Variation Control For Automation

Self-correcting controls are a vital part of automated systems. How some of them work is our story

By MATTHEW MANDL

AN important aspect of automation is electronic sensing and control of variations or changes in items being processed. Such deviations can be the omission of a particular step, a shift of position of the item on the assembly line or a change in the bulk of the item—a change in thickness or width, or in the case of fluids, of volume.

There are several types of control systems, and the choice depends primarily on whether the variations to be sensed are gradual or abrupt. Initially we'll consider gradual change and show some practical commercial applications. For gradual variations we need a sensing device that will recognize the change as it occurs and then actuate a device to correct it.

One device which will do this is the differential reactor (Fig. 1). It is essentially a coil with a movable plunger acting as an adjustable core, attached to a feeler (or roller) which moves over the material to be tested. The device is basically a transducer—it produces electric signals proportional to physical changes. As the core moves farther into the coil, the coil's opposition to ac (inductive reactance) increases. (Inserting a core into a coil increases permeability and inductance and, as inductance increases, so does reactance.)

To make the device practical, we have to get a dc correction voltage so a change in one direction produces a negative signal while a change in the opposite direction produces a positive one. Such variations can be observed on a center-zero meter or applied to a servo motor to correct the deviations as they occur.

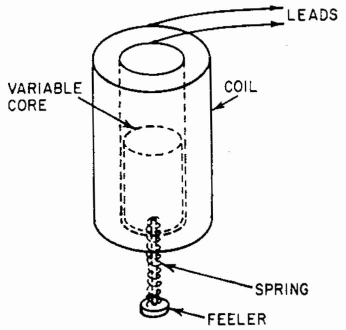

Fig. 1—Basic differential reactor.

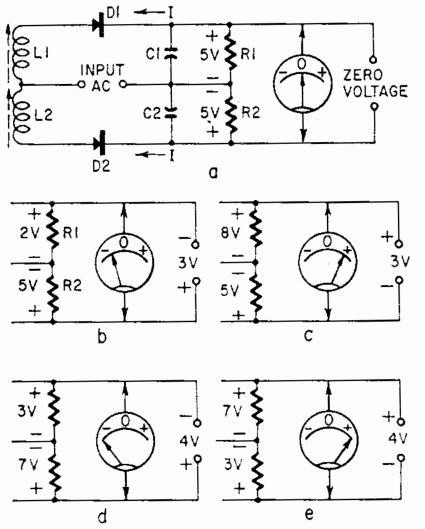

Fig. 2—Null indicator circuit and its possible outputs.

The necessary dc correction voltages can be supplied by a bridge type balanced circuit (Fig. 2-a). Two differential reactors are employed, L1 and L2. If L1 is the sensing device, L2 is adjusted for zero output from the circuit. Assume that both cores are midway within their coils and each presents the same amount of reactance. When the diodes D1 and D2 conduct for a positive alternation of the ac, current flow is in the direction shown by the arrows. But, since the circuit is balanced, the voltage drop across R1 is equal (but opposite in polarity) to the voltage drop across R2. The result is zero voltage output.

If the reactance of L1 goes up, less current flows through D1 and the voltage across R1 goes down. If this decrease is from 5 volts to 2, the voltage output would be −3, as shown in Fig. 2-b. If L1's reactance decreases, more current flows through D1 and the output voltage polarity changes as shown in Fig. 2-c (its value depends on the amount of reactance change).

Where both differential reactors are used for sensing, such as above and below a moving sheet of metal, both reactances vary. Assume, for instance, that the sensing devices are set up to indicate curvature. As the material bends upward, L1's core moves farther into the coil, while L2's core moves out of the core. Thus, the reactance of L1

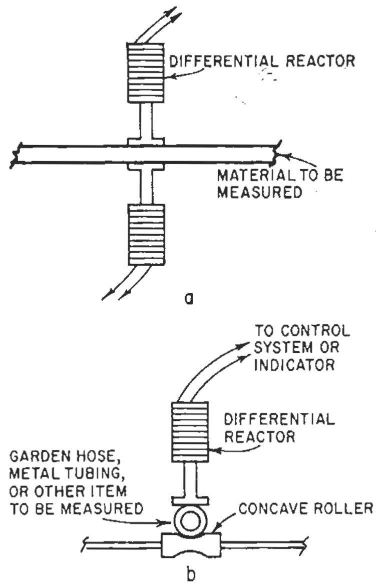

Fig. 3—Two ways of using differential reactors.

increases while that of L2 decreases. Voltages would then have the relationship shown in Fig. 2-d. If the material bends downward to the same degree as it bent upward, the same total output voltage is produced, but of opposite polarity (Fig. 2-e). Thus, the changes in voltage and polarity can be applied to a deviation-correcting device because they give a proportional voltage change for the errors which occur.

