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RUSTPROOFING PROCESSES



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RUSTPROOFING PROCESSES

A TREATISE ON THE APPLICATION OF
PROTECTIVE PAINTS AND VARIOUS ZINC-
COATING AND CHEMICAL PROCESSES FOR
RESISTING OR PREVENTING THE COR-
ROSION OF IRON AND STEEL

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RUSTPROOFING PROCESSES

CHAPTER I

CORROSION OF METALS AND USE OF PROTECTIVE PAINTS

WHEN we consider the rapidity with which iron, steel and other metals corrode under ordinary conditions, with the resultant expenditure of many millions of dollars annually for depreciation and expense of renewals, we see that the problem of metal corrosion is one of great importance to the metal trades. This question also interests people in general, because the security of life depends, to a large degree, on the durability and safety of structures and machines.

What is corrosion? Everyone has noticed the reddish-brown deposit that gathers on the surface of iron and steel that has been exposed to the air—particularly damp air. This reddish substance is called “rust” by the ordinary person, and is composed principally of oxide of iron, which is formed of two parts of iron and three parts of oxygen. The iron and the oxygen from the air unite in such a way that they cannot be separated without resorting to a process equivalent to smelting. Oxide of iron has great attraction for water, so it absorbs moisture from the air. The corrosion of iron or steel is the iron oxide combining with water. The result is similar in composition to iron ore, which is smelted and reduced to iron in a blast furnace. Corrosion of metal is often spoken of by workmen as the “eating of metals;” by scientific men it is called “oxidation.”

Corrosion takes place first on the surface of iron and steel and follows the path of least resistance. It does not take place evenly over the surface of the metal. Sometimes it will penetrate a plate before attacking the adjacent surfaces. This is due to the fact that corrosion varies as the material in the metal and the treatment the metal receives in the iron mill. For example, the more porous the metal the more rapidly it will corrode. Blow-holes furnish a splendid foundation for corrosion, as do also such impurities as slag, scale or segregated parts of the metal. This is the reason why it is impossible to tell just why one piece of metal will corrode more quickly than another piece of the same kind.

Corrosion takes place faster in the presence of acids than under ordinary conditions. Corrosion therefore proceeds more rapidly after a thunder shower, when the lightning has changed part of the nitrogen of the air into nitric acid. Alkalies seem to retard corrosion. Certain impurities, such as carbon, silicon and phosphorus, have a tendency to resist corrosion; hence cast iron does not rust rapidly in air, while other impurities, like manganese and sulphur, tend to increase corrosion. Steel corrodes according to the amount and condition of carbon in it. It is known that steel may contain carbon in either a free or a combined condition. That is, the carbon may be present in steel in the form of graphite, when it is called free carbon; or it may be united with the iron in such way that it cannot be separated, when it is called combined carbon. The free carbon prevents corrosion. When corrosion once sets in, it increases progressively. It is 50 per cent more rapid during the second than during the first year. This is due to the fact that in the process an acid is formed which tends to increase the rate of corrosion. For this reason corrosion should not be allowed to continue, or even begin.

Rust Prevention by Painting. Structural steel is generally protected from rust by painting. A rust retarding coat of paint may be suitably compounded from red lead

mixed with pure linseed oil. The average stock mixture consists of from 25 to 30 pounds of red lead to a gallon of oil. This mixture can be reduced to the proper consistency at the time of application. A small amount of turpentine added to this brush coating will greatly assist in its manipulation, and will also provide for proper penetration. Red lead should be mixed at the time of its application, as it settles quite readily, being an extremely heavy pigment. It appears to be a general opinion that linseed oil is not a desirable material for the prime coating of metals, when used without the addition of pigments. A foundation coat of linseed oil is very often the direct cause of peeling and blistering of the other coatings applied over it.

Paints containing the same kinds of pigments as are used for shop coatings can be successfully used for the first field coat, providing it is covered with another elastic outer coating. Otherwise, paints suitable for finishing coats should be applied, and the first field coat omitted. Red lead or oxide priming should be darkened for this coat by adding carbon or lampblack in the proportion of from 90 to 95 per cent of the red lead and from 5 to 10 per cent of carbon mixed. Carbon, lampblack, and graphite pigments, singly or mixtures of them, have given the best satisfaction as outer surface and finishing paints. These pigments, combined with some inert and reinforcing pigments according to special formulas, form the basis for nearly every satisfactory brand of metal paint on the market. The addition of some high-grade gum, like Kauri, improves a finishing paint greatly, producing more elasticity, resistance, and life. It is just as important that the oils entering into the make-up and composition of the various paints are of the proper kind and quality, as that the selection and composition of pigments be properly made. Paints containing tar, or those with a tar base, should not be used on steel structures exposed to the sun and weather conditions, as tar-paint films rapidly check, crack, and "alligator."

Repainting. When, for any reason, it becomes necessary to repaint an iron or steel structure, the paint should never be applied in wet or freezing weather, and the surface should be freed absolutely from all scale, rust, dirt, etc. When, however, it is not possible for the entire structure to receive a coat of some rust-retarding primer, the parts that have been cleaned and freed from rust, and all the exposed surfaces, should be touched up with either a red-lead or oxide primer before the finishing coat is applied. The use of turpentine in the paint applied over the old surface is advisable, as turpentine provides for the adhesion between the old paint film and the new coat.

Although more expensive, cleaning by sand-blast is much more thorough than the hammer, chisel, scraper, and wire-brush method, and the greater cost is readily offset by the better results obtained. Where the sand-blast has been used and the steel has been painted promptly, it has not shown signs of corrosion nearly as quickly as steel cleaned by hand.

Preparing Surfaces for Painting. In preparing iron and steel surfaces for painting, many different methods have been developed for removing rust and preventing future rusting. Painting is only a temporary means for preventing iron and steel from rusting, as rust forms on the metal beneath the paint. Consequently some treatment is necessary preparatory to painting to provide a permanently rustproof coating.

Three methods, which have been commonly used in the past for preparing steel for painting, and which are still used to a considerable extent are: (1) Washing or scrubbing the steel surface with gasoline or other oil solvent; (2) washing the surface with soda or other alkaline compound; (3) sand-blasting. Each of these methods, however, has certain disadvantages when applied in practice.

Gasoline, or other solvent for oil, mechanically removes the loose particles adhering to the surface to be cleaned, as well as part of the oil, but it does not remove all of the rust that has formed on the steel. Emery cloth may be

used in connection with the gasoline for rubbing off the rust, but this treatment merely exposes the steel to the atmosphere, thereby making it likely to rust again rapidly.

Alkaline compounds, such as soda, remove greases and oil, but do not remove rust, and after a steel surface has been treated with a soda compound, sufficient amounts of this compound are generally left on the steel to form a thin strata of soap between the paint and the metal. In this strata, the acids are neutralized, but the salts left behind have strong inclinations to produce rust, and the surface is not left in what may be called a "passive" condition.

The sand-blasting process removes rust, oil, and grease, because it removes the entire surface of the metal and, hence, all objectionable materials that cause rust; the process, however, is not entirely satisfactory, because it leaves the surface of the steel exposed and the metal, therefore, will rust rapidly. What is required is a method that will produce a surface that has no tendency to rust. The deoxidine process, which is used by the Hudson Motor Car Co., Detroit, Mich., in preparing the steel bodies of its passenger cars for painting, is claimed to meet these conditions.

The Deoxidine Process. Briefly described, the deoxidine process consists in washing or rubbing over the steel surface with deoxidine, a liquid consisting of a mixture of alcohol, phosphoric acid, and water; and then washing off the deoxidine with water, after which the surface is dried and ready to paint.

When the car bodies arrive in the plant of the company, they have been more or less exposed to atmospheric conditions during transit and while in storage, and are covered with a thin film of rust or, at least, there are indications of the beginning of an attack on the metal by the atmosphere. The car bodies, as they arrive in the department where the rustproofing takes place, are mounted on a truck so that they can be easily handled by one or two operators. This truck is then pushed into position for the rustproofing

treatment in a space surrounded by a pan or draining table, so that the deoxidine may be caught and prevented from spilling on the floor. When the body has been placed in position within the draining table, as shown in Fig. 1, it is painted over with deoxidine, much in the same way as varnish would be applied to the surface. The drippings caught by the draining table run off into pails or pans and are used for a second rubbing over of the surface to be treated. The men doing this work wear rubber gloves and rubber boots, as well as large rubber aprons, because the liquid contains phosphoric acid, and would therefore attack the skin, as well as leather aprons and boots.

The second rubbing over of the surface of the steel plates is done with steel wool soaked in deoxidine. This rapidly removes the rust that has formed on the surface, and the steel wool also enters into the crevices, cleaning the whole surface thoroughly. Sometimes emery cloth is used, but, on the whole, steel wool is recommended. The phosphoric acid in the deoxidine removes the rust, the alcohol being used merely as a carrier of the acid.

Washing Off and Drying the Car Body. As soon as the car body has been thoroughly cleaned by means of the deoxidine, the truck upon which it is mounted is pulled away from the draining table and the body is moved to another part of the floor, where hot water is played upon it with a hose, the object being to wash off all alcohol, as well as all surplus deoxidine. (See Fig. 2.) The reason for using hot water instead of cold is to assist in the drying of the body, it being unnecessary to put the object in a drying oven. An air hose is finally blown on the body for the purpose of drying out any cracks or seams, after which it is wiped off with a rag. It is now ready for the priming coat of paint. The treatment it has received has been found to prevent all rusting under the paint. In case it should not be convenient to start the painting immediately, the treatment will also prevent rusting for a considerable period. The experience of the Hudson Motor Car Co. in-

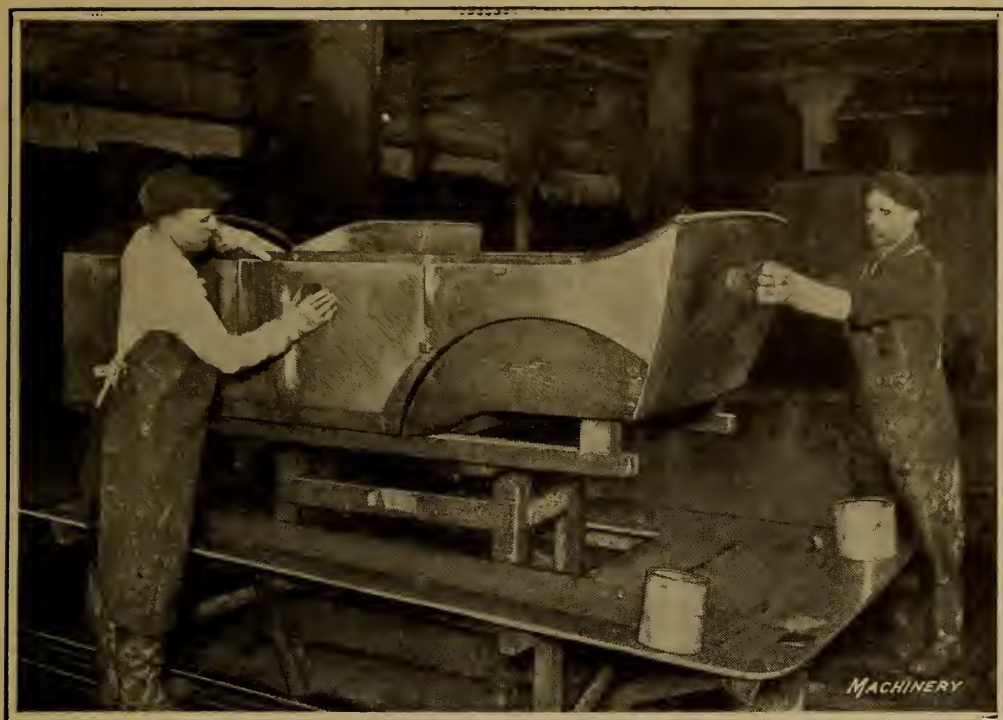


Fig. 1. Car Body in Position in Draining Table, Ready for Rustproofing



Fig. 2. Washing Car Body to remove Alcohol and Surplus Deoxidine

dicates that bodies may stand without rusting for several months exposed to the atmosphere indoors before painting.

It will be noted from the foregoing that the general process of applying deoxidine for rustproofing consists simply of washing over with deoxidine, washing off the deoxidine with hot water, drying and painting.

Different Methods of Applying Deoxidine. The deoxidine may be applied in various ways. It is not necessary to apply it as described, if the articles handled can be more satisfactorily manipulated in other ways. Instead of varnishing over and rubbing the surface, the liquid may be applied by dipping or spraying. Small work, for example, is generally dipped and removed to a draining table, while large work is handled in the same way as the motor car bodies. Wooden tanks or buckets should be used for holding the liquid, and care should be taken not to heat it.

