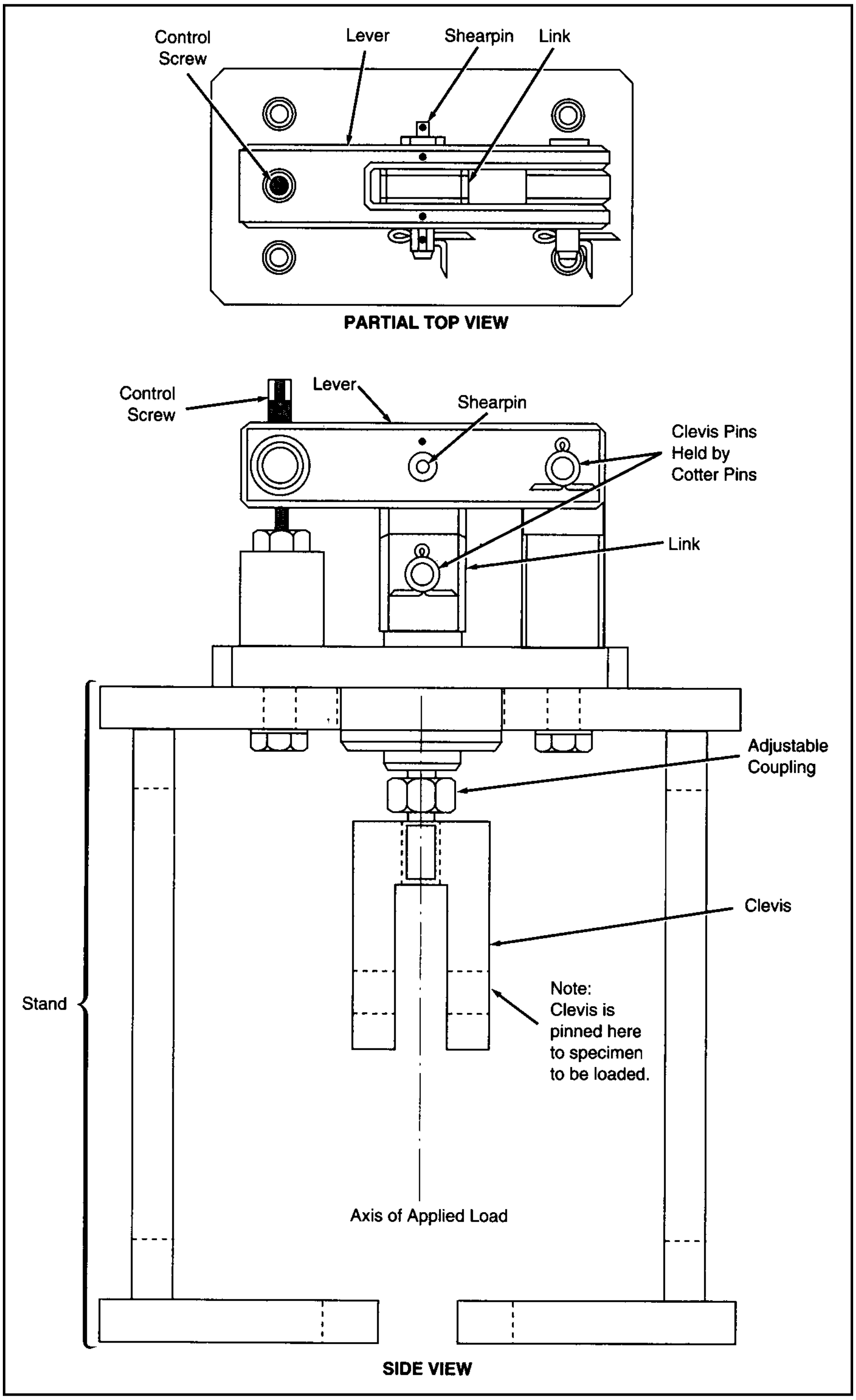
A compact, manually operated mechanical actuator applies a controlled, limited tensile or compressive axial force. The actuator is designed to apply loads to bearings during wear tests in a clean room. It is intended to replace a hydraulic actuator that is bulky and difficult to use, requires periodic maintenance, and poses the threat of leakage of hydraulic fluid, which can contaminate the clean room.

