Theory and Practice

OF

PAINTING ON METAL

BY

A. H. SABIN, M. S.

PUBLISHED BY

EDWARD SMITH AND COMPANY

45 BROADWAY, N. Y.

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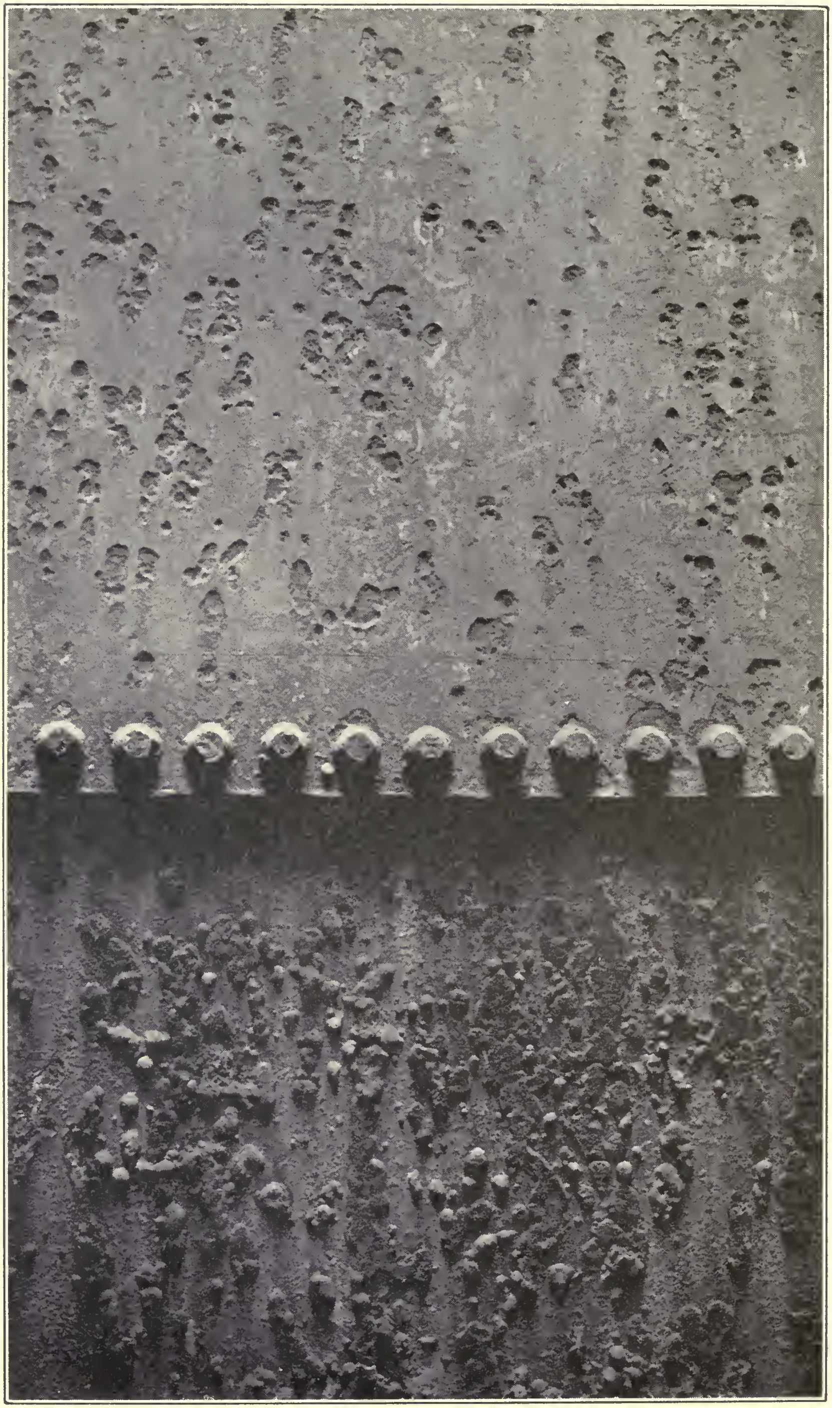

Rusted steel plates; upper plate cleaned, lower showing "tubercles" of rust.
(*Frontispiece.*)

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I.

In 1898 the writer put out a little book of specifications for painting on structural metal, which has been received with considerable favor; but the last edition (of two) is now out of print and it has seemed desirable to reprint the specifications and to add such remarks as further experience has suggested. The specifications themselves are almost unchanged; but some work has recently been done which exceeds in excellence and thoroughness anything heretofore described, and it seems well to give a somewhat detailed account of it, which will be done in proper course.

Uncombined metallic iron is so rare, as a natural mineral, that practically there is no such thing. It is found chiefly as an oxide, though carbonates, silicates, and other salts abound and in particular the sulphide, pyrite, is very widely distributed. It may be said that the coloring-matter of most of the dark-colored minerals and rocks is mainly iron. Metallic iron is obtained from the ore by using the most powerful chemical agencies and it constantly tends to go back into combination; when it does this by natural means the product is termed rust. Usually rust is hydrated oxide of iron, mixed with more or less carbonate, and often with sulphate, sulphide, chloride, or other salts of iron. The common cause of rust is the action of air containing moisture and acids, especially carbonic acid; and to prevent it we must exclude water and gases. This is very difficult, but has been attempted in many ways.

In the first place, by embedding the metal in cement. Bridge floors are sometimes covered with melted asphaltum an inch or more in thickness; a good result may thus be obtained, but as the material is of a viscous nature and tends to flow slowly off a surface not level and confined, it is of limited application. Of far greater use is Portland cement, or concrete made of it; this is strongly alkaline, not only with caustic lime, but the action of this on the potassium and sodium compounds originally present in the clay from which the cement is made sets free caustic potash and soda. These strongly alkaline bodies naturally prevent the access of acids and thus prevent rusting. The best Portland-cement mortar is somewhat porous; and concrete is liable to contain voids, which increase its permeability; cracks often occur, and it is known to be exceedingly difficult to make concrete even approximately water-tight. Whether steel which is to be embedded in concrete should or should not be painted is a question about which there is no sort of agreement. On one side it is said that cement naturally forms a strong bond with a metallic iron surface, and that even if it is a little rusty this rust will be taken up by the cement. The recent and apparently careful tests by Breullie appear to show that there is considerable adhesion between Portland-cement mortar and steel or iron surfaces, and that this adhesion is determined by chemical action; also that the compound thus formed is soluble in water, that if it be removed by percolation the bond is destroyed, and "that when it becomes

Stand-pipe at Racine, Wis., 135 ft. high. Steel tank painted with Durable Metal Coating. W. H. Laing, Supt.

necessary to rely upon this bond to preserve the integrity" of any composite structure "which is exposed to the action of water, it becomes necessary to make the concrete impervious to water." (Eng. News, Vol. LI, pp. 561, 562.)

M. Breullie made also a series of experiments to determine the strength of this bond existing between mortar composed of 1 part cement to 2 parts sand and iron. His conclusion was that after 30 days it amounted to 22 pounds per square inch of surface. When we consider that this is only 10 per cent of the strength of the concrete and a twentieth of 1 per cent of the strength of the steel, it seems of very doubtful value; and the almost universal practice of using twisted bars, or those rolled in irregular shapes so as to make anchorages, which utilize the rigidity of the cement, seems fully justified. Metal which is embedded in concrete is, however, strongly held in place by the pressure against it, caused by the shrinkage of the cement in the act of setting, provided the concrete sets in air; if it sets under water it expands. Metal which is painted will be gripped in this way quite as well as that which is unpainted; and if the action of percolating water is liable to cause rusting a coat of paint ought to have a good effect. The whole matter has not been sufficiently studied; but M. Breullie's experiments certainly seem to show that the claims made for the existence of a chemical "bond" of high efficiency between concrete and metal are extravagant and not founded on measurements.

In any case only a small percentage of structural steel can ever be embedded in concrete. It has been proposed to paint iron with a cement wash; but this is brittle, and, so far as my own observation has gone, does not adhere well. Newberry says that in order to have it adhere well it should be kept moist for a day or two, which is manifestly difficult. We come, then, to the use of films of paint and varnish to prevent the action of moisture and air.

Ordinary oil paint is composed of linseed-oil as the principal liquid ingredient, with which is mixed some pigment; which latter is a solid substance very finely powdered. The pigments in principal use for the protection of metal are white and red lead, the former more or less mixed with barytes and sulphate of lime and sometimes with the carbonates of baryta and lime, the latter with iron oxides, graphite, boneblack, and lampblack; with these are mixed chrome yellow, chrome green, and ochre as tinting materials. The lead pigments and lampblack are in their nature chemical precipitates, and are extremely fine; but the others are for the most part pulverized by grinding; and it is a general opinion that a given pigment is better the finer it is. Experiments in regard to the amount of pigment required are not in accord with each other; at one time it was commonly believed that the greater the proportion by weight of pigment the better was the paint; now it is claimed that the finer the pigment the better; but the finer the pigment the smaller is the proportion which can be mixed with the oil, so far as weight is concerned. The fact probably is, that the greater the number of particles of pigment in a given measure of paint the better it is, or else that the greater the aggregate surface of these particles the better; the latter is the more likely to prove correct, and would make reasonable allowance for the relatively coarse condition of graphite, which cannot commercially be ground to an extreme degree of fineness, but which is in thin flakes, presenting a large amount of surface.

Stand-pipe at Sedalia, Mo., of the M. K. & T. R.R. S. B. Fisher, Cons. Eng. Painted with Durable Metal Coating.

The use of pigment in a paint is threefold: it makes liquid paint thicker than oil and thus causes a thicker film to adhere to the surface; being composed of solid particles, it hardens the film and thus enables it to resist abrasion; and the particles of pigment fill up many of the pores in the oil film and so make it more impervious to air and moisture. The use of the oil, on the other hand, is to form a water-proof coating as impervious as may be to gases as well as liquids, and to act as a cementing material or binder, to hold together the particles of pigment and attach them to the surface. The best oil for this purpose is probably linseed w ich differs from almost all other oils in the fact that when it is exposed to the air it is converted into a dry, tough, leathery, or rubber-like substance known as linoxyn. This change is caused by chemical action; the oil absorbs and unites with oxygen, which it takes from the air, and so increases in weight; it dries, but not in the way a watery solution does. The film thus formed is not entirely impervious; it is quite insoluble in water, dilute acids, and all ordinary solvents; but it is somewhat porous. The supposition has been advanced that it absorbs oxygen, combines with it to form carbonic acid, and that the escape of this gas causes the formation of holes, or pores; this seems unlikely, because if this action took place it would be a true combustion and would be accompanied by a loss of weight; on the contrary, it increases in weight; the increase being stated by Livache at 16 to 18 per cent and by Andés at 14 to 19.7 per cent. Further, if the pores in an oil film were blow-holes it is difficult to see how the particles of pigment would close them; the latter would be pushed out of the way; but in fact nothing is better established than that the porosity of the film is greatly diminished by the presence of pigment. The cause, then, of the porosity of a paint film must be sought in some other way.

Let us look at it in this way. A gallon measures 231. cubic inches. Spread over 400 square feet of surface this would make a layer .004 of an inch in thickness. Now, I have measured with a micrometer-caliper a great many dry films, and two coats of dry paint seldom measure more than .004 and the most I have ever seen was .006; these were on test-plates, where care was taken to lay on full heavy coats, and the proportion of 400 square feet to the gallon (which is more than the average of commercial work in painting on iron) could hardly have been exceeded. Hence it appears that the film shrinks from 30 to 50 per cent in bulk. This means also that the specific gravity of the oil increases, which is the fact; I have never been able to oxidize linseed-oil without its containing air-bubbles, but notwithstanding this the oxidized oil is heavier than water; so it may be regarded as certain that considerable shrinkage in volume takes place. When an oil film dries it turns first to a gelatinous substance, or becomes tacky; this doubtless prevents its flowing; and then as it shrinks, the contraction causes pores to form in the film, which is drawn apart into a sort of network, differing from an ordinary network in that the openings occupy less area than the solid portions. The smallest of these pores probably do not let water pass through, unless under pressure, because of their capillary action; but it enters some of the larger ones. If the oil is mixed with particles of pigment, which do not contract, we would naturally expect these to stop up many of these holes in the film, and that is certainly what takes place. This explanation is simple and reasonable, agreeing with all the facts.