In washing off the deoxidine with water, small work may be washed off by dipping in a tank of water, a small stream of fresh water being constantly permitted to run into the tank, while an overflow pipe removes the surplus water. Gasoline should not be used for washing. Under ordinary circumstances, from five to ten minutes is allowed before the deoxidine is washed off. If there is a heavy scale of rust on the surface, the treatment described above—merely rubbing the surface with steel wool—will not be sufficient, but, in that case, scratch-brushing or the application of emery cloth or sandpaper before the deoxidine treatment would be used to remove the loose rust. Badly rusted work is often treated by rubbing with emery cloth while the work is kept wet by the use of deoxidine.

After the car body has dried, it may appear to be smeared with a white or yellow powdery deposit. This powder, however, need not be wiped off, as it has no effect upon the surface or upon the paint. In fact, this powdery deposit is a neutral salt which prevents the starting of any rust.

Other Uses of Deoxidine. In addition to the application of deoxidine for cleaning work for painting, as applied to

motor car bodies and similar parts, the liquid may be used for cleaning surfaces that are not to be painted. In that case, if the work is covered with a heavy coating of rust, it is first sand-blasted, and then brushed over with deoxidine and wiped dry with a cloth before the deoxidine has had a chance to dry. In this case, the surface is not washed with water.

For work that is only slightly attacked by the atmosphere, the process is as follows: The surface is first rubbed with the liquid and emery cloth, and then washed off in water, after which it is again brushed over with deoxidine and immediately wiped dry with a cloth, no water being used after the second brushing over with deoxidine.

Automobile bodies may also be prevented from rusting in transit, when manufactured in one place and shipped to another factory, by the application of one coat of deoxidine to the work just prior to shipping, this coat being permitted to dry on the surface without washing or wiping. After the body has arrived in the factory where it is to be finished, the steel surface is again treated for painting in the same way as described for the car bodies. The preliminary coating of deoxidine applied before shipping keeps the surface of the steel comparatively clean, and leaves but a slight coating produced by atmospheric conditions to be removed in the final rustproofing process, which, therefore, can be carried out easily and rapidly.

Effectiveness of Different Paints. The value and durability of paint, when used as a protection of iron and steel against corrosion depends largely upon the pigment used in the paint. The American Society for Testing Materials has undertaken tests to determine which pigments are the most valuable for protective paints. According to these tests, it was found that the following pigments have the greatest protective effect upon iron and steel: Zinc-lead chromate; zinc oxide; zinc chromate; zinc and barium chromate; zinc-lead white; Prussian blue (inhibitive); chrome green; white lead, made by the Dutch process; ul-

tramarine blue; and willow charcoal. The following pigments are classified as "indeterminates" by the American Society for Testing Materials; that is, they are not as distinctly protective paints as those in which the pigments already mentioned are used, but they do not stimulate the action of the atmosphere on the iron and steel. These pigments are: White lead (made by the quick process, basic carbonate); sublimed white lead (basic sulphate); sublimed blue lead; lithopone; orange mineral (American); red lead; litharge; Venetian red; Prince's metallic brown; calcium carbonate; calcium sulphate; China clay; asbestos; American vermilion; medium chrome yellow. The so-called "stimulators," that is, those which stimulate rust, are as follows: Lampblack; precipitated barium sulphate (blanc fixe); ochre; bright red oxide; carbon black; graphite No. 2; barium sulphate (barytes); graphite No. 1; Prussian blue (stimulative).

These results, however, must not be understood as being entirely conclusive, because the pigments, in making these tests, were suspended in water, and it does not necessarily follow that oil paints made from these pigments would show exact agreement with the tests, but it is reasonable to expect that the difference in results would be small.

Summary of Paint Tests. In a paper read before the British Iron and Steel Institute, J. N. Friend summarized as follows the results of his researches on the usefulness of paint for protecting ironwork from atmospheric corrosion:

The practical value of acceleration tests is very small in the present state of the knowledge on the subject. Reliable results can be obtained only from tests carried out under conditions like those prevailing in practice.

The addition of pigment to oil increases the efficiency of the latter as a protective paint until a maximum is reached; after this, further addition of pigment causes deterioration. The best results are obtainable from paints possessing as high a percentage of good oil as is com-

patible with good body and any other working property that has to be considered.

Linseed oil, on setting, expands about 3.3 per cent; this is the primary cause of crinkling. Further oxidation causes a decrease in volume, which leads to cracking.

Linnoxyn is permeable to moisture; the permeability is reduced by heating in absence of air, when the oil increases in density, viscosity, and molecular weight.

Polymerized linseed oil affords a better protection than raw oil when used as a paint vehicle.

The functions of a pigment are to toughen the film and render it less permeable to water, vapor, and oxygen; it also reduces the expansion of the oil on setting, and thus minimizes the tendency to crinkle.

A thick coat of paint protects the underlying metal more efficiently than a thin coat, provided the coat is not so thick that running or crinkling takes place.

The very best results are obtained, however, by multiple coats; two thin coats are better than one thick one of equal weight.

Thinners enable thin coats of paint to be applied; turpentine leaves a very slight residue upon evaporation, but its effect on the efficiency of the paint is small.

The most permanent paints are those containing black or red pigments, for these absorb the shorter rays of light and prevent them from hastening the destructive oxidation of the linnoxyn by the air.

Finer pigments afford more efficient protection than coarse pigments, as they are more thoroughly in contact with the oil.

Iron structures should be painted while their scale is still on, after loosely adherent flakes and rust have been scraped off. The paint will last longer than if applied to the pickled or sand-blasted surface and the labor of removing the scale is saved.

Experiments with rusty plates are not conclusive, but suggest that the rust need not be so carefully removed, prior to painting, as is usually thought to be necessary.

Japan Coatings. So-called "baking japans" are used widely in finishing a large variety of metal work requiring a decorative finish which is cheap and durable. In general, *black japans* are made by combining linseed oil and asphalt, gilsonite, stearine pitch, coal-tar pitch, and similar substances at high temperatures. The resulting product is thinned with turpentine, benzine, or light mineral oils, and when applied by spraying or dipping and baked at a temperature ranging from 200 to 450 degrees F., will give a coating which is quite hard, fairly impervious, and of a high luster. The baking period, which may vary from one to several hours, or longer, and the temperature of baking, depends upon the composition of the japan. Dull and medium-gloss japans are made by grinding the bright japan with lampblack or carbon black in a fine mill. The method of application and baking is the same as for glossy japans. Colored japans or enamels are essentially pigments ground in a boiled linseed oil which may or may not contain a percentage of varnish gums. They are generally baked at considerably lower temperatures than the black japans.

The japan film is much harder than an ordinary paint film, and will stand rougher handling and usage, a circumstance which gives them a marked advantage in many cases. While they are hardly intended for outdoor exposure and perhaps are not so durable and resistant under such conditions as the best oil paints, they give, nevertheless, very good protection even under severe service. Two or three coats may be applied in much less time than it takes for one coat of paint to become thoroughly dry, which is an added advantage of some importance. Altogether, japans furnish a means of producing quickly and cheaply a coating which has good protective and decorative qualities.

Electric Japanning. The electric japanning process, which is so named because electrically-heated ovens are used, is a modern development that is chiefly employed by automobile manufacturers. The following information on

this subject is from a paper read before the Cleveland Engineering Society, by C. D. Carlson.

Great strides have been made in shortening the time of japanning operations. Work that formerly required from five to nine hours is now often done in less than an hour, and even better speeds are expected, especially with the electric oven. The heating units of this oven consist, in general, of a framework of steel or cast iron, supporting insulators made from mineral compounds which afford high insulation resistance even at the fusing point of the metal resistor. This resistor is usually a nickel-chrome alloy, manufactured as a flat ribbon, which is wound continuously around two insulators, thus forming one heating unit. It is non-corrosive in air at 800 degrees C., but in japanning ovens the air seldom reaches a temperature above 600 degrees F. Practice has shown that it is best, where a number of these heaters are connected, as in ovens, to use steel bus bars and to have all connections mounted on insulators having the same characteristics as the heat insulators. The complete heater usually runs in units of from 2 1/2 to 10 kilowatts, which may be placed anywhere on the walls or floor of an oven until practically a uniform temperature is obtained throughout. This leads to high quality finish and speed together with duplication of work, both as to quality and time. Microphotographs taken of japanned pieces, where the same grade of metal was covered by the same japan in the same room, one man performing all operations, show that the higher the proportion of heat by radiation and the less by convection, the higher is the quality of the work. The second coat baked electrically is superior to a third coat of the other type.

Control of Temperatures. The control of temperatures in japanning is most essential, especially where it is desired to insure uniform production of duplicate parts. Electric control is of two kinds, hand and automatic. Hand control consists of numerous switches so connected with the heating elements that the desired number of heaters to produce or hold a given temperature can readily

be turned on or off. This is a "cut-and-try" method, but in several instances has given satisfactory service. Automatic control consists of a capillary-tube thermometer that actuates a contactor through a relay, throwing off part or all of the heaters when the oven reaches the desired temperature, and again throwing in these heaters when the temperature falls. The bulb, or sensitive member, of the thermometer is usually about 15 feet in length and is immersed inside the oven. The extension of this tube outside the oven is armored and made of sufficient length to locate the instrument properly. A liquid that vaporizes at a temperature slightly above ordinary atmospheric temperature is used as the actuating fluid. The instrument has two indicator hands, which are set at the maximum and minimum points of temperature desired.

Heat Losses and Ventilation. The principal heat losses of a japan oven are losses due to radiation from the oven, losses due to ventilation, and losses due to absorption of heat by the work together with all parts within the oven. The less the radiation and ventilation losses from the oven, the greater is the amount of heat available for actual work. As a result, the oven walls, roof, and floor should be constructed of a high-grade heat-insulating material and should have little mass, in order to keep its heat absorption as low as possible. A 4-inch to 6-inch wall lined with diatomic earth or similar products seems to meet these requirements. Furthermore, as little through metal as possible should run from the inside to the outside of the oven. The thermal conductivity value of wrought iron and mild steel, such as is used for channel irons and bolts, is about 1400 times that of a good insulating material; a $\frac{1}{4}$ -inch bolt will radiate nearly the same amount of heat to the outside air as a 7-inch square of good insulating material.

From both a baking and a safety standpoint, just enough air must be brought into the oven to reduce the vapors given off by the japan to below a point where it becomes an explosive mixture; but not enough air should be brought in to cool the oven and retard the baking. This means that

for every gallon of japan baked within an oven at one time, 1200 cubic feet of free air should be taken into the oven during the vaporizing period. It has also been found good practice to have the ventilators distributed in different parts of the oven. As the volatiles liberated from the japan are heavier than air, it is well to place some of these ventilator openings where the heavy gases will be removed first. With radiation, ventilation, and absorption values expressed in British thermal units, the installation of the proper number of electric heaters to equalize these losses becomes a simple matter. For, when heat is generated electrically, its conversion is accompanied by 100 per cent efficiency; in other words, one kilowatt-hour will always generate 3412 British thermal units.

Types of Japanning Ovens. Japanning ovens can be divided into three types: the box or kiln type, the semi-continuous conveyor type, and the continuous conveyor type. Little need be said about the box type, as everyone is more or less familiar with its construction. As used electrically the heaters are arranged on the side to give the proper distribution of heat. The semi-continuous conveyor oven has become popular with manufacturers who do not have sufficient output of one kind to warrant carrying on the operation continuously. It may be a rotary oven or a box type oven with a conveyor that is moved as the operator desires. The rotary oven is built in the form of a cylinder with a heat-insulating partition through the center; with this arrangement, the operator can load half the oven while the other half is baking. This oven is convenient when many pieces of different sizes and shapes are to be japanned. In the conveyor box type oven, doors are placed at both ends and a conveyor runs through the upper part, from which the work is hung. This conveyor is made long enough to extend the same distance beyond each end of the oven as its length within. One charge is baking within this oven while another charge is being loaded on the receiving end. When the first japan coat is baked, the conveyor takes the baked pieces out of the discharging

end and the newly dipped pieces into the baking chamber. Ovens of this type are usually built double or triple, depending on whether two- or three-coat work is desired.

The continuous conveyor oven is much more efficient than the others. It consists usually of a long enclosure through which the work is passed on a slowly moving conveying apparatus. If desired, all handling may be eliminated by installing apparatus for loading and unloading the conveyor automatically. In most cases, the electric heaters are so arranged within the different sections of the enclosure that the incoming work is brought up to its final baking temperature by steps. Usually no heaters are installed in the first section of the enclosure, as the hot baked work is brought out of the oven in such a way as to give up a good share of its stored up heat to the cold incoming work. For the same amount of energy consumed, as much as three times the amount of work has been gotten out of the conveyor oven, as out of the box type.

Fire Risk with Electric Ovens. Electrically heated ovens, from the first, have been looked upon as the solution of the problem of preventing the fires and explosions that were so common in japanning. Yet even in electric ovens two kinds of fires are possible, although at the same time easily preventable if proper care is taken to clean the ovens thoroughly and regularly. When pieces freshly dipped with japan are placed within an oven, there is likely to be what is called a secondary drip when the heat is first applied. This waste japan bakes on the floor of the oven and each successive oven charge adds to the accumulation until a thick, porous crust of baked japan has formed, which, when heated from 500 to 600 degrees F. in the presence of oxygen, will ignite spontaneously. If confined to the oven floor, this burning is harmless, but if it reaches freshly japanned work, a disastrous fire may result.

