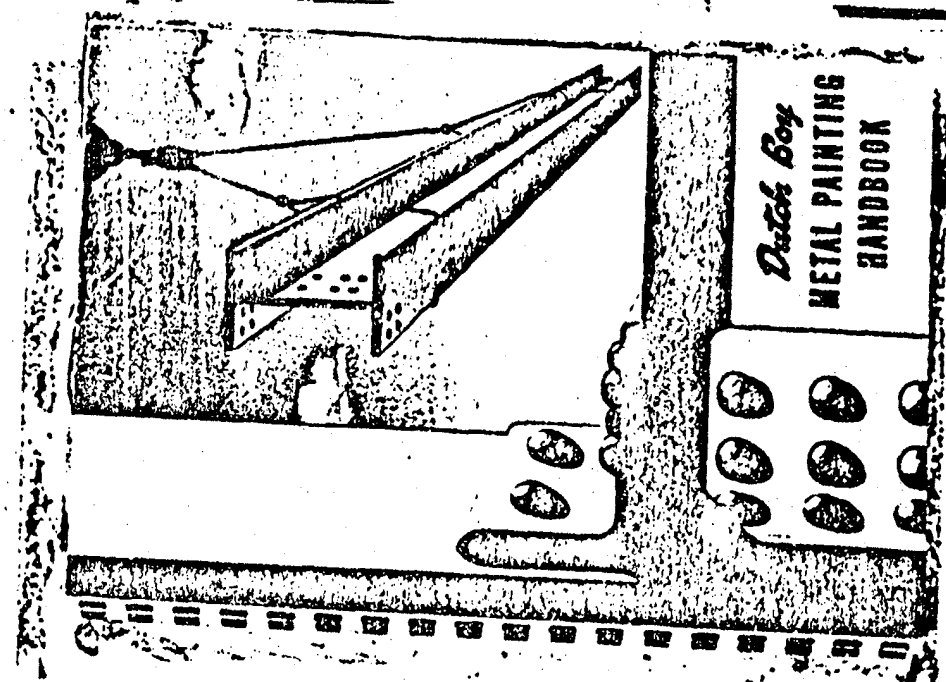

Dutch Boy
metal painting handbook

NATIONAL LEAD COMPANY
111 Broadway, New York 6, N. Y.

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Foreword

■ This booklet is intended to serve as a guide to those concerned with the use and manufacture of paint as an engineering material for the protection of structural iron and steel against corrosion.

■ By fully understanding the basic principles of corrosion, by making use of the most effective surface preparation methods developed by years of practical experience, and by utilizing modern protective paint coatings, such as red lead pigmented paint, engineers and fabricators of today are better able to cope with the problem of corrosion.

■ Therefore, the contents of this notice are some common measures drawn from a practical and theoretical viewpoint corrosion mechanism, surface preparation, and the formulation, application and specifying of metal protective paints.

■ *The technical personnel of our Research Laboratories will gladly cooperate in working out special metal painting problems. Consult the nearest branch for such assistance.*

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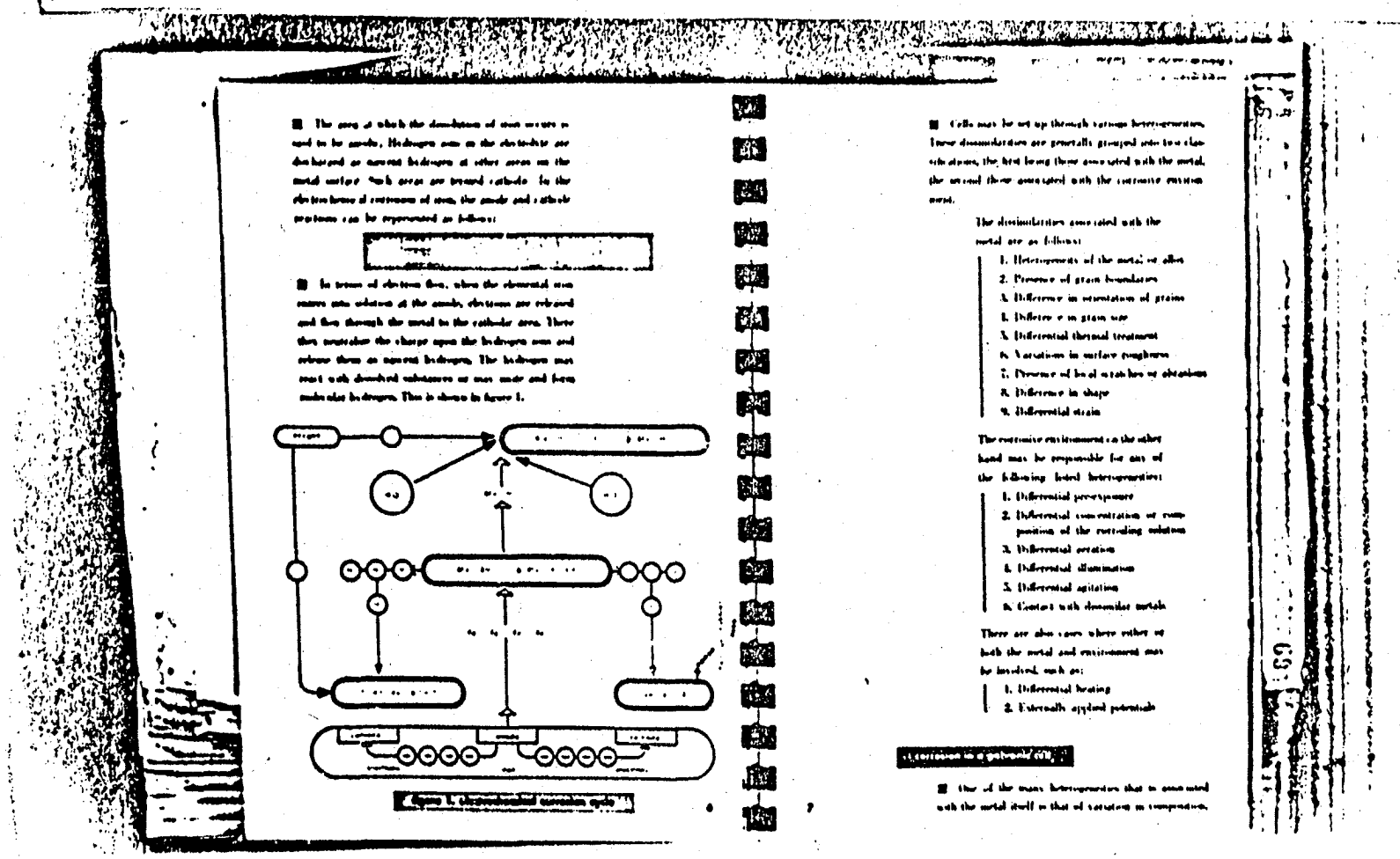
theory of corrosion

■ From the time when man started to use iron and steel as a material for his existence, he has had to contend with the forces of nature which cause corrosion. Early in this fight he learned that certain pigments in combination with organic binders were effective in resisting these environmental forces. However, his knowledge of why or how certain materials protected better than others was merely empirical. Recently, basic studies of the mechanism of corrosion and the role played by paints in protecting against corrosion were initiated. From these studies much of the empirical knowledge was substantiated and new ideas for producing better coatings developed. Naturally, due to the complexity of the many various types of corrosive forces existing in any one metal structure, fundamental studies of corrosion phenomena are best undertaken only when individual factors are isolated in the laboratory.

■ The type of corrosion most frequently encountered is the rusting of iron, which proceeds when water and oxygen are available in accordance with one of the following chemical equations:

■ An explanation of this corrosion mechanism is as follows: When an electrolyte containing oxygen comes in contact with iron, metal ions enter the electrolyte and the electrochemical process begins and the preceding chemical reactions could occur.



■ Cells may be set up through various heterogeneities. These discontinuities are generally grouped into two classifications, the first being those associated with the metal, the second those associated with the corrosive environment.

The discontinuities associated with the metal are as follows:

1. Heterogeneity of the metal or alloy
2. Presence of grain boundaries
3. Difference in orientation of grains
4. Difference in grain size
5. Differential thermal treatment
6. Variations in surface roughness
7. Presence of local scratches or abrasions
8. Difference in shape
9. Differential strain

The corrosive environment on the other hand may be responsible for any of the following local heterogeneities:

1. Differential pressure
2. Differential concentration or composition of the corroding solution
3. Differential aeration
4. Differential illumination
5. Differential agitation
6. Contact with dissimilar metals

There are also cases where either or both the metal and environment may be involved, such as:

1. Differential heating
2. Externally applied potentials

■ One of the main heterogeneities that is associated with the metal itself is that of variation in composition.

■ The area at which the dissolution of iron occurs is said to be anodic. Hydrogen ions in the electrolyte are discharged as nascent hydrogen at other areas on the metal surface. Such areas are termed cathodic. In the electrochemical corrosion of iron, the anodic and cathodic processes can be represented as follows:

■ In terms of electron flow, when the elemental iron enters into solution at the anodic electrons are released and flow through the metal to the cathodic area. These then neutralize the charge upon the hydrogen ions and release them as nascent hydrogen. The hydrogen may react with dissolved substances or may unite and form molecular hydrogen. This is shown in figure 1.

Figure 1. Electrochemical corrosion cycle [illegible]

mechanical protection by reason of the formation of hydrophobic lead compounds, the main method of protection is inhibition. An explanation of inhibition as it is exerted by an oxidizing type pigment is given below.

■ When the zinc substrate starts to corrode, ferrous ions are released. These ions can combine with the hydroxyl ions in the water to form a somewhat insoluble ferrous hydroxide. However compared to ferric hydroxide, the solubility product of the ferrous hydroxide is relatively large so that ferrous ions migrate away from the surface of the metal and are then oxidized to ferric ions. Ferric hydroxide is formed is much more insoluble and precipitates out at the point of formation. Now if ferric hydroxide could be formed as an insoluble film at the metal surface (anodic) and so maintained, the anode would be sealed and further corrosion could not proceed. A pigment with a sufficient oxidizing potential such as red lead can do this and it can then passivate the metal. With this kind of protection, maintenance of a perfect paint film is not as mandatory as with a paint offering only mechanical protection.

■ The third type of protection, electrochemical or galvanic, is of limited nature. Advantage is taken of a more anodic extended metallic pigment in the paint. When an electrolyte penetrates the paint film, the least noble metal (pigment) proceeds to corrode as illustrated in figure 2. In doing so, it makes the metal which is to be protected, cathodic, preventing corrosion from taking place. However, if the pigment is electrically isolated from the structure it is to protect, either by formation of insulating products on the pigment particle, or by the insulative properties of the vehicle, then the film can only protect in a mechanical manner. Similarly, upon depletion of the metal content of this type paint, protection can be offered only by mechanical means.

■ From these basic principles which have been established as a result of fundamental research into the nature of corrosion of iron and steel, we are better able to recognize in practice the type of corrosive action against which a paint must protect. We are, therefore, better able to formulate and recommend paints for specific problems.

function of red lead

■ By analyzing the basic principles of the electrochemical theory of corrosion outlined in the previous chapter, it becomes evident that one of the main reasons why iron and steel rust comes as a result of the environmental company they keep. With this understanding, the logical reasoning follows that an efficient protective paint coating must, in addition to shielding the metal by mechanical means, also afford inhibitor protection through its chemical composition by neutralizing the detrimental effect of the environment.

protection by mechanical means

■ The first requisite in the achievement of mechanical protection by a paint film is adhesion of the coating to the metal surface. Properly applied to a clean surface, red lead paint securely anchors itself to the metal and forms a union which is not easily disrupted. The need for a tough, yet elastic paint film is all important on metal surfaces. Much of red lead's film elasticity and durability is credited to the formation of organic lead compounds, commonly referred to as "soaps." These properties are realized by controlling the normal degradation of a paint film

which results from the transport of scale which dissociates product on the paint mass.

■ As previously stated, protection by sacrificial means is a process of shielding the base metal from the corrosive agent, in which structure is the most contributing factor to resistance. Therefore, a paint film, to protect successfully by shielding, must be highly impermeable to corrosive agents. Impermeability tests on numerous organic paint coatings have proved red lead paint's superiorities in this respect.

■ Durability, or long term protection, has always been associated with red lead pigmented paints and there are ship coats that stand a decade operation. Even after rough handling and storage out of doors at the job site, shop coated structures remain in excellent condition, and require only spot priming to restore film continuity.

red lead as a corrosion inhibitor

■ Actual testing programs under severe service conditions have demonstrated that, although many paints appear provide a continuous coating, few afford effective inhibition of the metal. The most important feature of red lead as metal protective paints is its inhibitive action. This is provided through the unique chemical composition of red lead which supplements and improves the physical protection, thus adding years of serviceable life. R.J. Ball's separate protective value has made it a proven leader in the field.

■ Inhibition is aided by the anodizing or buffering character of red lead which thereby limits the corrosive action normally resulting from the decomposition during exposure. Furthermore, red lead, being an oxidizing agent in and whatever acts as an anodic inhibitor and tends to form a thin layer of iron compounds on the surface of the metal at the anodic areas. This layer of film continues

In preventing fracture even from bursting the metal. It has been observed on shop coated steel structures where damage has resulted during transportation, that the scratched areas are not seriously extended due to the penetrating action of red lead. If the damage to the shop coat is so great as to expose large areas of bare metal, such those areas will be subjected to rusting, and the surrounding surfaces will remain unaffected due to the tight bonding of red lead film at the edges of the ruptured portions. Thus, instead of costly complete repainting, only spot priming is necessary on exposed areas.

