of passenger heating system is a further problem. The inter-urban bus, however, is usually a deluxe vehicle and may require a comfort cooling system. Space and weight limitations and vibration must be considered.

Heating

Recent designs of bus heating systems include improved air distribution. Heat in engine coolant liquid is used to warm air by means of suitable finned coils and air is distributed throughout the passenger space by ducts and outlets directed toward floor. Some designs include finned surface near the floor similar to application of heating surface in railway passenger cars. Forced air circulation over this finned floor heating surface has been provided to increase its effectiveness. Oil burning booster heaters have been applied to many Diesel-powered buses to raise temperature of engine coolant for maximum engine operating efficiency and to provide sufficient heat for passenger space.

Ventilation

Air for ventilation is usually brought into a bus at front and distributed throughout length of passenger space by a duct or ducts near ceiling. Except for a few designs employing 100 per cent outside air for heating, no heating of ventilating air has been provided. One recently designed distribution system for an inter-urban bus provides for a fixed minimum of outside air, and is arranged to increase percentage of outside air to 100 per cent when heating or cooling load diminishes. The distribution ducts and diversion damper arrangement of this system make available two supply ducts and one return duct for heating and for cooling, with a change-over to all three ducts to supply air during intermediate ventilating cycle. This system permits utilization of atmospheric cooling and ventilation to greatest degree when it can be most economically employed in interval between heating and cooling demand.

Conventional throw-away type filters or renewable filters are used in intake air ducts for many vehicles. Electrostatic filters have been successfully used in some installations. The need for elimination of dirt is great, but the problem is complicated by space limitations and limited power.

Refrigeration

Summer conditioning systems for inter-urban vehicles range in cooling capacity from 36,000 to 48,000 Btu per hour. Mechanical compression systems using refrigerants are used, and are powered by water-cooled gasoline engines of approximately 14 hp.

Complete systems add from 800 to 1300 lb to weight of coach. Sometimes an auxiliary generator driven by the refrigeration system engine is used and serves to help charge bus battery, thereby offsetting power drain imposed by the ventilating blower. Belted reciprocating compressors and direct-driven V-type and rotary compressors are used, with engine speeds up to about 1800 rpm. Air-cooled condensers for this service require about 5000 cfm of outdoor air, and this is provided by either centrifugal or propeller type fans belted or direct-driven by air conditioning engine. Preventing noise and vibration from affecting passengers is of vital importance. Installations must be so made that quick daily servicing of engine is possible. In all cases fuel is obtained from main bus tanks, and in some the main engine cooling system cools the air conditioning engine.

Control

Automatic temperature control is receiving more attention in design of new vehicles. Some municipalities and states have enacted laws requiring that buses operated on their streets and roads be so equipped. The simplest control systems for heating of urban buses consist of a single thermostat to start and stop the blower of the heater unit. Improved heating systems employ a thermostat to control liquid flow to heater cores by means of modulating valves in combination with a means of stopping heating blower when no heat is required. Heating and ventilating control is accomplished by controlling volume of fresh air over and above minimum required in accordance with temperature in passenger space. This is accomplished through automatic modulating dampers in outside air intake or by varying speed of ventilating air blowers.

In a large proportion of inter-city buses equipped with mechanical refrigeration, a single thermostat is used to start and stop the cooling operation. This may be accomplished by automatically starting an engine-driven compressor on cooling demand or by engaging a clutch to drive compressor. Modulated or graduated control of engine-driven compressors may be accomplished by automatic regulation of engine throttle controlled from a thermostat in the passenger space. Complete control systems are available to coordinate operation of heating, ventilating and cooling equipment from a single thermostat with automatic change-over from heating to ventilating to cooling.

AUTOMOBILE SUMMER AIR CONDITIONING

Recently summer cooling has been applied to automobiles. The average present day automobile with little insulation, large, single glazed window areas, and high infiltration and exfiltration losses, requires about 15,000 Btu per hour of cooling capacity. One system utilizes a reciprocating compressor belted from the main engine fan shaft thus operating at varying speeds up to 3000 rpm. The resulting refrigeration capacity varies from about 6000 Btu per hour at idling speed to 24,000 Btu per hour at maximum car speed.

A dry air condenser is placed in front of the engine radiator, and the liquid and suction refrigerant lines run back under the car floor to the evaporator which is located in back of the rear seat. Conditioned air is delivered into the car just above the shelf near the back of the rear seat. A return grille is provided under the rear seat, and the recirculated air is filtered. Outdoor air is provided by infiltration. Power for the air circulating blowers is obtained from the car storage battery. Equipment of this nature increases the car weight approximately 200 lb.

AIRCRAFT AIR CONDITIONING

In the space of a few years, heating, cooling and ventilating of airplanes has progressed from comparatively simple systems to highly complex multi-purpose designs. The attendant control problem has become correspondingly complex. On older, non-pressurized planes, the heating system consisted either of a steam boiler and radiator or a single stage or double stage heat exchanger. On both types, cabin temperature was adjusted by positioning face and bypass dampers. While these were sometimes moved by an automatic modulating control, in the majority of cases they were positioned by one of ship's crew, with results which, while not satisfactory, were passable. As these planes cruised at less than 200 mph and normally operated at low altitudes, changes in outside air temperatures