



Fluid Power (Part 3) - Hydraulic Components

An Online Continuing Education Course for Engineers

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Credit: 6 Hours / 6 PDH / 6 CPD

Fluid Power: Hydraulic Components

CHAPTER 1

MEASUREMENT AND PRESSURE CONTROL DEVICES

For safe and efficient operation, fluid power systems are designed to operate at a specific pressure and/or temperature, or within a pressure and/or temperature range.

The lubricating power of hydraulic fluids varies with temperature and that excessively high temperatures reduce the life of hydraulic fluids. Additionally, the materials, dimensions, and method of fabrication of fluid power components limit the pressure and temperature at which a system operates.

Most fluid power systems are provided with pressure gauges and thermometers for measuring and indicating the pressure and/or the temperature in the system. Additionally, various temperature and pressure switches are used to warn of an adverse pressure or temperature condition. Some switches will even shut the system off when an adverse condition occurs. These devices will be discussed in this course.

PRESSURE GAUGES

Many pressure-measuring instruments are called gauges. However, this section will be restricted to two mechanical instruments that contain elastic elements that respond to pressures found in fluid power systems—the Bourdon-tube and bellows gauges.

BOURDON TUBE GAUGES

The majority of pressure gauges in use have a Bourdon-tube as a measuring element. (The gauge is named for its inventor, Eugene Bourdon, a French engineer.) The Bourdon tube is a device that senses pressure and converts the pressure to displacement. Since the Bourdon-tube displacement is a function of the pressure applied, it may be mechanically amplified and indicated by a

pointer. Thus, the pointer position indirectly indicates pressure.

The Bourdon-tube gauge is available in various tube shapes: curved or C-shaped, helical, and spiral. The size, shape, and material of the tube depend on the pressure range and the type of gauge desired. Low-pressure Bourdon tubes (pressures up to 2000 psi) are often made of phosphor bronze. High-pressure Bourdon tubes (pressures above 2000 psi) are made of stainless steel or other high-strength materials. High-pressure Bourdon tubes tend to have more circular cross sections than their lower-range counterparts, which tend to have oval cross sections. The Bourdon tube most commonly used is the C-shaped metal tube that is sealed at one end and open at the other (fig. 1-1).

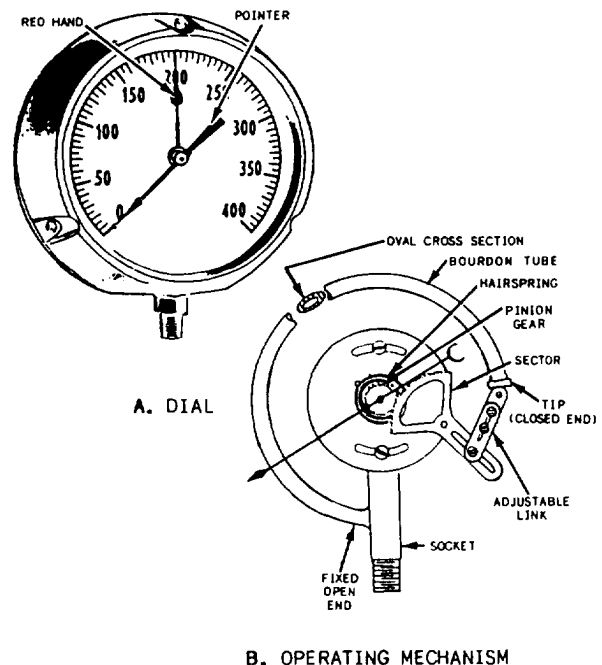


Figure 1-1.—Simplex Bourdon-tube pressure gauge.

C-shaped Bourdon Tube

The C-shaped Bourdon tube has a hollow, elliptical cross section. It is closed at one end and is connected to the fluid pressure at the other end. When pressure is applied, its cross section becomes more circular, causing the tube to straighten out, like a garden hose when the water is first turned on, until the force of the fluid pressure is balanced by the elastic resistance of the tube material. Since the open end of the tube is anchored in a fixed position, changes in pressure move the closed end. A pointer is attached to the closed end of the tube through a linkage arm and a gear and pinion assembly, which rotates the pointer around a graduated scale.

Bourdon-tube pressure gauges are often classified as simplex or duplex, depending upon whether they measure one pressure or two pressures. A simplex gauge has only one Bourdon tube and measures only one pressure. The pressure gauge shown in figure 1-1 is a simplex gauge. A red hand is available on some gauges. This hand is manually positioned at the maximum operating pressure of the system or portion of the system in which the gauge is installed.

