Table 3 .... Typical Tuna Clipper Capacities

Vessel Overall Length ft	Tank Capacities				Total Fish Capacity tons
	No. Brine Wells	No. Bait Tanks	Total Cu Ft	Total Gal	
105	8	3	7,200	54,000	180
110	10	3	8,000	60,000	200
122	12	3	9,600	72,000	240
131	12	3	12,000	90,000	300
150	14	3	18,000	135,000	450

Table 4 .... Typical Tuna Clipper Refrigeration Requirements

Vessel Overall Length ft	Ammonia Compressors[a]					Lineal ft 1½" tank coils	Condensing Surface,[c] sq ft
	No.	Size, (2 cyl. V.S.A.) inches	Rpm	Cfm Displ. each	Total Tons refrig.[b]		
105	2	5 × 5	450	51	39.9	8,000	870
110	3	5½×5½	400	60	42.4	8,800	900
122	3	6 × 6	360	71	54.3	10,000	1,125
131	3	6½×6½	360	90	60.6	12,000	1,250
150	3	7½×7½	360	138	101.7	18,000	2,100

[a] For fish cargo only—does not include ship's stores refrigeration.
[b] At 25 psig (11.3 F) suction and 185 psig condensing pressures.
[c] Coil and tank type condensers.

fish to 30 F the sea water may be transferred to another well or pumped overboard. Then the tank is refilled from a reserve tank of cold, dense brine. A brine cooler is used together with a brine circulating pump of large capacity. Brine coolers and brine pumps are usually provided in duplicate. Rapid freezing and reduction of temperature to 18 F and lower is secured by the circulation of cold brine in conjunction with the cooling effect of the direct expansion coils in the tank. With a brine cooler system only enough coil surface is provided in each well to take care of the precooling load. After the freezing is accomplished, the dense brine is pumped back to the reserve well to be held cold for use on the next well ready for freezing. In most cases one of the fish wells serves as the reserve brine tank, and it is the last one to be filled with fish.

The brine cooler method is somewhat more complicated and costly than the usual system having direct expansion coils only for the tanks. However, it is very economical in operation. The compressor equipment can be utilized at higher suction pressures and more nearly at full capacity with both external brine coolers and tank coils than is possible with the limited amount of coil surface that can be placed in each tank. Also the quality of fish brought in by vessels with this type of equipment is generally higher than obtained from other types of vessels. Furthermore, they have an extra safety factor with two ways to freeze, by brine or by direct expansion.

Mother Ships and Factory Vessels

Mother ships and factory vessels are used by some of the larger fishing companies and by foreign governments such as the Russian, Portuguese and Japanese. The fishing boats feeding such vessels often have neither ice nor mechanical refrigeration, as their hauls are short and delivery to the mother ship can usually be made every day. Other fishing companies use service vessels called tenders or packers which collect the fish from the smaller fishing boats. These packers may use ice, or mechanical refrigeration, or both.

In the Pacific Coast salmon fishery, packers have been equipped with sea-water tanks and refrigeration coils to cool the sea water down to 29 or 30 F. A 68 ft packer would have 3 tanks having a total volume of about 2800 cu ft and capable of stowing about 70 tons of fish. Each tank is provided with a 50 gpm sea-water circulating pump and refrigerant-cooled coil. The coils are baffled so that the circulating pump will provide a high velocity of sea water passing over them. Sea-water circulation should be 2 to 3 gpm per ton of fish holding capacity with tank coils, but 7 to 10 gpm if external brine coolers are used. Refrigeration capacities of about 1 ton of refrigeration for each 4 tons of fish holding capacity are required because of sudden hot loads.

A later development in the Pacific Coast salmon fishery has been the equipping of barges with this type of chilled sea-water refrigeration.

PART IV: AIR TRANSPORT

The increasing use of air transportation for the distribution of perishable commodities has focused attention on the maintenance of their quality in transit. Because speed is one of the primary advantages of air movement, little attention was given initially to providing the proper transit environment which had been found necessary by long experience and research with surface transportation. Because the very nature of those commodities most benefited by air transportation requires low temperatures for maximum retention of quality or effectiveness, it was soon found that transit refrigeration must be provided. Today there are no refrigerated cargo aircraft in the accepted sense of the word, although the cargo compartments of certain passenger aircraft are cooled to some extent by the air-conditioning system of the plane. However, the temperatures in these compartments are not in the range required by most perishable commodities. Therefore, proper transit temperatures must be provided by other means, such as adequate precooling of the product and the use of suitable insulated and refrigerated containers. This being recognized by the air carriers, and research on both containerization and transit refrigeration is being conducted.

