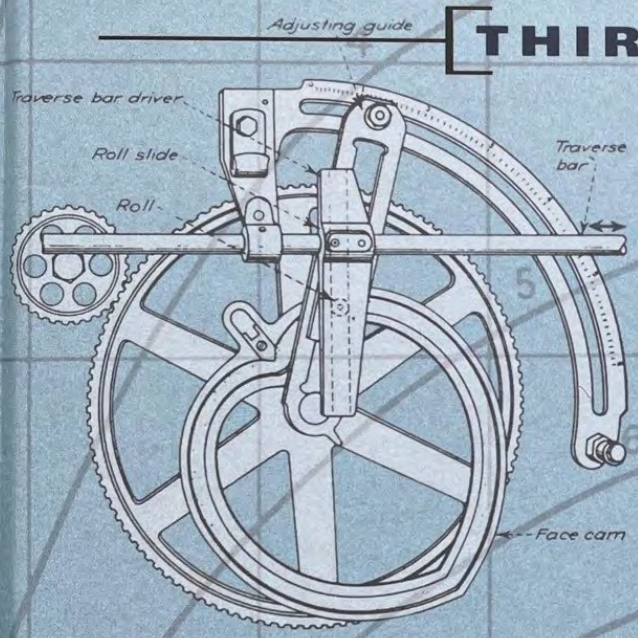
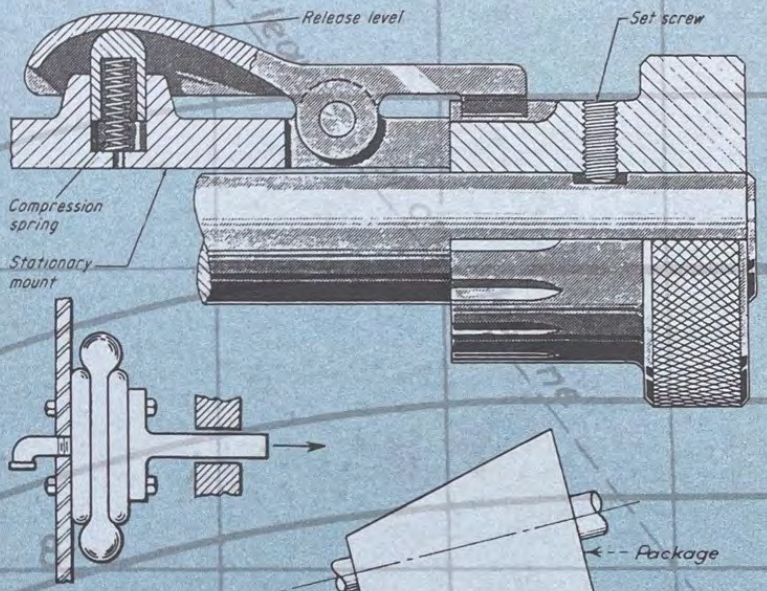
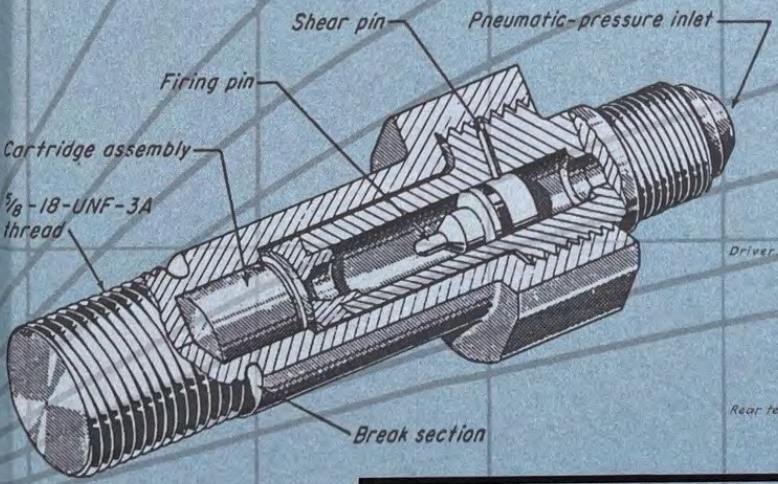
# MECHANISMS and MECHANICAL DEVICES SOURCEBOOK

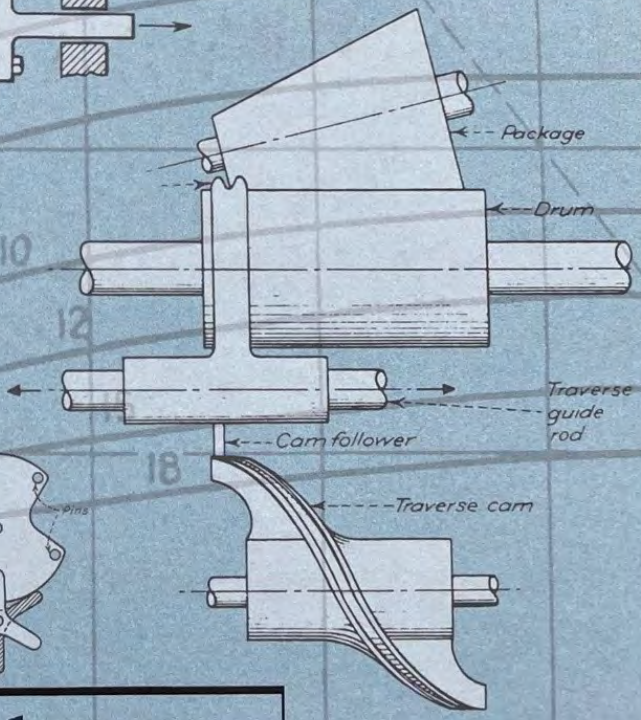
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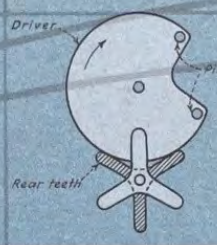





**Neil Sclater**
**Nicholas P. Chironis**

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# MECHANISMS & MECHANICAL DEVICES SOURCEBOOK

**Third Edition**

NEIL SCLATER
NICHOLAS P. CHIRONIS

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# PREFACE

This is the third edition of *Mechanisms & Mechanical Devices Sourcebook*, a well illustrated reference book containing a wide range of information on both classical and modern mechanisms and mechanical devices. This edition retains a large core of the contents from both the first and second editions, (published in 1991 and 1996, respectively), that has been supplemented by new and revised articles reflecting present and future trends in mechanical engineering and machine design.

The new articles in this edition address topics that are covered regularly in mechanical engineering and science magazines as well as being the subjects of technical papers presented at engineering conferences. Among these new articles is an overview of motion control systems, highlighting the influence of programmable computer and digital technology on those systems. Other articles discuss servomotors, actuators, solenoids, and feedback sensors—important electromechanical, and electronic components used in motion control systems. Also included are articles on gearheads, single-axis motion guides, and X-Y motion systems assembled from stock mechanical components.

Other articles in this edition describe commercially available 2D and 3D CAD (computer-aided design) software and update previous articles on industrial robots and rapid prototyping (RP) systems. Another article reviews recent research in MEMS (microelectromechanical systems) and recent spinoffs of that technology. All of these subjects are continuing to influence the direction of mechanical engineering, and they are having a profound impact on engineering education and practice.

Since the publication of the second edition, the term *mechatronics* has gained wider acceptance as a word that identifies an ongoing trend in mechanical engineering—the merging of mechanics, electronics, and computer science. Coined in Japan in the 1970s, mechatronics describes the synergistic blend of technologies that has led to the creation of many new functional and adaptable products that could not have been produced with a purely mechanical approach. While there is no formal definition of mechatronics, most mechanical engineers agree on its meaning.

The concept of mechatronics has been illustrated as a Venn diagram showing four overlapping circles representing the fields of *mechanics, electronics, computers,* and *controls*. Over the years, this convergence has spawned the more specialized disciplines of *electromechanics, computer-aided design, control electronics,* and *digital control systems*, all considered to be within the purview of mechatronics. These specialties have, in turn, fostered the creation of the even more focused technologies of *system analysis, transducers, simulation,* and *microcontrollers*.

Some of the important consumer products that have been identified as resulting from the practice of mechatronics are the computer hard-disk drive, the inkjet printer, the digital video disk (DVD) player, and the camcorder. Examination of these products reveals that they are eclectic assemblies of different kinds of mechanical devices, motors, electronic circuits, and in some of them, optics.

The inclusion of such classical mechanical elements as gears, levers, clutches, cams, leadscrews, springs, and motors in those advanced products is evidence that they still perform valuable functions, making it quite likely that they will continue to be included in the new and different products to be developed in this century.

A major attraction of the earlier editions of this book has been their cores of illustrations and descriptions of basic mechanisms and mechanical devices, accompanied by useful applications information. This material has been culled from a wide range of books and magazines that were published during the last half century. In an era of rapidly changing technology, most of this hardware has retained its universal value. As a result, this book has become recognized worldwide as a unique repository of historical engineering drawings and data not available in other more formal books. These earlier editions have served as a convenient technical reference and even as inspirational "mind-joggers" for seasoned professional machine designers as well as learning aids for engineering students.

Readers trying to arrive at new and different solutions for machine design problems can thumb through these pages, study their many illustrations, and consider adapting some of the successful mechanical inventions of the past to their new applications. Thus, proven solutions from the past can be recycled to perform new duties in the present. An old invention might be transferred without modification, or perhaps it could be improved if made from newer materials by newer manufacturing methods. What is old can be new again! For those unable to find instant solutions, this book contains a chapter of tutorial text and formulas for the design of certain basic mechanisms from scratch.

It is assumed that the reader is familiar with the basics of mechanics gained from formal education, practical experience, or both. This book is expected to be of most value to practicing machine designers and mechanical engineers, but its contents should


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also be of use to machine design instructors at the college and vocational school level, amateur and professional inventors, and students of all of the engineering disciplines and physical sciences. Last but not least, it is hoped that the book will be attractive to those who simply enjoy looking at illustrations of machines and figuring out how they work.

The drawings in this edition have stood the test of time. Certain material published in the previous editions has been deleted because reader feedback suggested that important design details were missing or unclear. Also, some material considered to be obsolete and unsuitable for new designs was deleted. For example, clockwork mechanisms for timing, control, and display have almost universally been replaced in contemporary designs by more cost-effective electronic modules that perform the same functions.

References to manufacturers or publications that no longer exist were deleted so that readers will not waste time trying to contact them for further information. However, the names of the inventors, where previously given, have been retained to help the reader who may want to do further research on any patents now or once held by those individuals.

Many of the mechanisms illustrated in this book were invented by anonymous artisans, millwrights, instrument makers, and mechanics over the past centuries. They left behind the sketches, formal drawings, and even the working models on which many of the illustrations in this book are based. It is also worth noting that many of the most influential machines from the water pump, steam engine, and chronometer, to the cotton gin, and airplane were invented by self-trained engineers, scientists, and technicians.

By themselves, many of the mechanisms and devices described in this book are just mechanical curiosities, but when integrated by creative minds with others, they can perform new and different functions. One need only consider the role of basic mechanisms in the crucial inventions of the past century—the airplane, the helicopter, the jet engine, the programmable robot, and most of our familiar home appliances.

Have you noticed how the size of objects is both increasing and decreasing? There is now a 142,000-ton cruise ship that can accommodate more than 5000 passengers, and plans have been announced for building jumbo jet aircraft capable of carrying more than 500 passengers. Moreover, laptop computers now have more computing power than mainframe computers that filled a room a quarter century ago. Work is progressing in efforts to combine the functions of computer, cellular telephone, personal digital assistant (PDA), and Internet-access terminal in a single wireless handheld device.

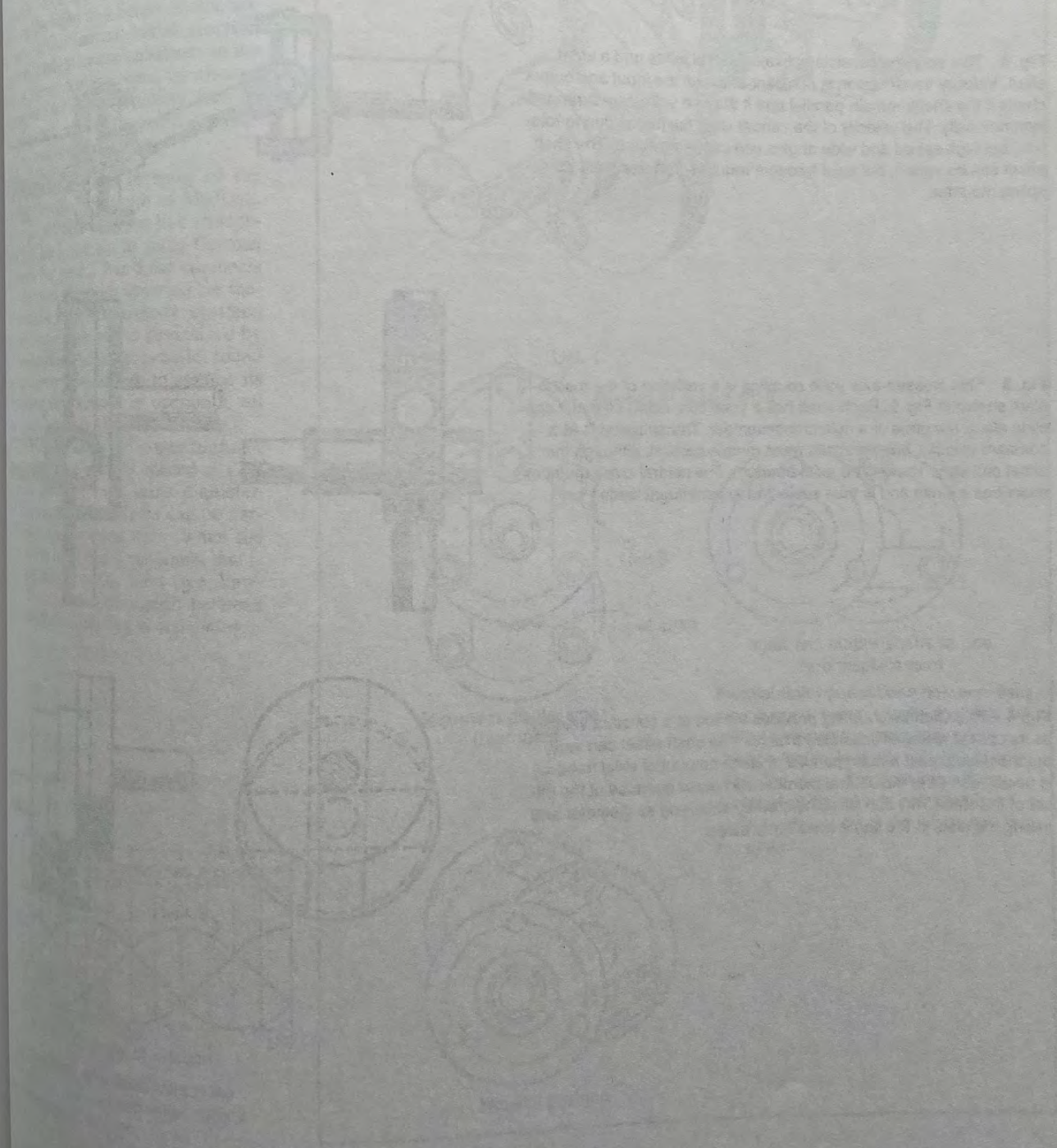
MEMS are expected to evolve beyond their current prime roles as sensors to become security locks for computers, optical switches, and practical micromachines. Meanwhile, scientists are studying the feasibility of microminiature, self-propelled capsules made with even smaller-scale nanotechnology that could navigate through the human body and seek out, diagnose, and treat diseases at their source.

