INDUSTRIAL CLUTCHES AND CLUTCH COUPLINGS

Table of Contents

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1.0 SCOPE

This data sheet describes various designs of industrial clutches and clutch couplings. Recommendations are provided for inspection maintenance programs.

1.1 Changes

January 2000. This revision of the document has been reorganized to provide a consistent format.

2.0 LOSS PREVENTION RECOMMENDATIONS

2.1 Introduction

To ensure equipment is in reliable operating condition, frequent testing and maintenance service is necessary. This should include scheduled inspection to check for wear, alignment of the unit, and tightness of components. These inspections should be conducted at least annually.

2.2 Operation and Maintenance

2.2.1 *Cooling Systems.* Electric coupling, magnetic-clutch, cooling systems should use water that is free from entrained solid matter. They should also be equipped with a strainer, a flow switch, and an alarm bell, or similar device, located at the machine control station or central operations control. Where feasible, inlet pressure and temperature, and outlet pressure and temperature, should be chart recorded. This will enable plant personnel to detect temperature and pressure differentials in their early stages and, if necessary, to remove the machine from service before damage.

A waterflow sight glass should be installed in the return line to indicate that the waterflow was unrestricted.

Cooling passages should be flushed out with a cleaning agent recommended by the manufacturer. The operation should be performed, at least, annually.

2.2.2 *Gear Couplings.* Gears should be examined for wear and alignment by removing the inspection covers annually. Continued service life of the lubricant should also be checked at this time.

2.2.3 *Nonmetallic Flexible Couplings.* The rubber element should be replaced after approximately 20% of the element is torn or separated at the line around the clamping flanges.

2.2.4 *Oil operating couplings* should be lubricated in accordance with the manufacturer’s instructions, and the oil tested annually when the couplings are subjected to heavy duty service.

2.2.5 Inspection and repair of couplings and clutches should be by competent personnel, properly trained and familiar with coupling and clutch construction and operation.

2.2.6 Replacements should be stocked for those components that present a lengthy replacement time.

2.2.7 Record keeping should include:

1. Original manufacturer’s drawings and specifications.
2. Dates of repairs or modifications.
3. Inventory of spare parts.

3.0 SUPPORT FOR RECOMMENDATIONS

3.1 Loss History

Loss experience shows that clutches and couplings used in the steel, rubber, and paper industries have been, and still are among the largest loss producers. The following occurrences are typical of the many losses experienced.

3.2 Illustrative Losses

3.2.1 Industrial Clutches and Clutch Couplings, Case Study 1

Overheating of a *liquid cooled magnetic clutch* resulted in an unscheduled shutdown of a paper machine. This clutch was designed for 80 gal per minute (5 dm^3/sec) of cooling water, at 30 psi (206.8 kPa) (2 bars) pressure, while operating at 1095 rpm (18 r/s). It was driven by an 800-hp (597-kW) ac motor, coupled to the inductor drum. The output rotor was coupled to a pulley which drives the paper machine line shaft The unit had an enclosed, water-cooled drum and four water jacketed field coils. The liquid cooled magnetic drive unit was an adjustable-speed unit, regulated with a solid state controller. The drive unit consisted of a prime mover providing a fixed speed input to a liquid cooled eddy-current clutch. The eddy-current clutch transmitted torque from the prime mover to the driven equipment.

Following a routine felt change, during which some minor repairs were made, the paper machine was returned to service, with the clutch cooling water valve inadvertently left closed. The machine operated for a few minutes, at which time the output rotor overheated and seized to the inductor drum.

3.2.2 Industrial Clutches and Clutch Couplings, Case Study 2

A *magnetic, mechanical clutch coupling* between two motors for reversing reel on a strip steel rolling mill failed during regular service. This magnetic clutch coupling operated as the driving connection between two direct current, 150-hp (112-kW), tandem, electric motors which directly drove the right-side reversing reel on the reduction mill. Upon activation of an electromagnet, the teeth on both clutch faces engaged, providing booster power to the mill, when runs of extra heavy steel were experienced. Damage to the coupling, consisted of stripped teeth on the faces of the clutch, and the breaking of most parts completing the assembly. The failure was attributed to the misalignment of the driving teeth, with subsequent excessive wear, that finally resulted in fatigue breakage.

3.2.3 Industrial Clutches and Clutch Couplings, Case Study 3

A high-speed, flexible-type, mechanical coupling, operated between the gear set and gas compressor unit, driven by a 1000-hp (746-kW) motor, overheated and failed during service.

The coupling was 12 in. (304.8 mm) long with a flexible connection at each end. Gear teeth in the sleeve portion, intermeshed with corresponding teeth on the hubs, attached to the shafts of the compressor and gear set. The speed at this point reached 7000 rpm (116 r/s).

Investigation disclosed that the coupling end nearest to the compressor ‘‘bellied’’ out due to overheating. The gear teeth in the outer half were worn almost completely away.

Lack of lubrication, aggravated by frequent starts, resulted in the shearing or breaking of teeth, excessive frictional heat, and final distortion.

4.0 REFERENCES

Data Sheet 12-24, *Corrugating Paper Machines*.
Data Sheet 12-25, *Paper Machine Dryer Rolls*.
Data Sheet 7-102/12-29, *Yankee Dryers*.
Data Sheet 12-30, *Weld Fabricated Dryer Rolls*.
Data Sheet 12-60, *Suction Press Rolls*.
Data Sheet 13-3, *Utility Steam Turbines-Generators*.
Data Sheet 13-7, *Gears*.
Data Sheet 7-100/13-16, *Dynamic Compressors*.
Data Sheet 13-17, *Gas Turbines*.
Data Sheet 13-24, *Fans and Blowers*.
Data Sheet 13-26, *Internal Combustion Engines*.
Data Sheet 1-62/17-16, *Cranes*.
Data Sheet 7-12/17-17, *Mining and Ore Processing Facilities*.

APPENDIX A GLOSSARY OF TERMS

Clutch: [Mech Eng] a machine element for the connection and disconnection of shafts in equipment drives, especially while running.

Coupling: [Mech Eng] the mechanical fastening that connects shafts together for power transmission.

APPENDIX B DOCUMENT REVISION HISTORY

Original Issue, August 1976

APPENDIX C TYPES OF CLUTCHES

Clutches and clutch couplings are built in many forms and can be classified as: positive drive, friction, flexible, magnetic, electric, and hydraulic.

C.1 Positive Drive Clutches

Positive drive clutches consist of cylinders, with mating jaws attached to each rotating member. The jaws are engaged at low relative speeds, and consist of either spiral claw, ratchet, or teeth on the periphery of the cylinders.

Clutches built into internal combustion engines, to permit load engagement after operating speed is obtained, are known as power takeoffs (Fig. 1). Clutches used to couple a driving motor to a shaft are known as cutoff couplings.