Supposing this explanation of the lack of continuity of a paint film to be the true one, as I believe it to be, we may next consider other means of making a less porous coating.

Films which are approximately water-proof may be made of

Stand-pipe at Lawrence, Mass. Steel tank painted with Durable Metal Coating.

varnish. The most durable varnishes are those which have linseed-oil as their elastic ingredient, with which is united a proportion of resinous matter. Coatings of this nature have been known from very remote times; the exterior wrappings of the Egyptian mummies were varnished, and the wooden boxes, or mummy-cases, in which they were laid, were thoroughly protected with thick coats of what undoubtedly is an oleo-resinous varnish, which is still in good condition, twenty-five centuries after its application; it may be seen in any of the large museums of antiquities. No oil-paint has ever shown such durability. It is no new thing to use such varnish as a preservative on iron. In a manuscript of the date of 1520, in the library of San Marco in Venice, is a recipe for varnish for iron armor consisting of two pounds of linseed-oil to 1 pound of a varnish resin; another author, Mathioli, in 1549 said that "with resin and linseed-oil is prepared the liquid varnish which is used for giving lustre to pictures and for varnishing iron"; and a Venetian author, Caneparius, in 1619 said that with resin and linseed-oil is made a varnish which "adds splendor to iron and preserves it from rust." Similar instances may be quoted down to the present time; this use of varnish has been more common in Europe than in this country; for example, the Eiffel tower was painted, when it was built, with a paint in which an oleo-resinous varnish, not oil, was the liquid with which the pigment was mixed. But it is not unknown here; the author has made oleo-resinous varnishes for painting hundreds of bridges and other important structures, with the most successful results. It is, then, worth while to inquire into the nature of these preparations. The resins from which varnish is made are of vegetable origin; but in most cases

Stand-pipe, Framingham Water Co., South Framingham, Mass. Height, 81 feet; diameter, 40 feet; capacity, 750,000 gallons. This stand-pipe is coated with Durable Metal Coating.

they are fossil or semi-fossil resins, which after the fall and decay of the trees by which they were produced, have laid buried in the earth for a long time, in some cases hundreds or even thousands of years; during which time they have hardened and have lost their perishable ingredients. To make varnish, a quantity of some of these resins is melted in a suitable vessel; to this is added a proper amount of hot linseed-oil, and the mixture is then heated for some hours until the ingredients have thoroughly combined. It is then thinned with spirit of turpentine until its consistency is such that when cold it will be suitable for use. When this liquid is spread out in a thin film it has the quality of hardening, as linseed-oil does, by the absorption of oxygen from the air, and is converted into a coating which is harder, smoother, and less porous than an oil film. It is natural to expect that it will be harder, because the resin which has been added to the oil is harder than the dried oil; but why should it be smoother and less porous?

Nearly every one is familiar with the common use of rosin for soldering; where, being melted, it acts as a flux, dissolving and carrying away the solid particles or film of metallic oxides which would otherwise prevent the contact of the solder with the metal. All resins appear to be able to act as fluxes; and when dissolved in oil they act in such a way as to make a compound which, instead of being a stiff jelly which breaks up on contraction into a network of holes, remains until it is dry (or nearly so) a continuous, sticky, elastic film, nearly free from porosity; and while the surface of an oil film is corrugated by countless minute wrinkles, a varnish makes a smooth surface; not only is this smoothness characteristic of the surface, but it is indicative of the nature of the film throughout its whole thickness; the film is continuous and of uniform structure. At least it appears to be so, and that is the general belief; but probably at the very last some pores are formed, for such films, though far less porous than oil films, do not form an absolutely perfect protection, but are more satisfactory than any other coating which dries in the ordinary way.

All good varnishes have this nature; but not all good varnishes are suitable for the protection of structural metal; because if the proportion of resin is too large the varnish is so hard that it is deficient in toughness, and cracks from sudden changes of temperature.

It is impossible to have a surface too hard, if it is not brittle; but it is absolutely necessary to have it tough. The larger the proportion of resin the more brilliant is the varnish; and for most purposes, that is, where varnish is regarded as an adornment as well as a protective material, it is desirable to have a high degree of brilliancy; moreover, there are many places, as for example the outside of a railway coach, where the surface is subjected to constant abrasion, where a considerable degree of hardness must be had at any cost, even though a sacrifice of elasticity and toughness result. So it is that all ordinary varnishes are deficient in this respect; and a varnish particularly designed for protective rather than decorative effect must be made of somewhat different materials and in a somewhat different way from those in ordinary use. Up to a certain point, the larger the proportion of oil in a varnish the tougher and more durable it is; but if more oil is put in than can properly combine with the resinous matter it acts as a mixture, and then the film begins to lose the characteristics of a varnish coating and to resemble an oil film. This proportion cannot be definitely stated, as it varies according to the character of the resin used (of which there are many kinds), and to some extent with the details of the process of varnish-making, in which practical men differ considerably.

It is often said that as any true oleo-resinous varnish is, when dry, harder than oxidized oil, it is therefore less elastic. No doubt a varnish may be made with so great a proportion of resin as to be lacking in elasticity, but it must be remembered that flexibility and elasticity are essentially different things; and while an oil film may be softer and more flexible, it may at the same time be less elastic than a varnish film; and this is certainly true. Steel is probably less flexible than lead, but it is more elastic, and wears better; and a baked varnish enamel may be made which is far harder than any ordinary varnish film, while it surpasses oil in toughness and is greatly superior to either in freedom from porosity and in durability under all conditions. So it is clear that hardness in a film is not necessarily an objection, but it is in part a desirable quality. It will be remembered that the three objects for which we add pigment to oil are to get a thicker, harder, and less porous film; varnish makes a film which is harder and less porous; but how about thickness? To this it may be said that pigment adds to the thickness of an oil film by making the liquid paint thicker or more viscid than oil alone; but varnish is in its nature more viscid than oil, hence it may be laid on in a thick coating. It is reasonable, then, to expect that a varnish—not any varnish, but a special varnish made of the most suitable materials and with proper knowledge—will be more durable than an oil-paint; it is smoother, tougher, less liable to be affected by chemical action, and more homogeneous. Such we believe to be the fact.

Practical experience supports this belief. The writer has recently inspected an important bridge of considerable size—two plate-girder spans of 100 feet each—which is subjected to refrigerator drip, and over which fifty trains pass daily, which has not had any repainting since it was built, more than ten years ago; and was unable to find any rust on it, or any sensible deterioration of the varnish, with two coats of which it was originally coated. Another bridge which had a similar pro-

Steel stand-pipe, Winchester, Mass. Height, 40 feet; diameter, 40 feet. This stand-pipe is coated with Durable Metal Coating.

tection has a draw 500 feet long; it is over sea-water, and tugs pass under it continually; this was badly rusted in 1895 and was then repainted; in the opinion of the writer it needs repainting now, after nine years, but such is not the judgment of the inspecting engineer, so it may be conceded that the treatment has proved exceptionally satisfactory. It is not possible to get as good results on an old and rusty structure as on a new one, and the situation is a hard one as regards corrosion. In Chicago there are a number of viaduct bridges about 1600 feet long, over railroad tracks, which were coated with this same varnish, one coat at the shop and one coat after erection, in 1895 and 1896, and have not yet needed any further care; and one of the large train-sheds in that city has been efficiently protected in the same way nearly as long. Scores of railway bridges can be seen which have stood eight to ten years with nothing on them but the varnish with which they were originally coated; and in Boston may be seen the great highway bridge connecting that city with Charlestown, a structure protected in part with varnish and the remainder with a varnish enamel paint, which has stood more than five and in part more than six years; not so much as a rivet-head has been repainted, and the surface is in fine condition. The anchorages of the Williamsburg bridge, the greatest suspension bridge in the world, which connects New York and Brooklyn, were protected only with varnish; and the cables and steel floor of the same bridge were treated with special compounds of the same general nature, which will be described later.

It is not enough to use the best kind of a protective coating; it must be properly applied. The first thing to be considered is the preparation of the surface; it makes no difference whether the coating is for protective or decorative effect, whether it is a piano, a carriage, the outside or inside of a house, a train-shed, or a railway bridge; whether it be wood, tin, iron, or steel; the original surface must first be put in proper condition, or the money spent on it will be likely to be wasted, at least in part. There are people who think that paint forms an impervious coating, and will therefore arrest any changes which may be going on where it is applied; but none of those people are in the paint business. The belief is absolutely universal among all those who are making a living from the use of paint and varnish, that no good results should be expected where the surface has not been properly prepared; it may fairly be assumed, therefore, that this belief is founded on knowledge, and the opposite belief on ignorance, of the subject. It is the custom of those who apply surfacing coatings to carriages, articles of furniture, and the like, first, to have the article, if a wooden one, made as dry and clean as possible; then to fill the pores of the wood with a suitable material, and rub it to a smooth surface with sandpaper or other abrasive agent, before the application of the paint or varnish. In a much cheaper class of work, exterior house-painting, the surface is made clean and dry, and the pores are filled with oil or some mixture, before painting; and painting is done only in dry and warm weather. Metallic objects are coated in a variety of ways; some receive a superficial layer of tin or zinc by immersing them in a bath of the melted metal; some have a nickel or silver layer electrically deposited; some are coated with a vitreous enamel; and still others are dipped in a special sort of varnish and then this is hardened by baking in an oven; this latter process is called japanning. But in all these cases it is regarded as absolutely necessary to clean off all the dirt, and even to remove, by the action of acid or by the sand-blast, absolutely all the oxide and scale, so as to show in all parts the color of the pure metal, before anything else is done. If this precaution is not observed, experience has shown that the coating will not adhere properly; either it is easily scraped off, or if more adherent, the difference of expansion causes it to flake off later. If such is the case with so perfect a protective material as electroplate or enamel, how can we expect it to be otherwise with a much less completely impervious substance, such as paint? There can be no doubt that the right way to paint structural metal is to apply the paint, not to a superficial layer of dirt or oxide, but to the pure, clean surface of the metal itself. This can be done; the metal may be made perfectly clean, either by the use of the sand-blast or by pickling with dilute acid, details of which treatment will be found among the following specifications.

Sometimes it is not practicable to have the metal cleaned in this thorough manner; it is therefore of interest to consider what are the most and what the least objectionable among the things which obscure its surface. Grease and mud are the worst, for paint does not adhere to them at all; then comes a thick, recently formed layer of ordinary rust. This is composed chiefly of the hydrated oxide of iron; but it always contains, even though it appears dry, moisture held in it as in a sponge, and with the water carbonic acid; and these, imprisoned beneath a layer of paint, soon assert their independence and regain their liberty. Such a coating of rust is itself a cause of chemical action; it is in the most intimate contact with the unoxidized metal, to which it gives up a part of its oxygen, quickly regaining from the external atmosphere an equivalent amount; in this way it is a carrier of oxygen between the air and the pure metal, and so it is that "rust doth corrupt." There can be no safety until such rust is removed; there should be no toleration of it.

Of quite another nature is the black, blue, or iridescent mill-scale which is formed on the red-hot iron at the mill. This is also an oxide, but is anhydrous, being either the magnetic or, more commonly, the anhydrous sesquioxide, equivalent to the mineral hematite; and the principal objection to painting over it is that its attachment to the underlying metal is not as permanent as could be desired. Its rate of expansion is somewhat different, and if this causes it to come off the superimposed coating comes off with it. It is usual for it to consist of more than one layer, and sometimes of several; in which case the outer part easily scales off from the inner. This anhydrous oxide is insoluble in acid; often the film next the metal is very thin, and instead of peeling off on account of the unequal expansion, it breaks up by microscopic cracks into pieces so small that they are able to yield to small stresses caused by changes of temperature; such a surface is very satisfactory for painting, provided it is taken in time, before rust has begun. The manner in which this kind of scale is thrown off by chemical action is seen when we put it in acid; the latter penetrates the minute cracks and works its way under the bits of scale, which are thus loosened and removed.