3

red lead manufacture—types—grades

■ Pure red lead is an oxide of lead, expressed by the chemical formula Pb_3O_4, and is the lead salt of orthoplumbic acid (plumbous orthoplumbate).

manufacturing procedure

■ In this country, the practice has been to make litharge first, then convert the litharge to red lead. The process proceeds according to the following equations:

$$2PbO + O_2 \rightarrow 2PbO_2$$

$$PbO_2 + 2PbO \rightarrow Pb_3O_4$$

By this method, the character of the red lead is controlled, to a large extent, by the character of the litharge from which it is made.

■ While the chemical are terms remain the same, there are two distinct processes generally employed in the manufacture of red lead which differ only in the method used to convert elemental lead to litharge.

■ In the more widely used method, the metallic lead is heated in a furnace until it is converted to litharge. In the other process, molten metallic lead is "atomized" by forcing it into the vicinity of a gas flame with compressed air. This atomization results mostly of it into litharge in a form which is collected in filter bags. When these two litharges are subsequently converted to red lead they are respectively called furnace and flame red leads. The final conversion of both types of litharge to red lead is achieved by means of further furnacing.

Types and Uses

■ Basically, the difference between the two types of red lead (flame and furnace) lies in their particle size, since the chemical composition and specific gravity are the same for both. Flame red lead is the finer of the two with regards to particle size. Furnace red lead, of intermediate particle size, is slightly coarser than flame red lead. Table I tabulates the comparative average diameters, the number of particles per cubic centimeter and the specific surface of each of the two products. Figure 4 illustrates the difference in particle size and fineness of the two types of red lead.

Table I. Red lead particle size

	Average diameter	No. particles per cc	Specific surface
Furnace red lead	0.8	[illegible]	1.0
Flame red lead	0.5	[illegible]	0.4

*This is a relative and arbitrary relationship of the particles in minutes.

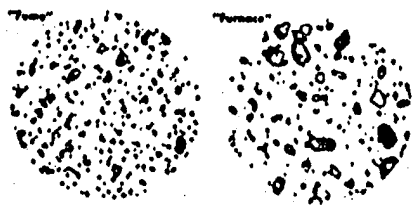
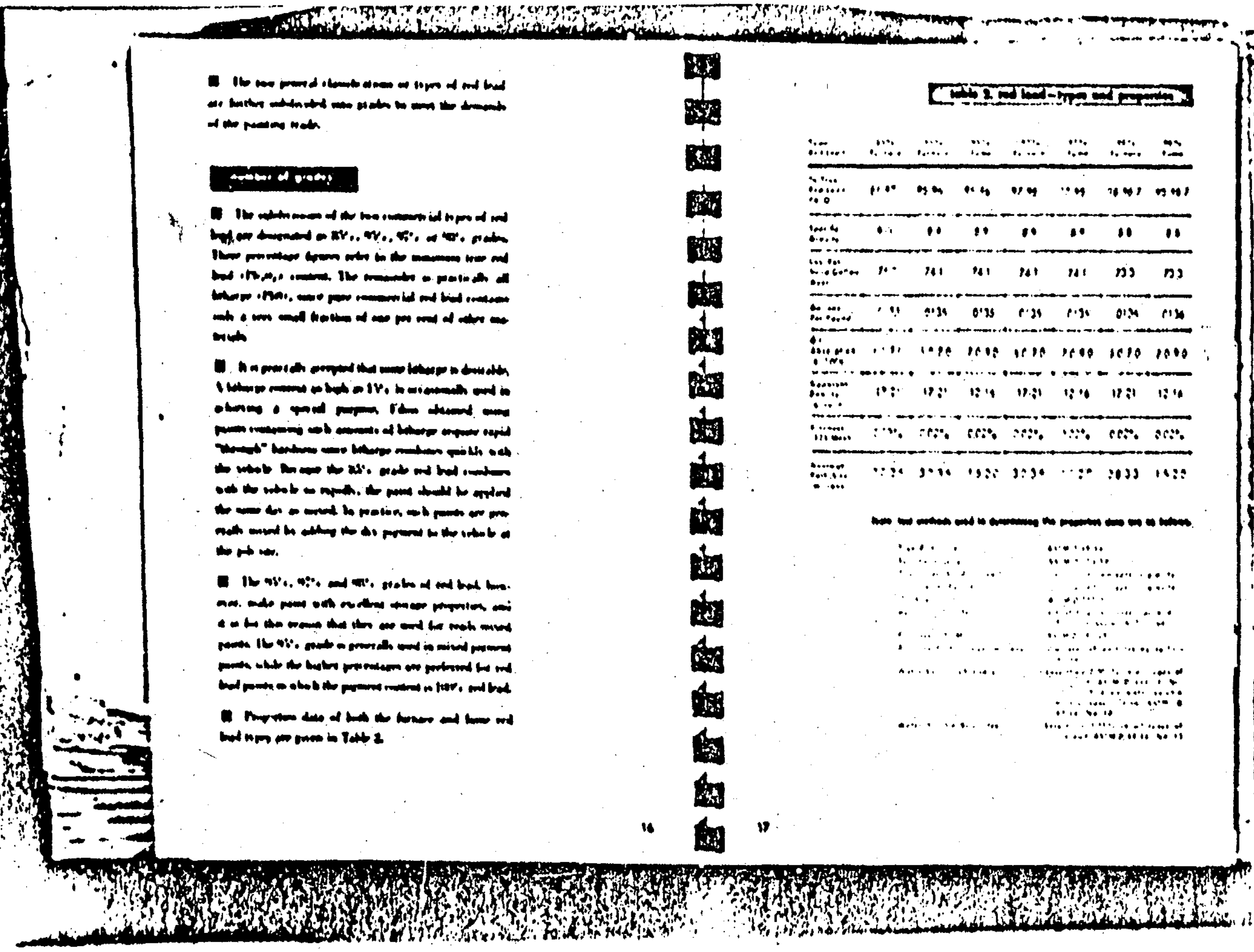


Figure 4. Photomicrograph red lead particles (1000x)

Paint Properties

■ The difference in particle size of these two types of red lead affects the consistency of the paints made from them when equal weights of each type are used. The finer particle size pigment results in paints of heavier, more putty consistency, while the coarser particle size gives heavy paint consistency and subsequently more leveling and flowing in applied films. For these reasons, heavy weight heavy red lead pigmented paints are best made with the furnace type pigment, since the larger particles impart sufficient leveling. Conversely, the finer particle size of the flame type red lead is more adaptable in light weight formulations to take advantage of its putty characteristics in maintaining satisfactory film structure. It is sometimes advantageous to use a blend of the two pigments in intermediate weight paints to obtain satisfactory applied film characteristics. In mixed pigment paints, either type may be used, since the problem of leveling and flow is usually taken care of by the rest of the pigment portion.

■ However, in the main, the choice of type depends on several factors, the most important of which are kind of vehicle, percentage of pigment specified, types of other pigments used, etc.



The two general classifications or types of red lead are further subdivided into grades to meet the demands of the painting trade.

Proportion data of both the furnace and fume red lead types are given in Table 2.

table 2. red lead—types and properties

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17

69

4

Formulating requisites

■ For the protection of metal surfaces, experience has proven that a properly formulated red lead paint has no superior. It is the paint most widely used on iron and steel as an inhibitor of corrosion and rusting. Its ease in down-to-job or site mixing, and lead is preferred by specifications and maintenance engineers.

■ However, in formulating red lead primers it should be understood that no one type will perform to the best advantage under all conditions.

■ Exposure conditions, surface preparation, method of application, drying schedule and compatibility with subsequent paint coats all must be considered in determining what specific formulation of red lead will give the best in long term service. Red lead's versatility and compatibility with a wide variety of vehicles, including most of the synthetic resin varieties, permits tailor made specifications to fit the needs of job and conditions.

■ The choice of pigments, and more particularly the choice of vehicle is governed, to a considerable extent, by the exposure conditions. Red lead paints of various formulations have been exposed to all types of corrosive agents. The more important environmental conditions can be placed in two main groups:

I. Atmosphere	II. Water
a. [illegible]	a. [illegible]
b. Acid	b. [illegible]
c. Alkali	c. [illegible]

■ Protection of iron or steel against any one or combination of the above conditions is provided by a series of protective coatings, known collectively as a paint system. Any such system will generally consist of an inhibitive shop coat primer, one or more field coats of inhibitive paint, a body and a finish coat. The primer or shop coat next to the metal, is formulated to promote inhibitive action and optimum adhesion so that a sound foundation will be established for the subsequent coats. By building up sufficient thickness of inhibitive paint film the subsequent field coats increase the system's impermeability to moisture and thereby provide the maximum in long term metal protection. The top coats are primarily designed to protect the primer, to provide decoration and to withstand the destructive action of the environment.

■ The discussion that follows primarily concerns itself with the formulation of metal paint primers in which red lead is used either as the sole pigment or in combination with other pigments to provide the necessary functions of inhibition and adhesion.

Red lead as the sole pigment

■ The best known primers with the record of longest performance are composed of red lead as the sole pigment in combination with linseed oil vehicles. They are still widely specified because they provide the most reliable protective coatings over the diversity of surface conditions which are encountered on structural steel. Red lead linseed oil primers are noted not only for their continuous inhibiting qualities, but also for their ability to adhere, even on steel surfaces which have not been thoroughly cleaned. In addition to functioning as an inhibitive agent red lead promotes such paint making properties as boiling, oil absorption, film formation and package stability to such a degree that it is unique among the inhibitive paint pigments of being able to be used alone in metal protective

primers. When the pigment phase of a primer is chalky or largely red lead, desirable properties are imparted which are not obtained with any other pigment of the common inhibitive type.

Red lead in other primers

■ The strong inhibitive characteristics of red lead, such as its ability to form strengthening organic lead compounds, make it the preferred pigment performing combined of properly designed oil-based primer paints.

■ In Chapter Six on formulation and type of examples are given of paints in which red lead is used either as a single pigment or in combinations in various percentages with other pigments. This spite also the continued general acceptance of red lead for the desirable properties that it provides in metal priming paints.

Adhesion

■ One of the most important properties of a paint primer for steel surfaces is strong adhesion. Strong adhesion is primarily dependent upon strongly bonding with the base metal. Thoroughly cleaned surfaces, such as those freshly sandblasted, provide a good base for bonding. However the structural steel usually encountered in practice is rarely so well prepared and generally the surface contains mill scale, rust, and other products. On such surfaces the paint must penetrate the chalks to set up penetrate to the base metal beneath the edges of any scale adhered mill scale, as well as through cracked rust.

■ The properties of setting to largely a function of the paint vehicle. When the vehicle possesses good surface wetting properties, a bonds are remade have penetrate into the pigment phase of the paint. The chalks of red

lead instead of primers to penetrate through surface contaminants and thereby adhere to steel surfaces which have not been thoroughly cleaned has been proven by actual practical experience. This property is, in large measure, attributable to the linseed oil which possesses the best known surface wetting characteristics of all the commonly used paint vehicles.

■ The synthetic resin type vehicles give excellent service on sandblasted or specially prepared steel, but few specials have shown unexpected and quick failure when applied to steel not so prepared.

■ Straight varnish vehicles, due to their rapid drying and setting, are limited in surface wetting properties because they bridge over cracks in mill scale, rust patches, etc., rather than wetting through to the base metal. Because they do not set as well as the slower wetting linseed oil, they should, in a majority of cases, be properly as is fed to give better surface wetting characteristics when used on surfaces which have not been thoroughly cleaned.

■ Synthetic resins are often combined with raw linseed oil to provide an effective compromise. The resulting paint gives faster drying than straight oil and better wetting than the straight synthetic resin type vehicles.

■ In recent years, a wide variety of synthetic resins has been developed and used in the formulation of protective coatings. These resins possess many special properties, and by their judicious use, and with due consideration for environment and surface condition of the metal, coatings can be formulated to cope with unusual exposures. Examples of the synthetic resin types available to the industry are the alkyds, phenolics, coumarone-indene, chlorinated rubber, and vinyls, which can be used alone or in combinations as metal primer vehicles. Such vehicles are being used with red lead to provide fast-drying metal primer paint coatings which successfully meet a wide variety of service requirements.

choice of primer

■ Considerable thought should be given to the type of red lead primer chosen.

■ If unlimited drying time can be allowed between painting and handling, primers whose vehicles have a high oil content are desirable, particularly where good surface preparation is not likely to be obtained. Where faster drying is required to meet a production schedule, a well formulated paint containing an oil resin varnish vehicle will prove satisfactory and handling on the following day, and will give very satisfactory service. Where primers, painting and handling within the working day is anticipated, a fast drying red lead paint containing a resin vehicle should be used. However, to obtain satisfactory service from such paint, the surface should be well cleaned, preferably by sandblasting or pickling methods.

■ The intended exposure conditions generally dictate the composition of the primer. For example, steel to be immersed in water should be coated with a paint system possessing a high degree of impermeability and the greatest possible resistance to the softening action of water. For general structural metal painting, an oil or oil resin type primer gives good service.

■ For interiors of fresh water tanks for portions of locks and dams immersed in river water, for air conditioning chambers, as well as steel surfaces subjected to very humid conditions, prior to all field testing make sure that red lead phenolic resin varnish or red lead vinyl resin types provide excellent service. For such items as railroad cars, coaches, cars and other steel fabricated materials where surface preparation and paint application can be carefully controlled, quick drying red lead primer of the alkyd resin types give very good protection.