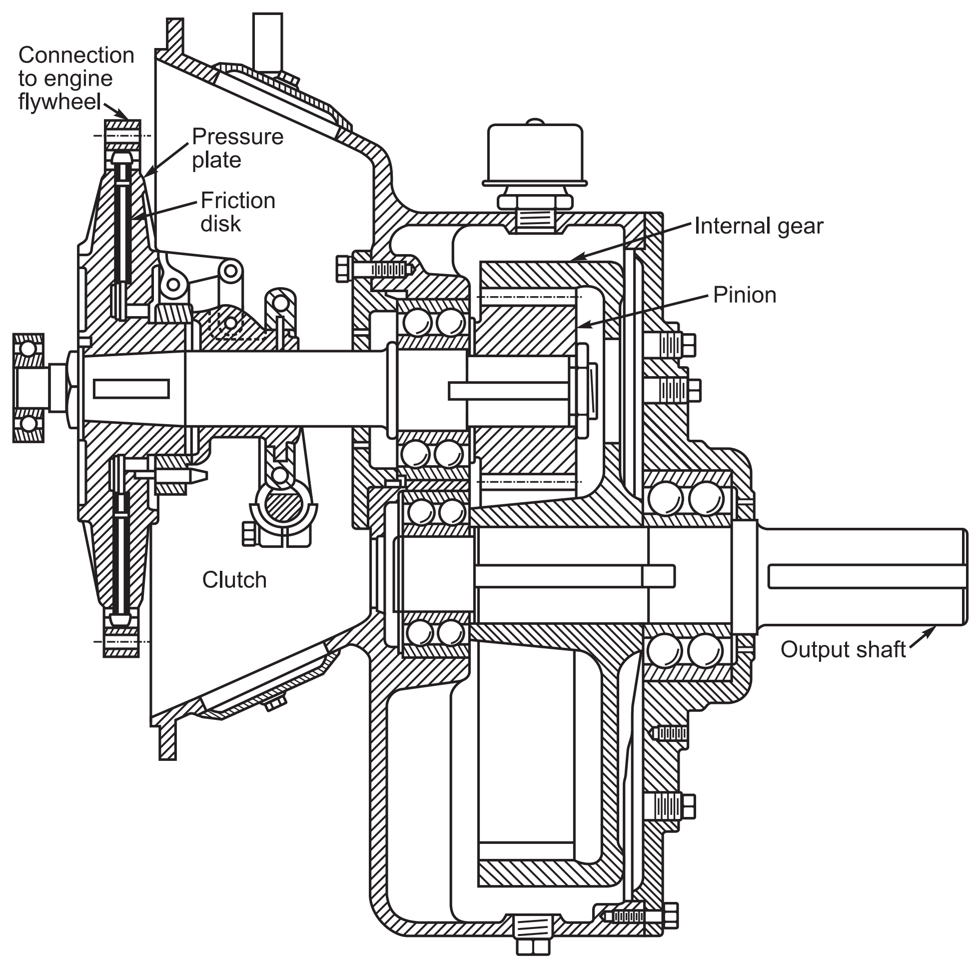

Fig. 1. Power takeoff type of positive drive clutch.

C.2 Friction Clutches

Friction clutches are by far the largest group, and have the widest use, of any clutch. They are normally engaged and disengaged at full speed, under load. When properly adjusted, they drive their loads without slip, unless excessively overloaded. One such type is the *disc clutch* (Fig. 2). This clutch is actuated by axial force. The sleeve to which the shaft is attached rides freely on a bearing. An extension of the hub carries the friction plate, restraining it from relative rotation, but allowing axial movement. The friction plate is between a backing plate and a pressure plate, connected to the hub and keyed to the driving shaft When the shifting collar is moved to the left, the linkage forces the pressure plate against the friction plate, which is stopped by the backing plate. Both surfaces of the friction plate are subjected to the full axial force, and resist slippage. The friction plate is made of flexible steel covered with a friction material, and runs without lubricant.

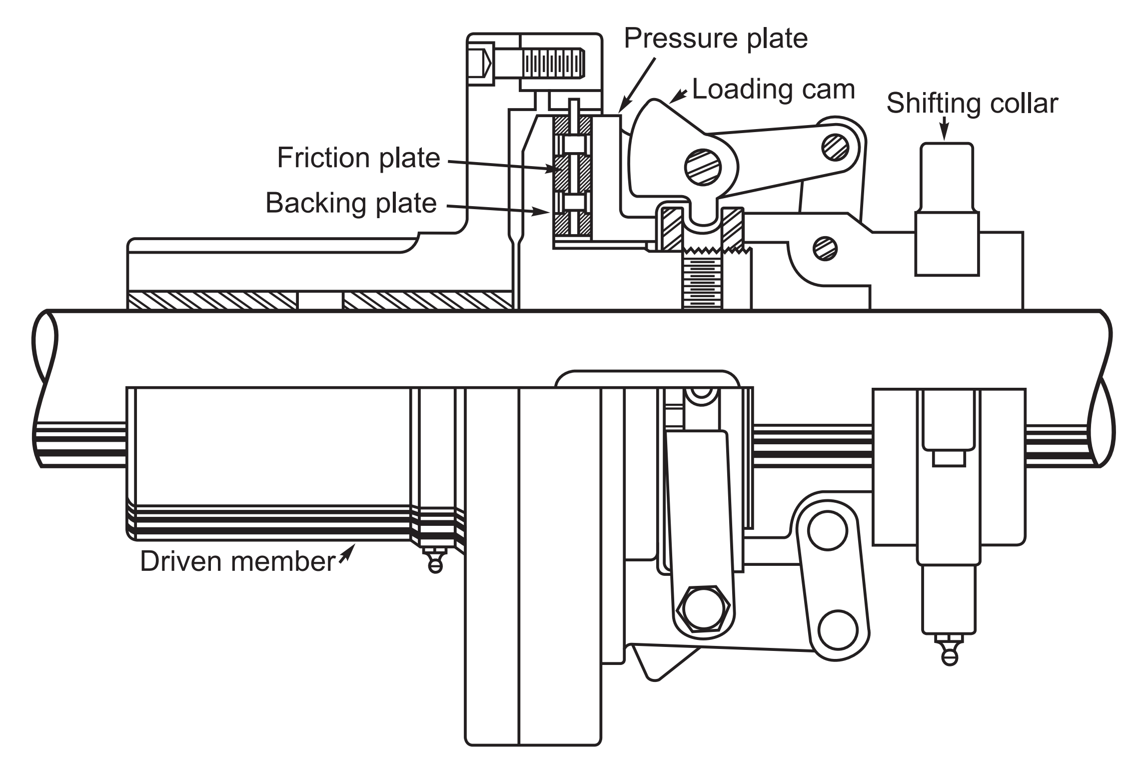

Fig. 2. Disk clutch.

When gradual engagement is desired, the friction plate may be divided into sectors by radial cuts, and warped slightly. Upon engagement the edges contact first, and deflect gradually until the whole plate is in contact.

Multiple-disc clutches have series of plates, alternately connected to the driving and driven hubs. They increase the capacity in direct proportion to the number of pairs of contacting surfaces. This clutch, with plates alternately of bronze and steel, operating in oil, is used extensively on machine tools.

Two clutches, arranged back-to-back and operated by a single shift collar, permit quick reversal of a shaft Such clutches are called duplex-disc clutches, and can be engaged and disengaged in fractions of a second.

Rim-force clutches utilize the force applied to either the inside or outside circumference of a drum by lined shoes, an expanding internal ring, a contracting external band, or a combination of these.

Coil clutches utilize a coil spring of rectangular cross section. One end of the spring is fastened to the driving plate. The other end can be actuated, through a leverage system, to force the spring to wrap snugly around a drum fastened to the driven shaft These clutches are usually designed for high-capacity applications.

C.3 Flexible Couplings

Flexible couplings must be capable of transmitting full power requirements efficiently. They must also compensate for unavoidable shaft misalignments, and be able to withstand, absorb, or cushion high-impulse shock loads and vibration.