*—Neil Sclater*



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# CHAPTER 9
# COUPLING, CLUTCHING, AND BRAKING DEVICES



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# BASIC MECHANICAL CLUTCHES

Both friction and positive clutches are illustrated here. Figures 1 to 7 show externally controlled clutches, and Figures 8 to 12 show internally controlled clutches which are further divided into overload relief, overriding, and centrifugal versions.

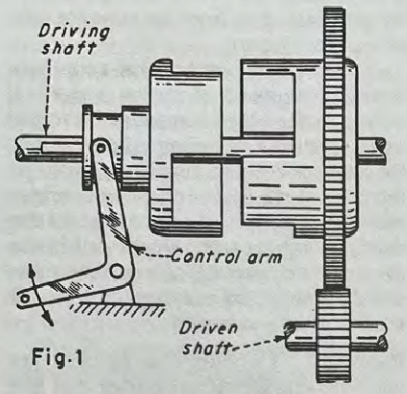


Fig. 1

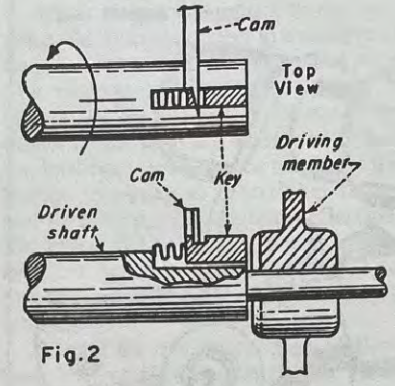


Fig. 2

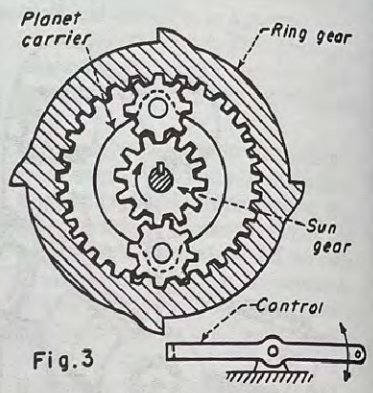


Fig. 3

**Fig. 1 Jaw Clutch:** The left sliding half of this clutch is feathered to the driving shaft while the right half rotates freely. The control arm activates the sliding half to engage or disengage the drive. However, this simple, strong clutch is subject to high shock during engagement and the sliding half exhibits high inertia. Moreover, engagement requires long axial motion.

**Fig. 2 Sliding Key Clutch:** The driven shaft with a keyway carries the freely rotating member with radial slots along its hub. The sliding key is spring-loaded but is restrained from the engaging slots by the control cam. To engage the clutch, the control cam is raised and the key enters one of the slots. To disengage it, the cam is lowered into the path of the key and the rotation of the driven shaft forces the key out of the slot in the driving member. The step on the control cam limits the axial movement of the key.

**Fig. 3 Planetary Transmission Clutch:** In the disengaged position shown, the driving sun gear causes the free-wheeling ring gear to idle counter-clockwise while the driven planet carrier remains motionless. If the control arm blocks ring gear motion, a positive clockwise drive to the driven planet carrier is established.

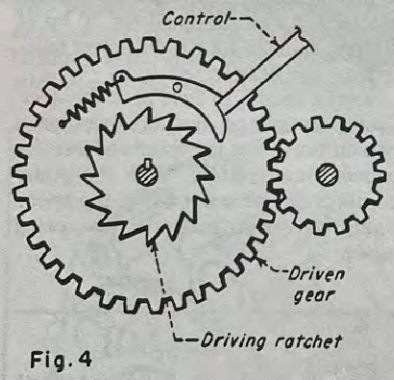


Fig. 4

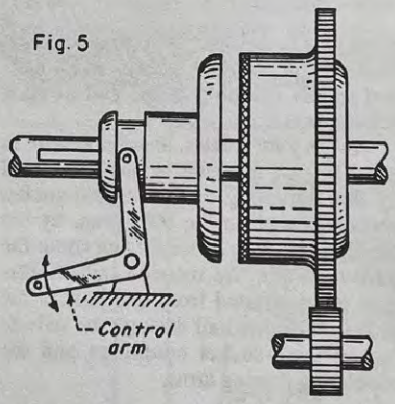


Fig. 5

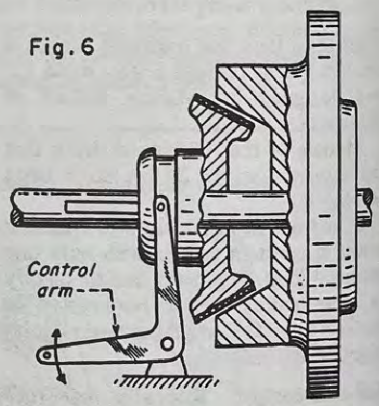


Fig. 6

**Fig. 4 Pawl and Ratchet Clutch:** (External Control) The driving ratchet of this clutch is keyed to the driving shaft, and the pawl is pinned to the driven gear which can rotate freely on the driving shaft. When the control arm is raised, the spring pulls in the pawl to engage the ratchet and drive the gear. To disengage the clutch the control arm is lowered so that driven gear motion will disengage the pawl and stop the driven assembly against the control member.

**Fig. 5 Plate Clutch:** The plate clutch transmits power through the friction developed between the mating plate faces. The left sliding plate is fitted with a feather key, and the right plate member is free to rotate on the shaft. Clutch torque capacity depends on the axial force exerted by the control half when it engages the sliding half.

**Fig. 6 Cone Clutch:** The cone clutch, like the plate clutch, requires axial movement for engagement, but less axial force is required because of the increased friction between mating cones. Friction material is usually applied to only one of the mating conical surfaces. The free member is mounted to resist axial thrust.



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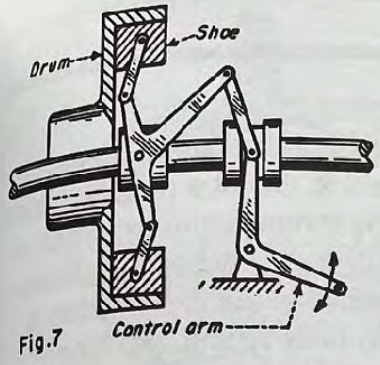


Fig.7

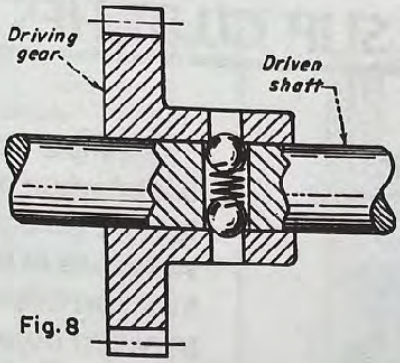


Fig.8

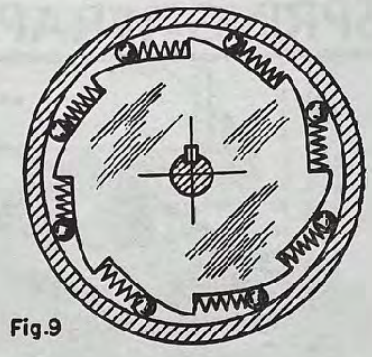
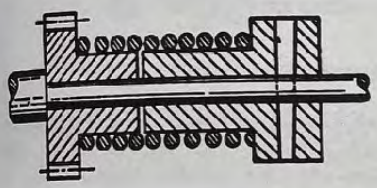

Fig.9

**Fig. 7 Expanding Shoe Clutch:** This clutch is engaged by the motion of the control arm. It operates linkages that force the friction shoes radially outwards so that they contact the inside surface of the drum.

**Fig. 8 Spring and Ball Radial Detent Clutch:** This clutch will hold the driving gear and driven gear in a set timing relationship until the torque becomes excessive. At that time the balls will be forced inward against their springs and out of engagement with the holes in the hub. As a result the driving gear will continue rotating while the drive shaft is stationary.

**Fig. 9 Cam and Roller Clutch:** This over-running clutch is better suited for higher-speed free-wheeling than a pawl-and-ratchet clutch. The inner driving member has cam surfaces on its outer rim that hold light springs that force the rollers to wedge between the cam surfaces and the inner cylindrical face of the driven member. While driving, friction rather than springs force the rollers to wedge tightly between the members to provide positive clockwise drive. The springs ensure fast clutching action. If the driven member should begin to run ahead of the driver, friction will force the rollers out of their tightly wedged positions and the clutch will slip.


Fig.10

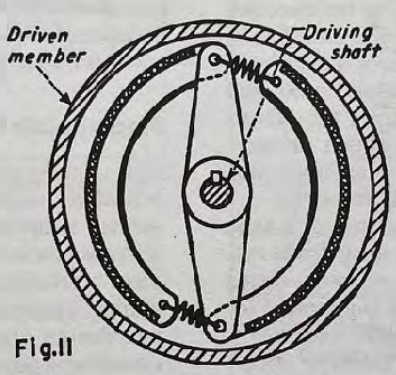


Fig.11

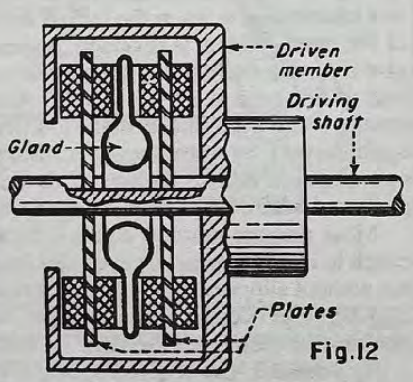


Fig.12

**Fig. 10 Wrapped Spring Clutch:** This simple unidirectional clutch consists of two rotating hubs connected by a coil spring that is press-fit over both hubs. In the driving direction the spring tightens around the hubs increasing the friction grip, but if driven in the opposite direction the spring unwinds causing the clutch to slip.

**Fig. 11 Expanding Shoe Centrifugal Clutch:** This clutch performs in a similar manner to the clutch shown in Fig. 7 except that there is no external control. Two friction shoes, attached to the driving member, are held inward by springs until they reach the "clutch-in" speed. At that speed centrifugal force drives the shoes outward into contact with the drum. As the drive shaft rotates faster, pressure between the shoes against the drum increases, thus increasing clutch torque.

**Fig. 12 Mercury Gland Clutch:** This clutch contains two friction plates and a mercury-filled rubber bladder. At rest, mercury fills a ring-shaped cavity around the shaft, but when rotated at a sufficiently high speed, the mercury is forced outward by centrifugal force. The mercury then spreads the rubber bladder axially, forcing the friction plates into contact with the opposing faces of the housing to drive it.

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# SEVEN OVERRUNNING CLUTCHES

*These are simple devices that can be made inexpensively in the workshop.*

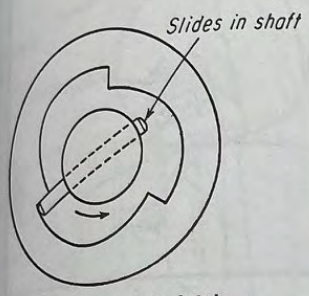



Fig. 1 **A lawnmower clutch.**

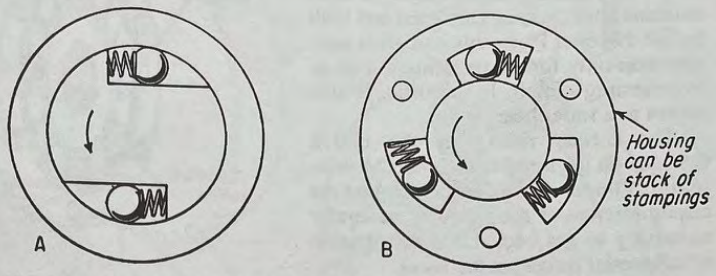



Fig. 2 **Wedging balls or rollers:** internal (A); external (B) clutches.

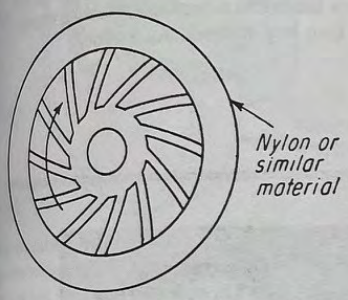



Fig. 3 **Molded sprags** (for light duty).

