4

Control elements, actuators, and displays

The reverse operation of computer data gathering is information output, particularly data display and control commands. We now look at the interface aspects of these – the transduction of the computer words to signals appropriate for operating valves, moving dials, running motors, etc. In this context, a control element is a device such as a valve, an actuator is a motor or solenoid which opens and closes the valve, and a display is an indicator on the operator's console.

4.1 SYNOPSIS

Because a computer works with binary words consisting of 0V and 5V bits, its outputs are rarely of direct use. A plant needs motors turned on and off, valves opened and closed, heaters adjusted, operator information displayed, etc. Hence the computer outputs must be processed.

The computer words must be transduced to other forms and are usually first conditioned. Thus the computer words are first amplified, perhaps converted to another electrical signal using modulation, and then used to control electromagnetic fields, heating of wires, lighting, and small motions, using various physical effects. These effects are either the final process control elements themselves, or are used to operate actuators which affect elements such as valves which adjust the plant variables.

The key ideas then are those associated with transduction of electrical signals to other physical signals and with the specification of control elements; the latter is the primary feature of this chapter.

An alternative to control output is the provision of information to operators using dials, flashing lights, and audio signals. The transduction here and the human factors characteristic of the displays are both of interest.

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4.2 ACTUATORS AND TRANSDUCTION

There are few direct control actuators, i.e. devices which take the low voltage electrical signal and convert it to fluid flow rate, temperature, acceleration, etc. Rather, the signals often command valve openings, switch openings and closings, amplifier outputs, etc. The valves, switches, airplane flaps, etc., are the actual control elements, the devices which affect the process; many of them have local feedback to maintain a commanded opening, and thus the elements are themselves servomechanisms. When packaged as such, they are smart controllers and are analogous to smart sensors.

Among the few direct transductions of electricity to other physical quantities are:

1. force or torque via EMF
2. heat
3. light
4. displacement

These appear to be the principal quantities to which electricity may be transduced, but usually the low-power output of the digital computer is inadequate for them. Amplifiers and signal conversions, such as to frequency or analog values via digital to analog converters (DACs), are therefore required, and such signal conditioning becomes part of the computer output process.

The transduction principles from electric signals to motion, heat, etc., are applied either directly to control a process or themselves are used in controlled subsystems to command the control elements (as in use of a motor to open/close a valve). Five simple principles of transduction are given below.

4.2.1 Linear-acting devices

A very common device which converts an electric current to linear motion (and hence to sound) is the **audio loudspeaker**. The relay is similar in operation, but it is used for switching of electrical signals and is in effect a sort of binary amplifier or signal conditioner. An electromagnetic device, used for translation of an electrical command into a mechanical straight-line motion, ordinarily has a moving core which is connected to the moved system, but fixed core moving electromagnet devices are not uncommon.