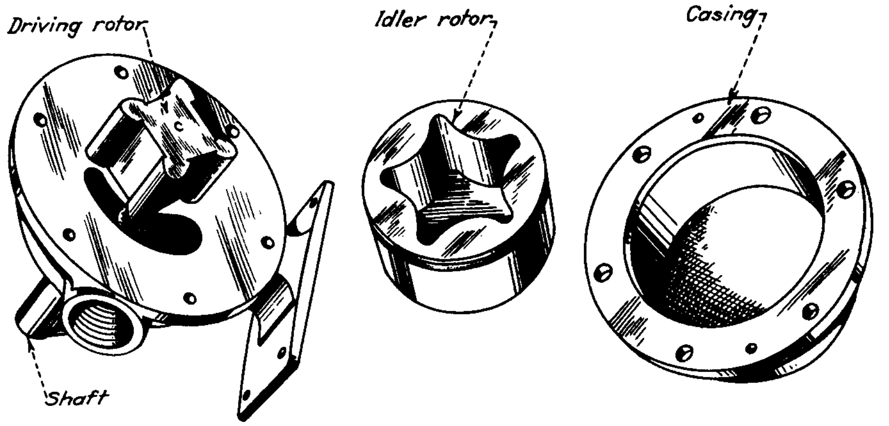
CHAPTER 11

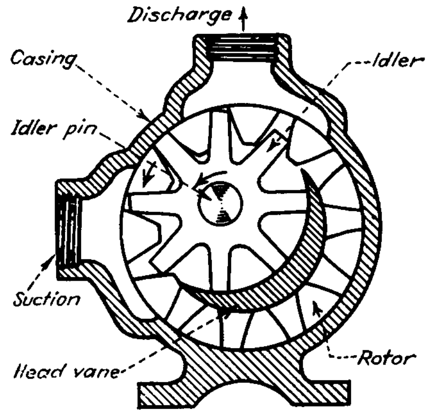
PNEUMATIC AND HYDRAULIC MACHINE AND MECHANISM CONTROL

DESIGNS AND OPERATING PRINCIPLES OF TYPICAL PUMPS

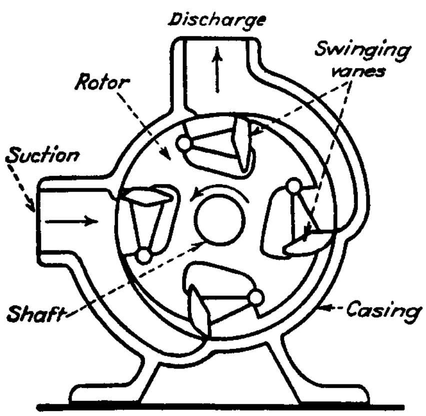
These pumps are used to transfer liquids and supply hydraulic power.



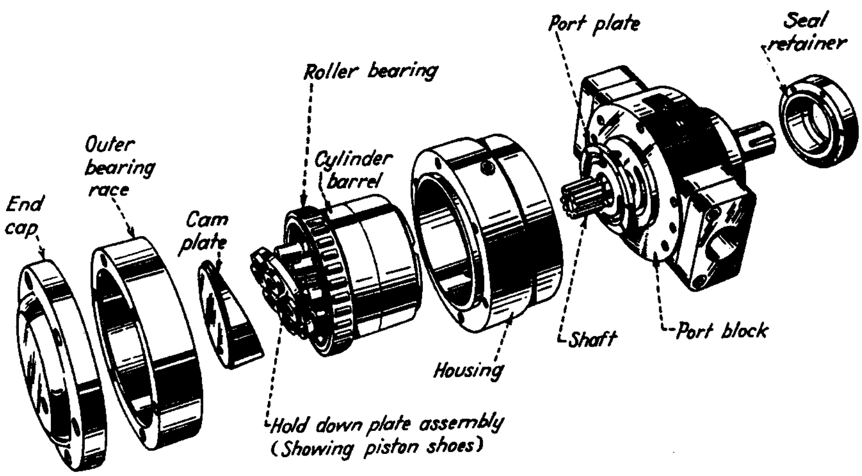
1. WITH BUT TWO MOVING PARTS, the rotors that turn in the same direction, this rotary pump has reduced friction to a minimum. The rotors rotate against flexible synthetic rubber cushions that allow sand, grit and other abrasives to flow freely through the pump without damage. It is a positive displacement pump that develops a constant pressure and will deliver a uniform flow at any given speed. The pump is reversible and can be driven by a gasoline engine or electric motor. The rubber cushions withstand the action of oil, kerosene, and gasoline, and the pump operates at any angle. It has been used in circulating water systems, cutting tool coolant oil systems and general applications.



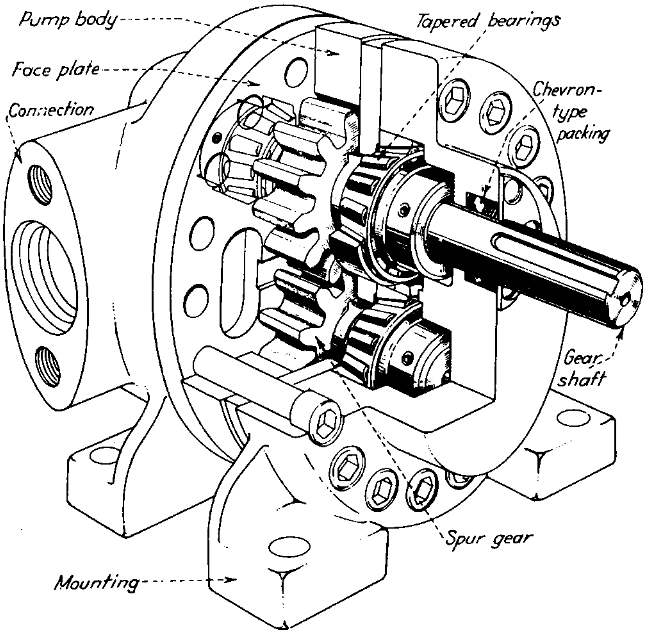
2. PUMPING ACTION is produced by the meshing of the idler and rotor teeth in this rotary pump. The idler is pin-mounted to the head and the rotor operates in either direction. This pump will not splash, foam, churn or cause pounding. Liquids of any viscosity that do not contain grit can be transferred by this pump which is made of iron and bronze.



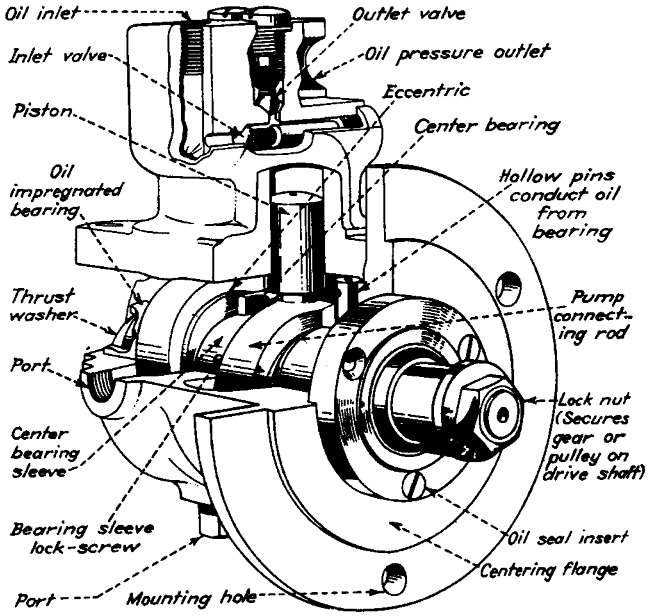
3. BASED on the swinging vane principle, this pump maintains its volumetric efficiency automatically. The action of the buckets, fitted loosely into recesses in the rotor, compensates for wear. In operation, the tip of the bucket is in light contact with the casing wall. Liquids are moved by sucking and pushing actions and are not churned or foamed.



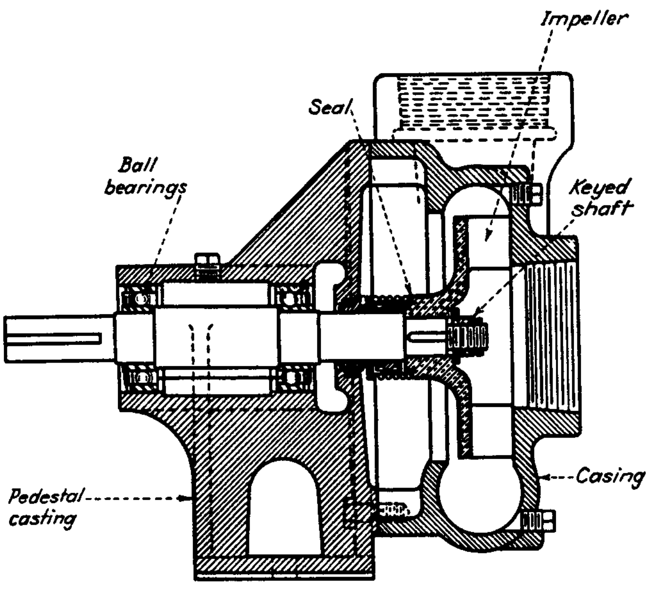
4. HIGH-PRESSURE, high-volume pumps of the axial piston, constant displacement type are rated at 3,500 psi for continuous duty operation; higher pressure is permissible for intermittent operation. A pressure-balanced piston shoe lubricates the cam plate and prevents direct contact between the shoe and cam plate. The use of the pressure balanced system removes the need for thrust bearings. The two-piece shaft absorbs deflection and minimizes bearing wear. The pump and electric driving motor are connected by a flexible coupling. The revolving cylinder barrel causes the axial reciprocation of the pumping pistons. These pumps only pump hydraulic fluids.



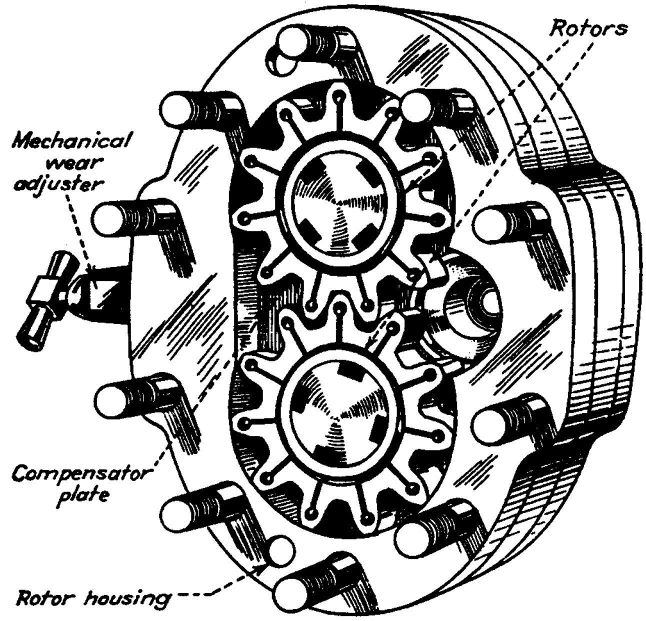
5. THE GEAR SHAFTS of this hydraulic gear pump are mounted on tapered roller bearings that accurately position the gears, decrease end play, and reduce wear to a minimum. This heavy-duty gear pump can be used at pressures up to 1,000 psi. These pumps were made with either single- or double-end shafts and can be foot- or flange-mounted. The drive shaft entrance packing is made from oil-resistant material, and the gear shafts are made from hardened molybdenum steel.



6. THIS HIGH-PRESSURE hydraulic pump has twin pistons that build pressures from 100 to 4,000 psi at speeds from 600 to 1,200 rpm. This pump can be operated continuously at 900 rpm and 2,500 psi with 1.37 gpm delivered. Because it can be mounted at any angle, and because it is used with small oil lines, small diameter rams and compact valves, the pump is suitable for installation in new equipment. This pump contains a pressure adjusting valve that is factory set to bypass at a predetermined pressure.

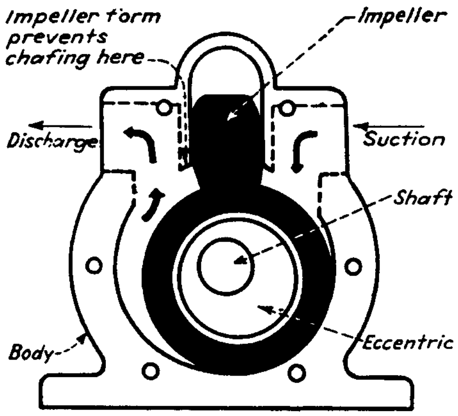


7. This pump is characterized by its pedestal mounting. The only non-critical fit is between the pedestal casting and the casing. Positive alignment is obtained because the sealed ball bearings and the shaft are supported in the single casting. The five-vaned, open, bronze impeller will move liquids that contain a high volume of solids. The pump is not for use with corrosive liquids. The five models of this pump, with ratings up to 500 gpm, are identical except for impeller and casing sizes.

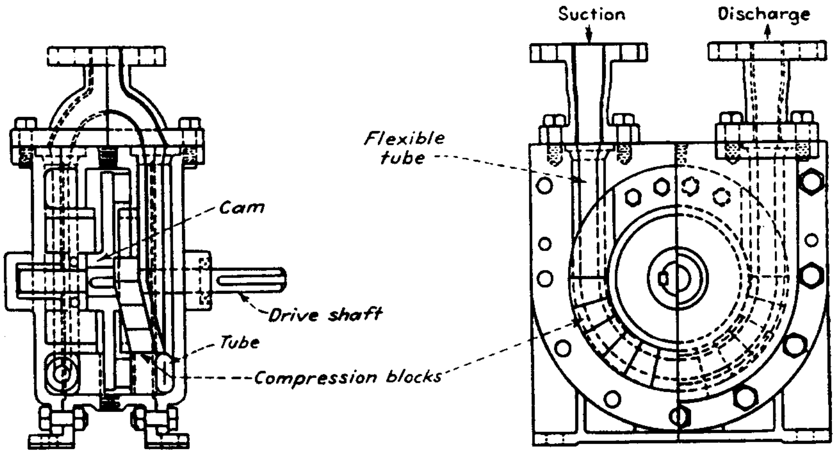


8. USED TO TRANSFER, meter, or proportion liquids of high or low viscosity, this pump is a positive displacement gear pump. It is made of stainless steel with a stainless steel armored, automatic take-up, shaft seal of the single-gland type. Automatic wear control compensates for normal wear and maintains volumetric efficiency. This pump will handle 5 to 300 gph without churning or foaming. It needs no lubrication and operates against high or low pressure.

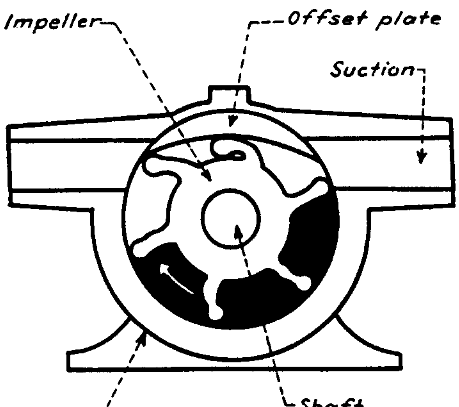
These pumps are used to transfer liquids and semisolids, pump vacuums, and boost oil pressure



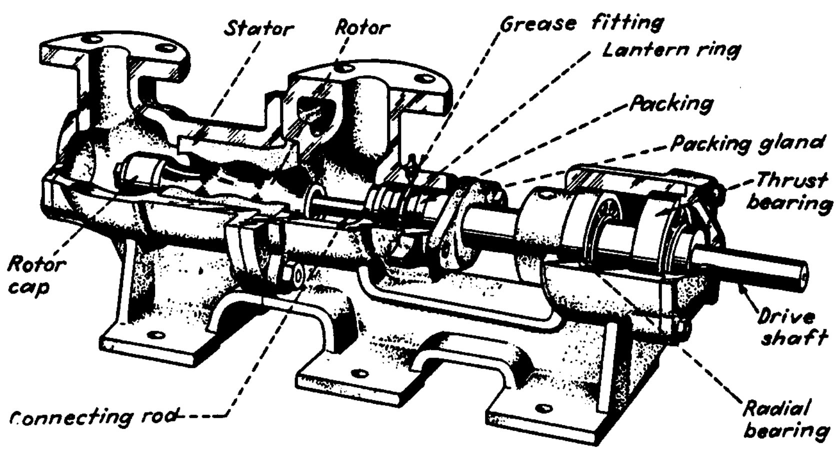
9. ORIGINALLY DESIGNED for use in the marine field, this gearless pump was made from stainless steel, monel, and bronze for handling acids, oils, and solvents. The impeller is made of pressure-vulcanized laminated layers of Hycar, 85 to 90 percent hard. Sand, grit, scale and fibrous materials will pass through. With capacities from 1 to 12 gpm and speeds from 200 to 3,500 rpm, these pumps will deliver against pressures up to 60 psi. Not self-priming, it can be installed with a reservoir. It operates in either direction and is self-lubricating.



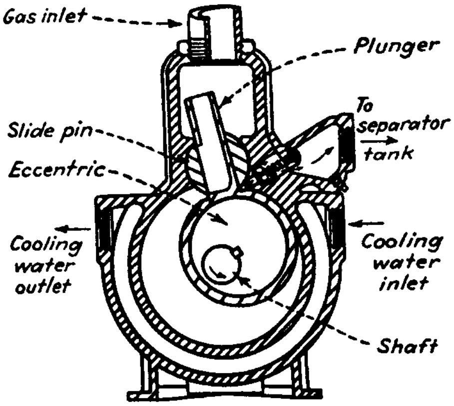
10. THE SQUEEGEE PUMP consists of a U-shaped flexible tube made of rubber, neoprene, or other flexible material. Acids and corrosive liquids or gases pass through the tube and do not contact working parts or lubricating oil. This prevents contamination of the liquid and avoids corrosion of metal parts. In operation, the tube is compressed progressively from the intake side to the discharge side by cams mounted on a driven shaft. Compression blocks move against the tube, closing the tube gradually and firmly from block to block, which forces the liquid out. As the cam passes the compression blocks, the tube returns to its original diameter. This creates a high vacuum on the intake side and causes the tube to be filled rapidly. The pump can be driven clockwise or counter-clockwise. The tube is completely encased and cannot expand beyond its original diameter. The standard pump is made of bronze and will handle volumes to 15 gpm. The Squeegee develops a vacuum of 25 in. of mercury and will work against pressures of 50 lb/in^2.



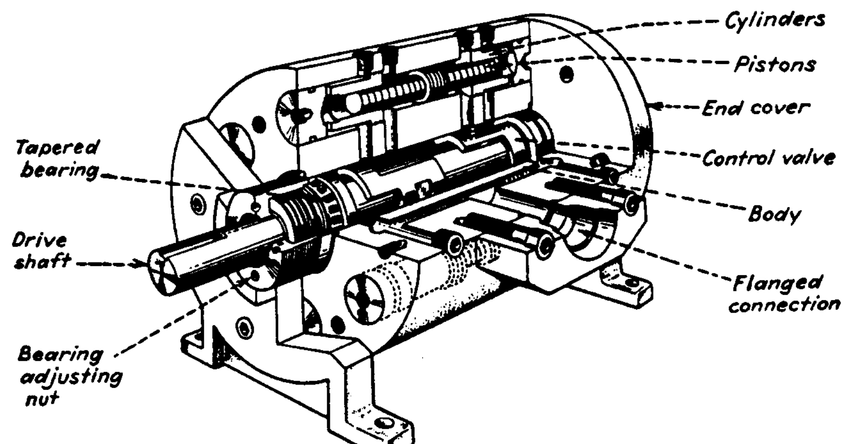
11. DEFLECTED BLADES of the flexible neoprene impeller straighten as they leave contact with offset plate. The high suction created draws fluid into pump, filling space between the blades. It handles animal, vegetable, and mineral oils but not napthas, gasoline, ordinary cleaning solvents, or paint thinners. The pump operates in either direction and can be mounted at any angle. It runs at 100 to 2,000 rpm, can deliver up to 55 gpm, and will operate against 25 psi. It operates at temperatures between 0 and 160 F.



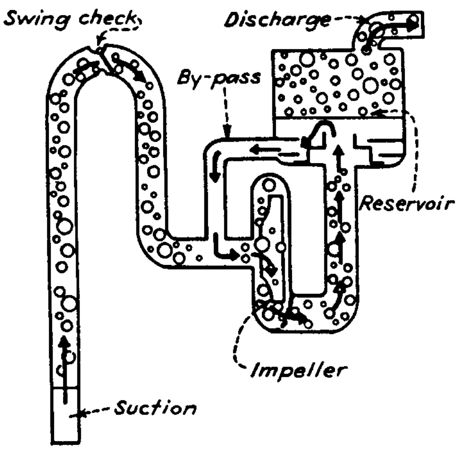
12. THIS PUMP CAN TRANSFER free-flowing liquids, non-pourable pastes, clean or contaminated with abrasives, chemically inert or active, homogeneous or containing solids in suspension. It is a positive displacement pump that delivers continuous, uniform flow. The one moving part, a low-alloy or tool-steel rotor, is a single helix, and the Hycar or natural rubber stator is a double internal helix. Pumping action is similar to that of a piston moving through a cylinder of infinite length. Containing no valves, this pump will self-prime at 28 ft of suction lift. The head developed is independent of speed, and capacity is proportional to speed. Slippage is a function of viscosity and pressure, and is predictable for any operating condition. The pump passes particles up to ⅞ in. diameter through its largest pump. Pumping action can be in either direction. The largest standard pump, with two continuous seal lines, handles 150 gpm up to 200 psi.



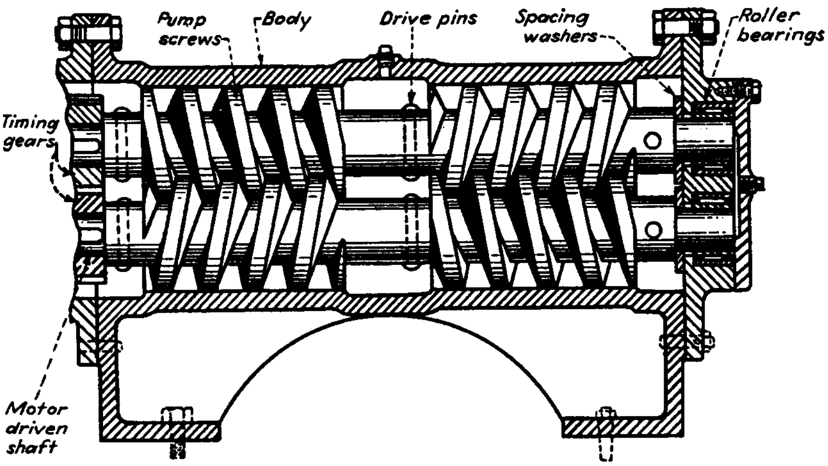
13. HIGH-VACUUM PUMPS operate with the rotating plunger action of liquid pumps. Sealing oil lubricates the three moving parts. Parts are accessible without disturbing connected piping. These pumps are used to rough pump a vacuum before connecting a diffusion pump; to evacute light bulbs and electronic tubes, and to vacuum dry and distill. Single pumps draw vacuums from 2 to 5 microns; in series to 0.5 micron, and compound pumps draw to 0.1 micron. They can be run in reverse for transferring liquids. Diagonal cored slots, closed by a slide pin, form the passageway and inlet valve. Popper or feature outlet valves are used.



14. A COMPACT MULTI-PLUNGER INTENSIFIER, this hydraulic booster is designed to convert low pressure to high pressure in any oil-hydraulic circuit. No additional pumps are required. Because of its six plungers, the pressure flow from the booster is both smooth and uninterrupted. High-pressure pumps are not required, and no operating valves are needed to control the high-pressure system. Small cylinder and ram assemblies can be used on operating equipment because the pressure is high. Operating costs can be low because of the efficient use of connected horsepower. The inertia effects of the small operating rams are low, so high speed operations can be attained. These boosters were built in two standard sizes, each of which was available in two pressure ranges: 2 to 1 and 3 to 1. Volumetric output is in inverse proportion to the pressure ratio. All units have a maximum 7,500 psi discharge pressure. Pistons are double-acting, and the central valve admits oil to pistons in sequence and is always hydraulically balanced.