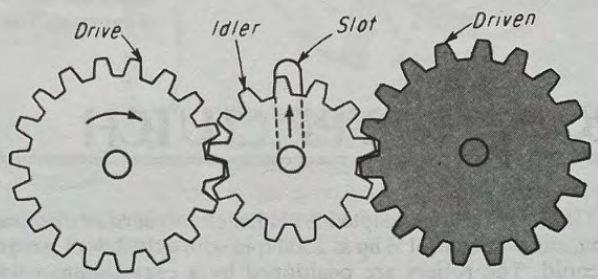



**Fig. 4 A disengaging idler** rises in a slot when the drive direction is reversed.

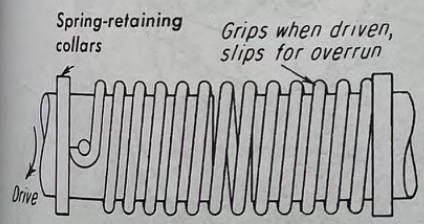



Fig. 5 **A slip-spring coupling.**



**Fig. 6 An internal ratchet** and spring-loaded pawls.

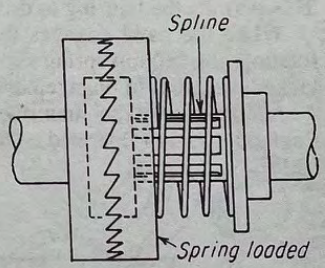
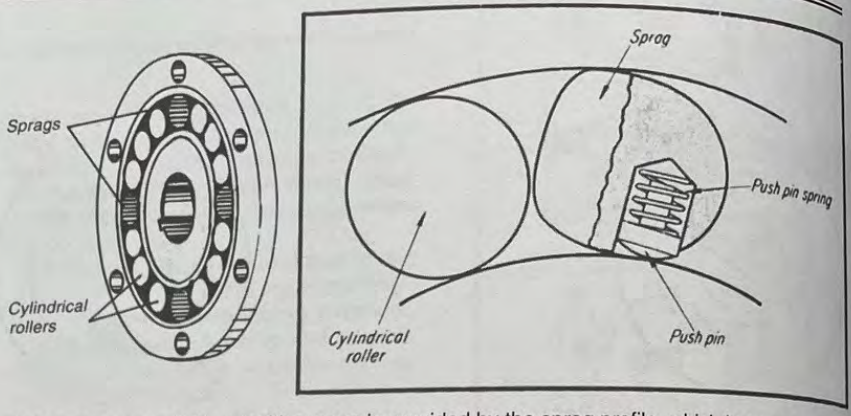



**Fig. 7 A one-way dog clutch.**

# SPRING-LOADED PINS AID SPRAGS IN ONE-WAY CLUTCH

Sprags combined with cylindrical rollers in a bearing assembly can provide a simple, low-cost method for meeting the torque and bearing requirements of most machine applications. Designed and built by Est. Nicot of Paris, this unit gives one-direction-only torque transmission in an overrunning clutch. In addition, it also serves as a roller bearing.

The torque rating of the clutch depends on the number of sprags. A minimum of three, equally spaced around the circumference of the races, is generally necessary to get acceptable distribution of tangential forces on the races.




**Races are concentric;** a locking ramp is provided by the sprag profile, which is composed of two nonconcentric curves of different radius. A spring-loaded pin holds the sprag in the locked position until the torque is applied in the running direction. A stock roller bearing cannot be converted because the hard-steel races of the bearing are too brittle to handle the locking impact of the sprag. The sprags and rollers can be mixed to give any desired torque value.

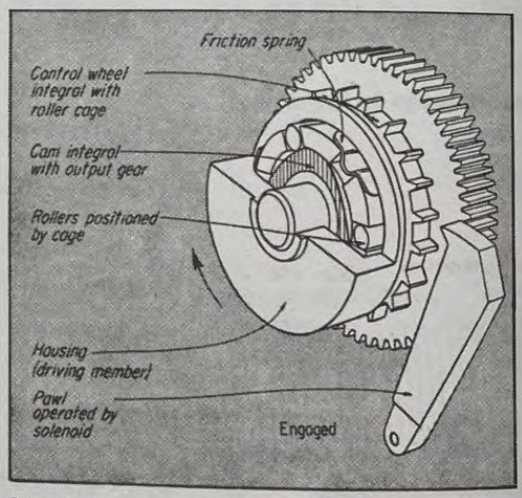
# ROLLER-TYPE CLUTCH

This clutch can be adapted for either electrical or mechanical actuation, and will control ½ hp at 1500 rpm with only 7 W of power in the solenoid. The rollers are positioned by a cage (integral with the toothed control wheel —see diagram) between the ID of the driving housing and the cammed hub (integral with the output gear).

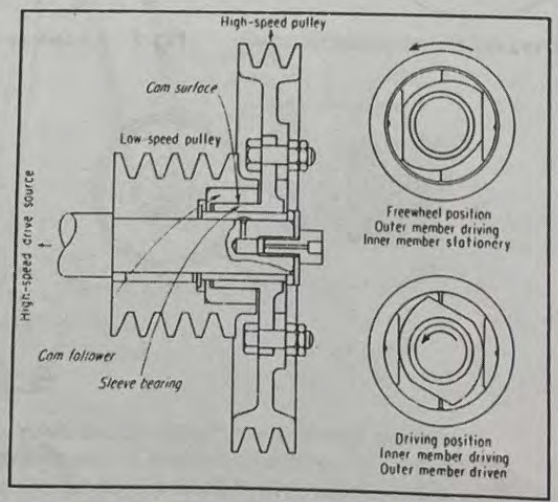
When the pawl is disengaged, the drag of the housing on the friction spring rotates the cage and wedges the rollers into engagement. This permits the housing to drive the gear through the cam.

When the pawl engages the control wheel while the housing is rotating, the friction spring slips inside the housing and the rollers are kicked back, out of engagement. Power is therefore interrupted.

According to the manufacturer, Tiltman Langley Ltd, Surrey, England, the unit operated over the full temperature range of –40° to 200°F.




**A positive drive** is provided by this British roller clutch.




Two-speed operation is provided by the new cam clutch

This clutch consists of two rotary members (see diagrams), arranged so that the outer (follower) member acts on its pulley only when the inner member is driving. When the outer member is driving, the inner member idles. One application was in a dry-cleaning machine. The clutch functions as an intermediary between an ordinary and a high-speed motor to provide two output speeds that are used alternately.



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# DETAILS OF OVERRIDING CLUTCHES

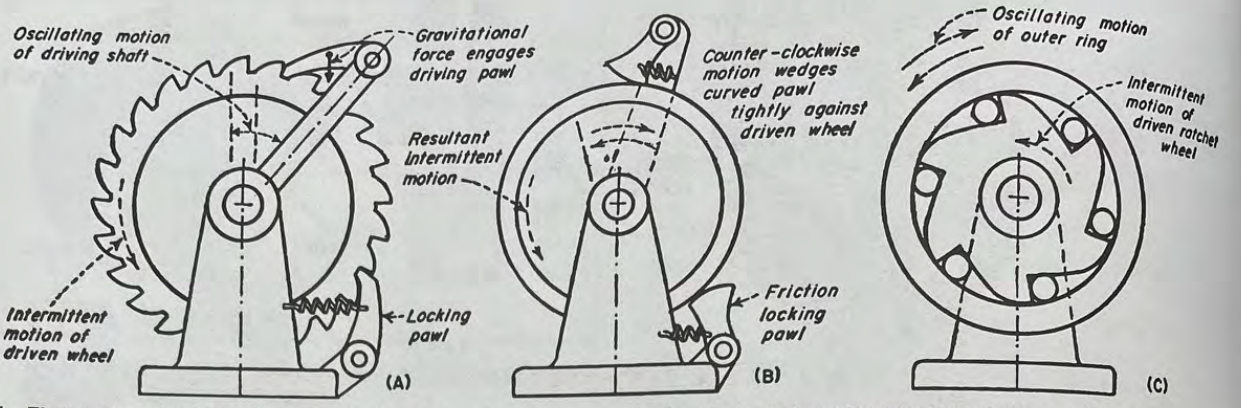



**Fig. 1 Elementary overriding clutches:** (A) A ratchet and pawl mechanism converts reciprocating or oscillating movement to intermittent rotary motion. This motion is positive but limited to a multiple of the tooth pitch. (B) A friction-type clutch is quieter, but it requires a spring device to keep the eccentric pawl in constant engagement. (C) Balls or rollers replace the pawls in this device. Motion of the outer race wedges the rollers against the inclined surfaces of the ratchet wheel.

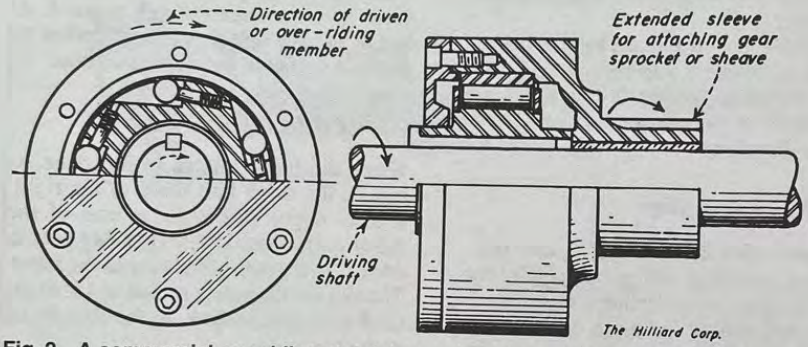



**Fig. 2 A commercial overriding clutch** has springs that hold the rollers in continuous contact between the cam surfaces and the outer race; thus, there is no backlash or lost motion. This simple design is positive and quiet. For operation in the opposite direction, the roller mechanism can easily be reversed in the housing.

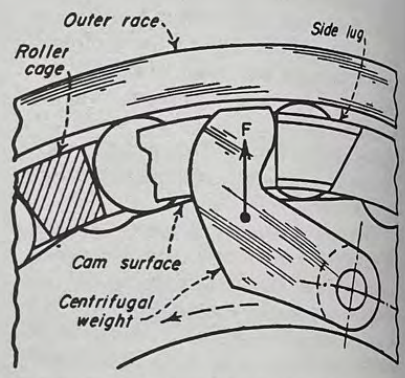



**Fig. 3 A centrifugal force** can hold the rollers in contact with the cam and outer race. A force is exerted on the lugs of the cage that controls the position of the rollers.

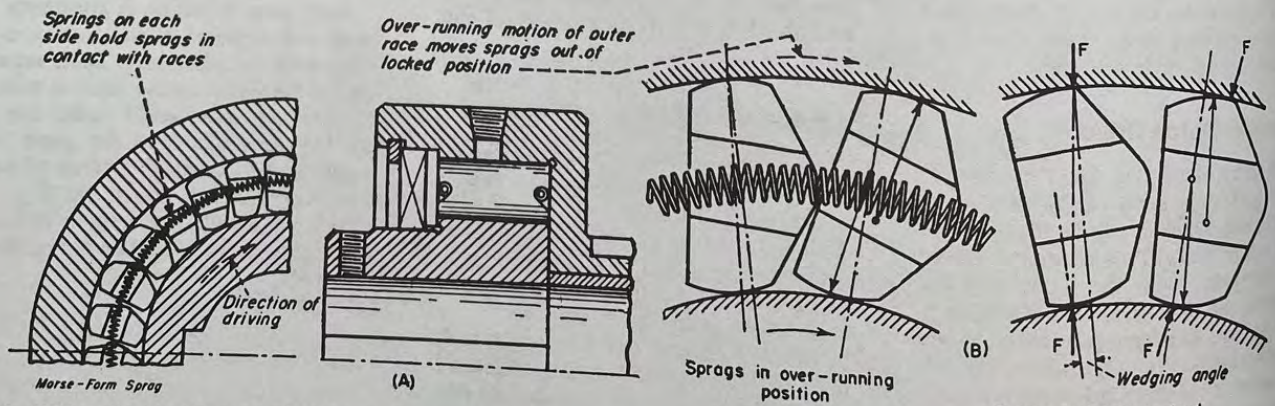



**Fig. 4 With cylindrical inner and outer races,** sprags can transmit torque. Energizing springs serve as a cage to hold the sprags. (A) Compared to rollers, the shape of a sprag permits a greater number within a limited space; thus higher torque loads are possible. Special cam surfaces are not required, so this version can be installed inside gear or wheel hubs. (B) Rolling action wedges the sprags tightly between the driving and driven members. A relatively large wedging angle ensures positive engagement.



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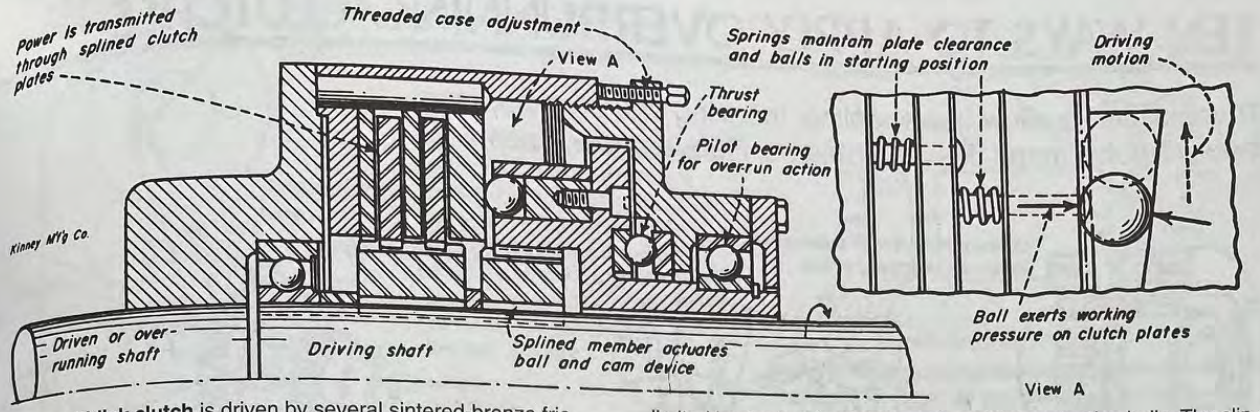



**Fig. 5 A multidisk clutch** is driven by several sintered-bronze friction surfaces. Pressure is exerted by a cam-actuating device that forces a series of balls against a disk plate. A small part of the transmitted torque is carried by the actuating member, so capacity is not limited by the localized deformation of the contacting balls. The slip of the friction surfaces determines the capacity and prevents rapid shock loads. The slight pressure of disk springs ensures uniform engagement.