Again, when the volatiles given off by the japan strike a surface with a temperature lower than their own, they condense; naturally the flues of the oven will gather most of this condensed volatile. These deposits may ignite

spontaneously, backfiring into the oven, or the flues may become so clogged with them that proper ventilation is cut off, leaving an explosive mixture within the oven. Then ignition of any sort might cause serious results. From an electrical standpoint great care has been taken to prevent ignition, even where the precautionary measures have been disregarded, as the heating units are designed to have a temperature not much over 100 degrees F. in excess of the oven baking temperatures. Except in unusual cases, this temperature is below the flashing point of japans.

Protecting Small Finished Articles against Corrosion.

Protection against corrosion is most difficult in the case of quantities of small-sized articles. A method which has given good results in the case of buckles, rings, and harness fittings, generally, will be found applicable to many other industries. The protective coating consists of cheap varnish diluted to two or three times its volume with methylated spirits. On account of rapid evaporation the mixture is made up as required. This mixture may be kept in a sheet steel can of a total capacity of about 10 gallons. A smaller receptacle holding about five gallons is then perforated with a number of $\frac{1}{2}$ -inch holes in the bottom and sides. The larger receptacle is filled about quarter full with the diluted varnish, and the articles to be coated are put in the smaller perforated receptacle which is then lowered into the larger can, so that the articles are immersed in the liquid. After immersion, the smaller container is immediately withdrawn, the major portion of the fluid draining back into the larger receptacle in a minute or less. The contents of the receptacle are then placed on a wire draining screen, where any surplus of the varnish will drain off and the coating harden. This will take only about fifteen minutes, after which the articles may be packed. The process is cheap and effective, the articles remain bright for a long time, and the coating is hardly perceptible to the eye.

Protection of Machined Surfaces. The finished or polished surfaces of machinery can be protected from rust

by applying (while warm) a mixture of white lead and tallow, this being very commonly used. Neutral petroleum jelly is also a good rust preventive for steel, provided the surfaces to which it is applied are perfectly dry. To prevent the rusting of tools stored in the stock-room, etc., a coating of what is known as "cosmolubric oil No. 1" will be found very effective. If the oil becomes too thick, heat it slightly. Another good rust preventing lubricant is made from equal parts of turpentine and linseed oil. Machinery that may be exposed to rain or considerable moisture while being exported can be protected by coating the surfaces with black enamel or japan.

When nuts, wash-out plugs, etc., are lubricated to prevent corrosion and facilitate their removal after a long period, a lubricant should be used which does not evaporate, and which does not corrode or otherwise injure the metallic surfaces. A lubricant should be used consisting of thick mineral cylinder oil, or petroleum jelly mixed with black lead. Tallow or any fat oil or grease should not be used, as fat soon undergoes a change and allows the thread surfaces to corrode. A thin mineral oil is also unsuitable as it soon flows out of the joint and evaporates. Sometimes there should be no lubricant, especially if the nuts are subjected to vibration which tends to loosen them, such as the nuts of rail fish-plates, etc.

Removing Rust. A simple method of removing rust from surfaces that are afterwards to be electroplated consists in dipping the articles first into a strong hot potash bath for about half an hour and then in a cold muriatic-acid pickling solution composed of 2 parts of water to 1 of acid. This solution removes the rust in a few minutes, leaving the metal apparently attacked but very little. The previous soaking in the strong hot potash solution is responsible for this rapid pickling, as tests have shown that, without previous dipping, 65 minutes is required by the acid bath, against four minutes when previously treated in the potash bath. Apparently a chemical reaction is set

up, changing the character of the rust, softening it, and making it readily soluble. The appearance of the rust as it comes from the potash kettle testifies to this, as it is black and soft, and may almost be rubbed off with the hand. The pieces that have been treated in the potash bath have a smooth and glossy finish.

Influence of Various Metals on the Corrodibility of Iron. Silicon in iron greatly increases its tendency to corrode; 0.3 per cent of silicon will make iron rust 20 per cent more rapidly than would ordinary iron free from silicon. On the other hand, alloying steel with nickel or copper gives it increased resistance to corrosion; 0.20 per cent of copper in steel produces a material which is attacked by acids at one-tenth the rate of ordinary iron. The corrosion in the atmosphere is only one-third that of iron free from copper. An increase of copper above 0.20 per cent does not add to the corrosion resisting qualities of the iron. These results have been obtained not merely by laboratory experiments, but in practice. Roofs have been covered in and around Pittsburg with ordinary sheet steel and also with a sheet steel containing 0.20 per cent of copper. The copper alloy roofs were in good condition when the ordinary sheet-iron roofs were completely corroded. The results of these experiments also showed that the metals are less attacked in rural districts than in cities, this being due probably to the carbon and acid fumes present in the city atmosphere.

CHAPTER II

ZINC COATING PROCESSES FOR RUSTPROOFING

IRON objects may be coated by dipping them in molten zinc (this is the process generally known as *galvanizing*); by placing them in an electrolytic bath, the process being known as *electroplating*; or by the vapor or Sherardizing process.

Galvanizing. Galvanizing, in general, is the process of coating one metal with another; the name, however, is more especially applied to the coating of iron with zinc to prevent the corrosion of the iron by excluding moisture from it. Tin and lead are sometimes used as coating materials, but are less effective. Considered as a mechanical protection, the principal requirement is that the coating will resist impact and abrasion, especially the latter. Soft metals, such as tin and zinc, do not stand abrasion well, but, unless their adherence is defective, they will stand impact because of their malleability at ordinary temperatures. Aluminum fulfills all the requirements of a good coating better than any of the commercial metals, but zinc is used because of its lower cost. The coating resulting from the dipping or galvanizing process does not adhere as perfectly as does the electrolytically deposited coating. Properly treated sheet-metal goods, however, have an attractive spangled appearance, but most articles receive the appearance of castings, and sharp edges are lost.

The thickness of the coating depends upon many factors. The temperature of the bath and the type of material dealt with affect the results, while it is possible to give a thinner coating to a plain sheet than to a made-up utensil. The galvanizing of wire, whether in the form of netting or single, is a continuous process, so that the factor of speed

is introduced. The amount of zinc deposited can be regulated to a nicety by varying the temperature or speed, or both. The wire passes through a flux and then through the molten metal, and emerges through a part of the bath continually skimmed from oxide. This process is, consequently, cheap as compared with the coating of made-up articles.

Galvanizing Bath. Zinc used for galvanizing should not contain more than 0.5 per cent of iron. It will absorb from 1 to 4 per cent, but each per cent absorbed raises the melting temperature of the bath, so that the zinc becomes thick and pasty; the absorption of iron from the articles being coated and from the sides of the container requires frequent skimming of the bath.

Pickle Bath. The articles to be coated must first be thoroughly cleaned by pickling in a sulphuric-acid or hydrofluoric-acid bath. Very heavy articles should also be heated so that they will not chill the bath. The sulphuric-acid bath is formed by pouring 1 part of acid into 6 parts of water. It removes all scale, sand, and rust that may remain on the articles. However, as this cleaning is accomplished by the eating away of the iron, the articles should not be left in the bath longer than is necessary. When removed, the articles must be thoroughly washed in water and then placed in a hydrochloric-acid bath containing 1 part of acid to 2 parts of water. This bath removes all rust that may have been left by the sulphuric-acid bath, and also prevents the formation of rust on the articles as they are dried by the formation of a thin layer of iron chloride upon them. Sometimes the sulphuric-acid bath leaves a slime upon the surface of the metal. This slime is difficult to remove, but, if left on, will produce unfavorable results.

The hydrofluoric-acid bath leaves the article in better condition than does the sulphuric acid, but the former acid is very poisonous. The bath consists of 1 part of acid to 20 parts of water, and dissolves the sand and not the iron.

The articles are not placed in this bath, however, but are placed on a platform attached to the tank containing the solution, and wet with the solution about once an hour until all the sand is removed. The excess solution drains back into the tank. The articles are then washed in the same manner as when the sulphuric-acid bath is used.

Sometimes metal chlorides are used as fluxes to clean the articles before dipping; they are supposed to remove the injurious salts left by the pickling, but it is a question if they are not the main cause of the decay that starts beneath the coating.

Dipping Articles for Galvanizing. Before the articles are dipped in the molten zinc, the surface of the bath is covered with a flux of sal-ammoniac, which not only prevents the zinc from oxidizing, but assists the iron to take the zinc quickly and evenly. A small amount of sal-ammoniac frequently sprinkled is much better than a greater amount at longer intervals. If the dross is separated with difficulty, a few drops of glycerine will thicken the flux and cause it to remain stationary so that, when the operator is ready to draw the article from the bath, a flux will not cover the spot skimmed for this purpose. The temperature of the bath may vary from 800 to 1000 degrees F. (from 430 to 540 degrees C.) depending upon the character of the work to be galvanized. For very thin work, or for large gray-iron or malleable castings, the temperature should be as low as possible. For very small work, including that which is handled in baskets or must be strung on wires, a temperature of 890 degrees F. (about 480 degrees C.) is desirable. After the articles are thoroughly heated and covered with the zinc, they should be withdrawn and the excess of metal shaken or wiped off, depending upon their shape. They are then dipped into hot water. If dipped in cold water, the coat loses its luster and becomes rough, and the article may be spoiled. Spangle is produced by the immersion of the material, while hot, into water; it adds to the appearance and finish of the goods. It is pos-

sible, however, by slow cooling apart from water, to produce galvanized articles free from spangle; it has been claimed that such goods have a more uniform coating.

New Method of Galvanizing Iron. As actual fusion of the two metals is not obtained by dipping an article in molten zinc, the zinc coating does not properly protect the iron surface underneath. This defect is avoided by a process in which the iron is so prepared that the zinc is deposited into its pores. After being steeped in sulphuric acid, the parts to be coated are placed in a solution of mercuric chloride and then heated, resulting in the decomposition of the mercuric chloride and precipitation of metallic mercury, which forms an amalgam on the surface. The iron is then plunged for three minutes into a zinc bath heated to 930 degrees F. (500 degrees C.). The zinc coating deposited by this method adheres very strongly to the metal. As the zinc penetrates into the pores of the iron, should a portion of the coating be worn or peeled off, the iron will not rust owing to the presence of sufficient zinc on the surface to protect the metal from the action of the atmosphere. In other words, there is a perfect alloy or association of the two metals at the point of juncture.

Electro-galvanizing. In the electro-galvanizing process, which is of comparatively modern development, the zinc is deposited electrolytically from a bath containing approximately a 10 per cent solution of crystallized zinc-sulphate. The essential elements of an electroplating plant are: the plating solution, or electrolyte; the receptacle for holding the latter and fittings; the anodes, which are zinc bars suspended in the electrolyte in proximity to the article to be plated and connected to the positive pole of a dynamo; and the cathode, which is in contact with the article and is connected to the negative pole of the dynamo. The electro-zincing of sheets, large iron receptacles, etc., is mainly done in still plants, which are essentially like the elementary apparatus just described. Work that is plated in still-solution tanks has a white frosty appearance, but can be

easily brightened by giving it a scratch brushing. A good deposit should be obtained in a still-solution apparatus in from one-half hour to an hour.

Equipment Used. Mechanical plating plants may be divided into two types, the plating barrel, for plating small work in bulk, and the conveyor type plants, or "moving" tanks, for large work. Material that is plated in a rotating barrel will not have the frosty appearance of work plated in the still tank, for the reason that the tumbling motion imparted to it causes a burnishing effect while the deposit is going on, which results in the work coming from the barrel in a bright condition.

In its elementary features, the plating barrel may be described as a drum made of a non-conducting material, perforated, supported in bearings, and rotated in a tank containing the electrolyte. The positive pole of the dynamo is connected to the zinc anodes, which are hung around the barrel. The negative pole is connected to the cathode conductor within the barrel, which is in intimate contact with the material. The plating barrel may be filled with work to a depth of three-quarters of the diameter, if it is of the totally submerged type, and about two-fifths the depth, if it is of the partly submerged type. These machines are rotated at from four to twelve revolutions per minute, depending on the grade of work. Plating barrels are made in various sizes up to a capacity of about 200 pounds of small work, such as nails, conduit boxes, etc.

The mechanical conveyor-type of plant, in its essentials, consists of a tank fitted like the still tank, and which, in addition, is equipped with a continuously moving conveyor mechanism of an endless chain or feed-screw type. The articles are hung on racks, which are fastened to the conveyor chain or screw, carried through the solution, and returned to the starting point. The time of travel is adjusted to suit conditions and requirements; in average practice, the rate of travel through the solution is about one foot a minute. The constant movement of the work through the

solution permits a higher voltage to be used than in the still tank, thus employing a greater ampere current with the consequent acceleration of the plating. Outputs ranging to 115,000 valves plated in a day of nine hours have been obtained from a single installation. Recent mechanical developments of this type are special equipments for galvanizing pipe, bar iron, angles, and other structural shapes. They are automatically carried through the tank, being turned as they advance, so that an even coating is procured. The pipes are then washed, drained, and delivered automatically. Flat and round wire and wire cloth are galvanized in continuous lengths, washed, dried, and reeled up automatically.