15. THIS SELF-PRIMING PUMP gives a rapid and smooth transition from priming cycle to centrifugal pumping. The pump starts with its priming chamber full. Liquid is recirculated through the impeller until the pump is primed. As priming liquid circulates, air is drawn through impeller and expelled through the discharge. When all air is evacuated, discharge velocity closes the priming valve completely. These pumps can have open or closed impellers. Solids up to 1 in. can be passed through a 3 in. size pump with an open impeller.



16. INTERNAL SCREW PUMPS can easily transfer high-viscosity petroleum products. They can be used as boiler fuel pumps because they deliver a pulseless flow of oil. For marine or stationary systems, the characteristic low vibration of screw pumps has allowed them to be mounted on light foundations. The absence of vibration and pulsing flow reduces strain on pipes, hose and fittings. The pumping screws are mounted on shafts and take in liquid at both ends of the pump body and move it to the center for discharge. This balanced pumping action makes it unnecessary to use thrust bearings except in installations where the pump is mounted at a high angle. The pumps can be used at any angle up to vertical. Where thrust bearings are needed, antifriction bearings capable of supporting the load of the shaft and screws are used. The intermeshing pumping screws are timed by a pair of precision-cut herringbone gears. These are self-centering, and do not allow the side wear of the screws while they are pumping. The pump is most efficient when driven less than 1,200 rpm by an electric motor and 1,300 rpm by a steam turbine.

ROTARY-PUMP MECHANISMS

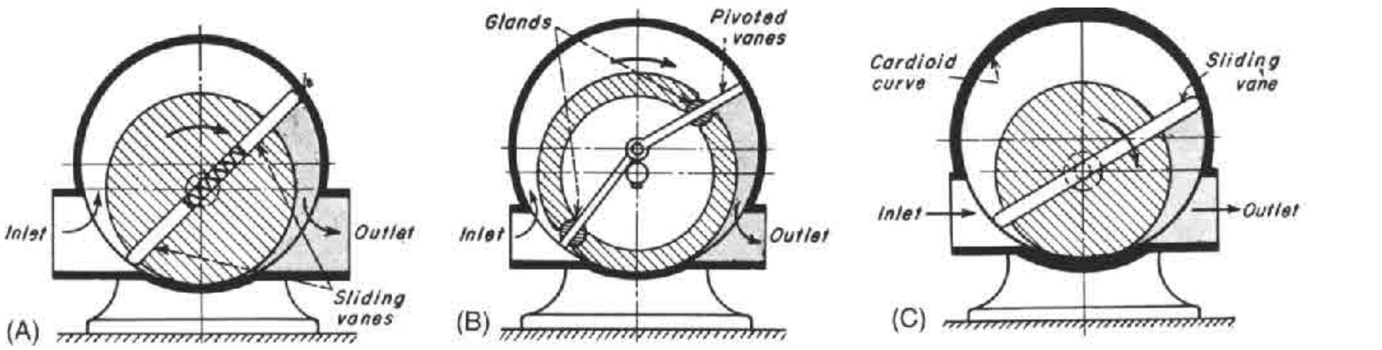


Fig. 1 (A) **A Ramelli pump** with spring-loaded vanes to ensure contact with the wall; vane ends are rounded for line contact. (B) Two vanes pivot in the housing and are driven by an eccentrically mounted disk; vanes slide in glands and are always radial to the housing, thus providing surface contact. (C) A housing with a cardioid curve allows the use of a single vane because opposing points on the housing in line with the disk center are equidistant.

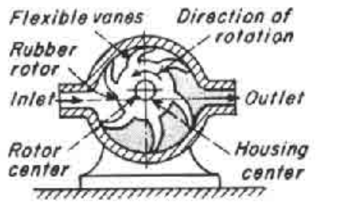


Fig. 2 **Flexible vanes** on an eccentric rubber rotor displace liquid as in sliding-vane pumps. Instead of the vanes sliding in and out, they bend against the casing to perform pumping.

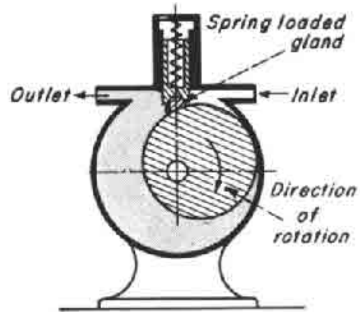


Fig. 3 **A disk** mounted eccentrically on the drive shaft displaces liquid in continuous flow. A spring-loaded gland separates the inlet from the outlet except when the disk is at the top of stroke.

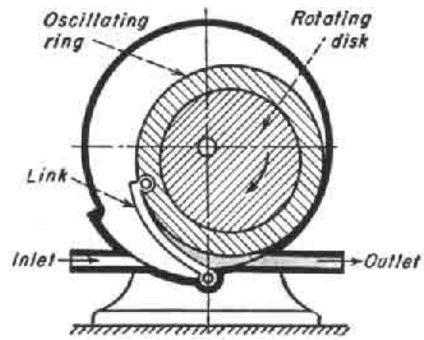


Fig. 4 **A rotary compressor pump** has a link separating its suction and compression sides. The link is hinged to a ring which oscillates while it is driven by the disk. Oscillating action pumps the liquid in a continuous flow.

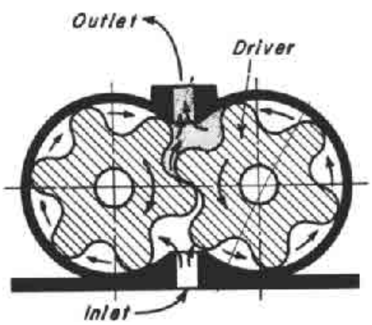


Fig. 5 **A gear pump** transports liquid between the tooth spaces and the housing wall. A circular tooth shape ha sonly one tooth making contact, and it is more efficient than an involute shape which might enclose a pocket between two adjoining teeth, recirculating part of the liquid. The pump has helical teeth.

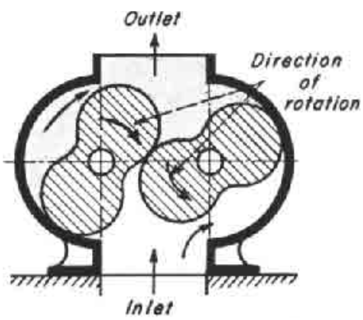


Fig. 6 **A Roots compressor** has two identical impellers with specially shaped teeth. The shafts are connected by external gearing to ensure constant contact between the impellers.

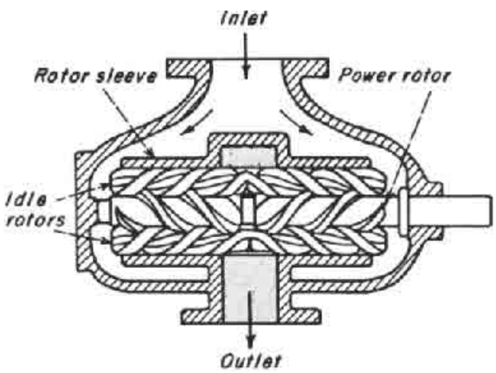


Fig. 7 **A three-screw pump** drives liquid between the screw threads along the axis of the screws. The idle rotors are driven by fluid pressure, not by metallic contact with the power rotor.

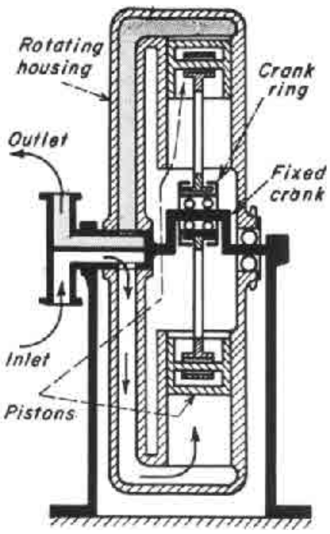


Fig. 8 The housing of the Hele-Shaw-Beachum pump rotates the round-cranked shaft. Connecting rods attached to the crank ring cause the pistons to oscillate as the housing rotates. No valves are necessary because the fixed hollow shaft, divided by a wall, has suction and compression sides that are always in correct register with the inlet and outlet ports.

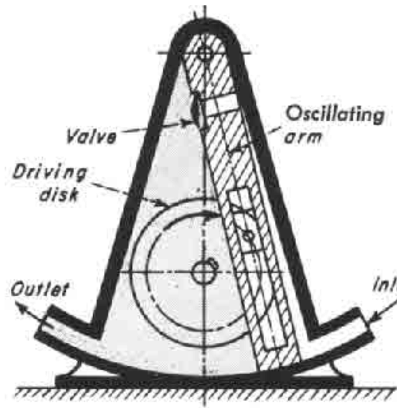


Fig. 9 A disk drives the oscillating arm which acts as piston. The velocity of the arm varies because of its quick-return mechanism. Liquid is slowly drawn in and expelled during the clockwise rotation of the arm; the return stroke transfers the liquid rapidly.

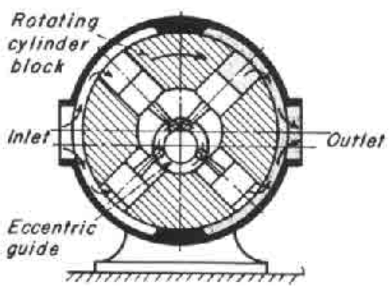


Fig. 10 A rotating cylinder block is mounted concentrically in a housing. Connecting-rod ends slide around an eccentric guide as the cylinders rotate and cause the pistons to reciprocate. The housing is divided into suction and compression compartments.

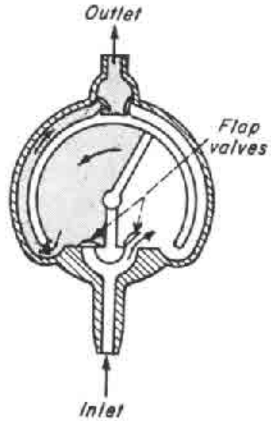
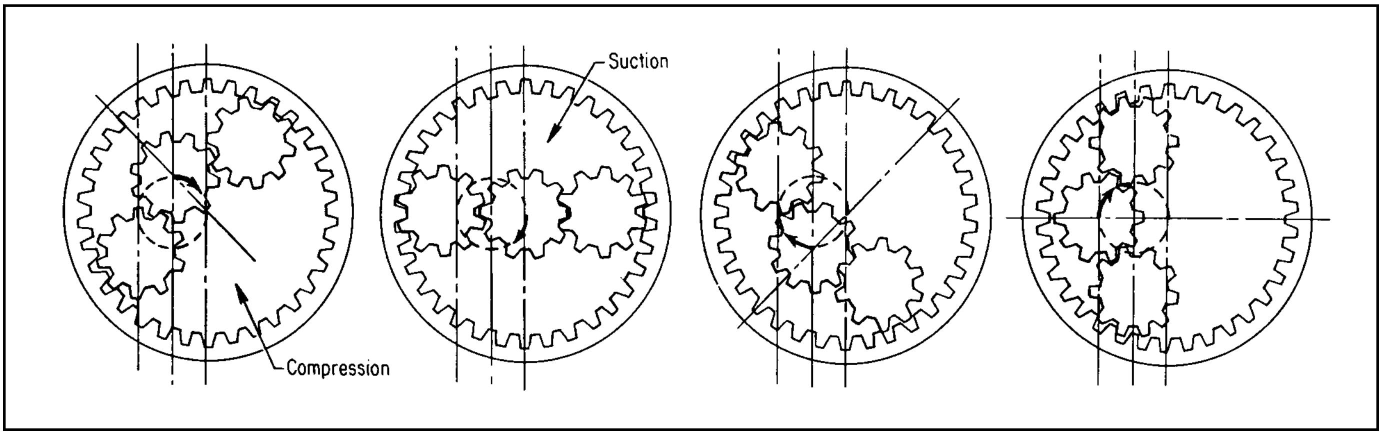


Fig. 11 A rotary-reciprocating pump that is normally operated manually to pump high-viscosity liquids such as oil.

OFFSET PLANETARY GEARS INDUCE ROTARY-PUMP ACTION



Two planetary gears are driven by an offset sun gear to provide the pumping action in this positive-displacement pump. A successively increasing/decreasing (suction/compression) is formed on either side of the sun and planet gears.

MECHANISMS ACTUATED BY PNEUMATIC OR HYDRAULIC CYLINDERS

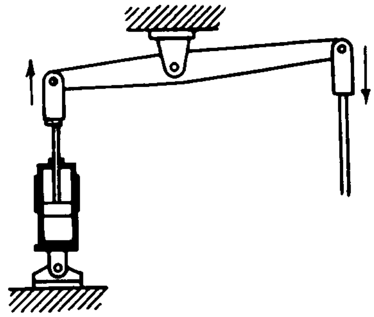


Fig. 1 A cylinder can be used with a first-class lever.

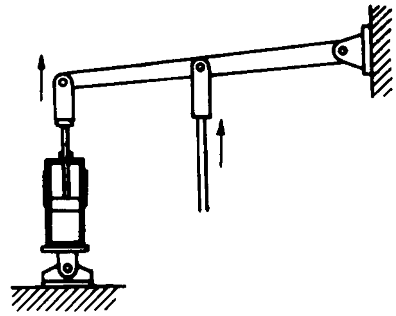


Fig. 2 A cylinder can be used with a second-class lever.

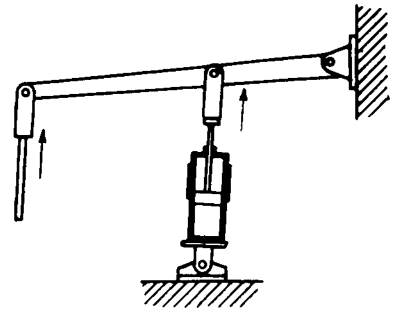


Fig. 3 A cylinder can be used with a third-class lever.

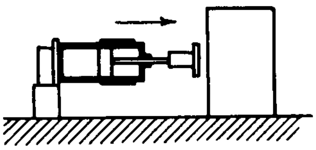


Fig. 4 A cylinder can be linked up directly to the load.

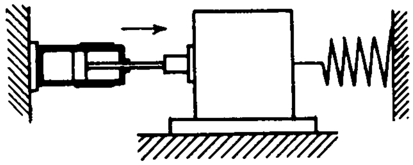


Fig. 5 A spring reduces the thrust at the end of the stroke.

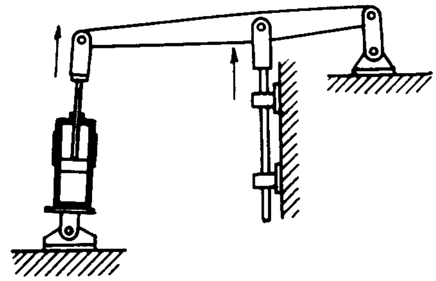


Fig. 6 The point of application of force follows the direction of thrust.

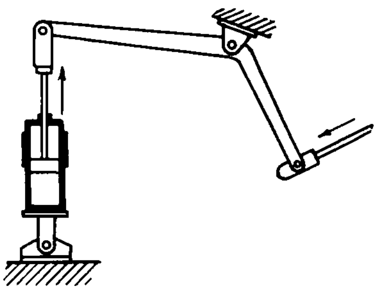


Fig. 7 A cylinder can be used with a bent lever.

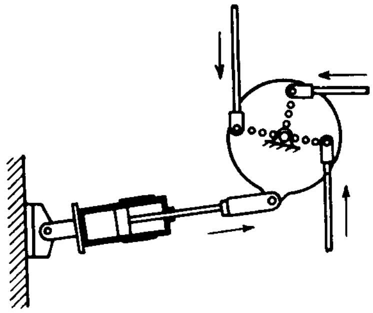


Fig. 8 A cylinder can be used with a trammel plate.

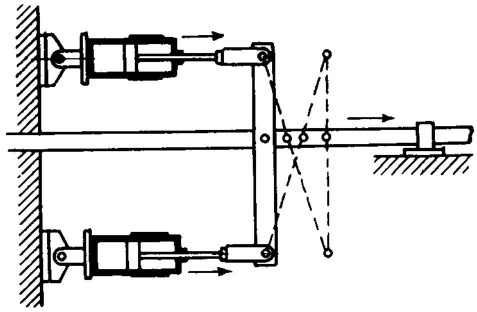


Fig. 9 Two pistons with fixed strokes position the load in any of four stations.

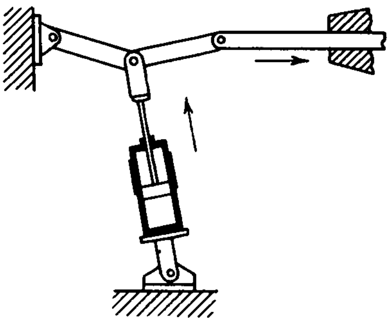


Fig. 10 A toggle can be actuated by the cylinder.

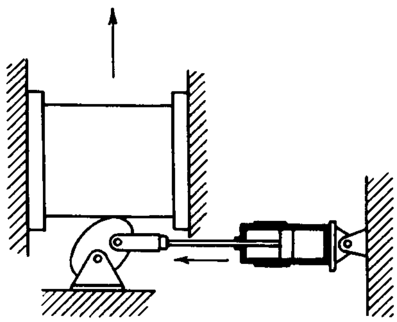


Fig. 11 The cam supports the load after the completion of the stroke.

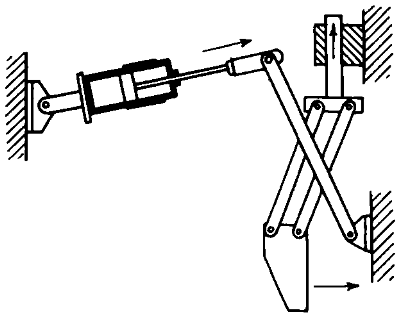


Fig. 12 Simultaneous thrusts in two different directions are obtained.

(Note: In place of cylinders, electrically powered thrust units or solenoids can be used.)

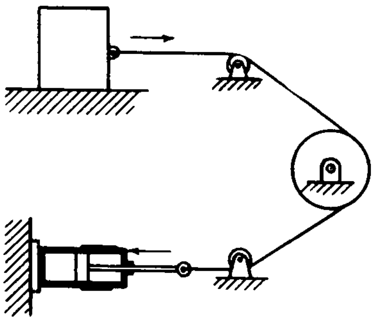


Fig. 13 **A force** is transmitted by a cable.

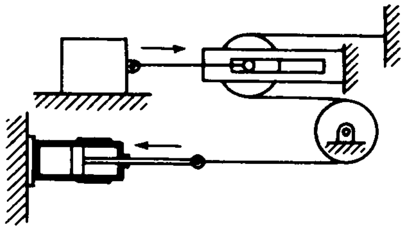


Fig. 14 **A force** can be modified by a system of pulleys.

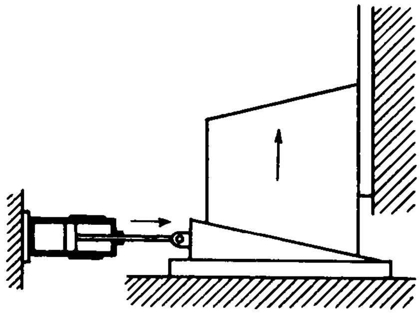


Fig. 15 A force can be modified by wedges.

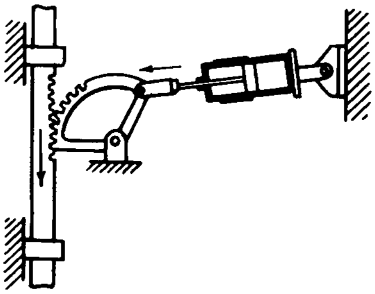


Fig. 16 **A gear sector** moves the rack perpendicular to the piston stroke.

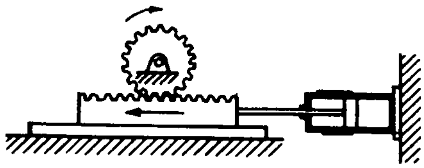


Fig. 17 **A rack** turns the gear sector.

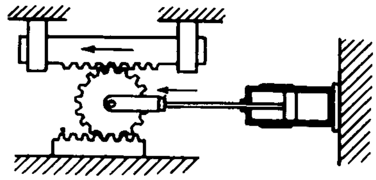


Fig. 18 **The motion** of a movable rack is twice that of the piston.

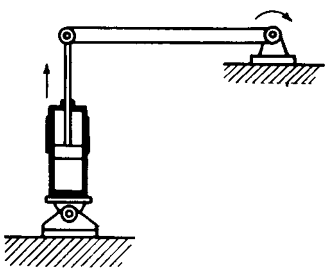


Fig. 19 **A torque** applied to the shaft can be transmitted to a distant point.

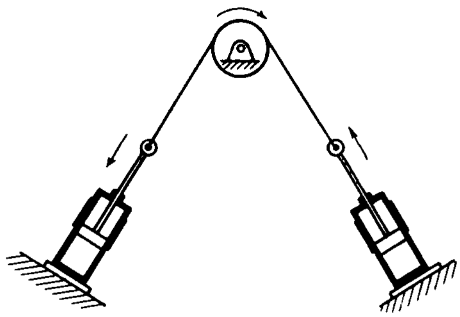


Fig. 20 **A torque** can also be applied to a shaft by a belt and pulley.

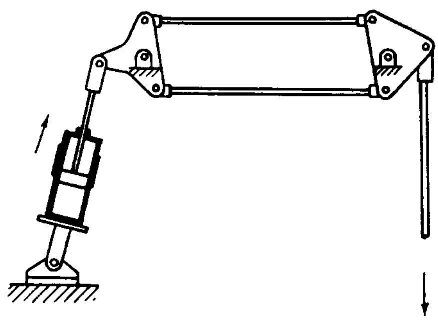


Fig. 21 **A motion** is transmitted to a distant point in the plane of motion.

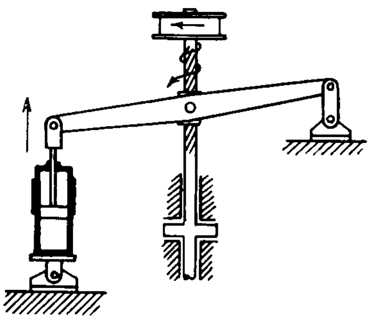


Fig. 22 **A steep screw nut** produces a rotation of the shaft.

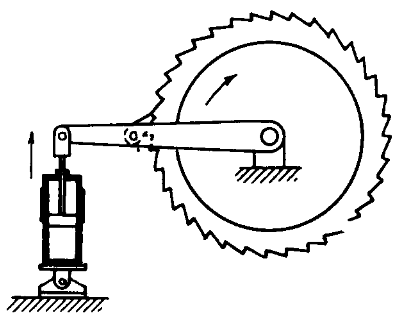


Fig. 23 **A single-sprocket wheel** produces rotation in the plane of motion.