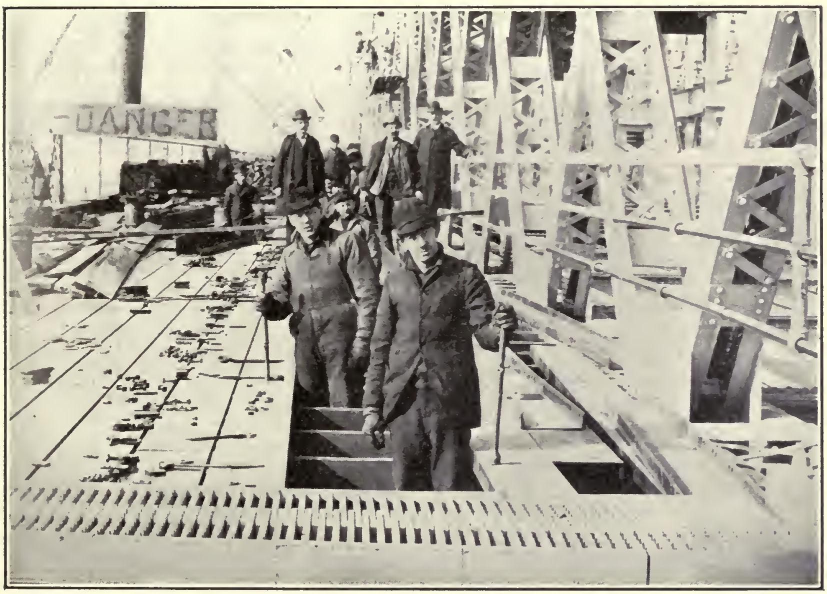
This suggests the treatment which should be given; all loose scale should be removed by mechanical means and painting should be done at once. Every one knows of the permanence of paint marks put on at the mill while the metal is still hot; the paint is melted into a sort of enamel and air and moisture never get a chance to attack the metal. If the latter is partially cooled by a spray of water, as is a common practice, and is then passed through bending or straightening rolls, most of the detachable scale is removed. In England it has been for many years a practice to coat the hot metal at this time, that is at a black heat, with a thin film of oil, which bakes on by the residual heat in the metal; this is done to steel rails and other metal work which is to be sent on a long sea voyage, as to India or Australia, and is found an efficient temporary protection against rust. It might be an excellent first coat, preliminary to painting, on ordinary structural metal; the film is thin, but hard and smooth; if desired, it might perhaps be made of a sort of varnish, and be somewhat thicker.

The floor of the driveways of the Williamsburg bridge is paved with wooden blocks which rest on an underfloor composed of steel channels, 12 inches wide and about 20 feet long, which are laid side by side like a plank floor. These channels were sent from the shop to an enamelling-plant; when received there they were covered with shop-grease and dirt, and were first put into a tank containing a hot 10 per cent solution of caustic soda, to clean them. Next they were dipped in a tank of boiling water; then in hot 10 per cent sulphuric acid; rinsed again in hot water, then put in a hot 10 per cent solution of carbonate of soda, to

Laying the steel underfloor (coated with Sabin Pipe Coating) on the Williamsburg Bridge, N. Y. City.

remove all traces of acid, again rinsed in hot water, dried in an oven, then dipped in a tank of hot varnish enamel, removed, drained, put in an oven and baked at about 400° F. until the coating was hard. They were then taken out and allowed to cool, and were shipped to the bridge. When laid in place there was not a scratch to be seen on more than one piece in fifty; and after they were in place it was two or three weeks before they were protected by the block pavement, during which time the force of employees, numbering six or eight hundred, walked to and fro on them, with wheelbarrows, casks of bolts, and the like; and at the end of this time the coating showed practically no injury. This was observed not only by the bridge engineers, but by visiting engineers from all parts, and was greatly admired. The sidewalks also have a steel underfloor, which was coated in the same way. This was probably the first structural metal (except pipe) which was ever enamelled, and, with the exception of the metal in the anchorages of the old Brooklyn bridge, is believed to be the first structural metal to be cleaned by pickling in the United States. Structural work has been sand-blasted here, and has been pickled in Europe for many years. This work I regard as the most thorough and perfect in the way of protection against corrosion which has ever been done.

Enamelling (by which is here meant the use of a varnish enamel) has been applied to water-pipes for about ten years. In 1893–4 a 38-inch steel-riveted pipe-line, about 28 miles long, was laid to supply the city of Rochester, N. Y., with water. Half of this pipe, about 14 miles, was protected by dipping the sections, which were 28 feet long and weighed up to $2\frac{1}{4}$ tons, in a varnish enamel, designed for the purpose by the writer, and were then baked. These pipes were not pickled; but care was taken that the steel plates should not be rusted, and in rolling such plates into form they are put under great strain and all the scale which can be got off is loosened; they were then carefully cleaned before coating; the enamel was thin, probably not over .003 of an inch in thickness; but the coated pipes stood



Laying steel underfloor (coated with Sabin Pipe Coating) on Williamsburg Bridge, N. Y. City.

the subsequent handling well, and have now been in service ten years. Regular and frequent inspection has shown the coating to be practically as good as when first applied; and in particular it has not afforded a foothold for the growth of aquatic organisms, a source of much trouble in ordinary water-mains. The judgment of the engineer, Mr. Kuichling, who took the respon-

Steel underfloor (coated with Sabin Pipe Coating) ready to receive wood-block pavement, Williamsburg Bridge, N. Y. City.

sibility of applying this coating, has thus been fully vindicated. The following year the pipe-line at Allegheny, Pa., which is nearly 10 miles long and is 5 feet in diameter, was similarly coated; these pipe sections were of $\frac{1}{2}$-inch plate and weighed 5 tons each; the oven had a capacity of 8 sections, or 40 tons, and as much as 64 of these sections, or 320 tons, was the output of a single day of 24 hours. The same year about $4\frac{1}{2}$ miles of 40-inch pipe was similarly treated for Cambridge, Mass.; all this work has been satisfactory.

Since that time the coating has been adopted for salt-water pipes (fire-mains and flushing-mains) by the U. S. Navy Department, and is now specified on all work of this kind on ships of war. By its use the durability of these pipes has been increased from fivefold to ten or twentyfold; and plants for its application have been erected in nearly all the navy yards of this country. Particulars regarding the construction and operation of these plants will be furnished on application by the writer.

In 1902 the company with which the author is connected did some novel and interesting work in making a coating for the wire suspension cables for the Williamsburg bridge. In the past it has been customary to protect such cables by covering them with white-lead putty and winding them with wire; this wire is continuously wound from the towers to the middle of the cable, the winding being as close as possible; this protects the cable from abrasion and makes a very tight covering. But it is well known that putty gets hard and brittle after years of age, and may very likely crack from vibration and changes of temperature; so it is the practice to protect the cables by frequent painting. It is not practicable to cut through the wound-on coating of wire to inspect the interior of the cable, and the engineers of the new bridge decided to use a new method of coating designed in part by us.

Referring back to what has been said about the drying of linseed-oil, and the use of resinous matters as a flux to avoid its gelatinization, it may now be added that while it has for hundreds

Applying Edward Smith & Co.'s materials on the saddles of the cables of the Williamsburg Bridge.

of years been known that oil can, by blowing air through it, or by exposing it in films to the air, be converted into linoxyn, or "oil-rubber," as it is commercially called, this oxidized oil (which is commonly made by allowing the oil to trickle down over sheets of cloth, forming a coating which constantly increases in thickness until it is thick enough to be mechanically removed) is of

Applying Edw. Smith & Co.'s materials on the cables of the Williamsburg Bridge, N. Y. City.

value only for very few and limited uses; it is insoluble in all solvents, and is not fusible by heat; if heated it chars but does not melt; it is therefore a very refractory material to work with. But many years ago the writer made a study of the effects of resinous fluxes on this material, especially to get such a compound as would retain as nearly as possible the good qualities—elasticity and resistance to chemical action—of the linoxyn. Such a compound was made, which could be fused by a moderate degree of heat, yet was quite unaffected by natural changes of temperature; and in the liquid made by melting this, cotton canvas was dipped and saturated, the excess of coating removed as it was drawn from the dip, and when this coated canvas had cooled it was perfectly air and water proof, yet was flexible; and although it was so free from tackiness that it could be rolled up on a spool, yet one layer could be made to adhere perfectly to another by going over it with a hot iron. This coated canvas, in strips about 10 inches wide, was wrapped around the cable, lapping it enough to make in all three thicknesses; and a man with a hot iron (such as is used in asphalt paving) followed the man who served on the canvas and, as it were, welded the whole together into one impenetrable covering.

This may be cut open anywhere at any time for examination, and repaired with more of the same material, as perfectly as the original. The coated cable was finally covered with a sectional tubular steel shield, to which the suspensory ropes are attached.

The compound in question had been known to the writer for several years, and its value and permanence are beyond doubt; but the use of canvas coated in this way was new. It would be impracticable to use an ordinary paint or varnish in this way, because these require the accession of air to oxidize them, which could not be provided; the compound used, being already oxidized, is in a perfect and mature state as soon as it has been applied. Canvas coated in this way may be made to adhere strongly to steel or other metallic surfaces, and no doubt will, if it becomes known, find many uses as a protective coating, as different from paint on the one hand as it is from cement on the other. Not

Applying Edw. Smith & Co.'s coating material on cables of Williamsburg Bridge, N. Y. City.

only is it ready for immediate exposure as soon as it is put on, but it has the strength and resistance to abrasion of canvas, which has long been used to cover the decks of yachts, steamboats, and other vessels, as well as the roofs of street-cars; and the cotton fibre is not subject to decay if kept from the weather, which condition is exactly fulfilled by saturating it with this

Using a hot iron in cementing the cable coating (design and material from Edw. Smith & Co.) on the Williamsburg Bridge, N. Y. City.

compound. It is not anticipated that such a coating will take the place of paint, but may serve for uses for which we have as yet had no satisfactory material. The introduction of a new kind of coating of merit and of practical and industrial availability is of sufficient importance to deserve more than a passing notice. The most serious defect of paint and varnish is the thinness of the film and its consequent inability to resist abrasion; but a heavy cotton duck, weighing before coating three-quarters of a pound to a square yard and upwards, is not open to that objection.

Cleaning bridgework preparatory to repainting it is a matter of great difficulty; but it is of the first importance, as all engineers and all paint manufacturers agree that if it is not well done the application of paint is of little use. The most thorough way is by the sand-blast; this can be accomplished at a cost, probably, of about two cents per square foot. The most important paper on this subject is one by Mr. Lilly, of Columbus, Ohio, in the Transactions of the American Society of Civil Engineers, Volume 50, 1903; but work in this line is being done in many places. It is attended by the inconvenience of dust, which may in considerable part, but not wholly, be obviated by screens of cloth. In isolated places this is of little account. If for any reason this is not thought practicable, it is necessary to thoroughly scrape and then wire-brush the surface. Some bridge gangs are equipped with complete sets of scrapers, some of which are wide, some narrow; most are straight, but some are hooked like a hoe, to be operated by pulling instead of pushing; they should all be long enough to be firmly grasped by both hands, and a hammer and chisel are sometimes useful auxiliaries. In 1903 the Chicago & Northwestern Railroad cleaned their train-shed in Chicago by scraping, after which a considerable part of the surface was washed with acid, which was subsequently removed by alkali; then washed, dried, and brushed before painting. In one of the largest chemical works in the country iron is pickled with rather strong sulphuric acid (the stronger it is, up to say 30 per cent, the more rapidly it acts), then this is immediately neutralized with hot milk of lime, no intermediate washing being done; the milk of lime, made by slaking lime in water, is cheap material, and may

Applying Edw. Smith & Co.'s coating material on cables of Williamsburg Bridge, N. Y. City.

be either rinsed off with water or allowed to dry on and then removed with a brush. This is excellent practice. Iron treated in this way is not so extremely prone to rust as is sand-blasted metal, but of course should be painted with the very least possible delay. The wire brush is certainly a most useful and efficient implement for getting dirt off metal; but it should not be depended on for the removal of scale or thick and strongly adherent rust. In our own factory we have a large rotary wire brush driven by power, which is naturally more efficient than a hand-brush; but even this will not remove anything which adheres very persistently. Thorough scraping should precede brushing. If it is certain that the old paint which was on the bridge was of good quality, which can be easily told at the time of repainting, and if it is in part in good condition, as is sometimes the case. it is not absolutely necessary to remove it; and in fact I think bridges should not be left without painting repairs until the old paint is destroyed. A better way is to keep watch of the structure and when any considerable break appears in the paint let that place be cleaned and repainted. An engineer would not wait until all the bolts and rivets rusted out of a bridge before he began to put new ones in, and I see no reason why all repairs should not be made in the same manner.