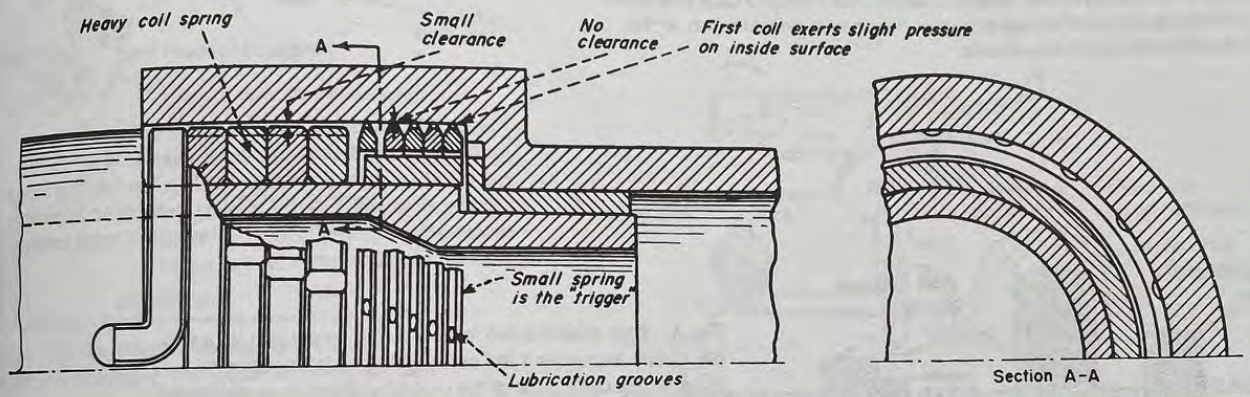



**Fig. 6 An engaging device** consists of a helical spring that is made up of two sections: a light trigger spring and a heavy coil spring. It is attached to and driven by the inner shaft. The relative motion of the outer member rubbing on the trigger causes this spring to wind up. This action expands the spring diameter, which takes up the small clearance and exerts pressure against the inside surface until the entire spring is tightly engaged. The helix angle of the spring can be changed to reverse the overriding direction.

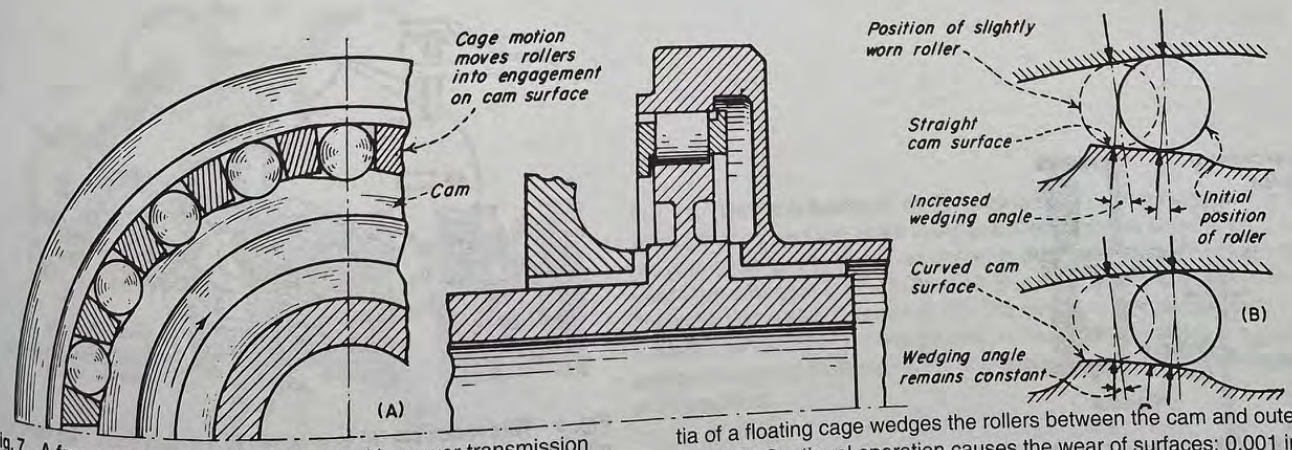



**Fig. 7 A free-wheeling clutch** widely used in power transmission has a series of straight-sided cam surfaces. An engaging angle of about 3º is used; smaller angles tend to become locked and are difficult to disengage while larger ones are not as effective. (A) The inertia of a floating cage wedges the rollers between the cam and outer race. (B) Continual operation causes the wear of surfaces; 0.001 in. wear alters the angle to 8.5º on straight-sided cams. Curved cam surfaces maintain a constant angle.


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# TEN WAYS TO APPLY OVERRUNNING CLUTCHES

These clutches allow freewheeling, indexing and backstopping; they will solve many design problems. Here are examples.

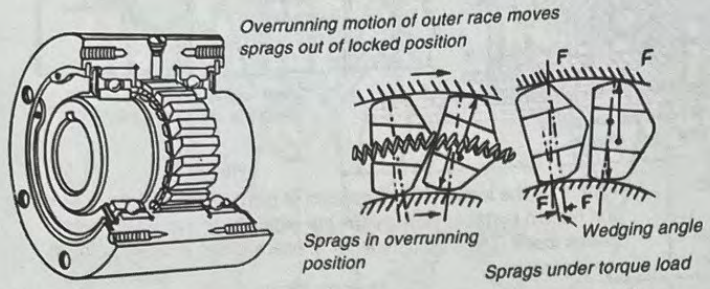



**Fig. 1 Precision sprags** act as wedges and are made of hardened alloy steel. In the formsprag clutch, torque is transmitted from one race to another by the wedging action of sprags between the races in one direction; in the other direction the clutch freewheels.

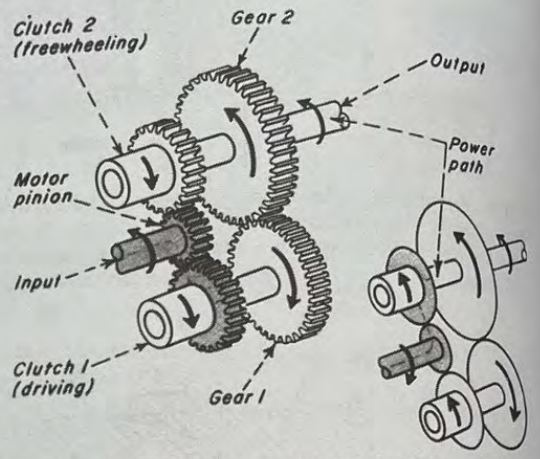



**Fig. 2 This speed drive** requires input rotation to be reversible. Counterclockwise input (as shown in the diagram) drives gear 1 through clutch 1; the output is counterclockwise; clutch 2 overruns. Clockwise input (schematic) drives gear 2 through clutch 2; the output is still counterclockwise; clutch 1 overruns.

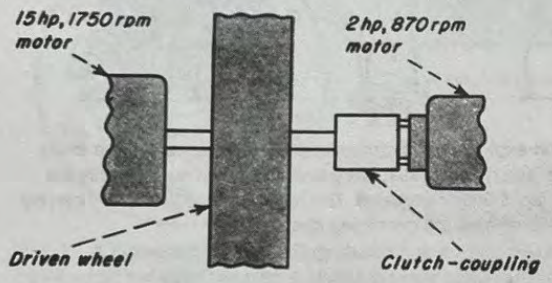



**Fig. 3 This speed drive** for a grinding wheel can be a simple, in-line assembly if the overrunning clutch couples two motors. The outer race of the clutch is driven by a gearmotor; the inner race is keyed to a grinding-wheel shaft. When the gearmotor drives, the clutch is engaged; when the larger motor drives, the inner race overruns.

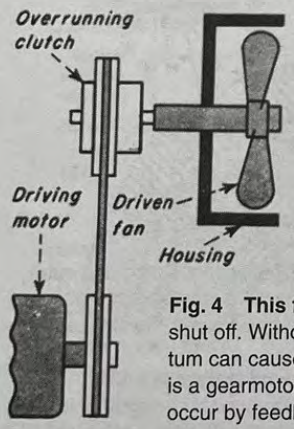



**Fig. 4 This fan freewheels** when driving power is shut off. Without an overrunning clutch, fan momentum can cause belt breakage. If the driving source is a gearmotor, excessive gear stress can also occur by feedback of kinetic energy from the fan.

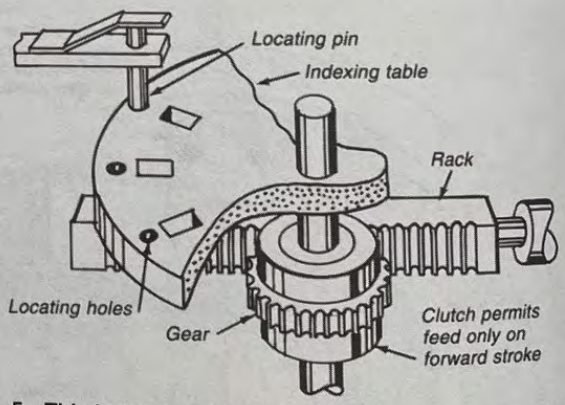



**Fig. 5 This indexing table** is keyed to a clutch shaft. The table is rotated by the forward stroke of the rack; power is transmitted through the clutch by its outer-ring gear only during this forward stroke. Indexing is slightly short of the position required. The exact position is then located by a spring-loaded pin that draws the table forward to its final positioning. The pin now holds the table until the next power stroke of the hydraulic cylinder.



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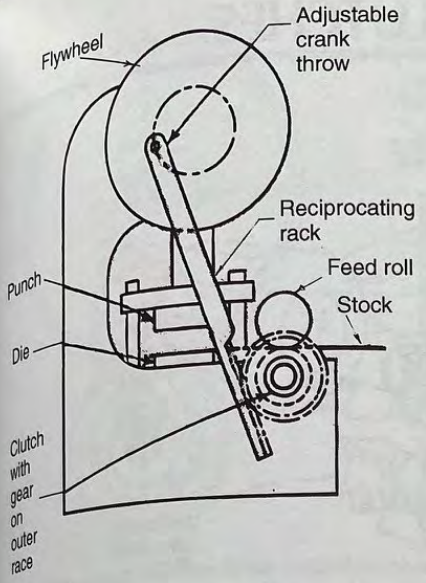



**Fig. 6 This punch press feed** is arranged so that the strip is stationary on the downstroke of the punch (clutch freewheels); feed occurs during the upstroke when the clutch transmits torque. The feed mechanism can easily be adjusted to vary the feed amount.

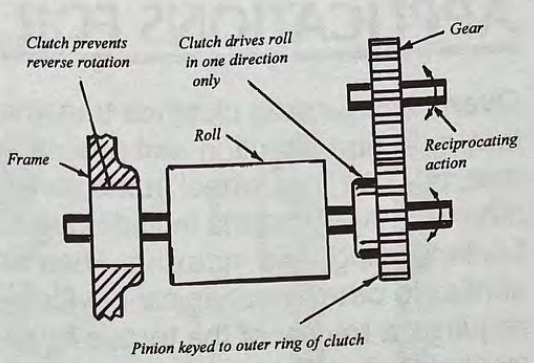



**Fig. 7 Indexing and backstopping** is done with two clutches arranged so that one drives while the other freewheels. The application shown here is for a capsuling machine; gelatin is fed by the roll and stopped intermittently so the blade can precisely shear the material to form capsules.

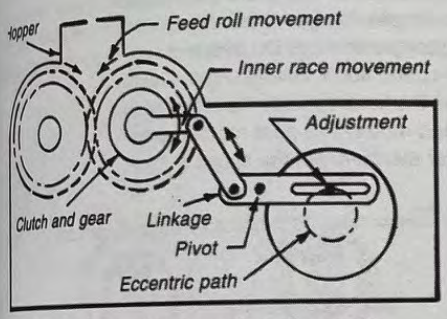



**Fig. 8 The intermittent motion** of a candy machine is adjustable. The clutch ratchets the feed rolls around. This keeps the material in the hopper agitated.

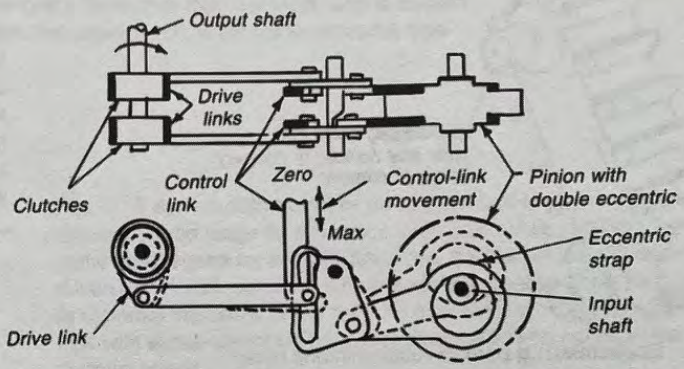



**Fig. 9 This double-impulse drive** has double eccentrics and drive clutches. Each clutch is indexed 180° out of phase with the other. One revolution of the eccentric produces two drive strokes. Stroke length, and thus the output rotation, can be adjusted from zero to maximum by the control link.

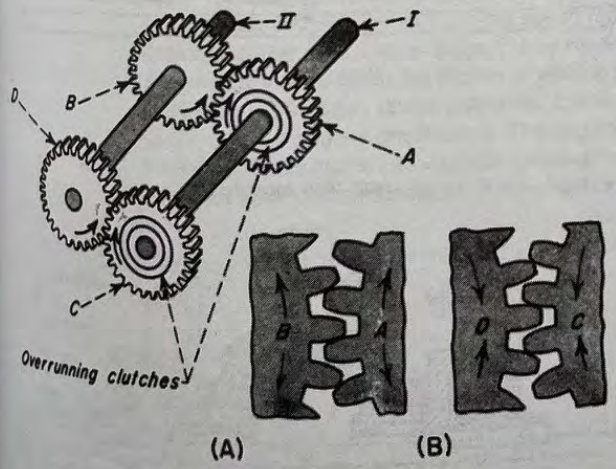



**Fig. 10 This anti-backlash device** depends on overrunning clutches to ensure that no backlash is left in the unit. Gear *A* drives *B* and shaft *II* with the gear mesh and backlash, as shown in (A). The overrunning clutch in gear *C* permits gear *D* (driven by shaft *II*) to drive gear *C* and results in the mesh and backlash shown in (B). The overrunning clutches never actually overrun. They provide flexible connections (something like split and sprung gears) between shaft *I* and gears *A* and *C* to allow absorption of all backlash.