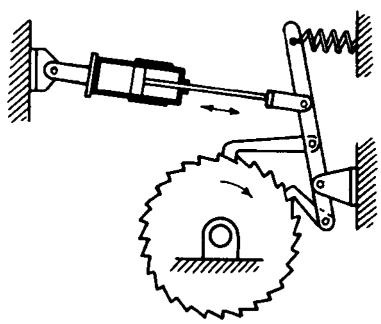
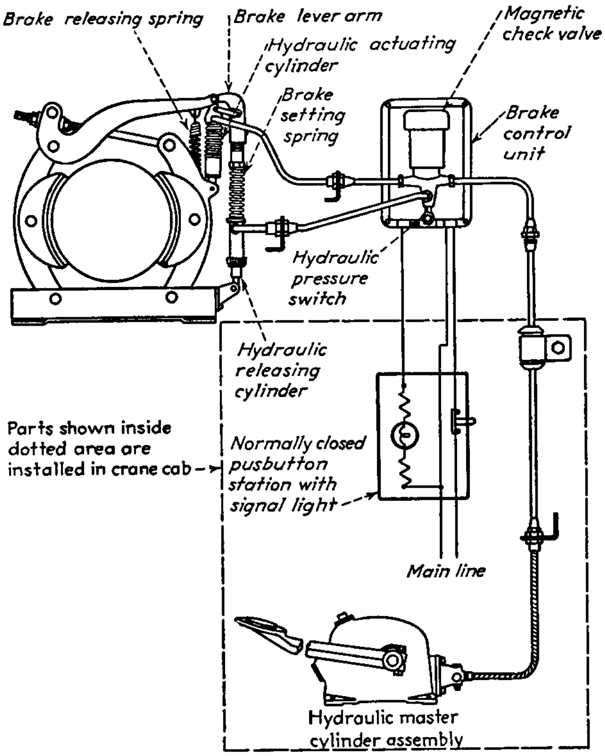


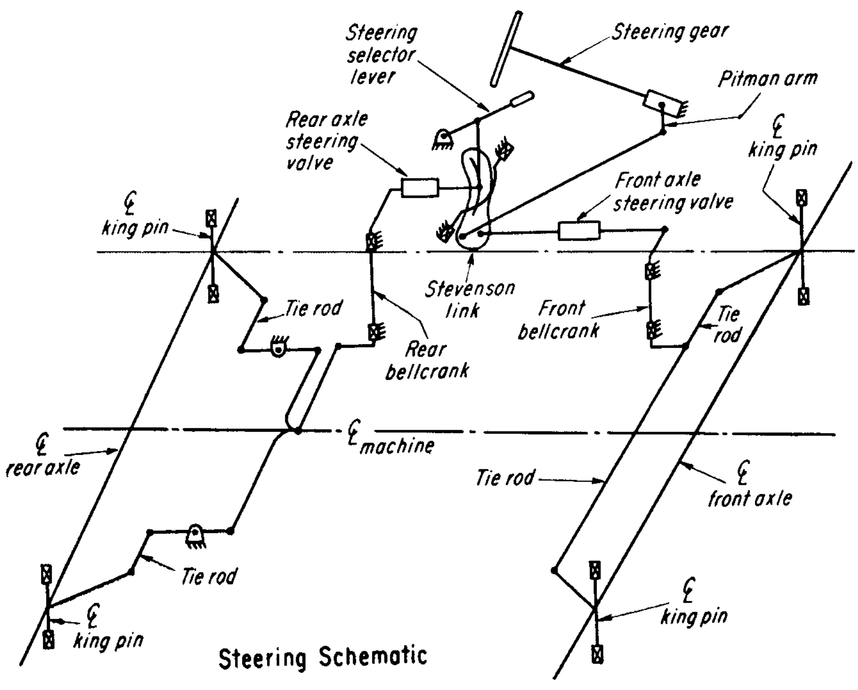
Fig. 24 **A double-sprocket wheel** makes the rotation more nearly continuous.

FOOT-CONTROLLED BRAKING SYSTEM

This crane braking system (see figure) operates when the main line switch closes. The full depression of the master-cylinder foot-pedal compresses the brake-setting spring mounted on the hydraulic releasing cylinder. After the setting spring is fully compressed, the hydraulic pressure switch closes, completing the electric circuit and energizing the magnetic check valve. The setting spring remains compressed as long as the magnetic check valve is energized because the check valve traps the fluid in the hydraulic-releasing cylinder. Upon release of the foot peal, the brake lever arm is pulled down by the brake releasing spring, thus releasing the brake shoes.



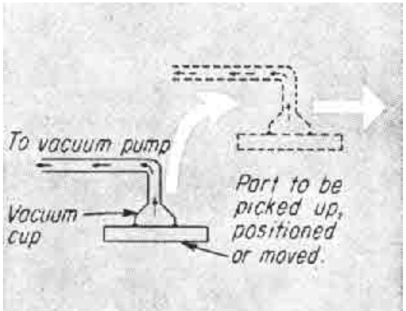
LINKAGES ACTUATE STEERING IN A TRACTOR



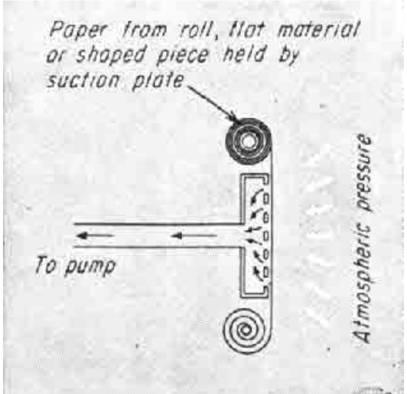
Hydraulic power for operating the brakes, clutch, and steering of a 300 hp diesel-powered tractor is supplied by an engine-driven pump delivering 55 gpm at 1200 psi. The system is designed to give a 15-gpm preference to the steering system. The steering drive to each wheel is mechanical for synchronization, with mechanical selection of the front-wheel, four-wheel or crab-steering hookup; hydraulic power amplifies the manual steering effort.

FIFTEEN JOBS FOR PNEUMATIC POWER

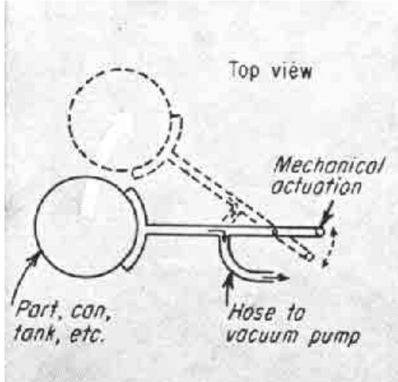
Suction can feed, hold, position, and lift parts, form plastic sheets, sample gases, test for leaks, convey solids, and de-aerate liquids. Compressed air can convey materials, atomize and agitate liquids, speed heat transfer, support combustion, and protect cable.



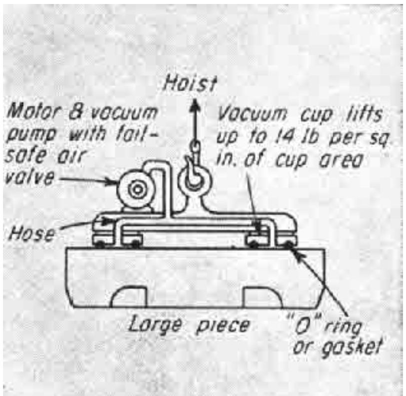
FEEDING PARTS



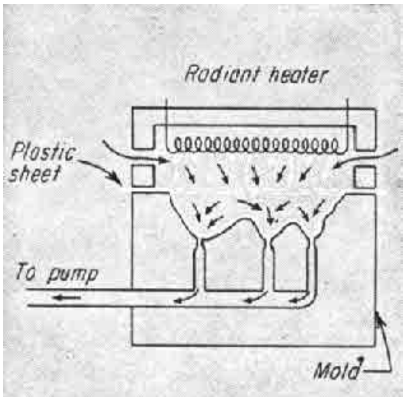
HOLDING PARTS



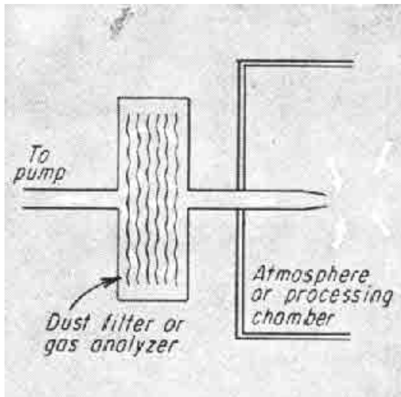
POSITIONING PARTS



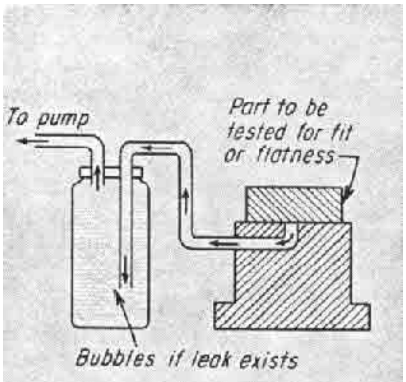
LIFTING PARTS



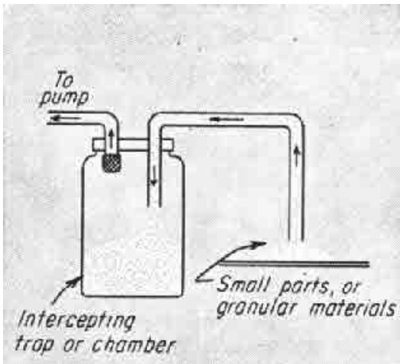
VACUUM FORMING



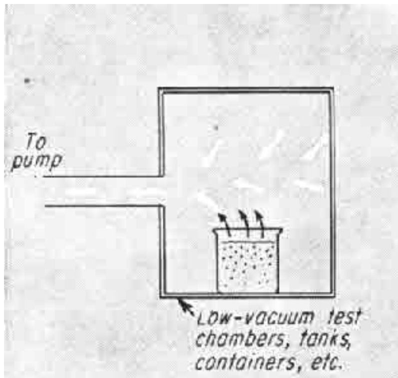
GAS SAMPLING



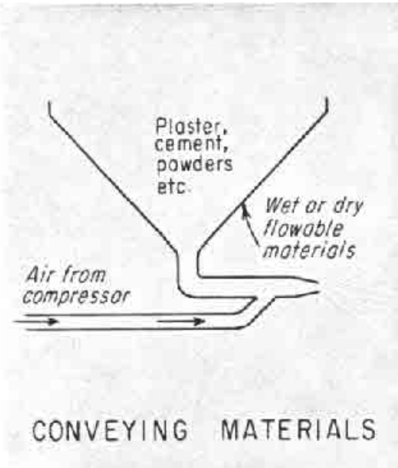
LEAK TESTING

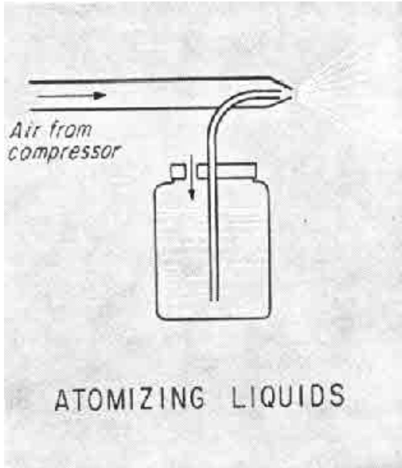


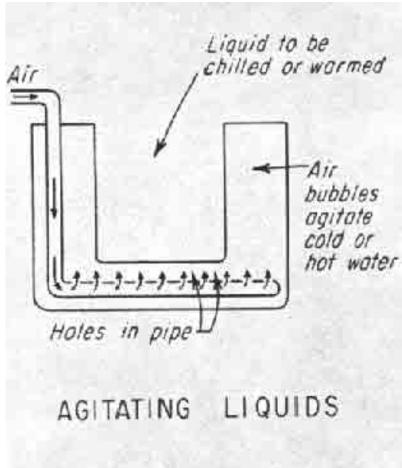
CONVEYING SOLIDS

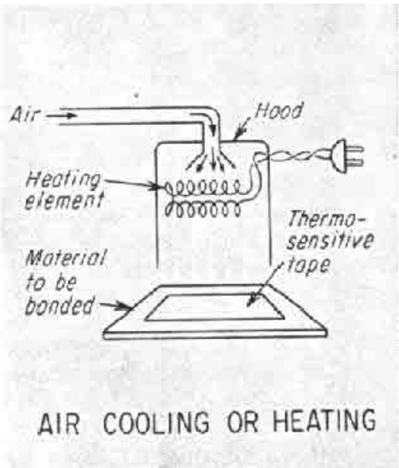


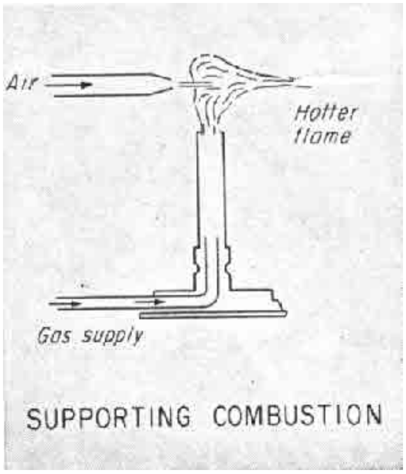
DE-AERATING HIGH-VISCOSITY LIQUIDS

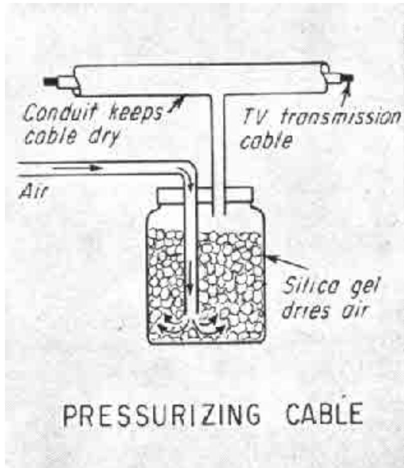












TEN WAYS TO USE METAL DIAPHRAGMS AND CAPSULES

Fig. 1

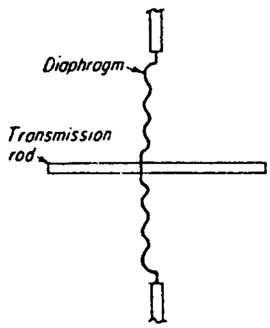


Fig. 2

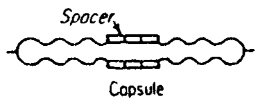


Fig. 3

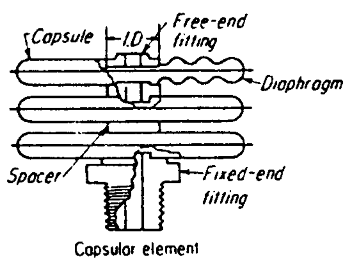
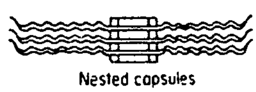
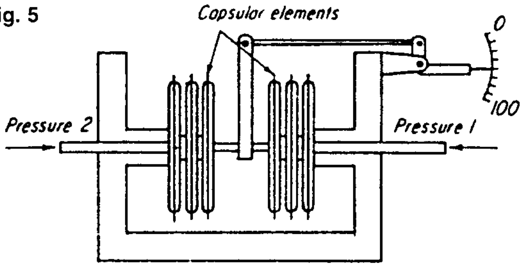


Fig. 4



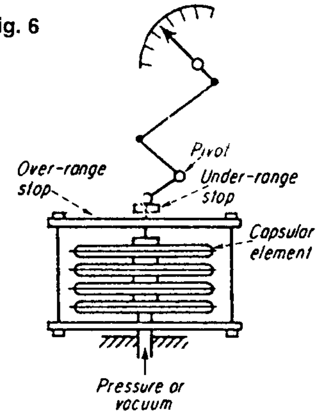
A metal diaphragm is usually corrugated (Fig. 1) or formed to some irregular profile. It can be used as a flexible seal for an actuating rod. The capsule (Fig. 2) is an assembly of two diaphragms sealed together at their outer edges, usually by soldering, brazing, or welding. Two or more capsules assembled together are known as a capsular element (Fig. 3). End fittings for the capsules vary according to their function; the “fixed end” is fixed to the equipment. The “free end” moves the related components and linkages. The nested capsule (Fig. 4) requires less space and can be designed to withstand large external overpressures without damage.

Fig. 5



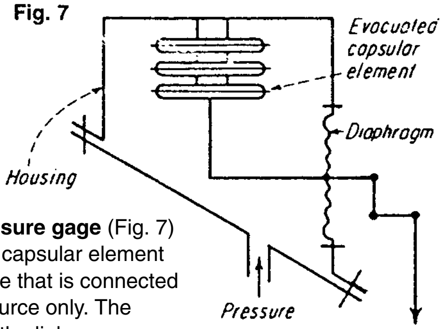
A differential pressure gage (Fig. 5) with opposing capsules can have either single or multicapsular elements. The multicapsular type gives greater movement to the indicator. Capsules give improved linearity over bellows for such applications as pressure-measuring devices. The force exerted by any capsule is equal to the total effective area of the diaphragms (about 40% actual area) multiplied by the pressure exerted on it. Safe pressure is the maximum pressure that can be applied to a diaphragm before hysteresis or set become objectionable.

Fig. 6



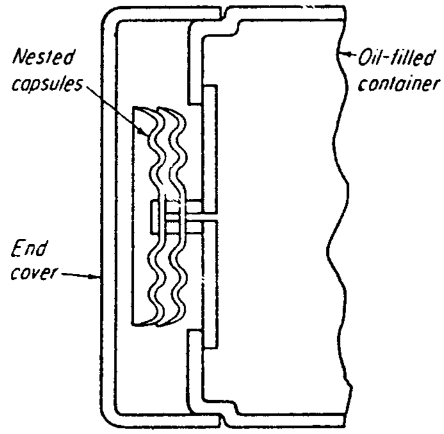
A pressure gage (Fig. 6) has a capsular element linked to a dial indicator by a three-bar linkage. Such a gage measures pressure or vacuum relative to prevailing atmospheric pressure. If greater angular motion of the indicator is required than can be obtained from the three-bar linkage, a quadrant and gear can be substituted.

Fig. 7



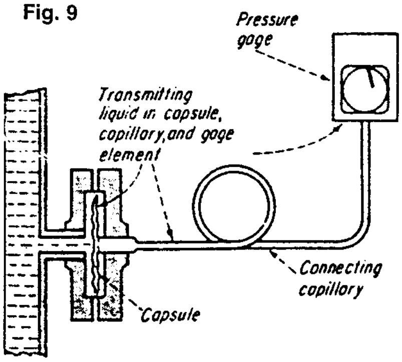
An absolute pressure gage (Fig. 7) has an evacuated capsular element inside an enclosure that is connected to the pressure source only. The diaphragm allows the linkage movement from the capsule to pass through a sealed chamber. This arrangement can also be used as a differential pressure gage by making a second pressure connection to the interior of the element.

Fig. 8



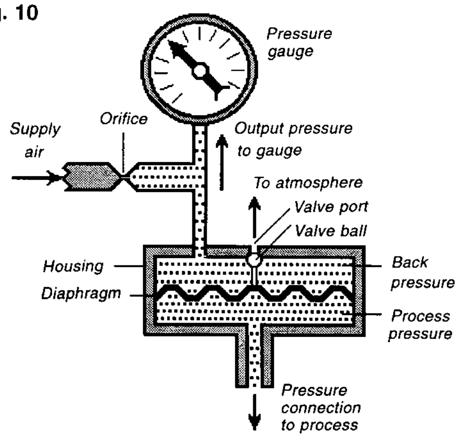
An expansion compensator (Fig. 8) for oil-filled systems takes up less space when the capsules are nested. In this application, one end of the capsule is open and connected to oil in the system; the other end is sealed. Capsule expansion prevents the internal oil pressure from increasing dangerously from thermal expansion. The capsule is protected by its end cover.

Fig. 9



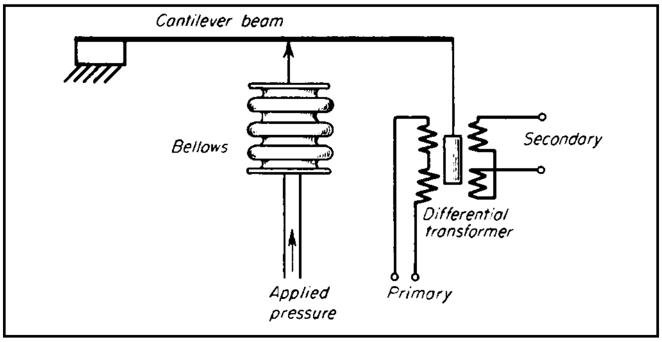
A capsule pressure-seal (Fig. 9) works like a thermometer system except that the bulb is replaced by a pressure-sensitive capsule. The capsule system is filled with a liquid such as silicone oil and is self-compensating for ambient and operating temperatures. When subjected to external pressure changes, the capsule expands or contracts until the internal system pressure just balances the external pressure surrounding the capsule.

Fig. 10

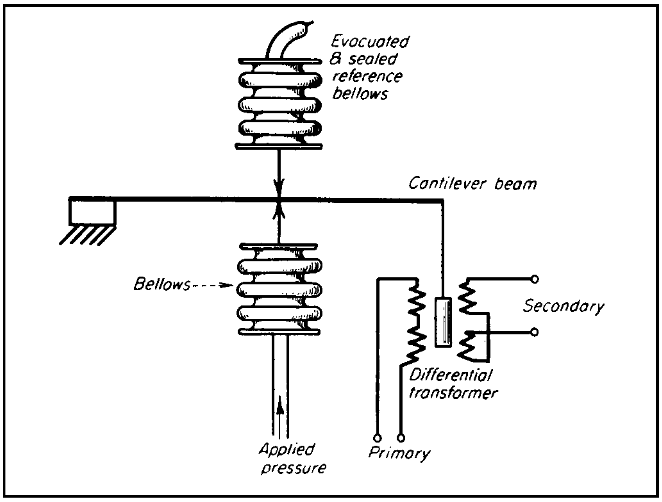


A force-balanced seal (Fig. 10) solves the problem, as in the seal of Fig. 9, for keeping corrosive, viscous or solids-bearing fluids out of the pressure gage. The air pressure on one side of a diaphragm is controlled so as to balance the other side of the diaphragm exactly. The pressure gage is connected to measure this balancing air pressure. The gage, therefore, reads an air pressure that is always exactly equal to the process pressure.

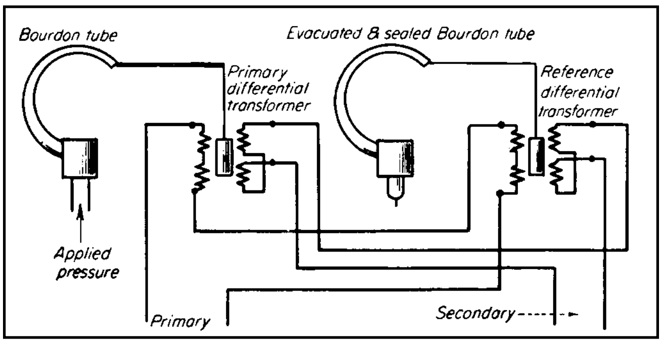
DIFFERENTIAL TRANSFORMER SENSING DEVICES



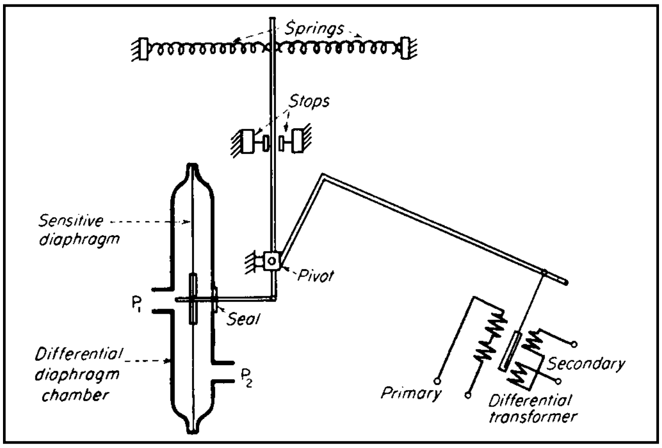
Gage pressure bellows transmitter. The bellows is connected to a cantilever beam with a needle bearing. The beam adopts a different position for every pressure; the transformer output varies with beam position. The bellows are available for ranges from 0–10 in. to 0–200 in. of water for pressure indication or control.



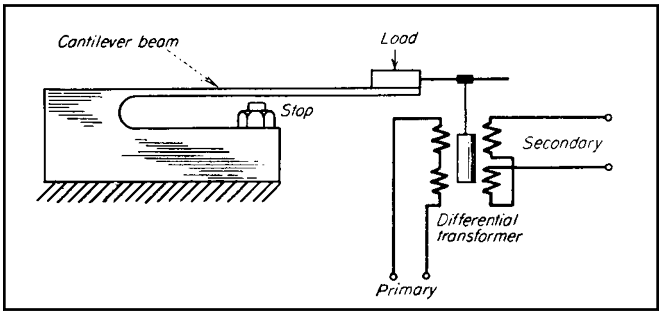
Absolute pressure bellows transmitter. This transmitter is similar to the differential diaphragm transmitter except for addition of a reference bellows which is evacuated and sealed. It can measure negative gage pressures with ranges from 0–50 mm to 0–30 in. of mercury. The reference bellows compensates for variations in atmospheric pressure.



