portance to make the exterior surface of any refrigerated enclosure as near vapor tight as possible. Because it seems to be nearly impossible to make the metal skin of a truck or trailer leakproof by itself, additional sealing of some kind is necessary. Two methods are becoming increasingly popular: (1) lining the inside of the exterior skin with a nonpermeable vapor barrier such as aluminum foil coated with a plastic binder which can be sealed at the joints, or, (2) coating the interior surface of the exterior skin with some type of vapor sealing compound such as neoprene. There are several types of material suitable for either method, and the care taken in installation is of great importance for each. Care must be taken not to destroy the vapor seal where wiring, piping, or frames must penetrate the barrier.

The interior skin need not be, and probably should not be vapor tight. It must be water resistant so that cleaning does not readily soak the insulating material. The movement of water vapor from the insulation to the refrigerated surfaces in the vehicle interior is quite slow as compared with the rate at which it is deposited in the insulation from air entering at higher temperatures and humidities. The best practical combination of exterior and interior surfaces would be one in which the amount of water vapor passing through the exterior surface was small, and the interior surface was sufficiently permeable to allow water vapor to be transferred to the refrigerated surface at an equal rate.

The interior walls of trailers which may be used in vacuum cooling of fresh produce must be vented, preferably into the cargo space, to prevent pressure damage to the insulated spaces during the pressure changes of the vacuum cooling operation.

Another approach to the moisture barrier problem is the use of insulating materials which are not permeable. These may be preformed and cut to fit, with adequate sealing materials between the cut sections, or may be of the foamed-in-place category. Packaging fibrous-type insulating materials in sealed bags of vapor resisting materials has been tried. Panel-type or *sandwich* construction has also been tried. This latter construction consists of prefabricating wall, floor and roof sections, usually with metal or plastic skins, with various forms of insulating material, usually block or foamed-in-place expanded plastics, and then assembling the sections with either gaskets and mechanically-fastened seams, or by bonding the mating surfaces with mastics or adhesives. These materials will undoubtedly receive greater attention in the future.

One company is now producing insulated bodies of several types with one-piece molded plastic exterior shells. Types and sizes range from a small retail meat truck to 5300 gal tank trailers. High impact resistance and good vapor sealing characteristics are claimed for this type of construction.

One company has manufactured transfer containers, for refrigerated use, of plastic surfaced balsa wood construction assembled with adhesives.

All doors must fit properly and be gasketed to minimise or reduce air and heat leakage. Hardware for these doors must be substantial enough to withstand the severe conditions imposed by road shock, vibration, racking of the body, and the hazards of normal use.

Features to Facilitate Air Circulation

Regardless of the type of refrigerating equipment in a truck or trailer, satisfactory product temperatures during transportation will not be maintained unless the load is surrounded by proper air or surface temperatures. This is usually accomplished by moving air circuits, either forced circulation or by gravity from plate or pipe coils. Product loads which are to be cooled in transit, or loads which have an inherent heat producing characteristic must be arranged so that refrigerated air can move not only around the load but through it as well. Non-heat producing loads, placed in the vehicle at the proper temperature need only be blanketed with air at the points where heat could otherwise enter the product. Most systems utilizing fans can move an adequate air supply along the top length of the load. USDA tests have shown that when fans are used and light density loads approach the ceiling, or when cross bows interfere with the throw of air, that supply ducts, either permanent or temporary, facilitate the delivery of air at the rear of the vehicle. Various researchers have reported the results of tests with temporary or permanent supply ducts.[7–10] Air channels which permit movement of air must be provided on the side walls and inside of the rear doors. Special attention must be paid to the movement of air along the floor under the load. Many vehicles are equipped with formed metal floors which provide channels for air movement along the length of the vehicle. If actual experience shows that sufficient air movement does not occur, then either floor racks which provide significantly greater air passage area must be used, or return air to the unit must be ducted from the floor in such a way that increased air flow results, as in tests reported by Redit[8,23] and Johnson *et al.*[11]

Fig. 2 shows a longitudinal section of a trailer with a plug-type unit equipped with a supply duct and a return air plenum formed by a false front bulkhead extending down to the top of the floor racks. Note application of wall strips and floor racks.

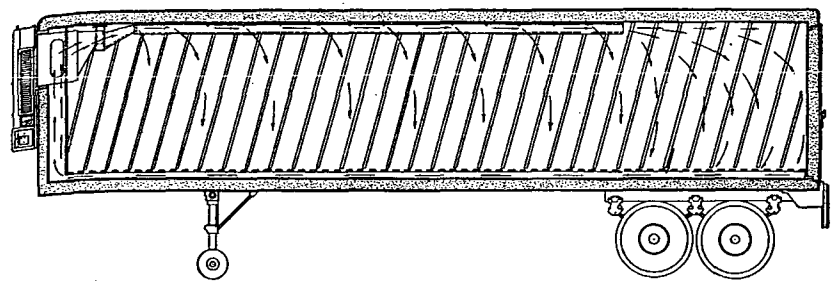
Floor racks of from 2 to 4 in. of clear height are a simple way to provide for air movement under the load. Floor racks can be hinged at the side walls to permit raising for cleaning and for loads not requiring the racks. Some operators emphasize the importance of keeping the air passage sections of formed metal floors clean of debris or ice.