■ For other special exposure environments such as high acid or high alkaline atmospheres, the previously mentioned vehicles, as well as modified forms of these and other types, have been successfully employed with red lead.

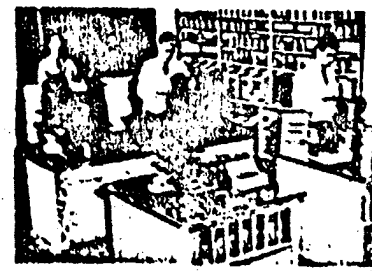
■ So far the discussion has concerned itself with the primer or first coat of paint. These paints are usually applied in the shop rather than at the job site. After erection, as has already been stated, it may be necessary to repair any damages to the shop coat by spot priming. The subsequent coats of paint, termed field coats, may be the same as those already mentioned for the primer, or their composition can be modified since wetting of the steel surface is no longer the primary consideration. This modification will be in the nature of raising the resin content to provide maximum protection against infiltration of the corrosive environment.

■ The undercoats, however, must not be expected to do all the protecting. Their main function is to prevent corrosion. As well as providing a decorative appearance, finish coat paints should be designed to resist the elements of the environment and thus protect the undercoats.

system compatibility

■ Of utmost importance in metal protective painting is the formulation and selection of paints for each coat, which when used together will be compatible. In other words, adjacent coats of paint used to make up a complete system should be selected for superior adhesion, one to another, and should contain no ingredients which would adversely affect previous or subsequent coats. It should be emphasized here that each paint coat should be allowed to thoroughly dry or "cure" before applying the succeeding coat.

■ To promote adhesion between coats, paints should be formulated to dry with low gloss in order to provide



research and tests

■ As a result of modern research, much has been accomplished in providing paint systems which give long-time protection to metal surfaces. Both improved paints and paint materials have been developed through laboratory research and actual testing at various experimental stations throughout the nation.

■ The National Lead Company has long been aware of the value of testing all paints under actual service conditions. Not only does this permit natural corrosion evaluations, but it also furnishes our chemists and technicians with a mass of valuable data to assist our customers in solving difficult exposure problems or special formulation requirements.

■ Practical field evaluation of all experimental paints for their metal protective ability is investigated by applying the paints to metal panels and exposing them to the atmosphere or water immersion at both Newville, N. J., Perth Amboy, N. J., or New Kensington, Pa. At these locations, the paints to be tested are applied at recommended and at normal spreading rates in the usual methods of application, i.e., spattering, brushing, dipping, etc. The specimens used for these tests depend on the ultimate application of the paints. For example, structural steel, galvanized plate or cold rolled sheet are used.

■ Research on new and improved metal protective paints truly originates in the modern research laboratories. Previous experience coupled with the knowledge of new pigments and vehicle developments results in thousands and

without "bleeds" for the proper exchange of the corrosion resist. When an undercoat dries too glossy and too hard, this condition may result lead to cracking or poor adhesion of the subsequently applied paint coats.

■ Care should be exercised in choosing paints for corrosion resist to make sure that they do not contain substrates which would bleed through applied films. Many of the substrates used in certain coatings, choose for one of these alkalies in oil resistant materials, act as paint in resistance. Where some coatings such as these are necessary, a red lead paint of similar composition, which would not be substrate affected, should be used.

■ A typical selection of specific systems has been made in Bulletin 10 of this booklet, and a complete formulation and suggested formulas designed especially to meet federal, state and municipal standards of quality and performance.

■ The Research Laboratories, with over half a century of experience and accumulated formulation data on metal protective paints, welcome inquiries on specific problems. This service is available through the branch offices of the National Lead Company which are listed at the beginning of the booklet.

formulations which lead to new improved metal protective paints. After this basic research has been accomplished, small batches are made up on the paint mills in the laboratory for an accelerated testing program to determine in the shortest time possible, the potential merits of the new product. The finished paint is subjected to such laboratory tests as pressurability, flexibility, brushing and spraying characteristics, alkali resistance, electrographic properties, salt spray and alternate immersion. If, after this program, the new material appears to have desirable customer substitute properties, additional batches are formulated for practical evaluation tests which are conducted under actual exposure conditions.

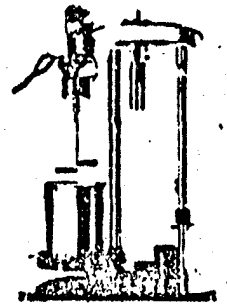
Quality performance on the job

■ Outlined on the following pages are some of the more evaluation procedures under which experimental and control batches of our paints are investigated.

■ The finished paint, composition, consistency, drying time, hiding, spraying and brushing properties, fineness of grind and weight per gallon are determined. These tests establish the quality of the packaged material. When these paints have been subsequently applied to metal panels the applied film is tested for such factors as flexibility, hardness, pressurability, freedom from pores and specular gloss. The substitute or protective value of the paints as applied coatings is further evaluated by accelerated testing of salt spray or alternate immersion.

■ Weight per gallon of a paint is measured either with a sub-mouth pycnometer or by the use of a standard sheet brass cylinder of such volume that contains the weight of the paint in grams needed to fill the cylinder is equivalent to the weight per gallon in pounds.

■ Consistency, or viscosity of pigmented paints is tested in our laboratories by the use of either the Ford Cup or the Stormer Viscosimeter. When using the Ford Cup, viscosity is expressed as the time necessary for a given volume of paint to flow through a standard orifice. The Stormer consistometer, on the other hand, is expressed as the number of grams necessary to drive a paddle in the paint at the rate of 200 rpm. An illustration of this apparatus is shown below, together with the stroboscopic tuner attachment developed in our laboratories. This tuner reads the speed when the paddle has reached the desired speed.



Stormer Viscosimeter

■ Drying time of a paint is determined by applying a .001" wet film to a thoroughly clean glass surface by means of a doctor blade. At various time intervals, the paint film is tested to determine when the film is dust free, tack free, dry to handle and dry through. This testing is accomplished by application of finger pressure to the film.

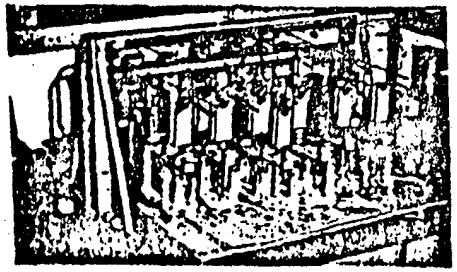
Power Reciprocator

Power Permeability Cup

continued testing of coated coatings

■ Salt spray testing equipment consists of a box or cabinet made of non-corrodible material such as wood, stone, or rubber covered metal. Numerous of glass or coated metal spray salt solution against baffles which are through drainage the salt fog or spray throughout the interior of the box. The continuous temperature of operation is 95° (see 1). A control of all factors is necessary to obtain uniform and reproducible results.

■ Immersion tests (alternate or continuous) are often conducted in our laboratories when some special problem is encountered. If the paints are to be subsequently exposed in an acid or alkaline environment, preference is alternately immersing the panels in an acid or alkaline medium is very helpful. The apparatus used in this test consists of a vertically sliding rack for the painted specimens, and an electric motor with a suitable clock mechanism to withdraw and immerse the panels according to a predetermined schedule.



Alternate immersion

■ The National Lead Company maintains a number of field exposure testing stations, two of which are located at Sayville, N. Y., where paint coatings are exposed to atmospheric and salt water environments. Another test station is located at New Kensington, Pa., on the Allegheny River near Pittsburgh, where fresh water evaluation tests are conducted. Still another is located at Perth Amboy, N. J., for the purpose of evaluating paints in industrial atmospheres. Other test facilities are also employed for special evaluations.

■ At Sayville, where atmospheric exposures provide a rural marine environment, the main volume of metal protective paint testing is conducted. At this test site metal protective paints are evaluated by application at normal spreading rates to structural steel shapes and hot rolled plates by either brushing or spraying. These painted specimens are exposed in a vertical position facing south and south and up at a 15° angle facing south. In order to eliminate as many variables as is feasible, paints are applied at controlled film thicknesses to cold rolled steel

surface preparation

■ Problems associated with maintenance painting of metal structures appear when the fact that the nature and condition of the surface at the time paint is applied is a very important factor in determining the protective life span of the coating.

■ Because of the primary importance of satisfactory surface preparation and its relation to the subsequent success of the protective coating, this subject has received considerable attention from paint manufacturers, construction and maintenance engineers, industry and others.

■ The life of a coal tar paint film, despite its inherent strength, impermeability to water and industrial gases, and high resistance to weather deterioration, will be governed by the condition of the surface to which it has been applied.

■ Surface preparation is accomplished by various methods or processes of cleaning and pretreatment and by conditioning material prior to painting. The term surface preparation is broad and generally embraces all cleaning — from simple wiping and wire brush up through abrasive blasting and vapor degreasing to sandblasting, and all pretreatments, such as pickling, phosphate and chromate, anodizing, etc. Inasmuch as this booklet is primarily concerned with structural metal painting, attention is made of only those cleaning processes pertinent to this field.

■ Each painting job presents its own specific surface preparation problems. In general, the most widely encountered surface contaminants are grease like substances,

corrosion products such as mill scale and rust, old paint and water. The degree to which these contaminants are removed largely determines the subsequent performance afforded by the applied protective paint system. It is for this reason that adequate surface preparation is considered of importance with the selection of the best paint system.

■ The primary importance of surface preparation can readily be appreciated by realizing that the protective nature of a painting coat in the preservation of iron and steel structures can be effective only as long as the coating remains in intimate contact with the base metal. Oil, grease and water are detrimental in that they prevent direct contact between the metal surface and the paint, and therefore the ultimate bonding of the protective coating with the base metal cannot be thoroughly achieved. The presence of moisture under a paint coating is yet to which disadvantageous in that it initiates corrosion. Rust or other corrosion products lessen the adhesion of the protective coating by generating the rusting of the base metal. Since rust is hygroscopic in nature, it retains moisture under the film and causes blistering and scaling.

mill scale

■ One of the most common contaminants present on the surface of structural steel is known as mill scale which forms on steel members during the fabricating process. Mill scale, hard and subject to cracking when affected by temperature changes, is mainly an iron oxide compound corresponding essentially to the composition Fe_3O_4. On freshly fabricated steel members, the mill scale formation is bright and almost silvery in appearance, but on longer exposure to atmospheric conditions it acquires a blue-gray color. Because the coefficient of expansion of mill scale differs from that of the base metal, adhesion between the two very often becomes impaired. The hardness of the mill scale is more pronounced under conditions of

[illegible] temperature variations. In addition, environmental moisture will often deliver beneath seemingly tight mill scale to form rust with the base metal, resulting in separation of the mill scale.

■ The application of paint over loosely adherent mill scale is unsupported as undesirable. Some adherent mill scale will, in time, become completely detached from the base metal, causing rupture and scaling of the protective coating. Mill scale, being cathodic to steel, will through electrochemical action, promote accelerated localized corrosion, particularly in the presence of moisture, and is therefore objectionable.

■ However, for exposure in an atmosphere environment a mill scaled surface which has not been previously allowed to rust and is otherwise free from moisture, grease, etc., is considered by many as a better surface for paint than one which has been weathered. The use of such a surface as a paint base eliminates most of the harmful effects of weathering, since a moisture variation cannot be influential in chemical composition, type and adherence of scale and degree of corrosion. While complete removal of mill scale immediately before priming, is the best practice, it is not always practical. For this reason the shop coating of structural members at the rolling mill goes in exposure is being advocated by steel fabricators and others concerned with the protection of iron and steel.

Grease and oil

■ Grease and oil are extremely detrimental to effective adhesion of a paint film. Vapor degreasing, in which solvents are vaporized in specially designed apparatus, may be employed to clean these products from the surface. On large steel structures where vapor degreasing is impractical, due to the physical size of the parts, a solvent wash may be used with satisfactory results.

Methods of surface preparation

■ There is an impressive number of various methods and materials available for surface preparation, and the advantages of each are peculiar to the size and shape of the metal surface to be cleaned and the practicalities of the method from an economic standpoint. A great number of the methods or materials described in the trade are applicable only to small articles and are of little or no use for large construction programs.

■ The majority of surface preparation methods can be placed in the following categories:

I – Physical or mechanical methods

- [illegible]
- [illegible]
- [illegible]
- [illegible]

II – Chemical methods

- [illegible]
- [illegible]
- [illegible]
- [illegible]
- [illegible]

■ Of these methods listed above, those in most common use for structural steel are weathering and wire brushing, dry or wet sandblasting, shotblasting, pickling, flame conditioning and chemical pretreatments.

Weathering

■ One of the oldest methods of removing mill scale is to allow metal surfaces to weather for periods varying from six months to a year. During this time the mill scale becomes loosened for the rusting of the underlying metal. In this process, naturally, there is extensive rust formation which should be completely removed before priming. However, such manual methods as wire brushing, chipping

paint or coatings do not effect complete removal of the more adherent mill scale or other corrosion products. This can only be done by sandblasting.

■ The sandblasting practice followed by the Missouri State Highway Department is another of note. Structural steel members ordered from the steel fabricator as an unfilled condition are erected and allowed to weather for several months until most of the mill scale has been undermined by the subsequent rusting. The erected structure is then thoroughly cleaned by sandblasting. Immediately following this surface preparation, the structure is coated with red lead primer. According to reports, this method of surface preparation results in completely cleaned steel with excellent performance from subsequent coatings a three coat system giving, on the average, from 10-15 years' service.