The most prevalent types of flexible couplings used with process equipment are (1) all-metal couplings with segmented joints, and (2) couplings with nonmetallic, resilient members.

All-metal couplings are capable of transmitting higher loads for their size than any other type of flexible coupling. They will compensate for minor misalignments within prescribed limits.

Another type of flexible gear coupling is a *quill shaft* It is designed for use with large pinion gear sets, such as part of the starting transmissions for gas turbines. A quill shaft coupling consists of a special shaft passing completely through a hollow bore in the gear rotor, to provide long, flexing length. The shaft is rigidly fastened to the gear rotor on one end, and to the driving or driven shaft on the other end. Bearings are used to support each end of the two connected rotors (Fig. 3). Since the quill shaft provides great flexibility, the gear mesh is less prone to change due to external disturbance.

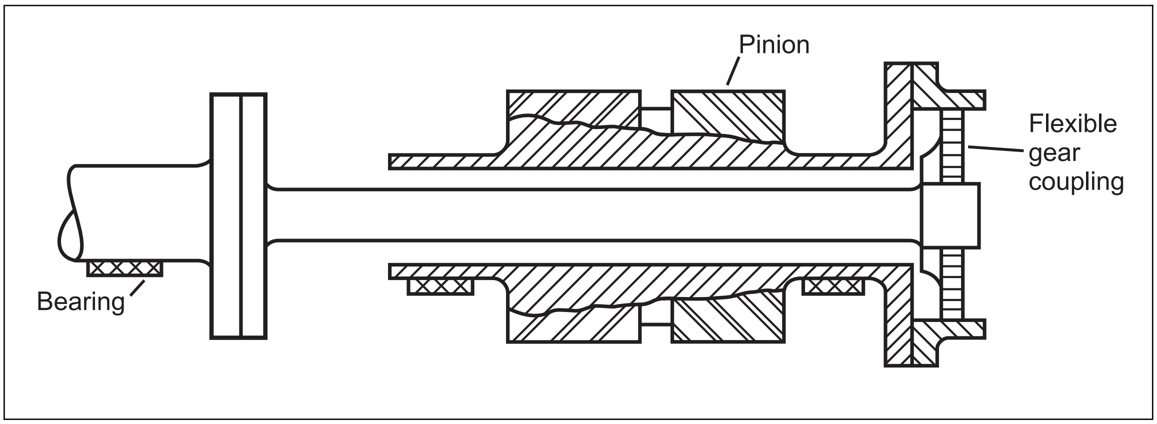

Fig. 3. Quill shaft with single engagement coupling with axial flexibility.

The gear coupling (Fig. 4) consists of two identical hubs, with external gear teeth, and a covering sleeve, or shelltype member, having machined internal gear teeth. The teeth in the sleeve mesh with the teeth on the hubs. There is no relative rotory movement between internal and external gear teeth. The sleeve may be of a single piece, but often consists of two halves bolted together to facilitate installation.

A slightly different style of metallic, flexible coupling consists of two serrated flanges laced with one or more metal strips (Fig. 5). Spaces between the end loops of the metal lacing and the flange serrations allow axial misalignment; parallel and angular misalignments are accommodated by the fit of the lacing in the serrations. The serrations are tapered to allow bending of the steel lacing. As the flexed length of lacing changes, a variable, torsional, stiffness effect if obtained (Fig. 6). A grease lubricant is required for the sliding metal surfaces.

Couplings with nonmetallic, resilient, connecting members use an elastomer, compounded or fabricated to provide the proper resiliency for the required service. Figure 7 illustrates two such designs. Bolting each leg of the connecting member between the shaft hub and an internal clamping ring eliminates the possibility that the soft, resilient member would rub or slide against metal, causing early failure during misaligned operation. There are no projections from either shaft flange to interfere, or cause the coupling to be bound during severe misalignments.

The flexible connecting element, shaped like an automobile tire, is split radially at one place through the cross-section. This split in the element allows it to be installed or replaced without moving or disturbing the drive and driven equipment. Since the resilient connecting member carries the full load of torque and compensates for misalignments, it is the only part of the coupling that would ever need replacement. Lubrication is not required.

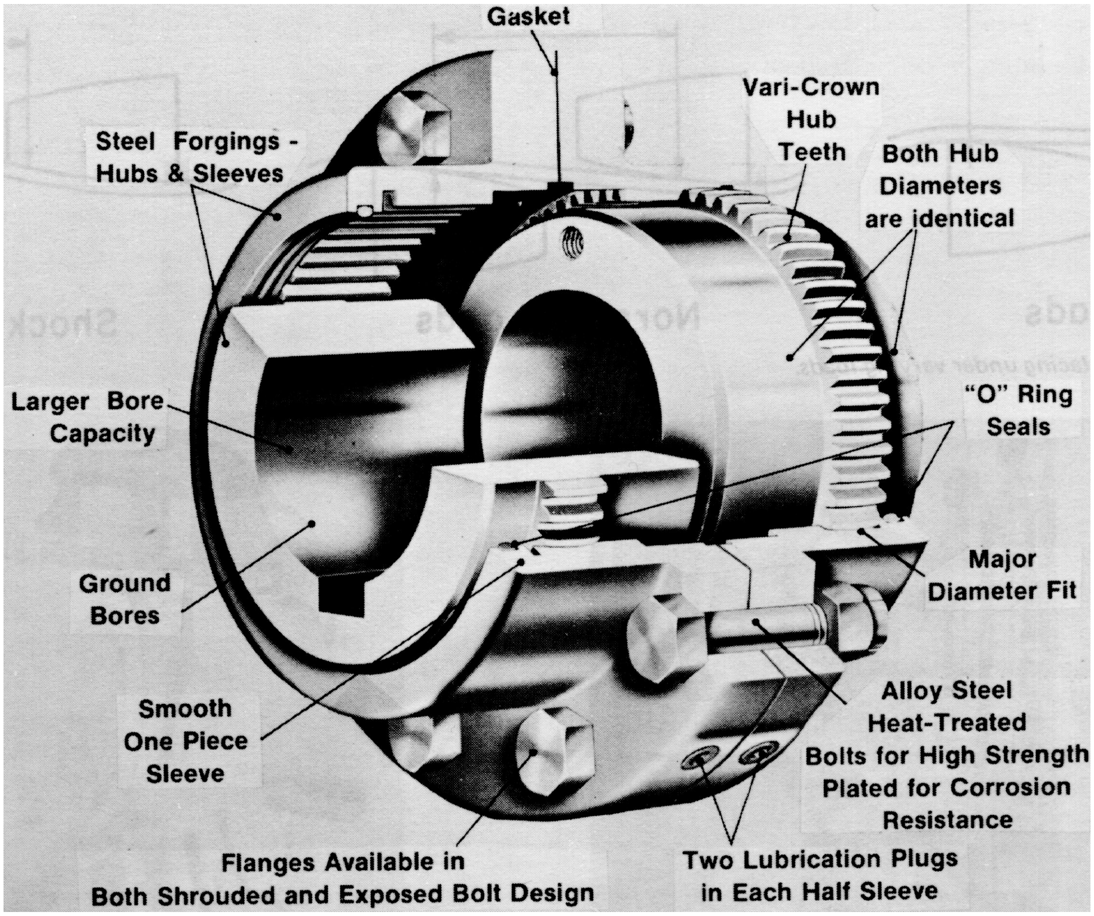

Fig. 4. Gear coupling.

