

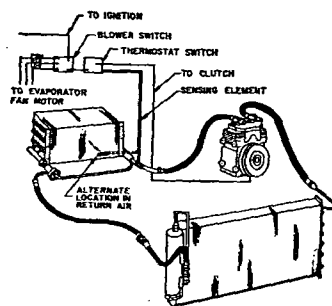


Fig. 7 Thermostatically Controlled Clutch for Cycling of Compressor

on strictly thermostatic control as a residential unit; (3) the air quantities available in relation to the cooling capacity requirements are considerably below the accepted cfm per 1000 Btu's per hour; and (4) the space limitations are very severe and considerably worse than the most compact room air conditioners. The demand for extreme compactness means that highly efficient heat transfer surface is necessary. Some of the amounts of radiation surface used for evaporators and condensers are shown in Fig. 6. In addition to the above considerations, some other factors must not be overlooked: The fan power should not exceed 150 watts because of the heavy electrical load that already exists on the generator. The condensate must be readily drained to prevent spillage due to the car movement. The coil must not clog up from dirt and dust, no oil traps should exist in the evaporator. The coil must not freeze up at any existing condition. This can be accomplished through the use of controls rather than through evaporator design alone.

Controls

The auto air conditioning units should have provisions for controlling: (1) the temperature in the car, (2) the coil temperature to prevent freeze-up, and (3) the air distribution in the car. There are a number of different control systems used to take care of functions 1 and 2, but most of them will fall into one or a combination of the following basic systems:

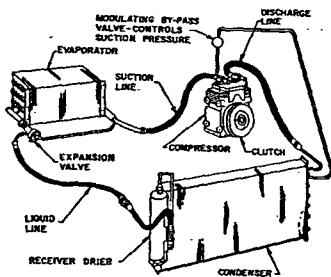


Fig. 8 Hot Gas Bypass Control

1. A thermostatically-controlled clutch to cycle the compressor. The thermostat is located to give both temperature control and freeze-up protection, as shown in Fig. 7.
2. A bypass valve that short circuits the hot gas refrigerant from the discharge to the suction side of the system (see Fig. 8). The valve may be a pressure modulating valve that senses suction pressure, or it may be a thermostatically controlled solenoid valve.
3. A hold-back valve in the suction line that controls the evaporator pressure or temperature to a given setting, usually adjustable down to the coil freeze-up margin. Fig. 9 shows an example of this method.
4. A reheat system that has modulated temperature control of the car heater to control the car temperature. Since the temperature control does not affect any part of the refrigerant system, a separate control is necessary to protect against evaporator freeze-up. This system is particularly good for high latent cooling requirements.

The air distribution controls are to control quantity and direction of the supply air flow. A three-speed fan or blower is commonly used to control the air quantity. The air direction is varied by a number of different systems ranging from simple adjusting vanes on under-dash units to convenient, vacuum-actuated push button controls.

FUTURE DEVELOPMENTS

The discussion presented in this chapter is not intended to dictate auto air conditioning design, but rather to outline the design approach to such a unit as we know it today. The future will bring in new approaches and completely new systems for auto air conditioning, but they will stem from a gradual development and improvement in several basic areas:

1. Methods of compressor speed control and corresponding condenser and radiator cooling control to correct the low speed capacity and engine cooling problem.
2. More consideration by the car manufacturers in accommodating the air-conditioning system.

PART II: RAILROAD AIR CONDITIONING

Less than thirty years ago the first major program of air-conditioning railroad passenger cars took place. Today in the United States, all new cars are completely air conditioned with the exception of subway cars, and even some of these are now fully air conditioned. Because of the decline in the long-haul and cross-country passenger car business, the total number of air-conditioned cars operating in this country, Canada, and Mexico has dropped from about 18,000 to around 14,000 cars. This figure would show a further decrease except for the air conditioning of all new commuter cars for such cities as New York, Chicago, Philadelphia and San Francisco.

Today, outside the United States, many foreign countries are in a position similar to what this country was twenty years

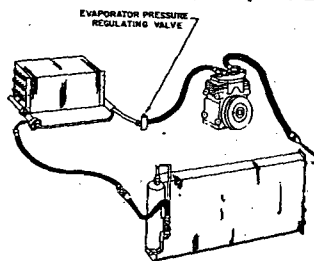


Fig. 9 Evaporator Pressure Regulator Control

Surface Transportation Air Conditioning

ago as far as railroad passenger car construction is concerned. Large programs are in progress to build passenger cars, but few are being air conditioned, because only the first class accommodations can justify the added cost.

PASSENGER CAR CONSTRUCTION

Passenger car construction like all other forms of transportation equipment has undergone a radical change in recent years. Emphasis has been on lighter car construction to combat the higher costs of building and to decrease the ever mounting operating and maintenance cost. This drive on weight reduction and cost has put strong pressure on the engineers to reduce the size and weight of the air-conditioning equipment and other auxiliaries. Between 1954 and 1957 several lightweight trains of the Talgo type were constructed in this country, with lightweight unitary air-conditioning equipment. Today most of these lightweight trains have been removed from service because of special operating problems encountered.