Wire Brushing

■ Hand or power wire brushing is one of the most widely used mechanical methods of surface preparation. This procedure generally removes the loosely adherent mill scale, rust, old paint, and results into only the "high spots" of the surface. Many types of equipment are manufactured for both hand and power wire brushing. A wide variety, in the shape of the brushes, the material used in the brushes, as well as any number of different rotation speeds are in common use in the industry. A disc type brush with an outside circumference of steel bristle gave very effective results when operated at 1,750 rpm and applied with a pressure of approximately 1 lb/in.

■ Of these two cleaning procedures, power driven wire brushes are by far the most efficient and economical on large structures.

Scraping and Chipping

■ Surface preparation by either of these methods is probably one of the least effective ways of cleaning a metal surface. Scraping by means of a hand operated tool with a sharpened edge merely removes semi-adherent scale and old paint. Chipping with pneumatic hammers is dangerous and cannot be recommended as a satisfactory means of surface preparation, since it beats contaminant products into the surface and leaves sharp edges which are harmful to a successful protective paint job.

Grit and Sandblasting

■ For conditioning structural steel surfaces where complete removal of foreign contaminants is required, sand or sandblasting methods are most generally used. Both processes operate on the mechanical abrasive action of various sized particles which impinge against the surface at high speed. Steel grit or shot is employed in the abrasive or blasting techniques where it is economicable, such as the cleaning of freight cars or structural steel.

■ In addition to careful blasting techniques, minimum permissible distances of nozzle from surface etc., care should be exercised in use the smallest size of sand and shot which will effectively remove the surface contaminants. Otherwise, excessive cutting of the metal surface and formation of craters like depressions will result, thus presenting a surface with pits and valleys. On such a surface the subsequently applied paint film may have inadequate thickness over the ridges and these become local points of premature failure, particularly if only one or two coats of paint are used. Also, excessive cutting of the metal surface causes stress-raised areas which become more anodic with resultant accelerated corrosion at these areas when the organic coating starts to fail.

■ In general, however, sandblasting is an undesirable use. Because of danger to the health of the operators from fine dust, proper precautions must be taken. In addition, the use of dry sandblasting should be limited to structures removed from operating machinery unless complete shielding can be provided.

■ Both certain practical limitations, hydraulic or wet sandblasting, a comparatively new method, circumvents the dust hazard of dry sandblasting. It also permits the addition of water soluble rust inhibitors of the chromate or phosphate types which temporarily retard superficial rusting during sandblasting and prior to painting.

Acid pickling

■ Where practical, acid pickling is by far the most satisfactory and effective means of surface cleaning. In this process, iron and steel bearing scale and corrosion products are immersed in a dilute solution of either hydrochloric, sulfuric or phosphoric acid with strengths varying from one to ten per cent by weight. Temperatures for pickling processes may range from room temperature to 200 F. This process, if allowed to continue for a sufficient length of time, will reach all portions of the metal being included in the pickle and will remove all mill scale and rust, leaving the bare metal free of inorganic compounds of iron.

■ There is, however, one disadvantage to this method in that the use of neutralizing or rinsing solutions is necessary after the acid bath, and following this step, thorough drying of the metal must be accomplished.

■ In the pickling method, the acid solution also acts on the base metal itself, but this undesirable action can be minimized by the use of suitable inhibitors which dissolved in the bath, allow a preferential attack on the mill scale and rust. Care should be taken to prevent deep or excessive etching of the surface; slight etching of the surface, however, aids in improved paint adhesion. Probably the main disadvantage of this type of surface preparation is that it is limited mainly to either small sized objects or structural members that are easily handled.

Flame conditioning

■ Preparing structural metal surfaces by flame conditioning has been in practice for only a decade. This process makes use of the intense heat from an oxy-acetylene torch which is slowly drawn over the metal surface. The heat develops stresses between surface oxidation products and the base metal due to the differences in their coefficients of expansion. Flame conditioning does not, however, remove tightly adhering mill scale and requires subsequent light wire brushing to remove the loosened scale. The prime virtue of the flame conditioning method lies in the dehydration of the surface caused by the action of the flame. However, to take full advantage of this feature, it is essential that painting should follow the conditioning procedure so that the coating is applied while the metal is still warm and dry. Recommended practice requires painting within two hours.

■ Tests have shown that flame conditioning prior to painting is more beneficial than wire brushing alone for steel which has been weathered. This is reflected in the better performance of paint coatings over a flame conditioned surface. Flame conditioning has had some acceptance, particularly in the steel fabricating shops where structural sections are readily accessible and where advantage can be taken of the dehydrating effect.

Chemical Pretreatment

■ Chemical treatments of many varieties have been developed for cleaning steel surfaces. In a few instances, these treatments have been used on large steel shapes, such as ship plate, lock and dam gates, etc., with success if the surface is first completely cleaned to bare metal.

■ Chemical inhibitors have been found to be effective in prolonging the protection afforded by paint coatings when applied over thoroughly cleaned steel surfaces. The U. S. Engineer Department, Upper Mississippi Valley Division, specifies the following suitable rust inhibitors in the "Report on Protective Coatings for Lock and Dam Structures, Upper Mississippi River," dated September 1942:

Orthophosphoric acid (H_3PO_4)	12 gallons
Chromium Sulphate (water soluble)	3½ pounds
Wetting agent (detergent)	1½ gallons
Lehel Cellosolve	¼ gallon
Add water to make 100 gallons	

The chemical rust inhibitor shall be an approved solution of water, a wetting agent, phosphoric acid, and a chromium compound, which will react chemically with the surface metal to etch the surface, form a dull greenish coating of iron chromium phosphate, and produce a rust inhibited surface receptive to the firm bonding of the priming coat. It shall be of such concentration as to give treatment with the base metal without leaving an embrittled acid residue.

■ All mill scale and other surface contaminants must first be removed from the steel by conditioning, or the application of such inhibitors may be detrimental instead of beneficial.

Selecting the Method

■ The choice of any one particular method of surface preparation will depend upon such governing factors as the initial cost, the size, shape and surface condition of the steel member, its location, the type of paint to be used and the environment to which the member will ultimately be exposed.

■ Another important influence on the selection of an effective surface cleaning method should be the composition of the vehicle of the paint which is to be applied. A vehicle whose solids contain at least 50% of free linseed oil will wet the surface even if a limited amount of corrosion products is present. However, it should be remembered that vehicles based on 100% synthetic resin type varnishes do not effectively wet surfaces bearing corrosion products and should be used only on thoroughly cleaned metal surfaces. A more comprehensive treatment of the subject is contained in Chapter 3.

■ Environmental considerations are also important so much so more severe exposures require more care in preparing the surface to insure good adhesion of the paint, and to take full advantage of its protective action. For immersion in salt or fresh water, either pickling or sandblasting is preferred for both new and repaint work. For atmospheric exposures it is very desirable to obtain a completely clean surface, but thorough wire brushing may be sufficient in most instances. With this type of exposure, lightly loosened mill scale is tolerable if the surface is painted before it starts to rust.

■ Regardless of what cleaning method is selected, the metal surface should be painted immediately - within two hours - by applying a properly formulated rust inhibitive primer. The need for this promptness can be appreciated when one remembers how rapidly bare steel washes or rusts.

■ Of the several methods of surface preparation available to the painter and engineer, one or more should be applicable to meet the requirements of any particular job, be it large or small. Surface preparation is of paramount importance to the success of any protective paint system. Even paint products should be outlasted or matched with surface preparation as the best overall system. In cases of preparation, on the basis of effective surface preparation is worth more than the paint of care required for expensive refinishing of a system badly undermined by premature failure.

Application

■ Red lead paint is versatile in that it may be formulated for use by one of the usual methods of application: brush, spray, dip or flow coating.

■ Most prepared paints are made for brush application as supplied. However, for spray application, paints of brushing consistency usually require some thinning to be desirable use in the spray equipment and to obtain a dense uniform film. It is impossible to give any general directions as to the amount or type of thinner to be used, inasmuch as paints of varying composition usually require different consistency adjustments. The nature of the spraying equipment is also an influencing factor to be considered.

■ In both flow coating and dipping, individual paints require specific handling to obtain the desired film properties. Care must be taken in adjusting the paints to prevent excessive flowing away from the upper portions and sharp edges of the work. The operator must, at the same time, guard against too fast a set which would result in piling up of the paint.

Temperature Conditions

■ The question of temperature conditions during painting has been, and still is, the subject of much debate. Actually, painting practice dictates that, in the case of cold weather painting, it is perfectly safe to apply coatings at temperatures above 50°F, when the sun is shining brightly and there is no immediate prospect of freezing weather. Painting in freezing or near freezing conditions should not be attempted for fear of moisture condensation on the metal surface, and difficulties in applying the paint due to the increased viscosity. Through drying of the film is also retarded.

■ At 50°F, however, satisfactory structural painting can be accomplished if certain precautions are observed. It is important that the paint be the same temperature as the surface to which it is to be applied. To facilitate thorough brushing out of the paint, an increase in the volatile content is desirable for cold weather application. The addition of volatile thinners naturally results in a reduction in the thickness of the dried film, and consequently, care enough should be added to give the paint the necessary degree of fluidity.

■ With regard to red lead applications at temperatures as high as 115°F it may be interesting to note that marking paints applied on hot-rolled sheets at the steel mill frequently outlast subsequent field coats. Yet during the hottest weather, steel structures never reach the temperature. At 115°F there is neither excessive oxidation nor undue hardening of the film.

■ However, an increase in temperature will cause the paint to thicken or coagulate with the result that the paint spreads further, giving a thinner dried film. To maintain approximately normal film thickness, which is necessary for adequate protection, it is inadvisable to add thinner unless absolutely necessary.

■ The disadvantage of the presence of moisture on a metal surface prior to painting has been previously discussed in Chapter 6. The most common source of surface moisture is excessive humidity. This is especially true during the rainy morning or late in the afternoon.

■ The effect of high humidity of the surrounding atmosphere should be taken under consideration. It is undesirable to apply paint to metal surfaces when high humidity conditions exist, especially when a drop in temperature is apt to occur during or shortly after paint application. Under such conditions, condensation of moisture will occur, either on the metal surface or on the freshly applied paint.

■ As previously mentioned, water condensation on a metal surface will detrimentally affect the adhesion of subsequently applied paint films. The water thus trapped below the paint film will cause corrosion of the metal, and blistering of the freshly applied paint film will result in loss of adhesion. Water condensation on a freshly applied paint film will also inhibit drying, adversely affect the gloss, and by penetrating the film will detract from the protective life of the coating.

■ A safe practice is to limit exterior paint applications to those hours when the temperature is sufficiently high to offset the possibility of condensation. This will generally mean that paint may be applied after the morning sun has thoroughly dried the surface. Applications should be discontinued two or three hours before sunset in order to give the paint time enough to set thoroughly.

Number of Coats

■ It has been verified through practical exposure evaluations that if all of the factors influencing paint performance were equal, the protective life of a paint system would be directly proportional to the dried film thickness of the coating.

■ Therefore, the success of a protective coating system depends, to a large extent, on the total film thickness. A paint film that is too thin does not completely cover surface irregularities and therefore pinholing and increased moisture permeability result. The factors determining the number of coats of red lead paint and finish coat paints to be applied are many. Paramount among them is the environment to which the paint system will be exposed, the condition of the surface to be painted and the economic considerations of repainting, such as cost of labor, materials, surface preparation and scaffolding. This latter factor is so important that a worthwhile reduction in maintenance costs can be realized by applying inhibitive paint in excess of normal recommendations in order to build up sufficient thickness and thereby forestall the expense of more frequent repainting.

Paint Systems

■ For the greater majority of atmospherically exposed structural steel, a system comprising three coats of paint is recommended for previously unpainted members. This system will consist of two coats of inhibitive paint, such as red lead, and a finish coat. Where the structural members have been shop coated prior to erection, they will require spot priming followed by a field coat of inhibitive paint plus the top coat. In those cases where the steel has not been shop coated, it will be necessary to apply a red lead priming coat in the field as well as a second coat

of red lead paint followed by the top coat. Where the top coat is extremely light in color, and therefore will not sufficiently hide the corrosion inhibitive paint beneath, it will be necessary to use an intermediate paint, in lieu of the second coat of inhibitive paint. Less than three coats of paint is not to be generally recommended with the possible exception of exterior work or exterior work which is shielded from direct contact with the deteriorating elements of the atmosphere. However, on repaint work where such occasional areas of failure are encountered, the accepted practice is spot priming with red lead paint followed by a full top coat.

Coat systems

■ For metal work where the environment is particularly severe, for example total immersion in water, high humidity, alkalinity or acid vapors, etc., a system comprising a minimum of four coats of paint should be employed. Depending upon the structure and the intended environment, the painting system need not be composed of four successive coats of corrosion inhibitive red lead paint, or two coats of inhibitive paint, a basic coat and a finished coat, or other variations.

■ To avoid "skips" or "holidays" a common practice is to add a sufficient amount of strong tinting color such as lampblack or prussian blue to the paint to give a distinctly contrasting color. This change in color permits the same paint to be used in multiple coats of a system without material formula changes. The small additions of tinting ingredients will not affect the quality of the paint.