When two Bourdon tubes are mounted in a single case, with each mechanism acting

independently but with the two pointers mounted on a common dial, the assembly is called a duplex gauge. Figure 1-2 shows a duplex gauge with views of the dial and the operating mechanism. Note that each Bourdon tube has its own pressure connection and its own pointer. Duplex gauges are used to give a simultaneous indication of the pressure from two different locations. For example, it may be used to measure the inlet and outlet pressures of a strainer to obtain the differential pressure across it.

Differential pressure may also be measured with Bourdon-tube gauges. One kind of Bourdon-tube differential pressure gauge is shown in figure 1-3. This gauge has two Bourdon tubes but only one pointer. The Bourdon tubes are connected in such a way that they indicate the pressure difference, rather than either of two actual pressures.

As mentioned earlier, Bourdon-tube pressure gauges are used in many hydraulic systems. In this application they are usually referred to as hydraulic gauges. Bourdon-tube hydraulic gauges are not particularly different from other types of Bourdon-tube gauges in how they operate; however, they do sometimes have special design features because of the extremely high system pressures to which they may be exposed. For

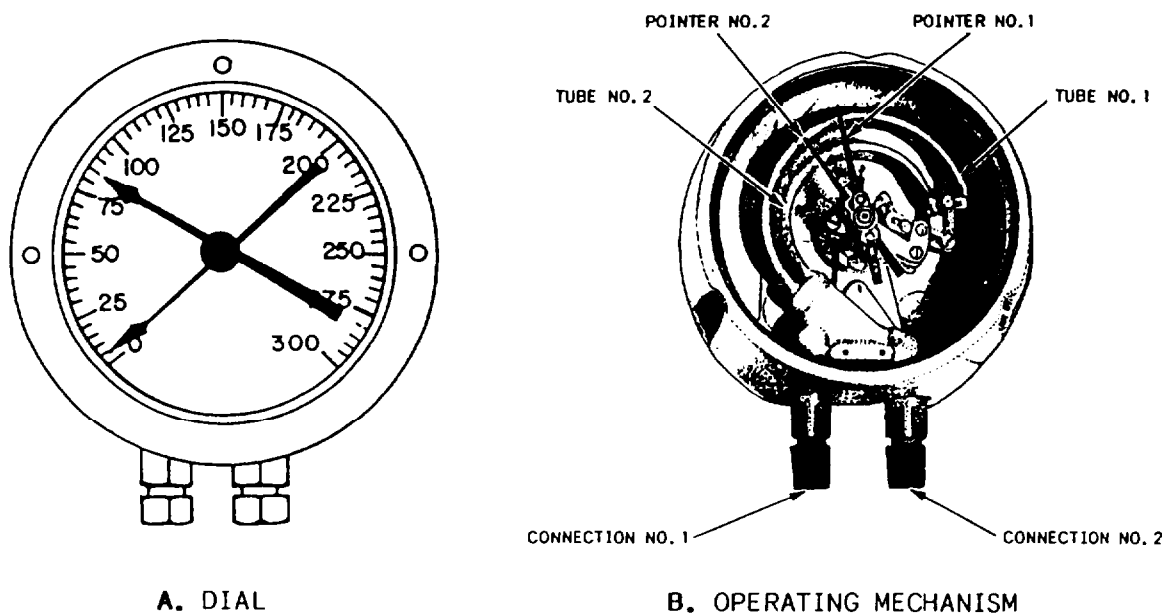
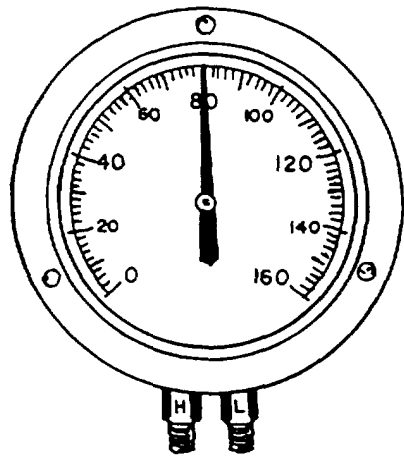
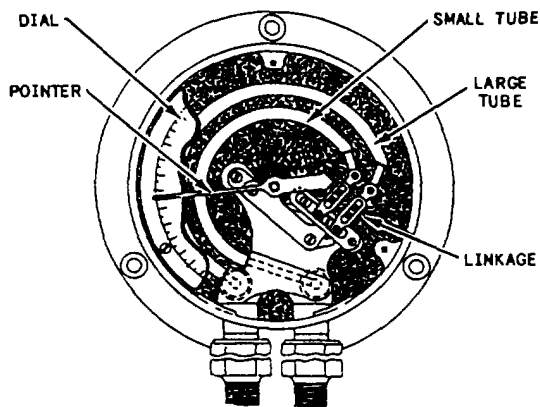


Figure 1-2.—Duplex Bourdon-tube pressure gauge.



