lack of adequate insulation in car bodies require this much capacity. Proper air distribution to avoid undesirable drafts on passengers also requires careful design. Air distribution fans and electrical controls secure power from the car's electrical system which in some cases may require heavier generators and batteries to handle the load. Most systems weigh about 200 lb or less.

Early installations, and many current ones, have the cooling units installed in the rear of the car with the cooled air introduced through the package shelf at the rear of the passenger compartment. Cooled air is then distributed with or without ducts. Warm air is returned through a grill in the package shelf, or below the rear seat, thence through a filter into the cooling units. Refrigerant lines from condensing unit to cooling unit are carried from the engine compartment to the luggage compartment along the car frame under the body.

Current design objectives are to reduce weight and first cost, simplify nstallation, increase reliability, and improve performance, especially pull-

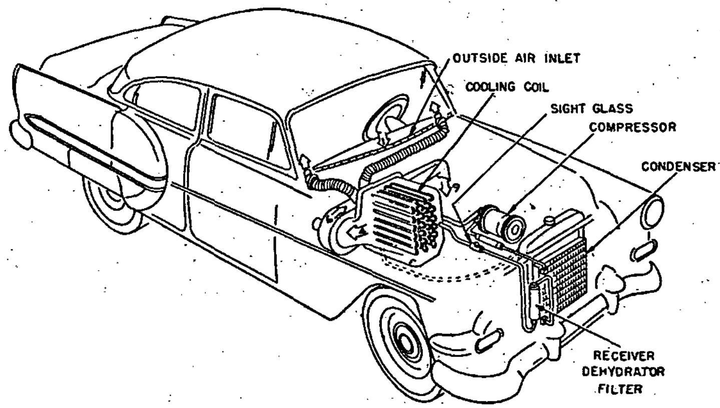

Fig. 1. Typical Front End System
(All components ahead of fire wall)

down from a hot car standing in the sun. Recent systems have shown such improvements. Performance at open-road speeds have been very satisfactory (even with early systems—when they were operating properly). Twenty percent or more outside air should be supplied, especially if passenger smoke. This air is picked up by scoops on the side of the car or cowl (See Fig. 1) and carried into the cooling unit and mixed with returned warm air from the car.

Car temperature control, compressor capacity control to compensate for the variable compressor speed, and prevention of ice formation on the evaporators (a common fault of early systems) are accomplished by bypassing compressor discharge gas into the low pressure side of the system, or cycling the compressor with a magnetic clutch. The solenoid bypass valve or a magnetic clutch is electrically operated by a thermostat, usually controlled by the return air to the cooling unit. The bypass is opened or the compressor stopped when the air gets too cold.

A recent development is a complete factory-assembled system, charged with refrigerant and ready to run, which is dropped into position ahead of the *fire wall* of the car and bolted into place (see Figure 1). Flexible suction, liquid, and discharge lines are used to connect the refrigeration components together. This facilitates initial installation. It also simplifies removal for service and maintenance and eliminates the necessity to open the refrigeration components to the atmosphere with resultant loss of refrigerant or infiltration of moisture into the system.

This system combines winter heating with summer cooling. It also permits use of all or limited quantities of outside air, with or without heating or cooling. Outside air is taken in through cowl openings. This air is then pulled through a combined heating and cooling coil assembly by a fan inside the car on the firewall. Cooled air is discharged from adjustable nozzles on the dash inside the car. Hot air for heating is discharged onto the floor as with conventional car heaters. Dampers change the air distribution from heating to cooling, and dash controls activate or shut off either heating or cooling.

Temperature control, prevention of evaporator icing and compensation for variable compressor speed are controlled by a thermostat with bulb in the air leaving the evaporator. This cycles the compressor on a magnetic clutch.

Public acceptance of current offerings has been excellent. Performance has been very satisfactory. What service difficulties have been encountered have been readily cared for by car dealers who have trained personnel to render this type of service, or by competent refrigeration service organizations. Future demand is estimated as high as 10 percent of total car production by one major manufacturer, while another estimates a million or more of its cars will be equipped in the not too distant future.

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, the cabin temperature was adjusted by positioning the 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 the 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 were generally gradual enough so that manual readjustment of controls could maintain reasonably comfortable cabin conditions. Nearly all of these heating systems were marginal in respect to heat available, and the main problem was lack of heat, rather than inadequate control.

Non-Pressurized Cabins

With the advent of the combustion type heater, and use of larger and faster planes, use of manual controls became impracticable. The combustion type heaters reach full rating in less than a minute after being turned on, and as they are rated at 100,000 Btu per hr and up, and since several heaters are generally used, it would take full time of one crew