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# APPLICATIONS FOR SPRAG-TYPE CLUTCHES

Overrunning sprag clutches transmit torque in one direction and reduce speed, rest, hold, or free-wheel in the reverse direction. Applications include overrunning, backstopping, and indexing. Their selection—similar to other mechanical devices—requires a review of the torque to be transmitted, overrunning speed, type of lubrication, mounting characteristics, environmental conditions, and shock conditions that might be encountered.

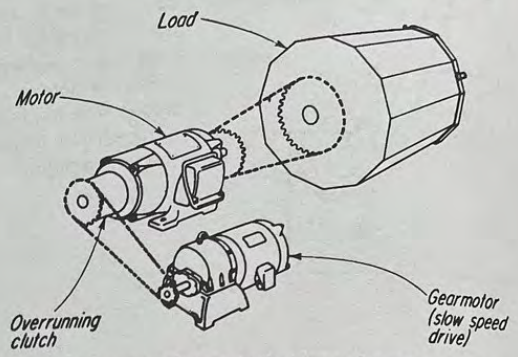



**Fig. 1 Overrunning** permits torque transmission in one direction and free wheels or overruns in the opposite direction. For example, the gar motor drives the load by transmitting torque through the overrunning clutch and the high-speed shaft. Energizing the high-speed motor causes the inner member to rotate at the rpm of the high-speed motor. The gear motor continues to drive the inner member, but the clutch is free-wheeling.

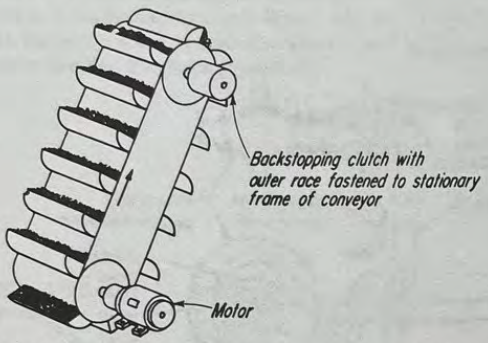



**Fig. 2 Backstopping** permits rotation in one direction only. The clutch serves as a counter-rotation holding device. An example is a clutch mounted on the headshaft of a conveyor. The outer race is restrained by torque-arming the stationary frame of the conveyor. If, for any reason, power to the conveyor is interrupted, the back-stopping clutch will prevent the buckets from running backwards and dumping the load.

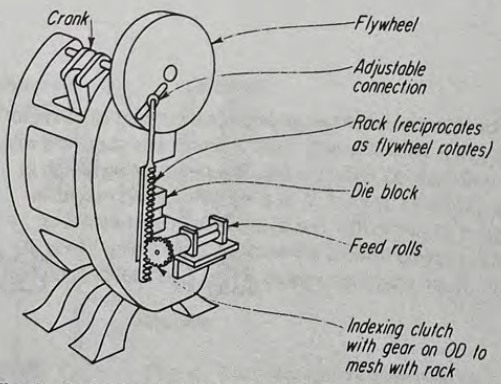



**Fig. 3 Indexing** is the transmission of intermittent rotary motion in one direction; an example is the feed rolls of a punch press. On each stroke of the press crankshaft, a feed stroke on the feed roll is accomplished by the rack-and-pinion system. The system feeds the material into the dies of the punch press.

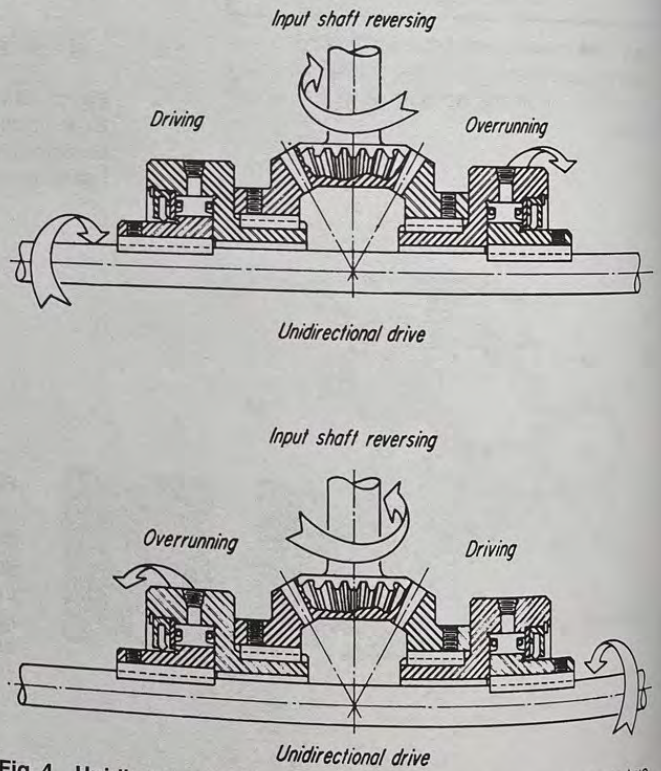



**Fig. 4 Unidirectional drives** with reverse mechanism incorporate two overrunning clutches into the gears, sheaves, or sprockets. Here, a 1:1 ratio right-angle drive is shown with a reversing input shaft. The output shaft rotates clockwise, regardless of the input shaft direction. By changing gear sizes, combinations of continuous or intermittent unidirectional output relative to the input can be obtained.



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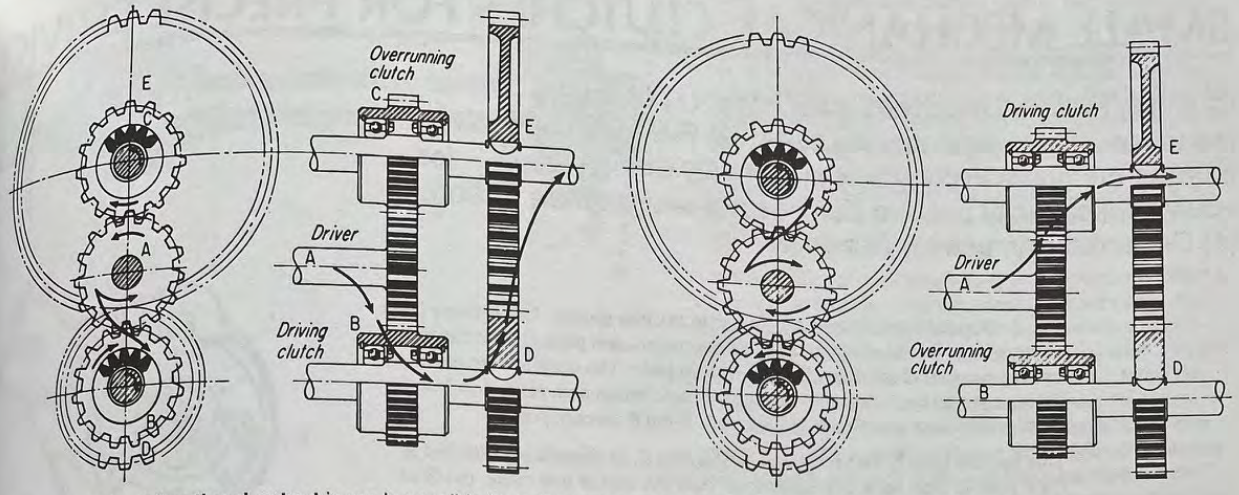



**Fig. 5 Two-speed unidirectional output** is made possible by using spur gears and reversing the direction of the input shaft. The rotation of shaft A transfers the power of gears B, D, and E to the output. Counterclockwise rotation engages the lower clutch, freewheeling the upper clutch because gear C is traveling at a faster rate than the shaft. This is caused by the reduction between gears B and E. Clockwise rotation of A engages the upper clutch, while the lower clutch freewheels because of the speed increase between gears D and E.

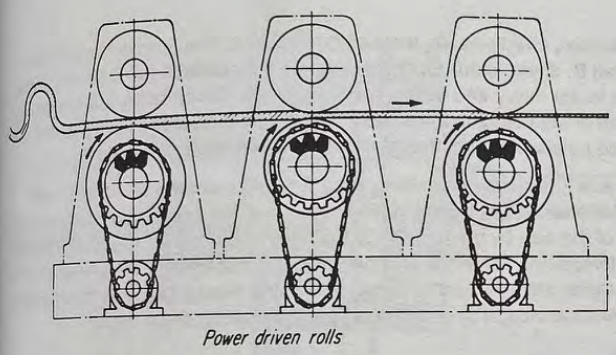



**Fig. 6 A speed-differential or compensation** is required where a different speed range for a function is desired, while retaining the same basic speed for all other functions. A series of individually driven power rolls can have different surface speeds because of drive or diameter variations of the rolls. An overrunning clutch permits the rolls with slower peripheral speed to overspeed and adjust to the material speed.

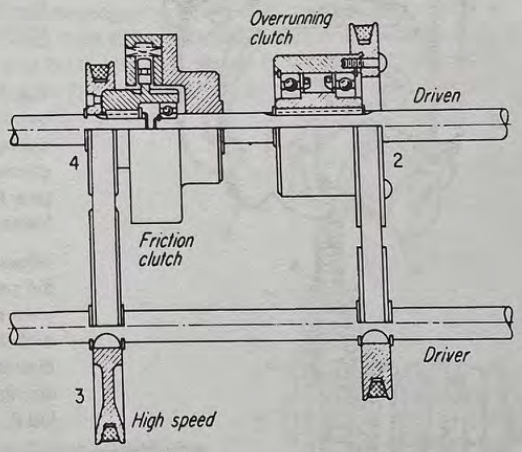



**Fig. 7 A speed differential application** permits the operation of engine accessories within a narrow speed range while the engine operates over a wide range. Pulley No. 2 contains the overrunning clutch. When the friction or electric clutch is disengaged, the driver pulley drives pulley No. 2 through the overrunning clutch, rotating the driven shaft. The engagement of the friction or electric clutch causes high-speed driven shaft rotation. This causes an overrun condition in the clutch at pulley No. 2.

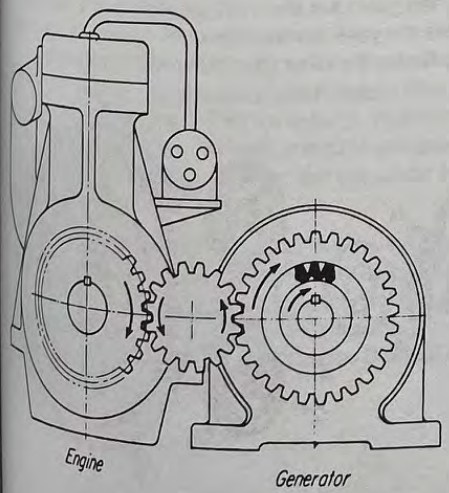



**Fig. 8 High inertia dissipation** avoids driving back through a power system. In machines with high resistances, it prevents power train damage. If the engine is shut down while the generator is under a no-load condition, it would have a tendency to twist off the generator shaft. The overrunning clutch allows generator deceleration at a slower rate than the engine deceleration.



LIFECORE EX. 1017

# SMALL MECHANICAL CLUTCHES FOR PRECISE SERVICE

Clutches for small machines must have: (1) Quick response—lightweight moving parts; (2) Flexibility—permit multiple members to control operation; (3) Compactness—for equivalent capacity positive clutches are smaller than friction; (4) Dependability; and (5) Durability.

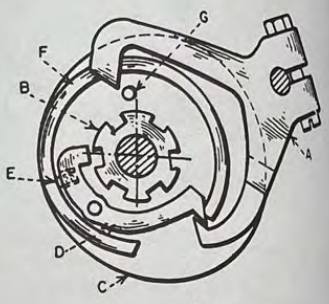



Fig. 1

**Fig. 1 A pawl and ratchet, single-cycle Dennis clutch.** The primary parts of this clutch are the driving ratchet B, the driven cam plate C, and the connecting pawl D, which is carried by the cam plate. The pawl is normally held disengaged by the lower tooth of clutch arm A. When activated, arm A rocks counterclockwise until it is out of the path of rim F on cam plate C.

This permits pawl D, under the effect of spring E, to engage with ratchet B. Cam plate C then turns clockwise until, near the end of one cycle, pin G on the plate strikes the upper part of arm A, camming it clockwise back to its normal position. The lower part of A then performs two functions: (1) it cams pawl D out of engagement with the driving ratchet B, and (2) it blocks the further motion of rim F and the cam plate.

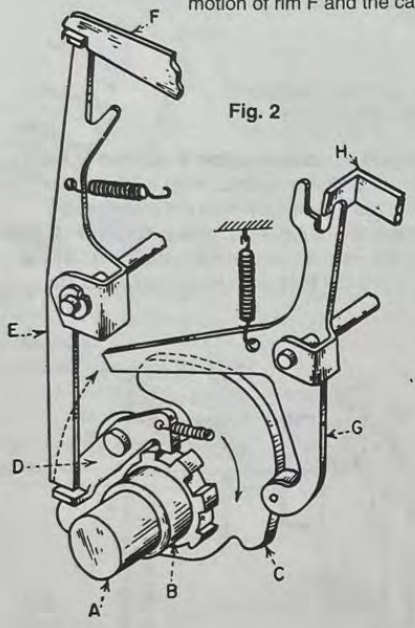



Fig. 2

**Fig. 2 A pawl and ratchet, single-cycle, dual-control clutch.** The principal parts of this clutch are driving ratchet B, driven crank C, and spring-loaded ratchet pawl D. Driving ratchet B is directly connected to the motor and free to rotate on rod A. Driven crank C is directly connected to the main shaft of the machine and is also free to move on rod A. Spring-loaded ratchet pawl D is carried by crank C, which is normally held disengaged by latch E.

To activate the clutch, arm F is raised, permitting latch E to trip and pawl D to engage with ratchet B. The left arm of clutch latch G, which is in the path of the lug on pawl D, is normally permitted to move out of the way by the rotation of the camming edge of crank C. For certain operations, block H is temporarily lowered. This prevents the motion of latch G, resulting in the disengagement of the clutch after part of the cycle. It remains disengaged until the subsequent raising of block H permits the motion of latch G and the resumption of the cycle.

