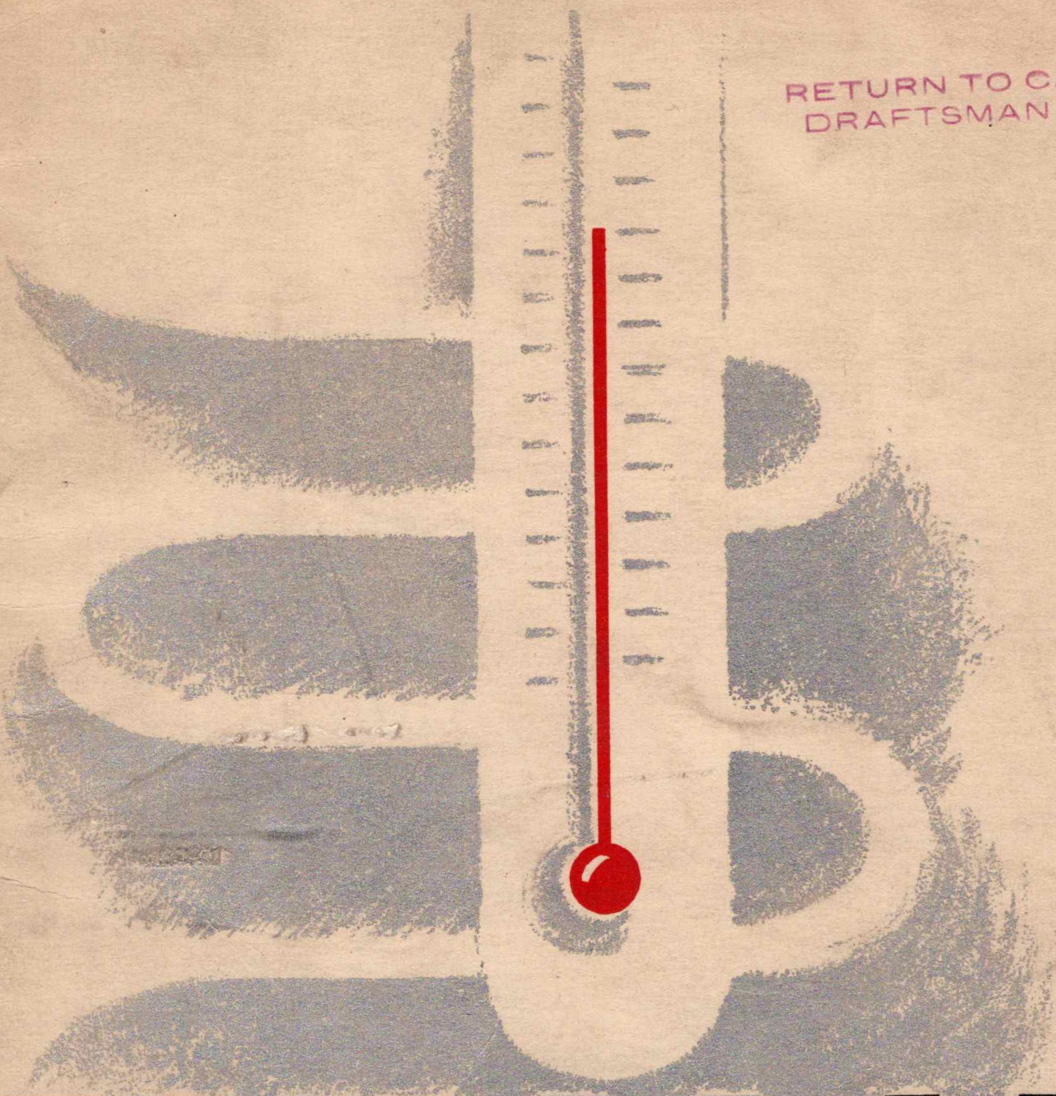


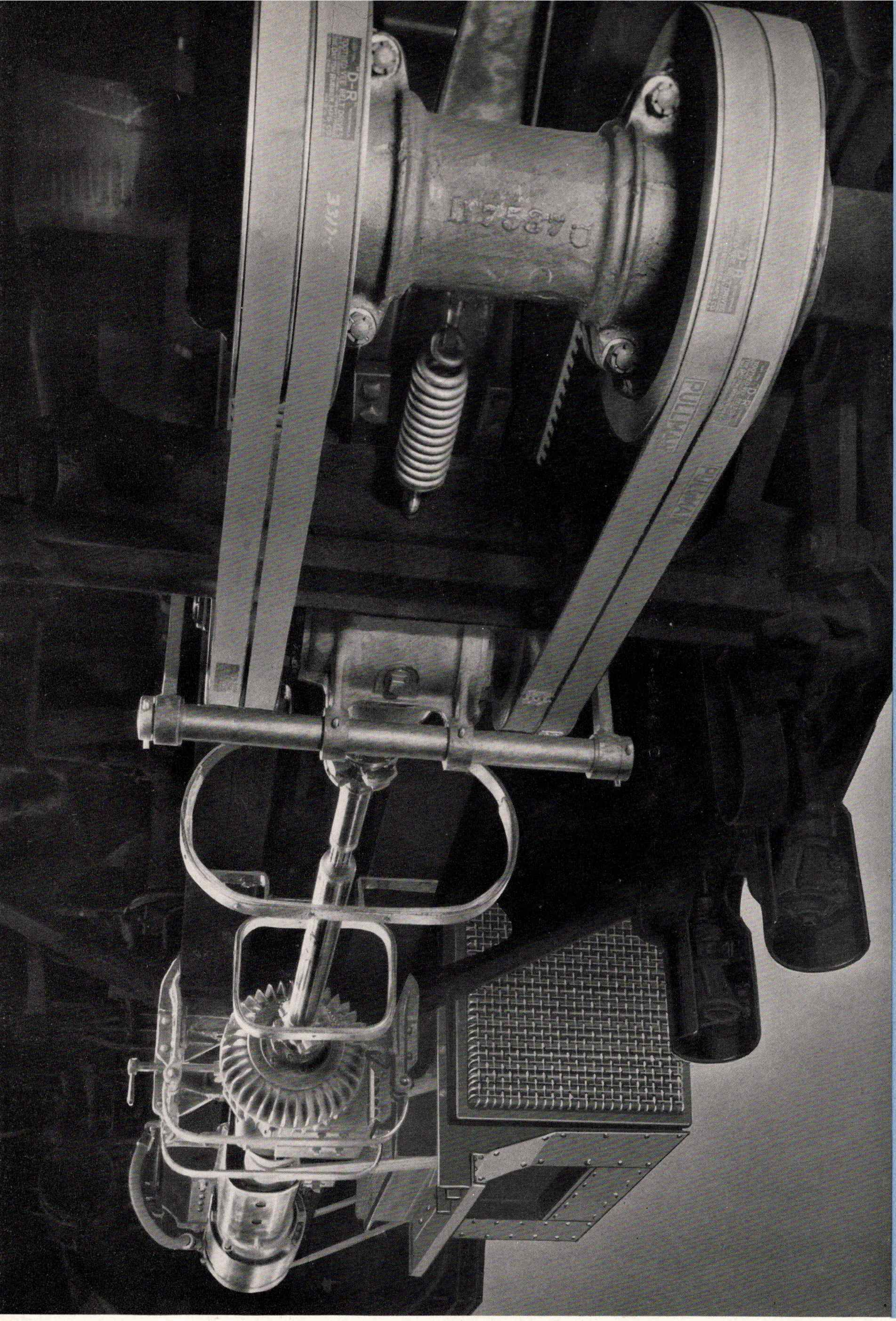
PULLMAN

CAR & MANUFACTURING CORPORATION

AIR CONDITIONING FOR RAILWAY CARS

AIR CONDITIONING

Air conditioning of rail passenger equipment has become an important factor during the past four years in retaining and increasing passenger traffic. With its introduction the railroads have presented an added comfort to traveling that is not offered by competitive forms of transportation; a comfort that the public has acknowledged with steadily increasing patronage. The value of air conditioned trains as a traffic builder is indicated by the increasing number of cars being equipped each year.



A worm's-eye view of the Pullman Direct Drive

RAILWAY AIR CONDITIONING

Railway air conditioning provides clean, fresh air at comfortable temperatures and at the correct relative humidity to give the passenger the maximum of comfort. It means a quiet trip in a car closed to external noises and a clean trip in a car closed to dust and cinders. It provides relief to travelers who suffer from hay fever, asthma, and other respiratory troubles.

Complete air conditioning provides controlled climate the year round—not simply cooling during the summer months. While the cooling and dehumidifying of air is perhaps the most striking feature of conditioning, the public is learning to appreciate just as highly the clean, fresh, warm air it produces during the winter months. Complete year-round conditioning will accomplish the best results in the development of year-round passenger traffic.

The air conditioning systems now in successful operation use a medium for cooling and dehumidifying the air, a filter for removing dust and dirt, a blower or fan for drawing in new air and keeping the air in the car in circulation, and coils for heating during the cold months.

The cooling of cars by mechanical means requires the use of a compressor for compressing the refrigerant vapors drawn from the cooling coils, and this compressor requires power.