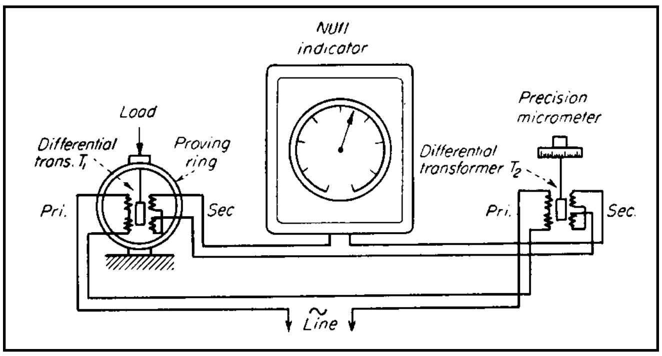
Absolute pressure Bourdon-tube transmitter. This device can indicate or control absolute pressures from 15 to 10,000 psi, depending on tube rating. The reference tube is evacuated and sealed, and compensates for variations in atmospheric pressure by changing the output of the reference differential transformer. The signal output consists of the algebraic sum of the outputs of both the primary and reference differential transformers.



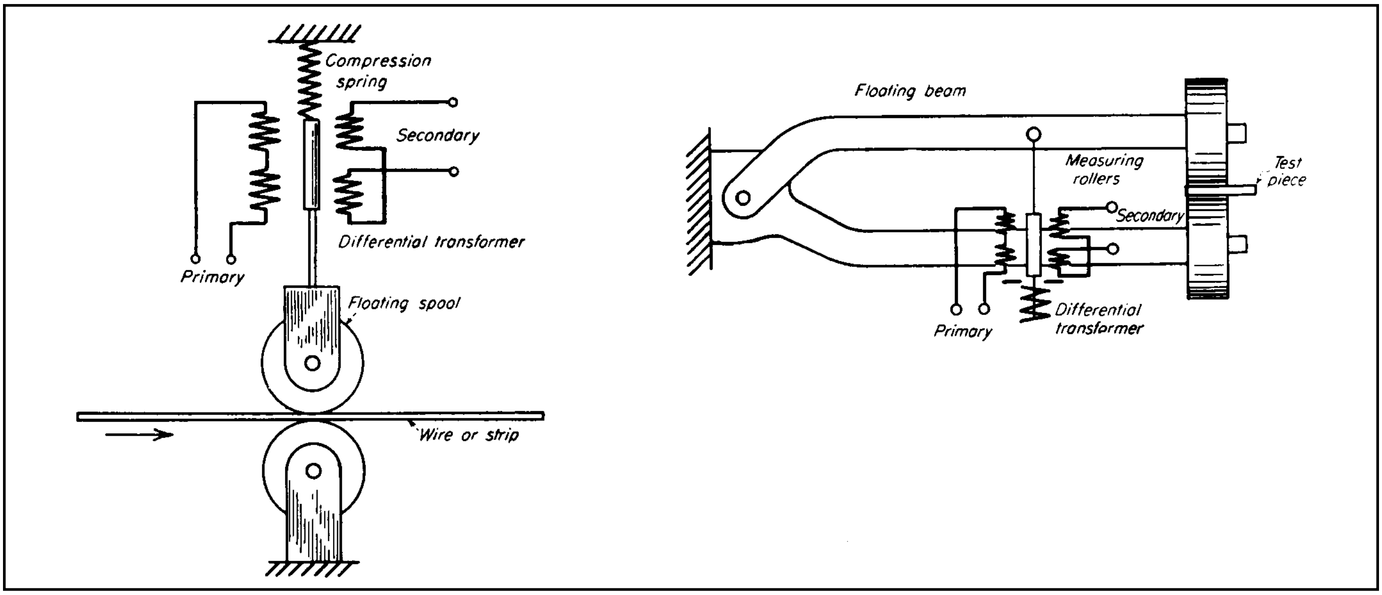
Differential diaphragm pressure transmitter. Differential pressures P_1 and P_2 act on the opposite sides of a sensitive diaphragm and move the diaphragm against the spring load. The diaphragm displacement, spring extension, and transformer core movement are proportional to the difference in pressure. The device can measure differentials as low as 0.005 in. of water. It can be installed as the primary element in a differential pressure flowmeter, or in a boiler windbox for a furnace-draft regulator.



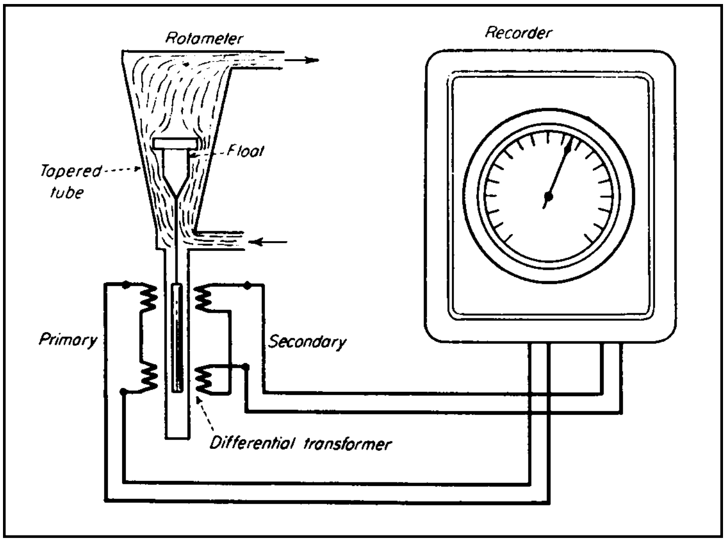
Cantilever load cell. The deflection of a cantilever beam and the displacement of a differential transformer core are proportional to the applied load. The stop prevents damage to the beam in the event of overload. Beams are available for ranges from 0–5 to 0–500 lb. And they can provide precise measurement of either tension or compression forces.



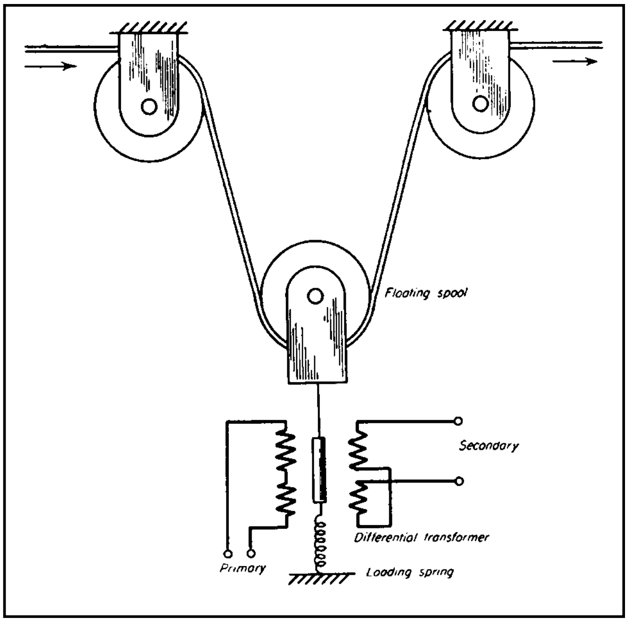
Proving ring. The core of the transmitting transformer, T_1, is fastened to the top of the proving ring, while the windings are stationary. The proving ring and transformer core deflect in proportion to the applied load. The signal output of the balancing transformer, T_2, opposes the output of T_1, so that at the balance point, the null point indicator reads zero. The core of the balancing transformer is actuated by a calibrated micrometer that indicates the proving ring deflection when the differential transformer outputs are equal and balanced.



Gaging and callipering. The thickness of a moving wire or strip is gaged by the position of the floating spool and transformer core. If the core is at the null point for proper material thickness, the transformer output phase and magnitude indicate whether the material is too thick or thin and the amount of the error. The signal can be amplified to operate a controller, recorder, or indicator. The device at the right can function as a production caliper or as an accurate micrometer. If the transformer output is fed into a meter indicator with *go* and *no-go* bands, it becomes a convenient device for gaging items.



Flow meter. The flow area varies as the float rises or falls in the tapered tube. High flows cause the float to rise, and low flows cause it to drop. The differential transformer core follows the float travel and generates an AC signal which is fed into a square-root recorder. A servo can be equipped with a square root cam to read on a linear chart. The transformer output can also be amplified and used to actuate a flow regulating valve so that the flowmeter becomes the primary element in a flow controller. Normally meter accuracy is better than 2%, but its flow range is limited.



Tension control. The loading spring can be adjusted so that when the transformer core is at its null point, the proper tension is maintained in the wire. The amplified output of the transformer is transmitted to some kind of tension-controlling device which increases or reduces the tension in the wire, depending on the phase and magnitude of the applied differential transformer signal.

HIGH-SPEED COUNTERS

The electronic counter counts electrical pulses and gives a running display of accumulated pulses at any instant. Because the input is an electrical signal, a transducer is generally required to transform the nonelectrical signal into a usable input for the counter.

With a preset function on the counter, any number can be selected within the count capacity of the device. Once the counter reaches the preset number, it can open or close the relay to control some operation. The counter will either reset automatically or stop. A dual unit permits continuous control over two different count sequence operations. Two sets of predetermining switches are usually mounted on the front panel of the counter, but they can be mounted at a remote location. If two different numbers are programmed into the counter, it will alternately count the two selected numbers. Multiple presets are also available, but at higher cost.

In addition to performing two separate operations, a dual preset can control speeds, as shown in Fig. 1. In the metal shearing operation run at high speed, one preset switch can be used to slow the material down at a given distance before the second preset actuates the shearing. Then both switches automatically reset and start to measure again. The same presets could also be used. The same presets could also be used to alternately shear the material into two different lengths.

One form of measurement well adapted to high-speed counters is the measuring of continuous materials such as wire, rope, paper, textiles, or steel. Fig. 2 shows a coil-winding operation in which a counter stops the machine at a predetermined number of turns of wire.

A second application is shown in Fig. 3. Magazines are counted as they run off a press. A photoelectric pickup senses the alternate light and dark lines formed by the shadows of the folded edges of the magazines. At the predetermined number, a knife edge, actuated by the counter, separates the magazines into equal batches.

A third application is in machine-tool control. A preset counter can be paired with a transducer or pulse generator mounted on the feed mechanism. It could, for example, convert revolutions of screw feed, hence displacement, into pulses to be fed into the counter. A feed of 0.129 in. might represent a count of 129 to the counter.

When preset at that number, the counter could stop, advance, or reverse the feed mechanism.

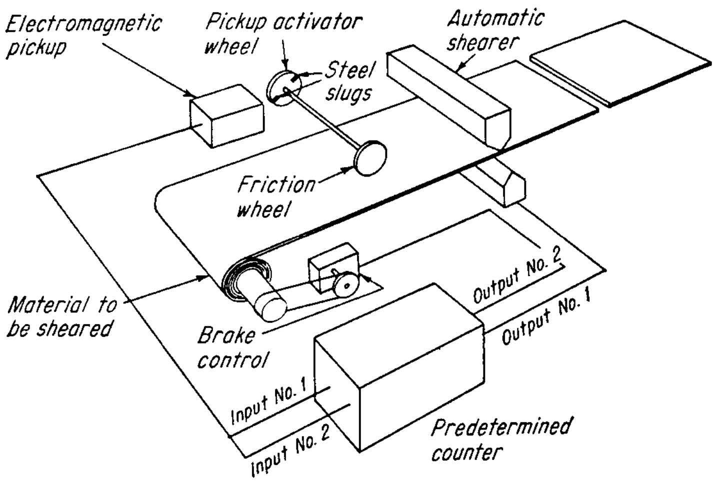


Fig. 1 A dual preset function on a high-speed counter controls the high-speed shearing operation. If the material is to be cut in 10-ft lengths and each pulse of the electromagnetic pickup represents 0.1 ft, the operator presets 100 into the first input channel. The second input is set to 90. When 90 pulses are counted, the second channel slows the material. Then when the counter reaches 100, the first channel actuates the shear. Both channels reset instantaneously and start the next cycle.

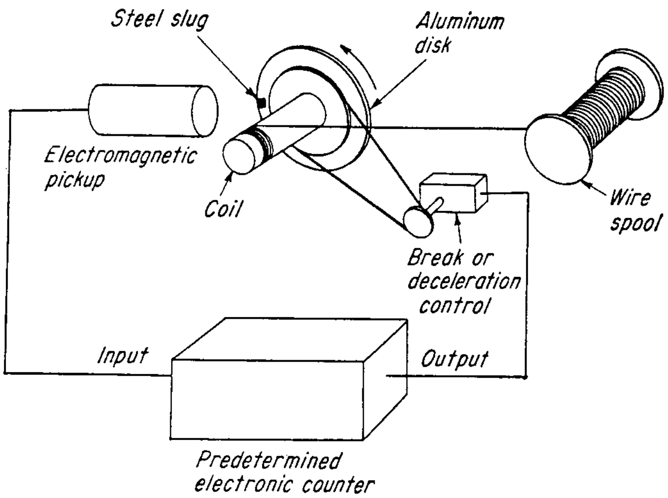


Fig. 2 A coil-winding machine with electronic counting for measuring length.

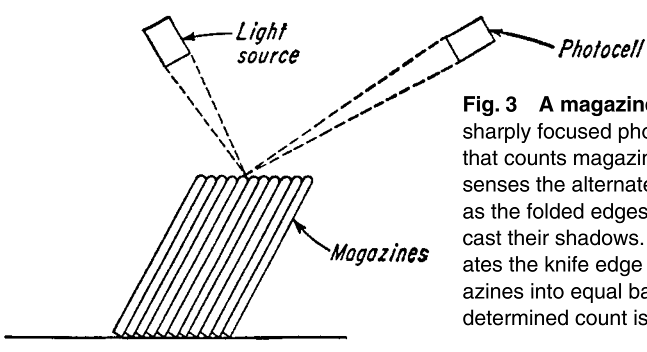


Fig. 3 A magazine counter has a sharply focused photoelectric pickup that counts magazines. The photocell senses the alternate light and dark lines as the folded edges of the magazines cast their shadows. The counter actuates the knife edge to separate the magazines into equal batches when the predetermined count is reached.

DESIGNING WITH PERMANENT MAGNETS

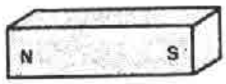


Fig. 1

Fig. 1 The simplest form of permanent magnet is a bar that has two poles which can have any cross section.

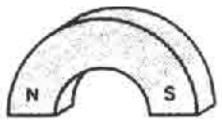
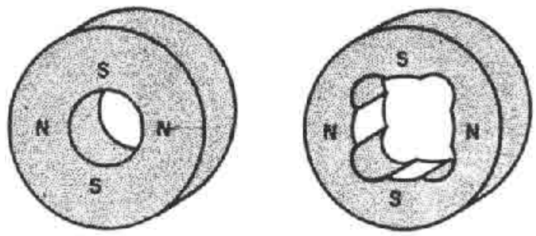


Fig. 2

Fig. 2 U or C-shaped permanent magnets are cast that way to bring both of the pole faces into the same plane.



(A) Fig. 3 (B)

Fig. 3 A cylindrical magnet can be magnetized with as many pairs of poles as desired on the outside diameter as in (A) or the inner diameter as in (B). Also, they can be made nonsalient (A) or salient (B).

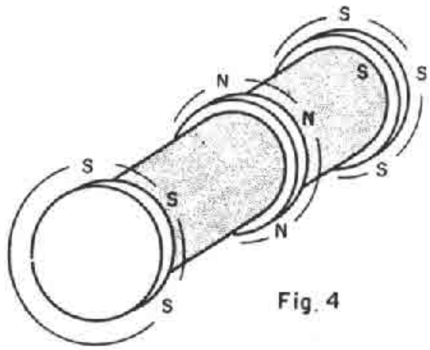
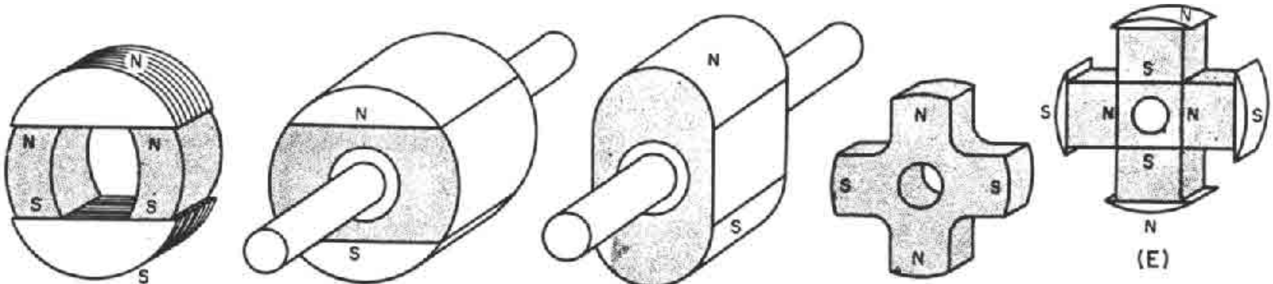


Fig. 4

Fig. 4 This magnetic roll for material separators is made from magnets and steel pole pieces that supply an equal magnetic field on 360º of the pole surface.

Fig. 5 Magnets for generators and other machines can be assembled from multiple magnets with laminated (A) or solid pole pieces (E), cast with inserts for pressing in shafts, nonsalient (B) or salient (C) or cast for assembly on shafts (D).



(A) (B) (C) (D) (E) Fig. 5

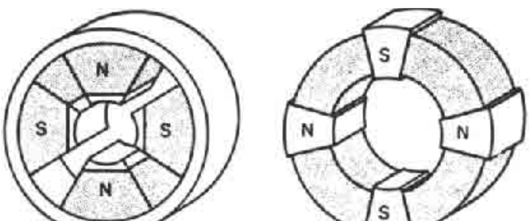
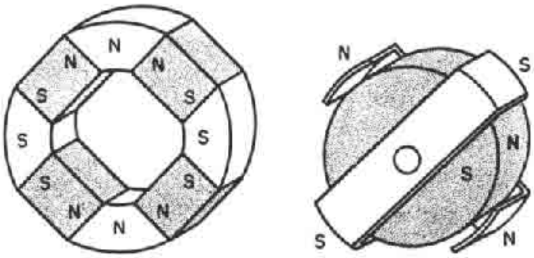


Fig. 6

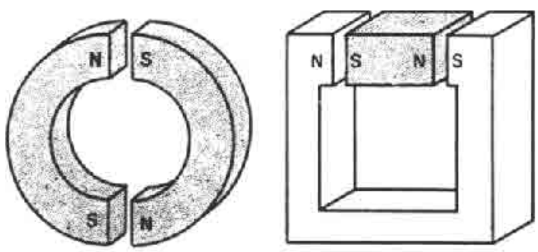
Fig. 6 Stator or internal pole assembles using steel pole faces and magnets are made in various ways depending on the mechanical space, magnetic and physical characteristics required.

Fig. 7 A four-pole magnet is shown with steel pole pieces, but it is possible to incorporate as many poles as are required (A) using bar magnets. In style (B) it is possible to obtain several poles by using one two-pole magnet.

Fig. 8 These permanent magnet assembles have double air gap. (A) has no steel poles, but (B) has them.



(A) Fig 7 (B)



(A) Fig. 8 (B)

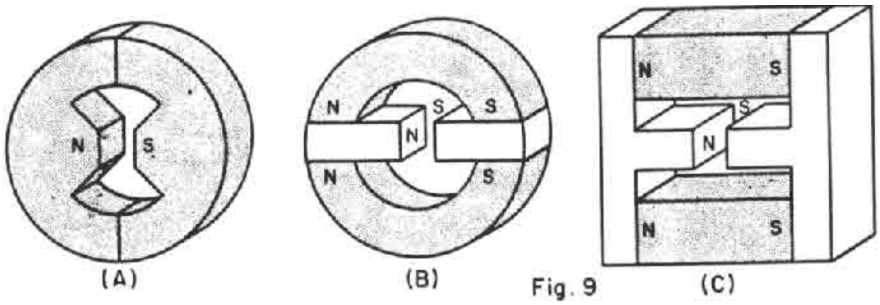
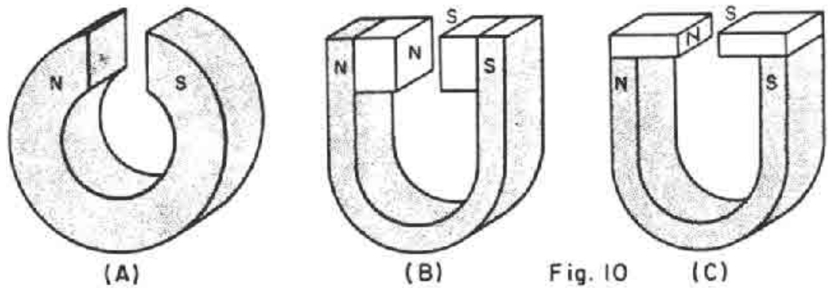


Fig. 9 Fixed air-gap magnets can be made from a multiplicity of magnets without steel pole pieces (A), or with pole pieces (B) and (C).

Fig. 10 Simple fixed air-gap magnets can be without pole pieces (A) or with pole pieces (B) and (C).



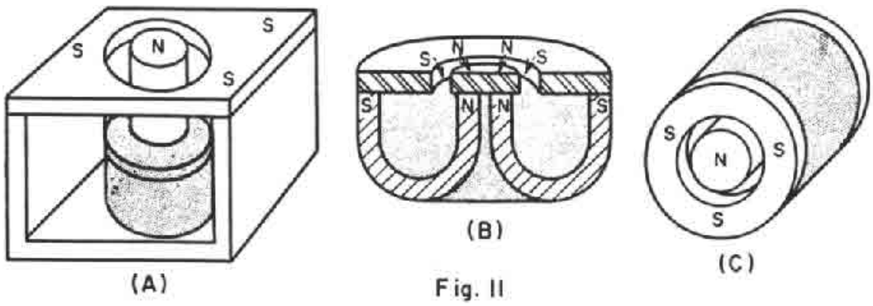


Fig. 11 Annular air gaps are useful in instruments and loudspeakers. The magnets can be (A) plug, (B) cylindrical, or (C) ring-type, depending upon the application.

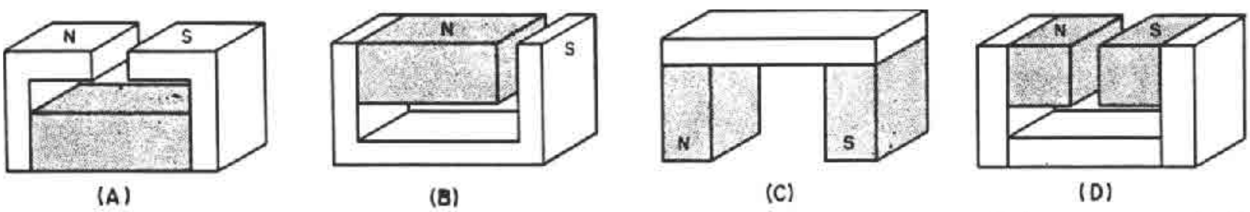
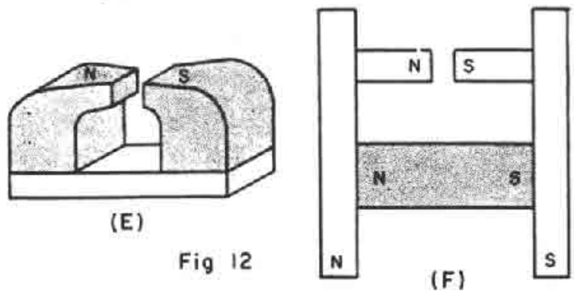


Fig. 12 Soft steel bars are used to complete the magnetic circuit, allowing maximum flux density through the air gap. The arrangement can use single magnets (A), (B), or double magnets (C), (D), (E), or a single magnet with a shunt (F).