Williamsburg Bridge, N. Y. City. Cables, floor, and anchorage metal work protected with Edward Smith & Co.'s coatings. L. L. Buck, Ch. Eng. O. F. Nichols, Prin. Asst. Eng.

Charlestown Bridge, Boston. Wm. Jackson, City Engr. The girders were painted with Durable Metal Coating, the rest of the bridge with Pelagic Enamel, made by Edward Smith & Co., N. Y.

II.

SPECIFICATIONS FOR BEST WORK.

I. All iron or steel, after being shaped, punched, bored, and otherwise made ready for assembling, must be cleaned by the sand-blast or other equally efficient means, so as to show, in all parts, the grayish-white color of the metal.

The cleaning of structural steel work by the use of the sand-blast is probably the simplest and most satisfactory way to have it done. The great objection to this, as to all such work, is the cost. Since there are practically no plants for doing such work in bridge shops—in fact there are no plants for cleaning steel by any process—any engineer who decides to call for thorough cleaning must expect to pay an additional sum for such work, which, if the work be of small extent, will be disproportionately great in comparison with the work actually done; but if the work be of great extent the incidental cost of the plant will make but a small item in the total cost. Plants have been installed since the publication of the first edition of these specifications by several of the railroad companies for cleaning bridges in place, by some municipal engineers, and by some manufacturing works where structural metal is treated. It has been objected that this is a patented process; it is therefore in order to observe that the original patent, under which work of great extent was carried on most successfully for fifteen years, was issued to Gen. Benj. G. Tilghman, of Philadelphia, on Oct. 18, 1870, being No. 108,408, and has therefore expired long ago.

Among the most important claims granted by that patent were the following:

"1. The cutting, boring, dressing, engraving, and pulverizing of stone, metal, glass, pottery, wood, and other hard or solid substances by sand used as a projectile when the requisite velocity has been imparted to it by any suitable means.

"2. The artificial combination of a jet or current of steam, air, water, or other suitable gaseous or liquid medium with a stream of sand, as a means of giving velocity to the sand when the same is used as a projectile as a means of cutting, boring, dressing," etc., etc.

" 7. When a jet or current of steam, air, water, or any other suitable gaseous or liquid medium is employed to give velocity to sand used as a projectile, as a means of cutting, boring, dressing," etc.; " the use of the following devices for introducing the sand into the jet of steam, air, water, etc.: First, the suction produced by the jet of steam, air, water, etc. Second, a strong, close vessel, or sand-box, into which the pressure of the steam, air, water, etc., is introduced, and through which, when desired, a current of it may be made to pass."

It is obvious from the foregoing that there is no existing patent on the process; and while there is some patented apparatus which is preferred by some of the people who use the process, this is equally true of a very large proportion of all machinery in use. The process of cleaning with the sand-blast is essentially as follows: Air at a pressure of 20 to 25 pounds per square inch is furnished by any suitable air compressor. If we assume that we will use a discharging nozzle 9-16 inch internal diameter when new, each such nozzle will require 120 cubic feet of air per minute, measured at atmospheric pressure compressed to show a pressure of 15 pounds per square inch at the nozzle. This is, however, to be regarded as a minimum, for it is advisable to use a somewhat higher pressure, say 20 pounds; and the nozzle rapidly wears away until it reaches a diameter of ¾ inch, at which it will discharge nearly twice as much as when new, so that in practice it is well to provide an air-compressor handling 240 cubic feet of air per minute and compressing the same to 20 pounds per square inch. For four of these nozzles, each connected with a No. 6 Ward & Nash apparatus, an Ingersoll compressor of 24-inch stroke, 22-inch steam, and 22¼-inch air-cylinder was used; and such a plant ought to be supplied with steam from a 150-H.P. boiler. These latter figures are, of course, rough; but from the number of cubic feet of air used and the pressure any one can compute the rest of the plant. It has been found that for the removal of hard, tough scale, a pressure of 35 pounds per square inch is necessary.

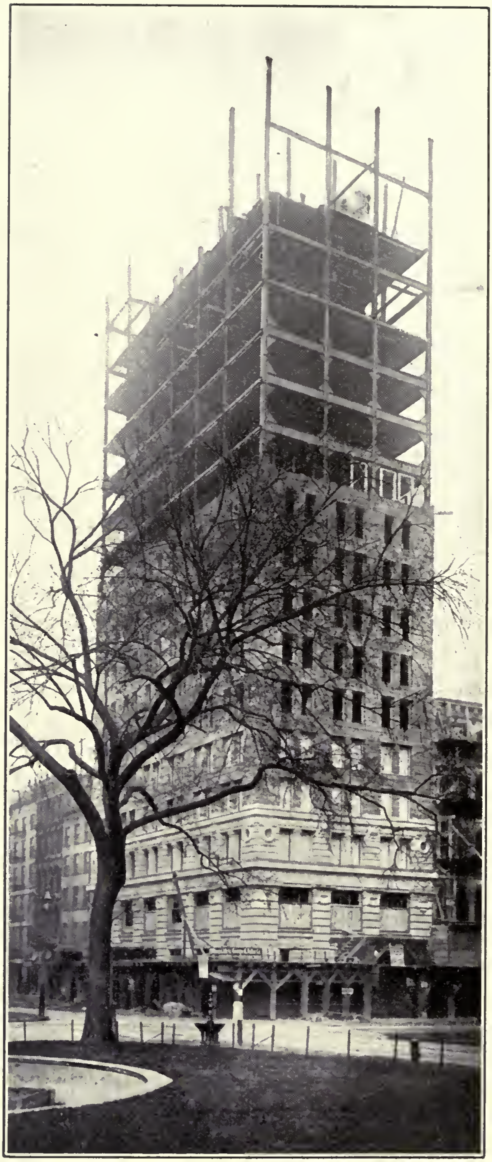
Into this current of air dry sand is introduced at the rate of about 10 cubic feet of sand per hour for each such nozzle, or 1 cubic foot of sand to 1000 cubic feet of air. The sand must be artificially dried. Some operators use coarsely powdered quartz;

this latter can be used five times in succession; and in general the sand may be used until it is broken up into a powder too fine for use. In the plants which the writer has inspected the sand and air are carried to the nozzle through a heavy rubber hose about 2½ inches in diameter. This is not worn away by the current as a metal pipe would be; but it is necessary that the air should not be hot, as this would rapidly injure the hose. The nozzles are short pieces of chilled-iron pipe, and have to be renewed at frequent intervals. From data furnished me by Naval Constructor Bowles I find that the cost of cleaning the bottom of a ship in dry dock amounted to about 4 cents per square foot; but this was done with an experimental plant, and the method of drying the sand, which was used only once, was costly, and the cost would certainly have been reduced to 3 cents per square foot if a permanent plant had been in use. Since the installation of a permanent plant no work has been done of sufficient magnitude to give figures. This was an exceedingly rusty surface; but with this same experimental plant the mill scale was removed from 3,55 square feet of surface of steel plates at a cost of $17.60, or about ½ cent per square foot, and at the rate of 4¾ square feet per minute per nozzle.

Work recently done indicates that bridgework may be cleaned in the field by this process for 2 cents per square foot.

It may be well to add that in all the work referred to, which was practically field work, being carried on out-of-doors and with a somewhat portable plant, the labor amounted to one man to hold each nozzle, one man to attend to each two sand-boxes, and one man to clean up and carry sand for each four nozzles. The supply of compressed air is an expense of a different sort, as is also in field work the matter of staging, etc.; but all are included in the prices given. It seems reasonable to suppose that where many pieces of metal of the same general character are to be treated in a shop fitted up for the purpose, contrivances may be introduced which will do away with a considerable part of the labor.

Iron and steel may also be cleaned by pickling in acid and the subsequent removal of the latter. This may be done in the following manner: The pieces of metal which have been made ready for assembling are immersed in hot dilute sulphuric acid having a strength of 25 to 28 per cent. Some use acid of 20 per cent. It is kept in this until the whole surface is free from rust and scale; this will take from 6 to 12 minutes. If the pieces of metal are somewhat rusty, so that rust has started underneath the



The steel framework of the Broadway Chambers Building, N. Y., was painted with Ebonite Varnish.

scale, the shorter time will be found sufficient; but if it consists of plates covered with closely adherent blue or iridescent rolled scale, the longer time will be necessary, since this scale is itself insoluble in acid and is removed by the latter penetrating the innumerable minute cracks in the scale and attacking the iron underneath, thus mechanically throwing off the scale. If, on the other hand, the iron is uniformly rusty, this coating of hydrated oxide readily dissolves in acid; and in fact a weaker acid of 10 per cent to 12 per cent might be used, although the stronger acid is quite safe, but will require a shorter time. It has been suggested that it is desirable to previously clean the metal with caustic alkali from all grease, etc.; but if acid of the above strength is used and kept as hot as possible this will not be necessary. As soon as the acid has reached the iron in all parts of the surface the metal is taken out and washed by jets of water discharged against it under high pressure, not less than 100 pounds per square inch, and much better if double that. In this way the acid may be thoroughly removed.

In Germany it is said to be customary to use acid of 9 or 10 per cent cold, and the metal is left in it five hours. This makes a much larger plant necessary and has no advantages.

If it is attempted to remove the acid by soaking the metal in still water the following difficulty is encountered: the iron becomes immediately coated with a gummy or colloidal substance very difficult to remove. What this is, is not known to the writer; but it is well known that there are a number of insoluble or difficultly soluble compounds of iron with sulphuric acid, and it is probable that some of these are precipitated on the surface of the iron when water removes the excess of acid; but if a jet of water is used the mechanical effect is to remove the adherent ferrous sulphate at the same instant, leaving a clean metallic surface. It is also possible that if the acid contains arsenic, as is the case with much of the acid made from pyrites, this may also be precipitated on the surface; in fact it is sure to be, and acid free from arsenic should always be used for this purpose, and as a matter of practice it is insisted on by many.

Very successful work is now done by (1) dipping the metal in 10 per cent solution of caustic soda, boiling hot; (2) in boiling water; (3) in hot 10 per cent. sulphuric acid; (4) in boiling water; (5) in hot 10 per cent carbonate of soda; (6) in boiling water; then put in the oven to dry. The process is economical and the results are all that could be desired.

It is often difficult and sometimes impracticable to pickle steel high in carbon, and cast iron containing graphitic carbon, on account of the deposit of a film of carbon, like stove-blacking, on the surface. Muriatic (chlorhydric) acid has been used instead

One of a group of four bridges on the Boston & Albany R.R., all painted with Durable Metal Coating. W. Shepard, Ch. Eng.

of sulphuric; but it is not well suited for the purpose, being much more expensive and difficult to remove. It also forms a gummy coating on the iron, worse than that with sulphuric; and in the subsequent alkaline treatment it must be removed by caustic soda instead of lime, or, better, by a solution of sulphate of zinc.

After the iron has been freed from sulphuric acid in the manner just described, it is put in a bath of lime-water or milk of lime, boiling-hot (it is very important that it should be hot), and left there long enough to reach the temperature of the liquid. It is then removed to an oven and dried, after which the lime is brushed off. If desired the lime may be removed by washing before putting in the oven; in this case it will be found that the surface, which is perfectly clean and bright, rusts very easily and quickly; whereas if the lime is removed by drying and brushing, the surface is much less likely to rust, although even then it rusts easily and should be painted immediately.

For most of the foregoing information relating to pickling I am indebted to Mr. E. G. Spilsbury, who has had extensive experience in this work both in Europe and the United States, and has applied the process to structural steel (bridge) work, as well as to wire and wire rods. Mr. Spilsbury estimates the total expense of pickling and cleaning steel for bridgework in a modern and well-arranged plant at about 25 cents per ton. As to the time when the cleaning is to be done, it may be said that the metal may be cleaned before it reaches the shop at all. This is in one respect a simpler method, as requiring less handling. It is obviously impracticable to do the work of cleaning either by the sand-blast or acid in the shop itself, and the method specified involves the removal of the pieces from the shop and bringing them back. This extra labor is variously estimated by shop owners and managers who have been consulted at from 50 cents to $2 per ton; doubtless some have much better facilities than others; and there will also be a difference of cost in handling light or heavy work. To offset this extra charge, which would be, if we average the estimates of the persons consulted, about $1 per ton, we save the application of a shop coat of oil. The metal will remain in the shop not less than a week, as an average; and it is necessary that it should be protected during that time from rust. The shop men all agree that it will not do to paint it at that time, and that an oil coat is the only thing which is practicable. It is quite well known that raw linseed-oil is much more durable than boiled oil, and if we apply a coat of boiled oil, which will dry in about twenty-four hours, we are in the irrational position of having taken great care to secure a perfect surface and then applied a foundation coat of inferior material.