**Fig. 3 Planetary transmission clutch.** This is a positive clutch with external control. Two gear trains provide a bi-directional drive to a calculator for cycling the machine and shifting the carriage. Gear A is the driver; gear L, the driven member, is directly connected to the planet carrier F. The planet consists of integral gears B and C. Gear B meshes with free-wheeling gear D. Gears D and G carry projecting lugs E and H, respectively. Those lugs can contact formings on arms J and K of the control yoke.

When the machine is at rest, the yoke is centrally positioned so that arms J and K are out of the path of the projecting lugs, permitting both D and G to free-wheel. To engage the drive, the yoke rocks clockwise, as shown, until the forming on arm K engages lug H, blocking further motion of ring gear G. A solid gear train is thereby established, driving F and L in the same direction as the drive A. At the same time, the gear train alters the speed of D as it continues counterclockwise. A reversing signal rotates the yoke counterclockwise until arm J encounters lug E, blocking further motion of D. This actuates the other gear train with the same ratio.

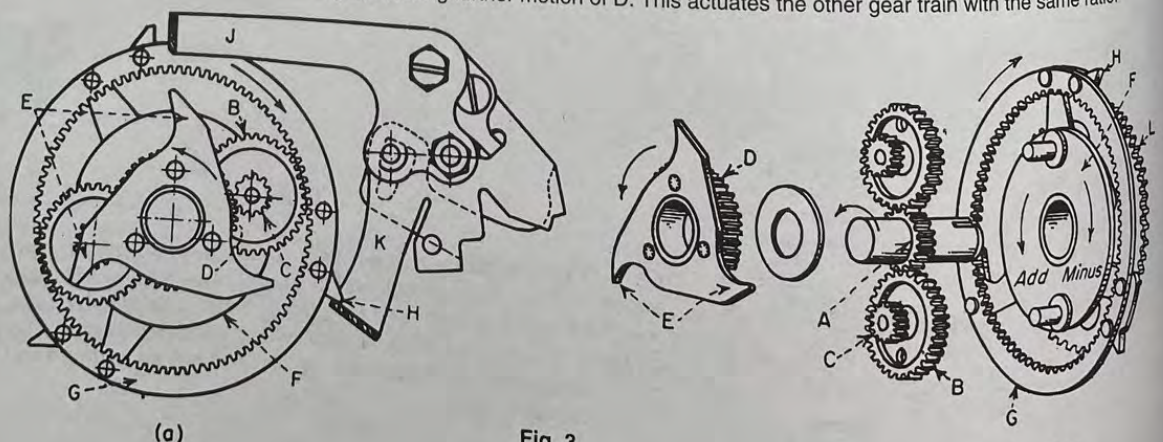



Fig. 3



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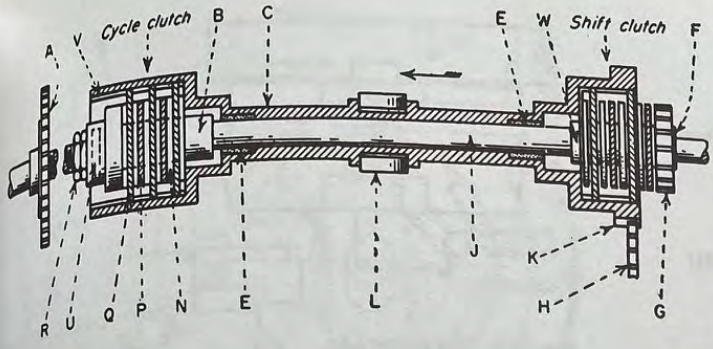



Fig. 4

**Fig. 4 A multiple-disk friction clutch.** Two multiple-disk friction clutches are combined in a single, two-position unit that is shown shifted to the left. A stepped cylindrical housing, C, encloses both clutches. Internal self-lubricated bearings support the housing on coaxial shaft J that is driven by transmission gear H, meshing with housing gear teeth K. At the other end, the housing carries multiple metal disks Q that engage keyways V and can make frictional contact with phenolic laminate disks N. They, in turn, can contact a set of metal disks P that have slotted openings for couplings with flats located on sleeves B and W.

In the position shown, pressure is exerted through rollers L, forcing the housing to the left, making the left clutch compress against adjusting nuts R. Those nuts drive gear A through sleeve B, which is connected to jack shaft J by pin U. When the carriage is to be shifted, rollers L force the housing to the right. However, it first relieves the pressure between the adjoining disks on the left clutch. Then they pass through a neutral position in which both clutches are disengaged, and they finally compress the right clutch against thrust bearing F. That action drives gear G through sleeve W, which rotates freely on the jack shaft.

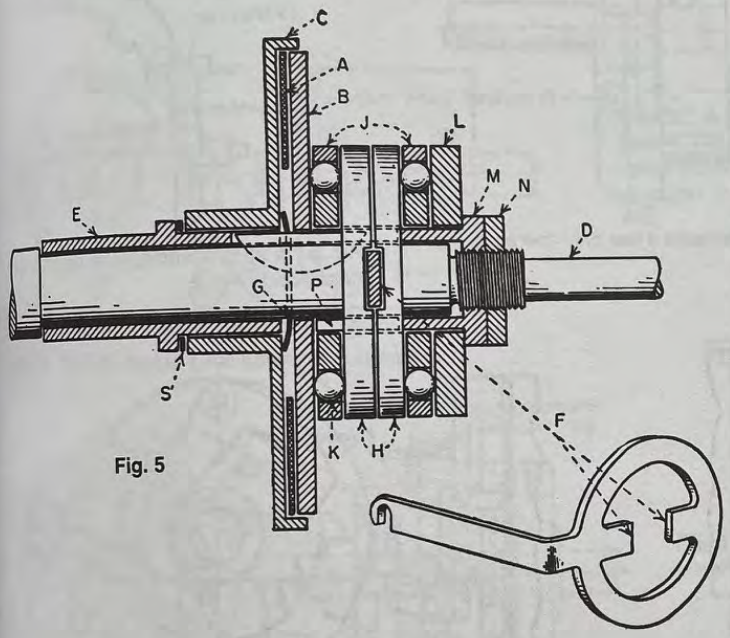



Fig. 5

**Fig. 5 A single-plate friction clutch.** The basic parts of this clutch are the phenolic laminate clutch disk A, steel disk B, and drum C. They are normally kept separated by spring washer G. To engage the drive, the left end of a control arm is raised, causing ears F, which are located in slots in plates H, to rock clockwise. This action spreads the plates axially along sleeve P. Sleeves E and P and plate B are keyed to the drive shaft; all other members can rotate freely.

The axial motion loads the assembly to the right through the thrust ball bearings K against plate L and adjusting nut M. It also loads them to the left through friction surfaces on A, B, and C to thrust washer S, sleeve E, and against a shoulder on shaft D. This response then permits phemolic laminate disk A to drive drum C.

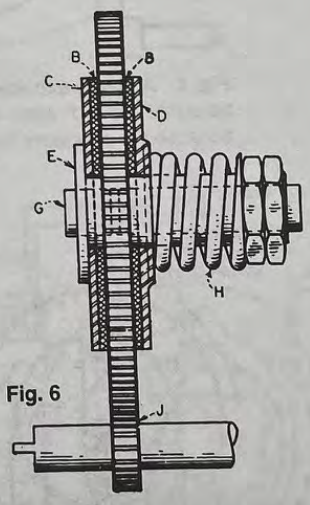



Fig. 6

**Fig. 6 An overload relief clutch.** This is a simple, double-plate, friction coupling with spring loading. Shaft G drives collar E, which drives slotted plates C and D faced with phenolic laminate disks B. Spring H is held in compression by the two adjusting nuts on the threaded end of collar E. These maintain the unit under axial pressure against the shoulder at the left end of the collar.

This enables the phenolic laminate disks B to drive through friction against both faces of the gar, which is free to turn o the collar. This motion of the gear causes output pinion J to rotate. If the machine to which the clutch is attached should jam and pinion J is prevented from turning, the motor can continue to run without overloading. However, slippage can occur between the phenolic laminate clutch plates B and the large gear.



LIFECORE EX. 1017

# METHODS FOR COUPLING ROTATING SHAFTS

Methods for coupling rotating shafts vary from simple bolted flange assembles to complex spring and synthetic rubber assembles. Those including chain belts, splines, bands, and rollers are shown here.

