Sometimes an auxiliary generator driven by the air conditioning engine is used and serves to help charge the bus battery, thereby offsetting the 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 propellor type fans belted or direct driven by the air conditioning engine. Preventing noise and vibration from affecting passengers is of vital importance. Installations must be made so that quick daily servicing of the engine is possible. In all cases fuel is obtained from the main bus tanks, and in some cases the main engine jacket water cooling system is used to cool the air conditioning engine.

In the de luxe equipment, after the driver has started the air conditioning engine by means of its own cranking motor, the engine speed is modulated automatically as the refrigeration demand is partially met, and if this demand is then fully met, the engine is stopped thermostatically. Restarting when the cooling thermostat is no longer satisfied is accomplished either automatically or manually. The various protective and automatic devices on the refrigerant and engine systems make some of the bus air conditioning control systems quite complicated.

AUTOMOBILE SUMMER AIR CONDITIONING

Recently summer air conditioning 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.

AIRPLANE AIR CONDITIONING

Air conditioning of airplanes is closely associated with heating and ventilation of airplanes, but air conditioning of planes in flight has received little attention to date, probably because of added weight of equipment necessary. Under ordinary conditions the cleanliness and humidity desired are fixed by natural conditions and therefore the supply of heat and temperature control become the chief consideration. Passenger planes and military planes even at low level flying are at altitudes which require no cooling and at extreme altitudes the design temperature of the atmosphere is 60 deg below zero.

In the operation of internal combustion engines the heating value of fuel appears approximately, one-third as power, one-third transferred to cooling fluid, and one-third in the exhaust gases.

Ordinarily, the heat in the exhaust gases is ample for all heating needs, despite the excessive transmission loss due to high speed, low temperatures, and light wall construction. The maximum coefficient of heat transmission without insulation is found to be 2.28. The minimum coefficient with insulation is 0.33. For present day construction a value of 0.56 may be assumed. Naturally, the waste heat in the exhaust gases offers an attractive source for designers of heating equipment, who in the course of design have followed closely the development of heating as applied to land structures. In first attempts heat was obtained from an annular space surrounding the exhaust pipe, from which branches conducted the heated air to grilles or to seats of passengers. The speed of the plane eliminated the need for a fan or pump. In present practice danger of carbon monoxide contamination is avoided by the use of both primary and secondary heat exchangers.

Heating systems using hot air are in use for passenger and military planes. Steam systems have been used with boilers located in the path of exhaust gases but difficulty experienced in preventing freezing of the water has apparently rendered this system obsolete. A similar system using glycol is in use and requires special care because of the peculiar qualities of glycol. Thermostatic control, mixing dampers and air distribution vary little from standard practice. Controlling devices are built to withstand the extensive vibrations experienced. Humidity determinations under flying conditions show need for humidity control. Passenger planes or other planes requiring air conditioning when on the ground are satisfactorily serviced by portable air conditioning machines. High flying airplanes—above an elevation of 14,000 ft—require oxygen supply or pressurized cabins. The compression of the outside air by the supercharger raises the temperature of the cabin air from an extremely low to a comfortable high. The compression of the air also increases the humidity. Cleanliness at flying altitude is not a consideration, except under special conditions such as above deserts or upon encountering dust storms. In small planes carrying several passengers or crew, localized heating and ventilation are provided. Electrically heated clothing and oxygen masks meet requirements. At high altitudes pressurized cabins require no special oxygen supply.

Medium bombers at one time were equipped with separately fired heating units, but larger bombers, to meet the heating load imposed by crew and equipment, demand too much heat to be supplied in this manner. The recovery of heat from waste gases is therefore imperative. In airplane operations light weight is a more important requirement than in any other type of transportation. Noise should be reduced to a minimum and combined use may be made of material for insulating and noise reduction.

REFERENCES

Railway Passenger Cars

Summary Report on Air Conditioning of Railroad Passenger Cars, by Division of Equipment Research, *Association of American Railroads*, November 24, 1936.

Engineering Report on Air Conditioning of Railroad Passenger Cars, by Division of Equipment Research, *Association of American Railroads*, April 15, 1937.

Report on Performance and Cost of Operation of 1937 Internal Combustion Engine Mechanical Compression Equipment for Air Conditioning Railroad Passenger Cars, by Division of Equipment Research, *Association of American Railroads*, May 1, 1937.

Report on Relative Performance of Air Filters, by Mechanical Division, *Association of American Railroads*, January 15, 1938.

Air Conditioning of Railroad Passenger Cars, by L. W. Wallace and G. G. Early, Jr. (*A.S.M.E. Transactions*, November, 1937).