vidual spaces during mild cooling conditions. This system is generally used for staterooms and small spaces devoted to first and second class passengers. The average total air per person is about 60 cfm and average outside air per person is about 18 cfm.

A third, less common, arrangement is a primary air system consisting of central filters, preheaters, cooling and dehumidifying coil, supply fan, and zone reheaters. In addition, each room is provided with an induction unit (floor type where possible) which reheats or recools the primary air supply. Automatic regulation of chilled or hot water flow, achieved by a room thermostat, controls the space temperature. The unit is provided with a drip pan and drain piping is required to remove condensation. Fig. 2 shows a diagram of this system, which is generally confined to passenger accommodations. The average primary (outside) air is about 35 cfm per person. No recirculation is used. The amount of induced air varies with the unit design.

Another system, which may be used to a limited extent, is similar to the third system, except that the room induction unit is used only to reheat the primary air, as all cooling and dehumidifying is done centrally. This simplifies the system and eliminates the unit drainage facilities. However, as no recirculation is used, the primary (outside) air requirements are somewhat larger, averaging about 40 cfm per person.

The duct work for all of the above systems may be designed for conventional velocities. However, if power is available, high velocity systems may be used providing suitably strong duct construction and adequate sound absorbing facilities are provided.

TYPES OF REFRIGERATION SYSTEMS

The kind of refrigeration equipment chosen for a particular vessel depends on the same factors which would govern selection on land.

Small tonnages use reciprocating or radial (Freon) compressors. Ships requiring in excess of approximately 125 tons of refrigeration generally use centrifugal compressors. Steam jet refrigeration has proven satisfactory on several large foreign liners and is being seriously considered in this country for similar applications. The two essential prerequisities of the steam jet—low-cost steam and condenser cooling water—are available. Also, the simplicity of principle and operation is a very desirable feature even for small installations.

Many ships have considerable refrigerated cargo space. The type of equipment used for this application should be kept in mind when selecting equipment to be used for air conditioning. This consideration can reduce materially the over-all cost, because a stand-by unit is always provided for cargo refrigeration. Also, most cargo systems are designed for cooling hot cargoes, and thus a large part of the capacity is available for comfort air conditioning most of the time.

DEHUMIDIFICATION

Merchant Vessels

Many merchant ships are fitted with dehumidification facilities for eliminating damage to the dry cargo by preventing condensation and dampness. The dehumidification load consists of moisture removed from the ventilation air passed through the dehumidifier, and also the moisture on, or given off by, the cargo, packaging, dunnage, battens, and other materials in the ship's holds. The most severe outside condition requires a

moisture removal of 90 grains (140-50) per pound of dry air, with 88 F cooling water. The largest cargo ships are provided with equipment for removing about 250 lb of water per hour.

The dehumidification systems generally utilize silica gel or lithium chloride with inhibitor (see Chapter 38). In most cases central drying equipment is provided, and a simple duct system distributes the dry air to the hold supply ventilation system. These ventilation systems use outside air when weather conditions are favorable. Recirculation and dehumidification are used only when necessary, *i.e.*, when the weather dew-point approaches or exceeds the temperature in the hold. On large passenger ships consideration is given to the use of two dehumidifying units, because the cargo-carrying spaces are usually concentrated at the extreme ends of the vessel. With this arrangement, almost all of the dry air distributing system may be eliminated.

Naval Vessels

The end of the war terminated the current need for a great number of naval vessels, and presented the problem of their economical preservation and readiness for speedy return to active service. This problem has been solved by making the ship a warehouse for its own non-perishable stores and supplies, painting the exterior, applying polar type rust preventives (requiring no later removal) to corrodible exposed metal, and sealing and dehumidifying the interior. Such ships can be returned to service in 10 to 30 days.

The dehumidifiers developed for this purpose are dual-bed, electric heat reactivating types, and represent improvements for their special application over commercially available equipment with respect to compactness, weight, reliability, performance, and economy. On most ships dry air from the machine is delivered to the remote portions of the vessel through the fire mains, which provide the most extensive piping system available. The air returns to the machine via accesses and passageways. Humidity is maintained constant at a prescribed value, usually 30 per cent, by a recorder-controller developed especially for the preservation program. This device continuously checks, records, and averages humidity readings of 8 *sensing* stations, located throughout the vessel, and starts or stops the dehumidifier accordingly.

SHIP INSULATION

In order to limit one of the major ventilation heat loads, which is that made necessary by heat transmission, and to prevent condensation, it is necessary to use insulation judiciously. The principal sources of heat in a ship are the power plant and sun load. The confinement or exclusion of this heat in the structure of a ship is not easy, principally because of the complex structural nature of the beams, stiffeners, bulkheads, decks, and hull. The continuous metal paths offer easy means of heat flow throughout the structure.

Insulation cannot be used indiscriminately because of weight and space limitations. Therefore, higher heat transmission coefficients are accepted for insulated structures of certain classes of vessels, than would be considered satisfactory ashore. Particular care must be taken to prevent metal-to-metal contact, which greatly reduces the effectiveness of the insulation.

Hull insulation must be of high quality with particular attention given to fireproofness, low density, low thermal conductivity, ruggedness, vermin