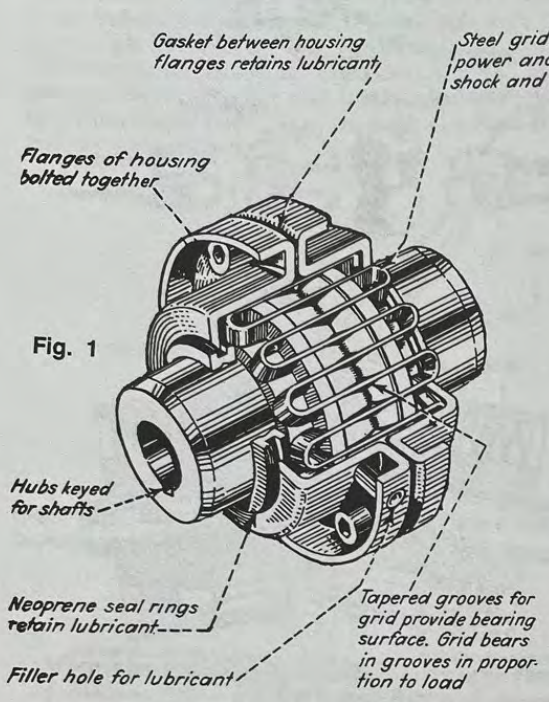



Fig. 1

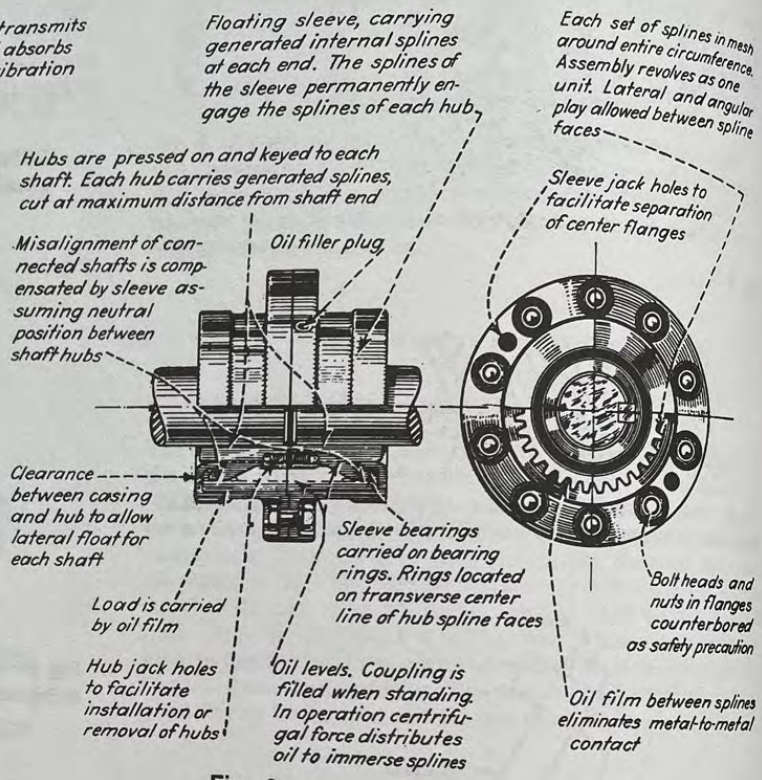



Fig. 2

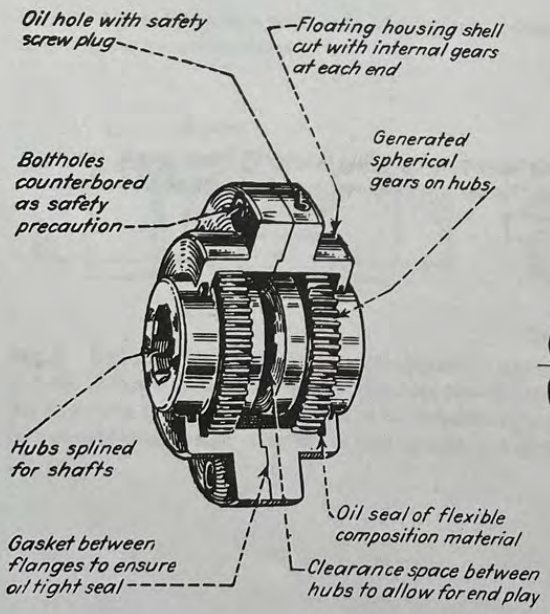



Fig. 3

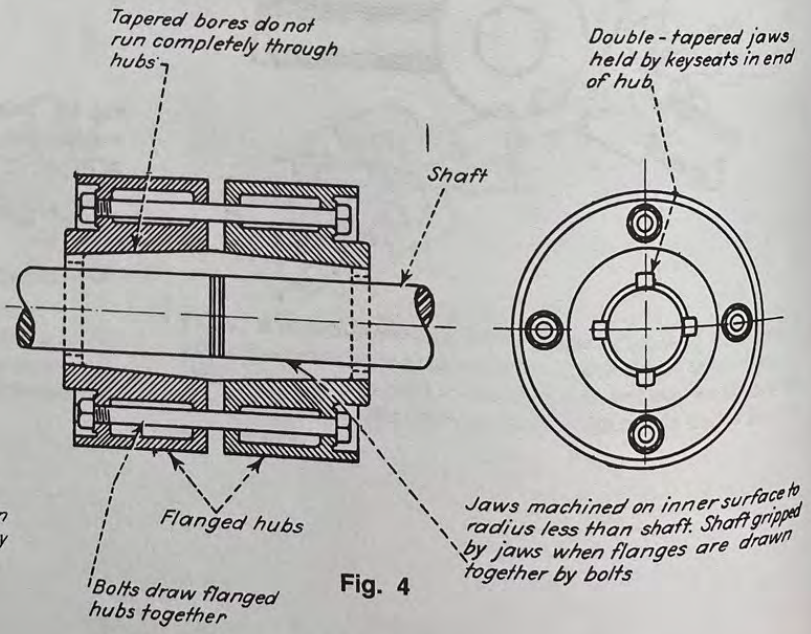



Fig. 4



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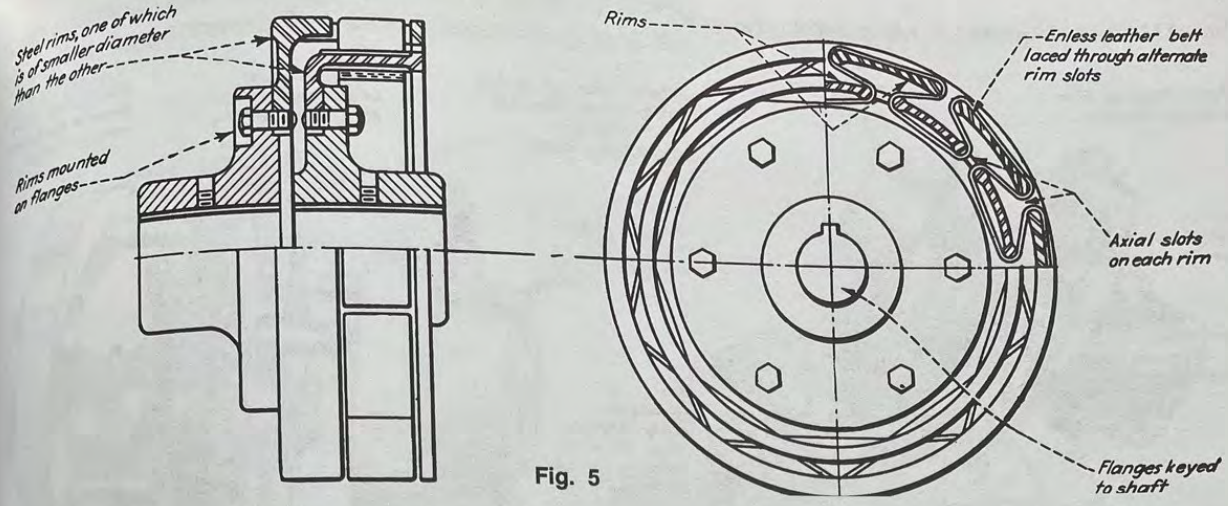



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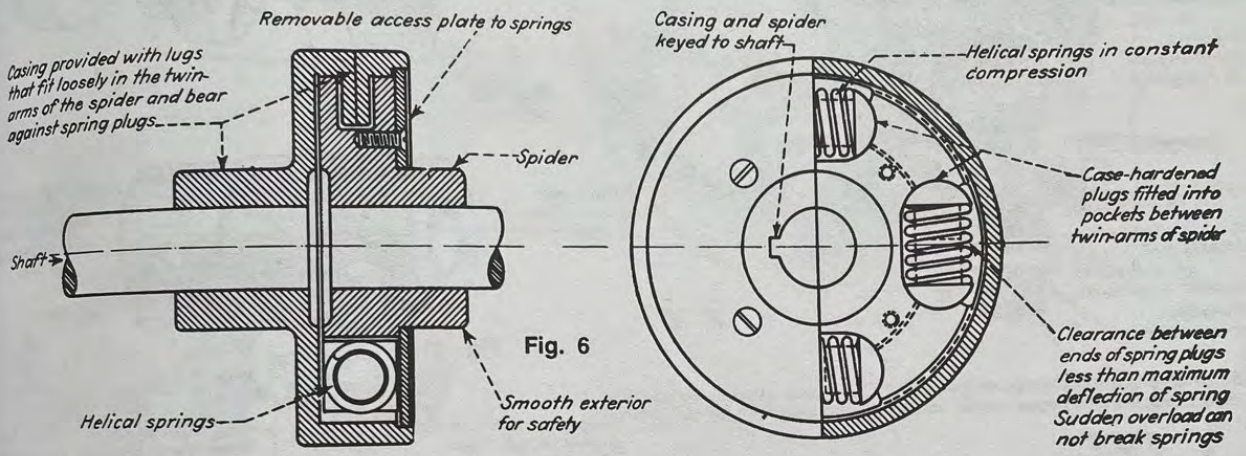



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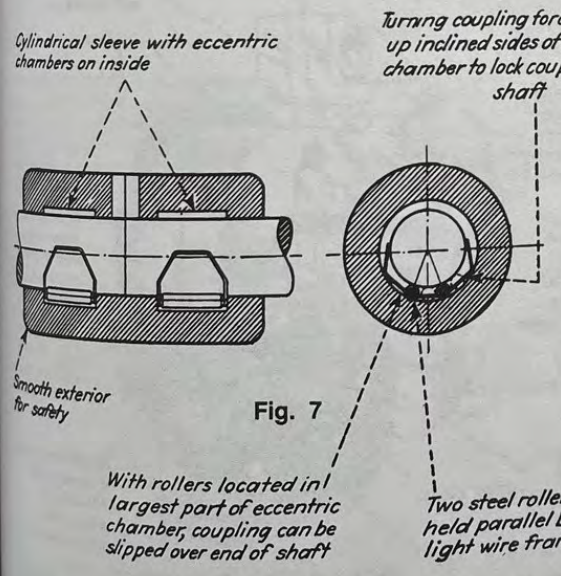



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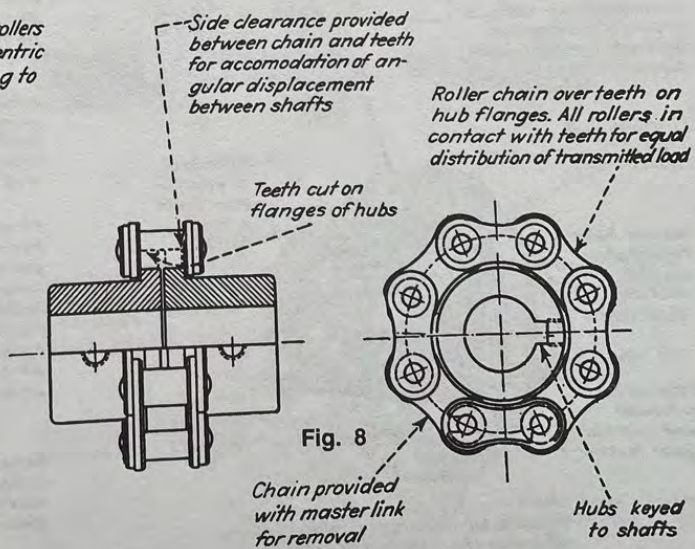
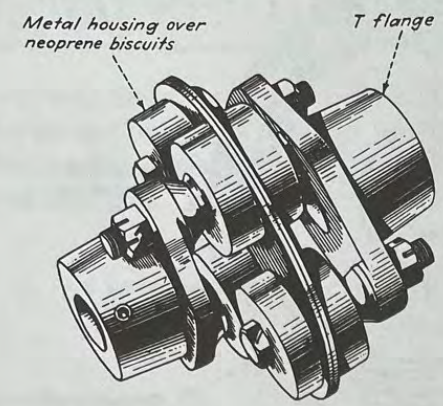



Fig. 8



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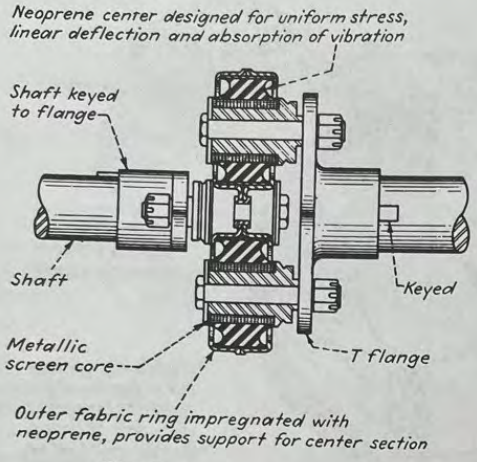




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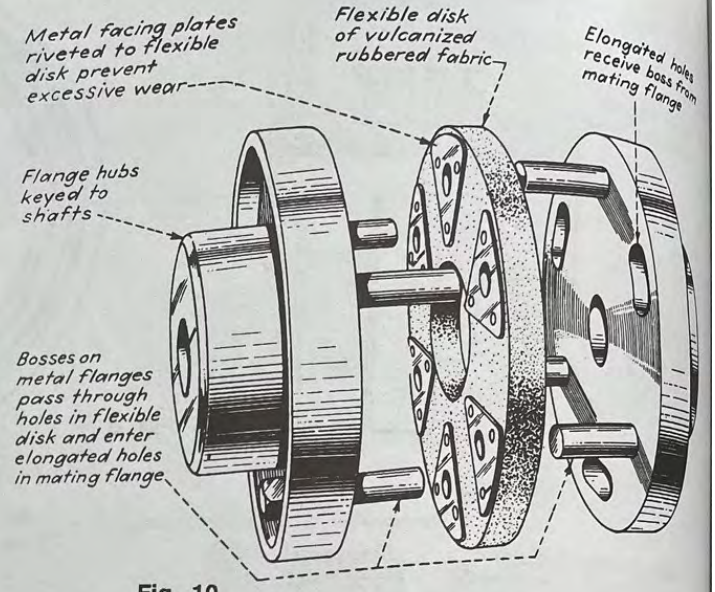



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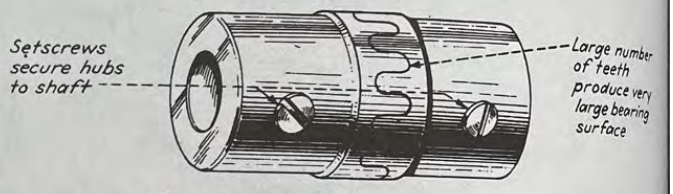



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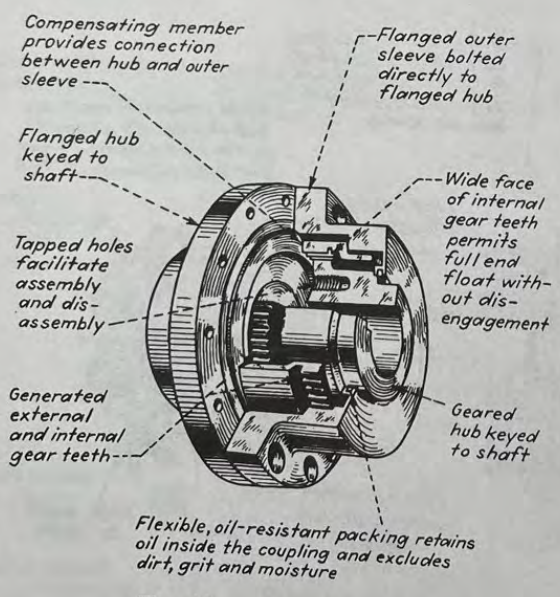



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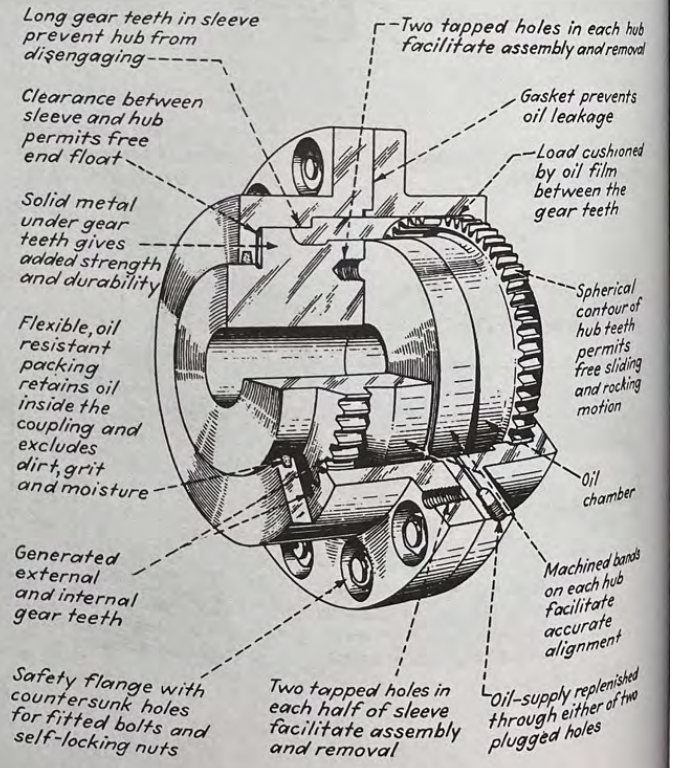



Fig. 13



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Shaft couplings that include internal and external gears, balls, pins, and nonmetallic parts to transmit torque are shown here.

