the fact that the application of the desired amounts of chemical may be kept under strict control. In plants which are operated on a continuous basis it is obvious that the effect of errors relating to the faulty application of lime must in a great measure vary inversely with the amount of water to be treated, or, in other words, with the amount of chemical to be used.

Although it is true that milk of lime is used in a small number of continuously operated water-softening machines of considerable size, the agitation factor is more particularly emphasized in such apparatus than would perhaps be feasible in larger plants. Without adequate mixing of the raw water and the milk of lime there is a marked loss in softening efficiency on the part of concentrated suspensions of lime, owing to the fact that the suspended particles of calcium oxide become coated over with the precipitating carbonate of lime and hydrate of magnesium, and thereby become inactive. With vigorous agitation this vitiating factor—the inactivity of a part of the lime suspensions—is greatly diminished, but doubtless it is still to be considered as important in proportion to the amount of suspended calcium oxide which the milk of lime contains.

From the evidence available it appears to be clear that limewater possesses distinct advantages over milk of lime in continuously operated water-softening plants for two reasons—first, because of the relative ease with which accurate and uniform application of this chemical may be maintained when it is applied in solution, and, second, because the softening efficiency of limewater is relatively higher. This second consideration involves questions of cost, which must be considered.

In a system of water softening operated on the continuous plan the device in which limewater is prepared is an important feature. In practice limewater is generally produced by diverting a portion of the raw water to the bottom of a tank or reservoir, sometimes known as the lime saturator, where it meets a continuous flow of cream of lime in slight excess of the quantity necessary to soften the raw water and to produce a saturated limewater. Thorough mixing of the cream of lime and the raw water is obtained by means of a stirring device situated at the bottom of the lime saturator. The raw water, softened to the fullest extent possible by treatment with cream of lime alone, becomes a saturated solution of lime. In order to obtain limewater which shall be practically free from undissolved lime and the precipitated salts of lime and magnesium the saturator is made sufficiently deep so that, as the water passes upward to the outlet at the top of the tank, the suspended matter will largely subside.

Preparation of Soda-Ash Solution.—Available evidence indicates that a 20 per cent. solution of soda ash in hot water should be used. Such a solution has a specific gravity of 1.23. A solution of approximately this composition is made by dissolving 20 pounds of soda ash in 100 pounds of water.

Limitations in Water Softening.—When once raw water, charged with carbon dioxide, has in its course over or through the earth become impregnated with calcium and magnesium there is no practical process applicable to municipal use which can restore the water to its pristine condition. The reactions and the resulting precipitation will vary in completeness with conditions of temperature, mixing, and sedimentation. Furthermore, the precipitates formed are not wholly insoluble. In a water softened under ideal conditions there may remain in solution 5.2 parts per million of calcium and 3.4 parts per million of magnesium, together with equivalent amounts of negative radicles, representing an alkalinity of nearly 30 parts per million. These figures may be increased by the presence of other substances, so that it is apparently certain that a water once hard can not be softened in a practical plant to less than 34 to 37 parts of alkalinity per million.

With regard to the permanent hardness, it is not generally thought economical or advisable to remove all of the incrustants. As soda ash, which is used for the removal of these constituents, constitutes one of the chief items of expense in softening a selenitic water, its use should be restricted to the lowest limit commensurate with the benefits to be derived therefrom.

Factors Influencing the Speed of Softening Reactions.—The process of softening water requires considerable time for its completion. Chief among the factors that influence the rapidity with which the chemical reactions involved in the softening process may take place are the temperature of the water, the thoroughness of the agitation to which the water is subjected following the addition of the softening chemicals, and the maintenance in suspension of the precipitating salts during the period allowed for the reactions to take place.

It is a well-known and accepted fact that the majority of chemical reactions take place with relatively more rapidity as the temperature is increased. Those chemical reactions which are involved in water softening belong distinctly to this class. Cold weather during softening retards the process to such an extent that considerably more time is required for the completion than when the water is at a higher temperature; in extremely cold weather the maximum softening effect is often not obtained.

Even when the amounts of chemicals theoretically necessary for complete softening are applied to a given water, a satisfactory removal of the dissolved calcium and magnesium salts will not be obtained without thorough agitation. The importance of agitation in softening water has long been recognized, the means for effecting this end constituting an important feature in the design of the majority of proprietary water-softening machines.

It is a well-known fact that the presence in suspension of the precipitate previously formed or of that formed in the initial stages of the reaction generally assists materially the completion of the process, its success depending on the removal of dissolved substances by the formation of a precipitate as the result of chemical reactions. In water softening this matter is of particular moment, owing in large measure to the fact that the chemical changes involved are taking place in solutions of a high degree of dilution. The importance of the presence of the suspended precipitates throughout the course of the softening reaction has been recognized for many years, and many water-softening machines have been designed with the view of retaining these precipitates.

Available information indicates clearly that at the beginning of the softening process it is highly advantageous to apply the entire amount of lime required to the major portion but not to the total amount of the raw water to be softened. Mention has already been made of the fact that the maintenance in suspension of the forming precipitates materially accelerates the softening reactions. By overdosing a major portion of the water to be softened, the initial softening reactions are greatly accelerated. The action is particularly marked in the precipitation of the magnesium, which is much more rapidly and completely removed under the conditions outlined above than would otherwise be the case. Further, the indications are