The power for operating any system of air conditioning must come from the locomotive. In some systems it is derived mechanically from the car axle (directly or indirectly); in others it is obtained in part directly from steam in the train line and in part as mechanical power from the axle. The power for hauling the weight of the added equipment must also come from the locomotive.

A railway passenger car at times requires from five to six tons of refrigeration effect per twenty-four hours (equivalent to the melting of 500 pounds of ice per hour). The conditioning unit must be capable of meeting this demand; should be self-contained in each car and capable of producing proper temperature and humidity conditions while in trains operating at slow speed, at stations or emergency sidings, without expensive power sources.

THE PULLMAN SYSTEM

During the eight years given to the development of air conditioning by the Pullman Car & Manufacturing Corporation, the desire to obtain the most economical and reliable system has guided the research which evolved the present Pullman System. During this research the relative merits of the various types of conditioning systems have been thoroughly analyzed in the laboratory and through actual operating experience.

The Pullman Air Conditioning System is of the mechanical type—it uses a compressor for producing refrigeration. It receives compressor power mechanically and directly from the car axle—there is no intervening generator and motor equipment between the axle and the compressor, with the attendant power losses.

In the Pullman System there is but one mechanism between the drive and the compressor—the speed control, which maintains a fixed compressor speed after the train speed passes a given rate, which may be varied to suit the run to which the car is assigned. This Pullman speed control is the most efficient device for delivering power that has been developed since it functions as a straight mechanical drive except at high speeds. At the average speed of train operation it delivers 85% of the power it receives.

Because of this direct and efficient transfer of power the Pullman Air Conditioning System is the most economical to operate. Because of its simplicity and direct drive, it is considerably lighter in weight than other systems—again effecting a saving in power.