Repaint work

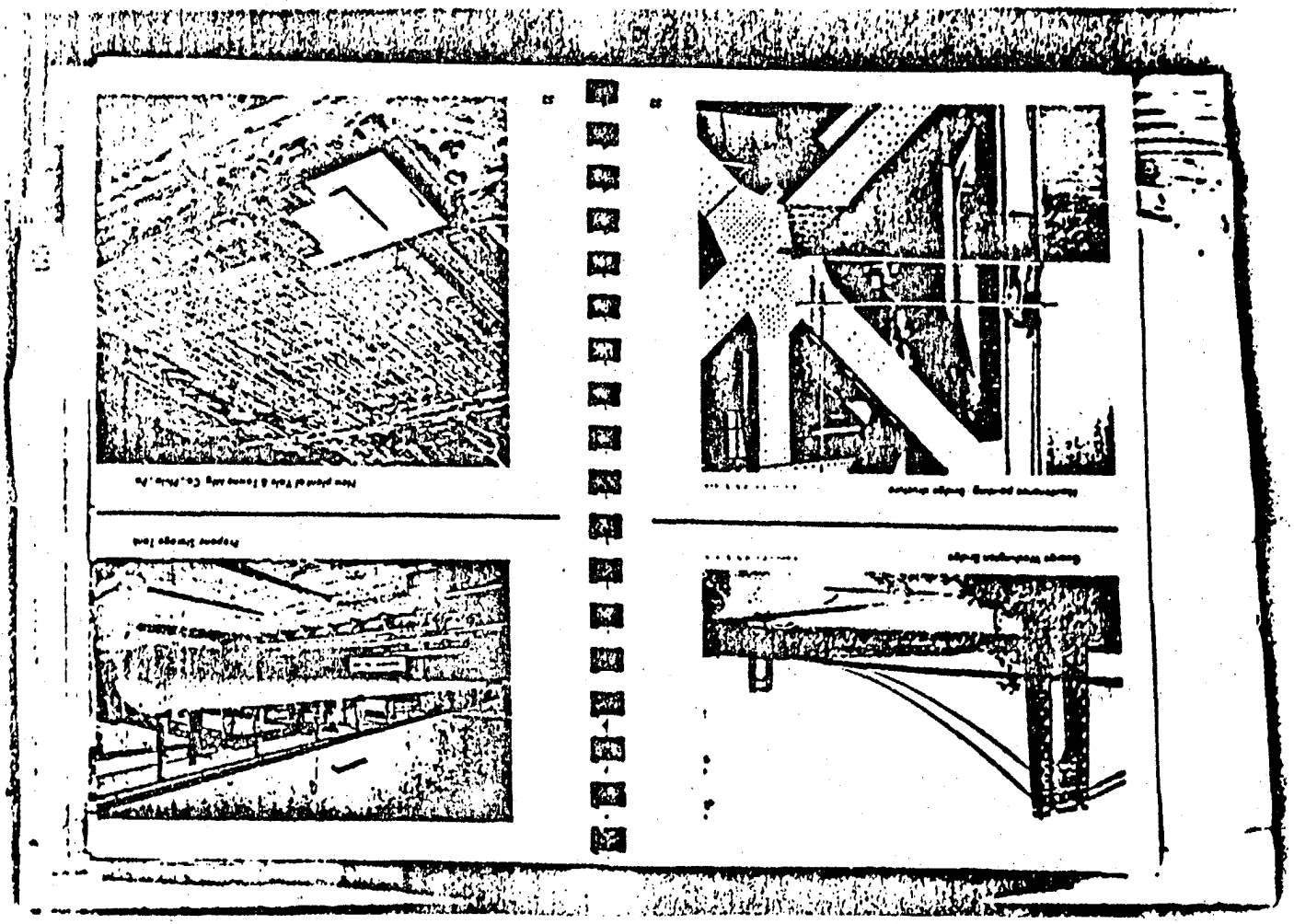
■ On repaint work, any areas showing failure should be thoroughly cleaned, spot primed with red lead paint

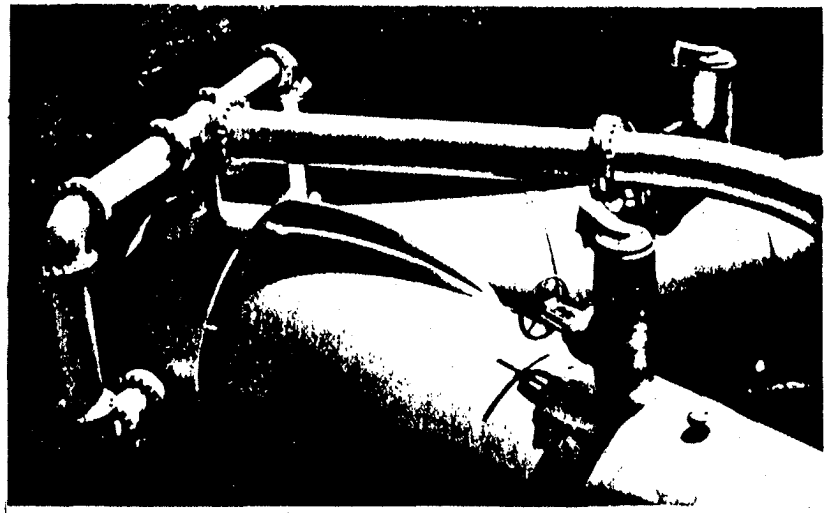
to give the desired thickness of inhibitive paint and then resume the finishing system. Where failure of the previous coating is quite general, it is advisable to thoroughly clean, spot prime, apply a full coat of red lead, and follow with a suitable top coat.

practical examples of metal painting

■ The theories of corrosive action, the preparation or pretreatment of metal surfaces to receive an organic coating, the formulation of inhibitive paints and their application have been treated generally so far in this booklet. Eventually, however, the protection of iron or steel against the corrosive forces of its environment by means of an organic coating becomes a problem specific to a particular structure.

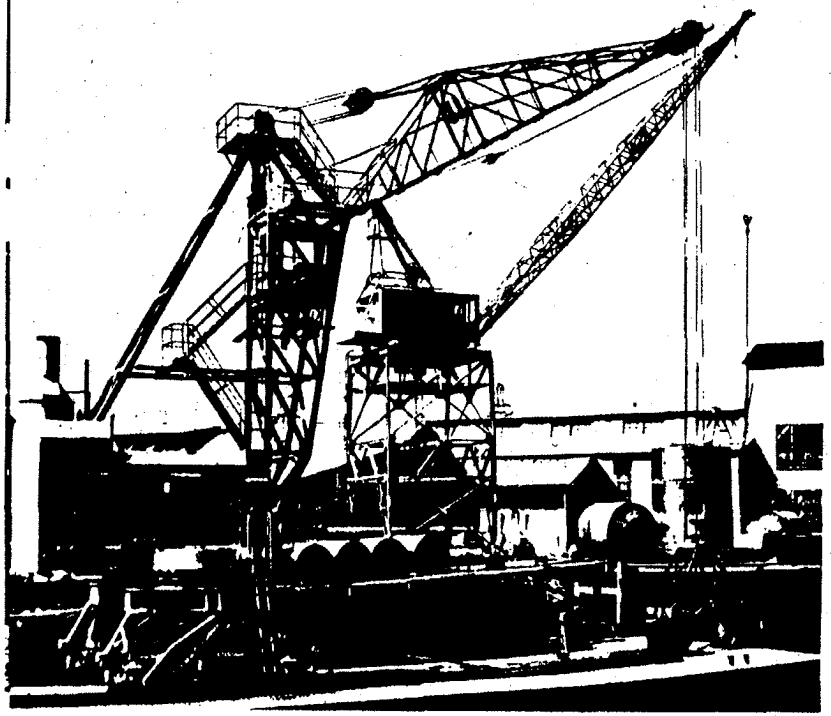
■ Red lead paints have been formulated for many varied specific problems of metal protection. These paints have been successfully used on such structures as skyscraper framework, highway and railroad bridges, water tanks, tanks for ships, pipelines and railroad equipment. Formulations have been prepared and specifications written for various organizations as well as for city, state and governmental agencies which embody principles as presented outlined in this booklet. To enumerate the many uses of red lead paint and the various successful paint jobs which are existing today would be impossible. However, to demonstrate what has already been said about red lead's versatility, typical pictorial examples of practical existing protection by red lead are shown in the following pages of this chapter.





Bouquet Canyon Pipe Line

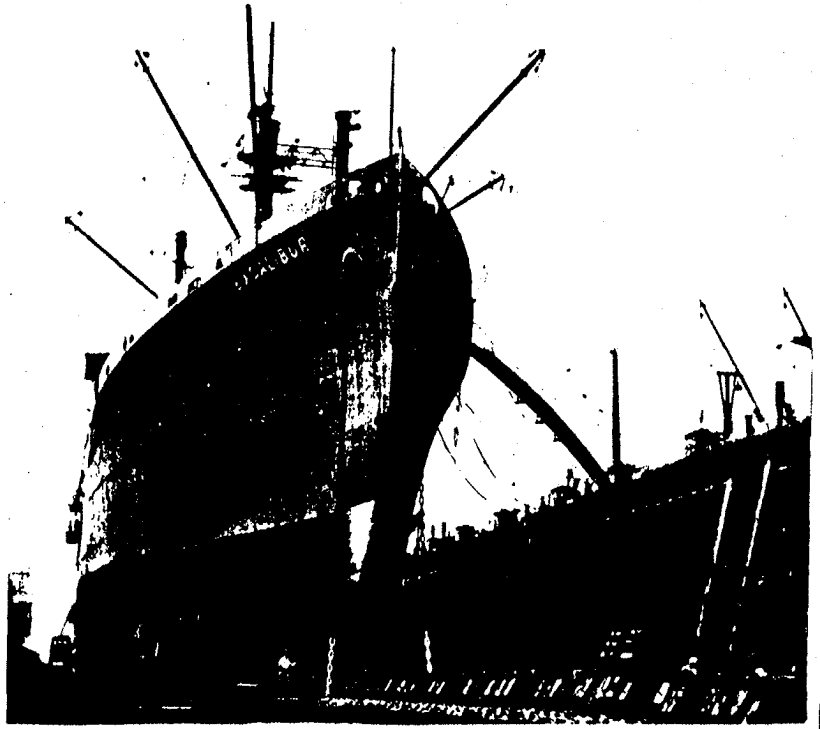
8-ton capacity travelling barge crane

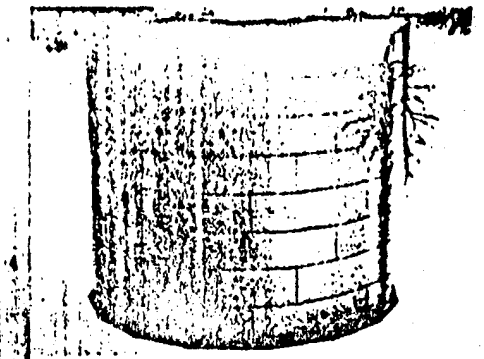


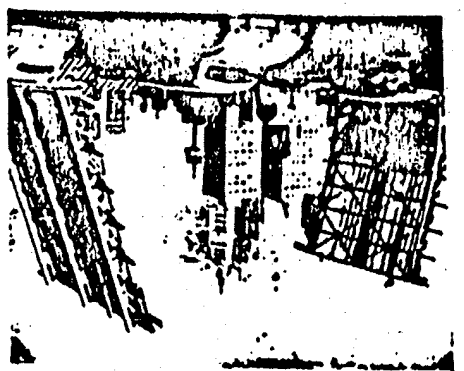
Blue Water Bridge, Port Huron, Mich.

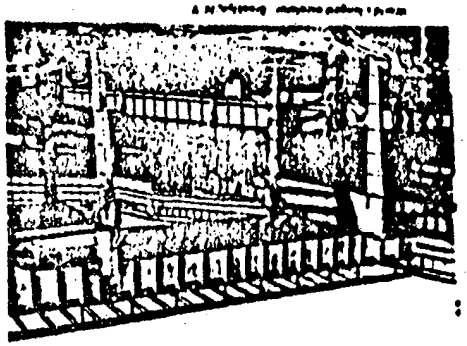
Courtesy American Export Lines, Inc.