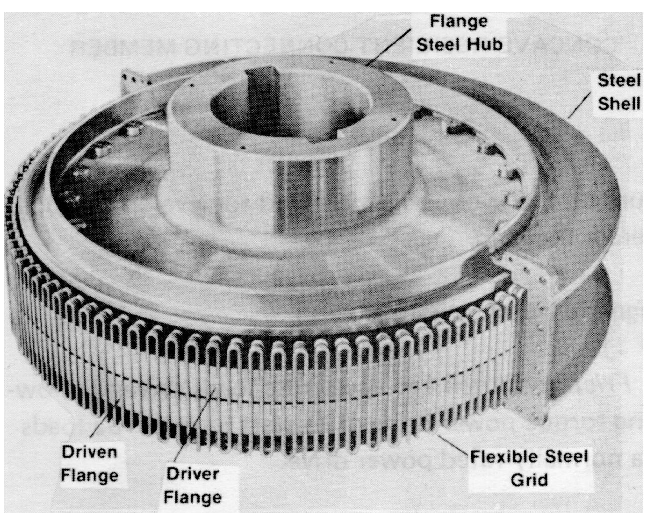

Fig. 5. Metallic flexible coupling.

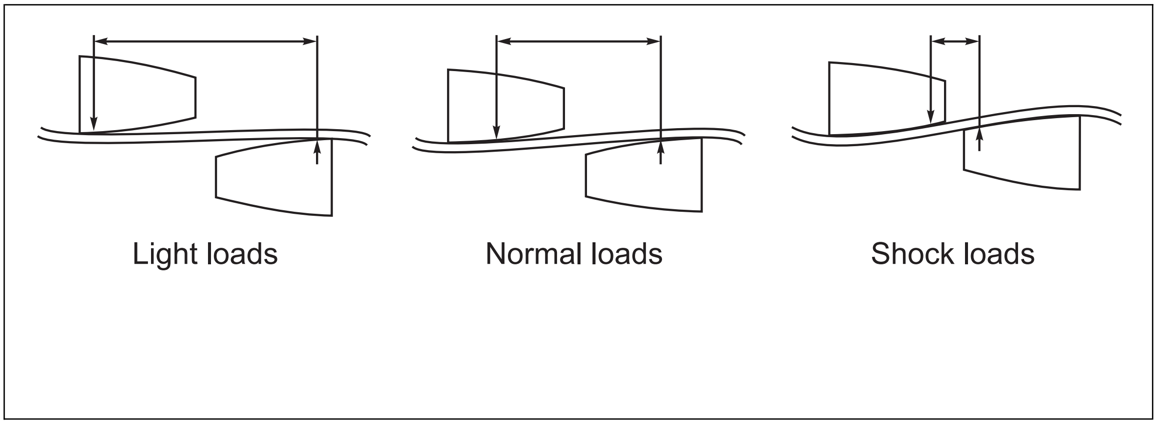

Fig. 6. Flexing of steel lacing under varying loads.

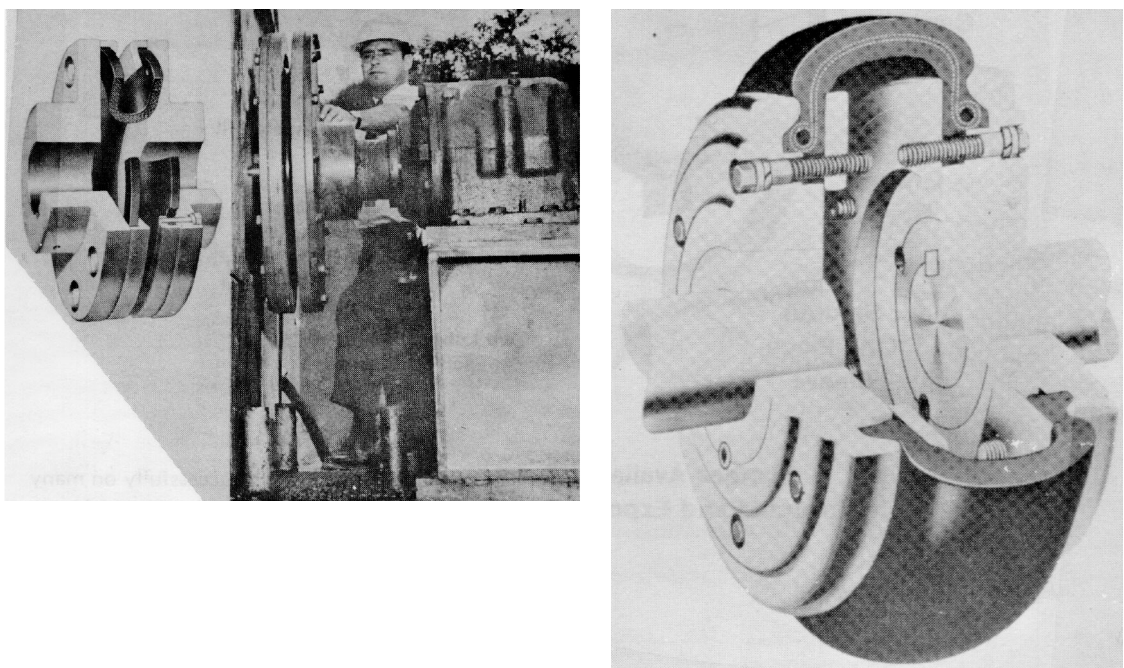

Fig. 7. Couplings with nonmetallic resilient connection members.

This type of coupling has been used successfully on many drives where the jamming of equipment is unavoidable. In extreme, shock overload conditions, the connecting member may be torn apart, disconnecting and protecting the drive or driven equipment from damage. Under excessive misalignment or constant shock loads, tell-tale cracks will eventually appear in the element at the clamped portion of each leg, usually starting at the joint. These cracks can be detected by visual inspection. However, such surface cracks do not mean that the rubber element will fail in a short time. The element need not be replaced unless the cracks progress through the thick rubber carcass, and the tensile cords begin to tear.

C.4 Magnetic Clutches

A magnetic clutch is a single or multiple-disc, friction clutch. It is operated by a dc electromagnet, energized through sliprings on the driving shaft

Figure 8 shows a single-disc, magnetic clutch with a single, friction lining. Recessed in the steel magnet's body, the magnet coil is protected by a heavy cast bronze ring which serves as a nonmagnetic shield. This part of the clutch is bolted to the driving hub, which also carries two sliprings to connect the coil to a dc power source.

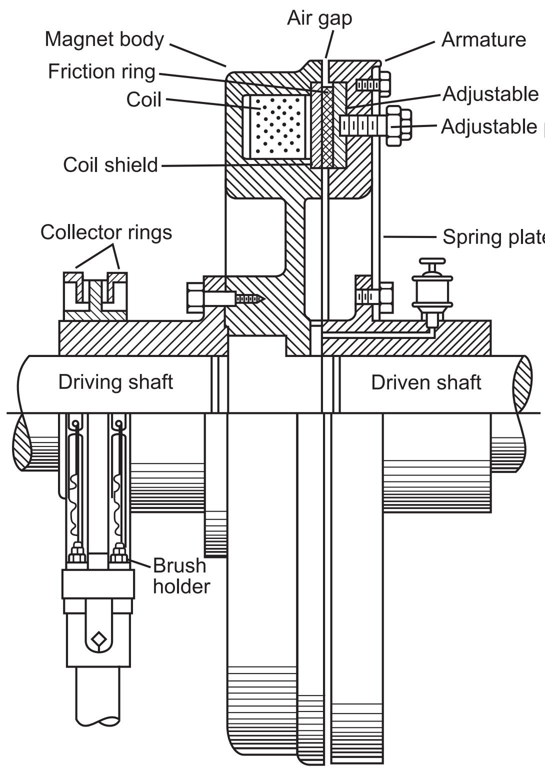

Fig. 8. Single-disk magnetic clutch.