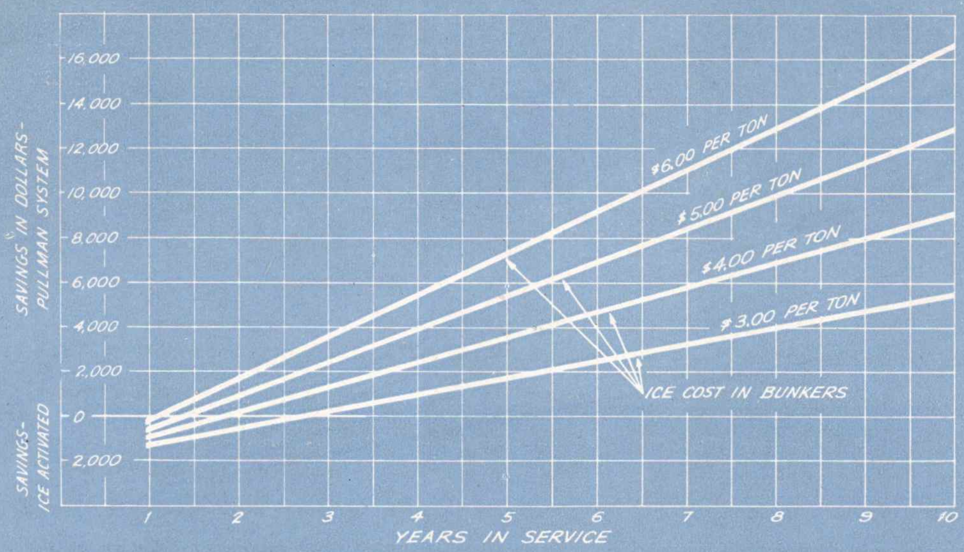
For operating the compressor in yards and at stations an AC motor is provided. Alternating current electric supply is more flexible and less expensive than other power sources as the connection may be made quickly in most cases to existing power circuits. The Pullman holdover tank (optional equipment) also provides cooling when the train stops or travels at very low speeds.

Record was kept on 397 cars equipped with the Pullman air conditioning system during the 1934 cooling season up to September 17th. During this period these cars were in cooling service 51,620 car days. Out of this total, interruptions in service occurred on only 318 car days . . . a performance of 99 4/10% perfect.

The Pullman System of Air Conditioning is designed and built for railroading conditions—by an organization that has long been a leader in design and development of passenger and freight equipment. It is installed by a shop organization that has both the equipment and skilled personnel for work of this character.

Millions of car miles of service have proved the Pullman System to be the most economical, the lightest in weight, and the most reliable in operation.

More railroad cars are equipped with the Pullman System of Air Conditioning than with any other system in which the refrigeration is produced on the car.



Comparison of savings of Pullman Direct Drive System over ice activated system of equal tonnage performance. Figures include yard facilities for handling ice, power for station cooling, testing and maintenance. Both systems depreciated in ten years, interest on diminishing balances 5% and on taxes 1%.

ECONOMY OF OPERATION

Air conditioning of railway cars is a success—it is here to stay. Satisfactory performance under all normal conditions is of course a primary consideration in choosing a system but it is equally important to choose a system that will in addition prove to be the most economical to operate over a period of years.

POWER SAVING

Pullman Direct Axle Drive eliminates the power losses caused by intervening generators and motors—eliminates the power losses due to the weight of additional equipment—eliminates losses due to the direct use of steam.

Extensive tests show that the average power efficiency of the Pullman Speed Control Drive is 85%.

The efficiency of a conventional generator-motor-battery system is slightly over 50%. One important factor responsible for this low figure is the need for passing much of the power current into and out of the battery with its inevitable losses.

The difference in these efficiencies is reflected in power consumption from the locomotive, and it means that the power required to drive the electric system is 67% more than that required to drive the Pullman System.

Because of its direct and efficient transfer of power, the Pullman Air Conditioning System is the most economical to operate—other systems will absorb from 30% to 67% more locomotive power.

REQUIRES LESS POWER

ECONOMY OF OPERATION

LIGHT WEIGHT

On a grade added weight becomes quite an important factor with air conditioning systems.

The difference between the power required to operate the Pullman System and some other systems, when consideration is given to the added weights and the added power used to drive the systems, is sufficient to reduce by one or more cars the ability of the locomotive to pull a long train.

LOW MAINTENANCE COST

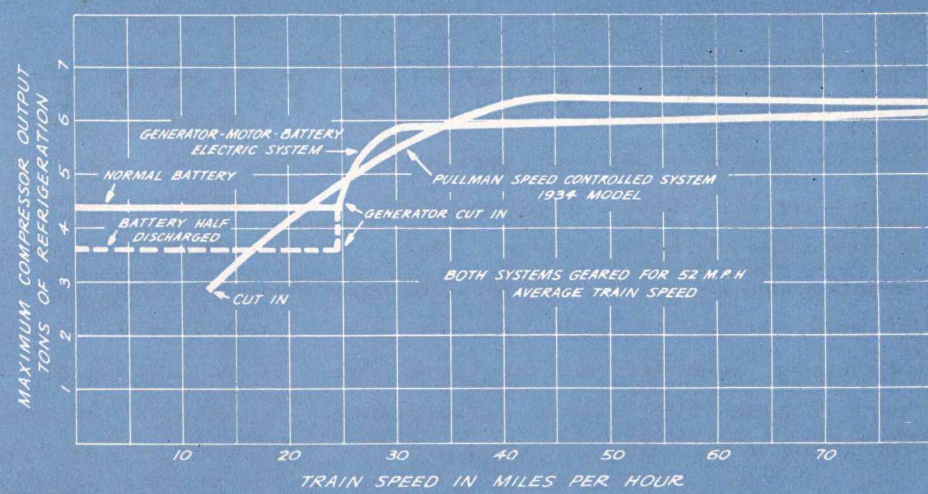
One familiar with maintenance of electrical power equipment will not challenge the statement that AC induction motors are the least expensive to maintain. The only electrical power equipment employed in the Pullman compressor drive is the speed control or electric governor, which is similar to an AC induction motor as to maintenance, and an AC induction motor for standby use. The control circuit is extremely simple, consisting of the main circuit carrying but 5 amperes and a one ampere pilot circuit.