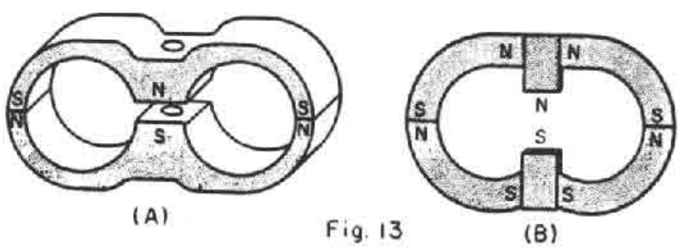


Fig. 13 Special magnets are cast for microwave power tubes—three-pole E style (A), and concentric-gap bowl type (B). Many other forms are possible.

PERMANENT MAGNET MECHANISMS

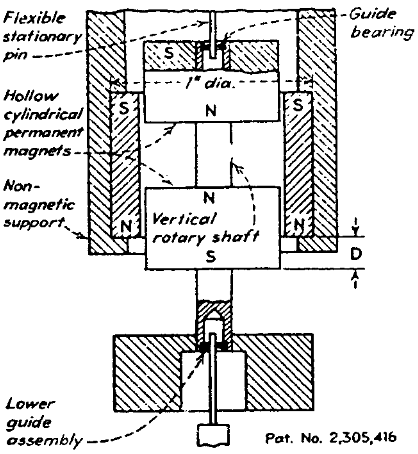


Fig. 1 A suspension.

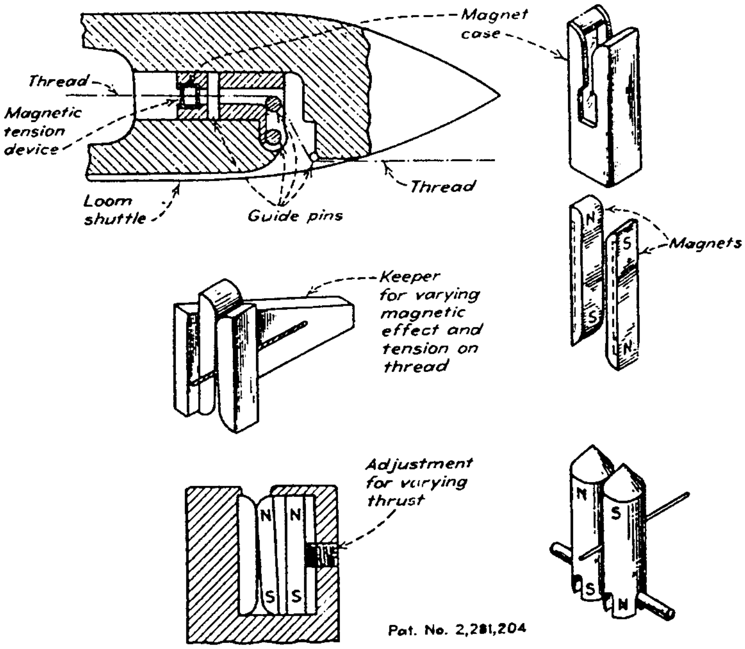


Fig. 2 Tension devices.

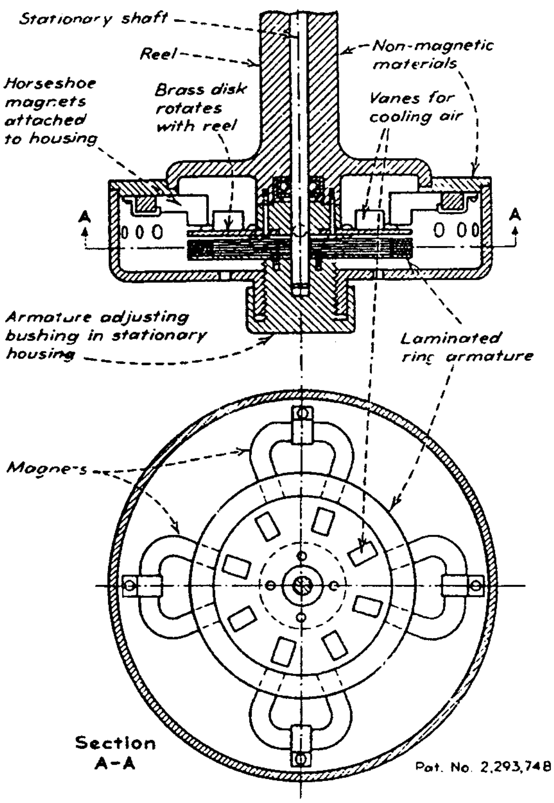


Fig. 3 A reel brake.

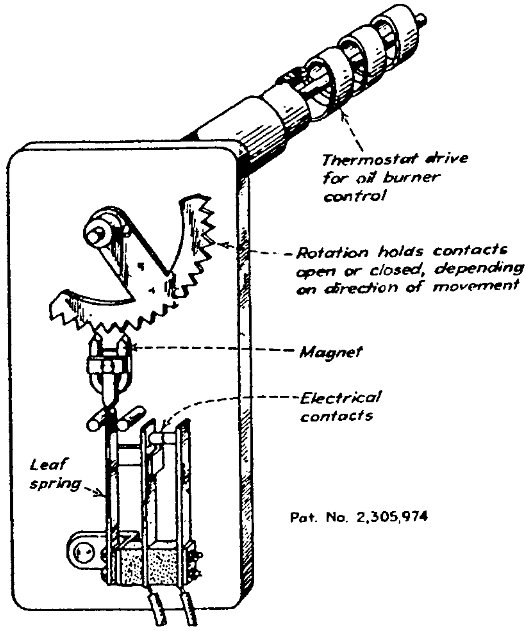


Fig. 4 An instrument coupling.

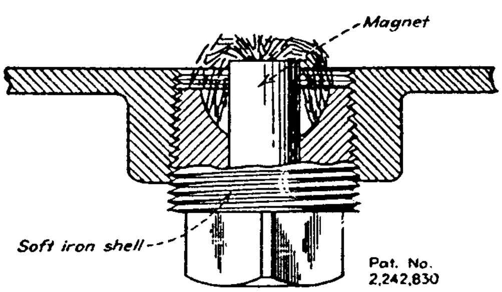


Fig. 5 A crankcase oil drain plug.

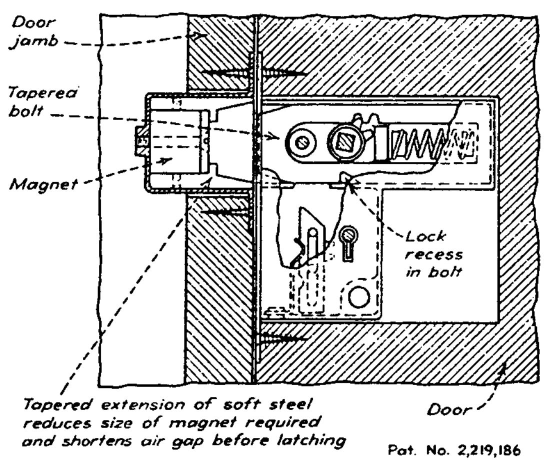


Fig. 6 A non-rattling door latch.

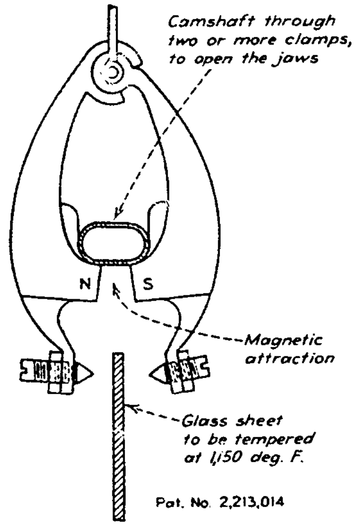


Fig. 7 A clamp.

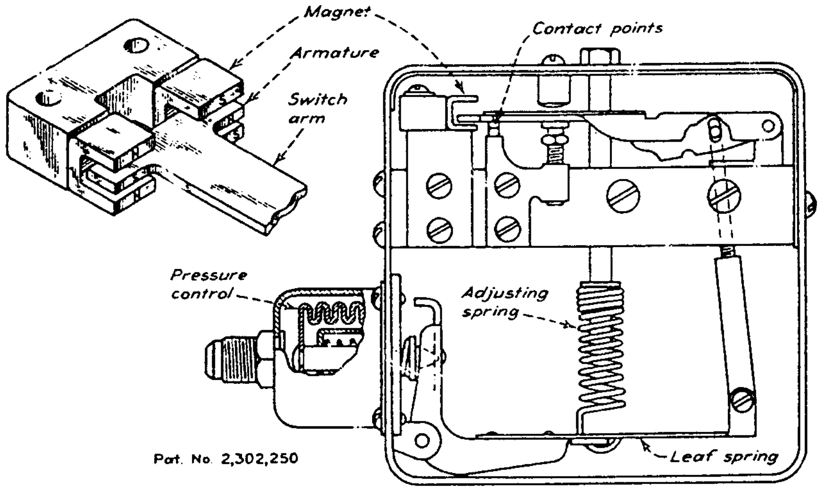


Fig. 8 A snap-action switch.

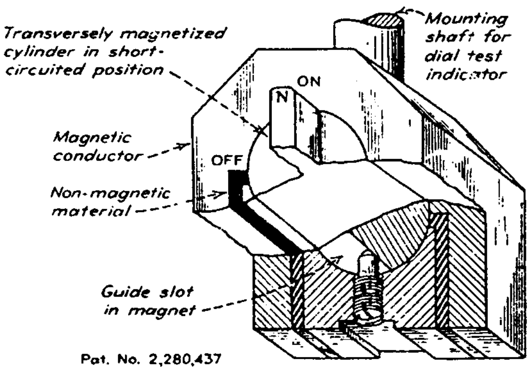


Fig. 9 An instrument holder.

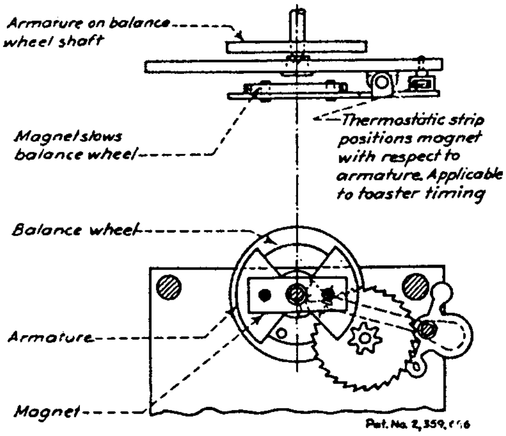


Fig. 10 An escape wheel.

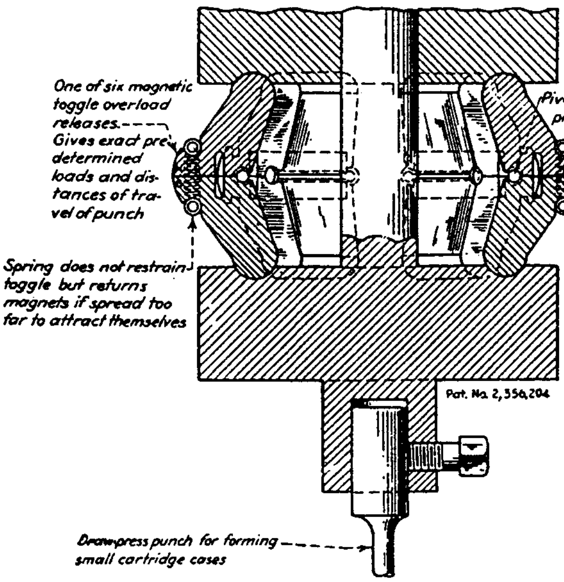


Fig. 11 A pressure release.

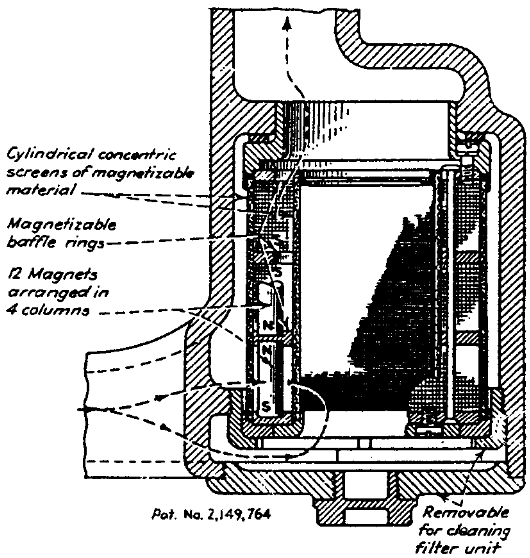
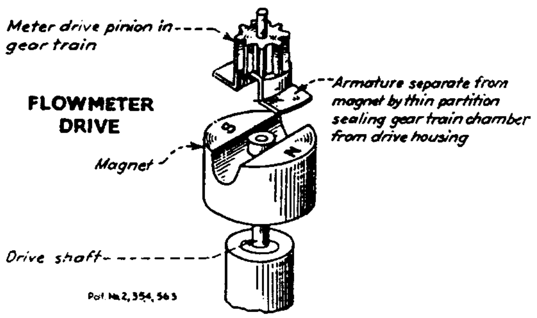


Fig. 12 A filter.



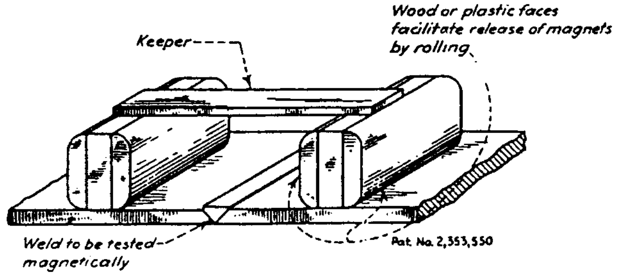


Fig. 13 A weld tester.

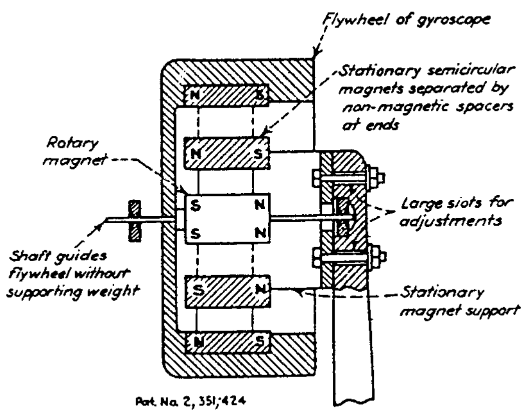


Fig. 15 A horizontal-shaft suspension.

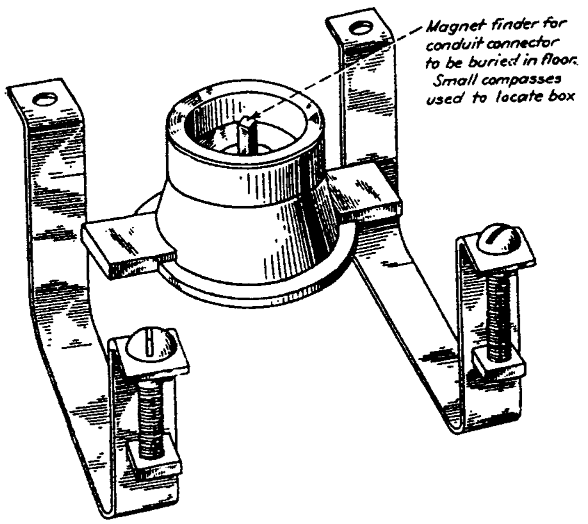


Fig. 17 A finder.

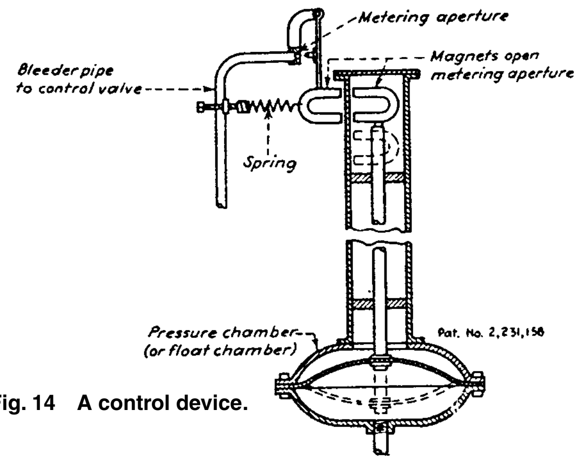


Fig. 14 A control device.

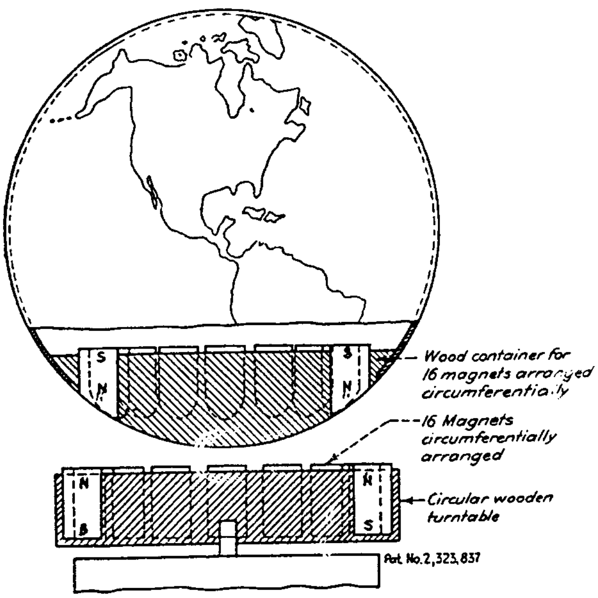
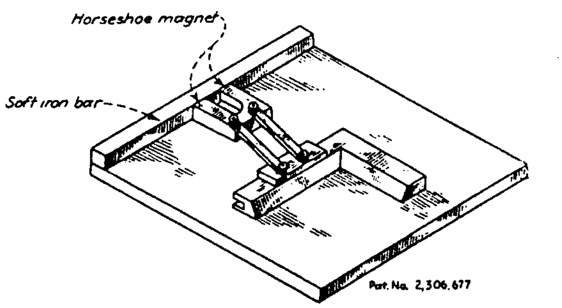


Fig. 16 A floating advertising display.



DRAFTING BOARD

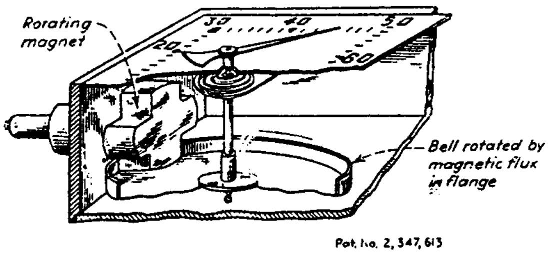


Fig. 18 A tachometer.

ELECTRICALLY DRIVEN HAMMER MECHANISMS

The application of controlled impact forces can be as practical in specialized stationary machinery as in the portable electric hammers shown here. These mechanisms have been employed in vibrating concrete forms, nailing machines, and other special machinery. In portable hammers they are efficient in drilling, chiseling, digging, chipping, tamping,

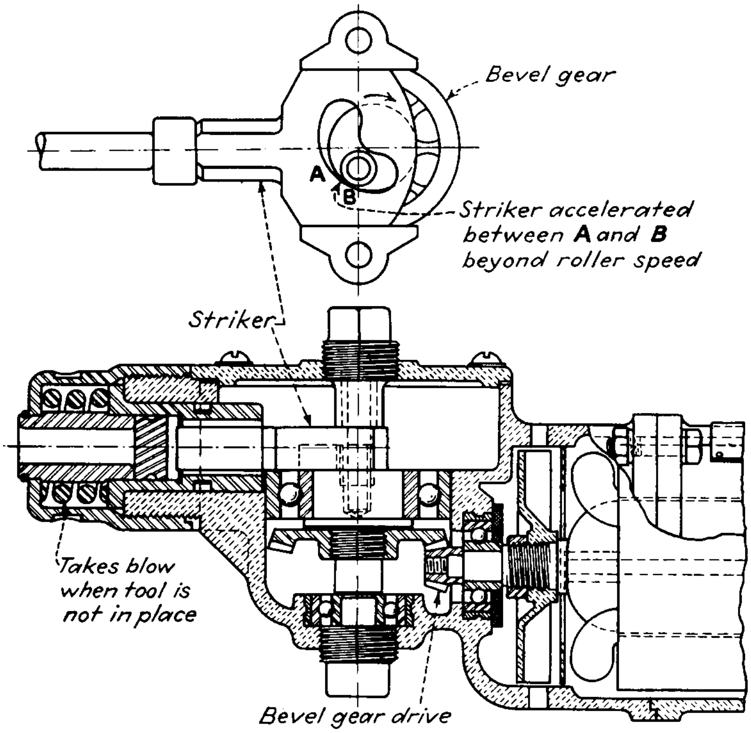


Fig. 1 A free-driving throw of the cam-slotted striker is produced by the eccentric stud roller during contact between points A and B of the slot. This accelerates the striker beyond the tangential speed of the roller for an instant before the striker is picked up for the return stroke.

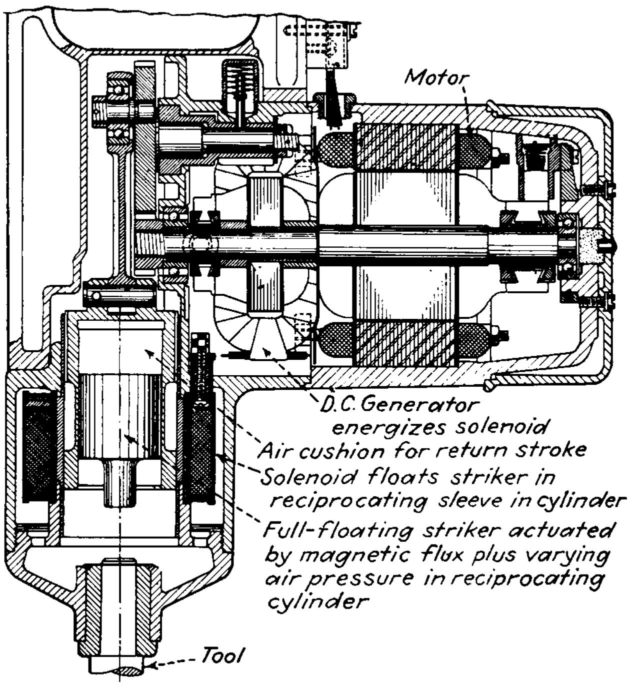


Fig. 3 The striker has no mechanical connection with the reciprocating drive in this hammer.

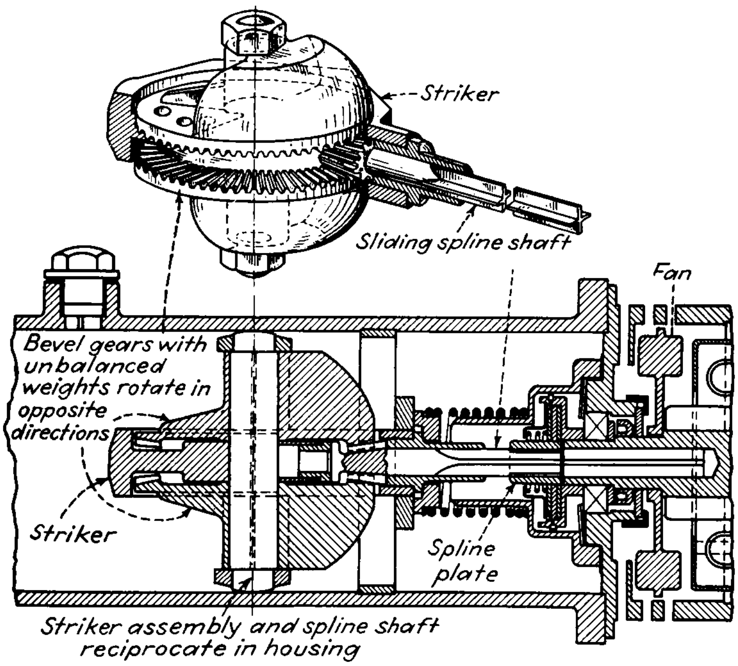


Fig. 2 The centrifugal force of two oppositely rotating weights throws the striker assembly of this hammer. The power connection is maintained by a sliding-splined shaft. The guide, not shown, prevents the rotation of the striker assembly.

