Report on Relative Performance of Air Filters, by Mechanical Division, *Association of American Railroads*, January 15, 1938.
Air Conditioning of Railroad Passenger Cars, by L. W. Wallace and G. G. Early, Jr. (*A.S.M.E. Transactions*, November, 1937).
Passenger Car Cooling Methods, by Kenneth Cartwright (*Refrigerating Engineering*, February, 1936, p. 83 and March, 1936, p. 158).
Diesel Drive for Passenger Air Conditioning, by J. R. Hornaday (*Refrigerating Engineering*, March, 1942, p. 139).
Railroad Air Conditioning, by Gordon T. Wilson (*Refrigerating Engineering*, May, 1943, p. 323). Railway Air Conditioning, by M. R. Eastin (*Railway Elec. Engr.*, August-December, 1942).
Head-End Power for Railway Cars, by F. L. Sahlmann and E. M. Bill (*Railway Elec. Engr.*, May, 1939). Head-End Power for Streamlined Passenger Trains, by J. D. Loftis (*A.S.M.E. Raleigh Section*, October 26, 1946).
P.C.C. Car Ventilation, B-3697 Westinghouse Electric Corp., September, 1946.

Buses and Automobiles

Bus Heating, by E. T. Todd and F. O. Gadd (*Heating and Ventilating*, Dec. 1946, p. 83).
Air Conditioning of Automobiles and Buses, by L. W. Child (*Society of Automotive Engineers Journal*, June, 1938). Bus Air Conditioning, by Jerry Hieke (*Heating, Piping and Air Conditioning*, October, 1938, p. 639). Bus Air Conditioning, by A. J. Mallinckrodt and Lars Hanson (*Refrigerating Engineering*, June, 1939, p. 388).
Problems in Air Conditioning Automobiles, by F. J. Linsenmeyer (*Society of Automotive Engineers Journal*, July, 1939).

Airplanes

Comfort in High Altitude Flying, by D. W. Tomlinson (A.S.H.V.E. TRANSACTIONS, Vol. 47, 1941, p. 57) Heat Exchangers for Aircraft, by Arthur J. Hess (*Refrigerating Engineering*, September, 1944, p. 192). Heating and Ventilating for Transport Airplanes, by B. M. Brod (A.S.H.V.E. TRANSACTIONS, Vol. 52, 1946). Comfortization of Aircraft, by Albert A. Arnhym (Pitman Publishing Corp., New York, 1945).
Refrigeration for Air Conditioning Pressurized Transport Aircraft, by B. L. Messinger (*Heating and Ventilating*, January, 1946, p. 63).

