The term dosed-loop control always implies the use of feedback control action in order to reduce system error.

Open-Loop Control Systems. Those systems in which the output has no effect on the control action are called *open-loop control systems.* In other words, in an open-loop control system the output is neither measured nor fed back for comparison with the input. One practical example is a washing machine. Soaking, washing, and rinsing in the washer operate on a time basis. The machine does not measure the output signal, that is, the cleanliness of the clothes.

Adaptive Control Systems. The dynamic characteristics of most control systems are not constant for several reasons, such as the deterioration of components as time elapses or the changes in parameters and environment. Although the effects of small changes on the dynamic characteristics are attenuated in a feedback control system, if changes in the system parameters and environment are significant, a satisfactory system must have the ability of adaptation. Adaptation implies the ability to self-adjust to self-modify in accordance with unpredictable changes in conditions of environment or structure. The control system having a candid ability of adaptation (that is, the control system itself detects changes in the plant parameters and makes necessary adjustments to the controller parameters in order to maintain an optimal performance) is called the *adaptive control system.*

Learning Control Systems. Many apparently open-loop control systems can be converted into closed-loop control systems if a human operator is considered a controller, comparing the input and output and making the corrective action based on the resulting difference or error.

If we attempt to analyze such human-operated dosed-loop control systems we encounter the difficult problem of writing equations that describe the behavior of a human being. One of the many complicating factors in this case is the learning ability of the human operator. As the operator gains more experience, he or she will become a better controller, and this must be taken into consideration in analyzing such a system. Control systems having an ability to learn are called *learning control systems.*

Part I. Comprehension Exercises

A. Put “T” for true and “F” for false statements. Justify your answers.

…… 1. Automatic control is an essential part of modern manufacturing and industrial processes.

…… 2. Any machine which is being controlled is referred to as a plant.

…… 3. The mechanism of a servo system is different from that of a position control system.

…… 4. A control system whose output is required to follow a prescribed condition may be called a servo system.

…… 5. The automatic controller functions more effectively in an open-loop control system.

…… 6. An adaptive control system is capable of accommodating unpredictable environmental changes, whether these changes occur within the system or external to it.

…… 7. An adaptive control system is designed to modify the control signal as the system environment changes, so that performance is always optimal whereas the human operator recognizes familiar inputs and can use past learned experiences to react in an optimal manner.

B. Choose a, b, c, or d which best completes each item.

1. A disturbance of a system.
   a. has a positive effect on the output
   b. has an unfavorable effect on the output
   c. increases the efficiency
   d. controls the efficiency
2. Feedback gives an automatic control system the ability…….. .
   a. to deal with the unexpected disturbances in the plant behavior
   b. to deal with the predictable disturbances in the plant behavior
   c. to maintain a steady relationship between the output and some reference input
   d. to maintain the actual value of a disturbance constant
3. It is true that …… .
   a. the mechanism of the automatic regulating system is based on that of the process control system
   b. the mechanism of the process control system is different from that of the automatic regulating system
   c. an automatic regulating system compares the actual value of the plant output with the desired value
   d. an automatic regulating system maintains the actual value of the plant output at the desired value in the presence of disturbances