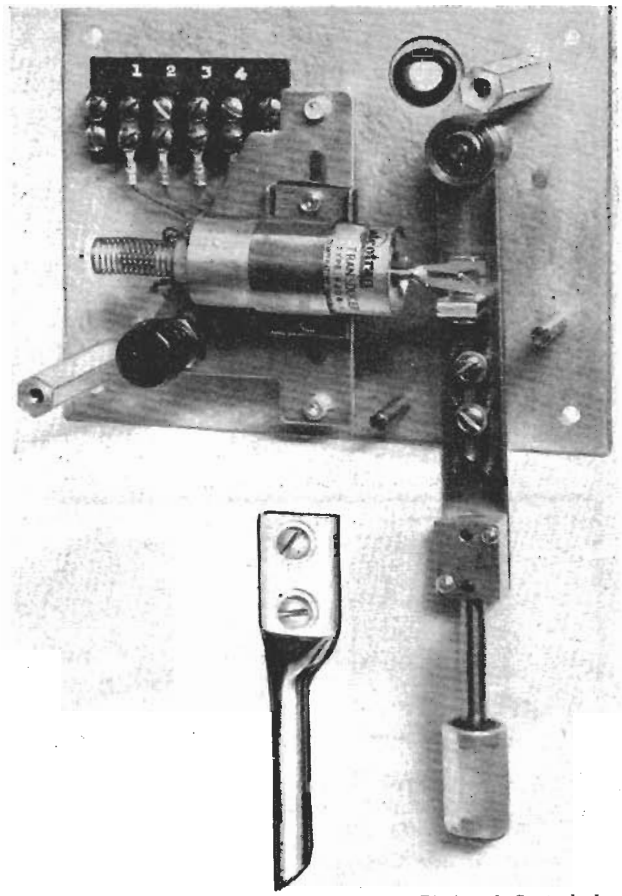

Fig. 4—A lever type edge control.

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Practical application

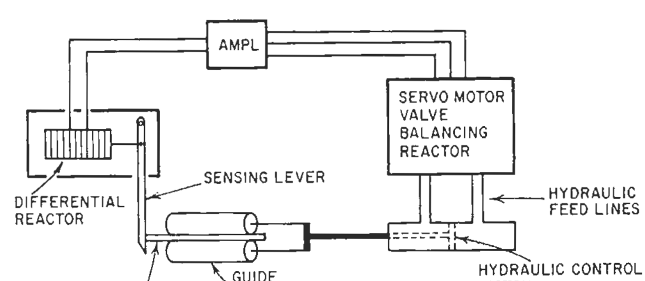
Placing one reactor above the material, and one below, as in Fig. 3-a can be used to sense differences in thickness. If both are wired as shown earlier, however, a change in thickness will result in both reactances changing identically and no correction voltage will be obtained. To measure thickness, the terminals from one reactor must be reversed. A single reactor can be used also, as in Fig. 3-b. Though less output voltage is obtained, increased amplification will compensate for the difference.

In some commercial installations a lever arm is used (Fig. 4). A typical industrial application of this device is shown in Fig. 5. Here, any sideways variations of the continuously moving sheet of material is sensed by the lever arm of the differential reactor. The voltage variations produced are amplified and used to operate a servo motor that rotates in one direction for one voltage polarity and reverses rotation for an opposite polarity. The motor actuates a hydraulic valve that causes the controlling piston to move in the direction necessary for correction. If the edge of the material pushes the sensing lever to the left, for instance, the piston is made to move to the right until a zero voltage is produced. A balancing reactor is used with the differential reactor to get a zero adjustment for proper placement of the material.

The device can also be used to sense abrupt changes. An inductance is still used but, instead of using a movable core, it senses a change by detecting metal passing beneath it. With ac applied to the reactor, the lines of force are cut each time metal passes under the unit, causing a slight change in the circulating current.

A practical application of this device is shown in Fig. 6, where it senses which bottles were not capped in beverage packing industries. Because a signal is obtained every time a metal bottle cap passes beneath the proximity-cell reactor, the *absence* of a cap would produce *no signal.* From a functional standpoint, the reverse should be true. To do this, the proximity-cell device is paired with a photo cell that generates an opposite voltage to form a "comparator" circuit. To generate a good field

Fig. 5—Edge control system.