The magnet's armature, a flat steel ring, has an adjustable ring recessed into its face. Faced with friction material, the ring forms the friction element of the clutch. A spring plate, bolted to the driven-shaft hub, supports the armature with its friction element. This plate maintains a small clearance between driving and driven parts of magnet when the coil is not energized. When the coil is energized, it pulls the armature, with its friction element, tightly against the friction ring in the magnet body. Friction between the two parts transmits the driving torque to accelerate the driven shaft, and bring it up to the same speed as the driver.

To increase the capacity of a magnetic clutch for a given diameter, discs are supplied with double-friction surfaces. Figure 9 shows a cross-section of one design of single-disc, with a double-friction surface. A spring plate bolted to the driven hub supports a double-faced friction ring between coil shield and adjusting ring. Energizing the coil attracts the armature toward the magnet body, to put pressure on the friction element and to develop torque to accelerate the load.

C.4.1 A magnetic clutch is used as:

1. *Friction Clutch* - to accelerate loads driven by lowstarting torque power units or to start high-inertia loads with a normally rated power drive.

2. *Positive engagement coupling* - to synchronize the motion of two rotating drives, as on steel mill screw-downs, flying shears, and pinch rolls. On some of these designs, friction surfaces are serrated to ensure positive engagement.

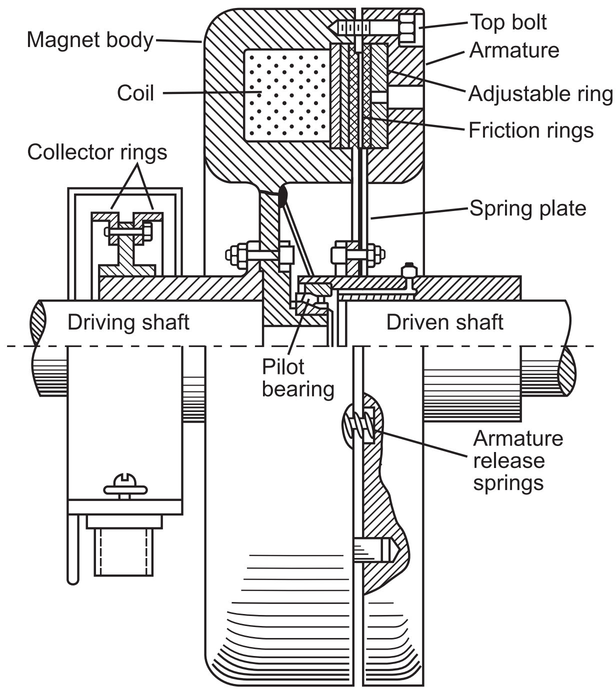

Fig. 9. Single-disk magnetic clutch with double-friction surface.

3. *Slip coupling* - to slip a predetermined torque, as on tapping machines and dredge pumps.

4. *Safety device* - to disconnect high inertia loads for quick stopping, when brakes are applied suddenly, as on rubber mills and printing press drives.

5. *Sectional drive* - to accelerate and lock one section of a machine with another, as on a Fourdrinier paper machine.

Figure 10 illustrates an application for a motor-driven, centrifugal compressor on refrigeration service. A magnetic clutch coupling with autovariable speed control is used.

C.5 Electric Clutches

Electric clutches are used for clutching, coupling, cushioning starts, reversing, speed changing, or for overload protection. When a clutch directly couples two shafts in line, it is often called a clutch coupling. It operates through belts, chains, or gears, the same as a clutch that transmits power to a secondary, parallel shaft

An electric clutch is considered suitable for any machine that is started and stopped so often that overheating is a problem. Disengaging a motor lets it run continuously, and yet allows it to cool. High-inertia loads can be started, and normal loads can be quickly accelerated because an electric motor's running torque is generally greater than its starting torque. The rotating assembly also acts as a flywheel.

Electric clutches are classified as friction-disc, tooth, magnetic spring, hysteresis, magnetic-particle, or eddy-current types. These various types are generally characterized by their size, torque-transmission capacity, ability to slip, heat dissipation, life expectancy, cost, speed limitation, and degree of control. Knowing how each type is built and operated helps to understand its advantages and limitations.

Single-Disc Friction. The simplest and most commonly used electric clutch is a single-disc, friction type that basically works like an electromagnet. When the electromagnet is energized, an armature is drawn into direct contact with the electromagnet's face. In the single-disc clutch, the electromagnet is shaped like a doughnut, and the coil creating the magnetic field is located inside the doughnut shell. Friction material on one side of the shell forms one of the clutch faces. The other face is an armature, an iron disc that may be segmented to help dissipate heat.