A. DIAL



B. OPERATING MECHANISM

Figure 1-3.—Bourdon-tube differential pressure gauge.

example, some hydraulic gauges have a special type of spring-loaded linkage that is capable of taking overpressure and underpressure without damage to the movement and that keeps the pointer from slamming back to zero when the pressure is suddenly changed. A hydraulic gauge that does not have such a device must be protected by a suitable check valve. Some hydraulic gauges may also have special dials that indicate both the pressure (in psi) and the corresponding total force being applied, for example tons of force produced by a hydraulic press.

Spiral and Helical Bourdon Tubes

Spiral and helical Bourdon tubes (figs. 1-4 and 1-5) are made from tubing with a flattened cross

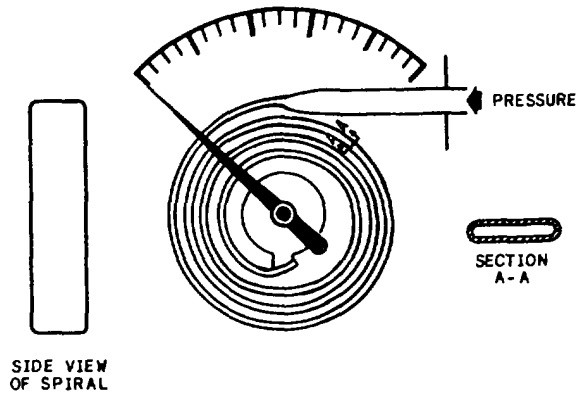


Figure 1-4.—Spiral Bourdon tube.

section. Both were designed to provide more travel of the tube tip, primarily for moving the recording pen of pressure recorders.

BELLOWS ELASTIC ELEMENTS

A bellows elastic element is a convoluted unit that expands and contracts axially with changes in pressure. The pressure to be measured can be applied to either the outside or the inside of the bellows; in practice, most bellows measuring

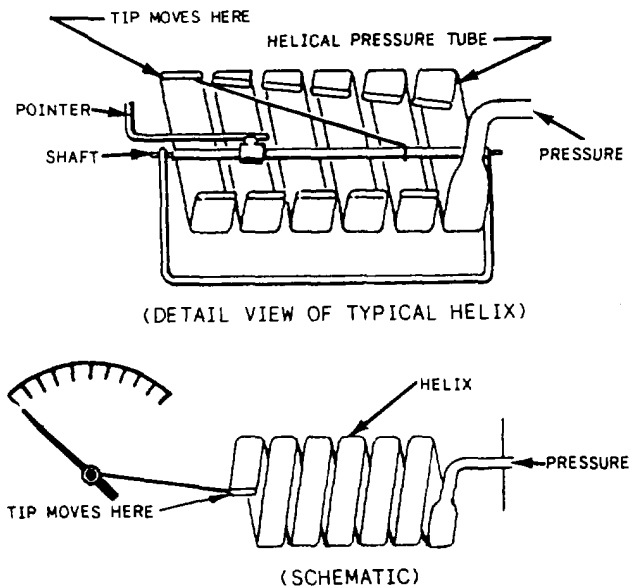


Figure 1-5.—Helical Bourdon tube.