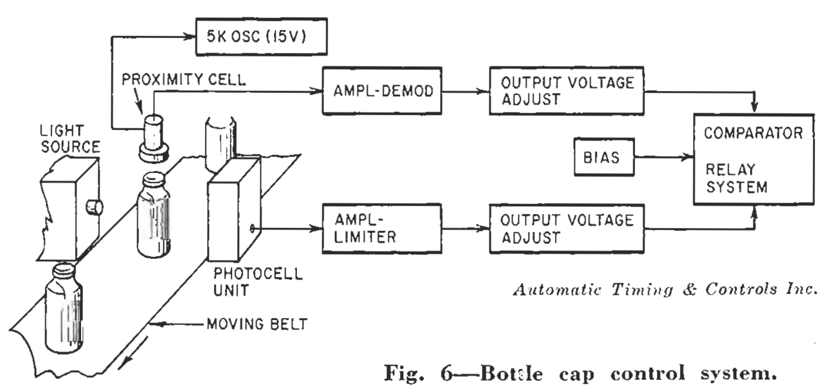


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Fig. 6—Bottle cap control system.

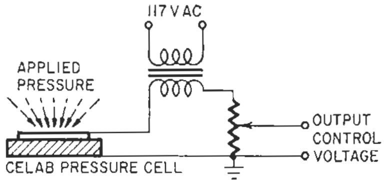
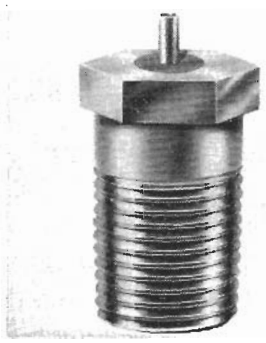


Fig. 7—Typical pressure-cell circuit.



Clark Electronic Labs.

Fig. 8—One type of pressure cell designed to measure liquid pressure.

in the proximity reactor, 5,000-cycle signal is applied, which is amplified and demodulated as shown. As each bottle reaches a position beneath the proximity cell, it also is between the light source and the photo cell, so that both cells produce signals at the same instant.

As shown in the figure, a bias voltage is compared with that produced by the photocell. If there is no signal from the proximity unit (uncapped bottle) a difference voltage is produced. It actuates the relay system that removes the uncapped bottle or stops the conveyor belt. When a capped bottle is sensed, the voltage produced by the proximity cell opposes the difference voltage and prevent the tripping of the reject relay. Thus, uncapped bottles are detected electronically, without any physical contact with the moving items.

High-pressure variations

Variation control is also employed where pressures are high—as in oil lines, gas lines and reactors. Pressure control is a safety factor and, when pressures become excessive, correction consists of closing a valve or controlling check valves that protect the pipe lines.

One commercial sensing device is made from intermetallic resins and rare earths processed with zirconion tetrachloride. Its resistance changes with applied pressure. The cells are available in a variety of mountings and with different characteristics to meet particular requirements. A typical unit is the No. 48 Celab solid-state load cell. It has a resistance of approximately 900,000 ohms at 5 pounds and zero resistance at a pressure slightly over 20 pounds. A typical circuit for the cell is shown in Fig. 7. It will function with dc as well as ac. Fig. 8 shows the housing for the cell where liquid pressure variations are to be sensed.

Overload protection

Simpler switch controls are also used in commercial applications. For example, pressure-switch controls are used for overload protection in all phases of industry. Such types are simple in operation and relatively inexpensive. The one shown in Fig. 9 is used to control air, gas or liquid pressure where close on–off deviations must be sensed. This control uses a brass bellows which trig-

United Electric Controls Co.

Fig. 9—Another type of pressure control.

gers a basic single-pole, single-throw switch. Other models have double-throw switches and various pressure ranges.

This pressure control, as well as the other control devices previously described, are adaptable to many control applications. In all instances, however, the basic principles are similar. Initially the variation must be sensed, and the signal produced by the sensing device is employed either for correction, for a metered display, or both. By using electronic circuits to process the signals, they can be amplified to control motors and valves to make corrections.

All must have provision for adjusting the system to the normal or correct setting. That is, the operator must indicate to the system by proper circuit balancing the normal condition, so the electronic devices can sense variations from it and make the proper corrections. After that, the control and correction processes are automatic and need only be checked occasionally as part of routine maintenance. END

THE MAILS ARE SAFER

An FCC inspector boarded a boat in California only to be ordered off by the uncooperative owner. When the inspector stepped off the boat to write his report, the boat owner followed him. In the resulting dispute, the inspector found himself in the water. He had to swim for shore to finish his report. The FCC is taking administrative action against the boat owner, this time by mail, and he is likely to find himself in much warmer water than he is used to navigating.