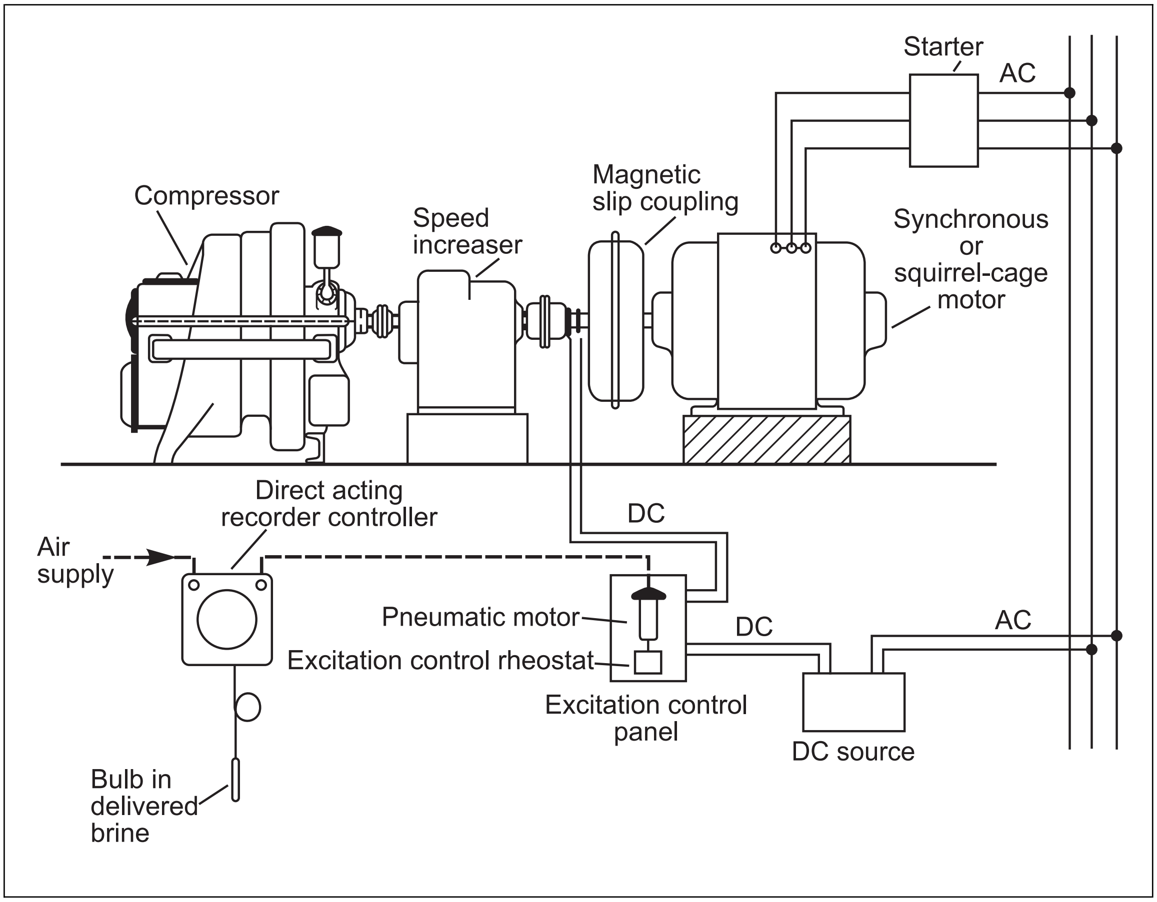

Fig. 10. Magnetic slip coupling with autovariable speed control.

The clutch's field winding rotates with the electromagnet body, and the field is energized through collector rings and brushes. However, a stationary-field clutch having three basic elements (stationary field, rotor, and armature) can also be used. Energizing the field draws the armature to the rotor, as the flux passes through the air gap, the rotor, the second air gap, and the armature.

Either the armature or the electromagnet can be mounted on the driving shaft of a directly coupled, rotating-field type clutch. The choice depends on whether heat dissipation for high-cycle rates or occasional high-inertia starts is the critical factor. For most applications involving high-cycle rates, the clutch does less total work in picking up the lower inertia armature. Hence, the higher-inertia electromagnet is mounted on the drive shaft The armature, however, is drive mounted (in the cooling air) for infrequent applications requiring that it dissipate large bursts of energy generated by occasional high-inertia starts.

Although basically an on-off device, the single-disc, friction clutch can be used for continuous slip, if it is derated to allow for the extra heat generated. Clutches specifically designed and rated for continuous-slip operation are generally equipped with special cast iron armatures that keep noise from the assembled unit.

Multiple-Disc Friction. Because the multiple-disc friction clutch provides much more friction area, it has greater torque capacity than a single-disc friction clutch of the same diameter. However, its more compact design makes it less able to dissipate friction-generated heat than a larger single-disc unit having as much friction area. Multiple-disc clutches, thus, have a limited duty cycle in air, and most units are designed for use in oil.

The multiple-disc friction clutch has a field coil, a pole assembly in which the magnetic field is set up, a set of discs, and an armature. Although the field coil can be either rotating or stationary, the stationary-field clutch is more common, because it eliminates slip rings and brushes.

Energizing the field coil generates a magnetic flux that links the pole assembly and the armature, moving the armature toward the pole assembly, and compressing the discs. One set of discs is attached to a hub that is keyed to a shaft The other set is fitted to a drive cup. Power can be transmitted either from the shaft to the drive cup, or from the cup to the shaft The discs separate when the field coil is de-energized. The discs are part of the magnetic circuit in some clutches, and are isolated from the magnetic field in other designs.

The main advantage of the multiple-disc clutch is high torque in a small package. The clutch can operate in wet (oil-filled) atmospheres, making it ideal for such uses as the control boxes of machine tools. In fact, available multiple-disc clutches must operate in an oil-filled atmosphere; only a few can operate dry.

Tooth. The tooth-type electric clutch provides high torque capacity and positive engagement. It is an on-off device that can be engaged only at low slip speeds. This clutch is available with either stationary or rotating fields, with the former slightly more common, because it eliminates brushes and slip rings.

When the field coil is energized, magnetic flux links the magnet body and the armature, and moves the armature toward the magnet body. Teeth on the armature mesh with the teeth on the magnet body, engaging the clutch. When the coil is de-energized, spring-loaded release plungers separate the two clutch members, forcing the armature back toward an adapter. Permanent magnets or springs complete the separation, which results in zero idle torque.

Magnetic Spring. The magnetic-spring clutch is a fixed-torque device that provides high torque transmission in a relatively small size. As with the friction and tooth clutches, electric current through an electromagnet creates a magnetic field that causes a torque-transmitting wrap spring to wind tightly around the output shaft Self-contained units feature an electromagnet as an integral part of the design. Larger spring clutches may have externally mounted solenoids.

A spring clutch's action is similar to that of a rope being wrapped around a capstan. Self-contained units, in addition to the wrap spring and input and output hubs, feature a coil, coil housing, and a control-collar armature. With the coil de-energized, both hubs rotate independently of each other. The shaft hub (output) rotates as one unit and is independent of the spring. The opposing hub is affixed to the spring and rotates with the control collar, as another unit. The coil is stationary and independent of either hub.

With the field coil energized, magnetic forces pull the control armature in an axial direction, until it is stopped by a flange on the shaft hub. Drag created by this action causes the wrap spring to wind tightly around both the input and output hubs, since one end of the spring rotates with the input hub while the other end attaches to the control armature, which is no longer free to rotate. Torque is transmitted via the spring's rope-and-capstan action, instead of by face engagement as in the friction-disc and tooth clutches.

Maximum torque is determined by spring strength. The clutch cannot be used for overtorque applications because it will malfunction rather than slip, if torque exceeds rated value. However, magnetic spring clutches offer a simple, economical way to obtain high torque in a small package.

Hysteresis. The hysteresis clutch is a constant-torque device that provides any amount of slip, as long as the heat dissipation capacity is not exceeded. In units with electromagnets, torque can be adjusted by control current.

The clutch's driving member is essentially a rotor, keyed to the input shaft A reticulated pole structure shapes the field. The driven member is a drag cup of hard magnetic material that fits within the rotor. In the rotating-field clutch, the field coil is contained within the rotor and is connected to the coil by slip rings on the input shaft The field is separate from both the rotor and the drag cup in the stationary-field.

Flux passes through the input rotor and drag cup when the field coil is energized. Poles in the rotor concentrate the field so that opposite poles are induced in the drag cup, which turns with the rotor. But the turning rotor cuts the dc field from the field coil and changes the magnetic field in the rotor. Hysteresis loss in the drag cup does not allow the flux through the cup to change as rapidly as that in the rotor, so the drag cup lags the rotor and torque is transmitted.

In a permanent-magnet hysteresis clutch, the rotor is a permanent magnet instead of an electromagnet. The clutch is a fixed-torque device; that is, torque for a particular model cannot be varied.

Magnetic-Particle. The torque of a magnetic-particle clutch varies almost linearly with coil current and is independent of slip speed. The device can be used at either zero or continuous slip. It consists of a driving member enclosed by, and concentric with, the driven member. An air gap, filled with fine ferromagnetic particles, separates the two rotating members. A stationary field coil is located within the clutch housing.

When not energized, the clutch's driving member rotates freely. The magnetic particles form a rigid bond that transmits torque when the field is energized. Because torque is independent of the speed of either member, the clutch can transmit torque at zero slip.

A magnetic-fluid clutch is basically a magnetic-particle clutch in which the magnetic particles are suspended in oil. It has the same electrical characteristics and, in general, the same applications as the magnetic-particle clutch.

Eddy-Current. An eddy-current coupling is primarily a variable-speed device. It cannot be operated at zero slip. Torque increases with slip up to rated slip speed, where the coupling becomes a constant-torque device. The most important application for eddy-current couplings is in adjustable-speed drives.