Voltage for Electro-galvanizing. The voltage employed in electro-galvanizing ranges from five to fifteen volts, depending on the class of work, the quality of the solution, and the speed of operation. Higher voltages will cause the work to "burn" and must be avoided. The amperage necessary is directly proportional to the surface to be plated; 1000 ampere-hours will deposit 42.8 ounces of zinc. It is common practice to allow 10 amperes for every square foot to be plated. A good deposit, in a mechanical plating apparatus, requires from one-half hour to two hours. The actual length of time of deposit depends on the class of work, current density, and the thickness of the deposit required.

Advantages of Electrolytic Process. The electro-galvanizing process is without question the most efficient and desirable from every consideration. Some inherent advantages of the electrolytic process over hot galvanizing and sherardizing are as follows:

It deposits a uniform coating of chemically pure zinc; hence much less zinc is required.

The adhesion of the deposited metal is better (482 pounds per square inch, against 280 pounds per square inch) and more flexible, so that plated sheet metals can be spun and plated wire bent without cracking the coating.

The temper and tensile strength of the material are not affected. Tempered articles, such as automobile hardware, frequently lose in tensile strength and temper when subjected to the heat of the molten bath (774 degrees F.) of the hot-dip process.

Bolts, nuts, and similar articles with small recesses are coated so smoothly that they require no recutting.

These advantages are confined to the efficacy of the electro-plated deposit in comparison with the product of the other processes of zinc deposition, and they, alone, are of interest to the engineer or manufacturer. There are, however, many other advantages of extreme importance in the operation of a plating shop. Among them are: economy of metal and time, decrease of upkeep expense, perfect control of process, and the elimination of the necessity of expert and high priced operators.

Test for Determining Zinc Deposit on Plated Article.

A simple decisive test for the comparison of galvanized products and the quali-quantitative determination of the zinc deposited on a plated article is the copper-sulphate dip test. This determination may be readily made by anyone, as it does not require any special skill. The article to be tested is thoroughly cleaned in water and immersed for one minute in a saturated solution of copper sulphate (bluestone). It is then withdrawn, quickly washed in water, and briskly rubbed dry with a towel. The chemical action is very simple, the sulphate tending to dissolve the zinc and plate the copper on the exposed iron. If the article shows no copper plating that cannot be effaced with the cloth, it is said to have withstood a one-minute test. These one-minute dips are continued until a distinct copper plate appears on the iron or steel. An article that is plated for reasons other than merely to improve appearance, should stand at least two one-minute tests, as described.

Sherardizing Process. The sherardizing process was originated in England by Sherard Cowper-Coles about 1904. The process is applicable not only in all cases where

hot or cold galvanizing can be used, but in numberless other cases where they cannot. Briefly, the process consists in packing the articles to be covered with the zinc coating into a closed drum, box, or other suitable receptacle in contact with the ordinary zinc dust of commerce. The receptacle is then put into an oven and gradually heated to the required temperature of about from 500 to 700 degrees F., for a period of four or five hours. At the same time, the retorts are turned intermittently so as to give the zinc dust access to all parts of the work. After holding this heat for several hours, the exact time depending upon the thickness of the coating desired, the drums are withdrawn from the furnace and allowed to cool down to a temperature convenient for handling, when its contents are dumped upon a screen, which allows the zinc dust to fall freely into the chamber below, from which it can be drawn for use again. The articles are found to be evenly coated with pure zinc, this constituting the entire process. The operation is so simple that the most ordinary class of unskilled labor can be employed without fear of securing poor results. A sherardized surface is light gray in color, and the finish imparted is a fine matted surface resembling that obtained by sand-blasting.

The action that takes place in sherardizing consists in forming both a zinc-iron alloy and a coating of zinc upon the material to be treated. The zinc dust becomes partially vaporized under the influence of the heat applied, and the vapor thus produced in condensing upon the hot iron forms the protecting coating, the inner layers of which alloy with the iron, while the outer layers provide additional surface protection of nearly pure zinc.

Advantages of the Sherardizing Process. Sherardizing has advantages over other methods of zinc coating, which may be classed under two heads: first, the superiority of the product, and, second, the economy of the process. The fact that the zinc coating penetrates unlike any other method of zinc coating, forming an alloy with the iron,

makes a finish that cannot be worn off. In addition, the coating is so evenly applied and so thoroughly driven into the surface of the metal that it does not alter the exterior of the article to any appreciable extent. In fact, sherardizing is perfectly practical for the protection of threaded screws of fine pitch and it is not necessary to recut them after the coating has been applied, if a slight clearance is provided for when cutting the thread. Because of the nature of the process, every part of the article treated is reached; the insides of tubes or sharp corners are coated just as thoroughly as the more exposed places. The depth of the coating may be controlled by the metallic percentage of the zinc dust, the length of time the heat is applied, and by the temperature to which the retorts are subjected. There is no distortion of slender pieces or thin objects such as might occur when using the hot dip, because in sherardizing the heat is applied gradually and the work just as slowly cooled off.

The economy of the process is at once evident when considering the low heat required, the temperature of from 500 to 700 degrees F. being far below the melting point of zinc which is 786 degrees F. Less zinc is required, because none is wasted. The thin but thorough coating that is applied is just as effective as the thick rough coating that the hot-galvanizing process gives. A sherardized coat of one-half ounce to the square foot affords more protection than a galvanized coating of one and one-half ounces to the square foot. No flux is necessary, and the presence on the work of non-fatty oil in a moderate degree does not interfere with the sherardizing. Any articles that may be placed in the drum may be treated. Drums of special shape may often be made to accommodate certain products. Screening, wire, etc., may be handled just as effectively as inflexible material by coiling it, and placing it in that state in the drum. After sherardizing, the wire or screen may be straightened without injury to the coat of sherardizing.

Practically the only limitation to the sherardizing process is the fact that on very small tempered steel articles such as springs, the heat of six hundred degrees or thereabouts will draw the temper. On most work, however, this is not objectionable. The process of sherardizing is not confined to the coating of the product with zinc alone, but aluminum, tin, etc., are also used for sherardizing to good advantage. Zinc, however, is the leading metal on account of its ability to resist corrosion, this quality of zinc being mainly due to its being electro-positive to iron.

Zinc for Sherardizing. The zinc dust used in the process of sherardizing is commercial zinc dust, of which at this time about 90 per cent is imported into the United States. On an average the composition of this material runs about 90 per cent of metallic zinc and 10 per cent of zinc oxide. Zinc dross is sometimes used, but not very successfully, as it will not alloy with the work being treated as intimately as the finely-powdered zinc dust, although when the two are combined in equal parts they show good results. The best results are obtained when the zinc dust has been reduced to about 50 per cent of metallic zinc by the addition of spent zinc; therefore, new zinc should be reduced to that percentage as rapidly as possible. Sherardized material requires as an average, a deposit of four pounds of zinc per hundred pounds of material treated. After the zinc has been reduced to the right percentage, it may be held at that strength by simply replacing four pounds of new zinc for every hundred pounds of material treated, taking care that it is thoroughly mixed with the spent zinc dust. A chemical analysis of the dust in use once a month is recommended.

Metal-spraying Process. The Schoop metal-spraying or coating process consists in reducing metallic wire to impalpable dust by means of an oxy-hydrogen flame, and then forcing these metallic particles with great velocity against the surface of the object to be coated. The particles then embed themselves in the surface of the piece to be plated

and homogeneously unite with the succeeding particles that are projected upon them. The result is an even coating of deposited metal, adhering to the coated object. The deposited metal is amorphous and not crystalline in its structure, and more dense than the wire from which it came. The spraying is done by a special torch or pistol, the wire being fed into the pistol from one side and emerging at the torch end in a fine spray. By means of this remarkable process, it is possible to coat metal, wood, paper, cloth, stone, cement, and other substances with lead, tin, zinc, aluminum, copper, brass, bronze, German silver, gold, and even steel. It is the only known method of plating with aluminum and steel.

One of the most singular facts relative to this process is that the metal is not applied in a molten state. The correct operating distance is from 5 to 6 inches from the pistol point to the work. At this distance, a piece of paper or even a match may be coated without danger of ignition. Protective coatings on steel or iron may be either original coatings of the whole of an object or any part of it, or local applications with the "pistol" to repair damage or wear of a coating made by another process. The repair of the troublesome defects on galvanized sheets is an example.

Many engineering structures used in the industries, such as steel and iron tanks, girders, and machinery of all descriptions, subject to the action of liquids and chemicals, corrode rapidly, particularly at joints. It is not possible to plate such structures by any other coating method. In such cases, a metal is selected which will resist the corroding agent, and this is sprayed in the form of a wire on all the seams and joints, these having previously been cleaned by sand-blasting.

CHAPTER III

CHEMICAL RUSTPROOFING PROCESSES

CHEMICAL processes have been developed for protecting the surfaces of steel or iron parts by the formation of protective coatings of various kinds, or by changing the surface of the metal so that it will resist corrosion. A brief review of a number of well known chemical processes will be given in this chapter.

Barff Process. The Barff or Bower-Barff process is for producing an oxide on iron or steel, in order to protect it from the corrosive effects of air and moisture. In this process, the parts to be treated are heated to a temperature of about 1650 degrees F. in a closed retort, for about forty minutes; then superheated steam is let into the retort for twenty minutes and a coating of a mixture of black and red oxides of iron is formed; producer gas is now substituted for the steam and permitted to act upon the articles for about the same length of time. If the coating formed in this manner is not sufficiently thick, the operations may be repeated several times. Paraffin or some other oil is afterward applied to the articles. This gives them a fine black color and, at the same time, affords additional protection.

The process produces a heavy coating consisting essentially of magnetic oxide of iron and gives a durable finish. While it is not absolutely rustproof, it is so nearly so that, for practical conditions, it meets all requirements. Small spots of rust will generally develop in the course of time, and under extremely bad conditions these will appear after a comparatively short time, but the breaking down of the coating is very slow. The strong adherence of the oxide to the articles treated allows the iron to rust only at the

exposed places, so that, although it may be deeply pitted, the effect of the corrosion is not as noticeable as if the corroded areas were extensive. The method can be applied only to parts where the high heat to which they must be subjected is not objectionable.

The cost of the process is rather high, but it has the advantage that it can be applied to any parts that are not injured by the heat, provided they are small enough to be placed in the furnace, and the coating is effective as a protection not only against the atmosphere, but also against sea water and acid fumes. The treated surface can be painted or enameled, and these coverings will adhere firmly. Parts having been treated by the Barff process can be heated to any temperature without injury, but they cannot be bent after the coating has been applied. The parts increase slightly in dimensions by the treatment, so that articles which must be within close limits of accuracy cannot be treated in this way. The process is used by several prominent concerns for the treatment of various articles met with in the hardware trade. A number of processes have been developed on the basis of the Bower-Barff process which differ in a number of details, but which are based on the same fundamental principle of providing a protective coating of oxide on the iron or steel.

Coslettizing. Coslettizing is a process for rustproofing iron and steel. A solution is made from one quart of concentrated phosphoric acid, one quart of water, and one pound of iron filings. This mixture is allowed to stand until the iron is entirely dissolved, and then it is added to water in the proportions of one part of solution to 50 parts water. The work to be treated is first cleaned as for plating, either by scratch-brushing or by immersion in a muriatic-acid dip, in order to remove any rust that may be present. The parts are suspended in the solution by means of iron wire or hooks, or, in the case of small articles, by placing in iron or earthenware baskets. The solution must be kept close to the boiling point, and the articles are al-

lowed to remain in it for from $\frac{1}{2}$ to 3 hours, depending upon the nature of the work, a heavy coating being produced in from 2 to 3 hours' time. A convenient arrangement for the bath is to make up the solution in an enamel or agateware tank, and heat this tank by placing it in boiling water. After the articles are removed from the solution, they should be allowed to dry in the air, and may then be scratch-brushed on a fine wire wheel, revolving at 600 revolutions per minute, and oiled with linseed or paraffin oil. Another solution is composed of 6 ounces of zinc, 1 pint of phosphoric acid, and 1 pint of water, making a stock solution which is diluted in the proportions of 1 ounce of stock solution to a gallon of water. The method of performing the work is the same as for the other solution.

Wells Process. The Wells process is practically the same as the Barff process, except that the work is finished in one operation by using steam and producer gas at the same time, instead of applying them alternately. The results obtained are practically the same.