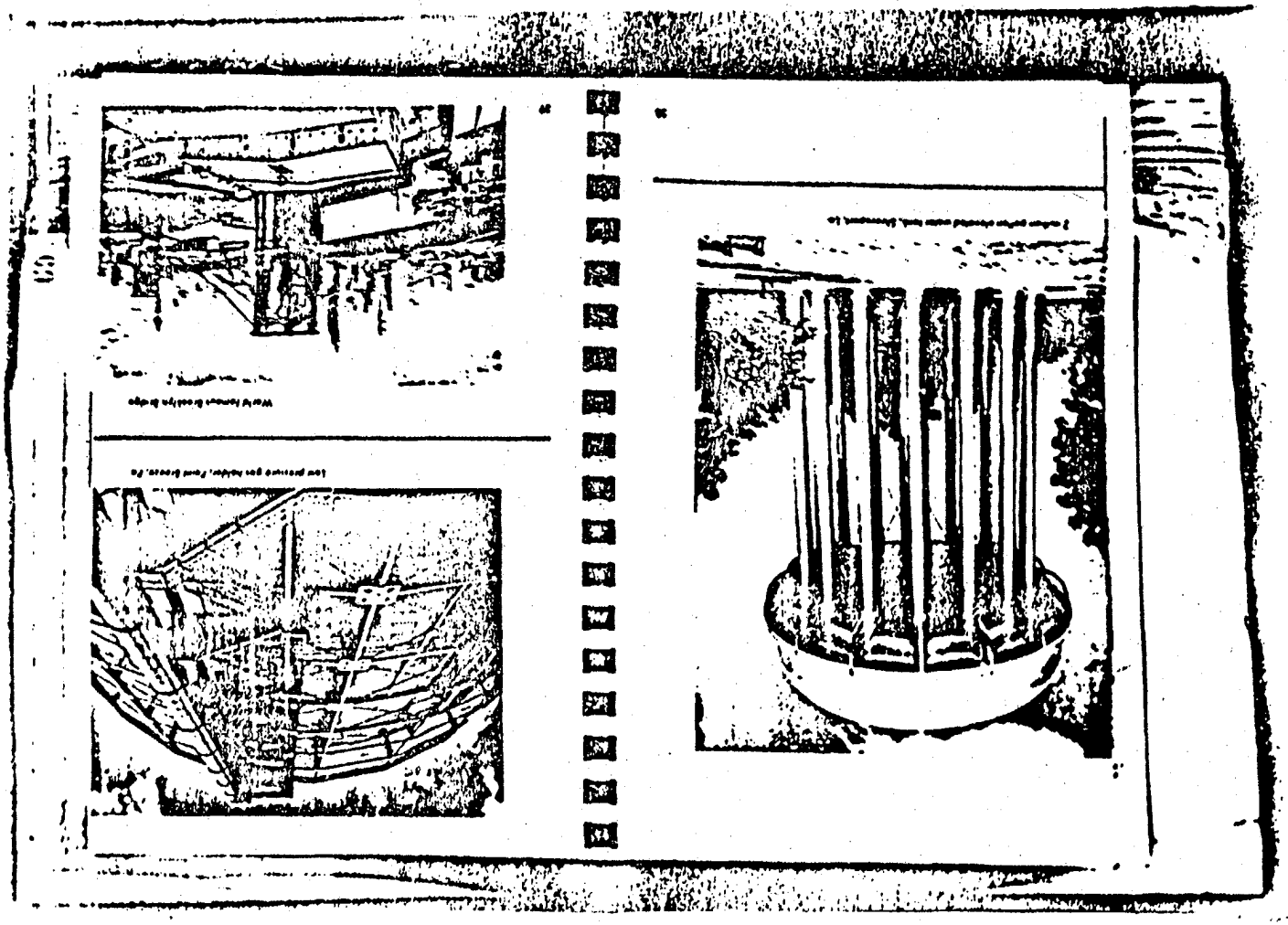
S.S. Excalibur

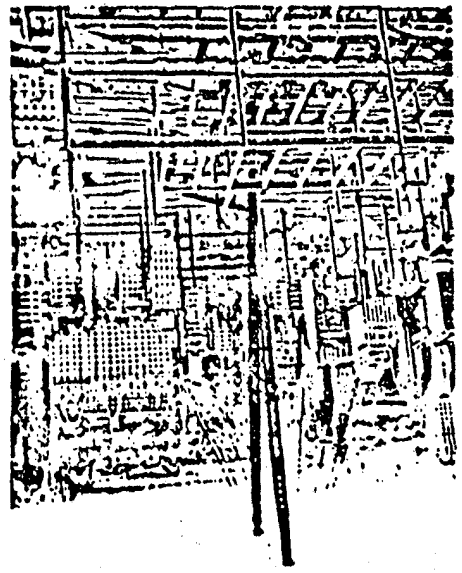












Dutch Boy metal paint products

■ Throughout this booklet, the subject of metal protection against corrosive environments by the means of an organic coating has been discussed from both an advanced and practical standpoint. However, in the final analysis, it becomes incumbent upon those concerned with the responsibilities of environmentally a metal protective paint system to select a specific product or products which will provide the ultimate in protection.

■ The National Lead Company, under the Dutch Boy trade mark, has for generations marketed metal protective paint products which have been used successfully to solve corrosion problems. At the present time, the Dutch Boy metal protective paint products line consists of Dutch Boy 066 Metal Primer, Dutch Boy 661 - Super Quick Drying Red Lead, Dutch Boy 663 - Quick Drying Red Lead, Dutch Boy 665 - Legend Red Lead (1-16), Dutch Boy 15-91 Metal Finish Paint - Black, as well as Dutch Boy Red and Paste Red Lead. To conclude the varied corrosive environments represented in the illustrations appearing in Chapter 8, one or more of the above-mentioned Dutch Boy metal protective paint products were specified and used successfully to produce long lasting, high-quality jobs.

■ However, the above-mentioned potential examples are only in spell of what has been and can be accomplished in the all important continual struggle against corrosion. In addition to these versatile Dutch Boy paint products find wide application on the following types of materials and structures:

Railroads

- Bridges - Trestles
- Signals
- Water-resistant tanks, etc.
- Car cleaning systems
- Coal towers
- Roundhouse equipment
- Roundhouses and sheds

Highways

(State, City, County)

- Bridges
- Culverts
- Guardrails
- Guardposts
- Bridges

Utilities

- Fire hydrants
- Fire escapes
- Poles
- Transmission towers
- Transmission towers
- Heating pipes
- Oil tanks
- Water mains
- Sewer mains
- Water towers
- Gas tanks
- Gas equipment

Miscellaneous

- Steel bridges
- Docks
- Steel piers
- Fences
- Fire escapes
- Metal bins
- Metal siding
- Gutters
- Window frames
- Oil storage tanks
- Sewerage disposal systems
- Farm equipment

■ In order to acquaint those not already familiar with the properties and intended uses of the various members of the Dutch Boy metal protective paint line and to aid, as well, in the selection of the particular paint or paints which may be used for any particular service, surface conditions, or drying schedule, the characteristics of each particular product have been summarized on the following pages.

Dutch Boy 010 Metal Primer

The newest member of the iron oxide line of Dutch Boy red lead metal protective paints is Dutch Boy 010 Metal Primer. This paint, a mixed pigment, reddish-brown, high red lead content primer, may be used either as a first coat on unpainted steel, or as a second coat on previously shop coated steel. Due to the presence of iron oxide as an anticorrosive pigment, this paint possesses high holing and low chalking and therefore has found acceptance as a finish coat. It may be applied by brush or spray with a spreading rate of [illegible] sq. ft. per gallon. The vehicle, composed of both varnish solids and free linseed oil, makes it applicable for painting schedules which demand fast drying enough for two coat systems on slightly contaminated with rust. It may be used as a maintenance paint on all atmospheric exposed structures and equipment. (See p. [illegible] of Formulator Index and p. [illegible] of Formulator Sections.)

Dutch Boy 011 Iron Oxide Drying Red Lead

As old standbys in the Dutch Boy metal protective paint line, Dutch Boy 011 Iron Oxide Drying Red Lead has found numerous acceptance for use as a shop coat paint for steel fabricators as a primer for freight cars, bridges, metal outdoor features, farm equipment, etc. This is a pure red lead paint similar in properties to Dutch Boy 010 Metal Primer with the exception that the full red lead content will give additional corrosion resistance. (See p. [illegible] of Formulator Index and p. [illegible] of Formulator Sections.)

A high quality pure red lead paint whose vehicle solids are entirely resin, Dutch Boy 012 Quick Drying Red Lead has for years been used as a primer for steel surfaces because it dries rapidly permitting recoating within the working day. The fast setting qualities of this paint do not permit good wetting of rusted surfaces. Thus, it should be applied only to thoroughly clean metal. It provides a tough, impermeable, adhesive film which makes it applicable for use where high humidity or water immersion is expected. It, therefore, finds use as a metal protective paint on trailers, steel drums, railroad cars, stock, storage disposal systems, dragslines, water mains, road tanks, etc. It may be applied by either brush or spray at a spreading rate of [illegible] sq. ft. per gallon. (See p. [illegible] of Formulator Index and p. [illegible] of Formulator Sections.)

A linseed oil [illegible] pigmented red lead with excellent storage properties in a ready mixed paint similar to that which may be made from Dutch Boy [illegible] Pure Red Lead following the mixing formulas appearing on p. [illegible]. Since its vehicle solids are all linseed oil it has excellent wetting properties for surfaces contaminated with rust, thus insuring good penetration and superior adhesion to such surfaces. The proper blending of linseed oil and volatile thinners in the vehicle produces a paint film which is low in gloss and dries hard for recoating within [illegible] hours. It may be applied by brush or spray to a spreading rate of [illegible] sq. ft. per gallon. (See p. [illegible] of Formulator Index and p. [illegible] of Formulator Sections.)

Dutch Boy Dry and Paste Red Lead

When mixed according to formulas outlined on p. 71 or p. 74, Dutch Boy Dry or Paste Red Lead, solid medium linseed, and lead powder whose whole solids are mostly linseed oil. These paints, which may be mixed at the job site, can be successfully used over surfaces which have not been thoroughly freed of rust-resistant contaminants. To be practicable used on the first coat on atmospheric-exposed steel, this paint will dry for recoating within 72 hours to a low gloss.

Dutch Boy 11-90 - Metal Finish Paint - Black

In order to satisfy the demand for a metal finish paint, Dutch Boy 11-90 Metal Finish Paint Black has been formulated. It is a durable linseed oil type black finish coat for use on atmospheric-exposed metal structures as a system component with the above-mentioned red lead primers. It dries within 18 hours to a smooth finish with a spreading rate of approx. 65 sq. ft. per gallon. This finish coat has been successfully used on bridges, buildings, and heavy industrial equipment. (See p. 71 of Formulas Index and p. 94 of Formulas Sections.)