Ships

The Ventilation of Ships, by R. McDonald (*Journal of the Institution of Heating and Ventilating Engineers* (British) October, 1939).
Ventilation and Air Conditioning of the S. S. Panama (*Heating and Ventilating*, September, 1939, p. 47).
Air Conditioning the New Mauretania (*Heating, Piping and Air Conditioning*, July, 1939, p. 431).
Heating, Ventilating and Air Conditioning on Shipboard, by J. H. Clarke (*Heating, Piping and Air Conditioning*, August, p. 467; September, p. 529; October, p. 610, 1940).
Care of Cargo at Sea, by O. D. Colvin, W. H. E. Hahne, and M. R. Colby (*Transactions of the Society of Naval Architects and Marine Engineers*, Part I, Vol. 46, 1938, p. 109; Part II, Vol. 49, 1941, p. 208).
Ventilation of Ships, by J. Dawson (*Journal of The Institution of Heating and Ventilating Engineers*, London, Vol. 10, June-July, 1942, No. III, p. 89).
Modern Marine Engineers Manual, Vol. II, Sections 16 to 19, Incl. (Cornell Maritime Press, 1943).
Warship Ventilating, Heating and Air Conditioning, by Comdr. T. H. Urdahl, U.S.N.R., and W. C. Whittlesey (A.S.H.V.E. TRANSACTIONS, Vol. 49, 1943, p. 35).
Standardized Heating and Ventilating Equipment for Fighting Ships, by Comdr. T. H. Urdahl, U.S.N.R., and Lt. John Everetts, Jr., U.S.N.R. (*Heating, Piping and Air Conditioning*, July, 1943, p. 333). Designing Warship Ventilation with Standardized Equipment, by Comdr. T. H. Urdahl, U.S.N.R., and W. C. Whittlesey (*Heating, Piping and Air Conditioning*, August, 1943, p. 419).
Ventilation and Heating of Maritime Commission Ships, by J. W. Markert (*Heating and Ventilating*, February, 1943, p. 32). Why Ship Ventilation, by J. W. Markert (*Heating and Ventilating*, October, 1943). Evolution of Ships Ventilation Systems, by J. W. Markert (*The Log*, 1944 Yearbook, p. 202). Refrigeration, Air Conditioning, Ventilation and Heating, by H. E. Parker (*Marine Engineering*, Vol. II, *The Society of Naval Architects and Marine Engineers*, 1944, Chapter VI, p. 319). Blackout at Sea, by J. W. Markert (*Heating and Ventilating*, March, 1944, p. 55). Your Merchant Marine Will be Comfort Air Conditioned, by J. W. Markert (*Heating and Ventilating*, May, 1945, p. 60).
Modern Air Conditioning, by J. W. Markert (*Marine Engineering and Shipping Review*, November, 1945, p. 177).
Modern Marine Refrigeration and Air Conditioning, by W. H. Carrier and L. E. Star (*Marine Engineering and Shipping Review*, April, 1946, p. 132).
Dehumidification Protects U. S. Navy's Inactive Fleet, by Capt. T. H. Urdahl and Comdr. E. R. Queer (*Heating, Piping and Air Conditioning*, March, 1946, p. 71).
Reconversion of Liner S. S. Lurline, by Robert Tate (*Society of Naval Architects and Marine Engineers*, May 12, 1949).
Air Conditioning of P-2 American President Liners, by J. W. Markert (*Pacific Marine Review*, August, 1946).
Export Lines Air Conditioning of Four Aces, by J. W. Markert (*Marine Engineering*, March, 1949).

CHAPTER 48

WATER SERVICES

Estimate of Demand Load and Pipe Capacity, Sizing Cold Water Supply Piping, Cooling Water Piping, Heating Load and Storage Capacity, Methods of Heating Water, Computing Heat Transmitting Surface, Hot Water Supply Piping, Control of Service Water Temperature, Safety Devices, Solar Water Heaters, Domestic Hot Water by Heat Pump

PROPER design of the water distributing system in a building is necessary in order that the various fixtures may function properly. The amount of either hot or cold water used in any building is variable, depending on the type of structure, usage, occupancy, and time of day. It is necessary to provide piping, water heating, and storage facilities of sufficient capacity to meet the peak demand without wasteful excess in either piping or equivalent cost. Many of the data on the sizing of the water supply pipes have been taken from various reports of the National Bureau of Standards.[1]

ESTIMATE OF DEMAND LOAD AND PIPE CAPACITY

The demand load in building water supply systems cannot be determined exactly and is not readily standardized. The two main problems to be considered are: (1) the satisfactory supply of water for a given fixture and (2) the number of fixtures which may be assumed to be in use at the same time.

The minimum flow that will be satisfactory to the consumer depends greatly on the consumer, his standard of living, his professional needs, size of family, garden requirements and similar factors. Depending on these factors, per capita water consumption for domestic use usually varies between 30–80 gal per day.

Table 1 gives the rate of flow desirable for many common types of fixtures, and the average pressure necessary to give this rate of flow. The pressure necessarily varies with fixture design; with some, a much greater pressure is necessary to give the same rate of flow than with others. In general, the lower the quality of the faucet the greater will be the pressure required.

In estimating the load, the rate of flow is frequently computed in *fixture units*. One *fixture unit* is equivalent to 7.5 gal per min. Table 2 gives the demand weights in terms of fixture units for different plumbing fixtures under several conditions of service, and Fig. 1 gives the estimated demand in gallons per minute corresponding to any total number of fixture units. Fig. 2 shows an enlargement of Fig. 1 for a range up to 250 fixture units.

The estimated demand load for fixtures used intermittently on any supply pipe will be obtained by multiplying the number of each kind of fixture supplied through that pipe by its weight from Table 2, adding the products, and then referring to the appropriate curve of Figs. 1 or 2 to find the demand corresponding to the total fixture units. In using this method it should be noted that the demand for fixture or supply