Gesner Process. This process consists in heating the parts to be treated in a retort at a temperature of about 1100 degrees F., for twenty minutes, and then allowing steam at low pressure to act upon the parts for about thirty-five minutes. The steam entering the retort is passed through a pipe heated to a red heat in the bottom of the retort, and is, therefore, it is claimed, practically decomposed into hydrogen and oxygen upon entering the retort. After the steam treatment, a small quantity of naphtha or other hydrocarbon gas is allowed to act upon the parts for about fifteen minutes. The red oxide formed by the previous treatment is reduced by the action of the hydrocarbon, and the surface of the article is carburized. The coating is said to be a compound of hydrogen, nitrogen, and carbon, and is believed to adhere more firmly to the treated articles than the coating applied by the regular Barff process. The cost of applying the Gesner process is

somewhat less than the cost for the Bower-Barff method. Another advantage claimed for this process is that, on account of the lower heat employed, there is less tendency to warp the parts treated, and the increase in size is hardly noticeable.

Bradley Process. This process, patented in 1908, makes use of hydrogen gas applied to the articles heated to a low red heat in a muffle. After the hydrogen has acted upon the articles, a small quantity of gasoline is permitted to enter. This improves the color of the coating. The articles are left in the furnace for an hour or longer, if the coating is not considered sufficiently heavy, after which they are taken out, allowed to cool, and treated with linseed oil or paraffin. The iron and steel parts treated by this process are generally prepared for the treatment by sand-blasting.

Bontempi Process. Another modification of the Barff method consists in heating the article in the same manner as in the Bradley process, but afterwards passing steam or fumes of zinc or some heavy hydrocarbon, such as tar or pitch, over it. It is claimed that this method aids in the formation of the black oxide.

Phosphatic Treatment of Iron and Steel. The basic principle of the phosphatic processes to be described lies in the deposition of a coat of insoluble ferrous phosphate on the iron or steel to be protected. The obstacles encountered have been in the control and regulation of the processing, particularly in obtaining a permanent deposition, and the developments during the past decade have been mainly improvements in that direction.

Iron, when placed in a solution of such acids as hydrochloric, sulphuric or nitric acid, is attacked and dissolved, precipitating ferrous salts. If a dilute phosphoric acid is used, a more or less adherent coat of insoluble ferrous phosphate is formed, which in the presence of an oxidizing agent becomes basic in character and black. If a piece of iron is placed in a hot basic solution of ferric chloride or

ferric sulphate, a black basic salt is formed which adheres to the metal. When the iron is removed and placed in a hot solution of an alkali phosphate, such as disodium or trisodium phosphate, the adherent film becomes permanent.

The governing of these reactions is quite difficult and the processes described here differ essentially only in the chemical or mechanical agencies introduced for the more efficient regulation and control of the processing. In the earliest application of the phosphatic process, the iron was treated with a solution of glacial phosphoric acid in water.

Iron Phosphate Process. Thomas Watts Coslett, an English chemist, was granted letters patent in 1907 for a process in which dilute phosphoric acid is employed, with iron in the form of iron filings or ferrous phosphate as the regulating agency. A solution that has been found to give satisfactory results in rustproofing iron and steel contains 1 ounce of iron, in the form of powder, 4 fluid ounces of concentrated phosphoric acid, and 160 fluid ounces of water.

In carrying out the process, a quantity of this solution is placed in an enameled iron bath and heated to the boiling point. The article to be treated, after being thoroughly cleaned, is then immersed and the solution evaporated until the desired coating of ferrous phosphate has been deposited. The articles are then withdrawn from the solution and, after being wiped and dried, may be oiled to set the tone of the deposit.

Zinc Phosphate Process. In a later process, zinc is employed as the controlling agent. By this method the iron is subjected to the action of phosphoric acid in the presence of zinc, zinc oxide, or zinc phosphate. The solution obtained by the action of the phosphoric acid upon the zinc is preferably made in concentrated condition. The concentrated solution may afterward be separated from any sediment or excess of zinc, and then applied to the iron or steel articles in concentrated or dilute solutions. The concentrated solution has about the following proportions:

zinc, 6 ounces; phosphoric acid, 1 pint; water, 1 pint. A suitable dilute solution contains one ounce of the concentrated solution to one gallon of water.

Under certain circumstances, it may be of advantage to treat the iron or steel with a solution containing not only zinc phosphate, but also iron phosphate. In such cases the iron filings or ferrous phosphate is dissolved with the zinc, or zinc compound, in the phosphoric acid; or the solution of zinc phosphate may be added to the solution in which the deposit of phosphate of iron on the article is being effected. The effect of the zinc-phosphate solution on the surface of the iron or steel under treatment is similar to that of the phosphoric acid on metallic zinc, as a certain amount of zinc must be dissolved to form phosphate of zinc before any deposition is formed. The coating consists essentially of normal zinc phosphate mixed with small amounts of normal ferrous phosphate and free phosphoric acid. The latter can be reduced by thorough washing. The normal ferrous phosphate is formed by the interaction of the free phosphoric acid with the metal treated. Iron or steel coated with phosphate of iron may be subjected to the zinc solution.

The formation of the deposit on iron or steel may be accelerated by passing an electric current through the dilute solution, as when electroplating. Iron plates are connected with the positive pole of the battery or low-voltage dynamo and the article to be rustproofed is connected to the negative pole.

Manganese and Iron Phosphate Process. A permanent protective phosphate deposit on iron and steel may also be obtained by the use of a solution of manganese dioxide dissolved in phosphoric acid. A satisfactory deposit, which consists, substantially, of manganese and iron phosphates, may be obtained after an immersion of from thirty to ninety minutes in a solution prepared by dissolving manganese phosphate in phosphoric acid and diluting to an acidity of 0.1 per cent.

The manganese phosphate may be prepared by decomposing the sulphate with phosphate of sodium. The process is carried out by heating the solution nearly to the boiling point and immersing the metal articles to be treated. A very small amount of the iron goes into solution and some hydrogen is set free, gradually diminishing to a slight reaction after about half an hour. The metal remains in the hot solution for from one to three hours, or until all action ceases, and the surface of the metal is changed to basic phosphates, which cannot be penetrated by the acids of the bath. The articles are then removed, dried and oiled. Fresh pieces of iron placed in the bath will be acted upon at once until the bath is exhausted. This process has a great advantage over that employing manganese dioxide, for the solution is clear and can be adjusted in strength at the beginning to suit the different classes of articles to be acted upon. The bath remains a solution of manganese phosphate until the introduction of iron or steel upsets the equilibrium of the solution by some of the iron being dissolved.

Ferric Phosphate Process. In the ferric phosphate process, the iron is oxidized outside the bath. Ferric phosphate prepared by any well-known method is dissolved in phosphoric acid, forming a soluble acid ferric phosphate. One of the advantages of this method is that the strong solution of acid ferric phosphate can be shipped to factories ready for use by diluting with water, thereby producing an oxidizing bath of known acid ferric phosphate content.

Preparation of Articles for Rustproofing Bath. Articles to be treated by the phosphatic process must be chemically clean to insure a perfect deposition of the protective coat of phosphates of iron. The articles are cleaned much the same as in electroplating, using the sandblast, acid pickling and alkali washes to remove coarse dirt, scale and grease, respectively. Sulphuric acid has generally been employed for the pickling bath.

Patents have been granted for the use of a strong phosphoric-acid pickling solution. It is claimed that the pickling cannot be properly performed by sulphuric acid for the reason that the removal of all traces of its basic salts is practically impossible, and as these basic sulphates are insoluble in the rustproofing bath, blotches result which rust almost immediately upon exposure to the air. This is also true when hydrochloric and nitric acids are used. It is well to remember that when phosphoric-acid pickling is employed and the acid is permitted to dry on the articles to be treated, or time is allowed for the action of the adherent acid phosphate solution, ferrous phosphates will be deposited upon the articles to be treated, which, when once formed, will not dissolve in the rustproofing bath. But when the articles are taken from the hot, strong, phosphoric-acid pickling bath and plunged immediately into the rustproofing bath, before the solution can evaporate, no such insoluble salts will be formed; the acid clinging to the articles will be taken up by the rustproofing bath and there will be formed on the articles the desired black surface of basic phosphates of iron.

Finish of Rustproofed Articles. The natural finish from the process is a steel gray, which when oiled becomes a uniform soft matte black. The phosphatic process may be often employed advantageously in combination with any other finish that may be desirable. Articles that are to be painted are not oiled, and the metal is left just as it comes from the chemical bath. The surface of the phosphatic processed metal is exceptionally well adapted for enameling, since there is a fine microscopic etching that helps to bind the enamel. If for any reason the enamel should crack, the exposed surface of the processed article will not rust, and consequently no peeling off of the enamel will occur, as is the case with enamelware that is not rustproofed. In cases where two or more coats of enamel are given to articles, one coat over the phosphate rustproof deposit may give better results. This method produces a very durable enamel coating.

The electroplating of the non-ferrous metals on iron and steel articles may also advantageously be preceded by phosphatic treatment, resulting in a more durable protective deposit and not seldom in a reduction in cost. In electroplating with nickel, the article is first finished, then greased, buffed, dipped in a hot potash solution, brushed with pumice, dipped in cold water, copper-plated, buffed, dipped in a potash solution and in hot water, brushed with pumice, dipped in cold water, and then nickel-plated. By employing the phosphatic process previous to the nickel-plating, the operations may be reduced to finishing the article, immersion in the phosphoric-acid solution, and immediately nickel-plating.

Advantages and Limitations of Process. The field for an effective and economical rustproofing process is really limitless as long as iron and steel will rust. The predominant advantage of the process described is its effect of increasing the longevity of iron and steel, because, when they are thoroughly processed, such metals are immune from corrosion due to atmospheric attack. Government statistics show that 23 per cent of all the iron and steel output in a year is "junked" because of rust. All forms of iron and steel articles can be processed, from dental needles to structural steel beams.

Another economical feature of rustproofing, particularly in the machine-building industry, is the substitution of processed iron and steel for articles heretofore made of copper, brass and aluminum. The substitution of rust-proofed steel for an expensive alloy for automobile carburetors resulted in the saving of from sixty cents to over a dollar on every carburetor.

While the phosphatic processed article is immune from corrosion when exposed to severe atmospheric corrosive agencies, it will not withstand actual exposure to hydrochloric, muriatic, acetic, sulphuric or similar acids. Neither is it protected against corrosion when subjected to the constant attack of chemical fumes, although it will

resist intermittent attacks well enough. Sterilizing solutions have no effect on processed iron and steel.

The mechanical equipment of a processing plant consists essentially of sandblasting apparatus, pickling tanks, tumbling barrels, and special tanks for the phosphatic processing. The latter are double steel tanks equipped with steam coils to cause a constant and uniform agitation of the solution. The accompanying illustrations Figs. 1, 2, and 3, are from a well equipped plant that covers an area of four acres, and has a processing capacity of 200 tons of metal a day.

Changing Composition of Surface Metal. The Parker process differs from all of those methods of rustproofing where a protective coating of paint, enamel, or some similar material is spread over the surface of the metal. Instead of covering the surface of the work in this way, the Parker process applies a chemical treatment which changes the composition of the metal to a depth of from 0.001 to 0.003 inch, making it proof against the corrosive action of air or moisture. As the size or contour of the work is not changed in any way by the rustproofing process, it is feasible to employ this method for protecting machined surfaces from rusting, including such parts as threads and nuts which must subsequently be assembled together. No allowance need be made for change of dimensions by the process, as this is practically a negligible factor. For this reason, it is a method of rustproofing that is especially adapted for protecting the finished surfaces of machined parts. The process is conducted at a temperature of not over 212 degrees F., and as it does not affect the temper, elasticity, or tensile strength of steel, it may be used for applying a rustproof coating to metal cutting tools; neither does it alter the magnetic properties of the work, although it does exert a slight insulating action against the flow of an electric current. Welding, brazing, soldering, or other operations requiring the application of heat to the work, may be performed after the work has been through the Parker process, but such a practice is not to

be recommended, because the rustproof coating deteriorates under the influence of high temperature. The rustproof coating applied by this process is permanently fixed to the surface of the work and will stand very rough treatment without damage. For instance, rustproofed test bars can be pulled in a tensile strength testing machine without causing the protective coating to flake off at the point where the neck is formed. The metal will also stand a considerable amount of bending without damage, although there is a tendency for the chemically treated surface coating to deteriorate considerably if the work is formed or drawn under a power press. Consequently, it is recommended that wherever practicable the rustproofing process be performed after all other manufacturing operations have been completed.

As this rustproofing process is conducted at a temperature not exceeding 212 degrees F., there is no danger of distorting the work, which is a feature that makes it possible to rustproof the parts of many delicate instruments which could not be treated successfully if it were necessary to employ a high temperature. The possibility of permanently rustproofing iron or steel has also made it possible to use one of these inexpensive metals in place of a more costly material such as brass, aluminum, etc. The Parker rustproofing process is said to make a perfect foundation for the application of paint or enamel, and affords a bonding coat which is made part of the metal by a chemical reaction. The way in which poorly applied paint or enamel tends to flake off in large pieces, is usually due to the fact that the enamel has been chipped at different points, thus exposing very small surfaces of the iron, and that rust has started at these points, which slowly eats its way beneath the enamel with the result just mentioned.

