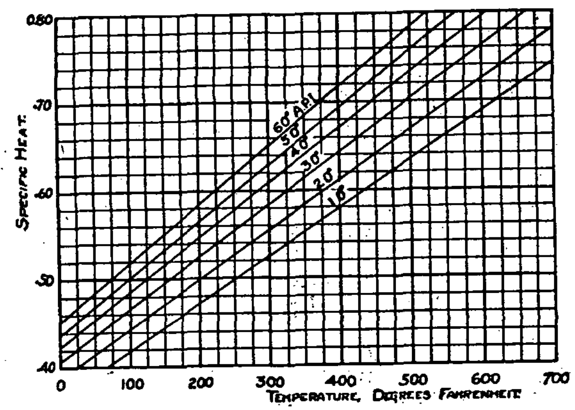

FIG. 7. VARIATION OF SPECIFIC HEAT OF PETROLEUM WITH GRAVITY

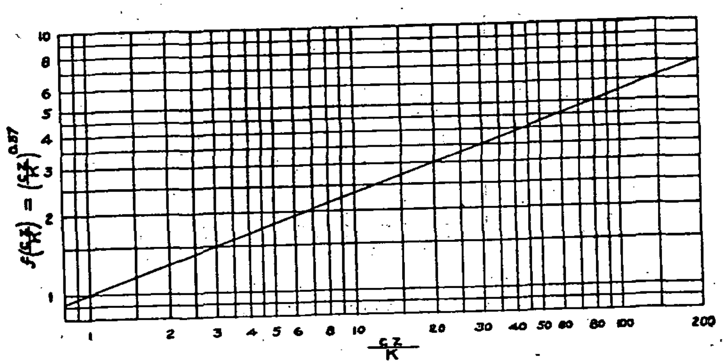

FIG. 8. VARIATION OF HEAT TRANSFER WITH $\frac{cz}{K}$

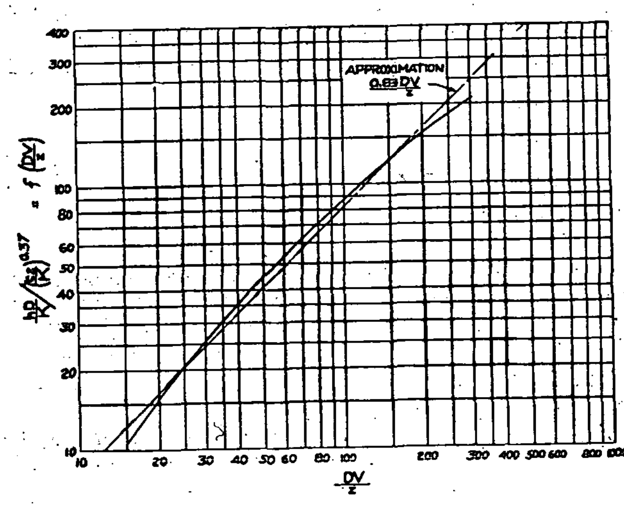

FIG. 9. VARIATION OF HEAT TRANSFER WITH $\frac{DV}{z}$

gives a convenient means of estimating the viscosity at any other temperature. Fig. 6 gives the conversion from Saybolt Seconds Universal, to kinematic viscosity which is absolute viscosity in centipoises divided by specific gravity. The viscosity of water at 68 deg. fahr., is one centipoise.

The heat conductivity K, for liquids, is usually assumed as a constant, but it is possible that improved results would be obtained if this were taken corresponding to the average main stream temperature. Data on the variation of K with temperature are scarce, but for water, an equation is given as $K = 0.304\ (1 + 0.00175\ t)$ where t is the temperature in degrees fahr. In the data of Morris and Whitman on oil (K) is taken as a constant with a value of 0.078.

The variation of the specific heat of oil with temperature has been investigated by many, especially in the lower ranges. Fig. 7 gives the results of the work by Fortsch and Whitman.

Figs. 8 and 9 give the results of the work of Morris and Whitman on heat transfer. In their work the end effect of the tubes was eliminated, and the properties used are those of the main stream. They recommend that values 25 per cent lower be used for cooling, and that a suitable correction be made for end effects.

As a check upon a given design, the following shows good general practice for the overall coefficient of heat transfer for different classes of apparatus, using tubular exchangers.

Condensing steam to water 300–500, Water to water 150, Steam to oil 75, Water to oil 50, Condensing oil vapors to water 60, Condensing oil vapors to oil 40, and Oil to oil exchanger 25.

The above figures can vary widely as they are naturally dependent upon individual conditions of velocity, viscosity, turbulence, diameter of tubes, and presence of scale, etc.

The design of the tube bundle in an exchanger should be made compatible with the available head. In this connection McAdams states that the friction drop in tubes when a liquid is being heated is lower than is expected from ordinary isothermal friction data. This is probably due to the reduction of the viscosity of the liquid film next the wall. As a rough indication of the magnitude of this correction the friction drop is reduced about 1 per cent for each 3 or 4 deg. fahr. temperature difference between wall and liquid, depending on the type of flow.

Many problems involve the transfer of heat to a relatively stagnant body of water, such as storage heaters. In this case, the velocity of the water due to convection currents is difficult to estimate, hence an assumption of the value of h must be made on the basis of experience. Tests on condensing steam in deep tanks with cast-iron sections have shown a value of h from 80 to 100, and a standard design of copper coil water heater is based on an average h of 120. Tests on similar oil heaters consisting of pipe-coils inside large tanks, show values of h from 4 to 20. This would depend greatly upon the viscosity of the oil.

OBTAINING QUOTATIONS

In obtaining quotations on heat exchange equipment, give as much data connected with the problem as possible. The more completely this