The actuator rests on a stand and imparts axial force to a part attached to a clevis inside or below the stand (see figure). A technician turns a control screw at one end of a lever. Depending on the direction of rotation of the control screw, its end of the lever is driven downward (for compression) or upward (for tension). The lever pivots about a clevis pin at the end opposite that of the control screw; this motion drives downward or upward a link attached through a shearpin at the middle of the lever. The link drives a coupling and, through it, the clevis attached to the part to be loaded.

The control screw has a fine thread so that a large adjustment of the screw produces a relatively small change in the applied force. With the help of a load cell that measures the applied load, the technician can control the load to within ±10 lb (45 N). An estimated input torque of only 40 to 50 lb·in. (4.5 to 5.6 N·m) is needed to apply the maximum allowable load of 2,550 lb (11.34 kN).

The shearpin at the middle of the lever breaks if a force greater than 2,800 ± 200 lb (12.45 ± 0.89 kN) is applied in tension or compressed, thus protecting the stressed part from overload. The shearpin is made of a maraging steel, selected because it fails more predictably and cleanly in shear than pins made from other alloys. Moreover, it is strong when machined to small pin diameters. Batches of pins are made from the same raw stock to ensure that all fail at or near the same load.

This work was done by John Nozzi and Cuyler H. Richards of Rockwell International Corp. for **Marshall Space Flight Center.**



This mechanical actuator applies an axial load to a test specimen inside or under its stand.

GRIPPING SYSTEM FOR MECHANICAL TESTING OF COMPOSITES

Specimens can be held without slippage, even at high temperatures.

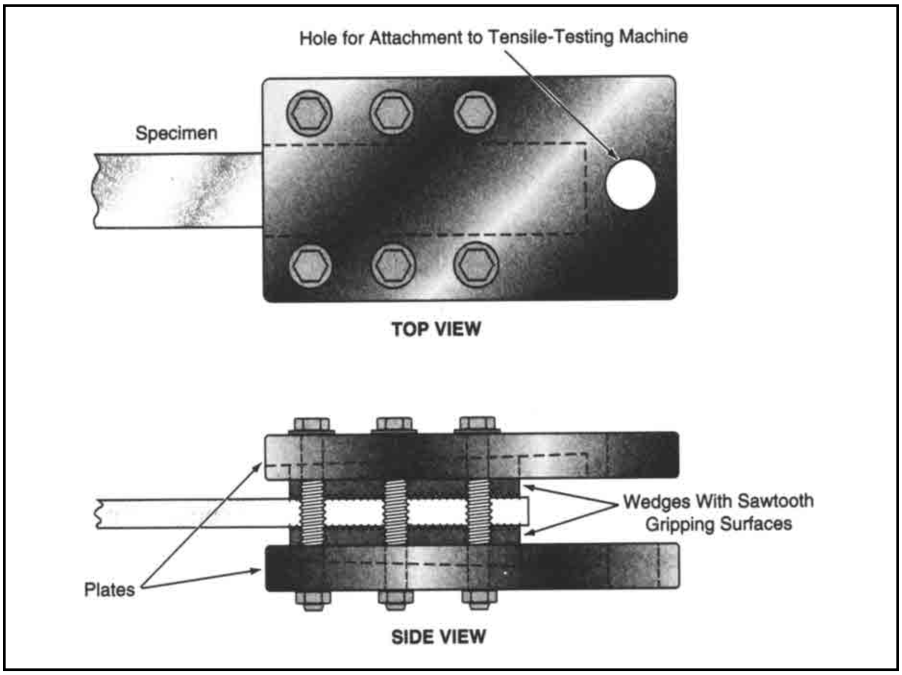
Lewis Research Center, Cleveland, Ohio

An improved gripping system has been designed to hold the ends of a specimen of a composite material securely during a creep or tensile test. The grips function over a wide range of applied stress [3 to 100 kpsi (about 21 to about 690 Mpa)] and temperature [up to 1,800°F (about 980°C)].