Semi-envelope and *envelope* construction, such as has been used for rail cars, is now being used for trailers.[12,13] In this construction, the side walls and floor incorporate a minumum depth return duct and the supply air is discharged over the load toward the rear. Walls and floor are smooth and the load can be placed directly against these surfaces.

Refrigerated delivery trucks can use curtains to reduce cold air losses during door openings. Guilfoy described construction of such a curatain.[26] Trucks with electrically driven fans often have switches which cut fans off when doors are opened. Albert has discussed air exchange due to door openings.[27]

Special Features for Other Refrigeration Methods

A refrigerated truck or trailer body must be designed with a particular type of refrigerating method in mind. If an ice-bunker is to be used, provision must be made for the bunker, the ice-loading doors, the fan or blower, the engine or motor for the fans and drains for the water from the melted ice. Ventilator doors must be installed in the front wall, the bunker partition, and the rear doors if this feature is desired. If eutectic plates are to be used, the roof or walls must be designed with sufficient support strength. Where a front-mounted plug type unit is to be used, the front wall framing must be adequate to support the weight. A fuel supply must be provided for the engine of independent systems, either gasoline from the truck tank, or from a separate tank mounted on the body, or special fuel tanks for Diesel fuel or liquefied



[a] Note false bulkhead which forms return air plenum taking air from floor.

Fig. 2 .... Section of Trailer Showing Air Circulation[a]

petroleum, such as propane or butane. For independent engine driven systems, battery containers must be provided. For side-loading dry ice bunkers, the door opening must be provided, and the necessary installation made for fans. Where two-piece mechanical refrigerating systems are installed, provision must be made for mounting the evaporators, fans, ducts, and for bringing the piping through the floor or wall.

AUXILIARY EQUIPMENT

Ice Bunkers and Brine Tanks

Ice and salt brine systems are seldom used.

The only brine tanks still in use are for the secondary brine circuit of dry ice systems which use the brine as a secondary refrigerant. These tanks are part of the refrigerating system rather than a special feature of the vehicle.

Many produce trailers use water ice in bunkers, usually at the nose end of the trailer. A lesser number of trailers and many trucks are equipped with various styles of dry ice bunkers for low temperature hauling. The auxiliary equipment is similar for both types. One company produces a trailer for use at both low and produce temperatures by using combinations of water ice and dry ice with a mechanical refrigerating unit, and a bunker must be provided for this installation.

Air Circulating Fans

The only vehicles which do not have some form of propeller fans or centrifugal blowers for forced circulation of the refrigerated air are those which use top ice, either water or dry, or those which are equipped with extended surface plate or pipe coils and intended for gravity circulation. Since the fans are an integral part of the various types of refrigerating systems, they are discussed in the section dealing with the types of refrigerating units. The various fans may be driven by:

1. Direct or belt driven by auxiliary engine.
2. Direct or belt driven from engine of plug type unit.
3. Direct or belt driven by separate electric motor: (a) powered by truck electric system, (b) powered by separate generator driven from truck engine, (c) powered by separate generator driven by friction contact with trailer wheel, or (d) powered by generator contained in the refrigerating unit.
4. Powered by flexible shaft from truck engine or power take-off.
5. Powered by fluid motor of hydraulic system.

Both fans and blowers are used. One manufacturer uses a blower, direct mounted on a shaft extending through the front wall of the trailer and installed in a scroll that turns the air 90 deg so that the discharge air is aimed along the same axis as the shaft. An advantage of this installation is that no belt slot is required in the front of the trailer which can admit air when the vehicle is moving.

One type of air circulating system for a dry or water ice bunker vehicle uses a tire driven alternator which produces electric power to operate the fan motor when the vehicle is in operation. This air circulating system, used in conjunction with a heater can be used for heating the vehicle. The fan can be operated from house current when the vehicle is off the road.

Heaters and Heater Fuels

Truck bodies may be heated by several means, such as with hot water from the truck engine, gasoline burning heaters connected to the truck engine manifold, heat exchangers from the engine exhaust, in addition to the methods which may be used with trailers, which must be independent of the tractor engine.

These methods include independent fuel burning heaters using alcohol, kerosine, butane, propane, or charcoal, electric resistance heaters powered by various generator combinations, and, of course, by reverse cycle, or hot gas, operation of mechanical refrigerating units, regardless of the manner in which they are powered. The majority of trucks or trailers which are heated use either the independent fuel burning heaters or the reverse cycle operation of the mechanical refrigerating unit. Some of the independent fuel-burning heaters are potentially dangerous. It seems hard to believe, but some operators top ice produce loads with crushed or snow ice in below-freezing weather with the incorrect notion that such procedure will protect the product from freezing.

One self-contained thermostatically controlled truck heater may be used directly in the cargo space. Methyl alcohol is used for fuel, and the manufacturer claims there is no hazard from carbon monoxide. A wire guard is available to prevent loose cargo from contacting the heated surfaces. The heater is anchored to the floor, and safety valves shut off fuel if heater is tipped more than 30 deg.

Doors, Floor Racks and Drains

Any refrigerated vehicle must have at least one door for loading and unloading, and some retail vehicles have as many