AIR CARGO

Fruits and vegetables, flowers and nursery stock, poultry and baby chicks, hatching eggs, meats, seafoods, dairy products, live animals, whole blood and drugs (biologicals) are now being transported by air. Because of the added transportation cost, items so shipped are generally of high value (in normal or seasonal short supply), of such perishable nature that slower modes of transportation result in excessive deterioration in transit, or air movement is the only possible means of delivery. In the latter category is the delivery of fresh fruits and vegetables by MATS to Air Force bases in the Arctic regions during the months when ship passage is blocked by ice. Certain early season and specialty fruits and vegetables can be flown to distant markets economically because of the high market prices that prevail when there is a short supply. Some items, such as cut flowers, arrive at far-distant markets in better condition than if moved by conventional methods so that the extra transportation cost is justified. Shipments of orchids and gardenias from Hawaii to the mainland are excellent examples. Ochra and turkey eggs from Texas, tomatoes and flowers from Florida, live lobsters from Maine, and fresh meat from Chicago all now move on a regular basis. Whole blood and drugs are flown to all parts of the globe.

In order to provide this service, there are generally two types of carriers; the all-cargo carriers, which carry only air freight and the regularly scheduled passenger airlines, which carry both cargo and passengers. The latter companies may also have all-cargo aircraft as well, but most of their cargo shipments are carried in the cargo compartments of their regular passenger planes. All lines maintain regularly scheduled flights so shippers may adequately plan delivery time of their product at distant markets. Some scheduled air carriers offer such services as *Reserved Air Freight* or *Confirmed Air Freight*, which confirms movement of goods on a specific flight. Special charter flights are also available, both from regular terminals and from airports located close to the producing areas. This is illustrated by an advance shipment, made by charter plane, of strawberries from the Hammond, La., area during the early part of the season. As speed is of utmost importance in air movement, every connecting link in the distribution chain must contribute effectively to expedite delivery. The time aloft is rapidly being reduced by the introduction of larger and faster aircraft, but this advantage is quickly lost if pick-up and subsequent delivery to the receiver does not keep pace. Some of the ground handling for small lots of air cargo is provided by the Air Express Division of the Railway Express Agency while the remainder is provided by the air cargo delivery system operated by the carriers. Plane-load lots, however, are generally ground-handled by the shipper or receiver, or by commercial surface carriers hired by them.

EQUIPMENT AND AIR CARGO VOLUME

The past and future growth of the industry is closely related to aircraft performance. During the initial stages of the development, air cargo aircraft was confined mainly to the DC-3. This airplane had a volume of 1637 cu ft; a maximum payload of 2¾ tons; with a productivity of 1.2 million ton-miles per year, at an operating cost of 15.4 cents per ton-mile. Next came the DC-4 after World War II with a 9.2 tons payload; cargo volume of 3570 cu ft and a productivity of 5.1 million ton-miles per year. Operating costs were reduced to 11.5 cents per ton-mile. The latest aircraft in general use is the DC-6A which has been designed specifically for cargo. Capacity is 5000 cu ft; the payload is 15.1 tons; and its productivity 11.6 million ton-miles per year. Operating costs have been reduced to 7.5 cents per ton-mile. It should be noted that these operating costs are not the rates charged to the shipper but, obviously, shipping costs will be benefited by lowered costs of operation. New specially designed turboprop cargo aircraft now being developed will reduce costs still further, or to around four cents per ton-mile, and increase productivity to 39 million ton-miles. It is in these highly efficient designs that the future expansion of air cargo transportation lies. Other factors that will contribute are more efficient air terminals, loading facilities and other ground-handling equipment.

The cargo carrying capacity of the certificated airlines has been substantially increased since the new jet-powered aircraft have been put in service. This came about from the increased cargo space available in the new jets, plus the conversion of many late model piston-powered aircraft from passenger to all-cargo configurations.

Air cargo volume is steadily growing. Between 1957 and 1960, the combined air express and air freight movement increased from 553,730,000 to 702,740,000 ton miles. Perishable freight represents a fairly substantial proportion of this business, or from 20 to 30 percent as reported by some airlines. However, even this record high volume for 1960 represents only 0.05 of one percent of the total inter-city freight moved by all modes of transportation in the United States.

PERISHABLE COMMODITY REQUIREMENTS

The justification for the air movement of perishable commodities is based on (1) the time element and (2) the delivery of a higher quality product than is possible by other modes of transportation. Better delivered quality makes possible increased returns to the shipper. This not only offsets the added transportation costs but increases consumer demand and acceptance as well. The market quality of the more perishable items such as strawberries, fresh figs, and cut flowers is definitely controlled by a time and temperature relationship. Temperature cannot be ignored even for the few hours now required for transcontinental air movement. To preserve fresh quality, the proper temperature and humidity must be maintained at *all* times, even during a short transit period. Desirable transit environments for most of the perishable horticultural commodities are given in Agricultural Marketing Service *Report* 280, October 1958. The importance of maintaining proper temperatures is shown in tests conducted by the U. S. Department of Agriculture. Air shipments of strawberries from California to Chicago in a refrigerated but uninsulated container were exposed to high ambient temperatures during ground handling at origin, resulting in fruit temperatures ranging from 50 to 60 F instead of the desired 32 to 34 F range (Fig. 14). These berries were compared with those shipped by rail in 4½ days with temperatures averaging 38 F for the transit period. Appearance and decay upon delivery were about the same for both lots. Thus, the advantage of the short 22-hr air movement was