Applying the Parker Rustproofing Process. In the Parker rustproofing process the work is dipped into a tank containing a chemical solution that changes the surface of the metal in the manner previously described. This rustproofing process is accomplished by means of a chemical

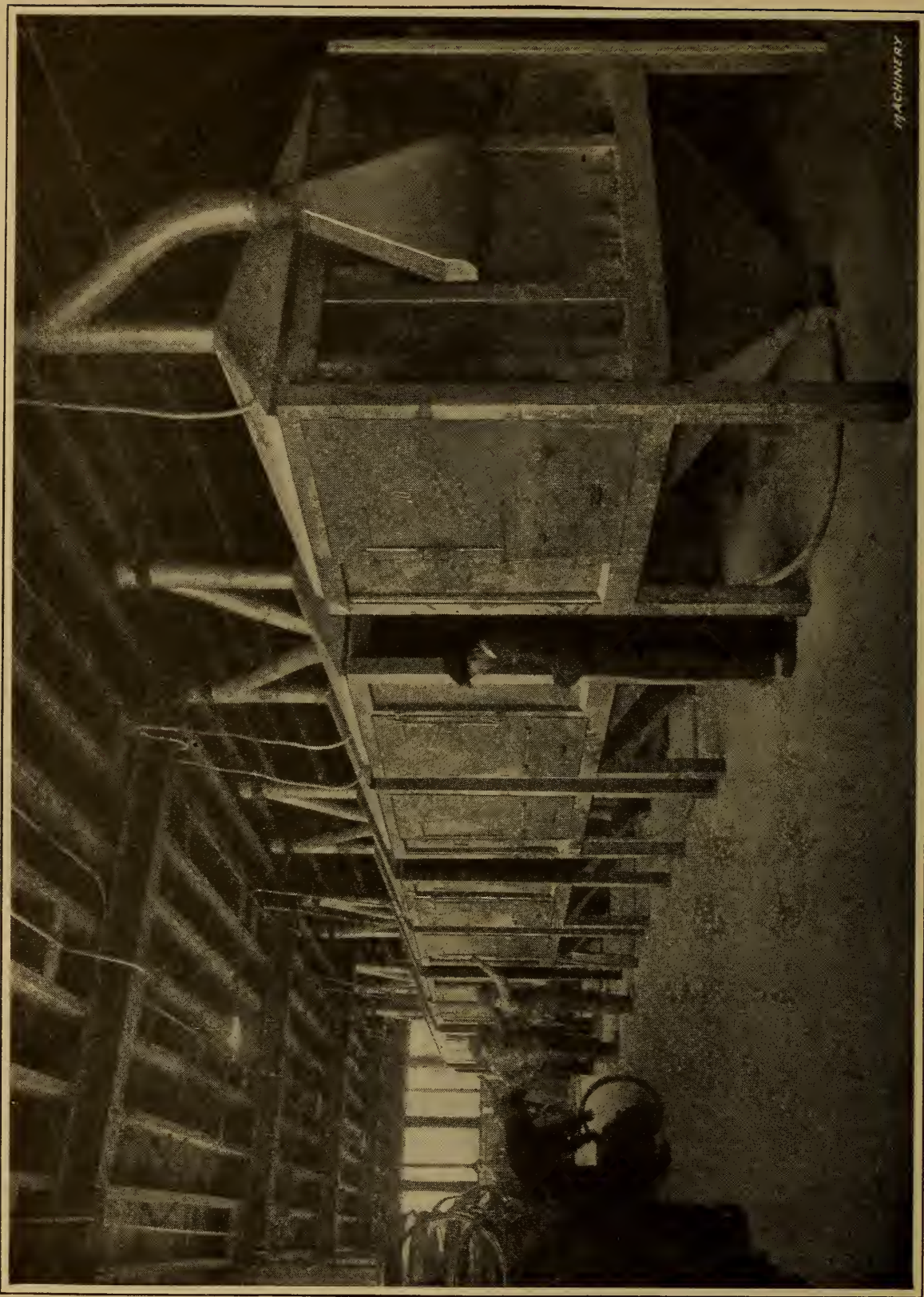


Fig. 1. Battery of Pangborn Sand-blasting Machines for cleaning Work before applying the Rustproof Protective Coating

reaction which takes place on the surface of the iron; therefore, in order to get uniform results, it is necessary first to have the metal perfectly clean. As a result, various means are employed for this purpose, the method adopted for each case depending upon the nature of the work. For instance, heavy castings are sand-blasted to remove scale and silica deposits. Forgings with a heavy oxide deposit are usually subjected to a pickling operation in a tank containing a 5 per cent solution of sulphuric acid. This acid cuts off the scale and other foreign matter and leaves the surfaces of the iron exposed for the rustproofing process. Stampings or punchings made from cold- or hot-rolled sheet may be cleaned by the pickle or sand-blast as desired. The plant shown in Figs. 1, 2, and 3 is for rustproofing by this process.

The third method of treatment, which is used in the case of power press or automatic screw machine products, and other parts from which grease must be removed, are cleaned in a solution of caustic soda or other alkali. After the work has been cleaned, it is put into the processing tank which contains a solution of acid ferrous phosphate and acid ferric phosphate of a strength that experience has found most suitable. This chemical mixture is shipped to the user in concentrated form and is diluted according to instructions given him for handling the particular kind of work on which the process is to be employed. The solution in the tank is maintained just below the boiling point, namely, 212 degrees F., by means of coiled pipes through which live steam is passed. After the work has been in the rustproofing solution for a short time, bubbles of gas begin to rise from it. This affords an index of the length of time the work should be left in the tank, because so long as these bubbles continue to come to the surface of the solution it shows that the process is incomplete. When no more bubbles rise, it is because the solution has exerted its maximum effect upon the work, which shows that the process has been completed.

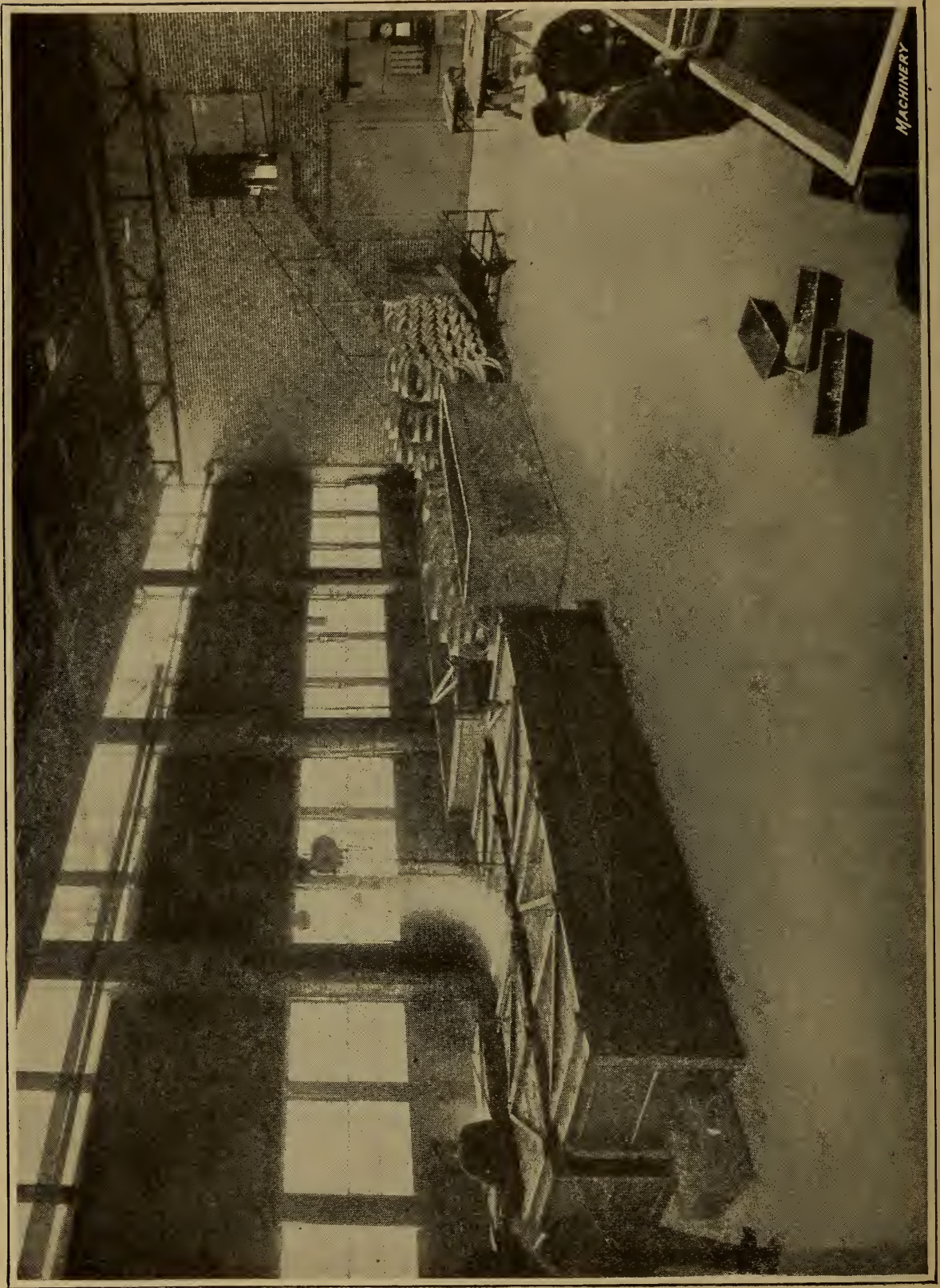


Fig. 2. Close View of the Processing Tanks in which the Work is immersed to apply the Rustproof Coating

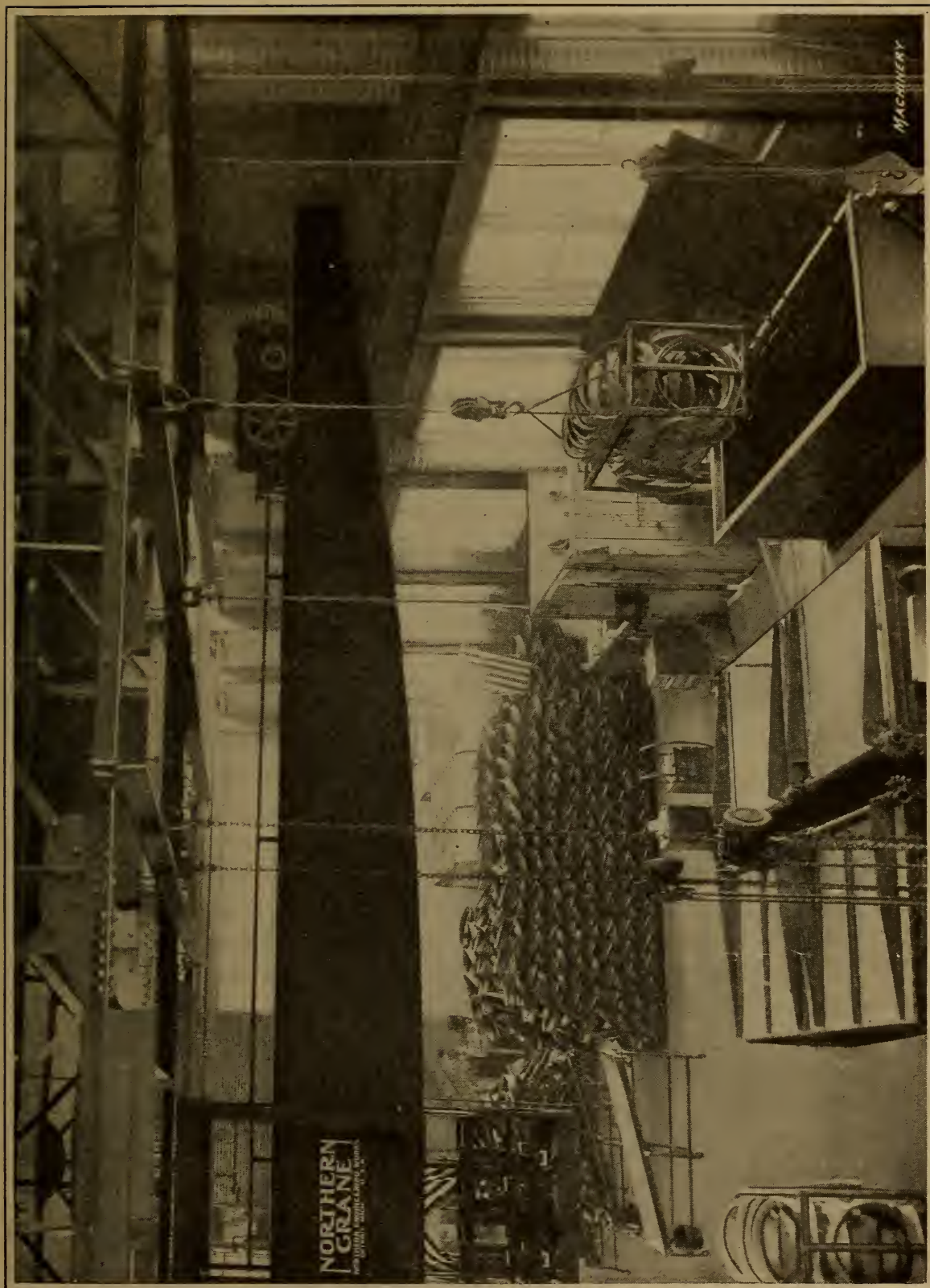


Fig. 3. Raising Automobile Wheel Rims from Rustproof Processing Tank. A Pile of Finished Rims will be seen in the Background

The effect of the chemical reaction is to cover the surface of the metal with a very thin coat of basic iron phosphate, which is of such a chemical composition that it is immune to either oxidation or corrosion under ordinary conditions of exposure. It keeps the air and moisture away from the iron, and prevents their exerting a corrosive action. The process differs fundamentally from painting, enameling, galvanizing, or electroplating in that the rustproof coating penetrates a very slight distance into the metal and is chemically bonded to the iron, instead of merely being spread over the surface. The length of time required to accomplish this result is usually from one and one-half to two hours. Experience has shown that iron with a low percentage of carbon takes a longer time to process than such a material as casehardened steel on which the process works rapidly. The pieces are then removed from the tank, and it is important to note that no drying is necessary because they retain sufficient heat to evaporate all of the water which adheres at the time the work is removed from the solution.