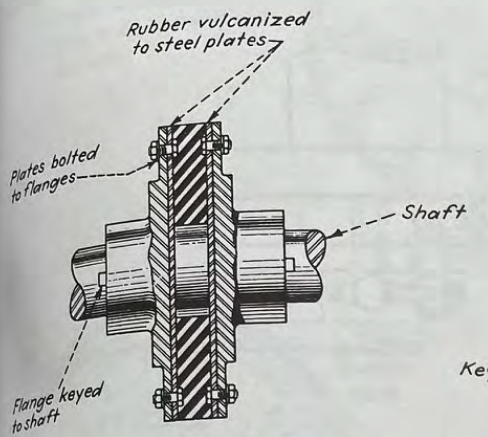



Fig. 14

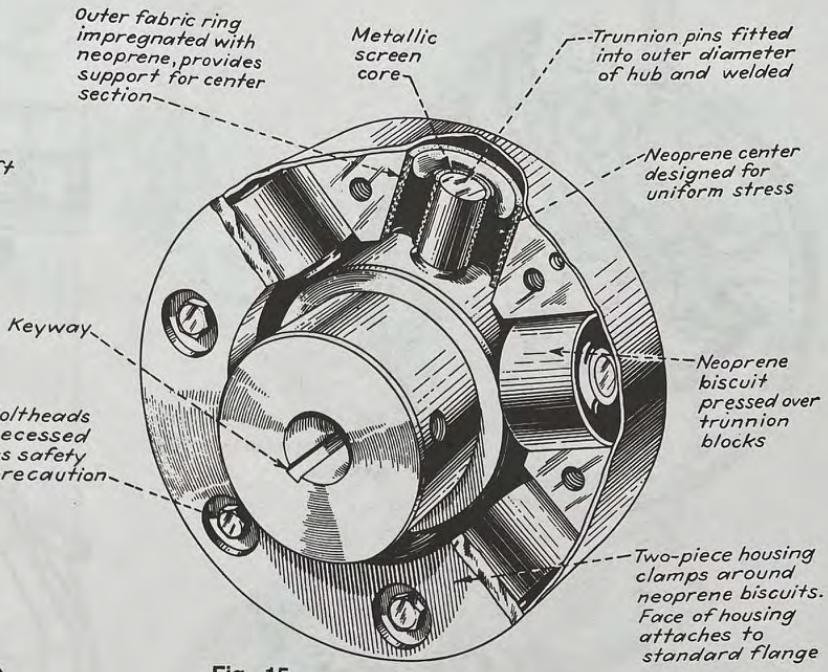



Fig. 15

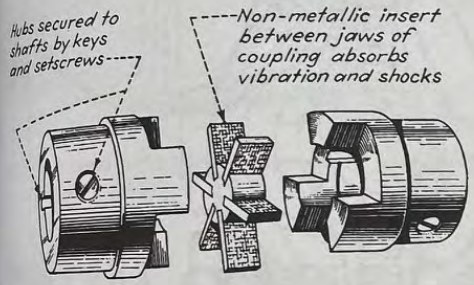



Fig. 16

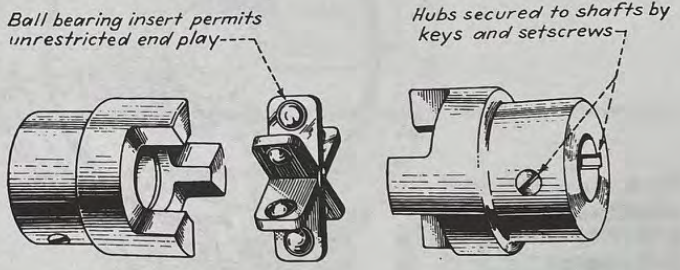



Fig. 17

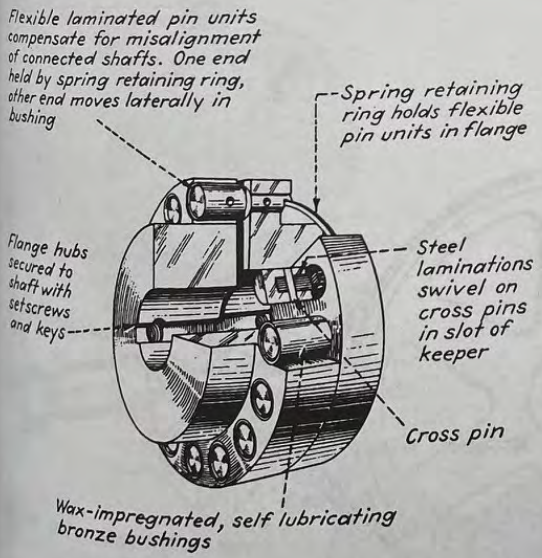



Fig. 18

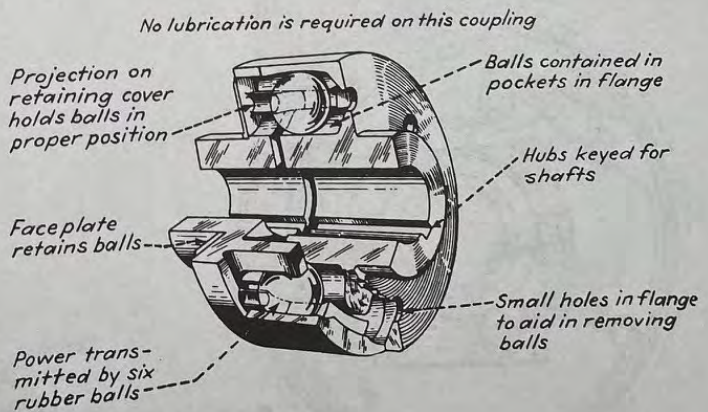



Fig. 19



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# CHAPTER 12
# FASTENING, LATCHING, CLAMPING, AND CHUCKING DEVICES

LIFECORE EX. 1017

# FOURTEEN WAYS TO FASTEN HUBS TO SHAFTS

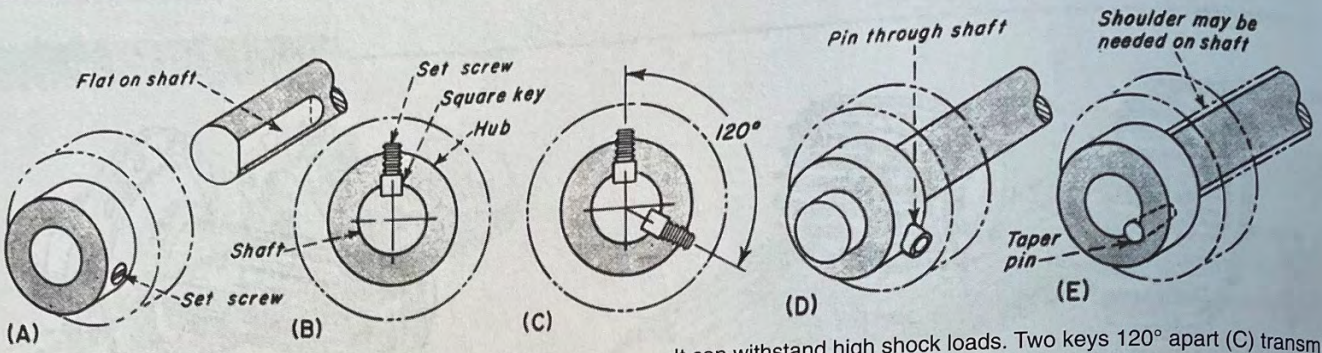



**Fig. 1 A cup-point setscrew** in hub (A) bears against a flat on a shaft. This fastening is suitable for fractional horsepower drives with low shock loads but is unsuitable when frequent removal and assembly are necessary. The key with setscrew (B) prevents shaft marring from frequent removal and assembly. 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.

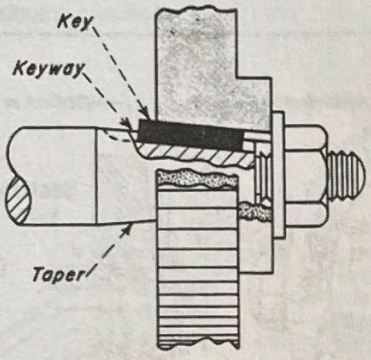



**Fig. 2 A tapered shaft** with a key and threaded end is a rigid concentric assembly. It is suitable for heavy-duty applications, yet it can be easily disassembled.

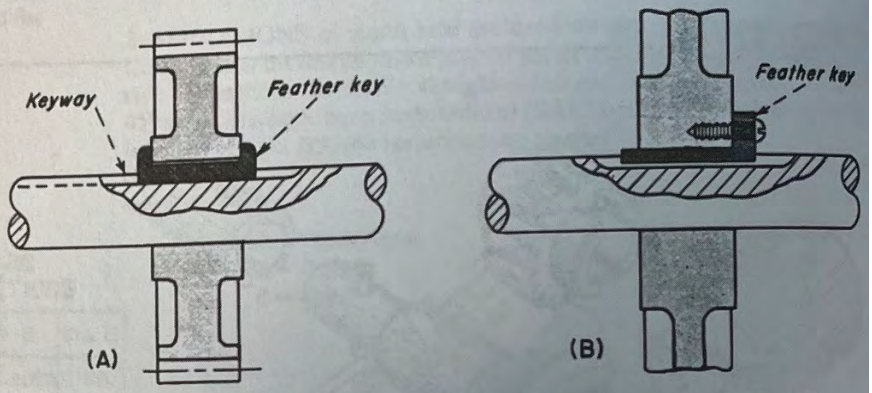



**Fig. 3 A feather key** (A) allows axial gear movement. A keyway must be milled to the end of the shaft. For a blind keyway (B) the hub and key must be drilled and tapped, but the design allows the gear to be mounted anywhere on the shaft with only a short keyway.

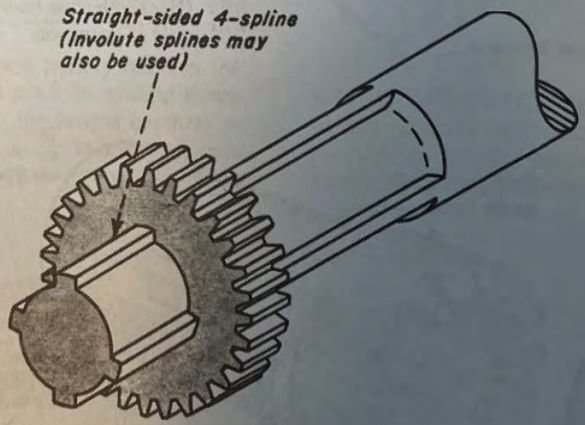



**Fig. 4 Splined shafts** are frequently used when a gear must slide. Square splines can be ground to close minor diameter gaps, but involute splines are self-centering and stronger. Non-sliding gears can be pinned to the shaft if it is provided with a hub.



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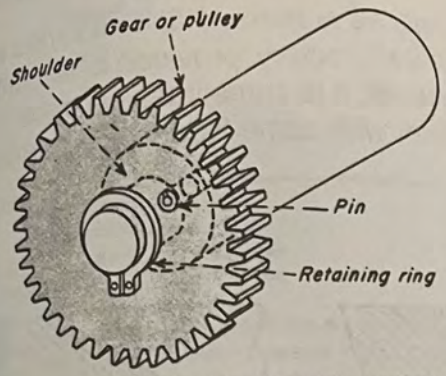



Fig. 5 **A retaining ring** allows quick gear removal in light-load applications. A shoulder on the shaft is necessary. A shear pin can secure the gear to the shaft if protection against an excessive load is required.

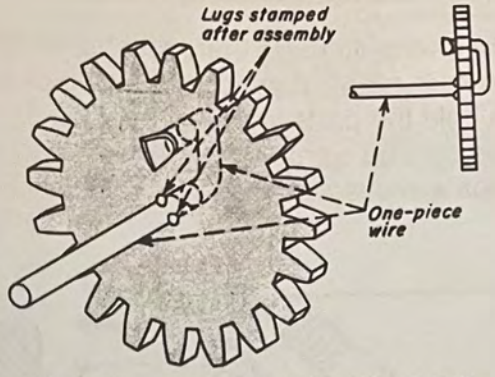



**Fig. 6 A stamped gear** and formed wire shaft can be used in light-duty application. Lugs stamped on both legs of the wire prevent disassembly. The bend radii of the shaft should be small enough to allow the gear to seat.

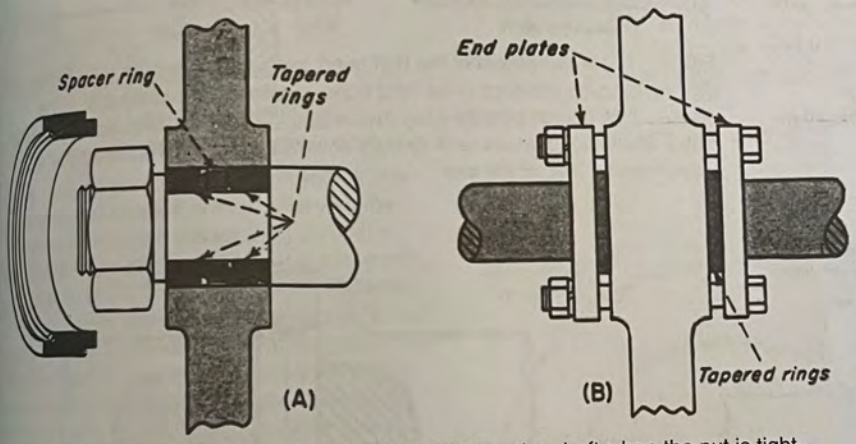



Fig. 7 **Interlocking tapered rings** hold the hub tightly to the shaft when the nut is tightened. Coarse machining of the hub and shaft does not affect concentricity as in pinned and keyed assemblies. A shoulder is required (A) for end-of-shaft mounting. End plates and four bolts (B) allow the hub to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

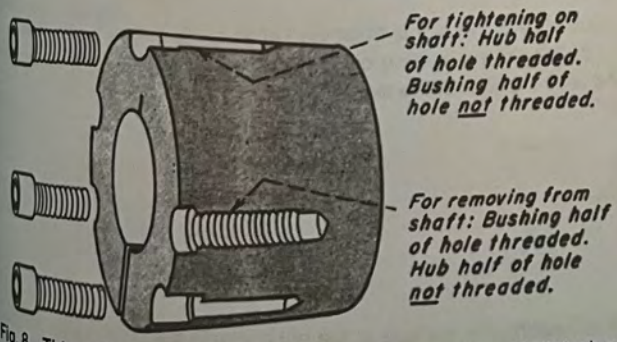



Fig. 8 **This split bushing** has a tapered outer diameter. Split holes in the bushing align with split holes in the hub. For tightening, the hub half of the hole is tapped, and the bushing half is un-tapped. A screw pulls the bushing into the hub as it is tightened, and it is removed by reversing the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

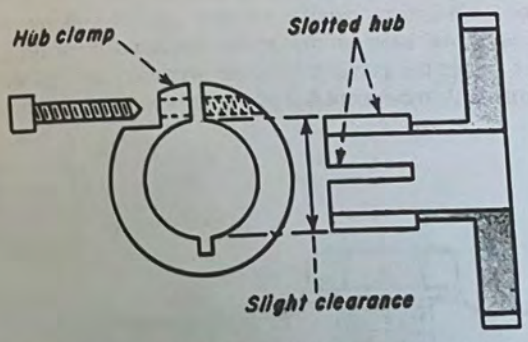



**Fig. 9 The split hub** of a stock precision gear is clamped onto a shaft with a separate hub clamp. Manufacturers list correctly dimensioned hubs and clamps so that they can be efficiently fastened to a precision-ground shaft.

Mechanical Engineering

# MECHANISMS and MECHANICAL DEVICES

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