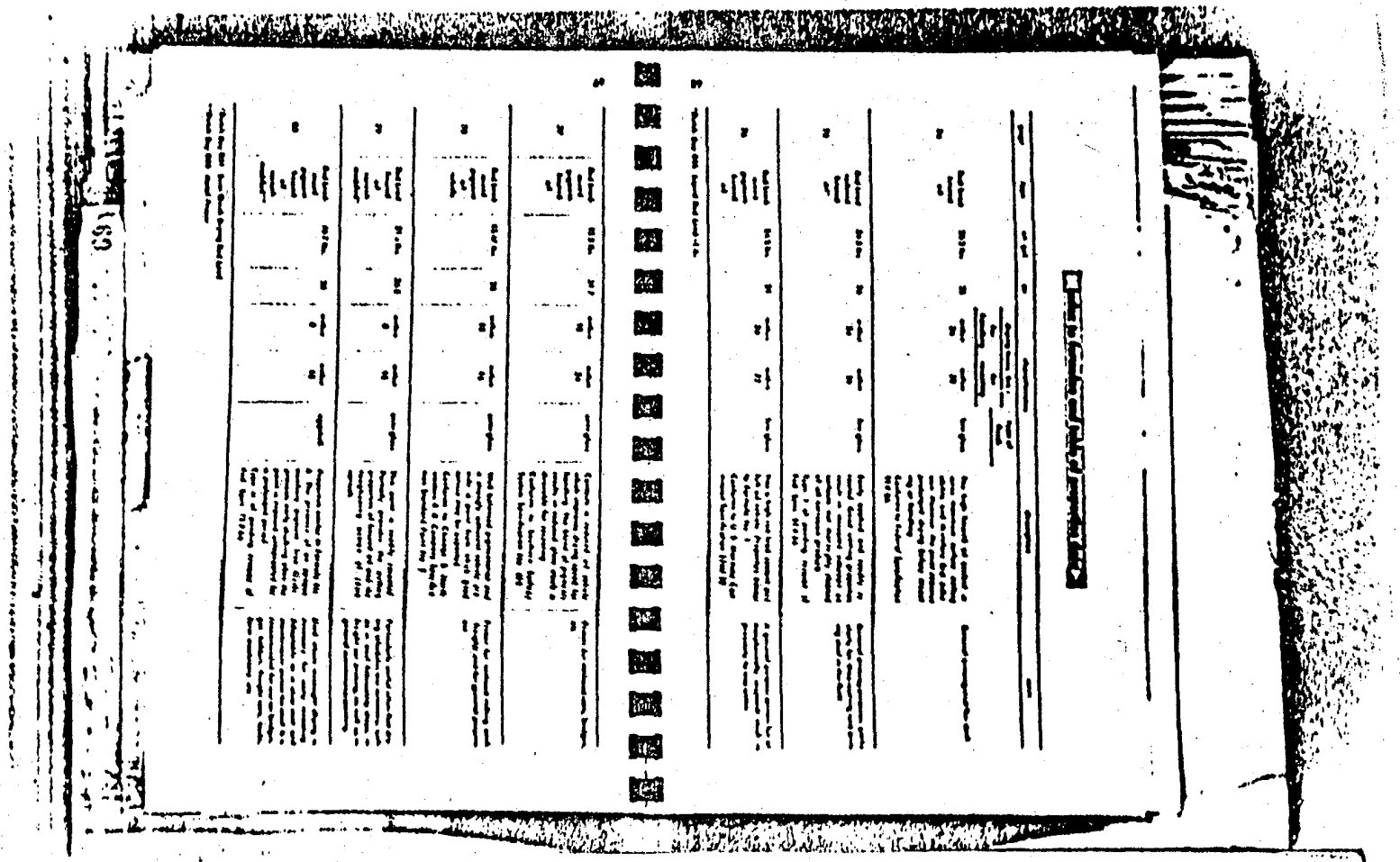
formulas and specifications

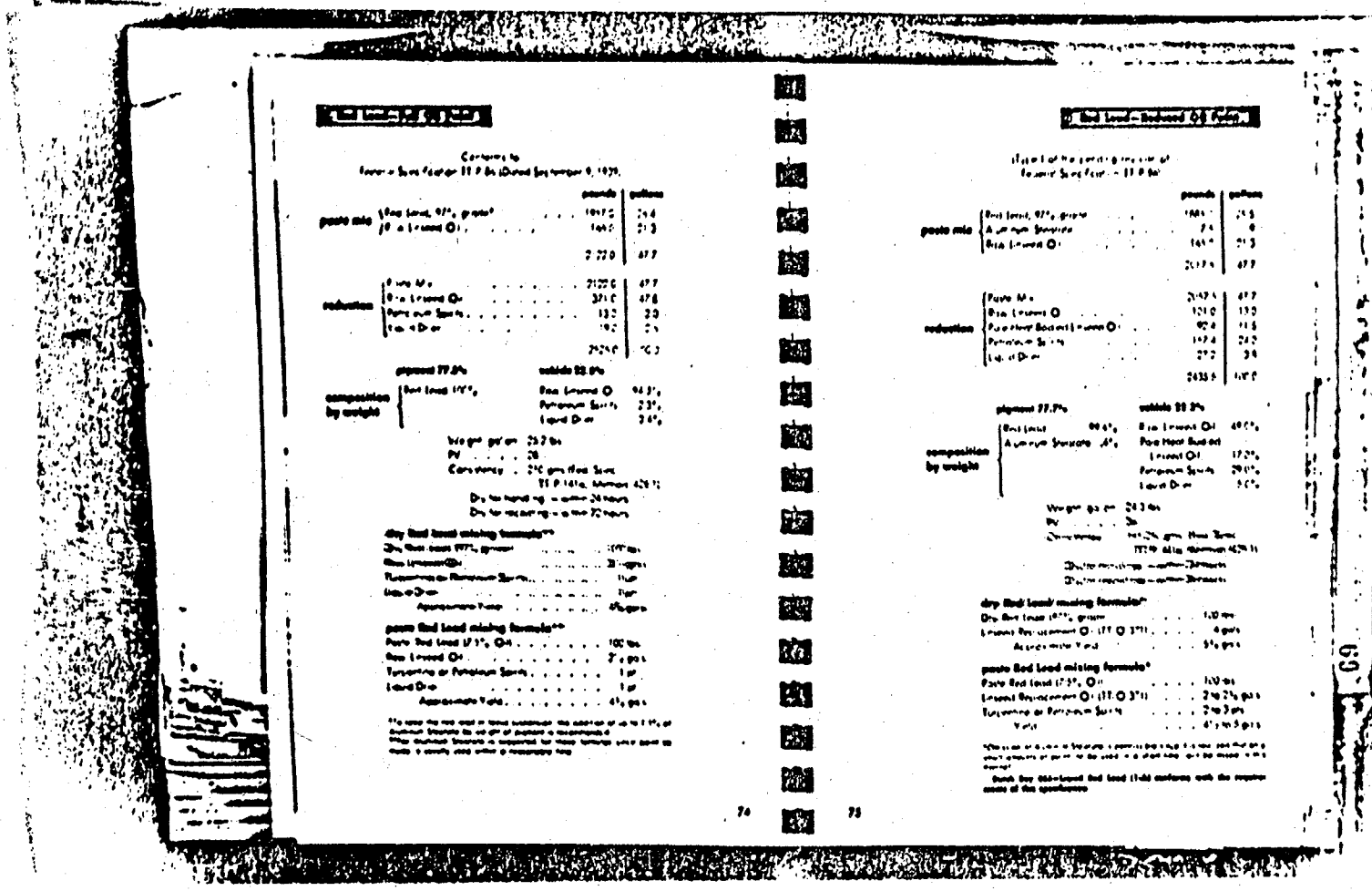
■ Red lead is included in many metal protective paint specifications established by the various departments of the Federal Government. It is also required in the recommendations of many associations as well as individual states, cities, industries, and railroads. Typical formulations from these specifications have been selected and included in this booklet to serve as a guide in the preparation of paints to meet some specific customer problems.

■ Inasmuch as the factors of cost, drying time, availability of materials, conditions of exposure, pigment and vehicle compatibility as well as many others may govern the drawing up of a paint specification, this section is included to show what has been and can be done with red lead as part of the formulations.

■ In the chapter, preceding the section of detailed formulas of the various paints, is a table of properties data, intended uses, and general descriptions of the various typical paints which have been shown. As an aid to the use of this section it has been indexed.

■ The Metal Protective Paint Department of our Research Laboratories has a large, ever-growing file of information gathered from many years of experience with the problems of the paint maker as well as the consumer. For those with specific requirements, we recommend that utilize the facilities of the National Lead Company Research Laboratories through use of the branch offices listed at the beginning of this handbook.





Red Lead – Boiled Oil Paint

		pounds	gallons
paste mix	Red Lead, 97%, green*	1661.5	24.4
	Raw Linseed Oil	144.0	21.3
		2 270	47.7
reduction	Paste Mix	2127.5	47.7
	Raw Linseed Oil	301.0	47.6
	Petroleum Spirits	133	23
	Liquid Drier	19.2	2.4
		2525.6	120.2

	pigment 77.7%	vehicle 22.3%
composition by weight	Red Lead 97%	Raw Linseed Oil 94.3%
		Petroleum Spirits 2.3%
		Liquid Drier 3.4%

Weight per gal. 25.7 lbs
PV 28
Consistency 240 gms (Flow Tube)
TT P 141a, Minimum 420 ft

Dry to touch in – within 24 hours
Dry to recoating in – within 72 hours

dry Red Lead mixing formula**

Dry Red Lead 97%, green	100 lbs
Raw Linseed Oil	21 gals
Turpentine or Petroleum Spirits	1 gal
Liquid Drier	1 gal
Approximate Yield	45 gals

paste Red Lead mixing formula**

Paste Red Lead 97%, Oil	100 lbs
Raw Linseed Oil	2 gals
Turpentine or Petroleum Spirits	1 gal
Liquid Drier	1 gal
Approximate Yield	4½ gals

*Red lead, 97% green, is a basic lead sulfate, the substance of which is 97% of minimum fineness, for use in oil paints or compositions.
Basic sublimed litharge is acceptable for these formulas when used as made in specific dried surface or measurable form.

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Red Lead – Boiled Oil Paint

		pounds	gallons
paste mix	Red Lead, 97%, green*	1661.5	24.5
	Aluminum Stearate	24	6
	Raw Linseed Oil	144.0	21.3
		2 217.5	47.7
reduction	Paste Mix	2 127.5	47.7
	Raw Linseed Oil	101.0	13.3
	Pure Heat Bodied Linseed Oil	90.4	11.5
	Petroleum Spirits	197.4	24.3
	Liquid Drier	27.2	3.4
		2 533.5	100.2

	pigment 77.7%	vehicle 22.3%
composition by weight	Red Lead 99.6%	Raw Linseed Oil 49.1%
	Aluminum Stearate .4%	Pure Heat Bodied Linseed Oil 17.3%
		Petroleum Spirits 29.1%
		Liquid Drier 3.4%

Weight per gal. 25.3 lbs
PV 26
Consistency 240 gms (Flow Tube)
TT P 141a, Minimum 420 ft

Dry to touch in – within 24 hours
Dry to recoating in – within 72 hours

dry Red Lead mixing formula*

Dry Red Lead 97%, green	100 lbs
Linseed Replacement Oil (TT O 371)	4 gals
Approximate Yield	5½ gals

paste Red Lead mixing formula*

Paste Red Lead 97%, Oil	100 lbs
Linseed Replacement Oil (TT O 371)	2 to 2½ gals
Turpentine or Petroleum Spirits	2 to 3 gals
Yield	4½ to 5 gals

*Minimum of 4 lbs of Aluminum Stearate per 100 lbs of red lead, when amounts of paste to be used in a dried film are to be made in the mixer, is desirable.
Quick Dry Boiled Red Lead (Old) conforms with the requirements of this specification.

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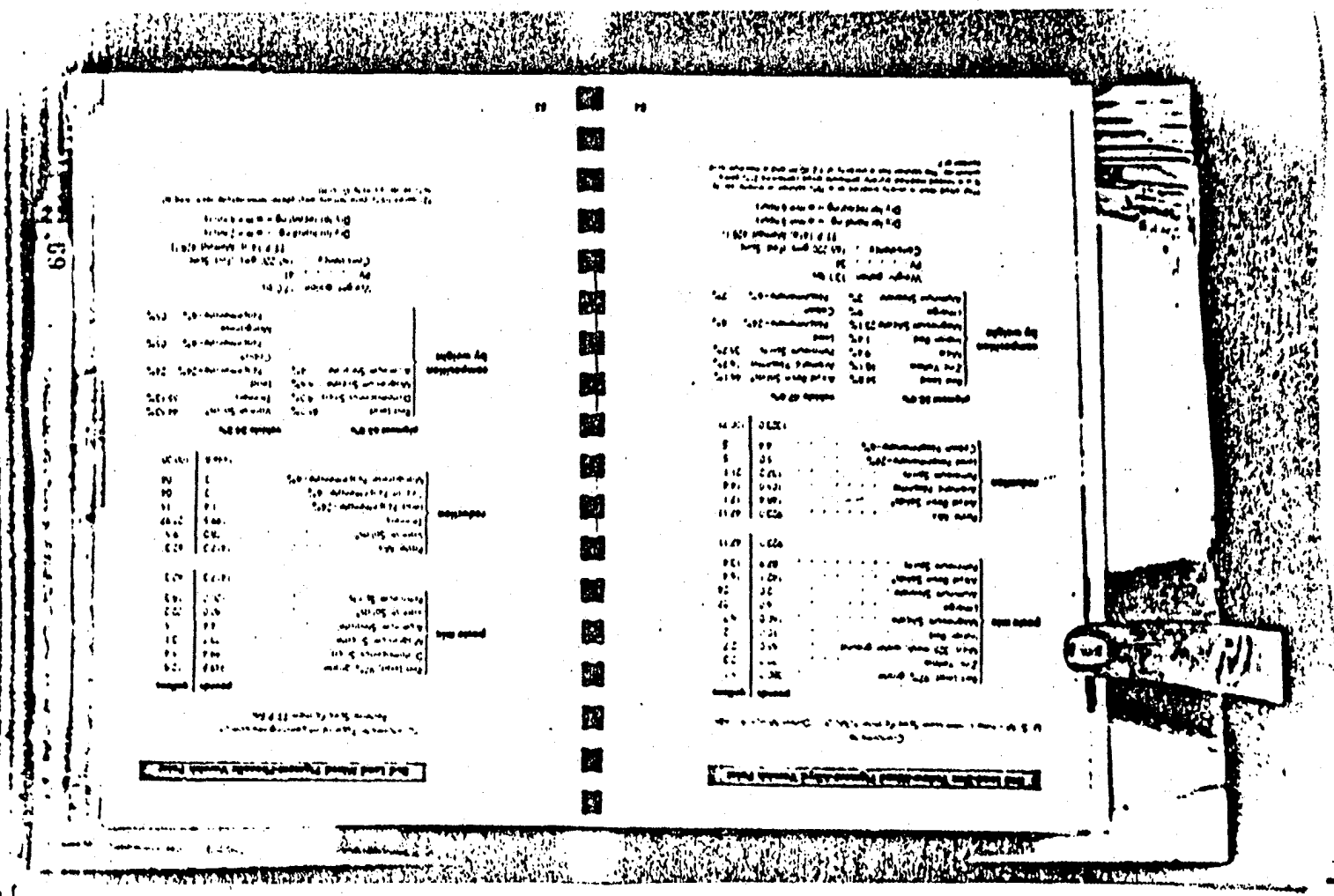


Red Lead-Zinc Yellow-Mixed Pigment-Phenolic Varnish Paint

Conforming to
U. S. Engineers, Ohio River Division
Specification P-210 (Water Power Coat No. 1)

		pounds	gallons
paste mix	Red lead, 97% grade	2427	34
	Iron Oxide, 94% Fe_2O_3	6723	164
	Zinc Yellow	881	10
	Chromomarine Brick	937	22
	Varnish Solids*	1785	217
	Thinners	1767	144
		13478	614
reduction	Paste Mix	13478	614
	Varnish Solids*	953	117
	Thinner	1481	227
	Lead Naphthenate-26%	41	13
	Cobalt Naphthenate-6%	16	5
		16969	1000

pigment 65.9%		vehicle 34.1%	
Red lead	24.6%	Varnish Solids*	46.4%
Iron Oxide	13.9%	Thinners	18.2%
Zinc Yellow	5.4%	Lead Naphthenate-26%	7%
Chromomarine Brick	8.9%	Cobalt Naphthenate-6%	3%

Weight gallon 16.6 lbs
PV 46.6
Consistency . 160 gms (Fed Spec TT-P-141a, Method 4211)
Dry for handling – within 2 hours
Dry for recoating – within 6 hours

*Oil varnish made of dehydrated castor oil, 40% tung oil, 60% solids in solvent naphtha (1.0 oil)

Red Lead-Zinc Yellow-Mixed Pigment-Resin Paint*

General Purpose Anti-Corrosive
Shop Primer Paint

		pounds	gallons
ball mill charge	Red lead, 97% grade	3324	45
	Zinc Oxide	584	12
	Zinc Yellow	631	21
	Mica	575	25
	Magnesium Silicate	1953	81
	Aluminum Stearate	62	4
	Cumarone Indene Resin (127°-137°C M.P.)	1671	186
	Cumarone Indene Resin (110°C M.P.)	575	64
	Liquid Coal Tar	584	59
	Zinc Resinate (9.6% Zn, 158-162°C M.P.)	207	22
	H. Flash Naphtha	1545	215
	Low Boiling Point Petroleum Naphtha (175°-205°F D-86 Range)	861	146
		12542	982
reduction	Ball Mill Charge	12542	982
	Chlorinated Rubber (20cps)*	414	30
	H. Flash Naphtha	450	88
		13406	1000

pigment 52.9%		vehicle 47.8%	
Red lead	46.9%	Cumarone Indene Resin (127°-137°C M.P.)	25.7%
Zinc Oxide	8.7%	Cumarone Indene Resin (110°C M.P.)	8.9%
Zinc Yellow	8.9%	Liquid Coal Tar	9.0%
Mica	8.1%	Zinc Resinate	3.2%
Magnesium Silicate	27.2%	Chlorinated Rubber*	6.3%
Aluminum Stearate	1%	H. Flash Naphtha	31.7%
		Petroleum Naphtha	13.3%

Weight gallon 13.4 lbs
PV 34.6
Consistency . 210 gms (Fed Spec TT-P-141a, Method 4211)
Dry for handling – within 2 hours
Dry for recoating – within 4 hours

*The chlorinated rubber should be added as a 20% solution in H. Flash Naphtha
For lower spatter, a H. Flash Naphtha or petroleum naphtha may be used

Red Lead (Anodic Mixed Pigments) Alkyd Vehicle Paint

Generic Paint Being Prepared

		pounds	gallons
ball mill grind	Red Lead 97% grade	474	7.6
	Red Iron Oxide	693.3	13.3
	Magnesium Silicate	1293.3	47
	Alkyd Resin Solution*	1481	167
	Monomer Formaldehyde Resin Solution**	143.3	3.6
	Petroleum Spirits	347.9	57.7
	Butyl	144	2.2
	Alcohol	171	2.6
		1281.0	1000

pigment 66.0% vehicle 47.1%

composition by weight

Red Lead	7.2%	Alkyd Resin Solution*	31.0%
Red Iron Oxide	13.0%	Monomer Formaldehyde Resin Solution**	4.7%
Magnesium Silicate	20.2%	Petroleum Spirits	47.7%
		Butyl	2.2%
		Alcohol	2.6%

Weight gallon 12.8 lbs
PV 46
Consistency 160 grms (4.5 oz) Vertical Drop 42 in.