Methods of Applying a Final Finish to the Work. As the pieces come from the processing tank they are light gray in color, this appearance being due to the fact that the surface is of a very fine crystalline formation which diffuses the light in a way to conceal the true appearance of the iron phosphate formed on the surface of the work, and also owing to the small spaces filled with air which are present all over the surface of the work. Various methods of final finishing may be employed, but one which gives very satisfactory results is to dip the work into a neutral mineral oil which displaces the air from between the crystals and affords a uniform reflecting surface all over the work. As a result, the apparent color changes from a light gray or a grayish green to a deep black. The work may be left with a dead black finish, or a high polish may be produced by buffing. In addition, the rustproof surface of the work may be utilized as a foundation for the application of lacquer, paint, or enamel of any desired color.

Application of Parker Process as a Foundation for Paint or Enamel. When paint or enamel is applied to iron and steel products in the usual way, there is danger of failure to obtain a perfect bond, and this is particularly true in cases where a slight amount of rust has developed on the metal before the paint or enamel is applied. Under such conditions, vibration or any form of shock is likely to cause the paint to flake off, but the application of a preliminary rustproofing treatment by the process effectually prevents trouble of this kind. Paint or enamel will flow uniformly and cling tenaciously to a surface prepared in this way, and it is stated that the application of a filler coat is unnecessary. Where so desired, two coats of gloss enamel may be applied on a surface prepared by rustproofing and produce a very good appearance. In this connection, it is stated not only that the surface prepared in this way will stand more rough service without damaging the enamel, but that in case the enamel is scraped off the metal, the exposed surface is still rustproof. There will be no trouble therefore, from rust eating its way in beneath the enamel and causing further damage. In this connection, it is important to note that if paint, enamel, or a similar finish is to be used, the work is not dipped in oil after being removed from the processing tank, as in the case where the natural black finish is required.

Chemicals Used for the Rustproofing Process. Chemicals that are used in preparing the rustproofing solution are shipped to the user in concentrated form, and they consist of a mixture of acid ferrous phosphate and acid ferric phosphate in the ratio of one part of the ferric iron to three parts of the ferrous iron. Additional oxygen is necessary to maintain the ferric iron content of the processing bath, and this is supplied by adding a chemical reagent known as solite. The processing bath is prepared by diluting the concentrated solution with water. Owing to the chemical reaction that takes place between the chemicals in the processing bath and the work to be rustproofed, the bath loses acidity and this must be restored through the

addition of a suitable quantity of the concentrate and half as much solite. The chemical reaction produced by this processing bath is a self-balancing one; that is to say, the excess of elemental iron on one side, and the excess of the rustproofing solution of acid phosphate on the other, are stopped in their inter-reaction through the chemically altered surface of the iron, which prevents the solution from coming into contact with the pure iron beneath the rustproof surface. When this result is obtained, chemical action ceases, which is denoted by the fact that no bubbles arise to the surface of the bath. The rustproof surface produced on the work is more or less crystalline in character, and possesses a marked capillary action, which aids in retaining other protecting substances, such as oil, paint, enamel, etc. The rustproof surface, it should be understood, possesses little resistance against wear if it comes into frequent frictional contact with other surfaces.

Among the different classes of products on which this method is used for rustproofing parts, the following may be mentioned: arms and munitions, automobiles, builders' supplies, cameras, dental supplies, electrical equipment, farm implements, hardware specialties, motor trucks, ornamental iron works, phonographs, railway supplies, ranges and stoves, sporting goods, steel furniture, telephone equipment, and typewriters.

CHAPTER IV

RUSTPROOFING CAST-IRON PARTS

THE method of rustproofing cast-iron parts to be described was developed by Hans Renold, Ltd., Manchester, England. While the following description relates to the process as used for rustproofing fuse bodies, it can also be applied to the rustproofing of miscellaneous cast-iron articles. The process is based on the fact that a film of magnetic or black oxide of iron is formed on the surface of iron castings when heated to a temperature of 700 degrees C. or over in an oxidizing atmosphere. This film affords considerable protection against rusting, but will, in the course of time, on exposure to the atmosphere, become converted to brown oxide of iron, hydrated, that is, iron rust. In order to prevent this atmospheric action, the articles are dipped while at 700 degrees C. in cottonseed oil. The heat causes the oil to form a varnish or protective coating which thoroughly impregnates the oxidized surface. The details of the process were worked out by the firm of Hans Renold, Ltd., to treat a weekly production of 40,000 fuse bodies, the operation of the plant requiring one man and eight girls per shift.

Cleaning Parts before Rustproofing. It is essential that the articles be absolutely clean before heating. They are first suspended in a bath of hot "Lyco" (Fig. 1), the strength being 11 ounces per gallon. The bath contains 40 gallons, and is renewed every two months. The fuse bodies are placed on hooks and suspended in this bath for about three minutes to remove all traces of grease and oil. They are then washed in cold running water for a few seconds and transferred to an electrolytic bath, which consists of cyanide of potassium (98 per cent pure) in the

proportion of 4 ounces per gallon of water. If less pure, a greater proportion is required, that is, at 80 per cent, 5 ounces to the gallon. A purity of less than 80 per cent is not recommended. This bath contains 35 gallons, and is made up every two or three days. The fuse bodies are suspended by steel hooks from cathode brass bars which stretch across the tank. The bodies, therefore, form the cathodes, and iron plates suspended in the bath form the anodes.

The bodies remain there five minutes, and when a current of electricity of 25 amperes at 8 to 10 volts is passed

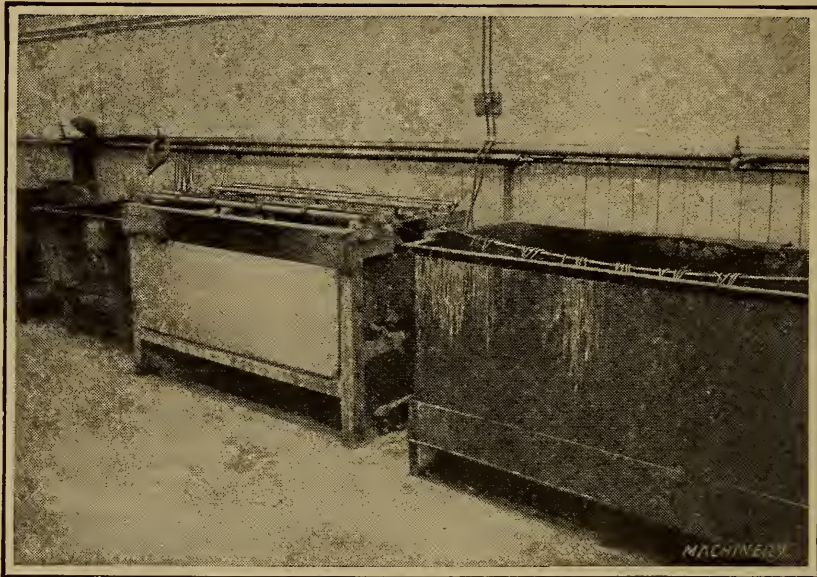


Fig. 1. The Cyanide and "Lyco" Baths

through the bath, a chemical action takes place at the surface of the articles, the result being that all foreign matter is removed. The bodies are then placed in cold running water for washing off the cyanide, after which they pass to a hot water tank, where they remain three or four minutes in order to become thoroughly warm, to facilitate drying.

Drying the Parts. After being washed, the articles are taken to a heated sawdust bin and dried; the sawdust is then blown off and the drying completed by hot air. The blast is supplied by a compressor, the compressed air being

dried and heated by the apparatus shown in Fig. 2. The cold, damp air enters at the top of the first chamber (shown at the right) and the moisture from it collects at the bottom. The air passes through a central pipe and out at the top, and is led to the bottom of the second chamber. There is a perforated cylinder containing calcium chloride in this chamber, through which the air must pass and where practically all the remaining moisture is absorbed. The air is then filtered by passing through a third chamber containing cotton-wool. The second and

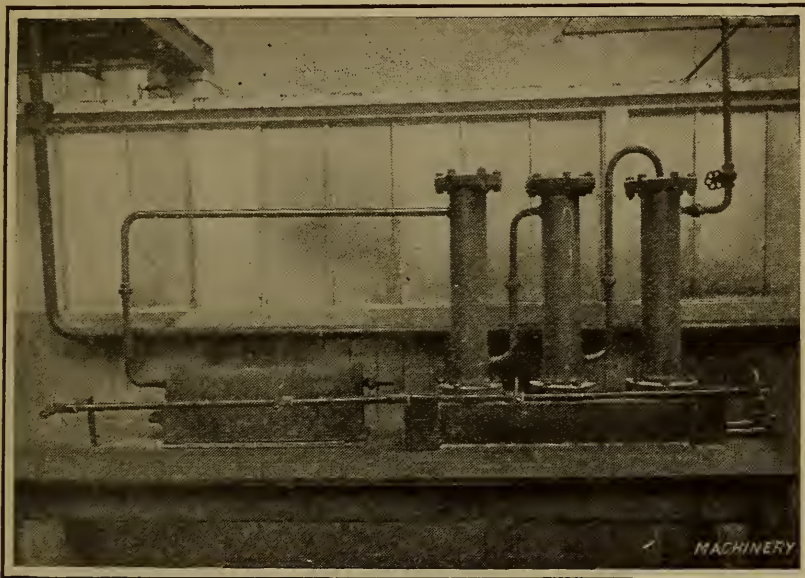


Fig. 2. Air Drying and Heating Apparatus

third chambers need replenishing about once a month. From the top of the third chamber the air is led to the heating apparatus. This consists of a sheet iron box triangular in section. The air pipe extends inside along the top, and a pipe with a series of bunsen burners is situated underneath about 6 inches below the air pipe. These burners heat the air to the required temperature, and it then passes to the blowing taps or nozzles. After drying, the bodies are placed in trays and transferred to the inlet end of the furnace.

Heating the Parts. The bodies are placed in a Richmond reverberatory furnace, 9 feet long, 10½ inches wide,

and 12 inches high, as illustrated in Fig. 3. The furnace will accommodate about 120 bodies at one time, and 400 bodies per hour can be treated quite satisfactorily. A ram, as shown in Fig. 4, actuated by a handwheel and rack, pushes the plates carrying the fuse bodies into the furnace.

A small hood is built over the inlet to facilitate the loading of the plates. A brick hood is also built over the exit so as to conserve the heat of the plates and prevent the bodies from being chilled. The plates for carrying the bodies have sets of lugs cast on the upper surface, on which

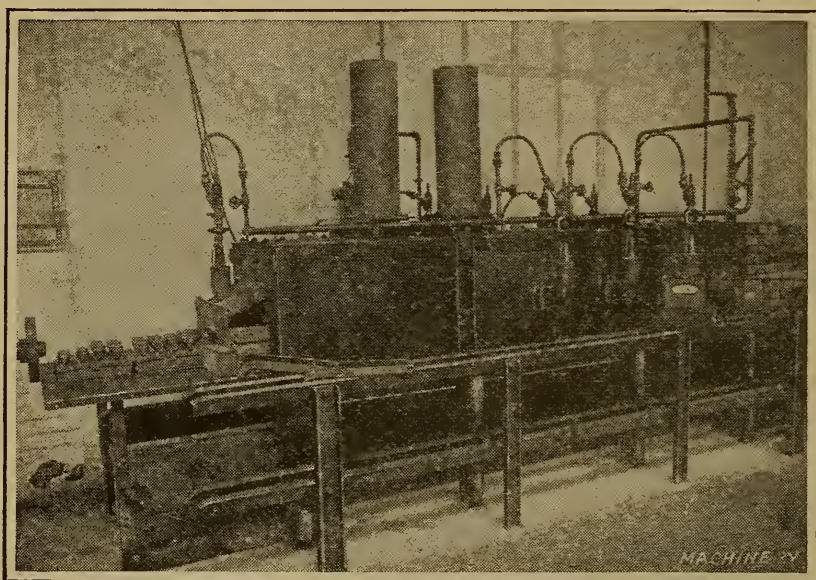


Fig. 3. Reverberatory Gas Furnace

the bodies rest. There are three lugs for each body, and they are cast to a knife-edge in order that the body may not be marked, which was found to be the case when it was placed on a flat surface. The bodies are placed nose downward on these lugs, each plate carrying twelve bodies.