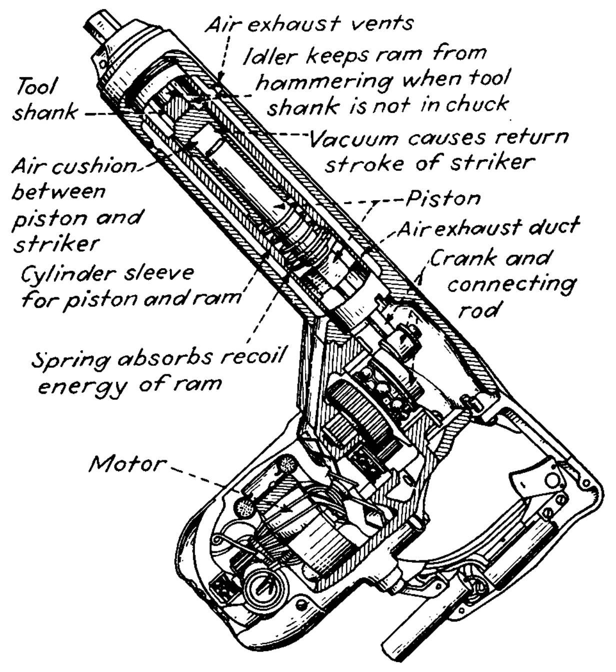


Fig. 4 This combination of mechanical, pneumatic, and spring action is included in this hammer.

riveting, and similar operations where quick, concentrated blows are required. The striker mechanisms illustrated are operated by springs, cams, magnetic force, air and vacuum chambers, and centrifugal force. The drawings show only the striking mechanisms.

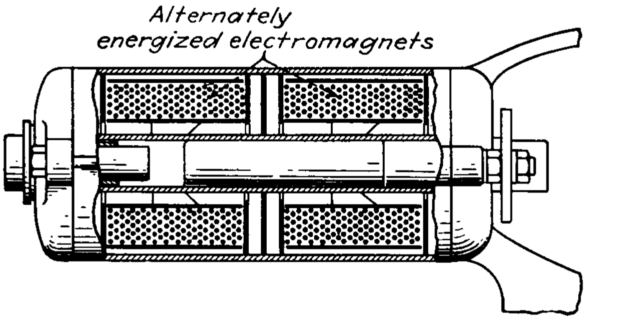


Fig. 5 Two electromagnets operate this hammer. The weight of the blows can be controlled by varying the electric current in the coils or timing the current reversals by an air-gap adjustment of the contacts.

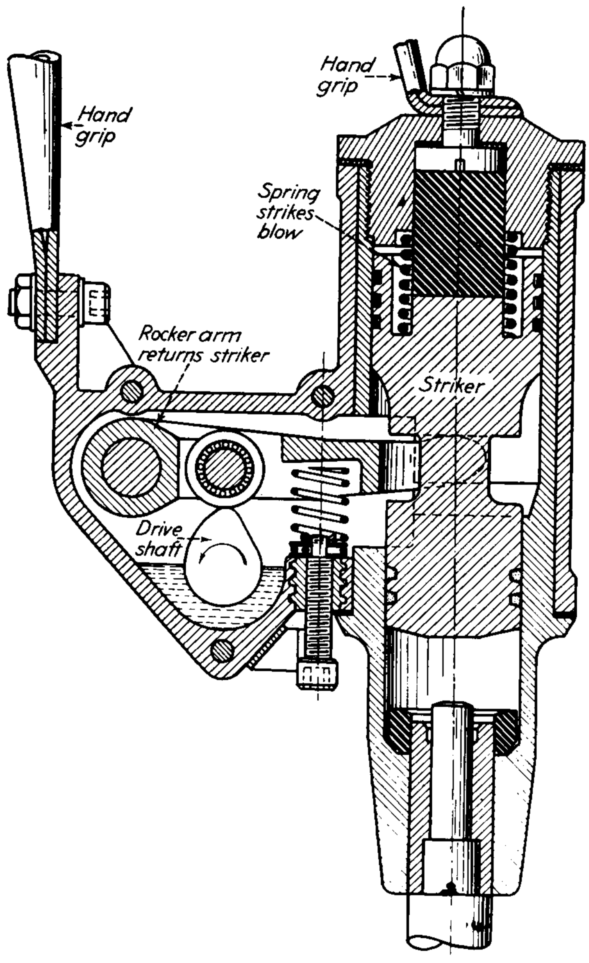


Fig. 6 This spring-operated hammer with a cam and rocker for the return stroke has a screw for adjusting the blow to be imparted.

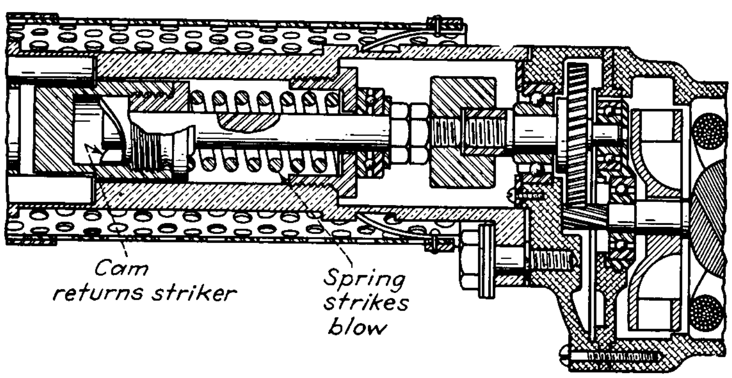


Fig. 7 This spring-operated hammer includes a shaft rotating in a female cam to return the striker.

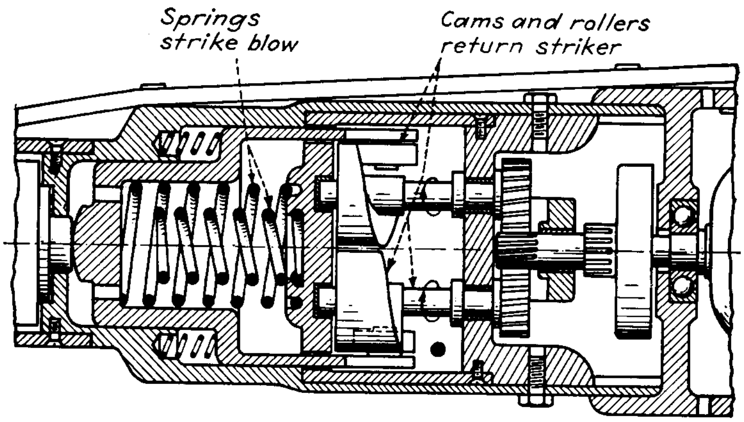


Fig. 8 This spring-operated hammer has two fixed rotating-barrel cams. They return the striker by means of two rollers on the opposite sides of the striker sleeve. Auxiliary springs prevent the striker from hitting the retaining cylinder. A means of rotating the tool, not shown, is also included in this hammer.

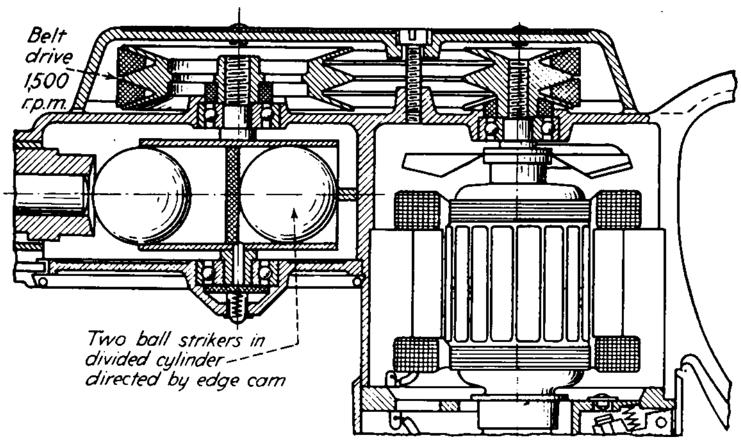


Fig. 9 Two steel balls rotated in a divided cylinder and steered by an edge cam develop centrifugal force to strike blows against the tool holder. The collar is held clear of the hammer by a compression spring when no tool is in the holder. A second spring cushions the blows when the motor is running, but the tool is not held against the work.

Sensitivity or change in deflection for a given temperature change depends upon the combination of meals selected and the dimensions of the bimetal element. Sensitivity increases with the square of the length and inversely with the thickness. The force developed for a given temperature change also depends on the type of bimetal. However, the allowable working load for the thermostatic strip increases with the width and the square of the thickness. Thus, the design of bimetal elements depends upon the relative importance of sensitivity and working load.

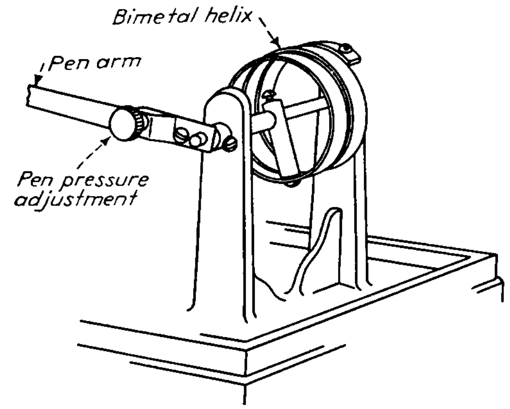


Fig. 1 This recording thermometer has a pen that is moved vertically across a revolving chart by a brass-invar bimetal element. To obtain sensitivity, the long movement of the pen requires a long strip of bimetal, which is coiled into a helix to save space. For accuracy, a relatively large cross section gives stiffness, although the large thickness requires increased length to obtain the desired sensitivity.

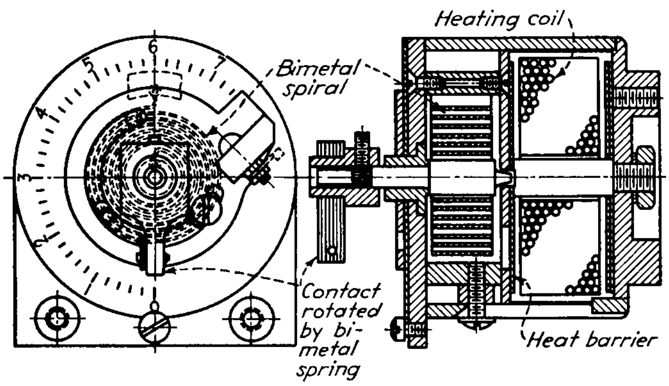


Fig. 3 This overload relay for large motors passes some of the motor current through a heating coil within the relay. Heat from the coil raises the temperature of a bimetal spiral which rotates a shaft carrying an electrical contact. To withstand the operating temperatures, it includes a heat-resistant bimetal spiral. It is coiled into the spiral form for compactness. Because of the large deflection needed, the spiral is long and thin, whereas the width is made large to provide the required contact pressure.

Heat barriers between the bimetal spiral and the heating coil make the temperature rise of the bimetal spiral closely follow the increase in temperature within the motor. Thus, momentary overloads do not cause sufficient heating to close the contacts. However, a continued overload will, in time, cause the bimetal spiral to rotate the contact arm around to the adjustable stationary contact, causing a relay to shut down the motor.

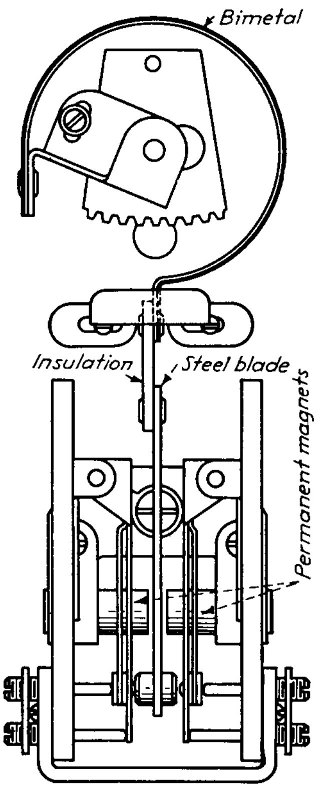


Fig. 2 Room temperatures in summer and winter are controlled over a wide range by a single, large-diameter coil of brass-invar in this thermometer. To prevent chattering, a small permanent magnet is mounted on each side of the steel contact blade. The magnetic attraction on the blade, which increases inversely with the square of the distance from the magnet, gives a snap action to the contacts.

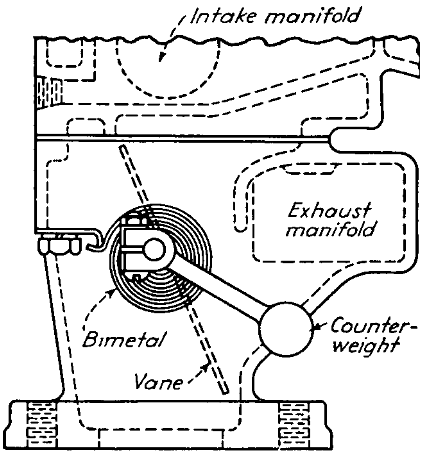


Fig. 4 Carburetor control. When the engine is cold, a vane in the exhaust passage to the "hot spot" is held open by a bimetal spring against the force of a small counterweight. When the thermostatic spiral is heated by the outside air or by the warm air stream from the radiator, the spring coils up and allows the weight to close the vane. Because high accuracy is not needed, a thin, flexible cross section with a long length provides the desired sensitivity.

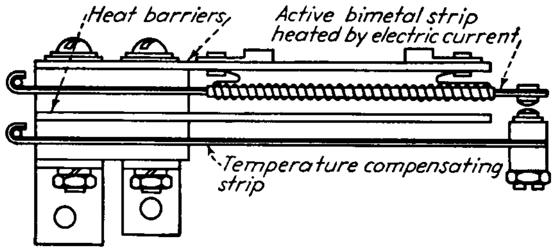


Fig. 6 The bimetal element in this time-delay relay protects mercury-vapor rectifiers. This relay closes the voltage circuit to the mercury tube only after the filament has had time to reach its normal operating temperature. To eliminate the effect of changes in room temperature on the length of the contact gap (and therefore the time interval) the stationary contact is carried by a second bimetal strip, similar to the heated element. Barriers of laminated plastic on both sides of the active bimetal strip shield the compensating strip and prevent air currents from affecting the heating rate. The relatively high temperature range allows the use of a straight, thick strip, but the addition of the compensating strip makes accurate timing possible with a short travel.

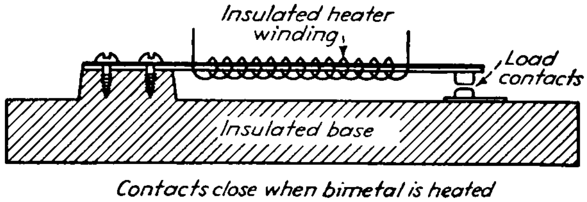


Fig. 5 Thermostatic relay. A constant current through an electrical heating coil around a straight bimetal strip gives a time-delay action. Because the temperature range is relatively large, high sensitivity is not necessary. Thus, a short, straight strip of bimetal is suitable. Because of its relatively heavy thickness, the strip is sufficiently stiff to close the contact firmly without chattering.

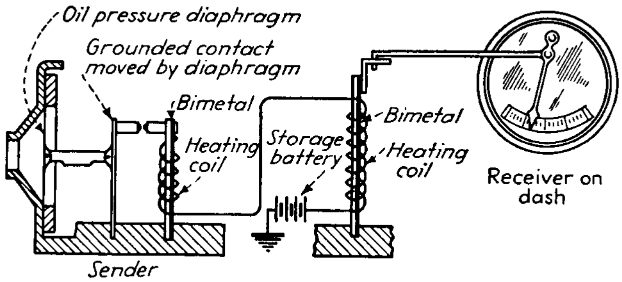


Fig. 7 Oil pressure, engine temperature, and gasoline level are indicated electrically on automobile dashboard instruments whose bimetal element is both the sender and receiver. A grounded contact at the sender completes an electric circuit through heaters around two similar bimetal strips. Because the same current flows around the two bimetal elements, their deflections are the same. But the sender element, when heated, will bend away from the grounded contact until the circuit is broken Upon cooling, the bimetal element again makes contact and the cycle continues. This allows the bimetal element to follow the movement of the grounded contact. For the oil-pressure gage, the grounded contact is attached to a diaphragm; for the temperature indicator, the contact is carried by another thermostatic bimetal strip; in the gasoline-level device, the contact is shifted by a cam on a shaft rotated by a float. Deflections on the receiving bimetal element are amplified through a linkage that operates a pointer over the scale of the receiving instrument. Because only small deflections are needed, the bimetal element is in the form of a short, stiff strip.

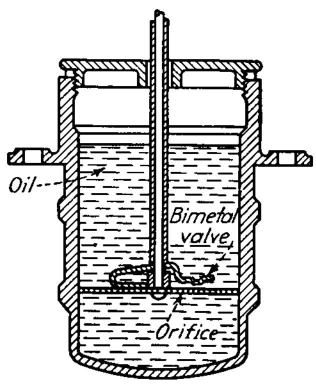


Fig. 8 Oil dashpots in heavy-capacity scales have a thermostatic control to compensate for changes in oil viscosity with temperature. A rectangular orifice in the plunger is covered by a swaged projection on the bimetal element. With a decrease in oil temperature, the oil viscosity increases, tending to increase the damping effect. But the bimetal element deflects upward, enlarging the orifice enough to keep the damping force constant. A wide bimetal strip provides sufficient stiffness so that the orifice will not be altered by the force of the flowing oil.

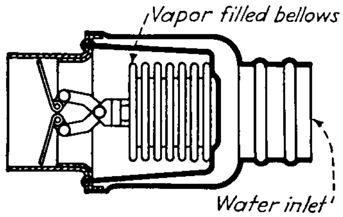


Fig. 9 Automobile cooling-water temperature is controlled by a self-contained bellows in the thermostat. As in the radiator air valve, the bellows itself is subjected to the temperature to be controlled. As the temperature of the water increases to about 140°F. the valve starts to open; at approximately 180°F., free flow is permitted. At intermediate temperatures, the valve opening is in proportion to the temperature.

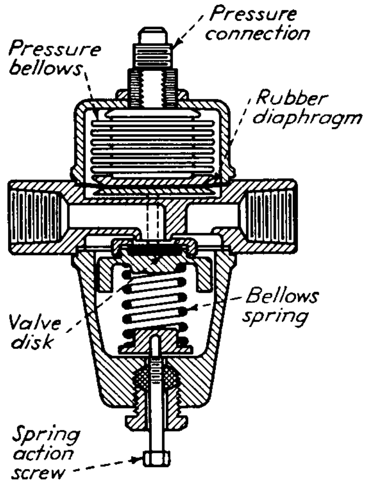


Fig. 10 A throttling circulating-water control valve for refrigeration plants has its valve opening vary with the pressure on the bellows. This valve controls the rate of flow of the cooling water through the condenser. A greater amount of water is required when the temperature, and therefore the pressure, increases. The pressure in the condenser is transmitted through a pipe to the valve bellows, thereby adjusting the flow of cooling water. The bronze bellows is protected from contact with the water by a rubber diaphragm.

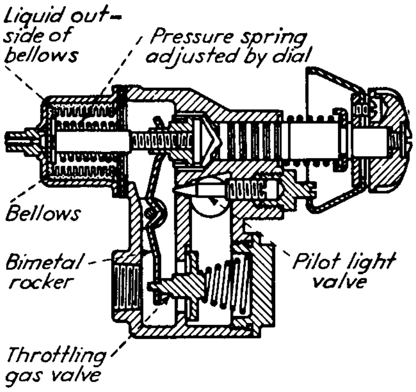


Fig. 11 An automatic gas-range control has a sealed thermostatic element consisting of a bulb, capillary tube, and bellows. As food is often placed near the bulb, a nontoxic liquid, chlorinated diphenyl, is in the liquid expansion system. The liquid is also non-flammable and has no corrosive effect on the phosphor-bronze bellows. By placing the liquid outside instead of inside the bellows, the working stresses are maximum at normal temperatures when the bellows bottoms on the cup. At elevated working temperatures, the expansion of the liquid compresses the bellows against the action of the extended spring. This, in turn, is adjusted by the knob. Changes in calibration caused by variations in ambient temperature are compensated by making the rocker arm of a bimetal suitable for high-temperature service.

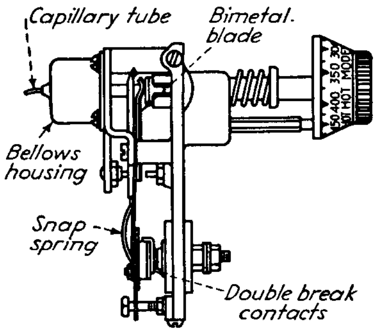


Fig. 12 For electric ranges, this thermostat has the same bellows unit as the gas-type control. But, instead of a throttling action, the thermostat opens and closes the electrical contacts with a snap action. To obtain sufficient force for the snap action, the control requires a temperature difference between *on* and *off* positions. For a control range from room temperature to 550°F., the differential in this instrument is ±10°F. With a smaller control range, the differential is proportionately less. The snap-action switch is made of beryllium copper, giving it high strength, better snap action, and longer life than is obtainable with phosphor bronze. Because of its corrosion resistance, the beryllium-copper blade requires no protective finish.

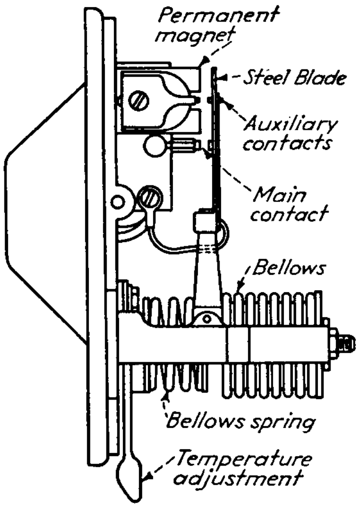


Fig. 13 For heavy-duty room-temperature controls, this thermostat has a bellows mechanism that develops a high force with small changes in temperature. The bellows is partly filled with liquid butane. At room temperatures this gas exhibits a large change in vapor pressure for small temperature differentials. Snap action of the electrical contact is obtained from a small permanent magnet that pulls the steel contact blade into firm contact when the bellows cools. Because of the firm contact, the device is rated at 20 A for noninductive loads. To avoid chattering or bounce under the impact delivered by the rapid magnetic closing action, small auxiliary contacts are carried on light spring blades. With the large force developed by the bellows, a temperature differential of only 2°F. is obtained.

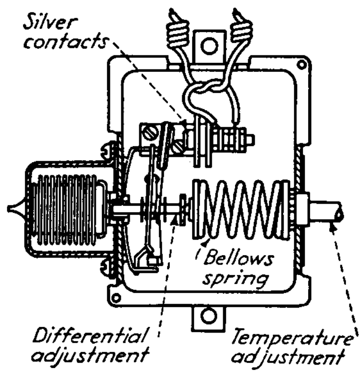
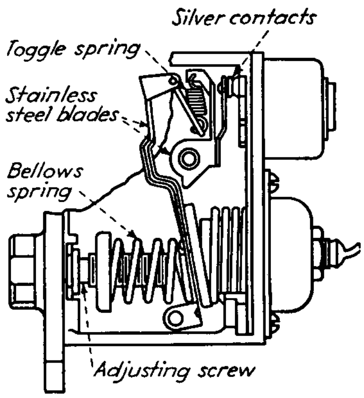


Fig. 14 Snap action in this refrigerator control is obtained from a bowed flat spring. The silver contacts carried on an extended end of the spring open or close rapidly when movement of the bellows actuates the spring. With this snap action, the contacts can control an alternating-current motor as large as 1½ hp without auxiliary relays. Temperature differential is adjusted by changing the spacing between two collars on the bellows shaft passing through the contact spring. For the temperatures needed to freeze ice, the bellows system is partly filled with butane.

Fig. 15 In this refrigerator control, the necessary snap action is obtained from a toggle spring supported from a long arm moved by the bellows. With this form of toggle action, the contact pressure is at a maximum at the instant the contacts start to open. Thermostatic action is obtained from a vapor-filled system. Sulfur dioxide is the fill for typical refrigerating service or methyl chloride where lower temperatures are required. To reduce friction, the bellows makes point-contact with the bellows cup. Operating temperature is adjusted by changing the initial compression in the bellows spring. For resistance to corrosion, levers and blades are made from stainless steel with bronze pin bearings.