The eddy-current coupling has three parts: an input drum, a stationary field coil, and a coupling-pole assembly, which is the output rotor. The coupling pole assembly is surrounded by the input drum. In some models, the stationary field fits into an annular portion of the rotor; in others, it is located in the coupling's housing, and it surrounds both drum and coupling-pole assembly. The coupling-pole assembly has two sections of ferromagnetic material that are magnetically isolated from each other.

When the field coil is energized, magnetic flux links the input drum and the coupling-pole assembly. Poles cast into the surface of the pole assembly confine the flux, forming areas of high flux density. Eddy-currents are induced in the inner surface of the rotating input drum. These eddy currents create a new magnetic field that interacts with the field in the pole assembly, causing the pole assembly to rotate. The drum must always rotate faster than the pole assembly. Torque can be varied by changing the excitation current. But at high slip speeds, torque is constant, regardless of slip, for any given current. Figure 11 illustrates a vertical type, air cooled, eddy-current coupling drive.

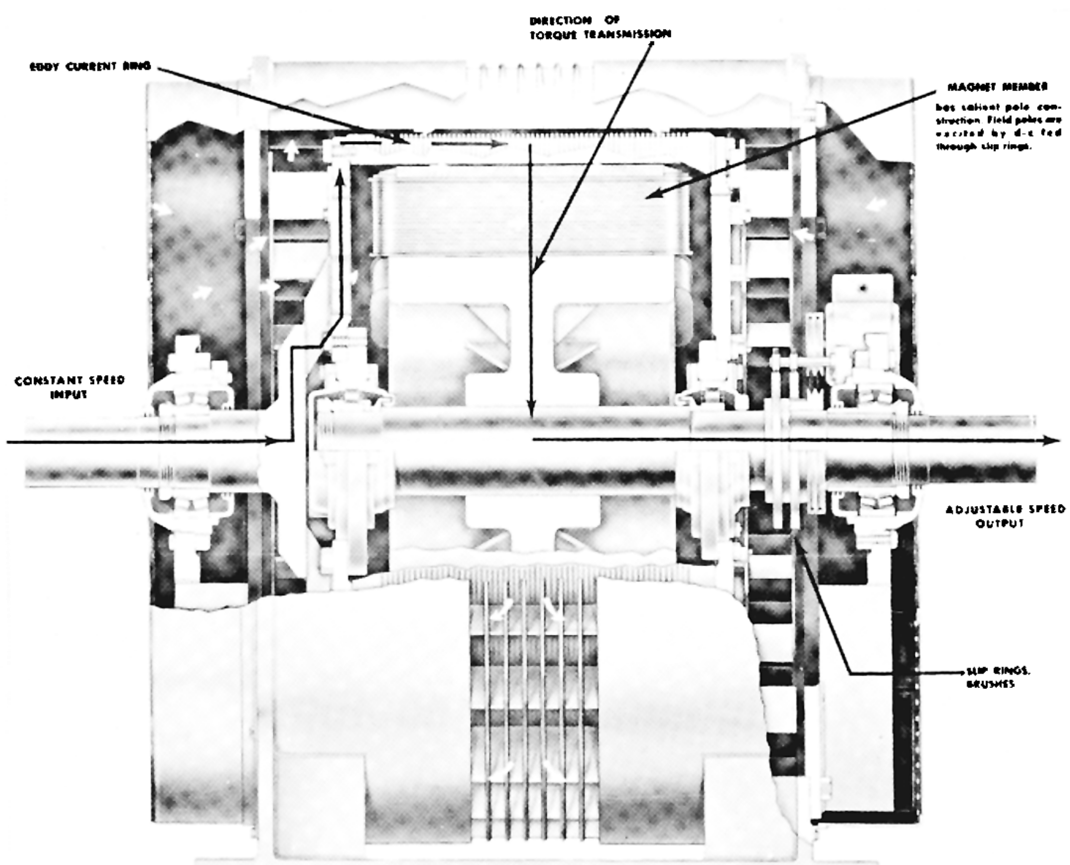

Fig. 11. Air-cooled eddy-current coupling drive of the vertical type.

The generation of torque, in slip devices, is always accompanied by the liberation of heat. In eddy-current machines, this heat is generated near the surface of the drum, adjacent to the field poles. Machines were first designed to use air for cooling, but as high dissipation of heat was required, liquid cooling was found to be more effective.

Figure 12 illustrates a typical liquid cooled coupling. The coolant is carried to the eddy-current generating region, by introduction into an annular chamber at the end of the drum. From the chamber, it is driven by centrifugal force along the air gap between the inner surface of the drum and the outside of the field magnet structure. The coolant then discharges to the external chamber between the drum and casing, from which it flows to a gravity drain.

Both sides of the coupling housing have vents to insure that there is no restriction in this line.