The heat is so arranged that the temperature of the bodies gradually rises until, by the time they reach the middle of the furnace (about ten minutes), they are heated to about 700 degrees C., and this heat is maintained until they pass out of the furnace, the whole heating taking twenty minutes. The nature of the flame must be such that the atmosphere of the furnace is an oxidizing

one, so as to form the magnetic oxide of iron on the fuse bodies, at a temperature of 700 degrees C. This means admitting as much air and as little gas as possible, consistent with the maintenance of the temperature. If the color produced after quenching is gray, the proportion of gas to air is too great, and the burners must be readjusted.

Adjustment of temperature may be made by admitting more or less gas, but it takes about an hour before the furnace responds to this adjustment. Control, however, may be exercised by passing the bodies through the furnace



Fig. 4. Ram for loading the Furnaces

more or less quickly. Care must be taken to shut down the gas when the last bodies of the lot are coming through; otherwise, due to the less amount of cold material entering the furnace, the temperature will rise, even to such an extent as to cause blistering of the bodies, which occurs at 900 degrees C. It is advisable to run the furnace fully charged for as long a period as possible. The deformation of the fuse bodies due to the temperature attained (700 degrees C.) is quite negligible.

Quenching. The quenching tank is placed at the end of the furnace. This tank, which is shown in Fig. 5, is

10 feet long, by 2 feet wide, by 4 feet 6 inches deep, and is let into the floor so as to bring the level of the tank 2 feet from the ground level. The top of the tank is therefore 5 inches below the level of the furnace floor, and a sloping iron plate connects the furnace floor with the tank. This tank is filled with cottonseed oil to within 3 inches of the top. If the body comes to rest quickly after being placed in the bath, it is marked by any surface it rests upon; therefore the bodies must not be dropped directly,



Fig. 5. Oil Tank in which Bodies are dipped to produce Rustproof Coating

and must be cooled to such a degree that the oil coating is formed evenly over the whole surface before they come into contact with the conveyor which carries them out of the oil tank.

For this reason they are immersed for seven or eight seconds in the main body of the tank and then transferred to a hopper fitted with baffle plates, which is situated in the same tank. They fall from side to side until they reach the conveyor at the bottom of the tank, into which they fall comparatively lightly, and, owing to the time taken in

falling, they are cooled sufficiently so as not to take the impression of the surface they fall upon. The baffle plates in the hopper have rounded sides and are covered with wood or linoleum so as to avoid marking the fuse bodies.

The hopper is situated at the furnace end of the tank. The red-hot castings are lifted from the plate by means of a fork. If the bodies are thoroughly submerged, no blazing will result. The temperature of the oil should be such that the castings may be easily handled when the conveyor carries them above the level of the oil. The conveyor, also shown in Fig. 5, consists of a series of horizontal buckets of a length to suit the width of the tank. These buckets are mounted on chains which are driven at a speed of 18 inches per minute by a motor through a reduction gear. The conveyor is situated in the oil tank at an angle, the lower end being submerged at the end near the furnace; the upper end projects above the tank at the farther end.

The hot oil is drawn from the top of the tank by a circulating pipe placed horizontally inside of the tank immediately below the surface of the oil. It is pumped to the cooler by a small reciprocating pump, and the cooled oil runs by gravity back into the bottom of the tank. The temperature of the oil in the tank should never exceed 100 degrees C., as otherwise blazing may occur. An oil cooler, of the rotary drum type, is used for cooling. The rotary drum carrying four series of concentric plates revolves at 11' revolutions per minute, and dips into the oil, which adheres to the plates. Cold air is drawn through the cooler and comes in contact with the film of oil on the plates, thereby cooling the oil.

The bodies are picked off the conveyor and transferred to the drying bins, where they are dried in sawdust. A good deal of sawdust is necessary for complete drying, and, as fine sawdust is difficult to obtain, coarse sawdust is first used for absorbing the greater portion of the oil. The body is then blown clean by the hot air blast and the small threads are dried out with fine sawdust. A final

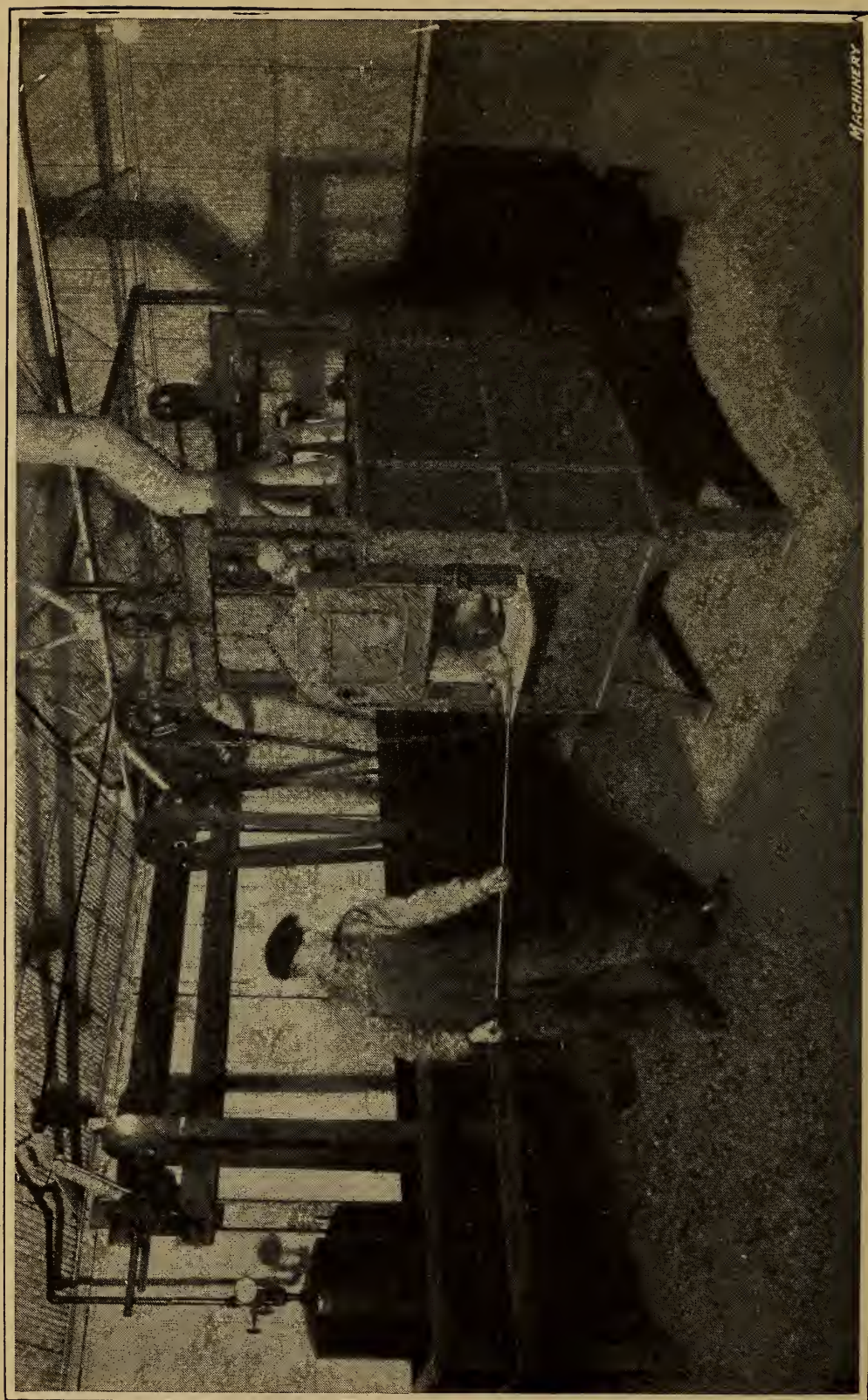


Fig. 6. Furnace used for rustproofing by the Andrews Process

blowing is given, and the fuses are then ready for inspection.

Some Difficulties that were Experienced. Some of the fuses had a slight copper deposit on the surface after heat-treatment. On investigation, this proved to have been deposited from oils and cutting compounds during the heating of the fuse bodies. These oils had been used in the machining of brass parts, and it was found that a chemical action had taken place between the free acids of the oils and the copper of the brass fuses, etc. The coppering is entirely prevented by the use of the cyanide cleaning bath. If copper should appear, it can be removed by immersing the body in diluted nitric acid, after which the bodies must again pass through the furnace.

Insufficient oxidation results in the finished bodies having a gray appearance. This is due to the atmosphere in the furnace containing too much gas, and is overcome, as previously mentioned, by admitting as little gas and as much air as possible consistent with the maintenance of the temperature.

Blistering, when it occurs, is due to overheating, and, as stated previously, occurs at 900 degrees C. or thereabouts. Finding the correct size for gas nozzles remedies this trouble.

Oil-sweating is due to all the oil not being absorbed. The final drying in fine sawdust and a thorough blowing with hot dry air overcomes this difficulty.

Andrews Rustproofing Process. To provide for the rustproofing of ferrous metals in order that they may be used as a substitute for copper, brass, bronze, etc., a process has been introduced by the Andrews Rustproofing Laboratories, Detroit, Mich., which is successfully used for protecting cast-iron parts. This process is applied by subjecting the work to a temperature of from 1150 to 1180 degrees F. in the presence of an oxidizing atmosphere, which results in opening the pores of the metal and sealing them with a layer of iron oxide. (See Fig. 6.) The

process can be used for projecting the surfaces of threaded work and similar parts which will later be required to assemble with corresponding close-fitting parts. This method of rustproofing applies an ebony-colored finish, which is of pleasing appearance and is said to be permanent as regards durability. The cost of operation is low, as unskilled labor may be utilized after the furnaces have been regulated and the burners sealed to assure operation under specified conditions that are adapted for the work in hand.

The process may be used in finishing machine parts or those which have been cast, rolled, stamped, etc. It is conducted by supporting the work on racks or some other convenient form of holder that will allow the oxidizing atmosphere of the furnace to come into intimate contact with all surfaces of the work to be rustproofed. Care should be taken not to lay the work on a rack or other form of supporting member which has a flat surface of any appreciable size in contact with the work, as such a condition would tend to retard the rustproofing process and prevent the obtaining of a uniform surface. In addition to detracting from the appearance, such a failure to rustproof the entire surface uniformly would also greatly detract from the efficiency of the treatment in preventing the formation of rust.

If moisture or any other corrosive element is able to penetrate beneath the rustproof surface at any point, it will start a formation of rust which will then proceed without restraint. The work to be treated is placed in the furnace and allowed to remain for a period of approximately fifteen minutes, after which it is removed and quenched in oil of a special composition. The work is then removed from the oil and dried in sawdust or by any other means, and finally it is rubbed to remove any slight traces of oil which may still adhere to the work, and to impart the desired degree of luster. Not only does this process afford an opportunity to substitute parts made of inexpensive

ferrous metals in place of more expensive brass, copper, or other materials formerly employed, but it is also claimed to be the means of making a substantial improvement in the appearance of the work.

Protection of Cast-iron Pipes. An interesting process is met with in the coating of large pipe for water mains. Dr. Smith, an English scientist, has patented a method of treating pipes, etc., by dipping them in a mixture of coal-tar, from which most of the volatile constituents have been distilled, and linseed oil, kept at a high temperature. The part is thoroughly cleaned and coated with linseed oil, which is baked on; it is then coated with the coal-tar mixture and the residual heat of the pipe serves to bake this on. The application of a coal-tar coating does not give very good results on sheet-steel riveted pipe, and a more or less soft asphaltum is used for this class of work. A material known as "maltha" and obtained from California petroleum as a residue which remains in the retort, after the more volatile portions have distilled off, is used, to a large extent, for this purpose. The dipping material is thinned with mineral oils of high flash point, and is heated to a high temperature for application, but the pipe is not baked afterward, the coating being allowed to cool in the air.

The Sabin Process. An improvement, known as the *Sabin process*, introduces the use of asphaltum and linseed oil, by means of which it is claimed to be possible to obtain a coating of any desired degree of elasticity, by adding the requisite amount of oil and baking properly. The use of volatile solvents is avoided by heating the compound to 300 degrees F. for application; a thin uniform coating results. After dipping, the pipe is allowed to drain for a time, until the excess has run off, which ordinarily takes half an hour or less. It is then put in the oven, which is heated somewhat above 300 degrees F., and allowed to remain for about two hours, or until the volatile substances have been driven off and the oil oxidized. A tough, hard coating is produced. The Sabin process has found a wide use.



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