Each grip includes a pair of wedges that have sharply corrugated (sawtooth-profile) gripping surfaces. The wedges are held between two plates that contain cavities which are sloped to accommodate the wedges (see figure). Two such grips—one for each end of the specimen—hold a specimen in a furnace which is connected to a tensile test machine for creep measurements.

In preparation for a test, the specimen is assembled with the grips in a fixture that maintains all parts in precise alignment: this step is necessary to ensure that the load applied during the test will coincide with the axis of the specimen. Unlike some older wedge grips, the specimen can be gripped in a delicate manner during assembly and alignment. While the assembled parts are still in the alignment fixture, hexagonal nuts and bolts on the grip can be tightened evenly with a torque wrench to 120 lb-in. (≈ 13.6 N-m).

During a test, the grips apply the required tensile stress to the specimen without slippage at high temperatures and, therefore, without loss of alignment.



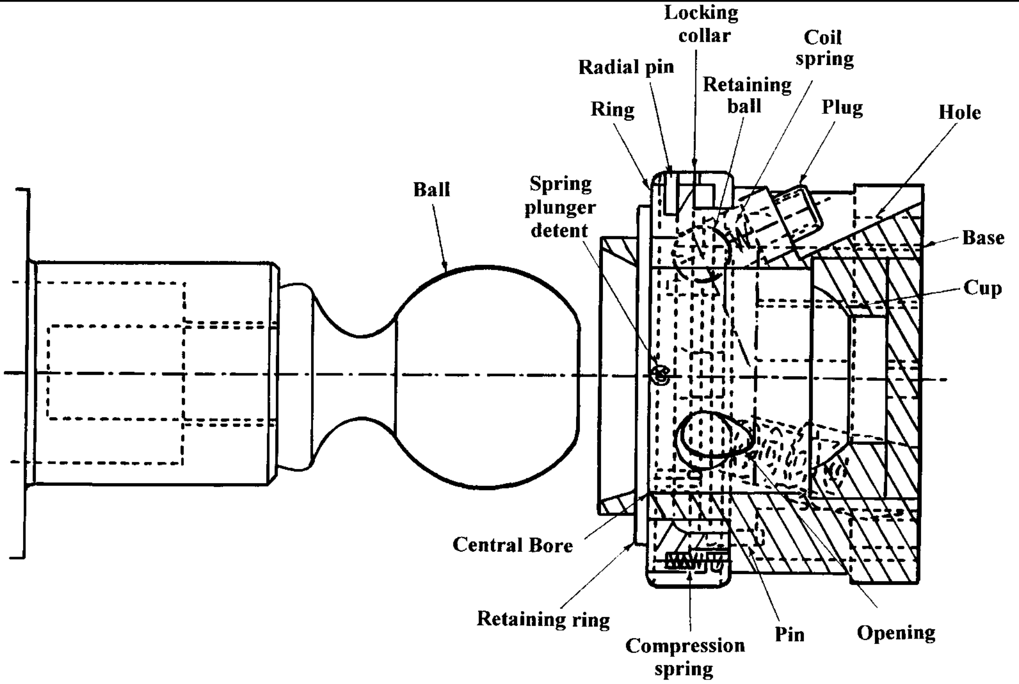
A pair of sawtooth wedges clamped between a pair of plates holds one end of a specimen. A mirror image of this grip is attached at the other end of the specimen. An alignment fixture (not shown) holds the grips and specimen during assembly.

In contrast, some older plate grips tended to sip at high temperatures when applied tensile stresses rose above 20 kpsi (≈ 140 Mpa), while older hydraulically actuated grips could not be allowed inside the testing furnaces, which introduced temperature gradients in the specimens.

This work was done by Rebecca A. MacKay and Michael V. Nathal of **Lewis Research Center.**

PASSIVE CAPTURE JOINT WITH THREE DEGREES OF FREEDOM

New joint allows quick connection between any two structural elements where rotation in all three axis is desired.
Marshall Space Flight Center, Alabama



The three-degrees-of-freedom capability of the **Passive Capture Joint** provides for quick connect and disconnect operations.

A new joint, proposed for use on an attachable debris shield for the International Space Station Service Module, has potential for commercial use in situations where hardware must be assembled and disassembled on a regular basis.

