be red lead paint tinted to a black or brown color, black paint made according to Federal Specification TT-P-61, red iron oxide paint conforming to Federal Specification TT-P-31, or white or light tinted paint made according to Federal Specification TT-P-40.

Another paint which has had some use for priming iron and steel is zinc chromate paint.

Under some conditions, a chlorinated rubber base paint made according to Federal Specification TT-P-91 may be used for the finishing coat, particularly where the presence of highly corrosive gases or contact with strong alkaline water would injure the standard paints. Rubber base paints should be used only for the finishing coat over regular priming and second coats.

BURIED PIPE LINES

Lines that are cold and in intimate contact with the earth are corroded from the same causes as in mineral waters, but pitting is usually more intense due to variations in concentration of salts and oxygen in solution, acidity, drainage, and presence of solid materials (such as cinder) in contact with metal pipe. Galvanic currents, induced by contact of certain dissolved constituents in the soil, often act over a large area, and accelerate corrosion where they leave the pipe line.

Certain bacteria that thrive in the absence of oxygen have the power to obtain hydrogen and dissociate sulphates in the soil, with a resultant production of hydrogen sulfide which attacks the iron to form iron sulphide.

Stray electric currents from electric power generating stations sometimes find their way into buried steel structures, and do damage in proportion to the current density where the current leaves the metal to enter the ground.

Pipe Materials

Under many conditions where steel would be corroded, the use of corrosion-resistant metals other than steel may be desirable, even if greater in first costs. Wholly austenitic stainless steels are very resistant to underground corrosion. In most environments copper, red brass, and copper-silicon alloys will resist corrosion and may, at times, be used to advantage. However,[34] soils with a high content of organic matter, or alkaline soils in which the ratio of chlorides and carbonates to sulfate is high, may be corrosive. Copper should not be embedded directly in cinders or in tidal marshes where it may be subjected to attack by sulfur compounds. Lead[35] corrodes chiefly in soils deficient in oxygen or containing cinders. Because lead is corroded to a considerable extent in most soils, lead coatings applied to steels are not adequate for underground use.

Galvanized iron pipe will resist corrosion for various periods of time, depending on the soil and how long the galvanized coating lasts. The zinc used for the galvanized coating, is on the electrochemical protective side of the iron, and the zinc is corroded and changed to zinc compounds before the iron is attacked. This accounts for the protection afforded by galvanized iron. Even if some protection is obtained, eventually the galvanized coatings are destroyed by chemical action and the corrosion of the steel begins.

Protective Coating

Protective coatings for buried pipe lines are in a class by themselves because of the unusual service conditions, and because it is not possible to maintain them by recoating when necessary. Buried steel pipe lines have been protected against corrosion with considerable success by the use of very thick bituminous coatings applied in molten condition. The best results are obtained by applying the bituminous coatings over a standard priming coat such as red lead or a bituminous paint, and for long service it has been found that after the bituminous coatings are applied, a wrapping of asbestos fabric saturated with bitumens will prevent movement and displacement of the bituminous coatings, and add greatly to the length of time satisfactory protection will be maintained.

Cathodic Protection

Protection is obtained by rendering the structure cathodic to the surrounding water or soil by means of a controlled difference of potential. This method, which has proved satisfactory and economical on a number of gas and oil pipe lines underground, has also been applied with some success to the protection of the inside of water storage tanks and other structures that are in contact continuously with water. Protective coatings that insulate a large portion of the metal surface will reduce very materially the total amount of protective current that must be impressed on bare anodic areas to arrest corrosion.

Because of differences in environmental conditions, it is necessary to determine or estimate the minimum current density required for each structure, and design the anode or anodes so that the necessary protection can be obtained most economically. In water having relatively high electrical conductivity such as in sea water, this is comparatively easy compared with fresh water. In the latter, the composition of the water is a major factor. It is therefore desirable to obtain an accurate estimate of the minimum current density required. The current is then controlled by the potential between the anode and the structure to be protected.

Rectifiers have generally proved to be the most practical means for supplying the necessary current for protection of surfaces in contact with neutral waters.[36]

HANDLING WATER TREATING CHEMICALS

Virtually all the chemicals used in water conditioning are injurious if taken internally in large doses. Many also cause severe skin irritation. Thus, they should be handled with caution.

Caustic soda, lime, and concentrated sulphuric acid will burn the flesh. In addition, if mixed with small amounts of water, sufficient heat may be generated so that spattering occurs or the container becomes too hot to handle.

The chlorophenol compounds, even in the low concentrations used in water conditioning, have been reported[37] to produce dermatitis. Chromitch is not uncommon among workers handling chromates. The amines are said to be absorbed through the skin.[38] Morpholine is said to cause kidney and lung trouble when so absorbed.

Chlorine gas irritates the skin, eyes, and mucous membranes. Concentrations as low as 0.004 percent by volume in air cause dangerous illness in 0.5 to 1 hour.

When relatively large amounts of the non-gaseous chemicals are to be handled, protective clothing, including goggles, should always be pro-