tained. Some change of the controlled condition must occur to alter the prevailing controller action.

Thermometer Lag: The instantaneous temperature differential existing at any time between the true temperature of the medium and the temperature indicated on the thermometer.

Controller Lag: The time delay in the controller's ability to reposition the controlled sources to properly compensate for a change in the controlled condition.

Process Lag: (Process Time Lag) The time which elapses between the instant the control valve is positioned by the controller and the instant the controller element senses the effect of the change. This depends upon the rate of heat transfer, the specific heat, and the velocity of the fluid movement. Generally a decrease in process time lag simplifies the control problem.

Rate of Load Change: Time element of change in the magnitude of load.

Magnitude of Load Change: The per cent load at a specified time. It directly affects the size of the controlling valve. Where the inlet temperature varies constantly, the control problem becomes more difficult as the thermal difference between the inlet temperature and the leaving temperature of the controlled media becomes greater.

Drift: The deviation from the control point due to change in load conditions from 0 to 100 per cent.

Drift increases as the sensitivity adjustment of the controller is lowered, thereby tending to decrease hunting. Drift decreases as the sensitivity adjustment of the controller is raised, thereby increasing hunting.

Hunting or Cycling: The temperature variation between the high and low points of the control cycle due to lag. This balances out at the point where each successive wave of temperature reaching the controller is as large as its predecessor. As the sensitivity is lowered, hunting decreases but drift increases. Oversized control valves increase hunting.

Throttling Range or Sensitivity Adjustment: The total rise in temperature at the controller bulb required to reposition the control valve from a fully open to a fully closed position or to operate several devices controlled in sequence throughout the full sequence range. In connection with chart type controllers, throttling range is usually expressed in per cent of the total range of the chart. For other types of instruments, sensitivity adjustment is expressed in pounds variation of branch pressure per degree change in temperature, or per other unit of change of the controlled media.

Low Sensitivity: A small change in branch pressure for a comparatively large temperature or pressure change in the controlled medium. This results in a greater deviation from the control point. Low sensitivity tends to reduce hunting but the lower the sensitivity, the greater will be the drift.

High Sensitivity: A large change in branch pressure for a comparatively small temperature or pressure change of the controlled medium. The extreme of high sensitivity is the on-off or two-position control. As the sensitivity is raised, drift decreases, but the tendency to hunt increases.

Automatic Reset: A mechanical addition to a controller which corrects for drift by constantly resetting the instrument to operate on the control point, while repositioning the controlled valve or damper from its fully open to its fully closed position. Reset action is superimposed on throttling range and both function simultaneously. The rate of reset is manually adjustable and must be set to meet the load requirements of the individual system. This supplementary device provides the accuracy of high sensitivity adjustment with a minimum of hunting.

Diaphragm hysteresis is the amount by which the stem travel of a given motor fails to assume the identical position on the upward and downward strokes for an identical air pressure in the diaphragm top. It prevails in varying degrees in connection with the operation of all pneumatic diaphragm motors, and is due to spring and diaphragm hysteresis and friction of guide bearing and stuffing box. Assume that a direct acting valve moving to a closed position will travel 50 per cent of its total with 8 lb air pressure on the diaphragm top. If the diaphragm pressure is increased to further close the valve and then reduced to 8 lb, the valve may be repositioned to be only 45 per cent open, indicating 5 per cent hysteresis. Hysteresis is usually expressed in per cent of the full stroke of valve stem.

RESIDENTIAL CONTROL SYSTEMS

The control installation in a residence may vary from the simple regulation of a coal-fired heating plant to the completely automatic all year air conditioning system. Residential installations with automatic fuel burning appliances, such as oil burners, gas burners or stokers, are

normally equipped with single room thermostat, limit and safety controls as outlined under Control of Automatic Fuel Burning Appliances.

Coal-Fired Heating Plant

Control in the normal coal-fired domestic heating plant consists of regulating the combustion rate in accordance with requirements. This function is accomplished by a spring or electric-driven damper motor which, under the command of a room thermostat and through chain linkage, operates the draft and check dampers of a boiler or warm air furnace. Such installation should be protected against excessive temperature or pressure by means of a limit control serving to check the fire when conditions at the boiler or furnace reach a predetermined maximum.

All Year Domestic Hot Water Supply

Hot water or steam heating boilers with automatic fuel burning appliances can be used for all year heating of domestic water supply. The fuel burning appliance in this case is controlled from the temperature of water or pressure of steam in the boiler to maintain uniform boiler conditions and domestic hot water is heated by means of an indirect heater. The heating of the residence is normally governed by means of a thermostat which operates a control valve in the flow line of a gravity hot water or a steam system or which controls the circulating pump in a hot water system.

Air Conditioning Systems

Residential air conditioning systems normally include a heating source and a motor-driven fan for circulating air. In addition, such installations may involve spray-head equipment to supply humidity. Such installations distribute heated and humidified air during the heating cycle, and during the summer or cooling cycle may be used effectively as conditioners if equipped with refrigeration means.

Regulation of the humidity during the heating cycle is normally accomplished by opening and closing a solenoid water valve supplying water to the spray-heads, the solenoid valve being under control of a room type humidity control. In the average installation the fan is permitted to run only during such intervals as the thermostat is calling for heat or at the command of a limit control to prevent the overheating of the bonnet of a warm air furnace. The limit control should also prevent the operation of the fan at the command of the thermostat until the circulating air temperature has increased to a predetermined point.

For the cooling equipment provided in such installations, control during the cooling cycle will be an adaptation of the control principles described for central fan systems selected for the type of cooling equipment utilized.

CONTROL OF AUTOMATIC FUEL BURNING APPLIANCES

It is essential that automatic controls be used with oil burners, gas burners, and stokers in order to maintain even temperatures and provide safe and economical operation of the heating plant.

Oil Burner Controls

In the normal oil burner installation as encountered in residential and small commercial installations, the burner operation is frequently regulated by electric controls and primarily governed by a room thermostat. It is essential that a limiting control be incorporated in the control system to prevent the temperature of the heating medium from exceeding any