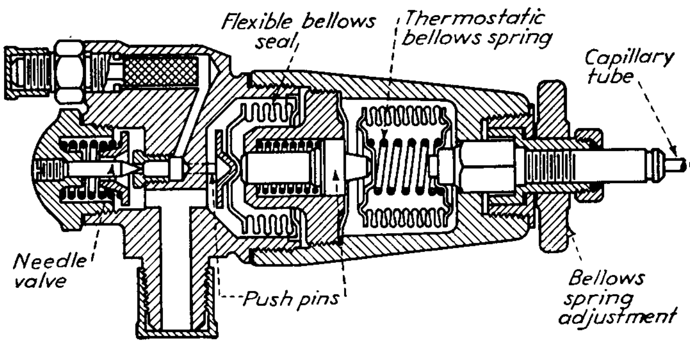


Fig. 16 Two bellows units in this thermostatic expansion valve control large refrigeration systems. A removable power bellows unit is operated by vapor pressure in a bulb attached to the evaporator output line. The second bellows serves as a flexible, gastight seal for the gas valve. A stainless-steel spring holds the valve closed until opened by pressure transmitted from the thermostatic bellows through a molded push pin.

TEMPERATURE-REGULATING MECHANISMS

Temperature regulators are either on-off or throttling. The characteristics of the process determine which should be used. Within each group, selection of a regulator is governed by the accuracy required, space limitations, simplicity, and cost.

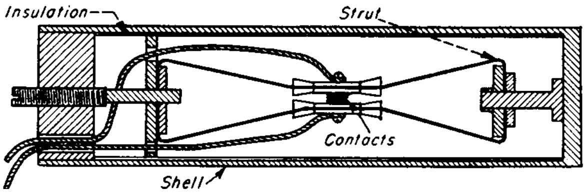


Fig. 1 A bimetallic sensor is simple, compact, and precise. Contacts mounted on low-expansion struts determine slow make-and-break action. A shell contracts or expands with temperature changes, opening or closing the electrical circuit that controls a heating or cooling unit. It is adjustable and resistant to shock and vibration. Its range is 100 to 1500°F, and it responds to a temperature changes of less than 0.5°F.

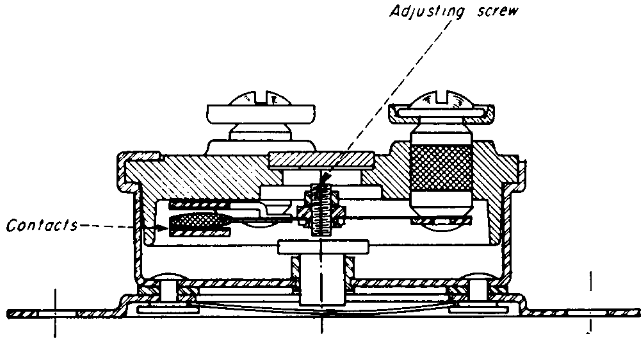


Fig. 2 This enclosed, disk-type, snap-action control has a fixed operating temperature. It is suitable for unit and space heaters, small hot water heaters, clothes dryers, and other applications requiring non-adjustable temperature control. It is useful where dirt, dust, oil, or corrosive atmospheres are present. It is available with various temperature differentials and with a manual reset. Depending on the model, its temperature setting range is from –10° to 550°F and its minimum differential can be 10, 20, 30, 40 or 50°F.

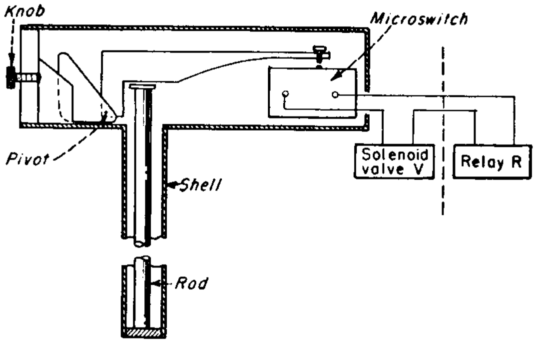


Fig. 3 This bimetallic unit has a rod with a low coefficient of expansion and a shell with a high coefficient of expansion. A microswitch gives snap action to the electrical control circuit. The current can be large enough to operate a solenoid valve or relay directly. The set point is adjusted by a knob which moves the pivot point of the lever. Its range is –20° to 175°F, and its accuracy is 0.25 to 0.50°.

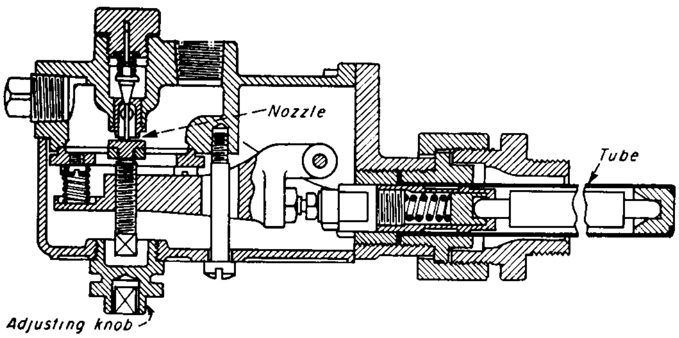


Fig. 4 This is a bimetallic-actuated, air-piloted control. The expansion of the rod causes an air signal (3 to 15 psi) to be transmitted to a heating or cooling pneumatic valve. The position of the pneumatic valve depends on the amount of air bled through the pilot valve of the control. This produces a throttling type of temperature control as contrasted to the on-off characteristic that is obtained with the three units described previously. Its range is 32 to 600°F, and its accuracy is ±1 to ±3°F, depending on the range.

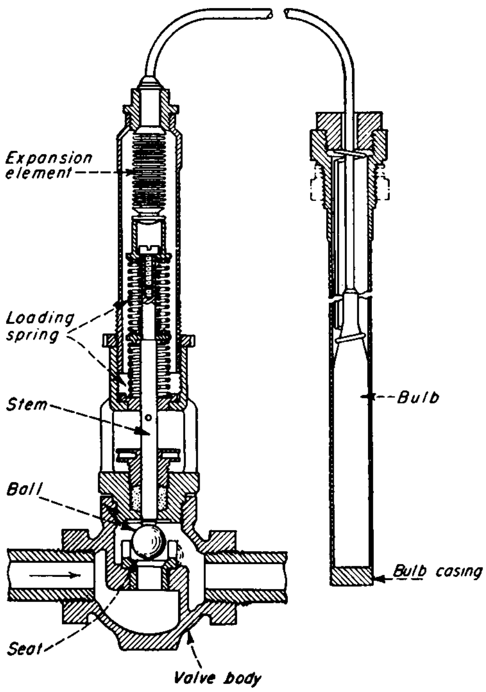


Fig. 5 This self-contained regulator is actuated by the expansion or contraction of liquid or gas in a temperature-sensitive bulb that is immersed in the medium being controlled. The signal is transmitted from the bulb to a sealed expansion element which opens or closes the ball valve. Its range is 20 to 270°F, and its accuracy is ±1°F. The maximum pressure rating is 100 psi for dead-end service and 200 psi for continuous flow.

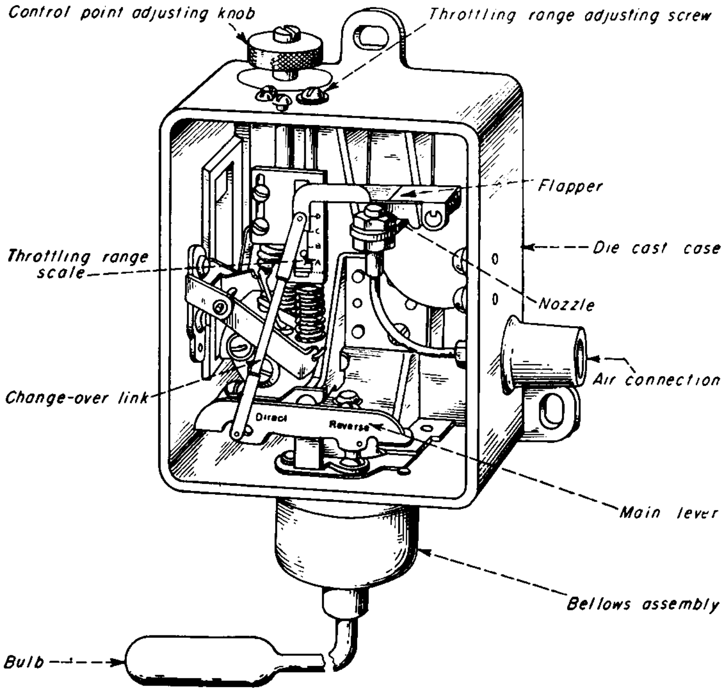


Fig. 6 This remote bulb, nonindicating regulator has a bellows assembly that operates a flapper. This allows air pressure in the control system to build up or bleed, depending on the position of the changeover link. The unit can be direct- or reverse-acting. A control knob adjusts the setting, and the throttling range adjustment determines the percentages of the control range in which full output pressure (3–15 psi) is obtained. Its range is 0 to 700°F, and its accuracy is about ±0.5% of full scale, depending on the way it is installed.

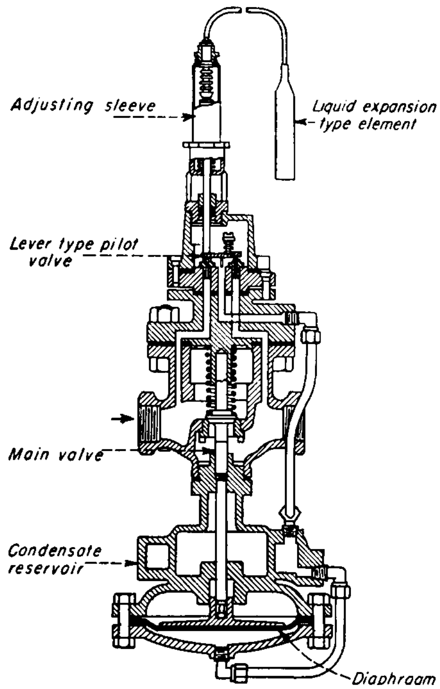


Fig. 7 This lever-type pilot valve is actuated by a temperature-sensitive bulb. The motion of the lever causes the water or steam being controlled to exert pressure on a diaphragm which opens or closes the main valve. Its temperature range is 20 to 270°F, and its accuracy is ±1 to 4°F. It is rated for 5 to 125 psi of steam and 5 to 175 psi of water.

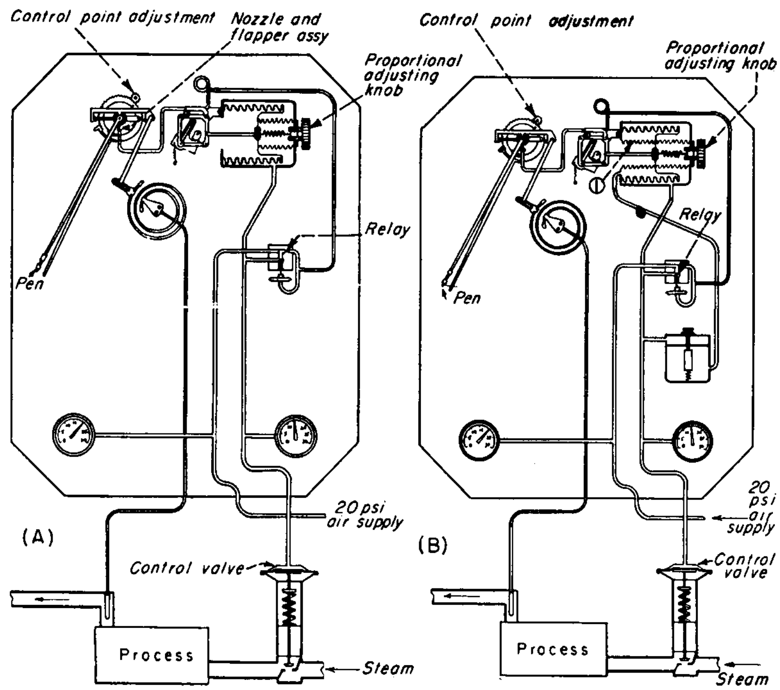


Fig. 8 These two recording and controlling instruments have adjustable proportional ranges. In both, air supply is divided by a relay valve. A small part goes through a nozzle and flapper assembly. The main part goes to the control valve. Unit B has an extra bellows for automatic resetting. It was designed for systems with continuously changing control points, and it can be used where both heating and cooling are required in one process. Both A and B are easily changed from direct to reverse acting. Its accuracy is 1% of its temperature range of –40 to 800°F.

PHOTOELECTRIC CONTROLS

Typical applications are presented for reducing production costs and increasing operator safeguards by precisely and automatically controlling the feed, transfer, or inspection of products from one process stage to another.

Fig. 1 Automatic weighing and filling. The task is to fill each box with an exact quantity of products, such as screws. An electric feeder vibrates parts through a chute and into a box on a small balance. The photoelectric control is mounted at the rear of the scale. The light beam is restricted to very small dimensions by an optical slit. The control is positioned so that the light is interrupted by a balanced cantilever arm attached to the scale when the proper box weight is reached. The photoelectric control then stops the flow of parts by deenergizing the feeder. Simultaneously, an indexing mechanism is activated to remove the filled box and replace it with an empty one. The completion of indexing reenergizes the feeder, which starts the flow of screws.

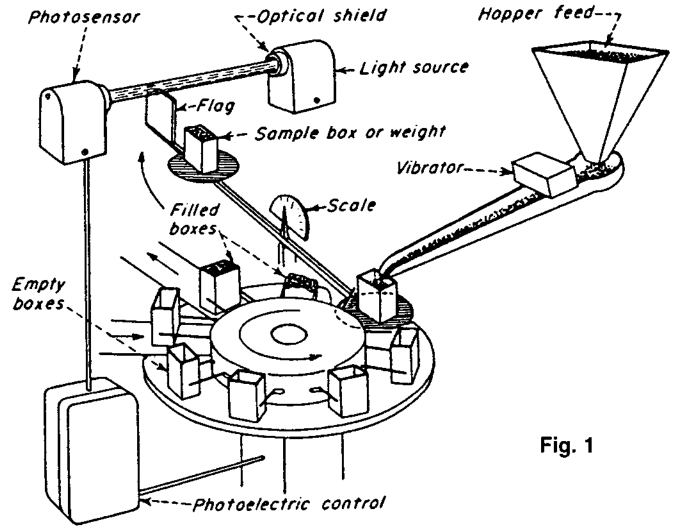


Fig. 1

Fig. 2 Operator safeguard. Most pressures are operated by a foot pedal that leaves the operator's hands free for loading and unloading. This creates a safety hazard. The use of mechanical gate systems reduces the speed of production. With photoelectric controls, a curtain of light is set up by a multiple series of photoelectric scanners and light sources. When a light beam is broken at any point by the operator's hand, the control energizes a locking mechanism that prevents the punch-press drive from being energized. A circuit or power failure causes the control to function as if the light beam were broken. In addition, the light beam frequently becomes the actuating control because the clutch is released as soon as the operator removes his hand from the die on the press table.

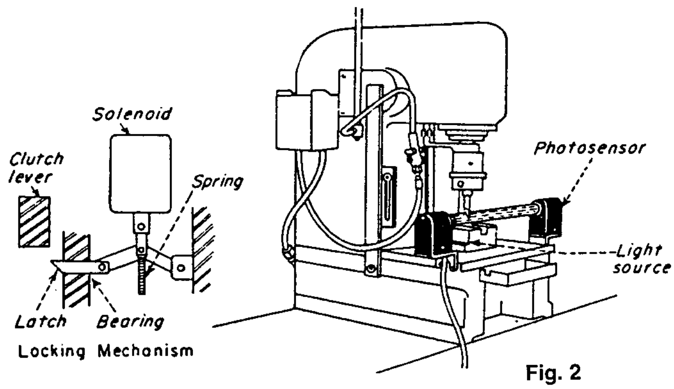


Fig. 2

Fig. 3 This apparatus sorts cartons of three different kinds of objects. Because the cartons containing objects differ widely in size, it is not feasible to sort by carton size and shape. A small strip of reflecting tape is put on the cartons by a packer during assembly. On one type of object, the strip is located along one edge of the bottom, and it extends almost to the middle. For the second type, the strip is located along the same edge, but from the middle to the opposite side. No tape is placed on the third type. Cartons are placed on the conveyor so that the tape is at right angles to the direction of travel. Photoelectric controls shown in A "see" the reflecting tape and operate a pusher-bar mechanism shown in B. This pushes the carton onto the proper distribution conveyor. Cartons without tape pass.

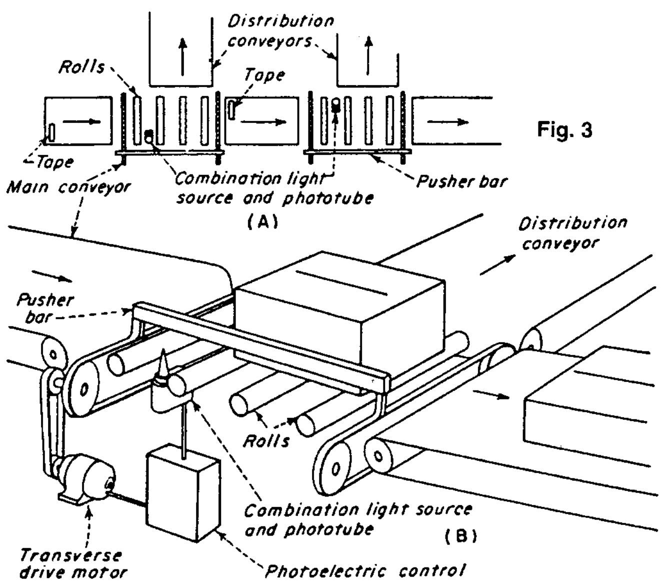


Fig. 3

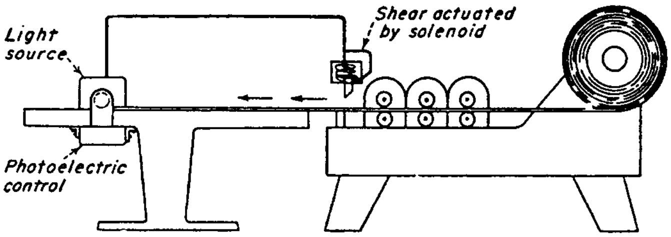


Fig. 4

Fig. 4 This cut-off machine has a photoelectric control for strip materials that lack sufficient mass to operate a mechanical limit switch satisfactorily. The forward end of the strip breaks the light beam, thus actuating the cut-off operation. The light source and the control are mounted on an adjustable stand at the end of the machine to vary the length of the finished stock.

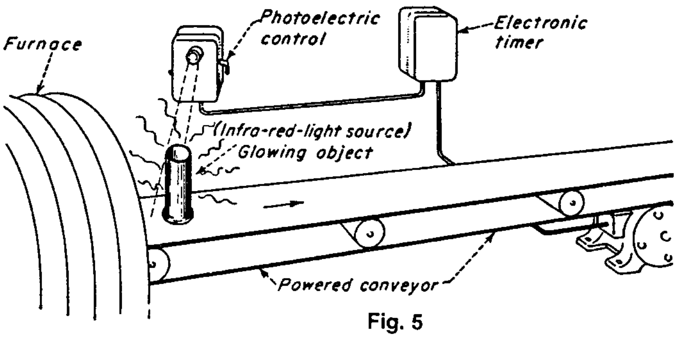


Fig. 5

Fig. 5 This heat-treating conveyor has an electronic timer paired with a photoelectric control to carry parts emerging from a furnace at 2300°F. The conveyor must operate only when a part is placed on it and only for the distance required to reach the next process stage. Parts are ejected onto the conveyor at varying rates. High temperatures caused failures when the mechanical switches were used. Glowing white-hot parts radiate infrared rays that actuate the photoelectric control as soon as a part comes in view. The control operates the conveyor that carries the parts away from the furnace and simultaneously starts the timer. The conveyor is kept running by a timer for the predetermined length of time required to position the part for the next operation.

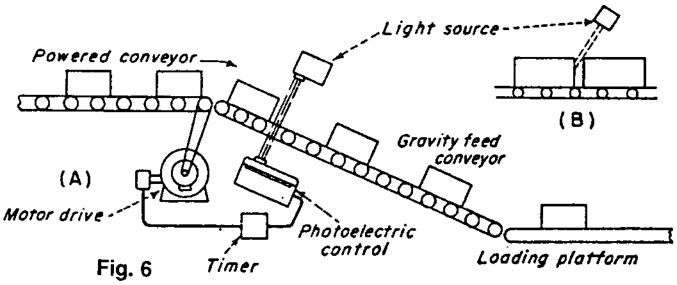


Fig. 6

Fig. 6 Jam detector. Cartons jamming on the conveyor cause losses in production and damage to cartons, products, and conveyors. Detection is accomplished with a photoelectric control that has a timer, as shown in (A). Each time a carton passes the light source, the control beam is broken. That starts the timing interval in the timer. The timing circuit is reset without relay action each time the beam is restored before the preset timing interval has elapsed. If a jam occurs, causing cartons to butt against each other, the light beam cannot reach the control. The timing circuit will then time-out, opening the load circuit. This stops the conveyor motor. By locating the light source at an angle with respect to the conveyor, as shown in (B), the power conveyor can be delayed if cartons are too close to each other but not butting each other.

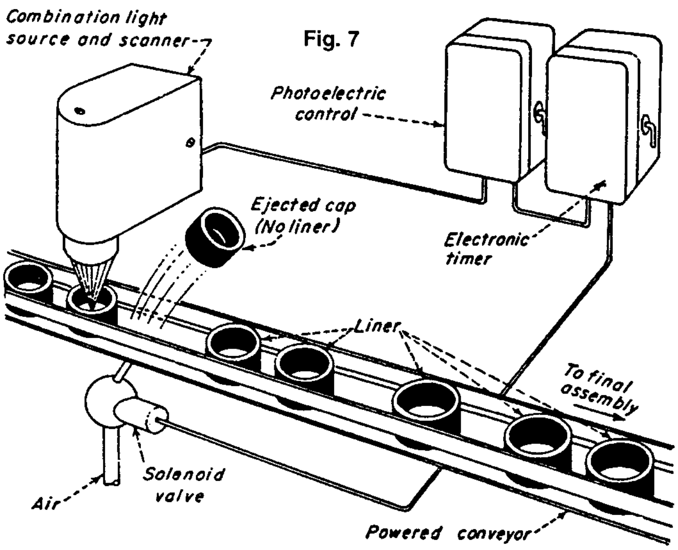
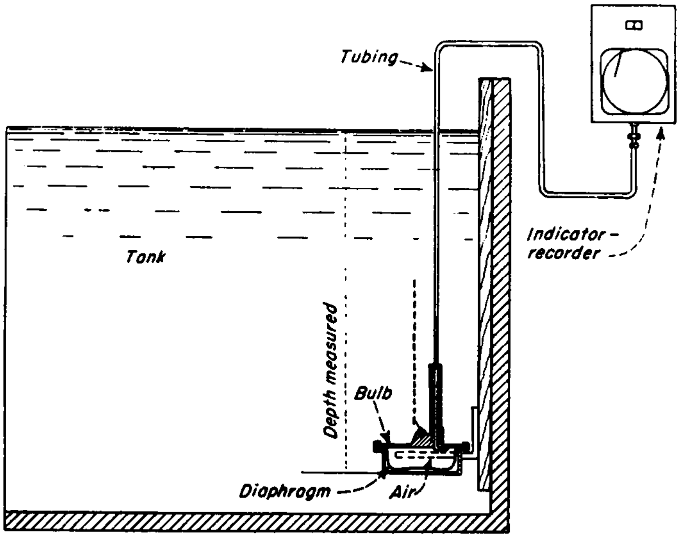


Fig. 7

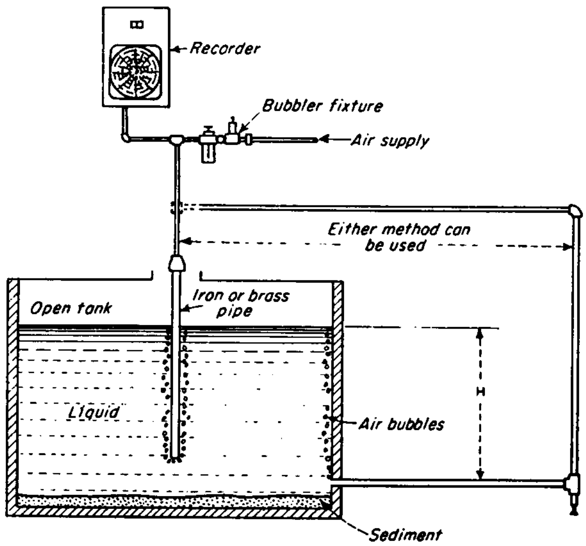
Fig. 7 Automatic inspection. As steel caps are conveyed to final assembly, they pass an intermediate stage where an assembler inserts an insulation liner into a cap. The inspection point for the missing liners has a reflection-type photoelectric scanner which incorporates both a light source and photosensor with a common lens system to recognize the difference in reflection between the dark liner and the light steel cap instantly. When it detects a cap without a liner, a relay operates an airjet ejector that is controlled by a solenoid valve. The start and duration of the air blast is accurately controlled by a timer so that no other caps are displaced.