So we are brought to the necessity of using raw oil; and this will require about a week to dry, during which time the metal certainly ought to be kept under cover. The expense of this

Erie R.R. bridge at Salisbury Mills, N. Y. Painted with Durable Metal Coating.

coat of oil, applied in this manner, is variously estimated at from 50 cents to $1 per ton; and it is pretty generally agreed that the result of this method of doing the work will not be as good as the specified method. For it must be remembered that dry linseed-oil is not a hard substance like a varnish film, but is a gummy substance, which during the shop handling will get dirty with solid matter and with machine-oil, which cannot be removed and must subsequently be painted over; while, if we wait until the shop work is done, all but the assembling, we get the surfaces perfectly clean, and can then apply our shop coat of paint, which will be dry so it may be handled in forty-eight hours; and then when we rivet it up we can apply a second coat of fresh paint to the surfaces to be riveted together, which are by far the most important to preserve, as it is in these and other crevices that most of the dangerous rusting is likely to occur, especially if the work is properly cared for in the way of maintenance. More will hereafter be said in regard to the matter of shop coat of oil.

II. Immediately after being so cleaned, and before any discoloration due to rusting has begun, the material shall be carefully inspected, and upon the approval of the inspector, shall receive one full coat of Durable Metal Coating made by Edward Smith & Co., of 45 Broadway, New York City; except planed and turned surfaces, which shall be coated with Vacuum Flushing Oil and shall be kept so coated until they are erected in place.

In order to carry this section into effect it will be necessary to paint the work at once, within one or two hours of the time when it is cleaned. If the metal has been pickled it will therefore be hot from the oven; it is then in the best condition, for paint spreads better and penetrates crevices when the metal is hot, and there is practically no air film on the metal to be displaced. It is the opinion of many engineers that the best results would be obtained by immersing the pieces of iron or steel in a tank of hot paint, at a temperature of about 175° F., and leaving it there fifteen minutes or more. By doing so all the surface would be reached, and it is probable that such a course would show great economy of labor, which is the most important item of cost in painting. It must be remembered, whatever method is adopted, that the most important matter about this whole work is to get the best possible foundation coat attached as securely as possible to the metal; the subsequent cost of maintenance will be greatly reduced if this is effectively done.

This is the crucial point of the whole work of painting.

III. The metal shall not be exposed to the weather nor taken to the shop until in the opinion of the inspector the paint is sufficiently dry. At no time after the preliminary cleaning shall the pieces of iron or steel be laid on the ground, but shall be laid on skids or trestles, and in all handling and loading and unloading of the same care shall be taken to avoid scraping off the preservative coating; and in transportation care shall be taken to avoid nesting the pieces except with packing material between them.

It is not expected that the work will be held in the paint shop until the paint is thoroughly dry, but only until it has got its initial set throughout; but of this the inspector is to be the judge. It is probable that it will take two days, sometimes three.

IV. After being taken back to the shop all surfaces which are to be there riveted or bolted together are to be cleaned, if necessary, and painted on each such surface with a second coat of said Durable Metal Coating; only such parts of surfaces as are to be thus brought in contact are to be so treated. After riveting, all small cavities which will hereafter be inaccessible shall be filled with a mixture of one part Portland cement and three parts clean sand, with a proper amount of water.

V. After erection the work shall be carefully inspected, and if there are any rusty spots these shall be thoroughly cleaned and all such places and also places where the paint has been rubbed off shall receive a coat of Edward Smith & Co.'s Durable Metal Coating; and all exposed edges and angles shall receive an extra striping coat of the same, covering the edge and the adjacent surface one or two inches from the edge on each side; all rivet- and bolt-heads and nuts shall also receive an extra coat; after this has become dry the whole surface, having previously been thoroughly cleaned from dirt, shall receive another full coat of said Durable Metal Coating.

When paint begins to dry there is at first a sort of skin formed on the surface, which contracts, and on rounded surfaces like rivet-heads, and on angles and edges, seems to press away the liquid paint beneath, so that on such surfaces there is less than the normal amount. The same tendency to contract also exists on flat surfaces, but in this case it is a balanced tension and produces no effect. There is besides the action of the painter's brush, which presses harder on such places and draws off the paint; but that this is not the main cause is shown by the fact that pipe sections and other things which have been coated by dipping exhibit the same appearance. In making paint tests, it is necessary to leave out of account a strip about an inch wide along the edges of the plate, unless that portion has received an extra coat; and the fact is well known to inspectors that such

Drawbridge at Ashtabula Harbor, L. S. & M. S. R.R. E. A. Handy, Ch. Eng.
Painted with Durable Metal Coating.

surfaces are always thinly coated. The extra striping coat is therefore necessary if we are to have two full coats or their equivalent over the whole surface; and it is the more important because these portions are more exposed than the flat surfaces.

VI. In no case shall a second or third coat of paint be applied until the previous one is entirely dry.

VII. During erection any small cavities which will hereafter be inaccessible shall be filled as provided in Section IV.

VIII. After receiving the second coat of Durable Metal Coating, and after the same has become quite dry, the whole structure shall receive two coats of such paint as may be designated and approved by the engineer, the pigment in such paint to consist of two parts by weight of white lead and one part of white zinc, tinted to a designated shade; and the vehicle to be a varnish composed of only hard varnish resins and pure linseed-oil and turpentine, the oil being in the proportion of not less than two parts by weight of oil to one part by weight of the aforesaid resin weighed before melting; and the product to be free from common rosin, benzine, and mineral-oil products; and samples of the paint which the contractor proposes to use for this work shall be obtained not less than one hundred days in advance and submitted to the engineer for examination and approval, and no such paint shall be used unless approved by him, and his rejection of any paint shall be final; and when such sample has been approved, the contractor

must use the paint made by the same manufacturer who made the sample, and the paint must be, when used, exactly the same in every respect as the tested sample and must not be thinned down or adulterated or changed in any way whatever; and it shall be used subject to all the conditions mentioned in the following section.

Section VIII is intended exclusively for structures which must be painted a light color. The only pigments which can be used as a base for light-colored paints are white lead and white zinc; neither of these is regarded as very durable, but their use is absolutely unavoidable. A mixture of the two is regarded as better in many ways than either alone. They may be mixed with good results in any proportion from two parts of lead to one of zinc, to one part of lead to two of zinc; the former proportion is a very common one. They are liable to be adulterated with sulphate of baryta, carbonate of lime (whiting), china-clay and ground feldspar. None of these has any value, and paint containing any of them should be rejected. White-lead paint has a tendency to show a granular surface which will brush off; it "chalks," to use the painter's words; zinc tends to come off in flakes. On this account it is better to use a varnish as a vehicle or binder rather than oil, as the former has more hardness

Forty-inch riveted steel pipe, Cambridge, Mass., 1895. Coated with Sabin Pipe Coating.

and tenacity; moreover, a varnish paint, if made of good materials, is more impenetrable to air and water, and therefore more desirable. But it is important that the varnish should be suited to the purposes. As a rule, the larger the proportion of oil to resin the more elastic and durable is the varnish; but a point is reached when the resin appears to be saturated with oil, beyond

Sixty-inch riveted steel pipe, Allegheny, Pa., 1895. Coated with Sabin Pipe Coating.

which any more oil has a deleterious effect. The exact proportions vary with the kind of resin, and also depend on some other conditions; but in general the most durable varnishes contain from two to two and a half times as much oil as resin, the latter being weighed before melting, during which process it loses about one-fourth its weight. Such a paint will not be required to be perfectly white, being usually tinted to some designated color, and can be sold in large quantities at a price probably not more than 30 or 40 per cent more than a straight lead-and-oil paint will cost; it will be found much more economical. As to testing such a paint, it is absolutely necessary to have a reasonable time, and 100 days is little enough. It would be better to have more. Of course, if it is admissible to leave the structure black this section will be omitted; but in that case, for really high-class work such as these specifications contemplate, a third coat of the protective coating will be advisable. It is expected that the coating of white or light-colored paint will require to be renewed from time to time, while the durable metal coating is depended on for permanent protection.

IX. All paint and Durable Metal Coating used for this work shall be purchased directly from the manufacturer or his authorized agent, and each shipment shall be accompanied by a signed certificate from the manufacturer or such agent, stating that he has, at that time, shipped a specified amount of the specified paint or Durable Metal Coating; and all paint and Durable Metal Coating shall be brought on to the premises where they are to be used in the manufacturers' sealed packages, which shall be opened in the presence of the inspector, who may then, and at any subsequent time, take samples for examination or analysis; and in case any analysis made by direction of the chief engineer shows impurity, adulteration, or substitution in these specified materials, the contractor shall pay all the costs of such analysis, and shall moreover thoroughly clean off all metal coated with such impure or unauthorized material and shall repaint it to the satisfaction of the inspector. And the contractor shall, upon demand, exhibit to the engineer or inspector the bills from the manufacturers or their agents, showing the amount of paint and Durable Metal Coating purchased, and also the certificates spoken of in this section; and neither the paint nor the Durable Metal Coating shall be thinned

Sixty-inch riveted steel pipe, Allegheny, Pa., 1895. Coated with Sabin Pipe Coating.

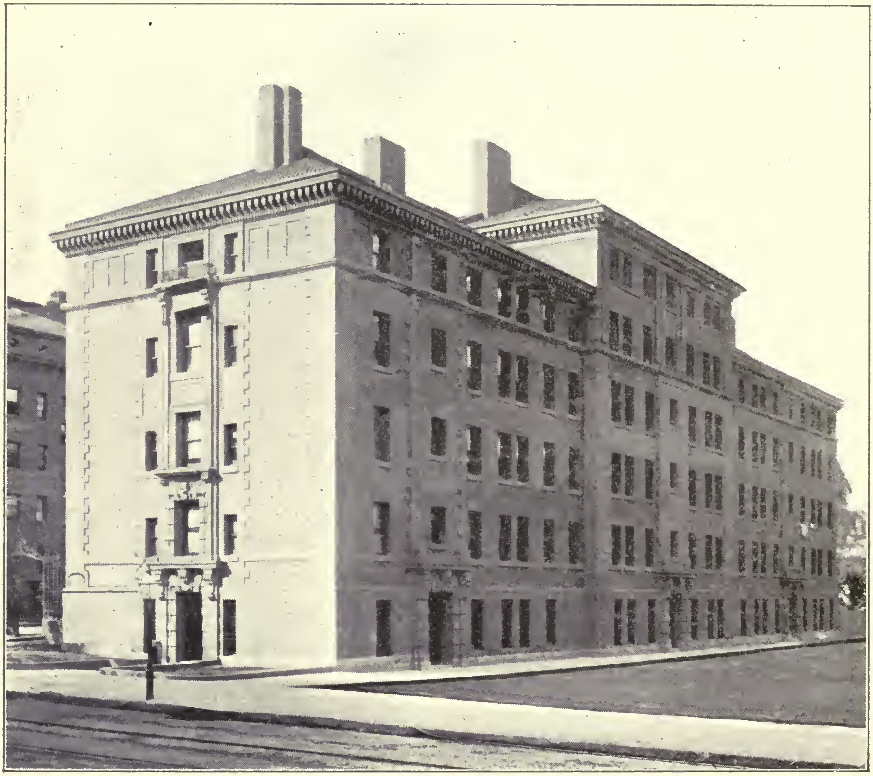
with anything whatsoever, nor shall any turpentine or benzine be allowed upon the premises for any purpose, except by permission of the inspector and in such quantity as he may allow.

X. The inspector shall be notified when any painting, either with Durable Metal Coating or other material, is to be done, and no such work is to be done until the inspector has approved the surface to which it is to be applied; and the contractor shall furnish all facilities for inspection and for necessary marking by the inspector, and all materials, such as paint, brushes, etc., for such marking. No such inspection or marking shall be done except by the engineer or his authorized inspector.