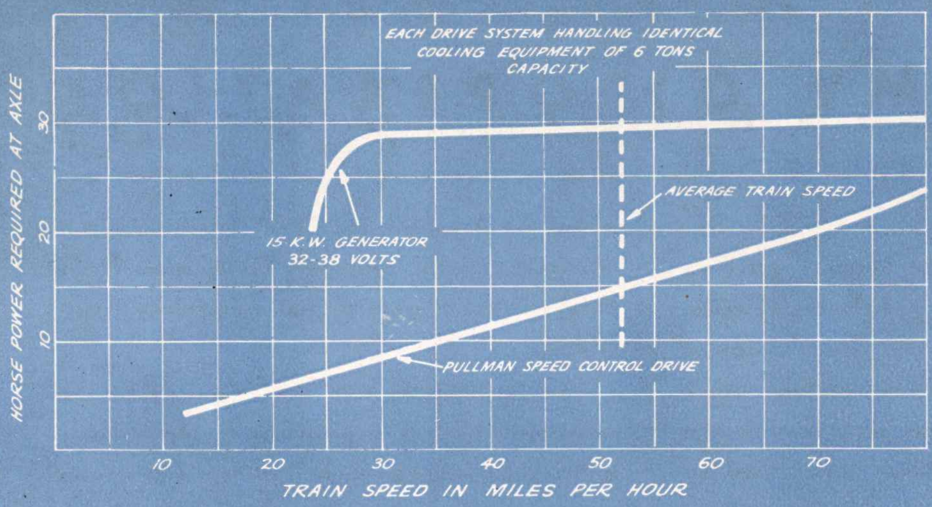
The Pullman System does not require any additional battery capacity over the standard lighting battery, as is the case with generator-motor-battery and steam jet systems. The tremendous load imposed upon the storage battery by the electrical system is shown in the graph. This compares the increase in battery capacity with battery loading for generator-motor air conditioning drive and indicates clearly that the batteries are greatly overloaded. This is bound to result in abnormal battery maintenance cost.

AMPLE CAPACITY

All cooling systems of adequate capacity operate intermittently; that is, the cooling equipment comes on and shuts off according to

Showing the maximum capacity of a Pullman compressor operating from a direct drive system and the maximum capacity at comparative road speed, when operating from a generator-motor battery system. Below 26 miles per hour the compressor operates from the battery alone on the generator-motor system.



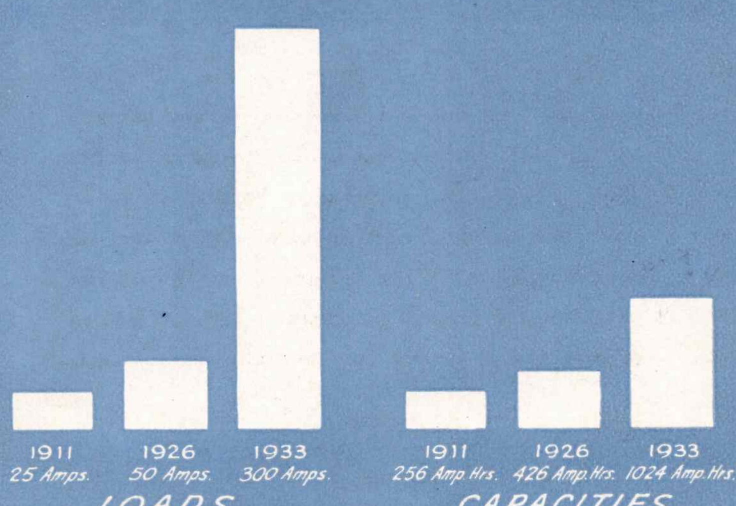


Showing the power taken from the locomotive for pulling a generator-motor battery drive and for pulling a Pullman direct drive. The net total difference in energy consumption is indicated at the vertical line showing the average speed.

inside temperature variations. So called "continuous" cooling equipment is not actually continuous unless in size it is under capacity.

It is not practicable with any type of generator-motor driven compressor system to maintain constant output under all conditions of train operation, i.e., high speed, low speed or standing. No matter what the type of drive there is considerable variation in compressor speed between the extremes. Actual tests show that a compressor operating off the battery, at times runs at only 60% of its capacity and the maximum is at about 75% capacity under the most favorable conditions.

The Pullman System has sufficient capacity for slow train operation so that only intermittent operation is necessary at high speed. On a normally hot day of say 95 degrees outside temperature the compressor is usually shut off one quarter of the running time; the cycles then running about three to five minutes off and fifteen minutes on. This illustrates the reason for the absence of noticeable temperature rise in the car during normal station stops when using the Pullman direct drive system without employing holdover feature or batteries.



Comparison based on typical loads and battery capacities, showing the extent to which increases in applied battery capacities for electrically driven air conditioning system have failed to keep pace with increases in loads.

MECHANICAL DESCRIPTION

The driving power to operate the Pullman Air Conditioning System, when the train is in motion, is obtained directly from the car axle. The only exception is the air circulating fan, the power for which is obtained directly from the car lighting battery by means of a 1/3 horse power, 32 volt DC motor.

