

paints, and created a demand for painters having a knowledge of the proper materials to use in the painting of steel, so that its life may be preserved and its strength maintained. Such knowledge is as important to the painter as a knowledge of how to properly select materials for the painting of wood, and how to temper these materials to suit the various conditions met with.

Every one is familiar with the appearance of rust, but few actually understand what causes rust. No attempt will be made here to present even an outline of the many theories advanced to explain the phenomenon of the rusting of iron, for the subject is as diverse as it is interesting. A brief résumé, however, will be given of the now generally accepted theory that explains the subject. This theory is called the electrolytic theory.

"Auto-electrolysis" is the term used to define the peculiar tendency of iron to be transformed from a metal possessing a hard lustrous surface, high tensile strength, and other useful properties, to a crumbling oxide that falls to the ground and again becomes part of the earth from which it was originally taken by man.

This "going back to nature" is more readily accompanied by most of the steel produced to-day than by the old hand-made irons produced many years ago. It seems to be a curious fact that the more quickly a product or an article is fashioned by man, the more quickly it tends to return again to its original oxidized condition. Some manufacturers of steel, however, through an understanding of the causes of rust, have progressed in the manufacture of slow-rusting materials, either by the elimination or by the proper distribution of impurities.

When iron is brought into contact with moisture, currents of electricity flow over the surface of the iron between the points that are relatively pure and points that contain impurities. These currents stimulate the natural tendency of the iron to go into solution, and the solution proceeds with vigor at the positive points. The air which the water contains oxidizes the iron which has gone into solution, and precipitates the brown iron rust with which you are all so familiar. Thus water, which acts as an acid, and air, which acts as an oxidizer, have combined together to accomplish the downfall of the metal. It is obvious that if means could be devised to stop the solution pressure of iron, and make it resistant to the flow of surface electric currents, rust could be prevented. Materials which prevent the rusting of iron have been called by Dr. Cushman, who first advanced these explanations, rust inhibitors, or materials which inhibit rust. The paint maker, realizing the importance of these rust inhibitors, is incorporating them into paints designed for the protection of iron and steel, and the success which paints of this type have met with from a practical standpoint is a justification of what was first called the electrolytic theory which suggested their use. The laws of electrolytic corrosion would be a better way of stating what have become facts, and these laws are a direct result of the early pioneer researches of Dr. Cushman, who was formerly for many years in the Government service, but who is now the director of the Institute of Industrial Research in Washington. By placing small, brightly-polished steel plates into a mush of paint pigment and water, a determination may be made of the pigment's effect upon the metal. Some pigments under such conditions cause rapid corrosion of the steel plates. Such pigments are stimulators of corrosion on account of acid impurities which they contain, or because of their effect in stimulating galvanic currents. Many carbonaceous pigments are of this type. Other pigments have the effect of keeping bright the steel plates and preventing rust. Such pigments are of the inhibitive type, and their action is to check or retard the solution pressure of the iron.

Results obtained in many laboratory tests suggested a practical exposure test, and a series of three hundred large steel plates were exposed by the writer, acting under the American Society for Testing Materials, at Atlantic City, where the action of the salt air is severe on both paint and metal. In these tests separate plates were painted with nearly all the useful paint pigments, ground in a vehicle of raw and boiled linseed oil. Later in the test it was found that many pigments of the carbonaceous type, as well as those which contained acid impurities, were showing bad results. It was also found that pigments of the inhibitive type, such as chromates of lead, zinc, barium, etc., acted in an almost miraculous way, transforming the surface of the metal upon which they were applied into a practically uncorrodible condition.

The excessive chalking which took place on the corroded white lead coatings began to disappear at the end of a year, being washed away by the rains and carried away by the winds, so that there was left upon the surface thin coatings of pigments, insufficient to give good protection. Had this white lead been reinforced with sufficient zinc oxide to prevent chalking, much better results would no doubt have been obtained.

The deep cracking of the zinc oxide indicated that such a pigment required a large quantity of oil in order to satisfy its brittle nature and prevent such effects. White paints containing zinc oxide and zinc oxide products were in excellent condition, and they confirm preliminary tests which showed zinc oxide to be one of the most valuable pigments for protecting iron.

Although sublimed white and blue leads chalked very heavily, the chalked pigment seemed to be tenacious, and adhered to the plate, presenting a good surface with absence of rust. Both these pigments gave very good protection to steel. When admixed in the right proportion with certain other pigments, they give still better results.

Lithopone was early destroyed, as is usual with the pigment when used alone on exterior surfaces. It became rough and discolored, presenting a very blotchy appearance. Red lead and orange mineral both afforded excellent protection to the plates upon which they were applied. They became covered, however, after exposure with a white coating of carbonate of lead, which was due to the action of the carbonic acid of the atmosphere on the red lead, which is an oxide of lead, and susceptible to chemical action.

The iron oxide gave fair service indeed. In one case, however, there were several eruptions, indicating slight corrosion beneath the surface of the paint. One iron oxide which did wonderfully well was the black oxide of iron which not only possesses great tinting value, but up to the present time has had a high protective value. The graphite was very deeply pitted at certain spots, indicating that galvanic currents had been set up, causing stimulating effects. Barytes and blanc fixe, when used alone, gave very poor service, showing scaling, chalking disintegration, and rust soon after the test was started. Barytes, combined with some other pigments, however, presented a very good surface. Under the paint film of gypsum rust soon appeared, and although the film itself remained fairly intact, rusting progressed throughout the test, indicating that gypsum films were very poor excluders of moisture. Coal-tar paints failed in the test, and this was due, no doubt, to the strong action of the sun, which early destroys such products. China clay and asbestine gave excellent service for eighteen months. After that time, however, indications of corrosion were shown, and the apparent breakdown of the film was predicted. These pigments, however, combined with other pigments, have given excellent service.