XI. In no case shall any paint be applied out-of-doors in freezing, rainy, or misty weather, and all surfaces to which paint is applied must be at the time dry and clean; and all work must be done in a thorough, neat, and workmanlike manner. If it is necessary, in cool weather, to thin the paint, this may be done only by heating it; and this may be required by the inspector.

The practice of heating paint before it is applied has been followed for a considerable time by some of the best engineers. It is sometimes done by keeping several tin pails of paint in a hot-water tank, kept hot by exhaust steam; or where there is no steam plant it is heated directly over a small oil-stove or other source of heat. If heated from 125° to 150°, which is perfectly safe if the paint contains no benzine—in fact it may safely be heated as hot as boiling water will make it—it flows much more freely, and penetrates the crevices of the work much better. It is indeed likely to make a thin coat, which is objectionable; but the advantages outweigh the disadvantages.

XII. The foregoing specifications shall be accepted and carried out faithfully in every particular and shall not be construed according to any prevalent practice not in full accord therewith.



Fayerwether Hall, Yale University. Edward Smith & Co.'s coatings used throughout on this building.

III.

SPECIFICATIONS FOR ORDINARY WORK.

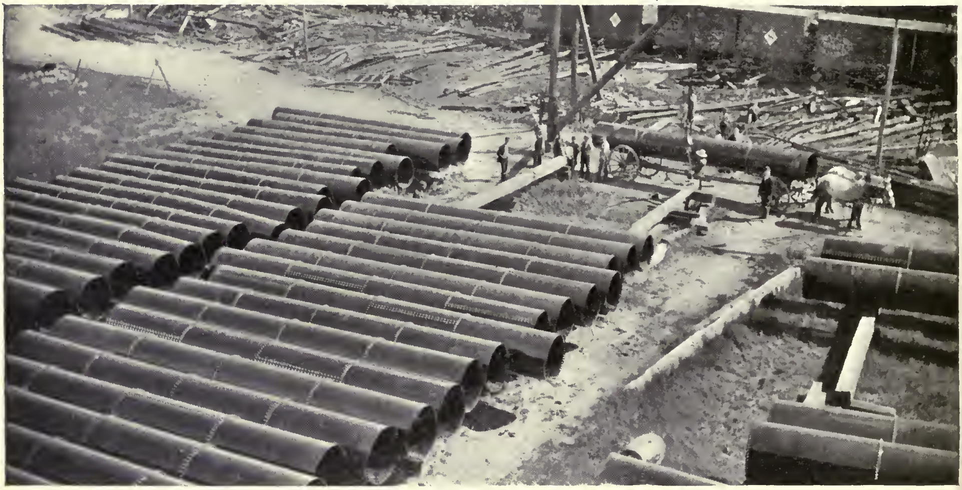
I. Shortly before riveting, all such parts of surfaces as are to be brought permanently into contact shall be thoroughly cleaned from dirt and rust, and from all scale which does not perfectly adhere to the metal, by the use of scrapers, chisels, and wire brushes; the latter alone shall not be considered sufficient. Each such surface shall then receive one full coat of Durable Metal Coating, made by Edward Smith & Co., of 45 Broadway, New York.

The wire brush is an efficient means of getting rid of loose scale and dirt; but it is practically worthless for removing thick rust or anything which adheres closely. Much of such material may be removed by steel scrapers; but deeply corroded spots should be thoroughly cleaned out with a chisel, and then well brushed. These crevices are hereafter to be inaccessible; and they are subject to the most dangerous corrosion, because rusting at such places impairs not only the strength, but also the stiffness, of the structure—a matter of much importance. These joints therefore deserve more care than any other part.

II. Shop-marks shall be compact and shall not cover more surface than the inspector directs, the intent being to have the surface occupied by such shop-marks as small as possible.

III. After assembling, the whole of the metal surfaces shall be thoroughly cleaned in the manner described in the first section, and shall then receive one full coat of said Durable Metal Coating, except planed and turned surfaces and shop-marks; and all planed and turned surfaces shall be coated with Vacuum Flushing Oil and shall be kept so coated until they are erected in place; and all small cavities which will hereafter be inaccessible shall be filled with a mixture of one part of Portland cement and three parts of clean sand, with a proper proportion of water.

Many engineers are in the habit of specifying a coat of either raw or boiled linseed-oil at the shop, instead of a shop coat of paint. The advantages claimed for a shop coat of oil are, first, it facilitates inspection, as the oil is transparent; second, it makes an extra coat; third, the paint is likely to be more carefully applied if used at the place of erection. Doubtless these considerations are entitled to some weight; but many of the best engineers practice shop-painting, which indicates that inspection can be carried on efficiently after the first coat of paint has been applied; and at many shops very excellent painting is done, while the contractor who does the erecting is, so far as my observation goes, extremely indifferent to the paint question. When it comes to the matter of architectural ironwork, we might as well give up the idea of having two coats of paint applied during



Thirty-eight-inch riveted steel pipe, Rochester, N. Y., 1893. Coated with Sabin Pipe Coating.

erection; it takes too much time, and delay is a word not in the contractor's vocabulary when paint is concerned. But another and more important matter is this: If we apply a coat of raw linseed-oil we must allow about a week for it to dry, and it certainly ought to be kept all this time under cover, for fresh oil will wash off to a considerable extent if exposed to rain. If, on the other hand, we use boiled oil, we will have it dry in twenty-four hours; but boiled oil is much less durable than raw, and as this is the foundation coat it is of the highest importance that it should be as durable as possible; and it is much more difficult to detect impurities in boiled than in raw oil. Further, there has grown up among the steel men a belief that the shop coat of oil is only for protection during shipment, and with this has come the practice of applying a cheap and worse than worthless substitute for linseed-oil, composed chiefly of mineral oil, sometimes further adulterated with rosin. This oil will penetrate the paint which is put over it, and as the film of oil is about half as thick as the coat of paint it is equivalent to thinning the latter with half its volume of very deleterious and injurious matter. It is then a question not how much good, but how little harm does the shop coat of oil do. I have no doubt that often a good paint has been a failure because of the shop coat of oil. And if the shop manager cannot be trusted to apply a shop coat of paint I would certainly be afraid of the oil he would use.

It is worthy of note that there is good authority for the following procedure in bridgework: A shop coat of the best raw linseed-oil is applied, and the work is then erected and allowed to stand one to six months, until the oil is supposed to have thoroughly penetrated and with the aid of the weather loosened the scale.

The whole surface is then very thoroughly cleaned (as in Section I) and given two coats of paint. It is claimed that by this means the mill scale is well removed, while rusting has been avoided. There are reasons for thinking this good practice, but it involves watchful care and thorough work.

If it is determined to use oil, the following specification is recommended:

The oil used for this purpose shall be raw linseed-oil of the best quality; shall be permanently clear and settled by aging or storage for not less than thirty days; free from rosin as well as mineral-, fish-, and cottonseed-oils, or any other impurities; shall contain no benzine, turpentine, or other solvent, nor any lead or manganese compounds; it shall be purchased directly from some reputable manufacturer of linseed-oil, and each shipment shall be accompanied by a signed statement from the manufacturer saying that he has, at that time, shipped a specified amount of pure raw linseed-oil of the best quality; and it shall be brought on the premises where it is to be used in the manfacturer's sealed packages, which shall be opened in the presence of the inspector, who may then and at any subsequent time take samples for examination or analysis; and in case any analysis made by direction of the chief engineer shows impurity, adulteration, or substitution in this material, the contractor shall pay all the costs of such analysis, and shall moreover thoroughly clean off all metal coated with such impure or unauthorized oil and recoat it to the satisfaction of the inspector. And the contractor shall upon demand exhibit to the engineer or the authorized inspector the bills and statements from the manufacturer showing the amounts of oil purchased.

In case boiled oil is to be used the word "boiled" would be substituted for "raw" in the foregoing, and omit "nor any lead or manganese compounds."

Unlined steel stack, 310 feet high, of the Nichols Chemical Co., Laurel Hill, N. Y. City. This has stood six years, painted on erection with Durable Metal Coating inside and outside, without repainting.

But the writer of this is of the opinion that a shop coat of oil is in most cases a useless expense (which might far better be applied to a striping coat), and in a large proportion of cases a positive and great injury. Vacuum flushing oil is a very heavy mineral oil, about as heavy as an oil for wagon axles, and has been successfully used for a long time. It appears to be much better than the usual mixture of white lead and tallow, which is not very satisfactory. It is not expensive.

"All *small* cavities." It is not proposed, for example, to fill hollow columns in this way. Large cavities which are liable to be wet should be drained; but this is not a matter of painting.

IV. The metal shall not be exposed to the weather nor loaded for shipment until in the opinion of the inspector the paint is sufficiently dry. At no time after the application of the first coat of paint shall the pieces of iron or steel be laid on the ground, but shall be laid on skids or trestles; and in all handling and loading or unloading of the same care shall be taken to avoid scraping off the preservative coating; and in transportation care shall be taken to avoid nesting the pieces except with packing material between them.

This section calls for shop painting to be done under cover. This is probably the most radical reform called for in these specifications. Few shops have a paint-shop where such work may be done; but while no serious objection can be raised to painting out-of-doors in dry, warm weather, it must be remembered that this kind of work is going on all the year round, and that during a large part of the time the weather is such that it is impossible to do good work outside. It seems to the writer that if this single reform can be enforced, as it is in all other kinds of painting, a great advance will be made in the matter of preserving steel from corrosion.

Incidentally it has the effect of making the painting a distinct step in the shop work, and recognizing paint as proper engineering material. The rest of the section is of the same tenor, and will be found difficult to enforce, not because it involves any hardship or much expense to the contractor, but because steel is handled in a slovenly and careless manner, being usually thrown off wagons or cars into the mud; and inspectors have really very great difficulty to get the mud cleaned off, or even to have a pretence made of cleaning it off, before the second coat of paint is applied. The reform needed is a change of the spirit in which the work is done, and must lead to a recognition by all, from the owner to the humblest laborer, of the fact that steel is a perishable material the preservation of which is a matter of serious and constant importance.

V. After erection the work shall be carefully inspected, and if there are any rusty spots these shall be thoroughly cleaned, and all such places and also all places where the paint has been rubbed off shall receive a coat of Edward Smith & Co.'s Durable Metal Coating; and all exposed edges and angles shall receive an extra striping coat of the same, covering the edge and the adjacent surface one or two inches from the edge on each side; all rivet- and bolt-heads and nuts shall also receive an extra coat; after this has become dry, the whole surface, having previously been thoroughly cleaned from dirt, shall receive another full coat of said Durable Metal Coating.

Steel stack, 200 feet high, of the Philadelphia Smelter, Pueblo, Colo. Painted with Durable Metal Coating.

VI. In no case shall a second or third coat of paint be applied until the previous one is entirely dry.

It is proper at this point to call attention to the fact that some engineers specify that successive coats of paint shall differ in color; some advise this on the ground that it makes it easier for the workmen to see if they are missing any places, and anything which makes painting easier is likely to be advantageous; others say it facilitates inspection and enables the engineer to find out for himself if the required number of coats has been applied. On the other hand, some say there is no difficulty in distinguishing fresh paint from that a day or two old—that, in fact, any inspection worthy of the name will determine whether the work is properly done without regard to this, while competent inspection of bridges cannot be done from the platform of a railroad car. Some of the most experienced and careful engineers specify paints of different colors for different coats, but others of equal standing do not approve of it; as a result of extended personal inquiry I am satisfied that a great majority belong to the latter class, and as I myself hold this opinion I have not specified such difference in colors, but only call attention to the matter, so that those who wish may insert an article to that effect.