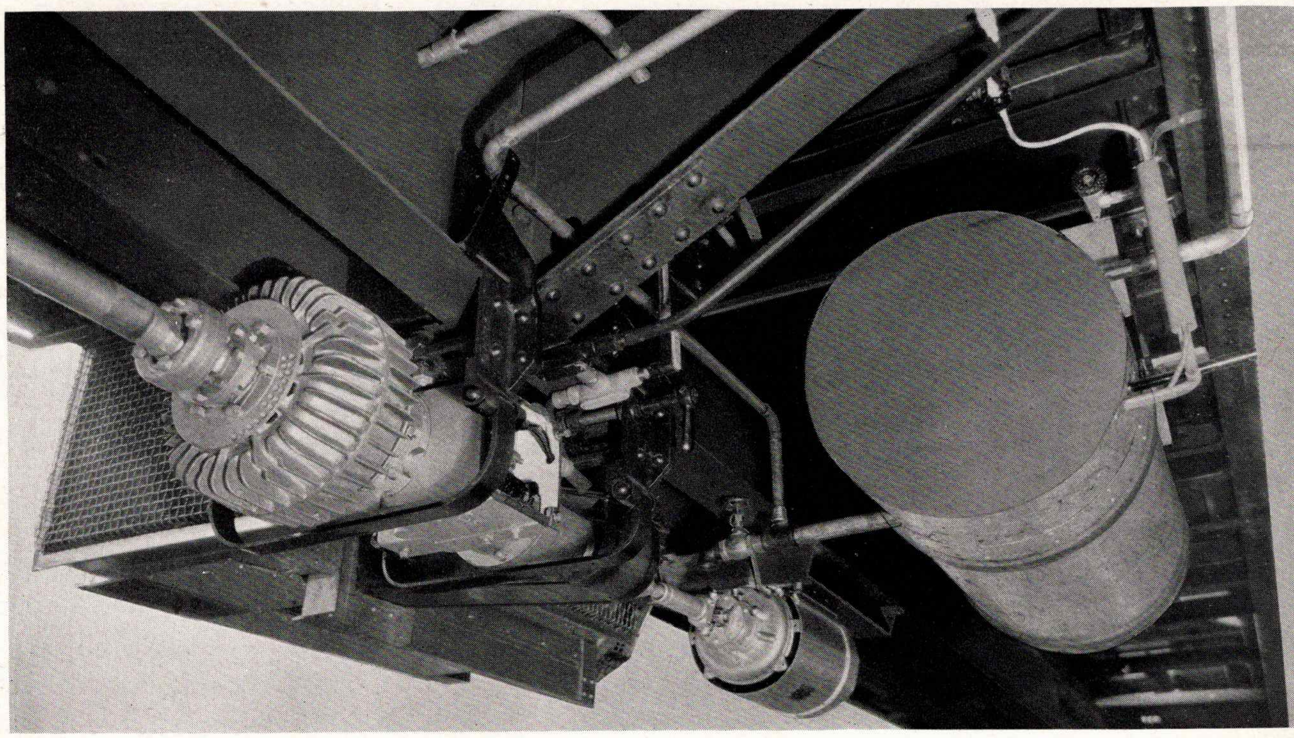
For operating the cooling equipment in yards and stations an AC 220 volt, 60 cycle motor is provided. This motor is mounted beneath the center sills and directly coupled to the driven member of the speed control, through a universal coupling.

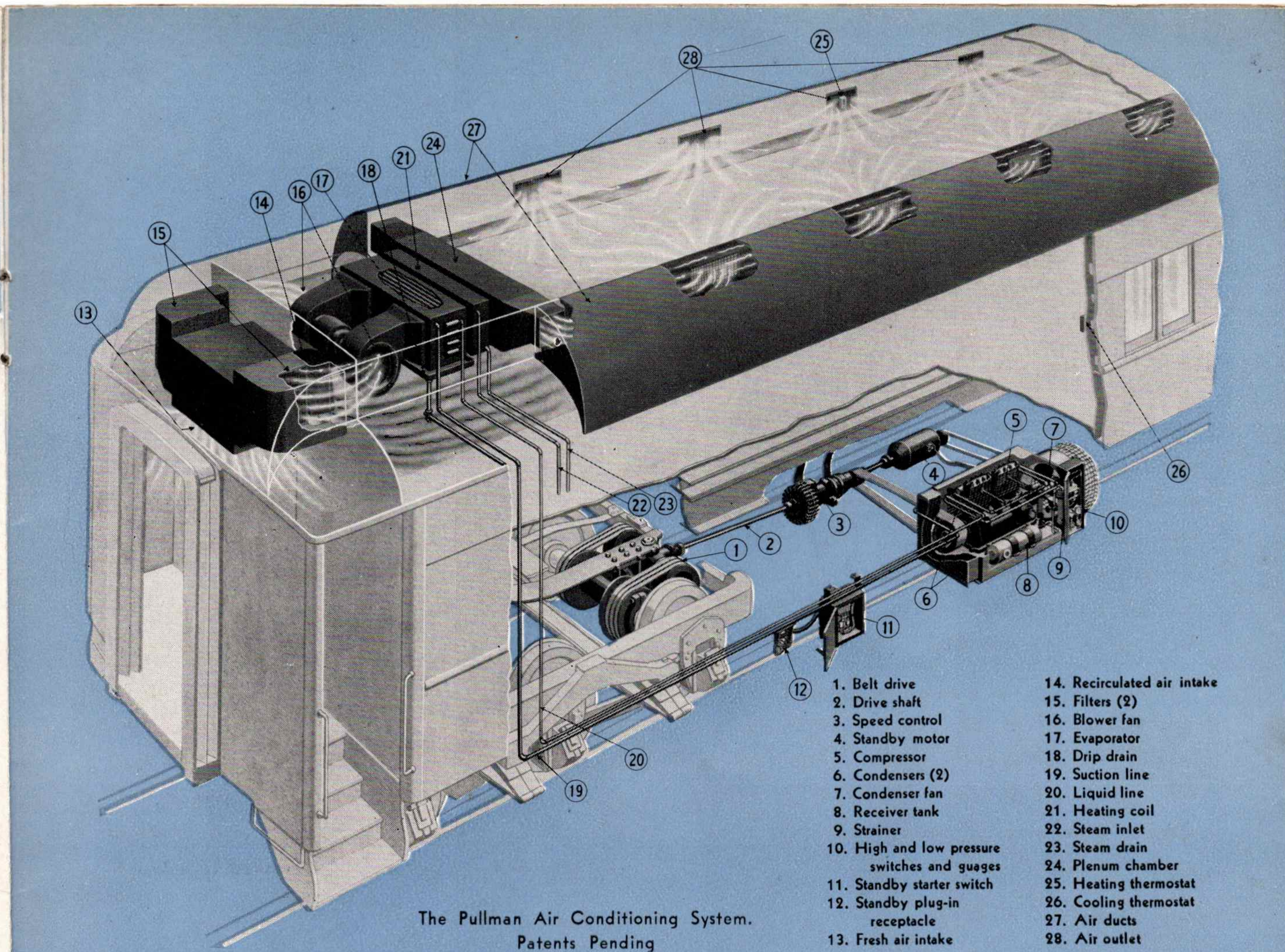
DRIVE

Upon the inner axle of the truck a large V-groove double split pulley is securely clamped to a rubber bushing placed between the pulley hub and axle.

