

hurled against these vulnerable parts by the enormous pressure, and consequent blast, of air that is exerted when the cars are running at full speed in the tubes. Another condition observed was the appearance of a white coating of salt upon the surface of the paint after the cars had been in operation but a short time.

Subjected to these trying conditions, some of the cars stood the test in a remarkable manner, while others, made of a different grade of steel, were in very bad condition.

The points of corrosion were indicated by the surface being covered with wart-like concretions which, under a high power hand glass, showed the presence of rust forcing through the paint coat and exposing the steel to direct contact with the air. This eczema of the iron, although general, seemed to be most marked in certain places, and this would lead to the conclusion that the impurities in the metal were segregated.

According to the electrolytic theory of corrosion, certain fundamental principles underlie the corrosion of iron.

They are, briefly, as follows:—

That, when iron is in contact with water, there will be a transfer of electricity from the free hydrogen ions of the water to the iron ions of the iron, causing the solution and subsequent oxidation of the metal.

The presence of impurities having a difference in potential to that of the iron in which they are contained, and the uneven distribution of such impurities, increases the amount of electrical action.

We are indebted to Dr. William H. Walker, for the most recent research on the function of oxygen in the corrosion for iron, who says:—

"That the film of hydrogen deposited on the metallic iron at the beginning of the action is a non-conductor of electricity and prevents further passage of the current, and hence, further solution of the iron. Atmospheric oxygen removes the film of hydrogen by combining with it, thus 'depolarizing' the iron and allowing the solution of the iron to proceed. When once in solution in water, this dissolved iron is also oxidized by the atmospheric oxygen and precipitated as rust; but this oxidation is incidental to, rather than a necessary condition of, corrosion."

"That when iron is in contact with any surface on which this combination of the hydrogen, set free from the water, and oxygen, from the air, will take place more easily than on the iron itself, such as copper, bronze, mill-scale, etc., corrosion of the iron will be accelerated thereby."

Certain compounds are of such a nature as to excite electrical action, and, consequently, stimulate corrosion, while still other compounds are of such a nature as to inhibit or prevent corrosion.

To the class of compounds that inhibit corrosion belong bichromates of the alkaline earth metals, these salts being pre-eminent among such compounds. It has been found that salts of certain metals may be precipitated with the chrome salts to produce pigments which afford protection for the steel surfaces to which they are applied.

The results of a series of investigations into the rust preventive nature of these compounds demonstrated that it was not safe to state that the chromates, as a class, were rust-inhibitives. Quite the reverse is true of many of these products, and their composition, method of preparation, and impurities are factors which influence, to a marked degree, their value as protective compounds. Aside from those chromates which prevent corrosion, we have those which act in an inert manner, also those in which any inhibitive value is overbalanced by the effect of impurities, showing a strong stimulating action in the rusting of metal. But a simple test will show in which class the chromates come.

Turning, therefore, to the conservation of structural iron and steel and to its rust inhibition through particular coatings, we have the problem of choosing the proper materials for manufacturing a paint which will both exclude the agencies of rusting, and which, when moisture and gases do penetrate the coating, will inhibit the iron from rusting; and

we also have the problem of giving to the chemist, engineer and architect some simple method of determining whether any given paint is, in at least a rough measure, harmful, safe or beneficial.

Some pigments largely used in the paint industry, and of value in a paint for protecting lumber, are unjustifiable in a paint for the protection of steel and iron. For example, sulphate of calcium, which, even if fully hydrated, has been shown to have a direct stimulative action upon steel. This is due to the fact that calcium sulphate, even if fully hydrated, is somewhat soluble in water, and when the water penetrates the coating of paint it carries this calcium sulphate into solution. Owing to the fact that calcium sulphate, in solution, has a high co-efficient of dissociation (or, in other words, has a tendency, in solution, to break up from its chemical form and identity), we get the reaction of the liberated sulphuric acid ions upon iron and steel, causing corrosion.

The highest type of paint product for the protection of iron and steel, therefore, avoids the use of such pigments as calcium sulphate.

Great caution must be used in selecting iron oxides for the protection of iron and steel, as they often carry traces of sulphates, etc., as impurities.

Venetian red, which is a favorite pigment, and which is of value for protecting lumber, is made by calcining green vitriol or sulphate of iron (commonly called copperas), in the ferrous form, in the presence of quick lime. The resulting mass from the furnace consists of artificial oxide of iron and sulphate of calcium, produced by the metathesis of the above reacting compounds.

Unfortunately, the reaction is never complete, and there is a tendency towards the formation of free sulphuric acid.

As a result, we have all the bad effects with Venetian red that we find in the use of calcium sulphate, and also the extra chance of corrosion due to free and aggressive sulphuric acid present.

It is true that there are some artificial oxides of iron which can with safety be used, as for instance, artificial black magnetic oxide produced by chemical precipitation, but, as a general proposition, the natural iron oxides should be used, unless it is absolutely certain that the artificial oxide has been proven safe.

Ochres are not meant to be included in the safe class in the above statements, for the reason that ochre is an extremely impure oxide of iron.

Recent investigations into the nature of pigments have revealed the fact that they may be divided into three groups and termed "Rust-Inhibitives," "Inerts," or "Rust-Stimulators." The nature of the pigment itself, or the nature of the impurities contained within the pigment, are factors deciding the position of the pigment in one of the three groups or types above mentioned. It may be expected that the use of rust-inhibitive pigments in paints designed for the protection of steel surfaces will give to such a paint very valuable properties. Further consideration of the subject will aid us in selecting the proper pigments for such a purpose.

In order to ascertain the rust-inhibitive value of all pigments, the Scientific Section was commissioned by the Bureau of Promotion and Development of the Paint Manufacturers' Association to erect a fence, having several hundred steel plates, upon which to try out the value of the different pigments when contained in an oil medium.

The American Society for Testing Materials was informed of the work proposed by the Scientific Section, and Committees E and U of that society decided to co-operate in inspecting and supervising the tests, proper specifications to be drawn up by the committees. The members of these committees and the Scientific Section conducted laboratory tests that served as a check upon the previous investigations and gave information upon which to base the main field tests. The plates used for the tests were