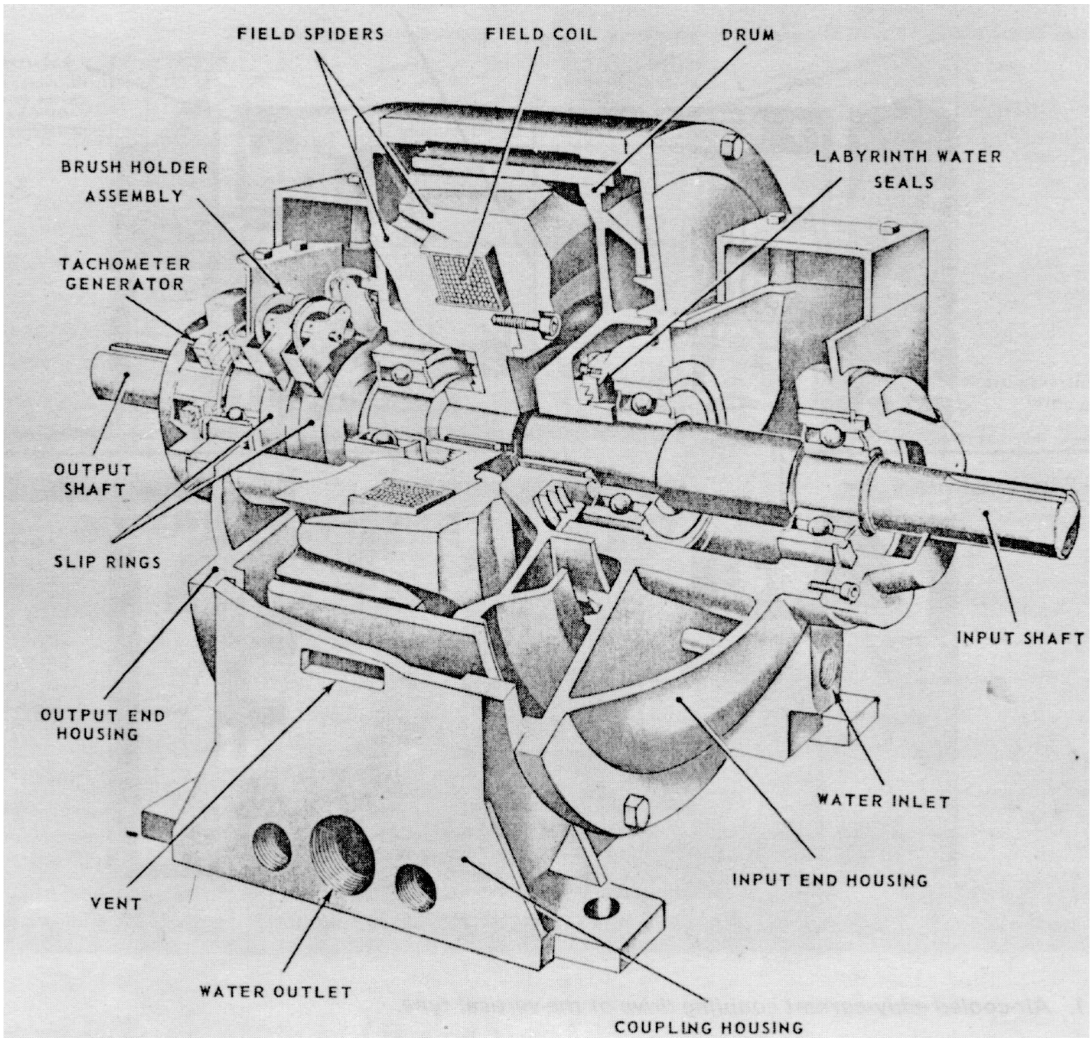

Fig. 12. Water-cooled coupling.

Recirculating cooling systems employing water-to-air and water-to-water heat exchangers have been furnished for use at sites where a limited supply of water is available, or where only water unfit for direct cooling is available. Refined oil or conventional antifreeze solutions can also be used as the coolant.

Being completely enclosed, this type of coupling is not affected by adverse, ambient conditions such as dust, dampness, or corrosive atmosphere. With minor modifications it can be made explosion resistant.

C.6 Hydraulic Couplings

All of the numerous designs of hydraulic couplings are composed of four basic elements: an impeller, a runner, a casing, and a means for changing the amount of oil contained within the unit, during operation. An adjustable speed output must be maintained while the speed input remains constant.

The impeller and the runner are mounted facing each other, on two separate shafts, with no mechanical connection between the two. The power is transmitted from the impeller to the runner entirely by a vortex of oil, circulating between the two. The impeller, mounted on the driven shaft that is connected to the driver, acts as a centrifugal pump and imparts energy to the oil, which is accelerated radially outward. The runner is mounted on a shaft connected to the driven equipment and acts as a reaction turbine, absorbing the kinetic energy in the oil as it passes inwardly, from the periphery towards the center of rotation. The circulation of oil between the impeller and runner is called the working circuit. A casing is attached to the impeller to confine most of the oil to the working circuit. An adjustable scoop-tube can withdraw a variable amount of oil from the working circuit to provide speed variation.

The construction of a hydraulic coupling is illustrated in Figure 13. The entire rotating assembly is enclosed in a welded steel housing, which is split on the horizontal centerline. The bottom portion of this housing serves as a support for the bearings, in which both the driving and driven shafts rotate. It also contains an oil reservoir from which the lubricating and operating oil is supplied to the unit. A centrifugal pump, gear-driven from the input shaft, picks up oil from this reservoir and sends it through an oil cooler. From the cooler it returns both to the tank and to the bearings.

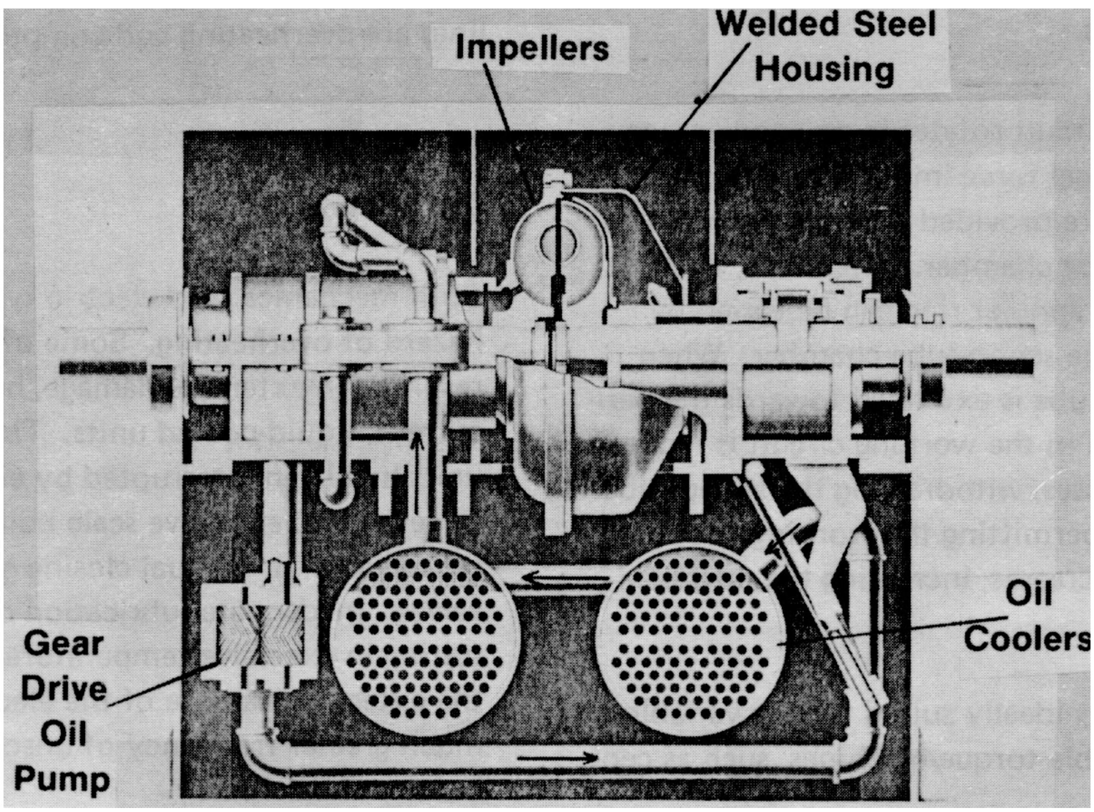

Fig. 13. Hydraulic coupling.

The oil in the working circuit rotates in an annular ring by virtue of the centrifugal force imparted to it by the impeller. Connections are provided between the working circuit and the scoop-tube chamber. Therefore, the amount of the oil in the annular ring can be varied by varying the oil level in the scoop-tube chamber. When the tip of the oil scoop-tube is extended towards the periphery, the amount of oil in the working circuit is reduced. The output speed decreases, withdrawing the scoop-tube towards the center and permitting the working circuit to fill with oil. The slip decreases, increasing the output speed.

The hydraulic coupling is ideally suited for the variable speed operation of variable torque machines, such as centrifugal pumps.

C.7 Hazards

The two hazards affecting industrial clutches and couplings are overheating and component fatigue.

C.7.1 Overheating

Both mechanical and electric types are subject to the hazard of overheating. Some of the most rapid failures, resulting in extensive damage, have occurred to eddy-current, liquid-cooled units. The cooling medium in these units had been interrupted by either automatic control valve failure, excessive scale buildup on internal heat transfer surfaces, or manual closing of coolant supply line valves. Inadequate lubrication of mechanical types, resulting in excessive temperatures, though not presenting the extensive damage of the electric types, has caused a much greater frequency of unscheduled shutdowns of industrial machinery.

C.7.2 Component Fatigue

This hazard is always present, but in many cases it is aggravated by adverse operating conditions. The most serious and repetitious failure is caused by shock loading. This failure is due to driving or driven object jamming, or faulty alignment, invariably resulting in shearing or breaking of susceptible parts.

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