can be covered, the closer the design can be fitted to the requirements. The following outline may be followed:

1. Normal quantities of liquids and / or vapors.
2. Normal desired temperature of liquid and / or vapors entering and leaving.
3. Maximum and minimum temperatures.
4. Overload requirements.
5. Permissible friction drop (pressure drop each side).
6. Specifications of liquid.

For oil or other liquids, give specific gravity, viscosity, specific heat, latent heat, water content, wax content, sediment content, corrosive or erosive characteristics, temperature fluctuations, pressure pulsations. Give a distillation curve for petroleum, if possible, as vaporization of oil must be accommodated by vents, etc., to prevent vapor binding.

ECONOMICS OF EXCHANGERS

In the design of heat exchangers, there is always one set of conditions which will give the desired result at a minimum overall cost when initial investment, carrying charges, and operation cost are all taken into account. In some cases it does not pay to install a very efficient exchanger because the additional heat recovered over that which would be saved by a less efficient exchanger would cost more than heat brought in from an outside source. On the other hand, an exchanger may increase plant capacity out of all proportion to its cost, and this may justify an exchanger which would not be economical on a heat recovery basis only.

In general, the higher the velocity which can be allowed in an exchanger, the lower will be its cost for a given result. In many cases an exchanger is specified to give a pressure drop of 2 or 3 lb., when there is available 30 or 40 lb.

For further data on the design of heat transfer equipment a partial bibliography is given:

Principles of Chemical Engineering, Walker, Lewis & McAdams; Heat Transfer & Evaporation, Badger; Evaporating, Condensing and Cooling Apparatus, Hausbrand; Engineering Thermodynamics, Lucke; Proper Design and Operation of Heat Exchangers, Kallam & Semino; Oil Flow, Viscosity and Heat Transfer, Danforth; Heat Transfer for Oil and Water in Pipes, Morris & Whitman, *Ind. & Eng. Chem.* (March, 1928); Heat Transmission for Condensing Steam to Water in Surface Condensers and Feed Water Heaters, McAdams, Sherwood & Turner, *Trans. A.S.M.E.* (1926); Heat Transfer Symposium, *Ind. & Eng. Chem.* (May, 1924); A Graphical Method of Determining Heat Transfer in Pipes, McAdams, *Chem. & Met. Eng.* (October, 1927); Heat Transfer for Water Flowing Inside Tubes, McAdams & Frost, *Am. Soc. of Ref. Engrs.* (December, 1923).

CHAPTER XVIII

PUMPS AND TRAPS FOR HEATING AND VENTILATING EQUIPMENT

Boiler Feed Pumps, Automatic Pumps and Receivers, Centrifugal Pumps, Vacuum Heating Pumps, Connections for Pumps, Specifications for Pumps, Definition of Terms, Installation Data, Traps.

THE various kinds of pumps ordinarily used in connection with heating and ventilating installations may be classed under the following heads:

(1) Boiler feed pumps, (2) condensation return pumps, (3) return line vacuum heating pumps, (4) sump pumps, (5) forced circulation hot-water heating pumps, (6) circulating pumps for water, brine, etc., (7) refrigeration pumps and compressors.

BOILER FEED PUMPS

Boiler feed pumps may be of the following types: (1) direct acting steam-driven reciprocating pumps, (2) power-driven reciprocating pumps, (3) centrifugal pumps, (4) screw or other similar type pumps.

Capacities

The capacity of a boiler feed pump should be based on 3.45 lb. of water per hour per maximum boiler horsepower served, with a slippage allowance of 10 per cent in the water cylinders and a factor of safety allowance of *two* for intermittently operating pumps and *one and one-half* for continuously operating pumps, to provide for unusual conditions, such as low water in boilers, drop in steam pressure or excessive loads.

Piston Speeds and Efficiencies

For reciprocating boiler feed pump not to exceed 10 times the square root of the number of inches in the length of stroke of the water pistons.

Direct acting reciprocating steam driven or power driven boiler feed pumps are generally found to be more efficient for smaller installations especially with widely fluctuating loads as the efficiencies of centrifugal boiler feed pumps drop off very rapidly for the smaller sizes of pumps and for low load conditions. For this reason centrifugal pumps are not usually employed for installations of less than 1000 boiler horsepower.

Material for this Chapter of THE GUIDE was prepared especially by Otto E. Goldschmidt and P. M. Hunt.