A gear box having a shaft crosswise of the car is mounted at the end sill of the truck. Each end of the shaft carries a V-groove pulley which lines up with the axle pulley. The drive from the axle to the cross-shaft is obtained with 2 inch multiple V-belts, joined by rugged flexible metallic couplings. From the cross-shaft in the gear box the drive is transmitted to a longi-

Holdover cooling tank (right), speed control and standby motor.





The Pullman Air Conditioning System.
Patents Pending

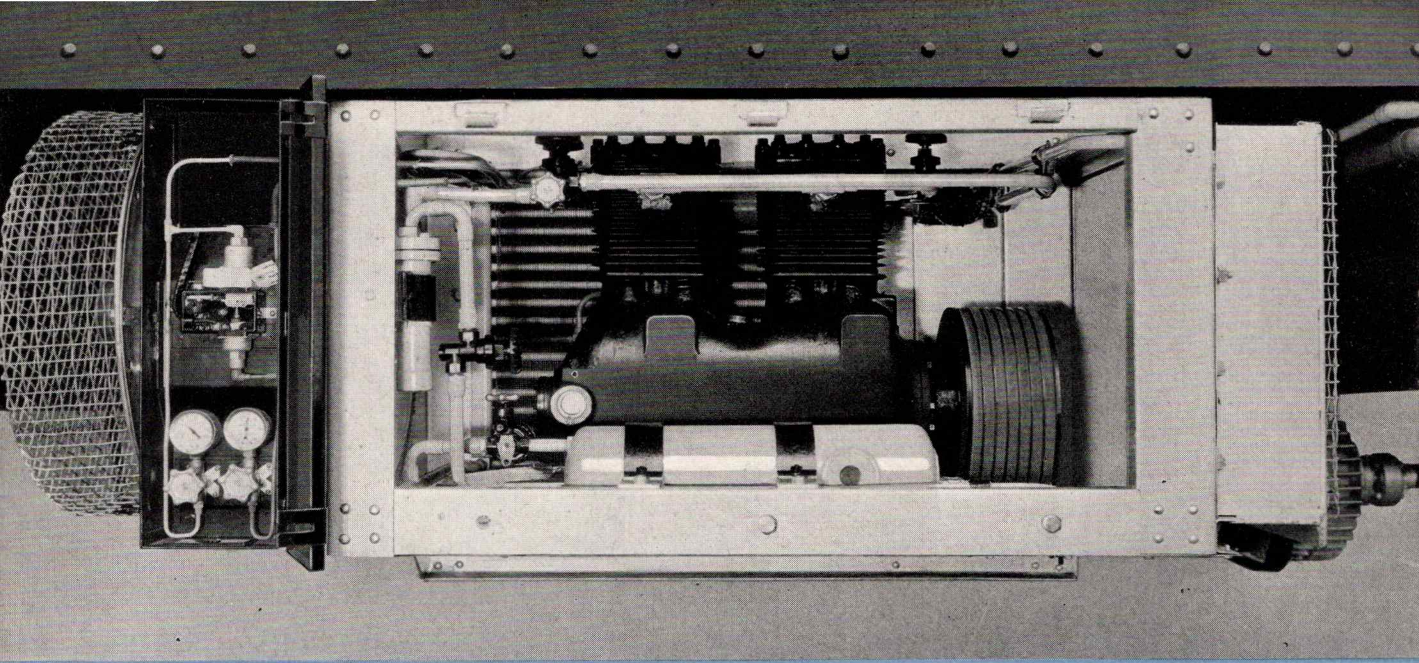
tudinal propeller shaft by means of a pair of bevel gears. This shaft is tubular and includes a universal joint at each end, thereby providing for freedom of truck movement in all directions without affecting operation of the drive.

A propeller shaft is attached to a speed governed electric induction clutch called a speed control, which functions to start and stop the system as called upon by the car thermostat. The equipment starts smoothly and silently. The speed control also maintains the proper compressor speed while train is in motion. It is placed longitudinally of the car and its driven member carries a pulley which is belted to the compressor fly-wheel. The compressor is installed in a rectangular box which also carries the condensing coils. This box is parallel to the speed control and is mounted between the center sill and the side sill of the car body underneath the floor. This arrangement provides a direct and highly efficient drive from the axle to the compressor.

COMPRESSOR UNIT

Forming part of the compressor box are the condensers which are air cooled by means of a specially designed propeller fan mounted at one end of the box and which is driven from either the speed control or the standby motor.

The compressor recompresses the refrigerant vapors drawn from the evaporator or cooling coil (conditioning unit) and these compressed



Close-up of compressor box showing compressor, condenser fan, receiver tank, strainer and gauges. Simplicity in arrangement keeps maintenance cost low.

vapors are then liquefied in the air cooled condenser where the heat previously taken from the car is extracted. The refrigerant liquid is then passed to a receiver tank and from there through a regulating valve (expansion valve), is returned to the air conditioning unit for evaporation and absorption of heat from the car.

With the exception of Freon, most refrigerants are either so disagreeable, irritating, toxic or flammable that a leakage into the car would be unpleasant and even dangerous to the passengers. The Pullman installation uses Freon, which is odorless and absolutely safe, and avoids these objections.