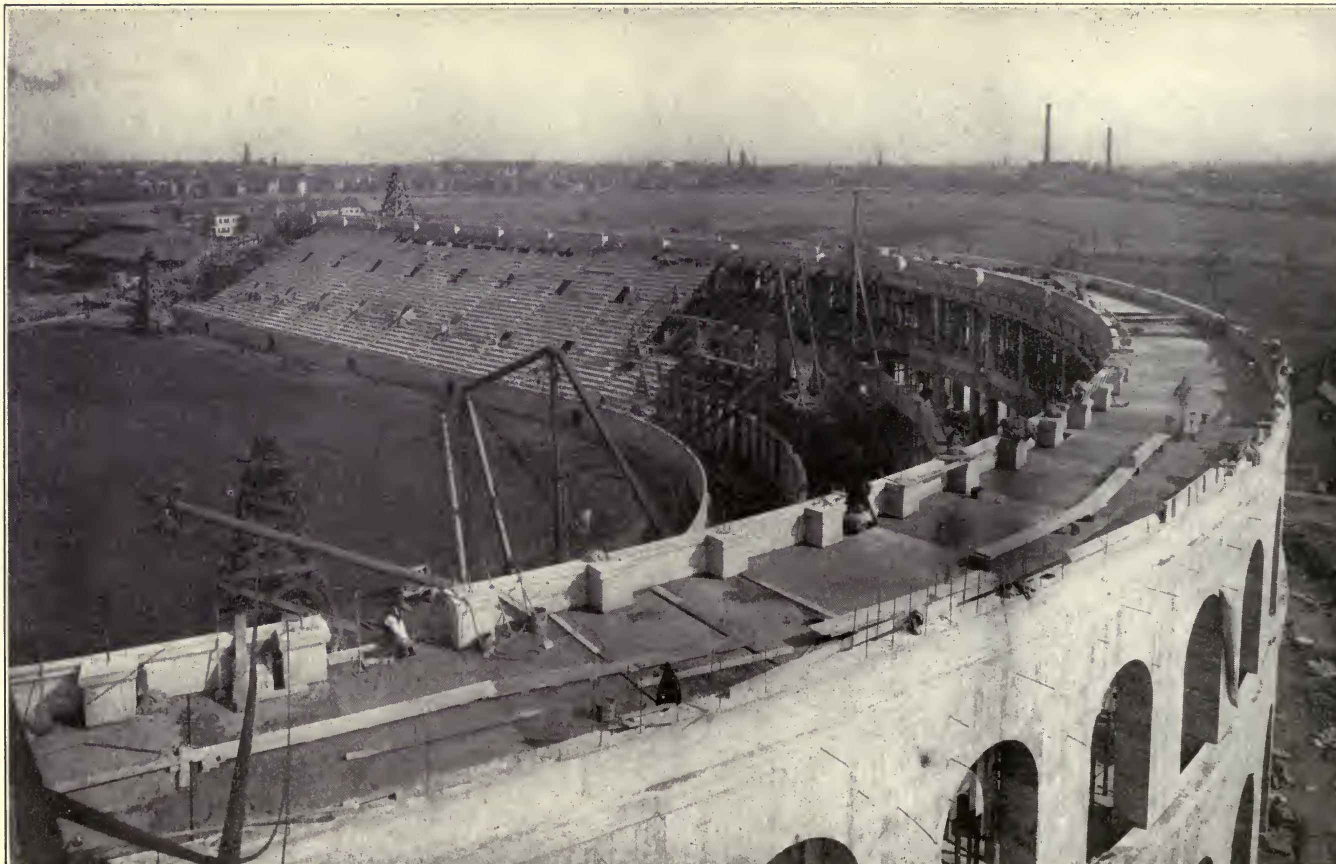
VII. During erection any small cavities which will hereafter be inaccessible shall be filled as provided in Section III.

VIII. All Durable Metal Coating used for this work shall be purchased directly from the manufacturer or his authorized agent, and each shipment shall be accompanied by a signed certificate from the manufacturer or such agent, stating that he has, at that time, shipped a specified amount of the Durable Metal Coating; and all Durable Metal Coating shall be brought on to the premises where it is to be used in the manufacturer's sealed packages, which shall be opened in the presence of the inspector, who may then, and at any subsequent time, take samples for examination or analysis; and in case any analysis made by direction of the chief engineer shows impurity, adulteration, or substitution in these specified materials, the contractor shall pay all the costs of such analysis, and shall moreover thoroughly clean off all metal coated with such impure or unauthorized material and shall repaint it to the satisfaction of the inspector. And the contractor shall, upon demand, exhibit to the engineer or inspector the bills from the manufacturers or their agents, showing the amount of Durable Metal Coating purchased, and also the certificates spoken of in this section; and the Durable Metal Coating shall not be thinned with anything whatsoever, nor shall any turpentine or benzine be allowed upon the premises for any purpose, except by permission of the inspector and in such quantity as he may allow.

IX. The inspector shall be notified when any painting is to be done, and no such work is to be done until the inspector has approved the surface to which it is to be applied; and the contractor shall furnish all facilities for inspection and for necessary marking by the inspector, and all materials, such as paint, brushes, etc., for such marking. No such inspection or marking shall be done except by the engineer or his authorized inspector.

X. In no case shall any paint be applied out-of-doors in freezing, rainy, or misty weather, and all surfaces to which paint is to be applied must be at the time dry and clean; and all work must be done in a thorough, neat, and workmanlike manner. If it is necessary in cool weather to thin the paint, this may be done only by heating it, and this may be required by the inspector.

XI. The foregoing specifications shall be accepted and carried out faithfully in every particular and shall not be construed according to any prevalent practice not in full accord therewith.



The Harvard Stadium, during erection; reinforced concrete, with steel beams for support. It encloses a football-field 481 × 230 ft.; seating capacity about 35,000. Prof. L. J. Johnson, engineer. All steel work protected with Durable Metal Coating.

IV.

SOME ANTI-CORROSIVE COATINGS.

Edward Smith & Company manufacture all lines of such varnishes as are used in structural work, as well as varnishes for carriages, railway coaches, yachts, and the like; but besides these they have for many years made a special business of making protective coatings to prevent the corrosion of iron and steel in bridges, train-sheds, water-tanks, and mains, and in fact all work where metal is exposed to risk of corrosion. There is no one material which is best for all places; and they maintain a chemical and testing laboratory, well equipped, and their officers are in a position to offer intelligent and expert advice on almost all questions of this sort, and to make special preparations for unusual conditions. This is now so well known that they are consulted as experts by many engineers of the highest repute.

Durable Metal Coating.

This is the best known and most popular of these anti-rust preparations made by this company, and the following is a brief account of its qualities and uses.

It is an oleo-resinous varnish, of the highest durability and elasticity; it is black in color. When dry it is not affected by nor does it affect any paint put on over it; it is therefore practicable to use paint of any color as a finishing coat if desired. Two coats of white zinc or white lead cover well, and if the desired color is of a neutral or dark shade one coat is often sufficient. If it is desired to throw it off color only a little, the painter may add to it pigments either dry or ground to a paste in oil; for example, a bronze-green suitable for certain ornamental ironwork in parks, etc., may be had by adding a little chrome green, or olive by medium chrome yellow. For engineers who desire to use different colors in successive coats, we will make it in dark green, chocolate-brown, or olive, if the order is of considerable amount. Used without the addition of any color it gives a very handsome and permanent black finish to iron and steel, which is generally liked, black being commonly regarded as a natural

Steel beams (painted with Durable Metal Coating) of the Stadium, Harvard University. Prof. L. J. Johnson, engineer.

and proper color for iron. Most of it is used in this way.

One gallon will cover from 300 to 400 square feet, according to the character of the surface. If the latter is very rough, owing to corrosion, it may not cover more than 250 square feet the first coat, because in that case it acts as a filler, but it will cover more than 300 square feet for the second coat. There is not a great difference in the amount of surface covered by different paints, if the surfaces are alike in material and smoothness, because all paints and varnishes are made up to a certain conventional standard of viscosity, suitable for working with the brush; and any paint or varnish made for general use must be modified if used in an unusual way, if applied by dipping, for example; and a skilful painter may make any structural paint cover 500 or 600 square feet by spending enough labor on it brushing it out thin; but this is practically not done because the labor costs more than the paint, and theoretically it never should be done, because such a coating is too thin to afford sufficient protection. For decorative effect thin coats are best; for protection they should be as thick as can be applied uniformly and lie smoothly.

Paints may be made to cover more surface if they are made very thin with benzine or turpentine, but are then of little value.

Durable Metal Coating is supplied ready to use, and must not on any account be thinned with anything. It is a perfect liquid, containing no pigment, does not require stirring, and can be used to the last drop in the barrel. It contains no coal-tar, no naphtha or other coal-tar product; no benzine or any petroleum derivative; no rosin or rosin-oil; no materials but the purest and best for the purposes for which it is made. It is usually sold in barrels, but will be put up in packages of any size, smaller packages being charged extra at the usual rates. It may be shipped to India and other hot countries in 100-gallon drums, or in sealed cans, if barrels are not thought suitable on account of the climate.

It is not necessary to have skilled labor for its application, unless it is to be used as an ornamental coating, as it sometimes is. If it is necessary (as often happens) to use it out-of-doors in cold weather, it may be heated to make it more fluid. Thou-

Pierce Hall (Engineering building), Harvard University. Steel framework painted with Durable Metal Coating. Prof. L. J. Johnson, engineer.

sands of gallons have thus been treated by the Northern Pacific Railroad Company and others; as it contains no benzine it is perfectly safe to heat it to as high a temperature as it is reasonable to subject the bristle brushes which are used in applying it—say to 150° F.

It is commonly estimated to require about thirty-six hours to dry so that it may be handled, and from three or four days to two weeks for it to dry through. It does, however, continue to harden for at least two weeks, and in cold or wet weather it may require more than thirty-six hours before it may be handled, while in hot, dry weather it has been known to dry to this extent in from eight to twelve hours.

Pierce Building (for engineering), Mass. Institute of Technology. Steel framework painted with Durable Metal Coating.

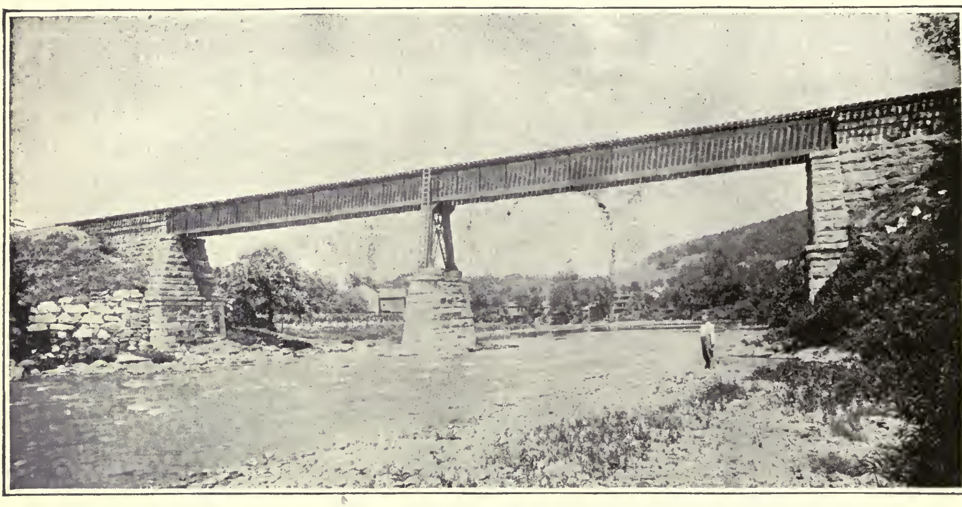
A second coat should not be applied in less than three days and a week or ten days is much better. In fact, in bridgework it is good practice to allow two to four weeks between coats, with any kind of paint. But if it can be dried by heat, as is the case with much ornamental ironwork and with small objects generally, it will dry in two or three hours at 200° to 250°. It dries by oxidation, and heat accelerates this process. If it is impossible to allow a sufficient time between coats, we advise the use of our Ebonite varnish for a first coat, which dries much more quickly.

We do not give any guarantee of performance. No reputable manufacturer can afford to do this, not knowing the character of the surface to which the paint is to be applied, the intelligence of the man who applies it, the treatment it is to receive, or any of the many things which affect the durability of a paint or varnish. If the reader will take the trouble to look up with the aid of any of the commercial agencies the standing ot the paint manufacturers, he will find that no one having a considerable rating offers a guarantee which amounts to anything; sometimes, to effect a sale, a guarantee is offered, but careful examination will always show that it is so protected by restrictions that no real guarantee is given. In general, no paint guarantee is good for anything except a contract to keep a structure painted a specified time for a certain sum of money. The curious investigator will also notice that some of the concerns which give recommendations for certain paints are not mentioned in the books of the commercial agencies; and that sometimes pictures of structures are sent out with advertising matter which were not painted with the advertiser's material; it is not expressly claimed that they were so painted, but the obvious intention is to make the public believe it. There are plenty of reputable paint manufacturers, and it is not necessary to do business with tricksters.

