approximately by the Langelier Index,[9] which is obtained by subtracting the actual *pH* of a particular water from the *pH* at which it is estimated precipitation of calcium carbonate would just begin. This estimate may be made by the use of Fig. 4.

There are various expedients which may be employed for avoiding or mitigating difficulties due to scales:

a. The water may be treated before use to remove elements such as calcium, magnesium, and iron, which form relatively insoluble compounds. In the various softening processes this removal of these elements is accompanied by the addition of other elements, particularly sodium, the compounds of which are relatively soluble.

b. The water may be treated within the equipment to promote the separation of dissolved solids as sludges, rather than as scale which is, in most cases, more objectionable.

c. The increase in total solids, due to the evaporation of water, may be controlled by the displacement, continuously or intermittently, of some of the used water by fresh supply.

d. Substances, such as the polyphosphates, having the property of inhibiting the precipitation of calcium carbonate from solutions supersaturated with it, may be added.

e. The *pH* of the water may be lowered (hydrogen ion concentration raised) to reduce the tendency for precipitation of carbonate. This is permissible only to such an extent as will not cause a serious increase in rate of corrosion.

The choice of the best expedient or combination of expedients must be made for each type of equipment, and will be affected by operating and water considerations. Item c above must be used, regardless of which other items are used, for all recirculating water systems from which evaporation takes place.

Once-Through Equipment

Where abundant supplies of water are available at low cost, the cooling water may pass through the equipment once, undergoing a rise in temperature. Little difficulty from scale should be encountered if the Langelier Index is lower than +0.5, based on the highest water temperature encountered in the system. This often corresponds to a carbonate hardness of less than 200 ppm when water temperatures are lower than 100 F. However, since many municipal supplies are softened so that incipient calcium carbonate precipitation is induced, the Langelier Index is a more reliable indication of scaling tendency.

Prevention of scale in once-through systems is based primarily on the adjustment of *pH*, the application of surface-active agents, or a combination of the two. Normally the addition of a few parts per million of a surface-active agent such as a polyphosphate[10] fed proportionately to a water with a scaling tendency is all that is required to control scale.

Where a given water does not respond satisfactorily to surface-active agents, reduction of *pH* with sulfuric acid or carbon dioxide is often employed. The *pH* is reduced only sufficiently to have it fall within the effective range of the surface-active agent. The use of acid or carbon dioxide is sometimes permitted without polyphosphates when corrosion will not be severe. In this case the *pH* is reduced so that the Langelier Index is less than +0.5. The acid or carbon dioxide must be added with care. Use of automatic *pH* controllers is required if corrosion is to be prevented.

A special case of scale from ferrous bicarbonate decomposition was mentioned previously. Ferrous bicarbonate is considerably less stable than calcium bicarbonate. The prevention of this decomposition can be ac-

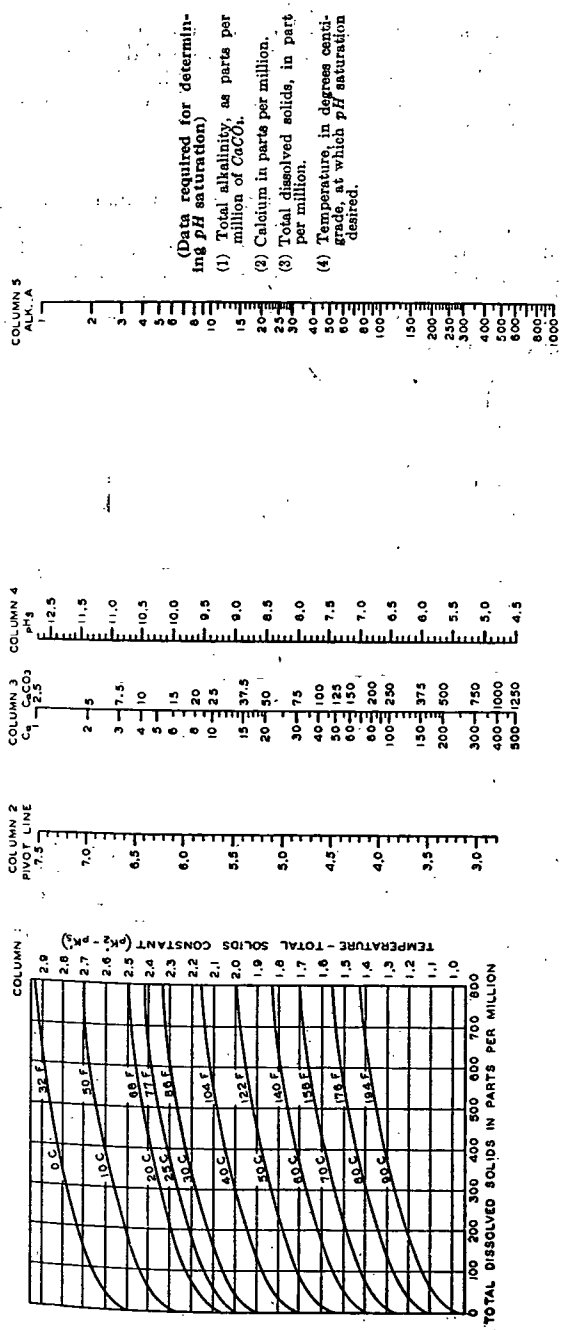


FIG. 4. GRAPH AND NOMOGRAM FOR DETERMINATION OF *pH* SATURATION BY LANGELIER'S FORMULA
(*Applicable within pH Range 7.0–9.5*)

Based on article in Oct. 1936 issue of *American Water Works Association Journal* and later corrections for Tables 2 and 4 of article. Prepared for Charles P. Hoover of the Columbus, Ohio, Water Softening and Purification Plant by M. L. Riehl.

Instructions for Using Chart:

1. Knowing temperature and total dissolved solids, find temperature and total solids constant on Col. 1.
2. Align this constant with given value of calcium on Col. 3 of Chart, then locate point in Col. 2 of Chart (Pivot Line).
3. Align this point on Pivot Line with given alkalinity on Col. 5; read *pH* saturation on Col. 4.

Saturation index is *pH* actual minus *pH* saturation.

e.g.—*pH* actual	*pH* saturation	Saturation index
7.6	8.1	−0.5 (corrosive)
8.4	7.8	+0.6 (scale forming)