circulated through the finned tubing by means of circulators. If steam is used directly, it is difficult to distribute the heat uniformly along the length of the car. In the case of steam it is customary to divide long finned tubes into separate sections which are fed independently. This is not true zoning since it is not based on principles for zoning. (See Chapter 43.)

The finned tubing at floor must have sufficient capacity to offset effects of cold walls and windows during normal operation, and to heat the entire car to a minimum temperature of 60 F during standby when the overhead system is not operating. The maximum capacity required (determined by standby requirements) varies with car construction and design temperatures, but is approximately 90,000 Btu per hour. This requires a heating capacity in finned tube of approximately 650 Btu per linear foot.

The overhead air heating coil must have sufficient capacity to heat outside air brought into car for ventilation and to supply approximately 20 per cent of internal heat loss of the car so as to permit supply of floor heat at all times at an output that will not be objectionable to passengers sitting near it. The usual capacity of overhead heating coil is approximately 100,000 Btu based on 2400 cfm of circulated air with 600 cfm of this being outside air for ventilation. All Btu figures are approximations of actual heating requirements and do not include heat losses in trainline (or leakage) or losses in undercar piping. The heat losses in undercar piping can become a major portion of train heating boiler load on cars having many undercar loops and steam regulating devices.

Refrigeration

For cooling and dehumidification during summer, refrigeration may be obtained from ice bunkers, steam jet systems, mechanical compressors driven directly from car axle, by electric motors or by gas engines. Refrigeration required varies with load conditions but $7\frac{1}{2}$ tons per car is one capacity frequently used. Evaporative type condensers are sometimes used in combination with the usual air condenser on either steam jet or mechanical refrigeration.

When an electric motor (approx. 10 hp) is used to drive the air conditioning compressor the electric power source is a problem. If power source is an axle-driven generator, there is an appreciable increase in the drag on locomotive, and power available for refrigeration, when train is stopped at a station, is limited to storage batteries. One solution to this problem is to use a d-c generator driven by a gas engine. Another is to use a Diesel-driven alternator in a special head-end car to furnish power to entire train. Recently there have been installations of a Diesel-driven alternator mounted on an individual passenger car to supply power requirements of car. The attractiveness of this type of installation can be increased by utilizing spare alternator capacity in winter for electric heating. If this capacity is supplemented by exhaust heat from the Diesel engine, there is sufficient capacity to heat entire car and provide hot water for wash rooms when outside temperatures are above approximately 30 F. This feature is important on trains using Diesel locomotives since it eliminates need for firing the steam heating boiler in locomotive during a portion of the year.

Air Distribution and Cleaning

Railway cars present critical problems in air distribution because air space per passenger is small (60 to 190 cu ft), and sun load is great. An average passenger car contains approximately 5000 cu ft of air and may seat as many as 80 passengers. The occupants are continually liberating heat, carbon dioxide, moisture, odors, and some organic matter from their breath, skin and clothing. The heat and moisture can be removed by cooling and dehumidification, but other constituents can be successfully handled only by proper ventilation and air cleansing. In an average car from 2000 to 2500 cfm are circulated by the air conditioning unit. Some of this air may be recirculated, but a portion of it should always be brought in from outside. The amount of outside air desirable depends upon type of car, number of passengers, air temperature, humidity, odors, and whether or not occupants are smoking, and will vary from 15 to 90 per cent of total air circulated.

Careful attention must be exercised in specifying rate of outside air taken in so as to fit type of service adequately and yet not to supply more ventilation than is necessary. Conditioning this outside air is a major factor in determining size of both summer and winter equipment.

For normal conditions, 10 cfm of outside air per passenger are provided. When smoking is permitted, at least 15 cfm should be admitted. In some dining cars and deluxe sleeping cars, outside air rates as high as 20 to 30 cfm per occupant are used. A ceiling duct lengthwise along center of the car is usually used to distribute the air to interior by fans or blowers. A perforated ceiling supplied from an overhead duct, or delivery grilles and plaques designed to give considerable entrainment and mixing, are used to deliver air to car space.

Smoking rooms present a special problem. The cloud of smoke that usually hangs near ceiling can be broken up by directing incoming air along ceiling at a velocity somewhat higher than that used for the rest of car. The air is exhausted through washroom or lavatory. For compartments, provision is made in door or partition for removal of used air. Lower berths are provided with a low velocity air outlet.

Recirculating air grilles are usually of straight flow type. Outside air intakes are usually located in vestibule, on side of car, or on roof, depending upon location of cooling coils. On many recently air-conditioned cars, there are no dampers or shutters at outside air intakes; the percentage of outside air is controlled by adjusting flow through the recirculating grille.

A considerable number of coach cars are now being equipped with return air ducts fitted in structure of baggage racks. Part of air circulated is returned to blower unit through these ducts and part through car body. This arrangement reduces quantity and velocity of air returning through car body and removes smoke fumes at the source. This, and any other design features aimed at taking recirculated air at floor and adjacent to both end doors (rather than drawing all recirculated air to one end of car) also reduces infiltration of cold air in ankle height strata, when doors are opened during heating season.

All air circulated by blower is filtered before passing over cooling and heating coils. In some cars outside and recirculated air are filtered separately before mixing, while in others air from the two sources is mixed before passing through a common filter. Filters in use are combinations of metal, wool, cloth, spun glass, hemp, paper, hair and wire screen. Most filters have a viscous coating of oil for greater cleaning efficiency. Some types may be cleaned, re-treated, and re-used, while other types are discarded when dirty. Applications are also being made of electric precipitation for air cleaning. In this system coarser particles are removed from air by mechanical separation, finer materials by electrostatic action.

Activated carbon units sometimes are used in addition to the regular