Edward Smith & Co. wish to call attention, especially on the part of architects and engineers, to the fact that it is desirable to specify "Durable Metal Coating made by Edward Smith & Co. of 45 Broadway, N. Y.," because at least one concern has sent its agents around to our customers offering to sell them a paint under the same name and guaranteed "equal to Smith's," at prices varying from 90 cents or $1.00 per gallon, in the case of architects, to as low as 12½ cents a gallon to the large steel companies. This paint was not worth 12½ cents per gallon, and will not be satisfactory to people who want Edward Smith & Co.'s goods; and it has been used when the latter were specified. Therefore take warning.

While we strongly recommend thorough cleaning of all surfaces which are to be painted, we do not wish to be understood as meaning that our paint cannot be applied to any but a clean metallic surface. It has been and is constantly being used as a protective coating over red lead (on the ground that the good qualities of the latter depend on its protection from the atmosphere); and there is no serious objection to using it over old paint which is in good condition and adheres well.

Durable Metal Coating has a considerable use in railroad work. The bridge at Eagle Bridge, N. Y., consisting of two plate-girder spans aggregating about 200 feet in length, was painted with two coats of this material when erected, in 1893; it gets all the refrigerator drip from the east-bound trains of the Fitchburg R.R.; it has not been repainted, even in part,



Eagle Bridge, N. Y. Painted with Durable Metal Coating.

and is now (1905) in excellent condition. Now, it is impossible to make a paint which will stand refrigerator drip ten or twelve years unless it is carefully and thoroughly applied to new or clean metal, under favorable conditions; and any good paint thus applied will give better than average results; but it is beyond question that a paint which has stood as long as this, and is apparently good for many years yet, must be of exceptional quality.

To take another case: In 1896 the large train-shed of the Illinois Central R.R. in Chicago (which is also used by the Michigan Central) was painted inside with Durable Metal Coating, two coats. This was a repainting job; the paint originally used had perished, and was thoroughly cleaned off by scraping and wire-brushing before the application of our material. This stood all right without repairs for six years; at the end of which time the exterior of the shed was being painted with Durable Metal Coating, and a third coat was then put on the interior; no scraping was necessary, only ordinary cleaning with brushes; the 1896 paint was all right, but the additional coat was applied over the others. It is now in excellent condition. This is both a terminal- and a through-train shed, 670 by 140 feet, and the test is a severe one. Its fine condition was one reason why the Chicago

& Northwestern R.R. painted their large train-shed at their main station (Wells Street) in Chicago, in 1903, with Durable Metal Coating. This is the only C. & N. W. structure of considerable importance, so far as known to the writer, which is painted with anything but the C. & N. W. standard paint made in the shops of the railroad company; it was adopted without solicitation, and after careful investigation by the officials in charge of the work.

The Illinois Central has used thousands of gallons of Durable Metal Coating for bridgework and are still using it, especially for first-coat work, at the bridge shops. A large amount has been used on the Northern Pacific and other roads in the Northwest; this was probably the reason that caused the Canadian Pacific R.R. to use it on their train-shed at Montreal and elsewhere; they were never asked to use it.

Another thing for which Durable Metal Coating is used is for painting wire cables of electric wires, such as are used for block-signal lines and the like. The New York Central R.R. has used

Highway Bridge at Albany, N. Y. Painted with Durable Metal Coating. Stowell and Cunningham, designers.

some thousands of gallons for this purpose; and the Western Union Telegraph Co. has used considerable quantities of it for many years. It is also used by the Postal Telegraph Co. on cables and other work. It has proved satisfactory for painting all sorts of exposed work for telegraphs and electric light and power, such as metallic poles, cross-arms, and the like. For all

Train-shed of the Wells Street Depot of the C. & N. W. R.R., Chicago. Painted, 1903, with Durable Metal Coating. E. C. Carter, Ch. Eng. W. H. Finley, Prin. Asst. Eng.

such uses it is better than an oil paint, because, for one thing, it contains no pigment; most sorts of pigment are conductors of electricity, and the better insulator a coating is the less likely is rusting to be set up, particularly on metal which is more or less charged with electricity. The metal work of steel-frame buildings is essentially similar to bridgework, and many of the finest structures of this sort in the country have been protected with this coating. If it is necessary to use a more rapid drying material our coating called Ebonite is recommended.

For painting water-towers and tanks for drinking-water it is unequalled. It is generally admitted that lead paints are not suited for such uses, because of the possibility that the lead may be dissolved in the water; in this varnish there is nothing which can be dissolved, nor that would be objectionable if it were dissolved. It is particularly liked for painting tanks for water on ships and yachts; it never becomes loosened by the vibration of the boat. In his annual address one of the presidents of the New England Water Works Association mentioned it as the best coating for water-towers; a great many of them have been painted with it, and we have yet to have the first complaint. It has also been used for ten years on both steel and cast-iron water-mains, with satisfactory results.

It is well adapted for painting metal roofs. It is well known that new tin or galvanized-iron roofs are difficult to paint; this is because in making the sheets of coated metal they receive a closely adherent thin film of such sort that paint of any kind will not adhere to it; the remedy is to thoroughly clean by scrubbing with soap and water, and if greasy by rubbing with coarse cloths wet in benzine. If the roof is very thoroughly cleaned any paint will stick on it. Durable Metal Coating is extremely water-proof and permanently elastic, and is in every way a good roof paint.

Windsor Street Station, Montreal, of the Canadian Pacific R.R. Train-shed painted with Durable Metal Coating.

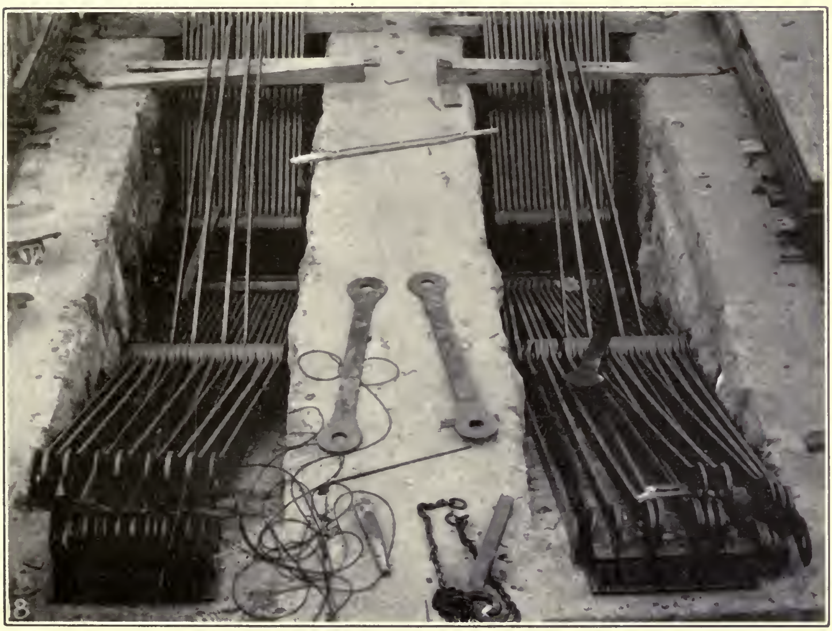
As it stands high temperatures well, it is suitable for painting smoke-stacks, steam-pipes, and the like. No organic material will stand a heat much in excess of 400° F.; beyond this it is more or less rapidly burned off; but this coating bakes to a sort of enamel with any reasonable temperature, and is a very perfect coating. It is not affected by acid gases and is extensively

Eye-bar chains in the anchorages of the Williamsburg Bridge. Protected with Ebonite Varnish.

used about chemical works; the chief cause of deterioration of paint in such places is the action of acids on the pigment which constitutes a large part of an ordinary paint; as this does not contain any pigment it is not affected.

It stands well over sea-water, not being readily affected by the spray; but we do not recommend it for use under the surface of sea-water. If Durable Metal Coating is to be used on decorative work, it must be brushed out thin; otherwise it will wrinkle. If it is brushed out thin it dries more rapidly, which is an advantage for this kind of work; but enough coats must be applied to make a substantial film. If treated intelligently in this way it has been a most satisfactory material; for example, it was thus used on the ornamental ironwork of the Delmonico building, by John Williams, well known as a leading manufacturer of bronze and iron ornamental work, in whose shops it has long been used. But it must not be forgotten that a very thin coat of the best material will not long stand exposure to the weather; enough must be used to ensure protection.

Ebonite Varnish.—This is a preparation which differs from Durable Metal Coating by containing less oil in proportion to the resinous material; it dries more rapidly on that account, and its drying is greatly increased by the fact that as it contains less oil and would therefore be less fluid it is necessary to make it contain more turpentine; and a large proportion of turpentine makes a varnish dry quickly. It is subject to the objection that it makes a thinner film than the other; but besides the advantage of quicker drying it naturally resists alkalies better because of its large proportion of resinous material; this latter being unaffected by alkali. Where the coating is to be in contact with hydraulic cement this is an important advantage. The entire metal work in the anchorages of the Williamsburg bridge, connecting New York and Brooklyn, was painted with several coats of this compound; and its good condition several years



Eye-bar chains in the anchorages of the Williamsburg Bridge, N. Y. City. Protected with Ebonite Varnish.

later was undoubtedly one reason why the equally important task of making a coating material for the cables of that great engineering work was entrusted to our company.

Another instructive instance of its use in contact with cement is afforded by a paper read before the American Institute of Mining Engineers in February 1904, describing the dust-flues at the smelter in Leadville, Colo., built in 1898 and still in good condition. The engineer of construction said:

"In regard to the effect of sulphur dioxide and furnace-gases on the cement, I have found that in certain cases this is a matter which must be given very careful attention. When there is sufficient heat to prevent the existence of condensed moisture inside of the flue, there is apparently no action whatever on the cement, but if the concrete is wet, it is rapidly rotted by these gases. At points near the furnaces there is generally sufficient heat not only to prevent internal condensation of the aqueous vapor always present in the gases, but also to evaporate water from rain or snow falling on the outside of the flue. Further along a point is reached where rain-water will percolate through minute cracks caused by expansion and contraction, and reachs the interior even though internal condensation does not occur there in dry weather. From this point to the end of the flue the roof must be coated on the outside with impervious material. In very long flues a point may be reached where moisture will condense on the inside of the walls in cold weather. From this point to the end of the flue it is essential to protect the interior with an acid-resisting paint, of which two or more coats will be necessary. For the first coat a material containing little linseed-oil is best, as I am informed that the lime in the cement attacks the oil. For this purpose I have used Ebonite varnish, and for the succeeding coats, Durable Metal Coating."

Ebonite is particularly serviceable for work on steel-frame buildings, especially where haste is unavoidable. It dries so that it may be handled in a few hours, and two coats may be applied in a day; but the rapidity of drying is somewhat more apparent than real; what really happens is that it takes an unusually hard preliminary set, and the final permanent drying is about as slow as that of Durable Metal Coating. Having had it in use about ten years, we do not hesitate to recommend it.

Edward Smith & Company have made a great variety of special protective and decorative coatings for particular uses. For instance, in a case where it was desired to paint a highway bridge a certain color, they made a varnish enamel paint especially for that bridge. This was made with a special varnish, adapted to resist the action of the weather and to protect the iron; some varnishes do not act well on iron, and no ordinary varnish will permanently resist the weather in such a place as a bridge over sea-water. This was the bridge connecting the city of Boston with Charlestown, the one on which the elevated railway crosses; and it is subjected to very trying conditions, being exposed to smoke from tugs and other vessels, to fog and spray from sea-water, and great extremes of rapidly varying temperature. After five or six years' use, during which time not the least repainting has been necessary, the condition of the surface is such as to constitute the best sort of a recommendation for the paint. This is one of the largest and most important structures of its kind in the country; and when we consider the high grade of municipal work done in Boston, the fact that the coating is satisfactory to the engineers for the city is enough to recommend it.

The baked enamel coating of our invention which has been so successfully applied to pipework and, as described in the first part of this book, to the floor of the Williamsburg bridge, and the special coating made for the cables of that structure, are other instances of our special work. It may be confidently stated that no other company has done anything like as much of this difficult special work, or has the scientific and technical equipment and experience to successfully carry it out. This is a consideration which should properly influence engineers and architects in the choice of material.