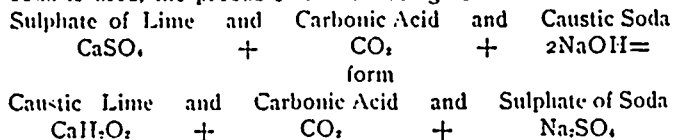


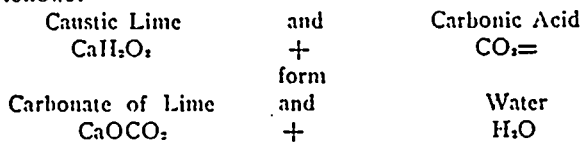
course, more slowly), and anything that will corrode the boiler itself certainly cannot be desirable. To test this, anyone can obtain a few cents' worth of tannic acid from the druggist, and by dissolving the crystals in a glass of water and adding some iron filings, a very fair quality of ink can be made, due to the action of this acid on the iron.

In practice, the reaction of caustic soda ($\text{Na}_2\text{O.H}_2$) with the sulphates seems to be more active than when the carbonate of soda is used, the probable reaction being as shown thus:



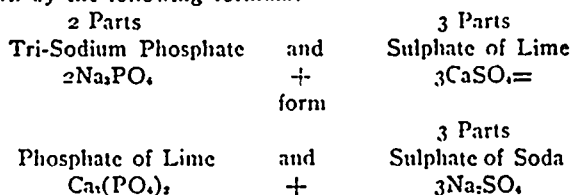
The carbonic acid used in this formula results from the precipitation of the mono carbonates from the bi carbonates, as has been explained.

The secondary reaction from the result just arrived at is as follows:

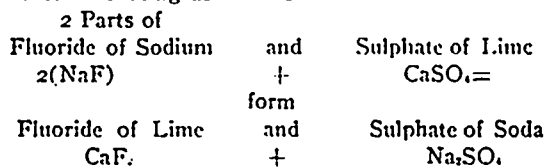


The use of caustic soda may be considered less desirable than the use of the carbonate of soda for several reasons. In the first place this present in excess will cause violent foaming in the boiler, and with this foam often the light precipitated matter in the boiler will be carried along steam pipes into valve seats, gauge glasses, etc. It will also attack and cause corrosion of the brass fittings, and it is also dangerous to handle, owing to its caustic qualities, burning the flesh painfully wherever it comes in contact. An excess of carbonate of soda may also cause foaming in the boiler, but not as violent as when caustic soda is used.

Sal ammoniac (i.e. ammonium chloride) (NH_4HCl) is most undesirable for use in a boiler, due to the liberation of hydrochloric acid (HCl) following its introduction into the boiler. This acid leaves the boiler in a vaporous form, with the steam, corroding boiler, piping and nearly everything it comes in contact with. There are other "compounds" falling under this classification, of known chemical composition, which are more satisfactory than those named above, such as bi-sodium phosphate and tri-sodium phosphate, the latter being obtainable in both a hydrous and anhydrous state. The latter is less bulky and its reaction with the sulphate of lime is shown by the following formula.



The phosphate of lime, after this reaction, falls, forming a slushy mud, making at the most a very weak crust, while the sulphate of soda remains in solution, as previously described. The fluoride of sodium is another "compound" of known composition, which has also proved satisfactory, especially when much sulphate of magnesia is present: its reaction with the sulphate of lime being as follows:



The fluoride of lime precipitated in the boiler behaves much like the phosphate of lime just described, while the remaining sulphate of soda is found in solution, as stated above.

Our second division of compounds includes a class of materials which are gradually falling into disuse, due to their proved undesirability. They thicken and foul the water in the boiler and coat its surfaces with non conducting material, and occasionally the precipitated scale making matter, along with this class of compound, will obstruct the passage of heat through the boiler plates, so as to cause bagging and burning.

In this class we find slippery elm, ground bones, horns and animals' hoofs, potatoes, dextrine, and starch, animal fats and animal or vegetable oils. As rapidly as the scale-forming crystals are precipitated from the feed water, they fall into this sticky cooking fluid and become coated with its filth, and they finally fall to the place of deposit, where they remain in a mushy, separated state until the organic matter chances to be burned out, when they will form into a loose, friable scale.

A surface blow-off or skimming device is most essential to reduce the evil, when this class of compound is used, and the bottom blow-off cock should also be opened very frequently.

We now come to our last division of this subject. The principal substances used for this third class of compounds are petroleum and kerosene. Petroleum oil has much more of the enveloping quality described under the last (or third) classification than the kerosene. Besides producing this effect on the scale matter, both have an active rotting effect on the scale already formed, the kerosene in this case being superior to the petroleum. Crude oil should never be used, but a carefully refined oil, which has been deprived of its tar or wax, should be selected for this purpose, as these cause the formation of a tough, impervious scale productive of bagged sheets and collapsed flues. Petroleum or kerosene should be fed to the boiler with the feed water, drop by drop, through a sight-feed apparatus similar to those used to feed oil to the cylinders of engines. There are several forms of this apparatus on the market. Under no consideration should large amounts of these oils be fed to a boiler at one time, as it must be remembered that the more volatile portion of the petroleum will be quickly distilled off in the hot boiler, leaving the least efficient portion behind, while the more volatile kerosene will be vaporized very quickly, before it has time to thoroughly mix with the water.

Where hard scale has formed in a boiler, it is most effectively treated by giving it a coat of petroleum or kerosene, to partially dissolve or rot it. These may be applied with a brush or squirted on, but an easier method of application is to first fill the boiler with water above the line of scale deposit and then pour the oil on the surface of this water, and let the water gradually run out of the bottom of the boiler, thus leaving the oil behind clinging to the whole interior surface. As stated above, kerosene is the most effective in destroying the tenacity or coherence of this deposited scale, but this method of using either oil is not without attending danger, on account of the explosiveness of the vapor given off, so great care must be taken to have no lights in the vicinity of the boiler under such treatment, as men have been seriously injured by this lack of prudence. The treatment of feed waters inside of the boiler has been a practice of many years' standing, but in the light of recent progress is not to be commended. A boiler certainly has all that it can reasonably be expected to do when it is generating steam, without being called upon to perform the functions of a chemical laboratory. Everyone knows that when a new boiler is started it "steams lightly" and is most economical in its use of fuel, but generally after it has been in service for some time harder firing is necessary and larger fuel bills appear. Following this reasoning, I would ask if it is not far more sensible to keep the boiler constantly up to its original state of efficiency by preventing the scaling and corrosive agents from entering it, rather than accepting such evils and trying to correct them after they have occurred?

The external method of treating feed water, chemically or mechanically, is being adopted by many progressive plants in this country: and in this, I am sorry to say, Americans are far behind the English, French, Germans, Belgians and Austrians, in whose countries the external treatment has been largely and most successfully practised for many years. There are, of course, plants where the internal treatment of feed water is an enforced necessity, owing to surrounding conditions or lack of funds necessary to install apparatus for external treatment, but as such apparatus has invariably proved to be an excellent investment, it should receive careful consideration from all steam users.

Before closing I feel that I must add something in the way of warning to the users of boiler compounds. Owing to the unfortunate fact that boiler users have, as a general thing, been too busy to give this important matter of scale and corrosion a proper amount of study, they have become the victims of