tion weighing 2 to 3 times the weight of the motor and compressor, in order to maintain the machine movement below 0.03 in.

Compressor and motor	4,500 lb
Concrete foundation	9,000 lb
Total	13,500 lb

Practical application dictates the number of springs to be used, which is based on the design of the machine foundation and the supporting floor structure. However, it is desirable to design for at least 8 springs and one or two spares for cases of unknown weights. As many as 50 springs have been used on one installation. The distribution of the springs must be balanced against the masses to be supported, otherwise the foundation design and supporting structure determine the location of the springs.

The choice of the material used in the design of the resilient mounting is also important. For the slow-speed type compressor a common speed found in practice is 360 rpm. For speeds below this, isolation should not be attempted except under careful supervision. Referring to Fig. 7, it is found that for 360 rpm the static deflection required for a ratio of w/w_n of 3 to 1 (line *EF*) is 2.5 in. and for a ratio of 5 to 1 (line *GH*) it is 7 in. For these values of deflection the only choice of material is the coil spring. This is also true for speeds up to about 700 rpm. In consideration of the transverse spring constant (so as to maintain good ratios among the various degrees of freedom) experience has shown that the spring should be designed with a *working height* equal to 1.0 to 1.5 times the outside diameter. A long spring of small outside diameter has very low transverse rigidity and therefore requires some additional means of preventing side drift of the unit and on very sensitive applications this may tend to destroy the isolation efficiency. For speeds of 700 to 1200 rpm the required deflections range from 0.22 in. to 1.75 in. For these conditions rubber in shear serves as a rather satisfactory material if protected from oil. For speeds higher than 1200 rpm cork specially made for vibration damping can be applied with good results. These limitations are by no means absolute because with careful and well engineered installations, especially, in consideration of all six degrees of freedom, certain liberties may be taken and still good results accomplished.

When a machine unit is properly isolated it will have a definite amount of movement which is determined by the ratio of the unbalanced forces to the total mass of the machine. If this resultant machine movement is too great for the necessary connections or the satisfaction of the customer it can be reduced only in two ways without destroying the quality of the isolation; first, adding mass or dead weight to the machine (such as concrete) common in the application of low speed, partially balanced machinery; second, accurately balancing (both statically and dynamically) all moving parts so as to eliminate the vibration at the source. This latter method is the best engineering practice and is the modern trend. However, even with well balanced machinery, installed in the vicinity of quiet offices it is usually necessary to properly isolate the equipment to prevent the transmission of vibration likely to cause complaints.

Where limitation of machine movement is desired during the starting and stopping periods, the application of friction or hydraulic damping will serve without seriously interfering with the efficiency of the isolation.

CHAPTER 34

Automatic Control

Basic Types of Control, Types of Functions of Controllers, Designation of Temperature Control, Automatic Control Terminology, Residential Control Systems, Control of Automatic Fuel Appliances, Zone Control, Control of Unit Systems, Control of Refrigeration Equipment, Application of Control Devices to a Typical System

THE function of *automatic control*, as applied to the heating, ventilating and air conditioning industry, may be broadly subdivided into the maintenance of *temperature*, *humidity*, *pressure*, and *liquid levels* within predetermined ranges. It automatically coordinates the operation of the various controlled mechanisms in proper sequence to produce the desired result. A thermostat, for instance, is a controller responsive to temperature which initiates a force that repositions valves, dampers, etc., as required to maintain selected temperatures. Similarly, a hygrostat or humidistat is a controller responsive to relative humidity which initiates a force that repositions the controlled sources as required to maintain a selected relative humidity.

BASIC TYPES OF CONTROI

There are two basic types of contollers, (1) the *two-position*, *on-off*, or *positive acting controller*, which functions to move a valve, damper or electric switch through its full travel (not necessarily 100 per cent) from open to closed position and vice versa, and (2) the *throttling*, *proportioning*, or *intermediate acting controller* which functions to reposition the valve, damper, or other controlled device by small increments of its total travel as the controller senses a slight change in the controlled condition. The available equipment may be broadly sub-divided into three main groups, (*a*) *self-contained equipment*, (*b*) *electrically operated equipment*, and (*c*) *pneumatically operated equipment*.

Self-Contained Equipment

In *self-contained controllers* the primary source of power is the vapor pressure of an enclosed volatile liquid which varies with the temperature changes of the controller bulb. Such pressure changes are transmitted directly into the bellows or diaphragm mechanism of the controlled valve. Devices of this type produce gradual operation and are used to regulate the flow of heating and cooling media to coils, radiators, and liquid tanks. Each instrument is designed to operate within a predetermined selected temperature range and for a given condition. Care must be exercised to select a type which has the ability to withstand any possible over-run of temperature at the control bulb without damage to