LIQUID LEVEL INDICATORS AND CONTROLLERS

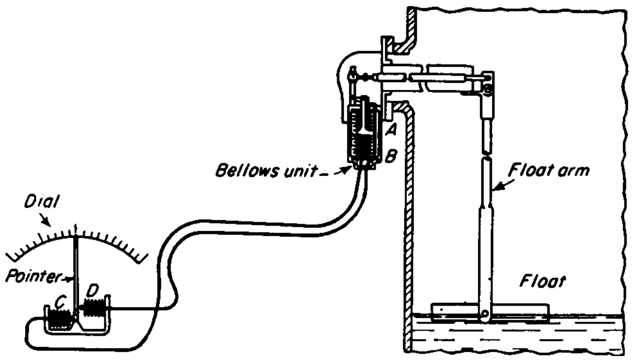
Thirteen different systems of operation are shown. Each one represents at least one commercial instrument. Some of them are available in several modified forms.



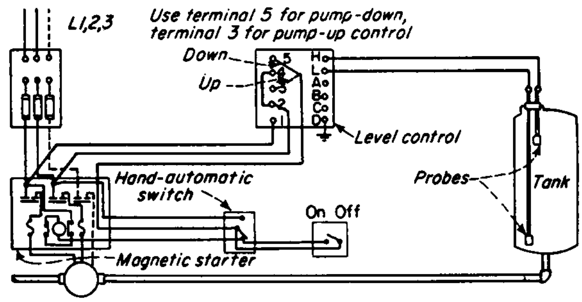
A diaphragm actuated indicator will work with any kind of liquid, whether it is flowing, turbulent, or carrying solid matter. A recorder can be mounted above or below the level of the tank or reservoir.



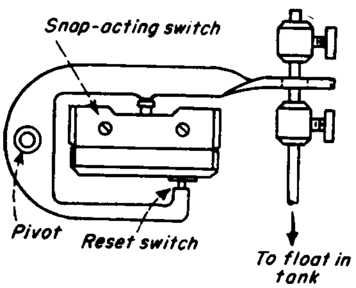
A bubbler-type recorder measures height *H.* It can be used with all kinds of liquids, including those carrying solids. A small amount of air is bled into a submerged pipe. A gage measures the air pressure that displaces the fluid.



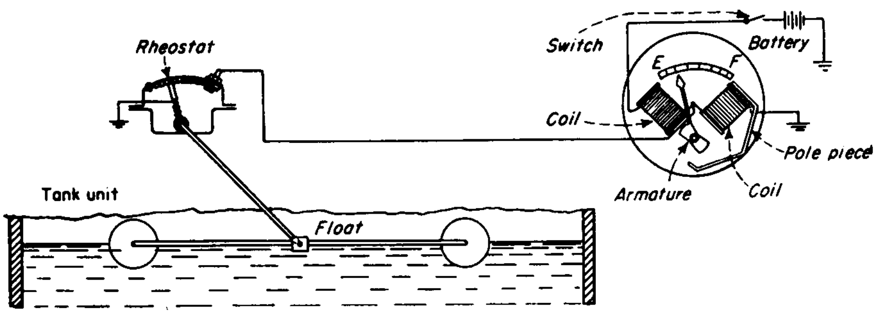
A bellows-actuated indicator. Two bellows and a connecting tubing are filled with incompressible fluid. A change in liquid level displaces the transmitting bellows and pointer.



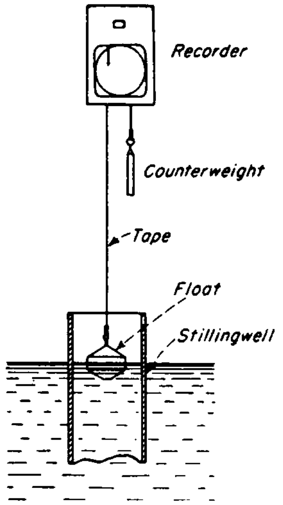
An electrical level controller. The positions of the probes determine the duration of pump operation. When a liquid touches the upper probe, a relay operates and the pump stops. Auxiliary contacts on the lower probe provide a relay-holding current until the liquid level drops below it.



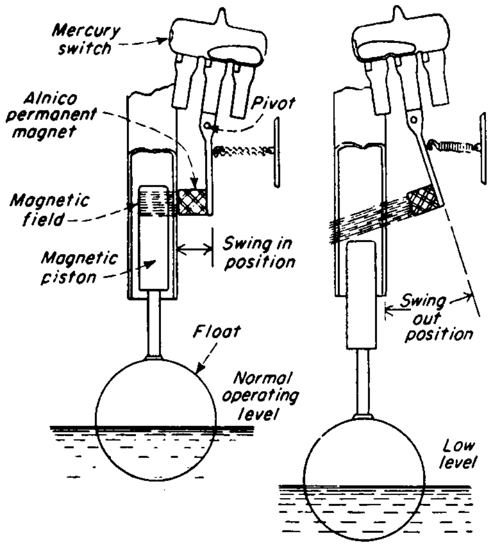
A float-switch controller. When liquid reaches a predetermined level, a float actuates a switch through a horseshoe-shaped arm. A switch can operate the valve or pump.



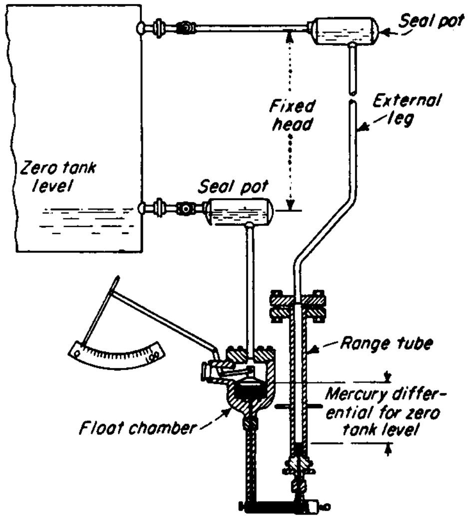
An automotive liquid-level indicator. The indicator and tank unit are connected by a single wire. As the liquid level in the tank increases, brush contact on the tank rheostat moves to the right, introducing an increasing amount of resistance into the circuit that grounds the F coil. The displacement of a needle from its empty mark is proportional to the amount of resistance introduced into this circuit.



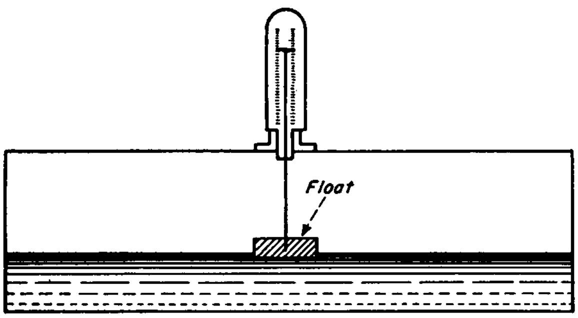
A float recorder. The pointer can be attached to a calibrated float tape to give an approximate instantaneous indication of fluid level.



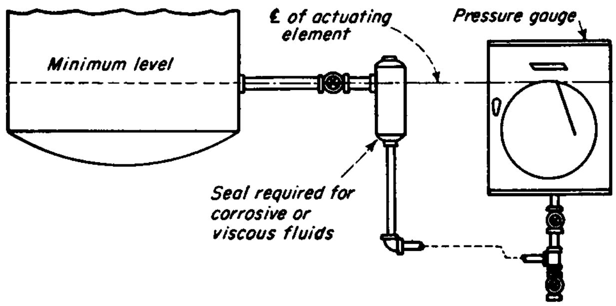
A magnetic liquid-level controller. When the liquid level is normal, the common-to-right leg circuit of the mercury switch is closed. When the liquid drops to a predetermined level, the magnetic piston is drawn below the magnetic field.



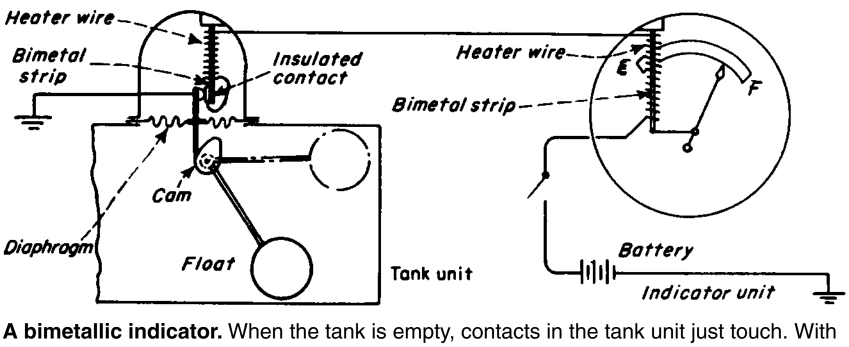
A differential pressure system. This system is applicable to liquids under pressure. The measuring element is a mercury manometer. A mechanical or electric meter body can be used. The seal pots protest the meter body.



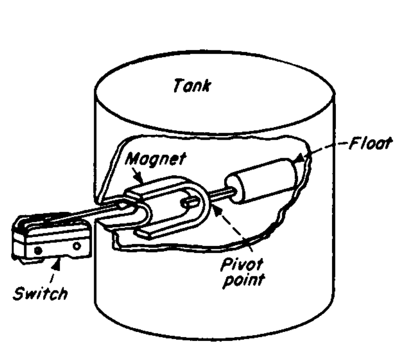
A direct-reading float gage. This inexpensive, direct-reading gage has a dial calibrated to the tank volume. A comparable gage, in terms of simplicity, has a needle connected through a right-angle arm to the float. As the liquid level drops, the float rotates the arm and the needle.



A pressure gage indicator for open vessels. The pressure of the liquid head is imposed directly upon the actuating element of the pressure gage. A center-line of the actuating element must coincide with the minimum level line if the gage is to read zero when the liquid reaches the minimum level.



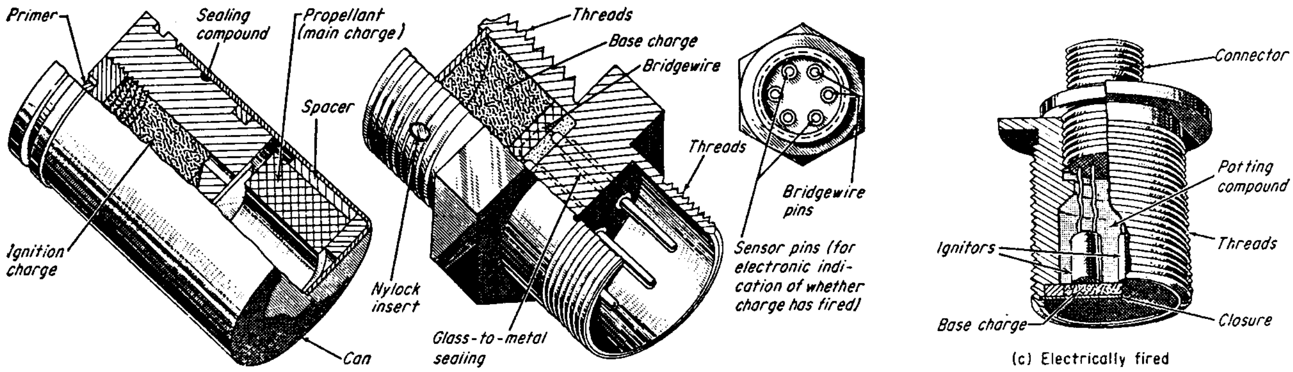
A bimetallic indicator. When the tank is empty, contacts in the tank unit just touch. With the switch closed, heaters cause both bimetallic strips to bend. This opens the contacts in the tank, and the bimetals cool, closing the circuit again. The cycle repeats about once per second. As the liquid level increases, the float forces the cam to bend the tank bimetal. This action is similar to that of the float gage, but the current and the needle displacement are increased.



A switch-actuated level controller. This pump is actuated by the switch. The float pivots the magnet so that the upper pole attracts the switch contact. The tank wall serves as the other contact.

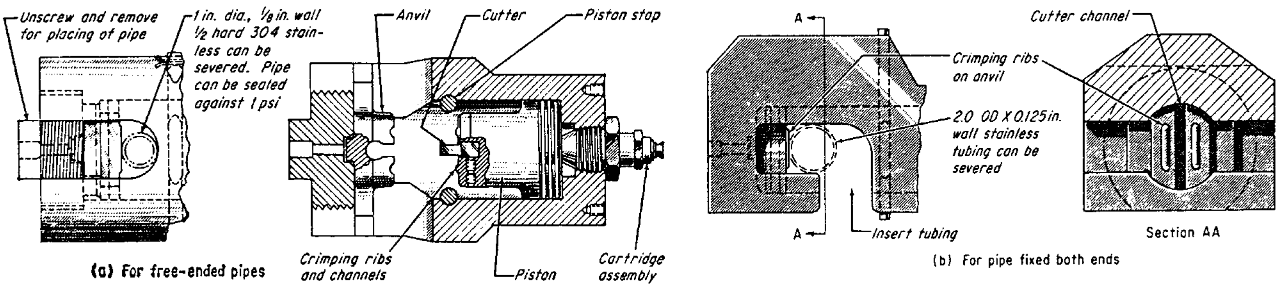
INSTANT MUSCLE WITH PYROTECHNIC POWER

Cartridge-actuated devices generate a punch that cuts cable and pipe, shears bolts for fast release, and provides emergency thrust.



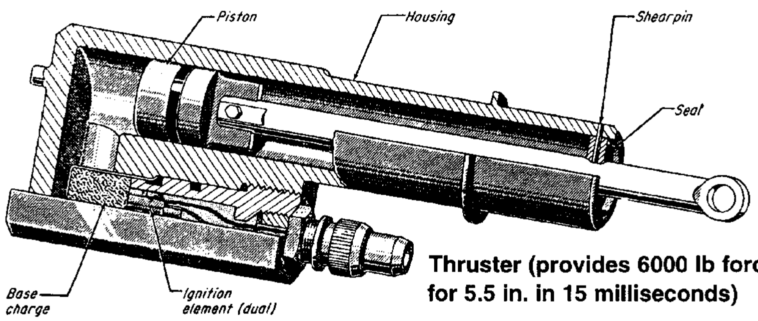
(a) Percussion fired (b) Electrically fired (reduntant bridgewire, but nonreduntant charge) (c) Electrically fired (reduntant wire, reduntant ignitor charge)

Cartridge Assemblies

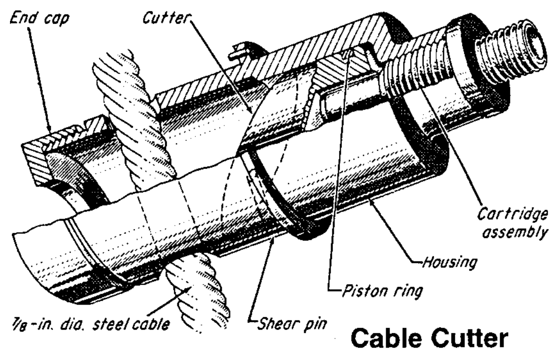


(a) For free-ended pipes (b) For pipe fixed both ends

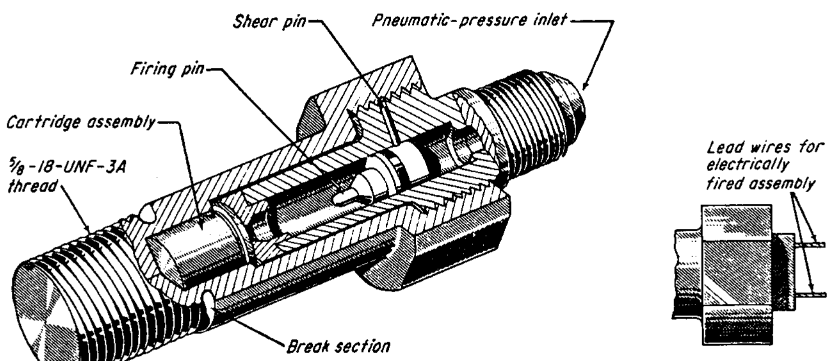
Pipe Cutters



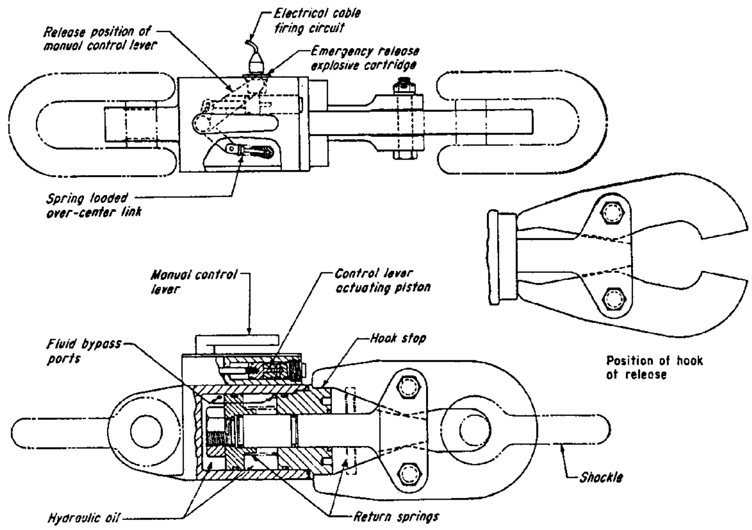
Thruster (provides 6000 lb force for 5.5 in. in 15 milliseconds)



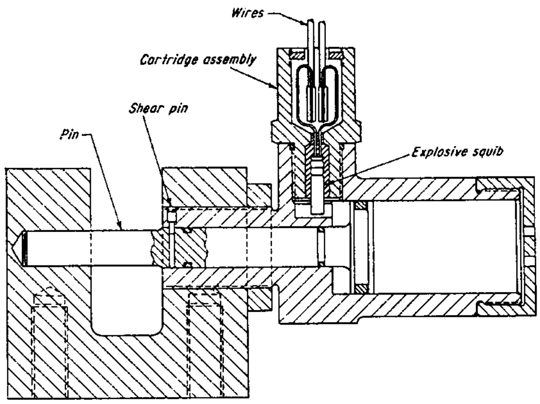
Cable Cutter



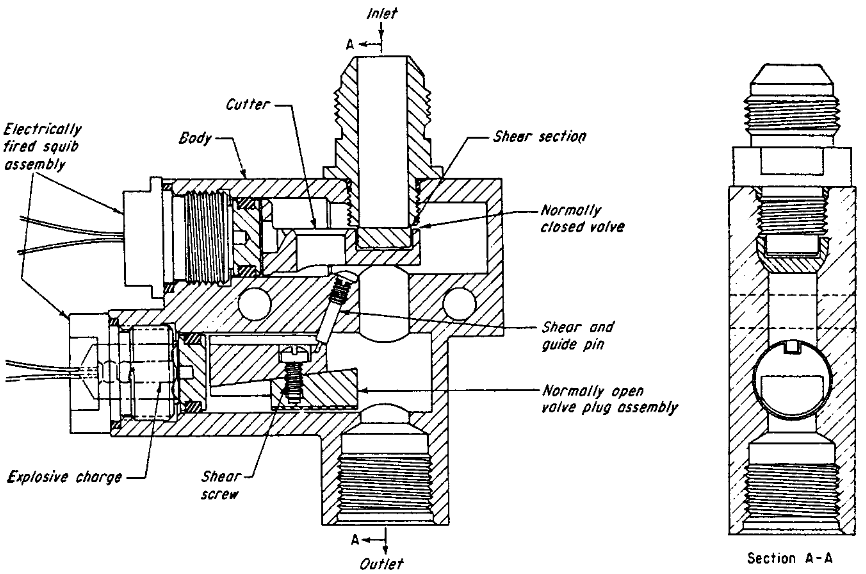
(a) Pneumatic-fired **Explosive Bolt** (b) Electrically fired



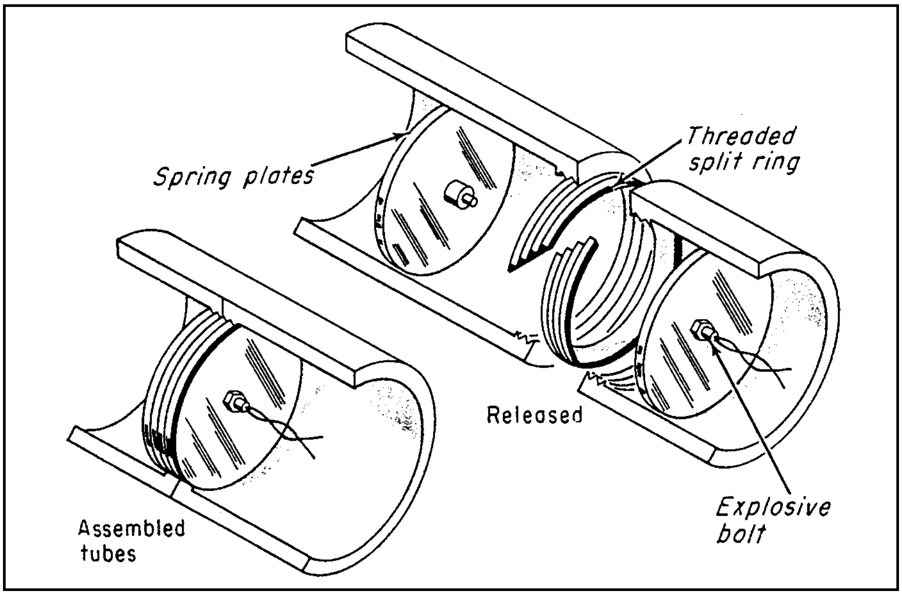
An emergency hook release lets the loads be jettisoned at any time. The hook is designed to release automatically if it is overloaded.



The pin retracts to release the load or clear a channel for free movement.



This dual valve is designed so that the flow will be started and stopped by the same unit. Firing one squib starts the flow; firing the other squib stops the flow.



A threaded split ring with a helical-spring response holds the ends of the tubes at a joint until the explosive bolt is fired; then it releases instantly.

Quick Disconnector

A tube joint can be separated almost instantaneously by remote control with an explosive bolt and a split threaded ring, in a design developed by James Mayo of NASA's Langley Research Center, Hampton, Virginia.

External threads of the ring mesh with the internal threads of the members that are joined—and they must be separated quickly. The ring has a built-in spring characteristic that will assume a helically wound shape and reduce to a smaller diameter when not laterally constrained. During assembly, it is held to its expanded size by two spring plates whose rims fit into internal grooves machined in the split ring. The plates are fastened together by an explosive bolt and nut.

Upon ignition of the explosive bolt, the plates fly apart form the axial spring tension of the ring. The ring then contracts to its normally smaller diameter, releasing the two structural members.

The tube joint can be made in any size and configuration. The retaining media need not be limited to V-type screw threads.