monitor-roofed cars and on the inside of turtle-back or arched-roof cars. In some instances, a center duct is used and in others the air is discharged directly from the conditioning units into the upper part of the car either through the end bulkheads or from a unit placed overhead in the center of the car. For details of air distribution and duct design see Chapters 19 and 20. Care should be taken to keep the air velocity in the ducts below the point where the noise would be objectionable.

Suitable grilles should be used at duct outlets to reduce the velocity and to direct the air so as to insure thorough mixing without objectionable drafts. The incoming air should be introduced as near room temperature as possible and should have a velocity of not over 120 fpm when it reaches the passengers. The outlet grille nearest the recirculating air grille should deflect 45 deg in one direction towards the center of the car to prevent the incoming air from passing directly to the recirculating grilles. The other outlet grilles installed along the ducts should deflect a portion of the air 45 deg to the right and 45 deg to the left and to all points between.

Smoking rooms present a special problem. The cloud of smoke that usually hangs near the ceiling can be broken up by having the incoming air directed along the ceiling in all directions at a velocity somewhat higher than that used for the rest of the car. The air should be exhausted from the room by a fan or through a grille to the wash room or lavatory, to be exhausted to the outside through a ventilator.

For compartments a supply duct outlet grille of suitable size and design should be provided and provisions made in the door or partition for removal of the recirculated air through a special grille, which will allow the air to pass from the room to the main recirculating air grille. The exhaust grille should be designed and arranged so as to obstruct the vision of passengers.

Lower berths in sleepers and office cars should be provided with an adjustable air outlet which will discharge the amount of air desired at low velocity in any direction so that the occupant can regulate the ventilation to meet his own requirements.

Recirculating air grilles are usually of the straight flow type, arranged to hold two 2 by 16 by 20 in. filters and hinged on an angle iron frame to permit easy access for cleaning and repairs. They should be located so that objectional drafts will not be created by the return air. The outside air intakes should be of ample size and provided with filters and dampers or shutters for regulating the amount of outside air.

In cars containing but one or two rooms or compartments, satisfactory results may be obtained by discharging the air directly from the conditioning unit into the upper part of the car. Care must be taken to have a proper discharge velocity. If the velocity is too low, the air will drop before reaching the end of the car and if too high it will discharge against the end bulkhead and be reflected back. Greater care must be exercised to secure proper circulation without more objectional drafts than when ducts are used.

Filters made of metal wool, spun glass, hemp, paper, cloth, and wire screen are in use. Some types may be cleaned, retreated and returned to service while other types are discarded when dirty.

STEAM OR VAPOR HEATING

The majority of cars in service are heated by circulating low pressure steam or vapor through pipes located along the side walls near the floor. When an overhead air conditioning unit, using air from the outside and discharging it into the car, is installed it is necessary to provide a heating coil to warm the air during cold weather. Most of the heat required in the car can be supplied by the overhead unit but in extreme weather some heat must be supplied at the floor to keep the lower part of the car at a comfortable temperature. It is also desirable to have sufficient floor radiation to keep the car from freezing up while standing in the yard with the air conditioning unit shut off. Usually from 30 to 40 per cent of the heat required is supplied from the overhead unit and the balance from the floor heating system. The amount of heat required depends upon the type and construction of car, especially the amount and kind of insulation, outside temperature, wind velocity and direction, train speed, number of passengers, and inside temperature desired. In severe weather, −10 to −20 F, an average of approximately 200 lb of steam per car per hour is required. Pullmans will require approximately 250 lb per hour, coaches 150 to 175 lb and baggage cars 150 lb.

COOLING EQUIPMENT

Three general types of cooling or refrigerating equipment are being used with satisfactory results. These are the ice, steam jet, and mechanical compressor systems. These systems when arranged for car use, function the same as in stationary service, but must be more compact and lighter in weight. See Chapters 2 and 11 for the general principles of the various systems.

The mechanical compressor systems are divided into two general classes, the direct drive and the electro-mechanical, differing only in the method of driving the compressor. With the direct drive system, the compressor is driven from the car axle through a combination of pulleys, belts, gears, a shaft, and a speed control device. With the electro-mechanical system the compressor is driven by an electric motor. The refrigerant most commonly used in the mechanical compressor systems is Freon.

Another type of system which has possibilities of being adapted to railway air conditioning uses methylene chloride as the refrigerant, dry ice, and a small circulating pump in place of the conventional compressor. The refrigerating unit consists of a condenser built into an insulated dry ice box. The methylene chloride is liquified by the low temperature produced by the dry ice and is circulated by the pump through the evaporator coils where part of it is vaporized by the heat from the air passing over the evaporator coils. The mixture of gas and liquid passes back to the condenser where the heat is removed and the gas liquified. This system will probably not offer many possibilities until an adequate supply of dry ice can be assured at a stable and reasonable price.

A system using a compressor driven by an internal combustion engine operating on propane has also been considered for railway air conditioning. The engine, compressor, condenser, starting motor and battery are