quired, control response must be phenomenally fast. For example, on some the air going to the cabin from jet engine compressor can change temperature at rate of 150 deg per second. This, coupled with the fact that on smaller size pursuit ships air is changed in cabin as much as four times per minute, makes instantaneous sensing of change and extremely rapid control movement essential. Also, in airplanes operating at Mach numbers in excess of 0.7, the control must react to large adiabatic temperature rises encountered. Some of these problems are so new that controls still have not been developed which will meet all of desired conditions. However, present studies being made by control manufacturers should result in developments of such controls in the near future.

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CHAPTER 49

MARINE HEATING, VENTILATION, AIR CONDITIONING

General Considerations, Ship Construction Features, Factors Affecting Design, Ventilation Requirement for Various Types of Space, Air Conditioning Space Treatment, Typical Air Conditioning Systems, Types of Refrigerating Systems, Dehumidification, Ship Insulation

THE importance of adequate shipboard heating, ventilation, and air conditioning arrangements cannot be overemphasized. Installations must be designed to keep the passengers comfortable and the operating personnel physically and mentally fit. The provision of satisfactory living and working conditions is one of the most economical means of keeping a high morale.

GENERAL CONSIDERATIONS

A ship must be self-sufficient and provide for all human needs. Facilities must be limited to the minimum space and weight practicable to conserve dead weight and to increase the pay load. The pay load may be expressed in terms of cargo-carrying ability, passenger-carrying capacity, fighting strength, or towing ability.

Conditions in living spaces must permit adequate rest and comfort. Passenger accommodations must be treated to provide service and living conditions similar to those afforded by the various classes of hotels. Many of the expedients used ashore for this purpose are not applicable afloat. For instance, all living quarters aboard ship cannot be located at a distance from the power plant, but must often have boundaries in common with heat producing spaces. The thermal conductivity of shipbuilding materials such as steel, copper, brass, etc., is many times the value for building materials used ashore, and this, together with concentrated arrangement of equipment, produces a difficult heat transfer and insulation problem. Furthermore, the use of portholes, windows, skylights, and similar openings is greatly restricted in marine applications because of the necessity for strength, water-tightness and protection from the sea in foul weather. During wartime, the utility of portholes, windows, and skylights is greatly restricted because they must be fitted with light-excluding devices.

Mechanical ventilation is absolutely necessary for most shipboard spaces to enable the crew to operate the vessel, to prevent the accumulation of objectionable combustible and toxic gases, and to preserve stores and cargo. Shipboard equipment must also be reliable inasmuch as specialized servicing facilities are not available at sea and failure during an emergency may jeopardize the vessel's safety. Adequate spare parts form an integral part of all equipment furnished. Experience has demonstrated that *simple* and *foolproof* heating, ventilating, and air conditioning arrangements are essential for satisfactory service. The only variation between ship and shore applications is that emphasis is placed on different aspects of the design.