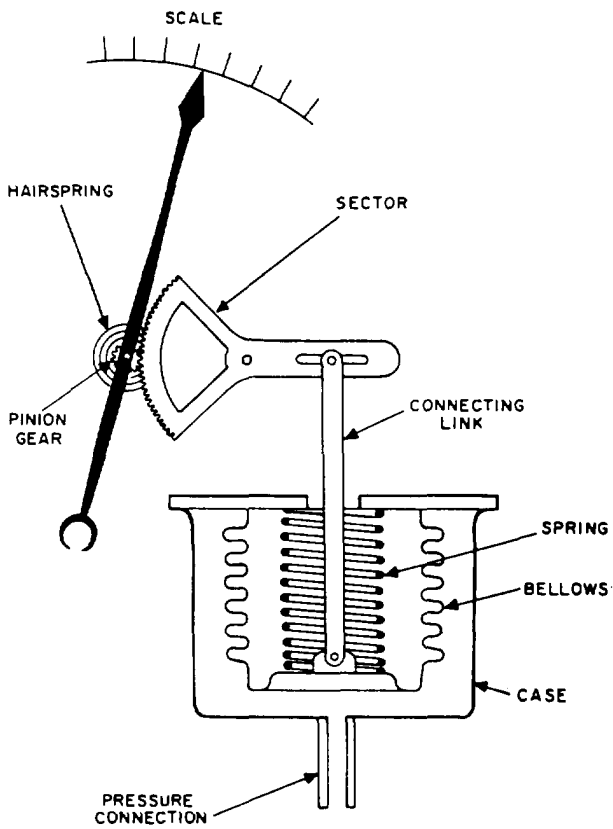


Figure 1-6.—Simple bellows gauge.

devices have the pressure applied to the outside of the bellows (fig. 1-6).

Simple Bellows Elements

Bellows elastic elements are made of brass, phosphor bronze, stainless steel, beryllium-copper, or other metal suitable for the intended service of the gauge. Motion of the element (bellows) is transmitted by suitable linkage and gears to a dial pointer. Most bellows gauges are spring-loaded—that is, a spring opposes the bellows and thus prevents full expansion of the bellows. Limiting the expansion of the bellows in this way protects the bellows and prolongs its life. Because of the elasticity in both the bellows and the spring in a spring-loaded bellows element, the relationship between the applied pressure and bellows movement is linear.

Dual Bellows Indicators

Another type of bellows element is the dual-bellows element. Figure 1-7 is a schematic diagram of this indicator. Dual-bellows element pressure indicators are used as flow-measuring, level-indicating, or pressure-indicating devices.

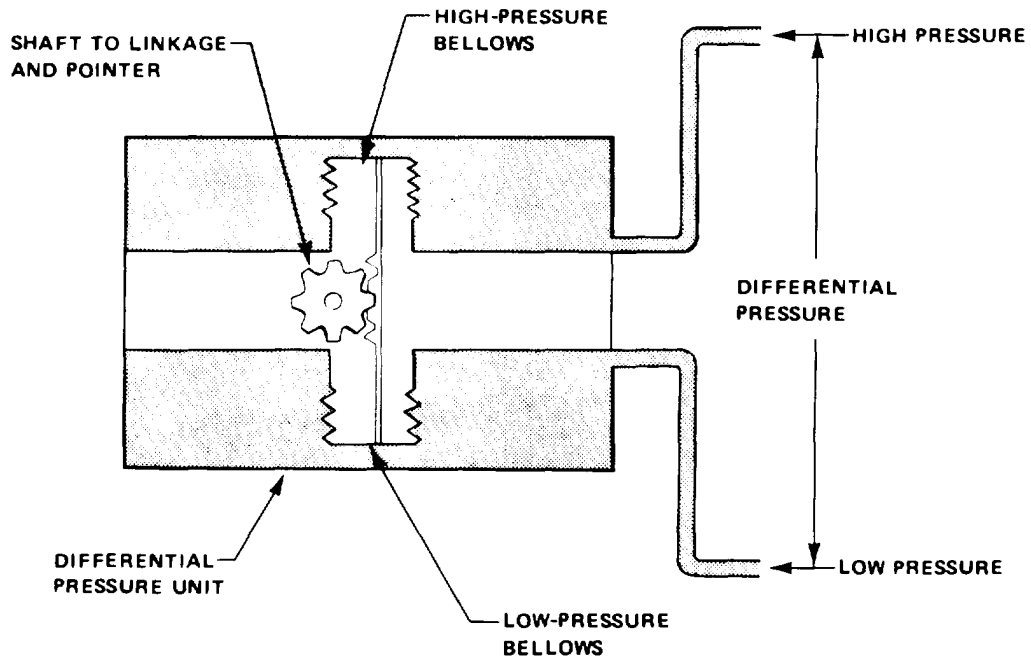
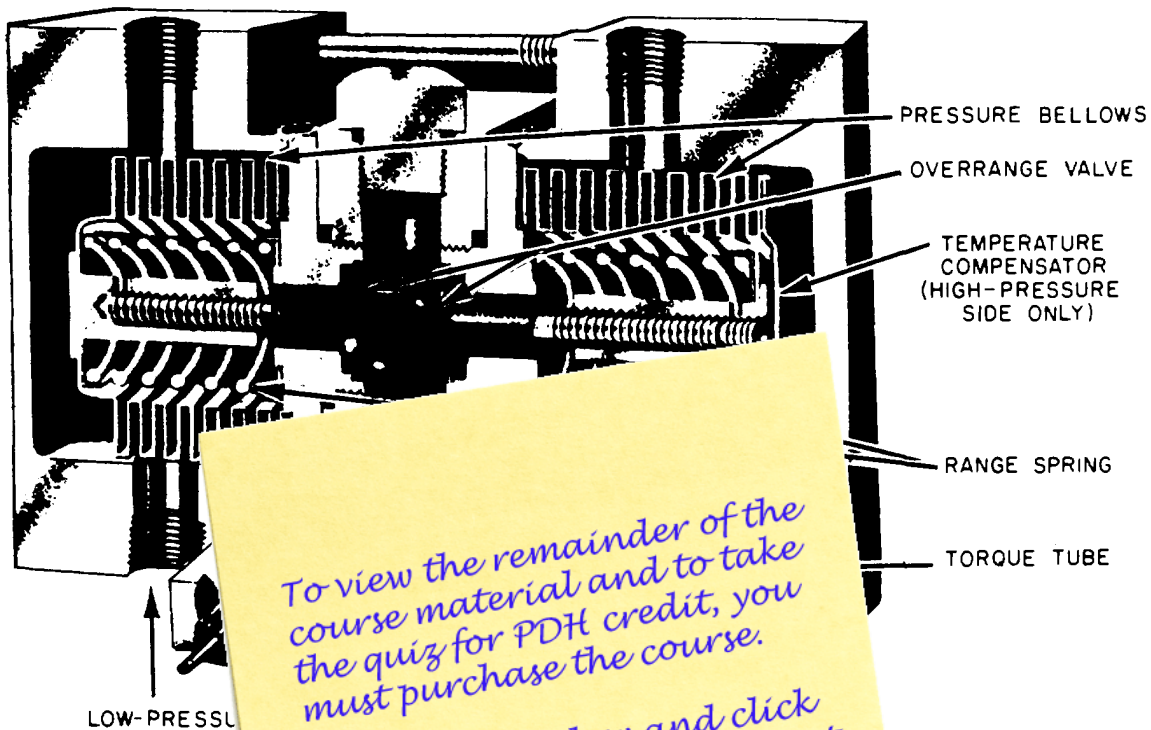