This joint can be useful in a variety of applications, including replacing the joints commonly used on trailer-hitch tongues and temporary structures, such as crane booms and rigging. Other uses for this joint include assembly of structures where simple rapid deployment is essential, such as in space, undersea, and in military structures.

This new joint allows for quick connection between any two structural elements where it is desirable to have rotation in all three axes. The joint can be fastened by moving the two halves into position. The joint is then connected by inserting the ball into the bore of the base. When the joint ball is fully inserted, the joint will lock with full strength. Release of this joint involves only a simple movement and rotation of one part. The joint can then be easily separated.

Most passive capture devices allow only axial rotation when fastened—if any movement is allowed at all. Manually- or power-actuated active joints require an additional action, or power and control signal, as well as a more complex mechanism.

The design for this new joint is relatively simple. It consists of two halves, a ball mounted on a stem (such as those on a common trailer-hitch ball) and a socket. The socket contains all the moving parts and is the important part of this invention. The socket also has a base, which contains a large central cylindrical bore ending in a spherical cup.

This work was done by Bruce Weddendorf and Richard A. Cloyd of the **Marshall Space Flight Center**.

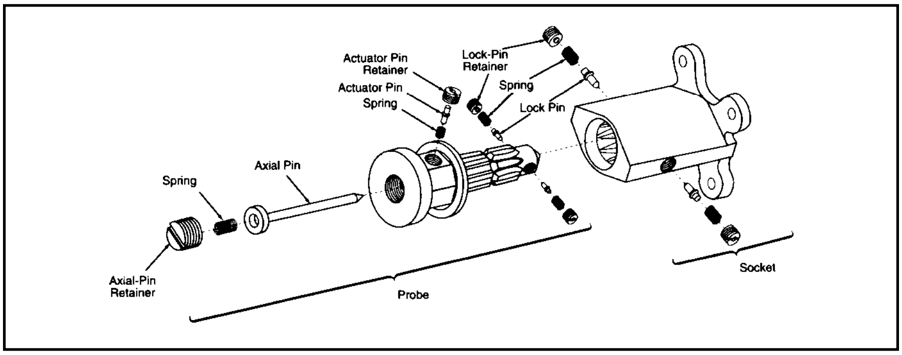
PROBE-AND-SOCKET FASTENERS FOR ROBOTIC ASSEMBLY

Self-alignment and simplicity of actuation make this fastener amenable to robotic assembly.

Lyndon B. Johnson Space Center, Houston, Texas

A probe-and-socket fastening mechanism was designed to be operated by a robot. The mechanism is intended to enable a robot to set up a workstation in a hostile environment, for example. The workstation can then be used by an astronaut, aquanaut, or other human who could then spend minimum time in the environment. The human can concentrate on performing quality work rather than spending time setting up equipment, with consequent reduction of risk.

The mechanism (see figure) includes (1) a socket, which would be mounted on a structure at the worksite, and (2) a probe, which would be mounted on a piece of equipment to be attached to the structure at the socket. The probe-and-socket fastener is intended for use in conjunction with a fixed target that would aid in the placement of the end effector of the robot during grasping. There would also be a handle or handles on the structure. The robot would move the probe near the socket and depress the actuator pin in the probe. The inward motion of the actuator pin would cause rearward motion of the axial pin, thereby allowing two spring-loaded lockpins to retract into the probe. The robot would then begin to insert the probe into the socket.



Lockpins in the probe engage radial holes (not shown) in the socket. Depressing the actuator pin temporarily retracts the lockpins into the probe so that the probe can be inserted in the socket.

Tapered grooves in the socket mesh with tapered ridges on the probe, thereby aligning the fastener parts and preventing binding. When the probe bottoms out in the socket, the robot releases its grip on the actuator pin. The resulting forward motion of the axial pin pushes the lockpins of the probe outward into mating holes (not shown) in the socket. Also, when the probe bottoms in the socket, additional lockpins in the socket spring into detents located at about the midlength of the tapered ridges on the probe.

This work was done by Karen Nyberg of **Johnson Space Center.**