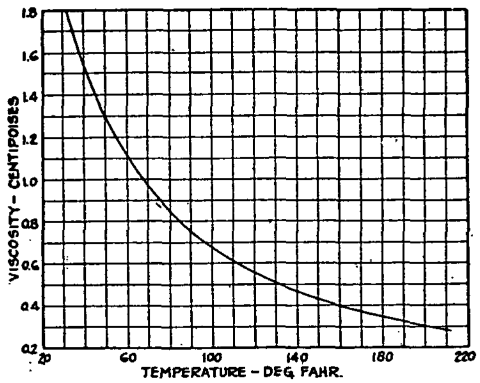


FIG. 4. VARIATION OF VISCOSITY OF WATER WITH TEMPERATURE

thickness would be $\frac{0.125}{25 \times 12} = 0.0004$. Compared with these values, the resistance of an oil film or a water film may be as high as 0.03 and 0.004 respectively, so that in steam heaters the overall resistance may often be assumed with little error to be equal to that of the liquid film only.

Having determined the individual resistances, they should be added, with corrections made to bring them all to the same unit of area where thick tubes are used. Thus, if the inside area of a pipe be accepted as a base, the resistance of the outside film would be multiplied by $\frac{D}{D_o}$ and the resistance of the tube by $\frac{D}{D_a}$.

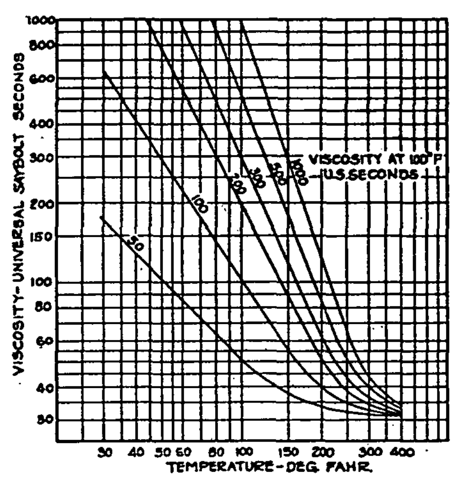


FIG. 5. VARIATION OF VISCOSITY OF PETROLEUM WITH TEMPERATURE





where

$D$ = inside diameter of pipe in inches.
$D_a$ = average diameter of pipe section in inches.
$D_o$ = outside diameter of pipe in inches.

The next step is to determine the average temperature difference, which is the driving force. This value is usually a logarithmic function of the difference in temperature between the two fluids at entrance and exit of an exchanger.

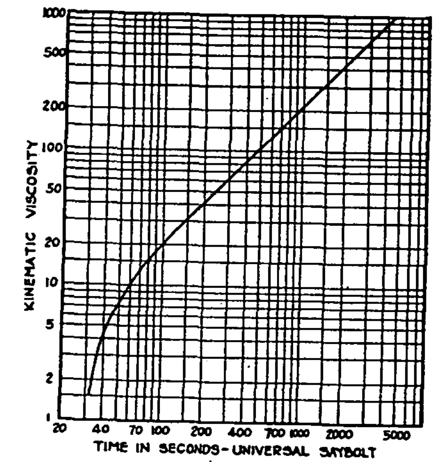


FIG. 6. RELATION OF SAYBOLT TIME AND KINEMATIC VISCOSITY = $\frac{\text{ABSOLUTE VISCOSITY IN CENTIPOISES}}{\text{SPECIFIC GRAVITY}}$

Fig. 2 shows temperature differences for counter-current flow, parallel flow, condensation of a pure vapor, and vaporization of a pure fluid.

The logarithmic mean temperature difference for each case in Fig. 2 is given as

$$\frac{dt_1 - dt_2}{\log_e \left(\frac{dt_1}{dt_2}\right)}$$

$\log_e$ = natural or hyperbolic logarithm.
$dt_1$ = greatest temperature difference.
$dt_2$ = least temperature difference.

A convenient curve for calculating the logarithmic mean temperature difference with a slide rule is given in Fig. 3, which gives the value of the above function divided by $dt_1$ for various values of $dt_2$. To obtain the logarithmic mean difference, multiply the value from the curve for a given ratio of $\frac{dt_2}{dt_1}$, by $dt_1$.

The viscosity of water changes with temperature, as shown in Fig. 4. If the viscosity of an oil at any given temperature be determined, Fig. 5