This paint should be thinned with petroleum spirits for spray application.

Suggested baking schedule = 30' minutes at 275° F

Paint has 10% solids content (based on total non-volatile content of formulation solids).
Melamine Formaldehyde Resin Coating Alkyd Modified Resin, 50% solids in petroleum spirits sold under other trade names as

Finish Coat—White

Conforms to
Federal Specification Enamel 11 P 101, Amend. 2, Type I, Class A
(Dated 2 2 61)

		pounds	gallons
paste mix	Titanium Dioxide	1440	4.5
	Zinc Oxide	3120	8.4
	Basic Carbonate White Lead	4290	7.6
	Magnesium Silicate	1560	6.9
	Linseed Oil	2430	34.0
		13340	61.1
reduction	Paste Mix	13340	61.1
	Heat Bodied Linseed Oil (22 Visc.)	910	11.4
	Petroleum Spirits	150.0	23.8
	Liquid Drier	27.0	3.7
		14290	100.0

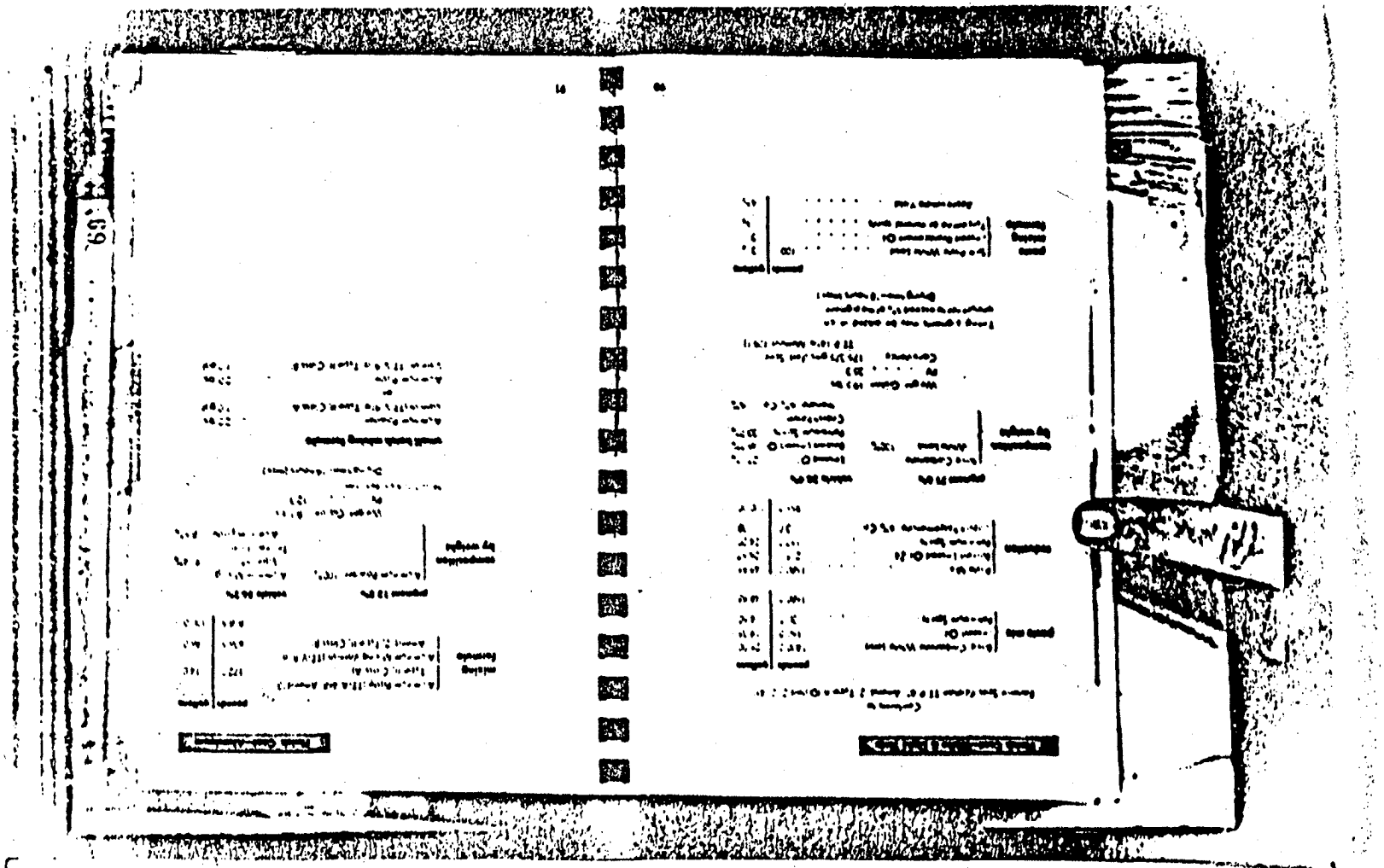
pigment 66.0% vehicle 34.0%

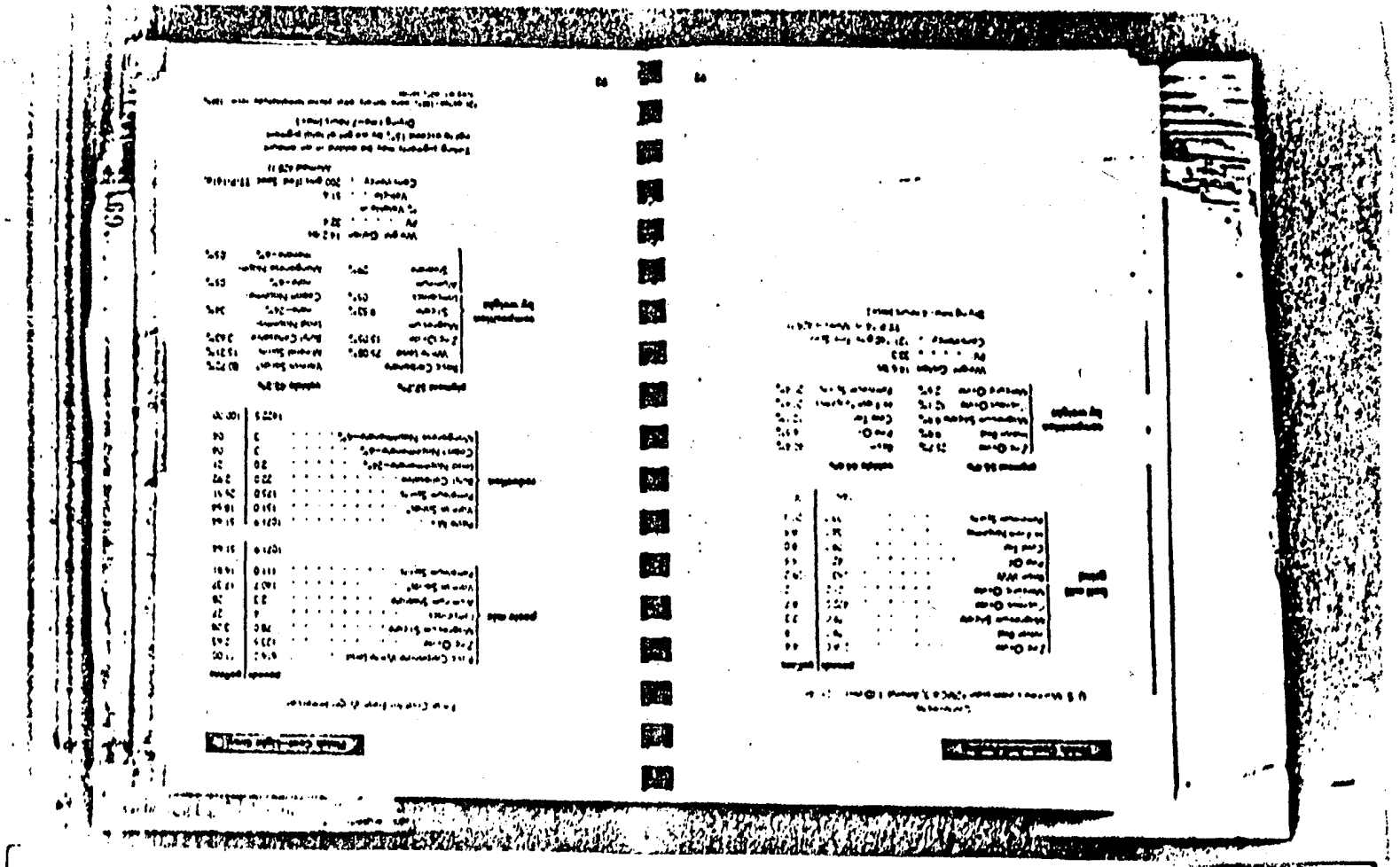
composition by weight

Titanium Dioxide	14.0%	Linseed Oil	49.0%
Zinc Oxide	30.0%	Heat Bodied Linseed Oil	17.0%
Basic Carbonate White Lead	41.0%	Petroleum Spirits	29.0%
Magnesium Silicate	15.0%	Liquid Drier	5.0%

Weight Gallon 15.8 lbs
PV 37.3
Consistency 175-375 grms (Fed. Spec. 11 P 101 (4 Meet 428 II)

Dry time = 18 hours (max.)





Finish Coat—Medium Green

Conforms to
Maine State Highway Commission—Bridge Division*

		pounds	gallons
paste mix	Basic Carbonate White Lead	1040.0	19.0
	C.P. Chrome Oxide Green	183.0	4.3
	Linseed Oil	177.5	22.8
	Petroleum Spirits	37.0	5.6
		1445.0	51.7
reduction	Paste Mix	1445.0	51.7
	Linseed Oil	190.0	24.2
	Varnish Solids**	22.9	2.7
	Petroleum Spirits	130.0	19.4
	Liquid Drier	14.7	2.0
		1802.6	100.0

composition by weight	pigment 68.4%		vehicle 31.6%	
	Basic Carbonate White Lead	85.4%	Raw & Heat Bodied Linseed Oils	64.2%
	C.P. Chrome Oxide Green	14.6%	Varnish Solids**	4.0%
			Volatile Thinners	29.2%
			Liquid Drier	2.6%

Weight/Gallon 18.2 lbs.
PV . . . 32.8
% Volatile in Vehicle . . 31.8
Consistency . 300 gms (A.S.T.M. Method D562-42-T)
Drying time—20 hours (max.)

		pounds	gallons
paste mixing formula	Soft Paste White Lead	100	3.25
	C.P. Chrome Oxide Green Paste	20	1.0
	Linseed Replacement Oil		3.25
	Varnish**		0.5
	Turpentine or Petroleum Spirits		0.25
	Approximate Yield		8.25

*This paint is usually specified by State and Municipal Agencies with only slight variations in formulation.
**Long oil varnish, 50% solids by weight, 40% (min.) film reduction, viscosity A-B

Finish Coat—Green

		pounds	gallons
soft paste	Red Lead, 97%, Grade	90.0	1.21
	Carbon Black	27.0	0.13
	Silica and Silicates	134.3	5.81
	Raw Linseed Oil	423.3	54.44
	Heat Bodied Linseed Oil	63.3	8.35
	Petroleum Spirits	163.6	23.39
	Liquid Drier	12.0	1.47
		953.5	100.00

composition by weight	pigment 31.0%		vehicle 68.9%	
	Red Lead	30%	Raw Linseed Oil	61%
	Carbon Black	2%	Heat Bodied Linseed Oil	10%
	Silica and Silicates	44%	Petroleum Spirits	23%
			Liquid Drier	2%

Weight/Gallon 9.5 lbs.
PV . . . 16.7
Consistency . 130-200 gms (A.S.T.M. Method D562-42-T)
Drying time—18 hours (max.)

Paint of this type is available on Grade Day 10-Medium Finish Specification.