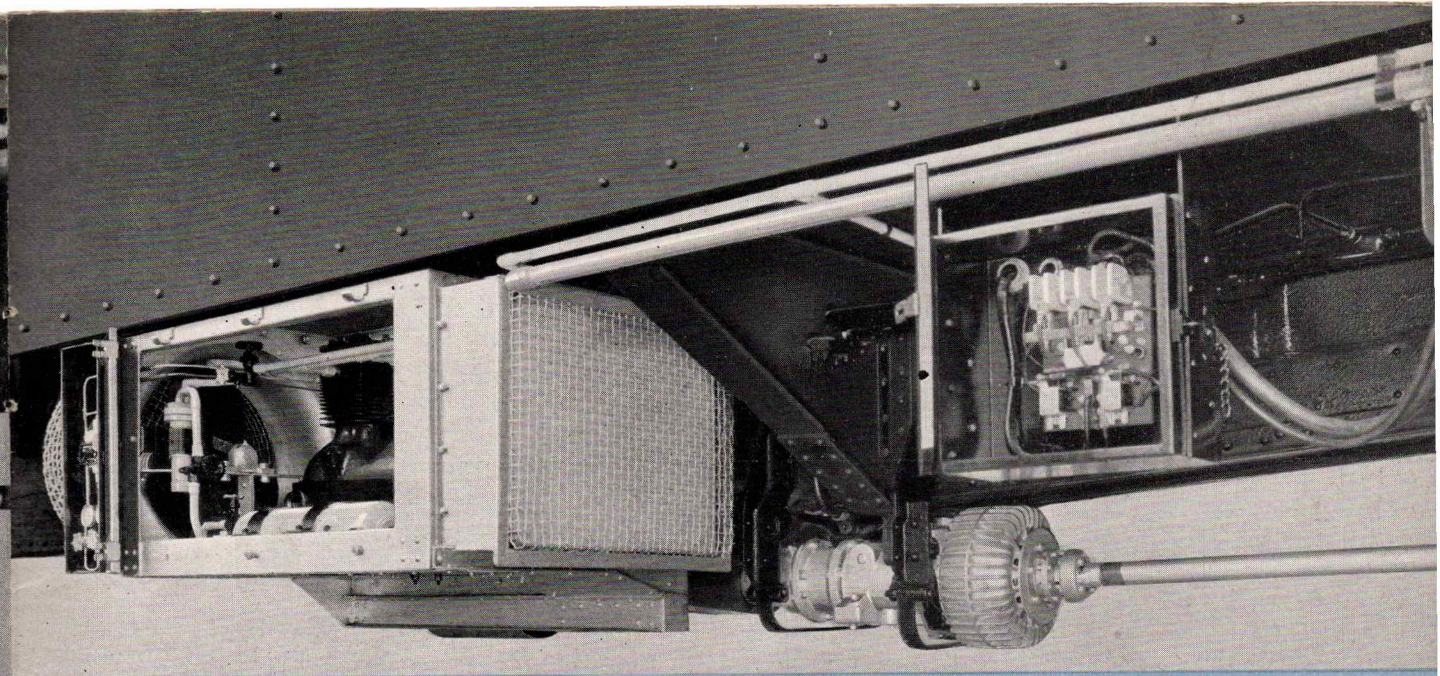
CONDITIONING UNIT

The air conditioning unit is placed beneath the roof at one end of the car. Here the air drawn into the blower passes through filters where it is cleaned of all foreign matter and passes through coils to be cooled and dehumidified during hot weather—to be warmed during cold weather.

The conditioned air is then delivered through suitable ducts, whence it is distributed to the passenger space by means calculated to obtain the best distribution for the particular plan of the car. The most popular form of duct for existing cars is that which is placed on the outside of the car roof adjacent to the clere-story and which delivers conditioned air to the car through properly arranged diffuser plates set into the openings ordinarily used for ventilators. Of the air delivered to the car body about one-fourth is gradually ejected through crevices around the windows and doors and is replaced by fresh air taken from outside. This provision complies with the health standards for public buildings.

HOLDOVER TANK

In the Pullman Direct Drive System an alternating current electric motor is provided on the

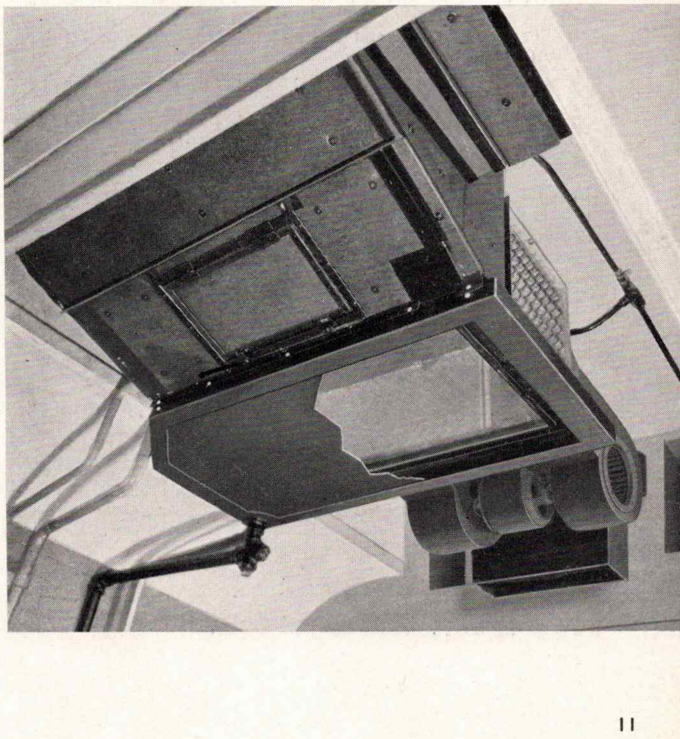


Drive shaft and induction end of speed control together with compressor box and standby starter switch.

