from the air by mechanical separation; finer materials, by electrostatic action.

Activated carbon units sometimes are used in addition to the regular filters for adsorbing odors and other impurities, thus reducing the amount of outside air necessary for ventilation.

Temperature and Humidity Control

Controls in a passenger car should be as automatic as possible. The regular train crew cannot be relied on to make adjustments for the comfort of passengers. For this reason the latest systems of temperature control have only an off-on switch to be operated by the train crew. When the system is in operation, heating or cooling is provided automatically as required.

When heating, it is important that floor-heat finned tubing be controlled at stable temperatures. Wide fluctuation in its temperature is highly objectionable because of location close to the passengers. Stable operation may be secured by cycling the floor heat on the basis of inside conditions in conjunction with an overhead air-circulating system to maintain final car temperatures.

Because of window condensation and other problems, usually no attempt is made to raise relative humidity in a railroad car in winter time.

When cooling, the steam jet refrigeration system is controlled in an on-off manner. Some means are ordinarily provided for operating mechanical compressor systems at partial capacity. In this case split evaporators are used, so that evaporator surface and compressor capacity can be reduced together under light load conditions.

Attempts have been made in the past, largely on an experimental basis, to control the relative humidity in railway cars. This was done by operating the air conditioning equipment according to outside temperatures and then re-heating the air to an acceptable temperature. This was found to be an expensive method of operating and the results did not justify the cost. A common method of controlling heating and cooling is to provide a thermostat to control heating only and a separate thermostat set at a slightly higher temperature to control the cooling equipment. This gives heating control, ventilation, and cooling control and the reverse, as the case may be. A car in service can go from heating into cooling in a very short time. An example of this is found on the full-dome cars in service on several railroads in the country. In the early morning hours before sunrise, the car may be requiring a considerable amount of heat. Shortly after sunrise, the car may go into the ventilating cycle and as the sun load increases, cooling may be required. On the majority of car heating systems, frequent cycling of the compressor is prevented by the one degree difference between the heating and cooling control points and by lag imposed on the system by applying artificial heat to the heating thermostat when cooling is required. On some car heating systems, a degree of modulation is obtained by the use of split evaporation. This requires two cooling thermostats with one of them set at a somewhat higher temperature than the other. The lower temperature cooling thermostat controls a portion of the cooling capacity and, if unable to maintain the car temperature, the higher thermostat adds the remaining capacity.

STREETCAR AND TROLLEY COACH HEATING AND VENTILATING

Streetcars and trolley coaches present a special problem in the maintenance of satisfactory comfort conditions because of the frequent opening of the doors and highly fluctuating passenger load. Space limitations for ducts, and a desire to keep outlet grilles well above the floor to facilitate car cleaning, add further problems to the distribution system. Maintaining comfort conditions at the driver's station cannot be overlooked, since his term of occupancy is considerably longer than that of any passenger, and because he is usually dressed more lightly than passengers. A separate source of heat is usually provided for the operator, and is under his control.

Heating and Ventilating

Recently-built streetcars and trolley coaches obtain heat from air blown over the main accelerating resistors and track switch resistors, to heat the passenger space. In the modern streamlined streetcars, designated P.C.C., approximately 2400 cfm are drawn from the car and blown over these resistors to dissipate their heat. In trolley coaches, an amount of 800 cfm is customary. The heated air is then delivered to the passenger space or diverted to the outside by means of dampers, as required. If available heat from this source is insufficient, auxiliary electric heaters in the supply ducts may be cut in. The air distribution system is 100 percent recirculating when the maximum heating requirement is being met. At conditions other than maximum heating demand, part of the air drawn from the car is exhausted to the atmosphere. Outside air enters the car, under these conditions, by infiltration at all cracks and through doors when opened at stops.

The most recently-built streetcars have added ventilating fans in the roof structure to introduce outside air through ceiling diffusing grilles. By governing the outside air volume introduced through these roof fans in coordination with the heated air distributing system, it is possible to maintain a slight pressurization of the passenger space and avoid inrush of air when the doors are opened to load passengers. The roof fans also provide an effective means of maintaining lower inside temperature during summer operation. Ventilation tests on P.C.C. streetcars indicate that with 90 F outside temperature and above, 12,000 cfm are required to provide sufficient air change to keep inside temperature within a few degrees of outside air temperature, and to provide enough air movement over passengers for comfort. The best results have been obtained by operating the ventilating fans and keeping the windows closed. New cars provided with adequate ventilating capacity have been built with fixed sash.

Control

Temperature control, consisting of equipment especially designed to withstand the vibration present on transportation equipment, is used. Automatically operated dampers are used to control flow of heated air to the passenger space, or to direct heated air to the atmosphere. An automatically operated rheostat or multi-point switch is used to vary the speed of the ventilating fans. Recent control system applications employ one thermostat to operate both heating dampers and ventilating fans in a modulating or graduated manner, with a compensating thermostat in the heat supply duct to correct for wide fluctuations in temperature of air leaving the resistors. Ventilating fans are usually stopped or operated at lowest speed during the heating cycle, and then their speed is gradually increased as the car temperature rises above the heating-cycle control point.