Figure 1-7.—Differential pressure sensor dual bellows.



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When in operation, the motion of the bellows is proportional to the difference across the bellows unit. This motion is transmitted as a rotation to the torque tube assembly (figure 1-8). The torque tube assembly multiplies rotation through a gear and pinion to the indicating pointer.

Bellows elements are used in various applications where the pressure-sensitive device must be powerful enough to operate not only the indicating pointer but also some type of recording device.

PRESSURE SWITCHES

Often when a measured pressure reaches a certain maximum or minimum value, it is desirable to have an alarm sound a warning, a light to give a signal, or an auxiliary control system to energize or de-energize. A pressure switch is the device commonly used for this purpose.

One of the simplest pressure switches is the single-pole, single-throw, quick-acting type shown in figure 1-9. This switch is contained in a metal

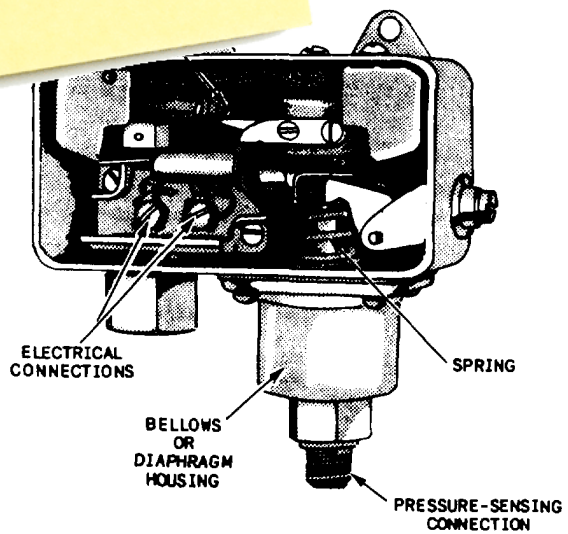


Figure 1-9.—Typical pressure switch.