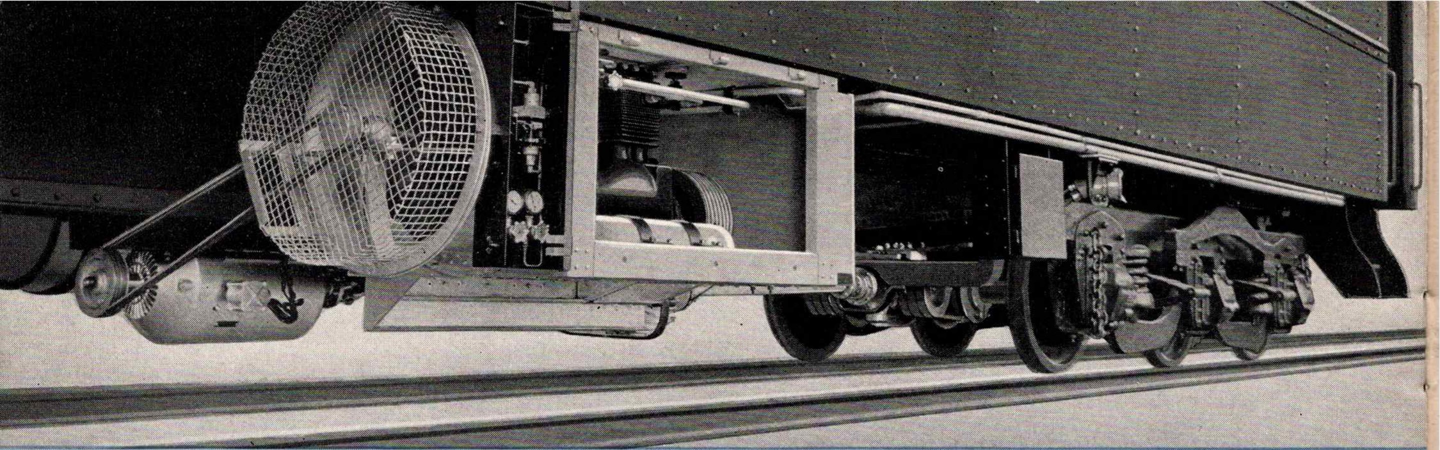
car for operating the cooling equipment at terminals and for testing or pre-cooling in the yards. However, a simple holdover feature can be furnished.

This feature may be used when long train stops are encountered or where there occurs an extended period of operation at very slow train speeds on an otherwise fast schedule. It can also be used for cooling at stations while loading passengers. Its capacity for cooling is limited to approximately the same extent as that of cooling by compressor operation from a storage battery, both methods being limited to the extent of the stored charge. However, the holdover tank is more simple and positive in operation, and can be repeatedly charged and discharged without detrimental effects.

The Pullman holdover tank contains about 50 gallons of an inexpensive solution of non-corrosive, non-poisonous liquid. When the compressor operates it either cools the car or freezes ice out of the solution. Horizontal ice columns closely spaced are formed in the holdover tank. When the train stops or operates at very low



Conditioning unit in ceiling at end of car easily accessible from inside the car.

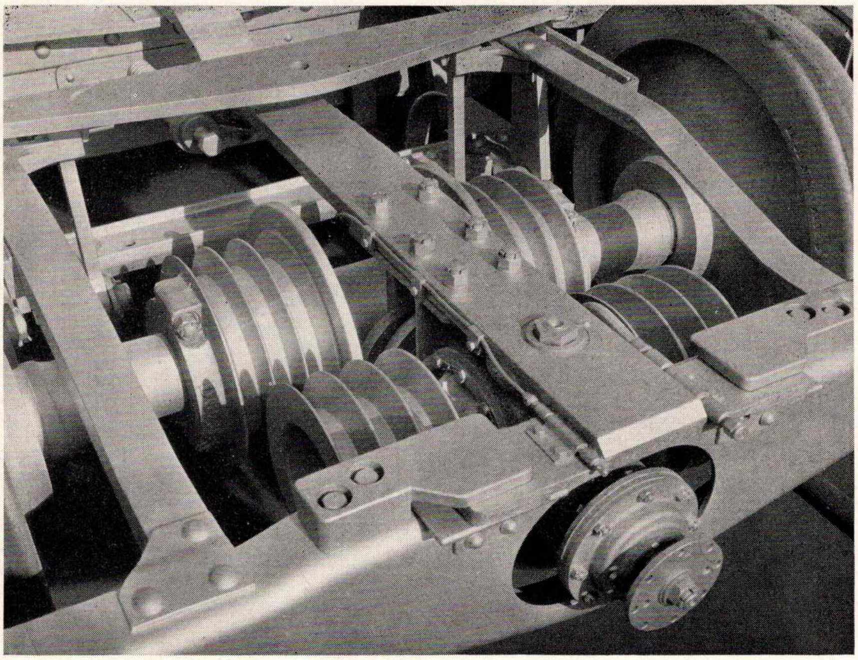


Compressor box showing standby motor, fan, switches and gauges.

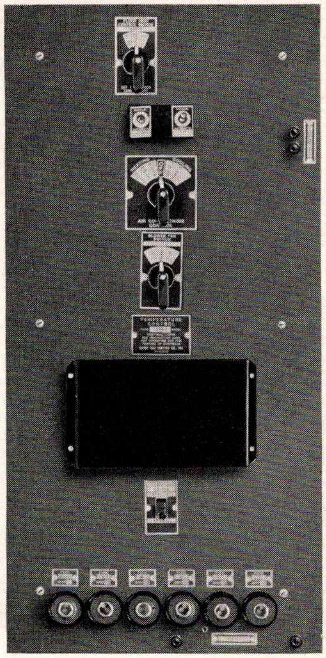
speed and the temperature rises in the car, a thermostat actuates a 32 volt motor driven pump which circulates the cold liquid surrounding the ice columns through pipes to a cooling coil placed next to the regular cooling coil or evaporator in the air stream at the air circulating blower. Thus the built-up ice is gradually melted away and the temperature of the liquid raised as it imparts its cooling effect to the car.

The holdover equipment requires little maintenance as the only moving parts are the small motor driven pump and the control switches.

V-grooved pulleys transmit power from axle to drive shaft. A sturdy belt drive that gives two seasons of belt life.



Control panel for regulating cooling and heating.



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