Today the kind of railroad car, the type of construction used, where the car will operate greatly determines what special design of air conditioning equipment will be used. The most common and numerous car today is still the *long-haul coach* with or without reclining seats. Revenue space is usually at a premium and generally no floor space is allowed for the air-conditioning equipment. In this case the motor-compressor and condenser is located under the floor and the evaporator and blower fans are located between the ceiling and roof.

The *commuter cars* for the large cities will in a few years probably surpass the number of air-conditioned coaches in long-haul service. The need for additional commuter cars of modern design with air conditioning will increase as our highways become more clogged with vehicles, whereas cross-country travel by rail will greatly diminish as other forms of transportation take over.

Most commuter cars obtain their power from a third rail carrying 600 volt direct-current or from an overhead catenary system carrying high voltage, single-phase alternating current which is transformed down to a lower voltage for use or in some cases converted or rectified to direct-current. In some areas the train is pulled by a conventional diesel engine with an added diesel generator supplying 480 volts, 3-phase, 60 cycle power down through the cars for both the air conditioning and electric heating. A trend is under way, where clearance permits, to use double-deck or gallery cars which seat up to 165 people and usually requires 16 tons of air conditioning capacity. The standard single-level commuter car seats 125 people and requires 8-9 tons of air-conditioning capacity. To gain maximum utilization of floor space, the air-conditioning equipment is usually located beneath the floor of the car, or in the case of unitary equipment in the roof section or one unit at each end of the car.

At present very few of the *subway cars* operating in large cities are air conditioned. The high initial cost, the lack of space and the maintenance cost of 600 volt d.c. equipment have prevented the publicly-owned transit systems from installing air conditioning. During rush hours some 160 to 200 people are jammed into a 65 ft car. To properly air condition such cars requires 12-16 tons of capacity which might only be required during the morning and evening rush hours.

Many *special purpose cars* have air-conditioning equipment. Today all sleeping or Pullman cars are adequately air conditioned with 6-8 ton systems. Very few, if any, will be built in the future because the need for such cars is dropping off fast. Diners, buffet-lounge cars and club cars offer no special problems and usually are equipped with an 8 ton component system with the condenser and compressor underneath the floor

and the evaporator and blowers in the ceiling at one end of the car.

Full dome or partial dome cars have presented some new problems. The radiant heat from the sun through the glass dome in the early cars created uncomfortable conditions. This problem has been overcome by increasing the refrigeration capacity and providing better air distribution and control. Most dome cars today have from 16 to 20 ton equipment.

Similar to the dome car is the *high level car*. All the air conditioning equipment and the diesel engine generator which powers it are located in the space between the lower floor and the upper level.

The day of the private car is fast coming to an end. In its place is the *business car* used by the railroad executives. From an air conditioning standpoint the system is similar to that as used on sleepers with one exception. This exception is the manner in which electric power is obtained for operating the air-conditioning equipment. The usual case is to provide standby power which operates the car generator or a diesel driven generator is installed on the car. The main objection to the diesel generator comes from the noise of the engine when parked on a siding for the night.

Similar to the subway cars the *mail cars* are the last type cars which have not been air conditioned. The technical problem of air conditioning the mail cars is not as difficult as many of the above mentioned cars. The required capacity is approximately 4-6 tons, depending on the car size. The drawback is the problem of initial cost and maintenance. The railroads receive so many dollars for carrying the mail from the government. Any funds to air condition the mail cars would probably have to come from increased rates to the railroads by the government. Although the problem has been thoroughly discussed, no agreement has been reached.

Railroad air conditioning is playing an important part in the missile field. Special cars have been built or designed for the transporting, control and launching of ICBM missiles. The *personnel cars* that transport the military people who operate the missile train must be considered. All cars in a missile train except the power car have some air conditioning. Each car receives its electric power from the power car and is usually 440 volt, 3-phase, 60 cycle power. This allows the use of hermetic compressors and light weight a.c. motors. On the *missile car* itself, air-cooled condensers used with dry type direct expansion chillers provide the air-conditioning and refrigeration requirements.

The military forces have also replaced old ice-cooled equipment by removing the ice bunkers and replacing these with a packaged condenser and brine chiller. Such cars are used by the military for special purposes such as electronic control and tracking units.

Generally, the military forces require that the air conditioning equipment be far superior than that commonly used by the railroads. The problem of reliability demands many special tests and other requirements and refinements which would not be economically feasible for regular railroad service.

EQUIPMENT SELECTION CONSIDERATIONS

The *source and type of power* primarily dictate the particular type of air conditioning equipment that will be used on a railroad car. There has been no standard. Today, operating on American railroads we have direct mechanical power from the wheels, direct current from axle driven generators, steam for the steam jet equipment from head end boilers, direct current and alternating current power from diesel generators on each car or from a head end power car and high voltage power from a third rail or overhead power lines. The common voltages for direct current are 32, 64, or 110 volts when using an axle driven