

Reference

NP1

Publ

NAT'L INST. OF STAND & TECH



A11106 454605

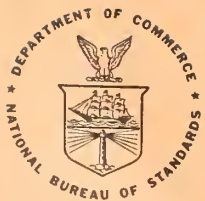
NIST
PUBLICATIONS

CORROSION

Facts for the Consumer

U.S. DEPARTMENT
OF COMMERCE

National Bureau
of Standards



JUL 17 1978

Notacc-14f

+X 335

.A146

"Keep up your bright swords
for the dew will rust them"
—Shakespeare

TODAY, as it was in Shake-
speare's time, rust or corro-
sion is the deadly enemy of
metals. While the rusty condi-
tion of a sword may indicate
inactivity, rust and other forms
of corrosion usually signify that
an "active" and destructive
process is taking place. Corro-
sion is the destruction or "eating
away" of metal due to its expo-
sure to various environments,
particularly moisture.

In addition to its unsightly
appearance, corrosion can
cause holes, cracks, or thinning
in metal objects making them
unsafe or useless. This pam-
phlet describes some of the
ways that corrosion can be
prevented, slowed, or stopped.
The four kinds of corrosion are
explained and guidelines for
preventing or removing corro-
sion are provided.

TYPES OF CORROSION

IN order to combat corrosion,
it's important to know the
kinds of corrosion and the
conditions that promote them.
There are four major types of
corrosion:

GALVANIC

Galvanic corrosion occurs when
two different metals, for exam-
ple, aluminum and steel are in
contact with each other and are
exposed to wet corrosive
environments such as salt
water, bleach, or detergent.

CREVICE

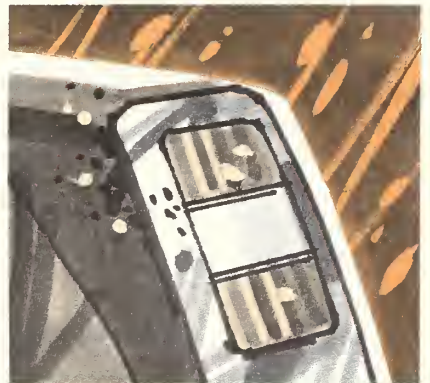
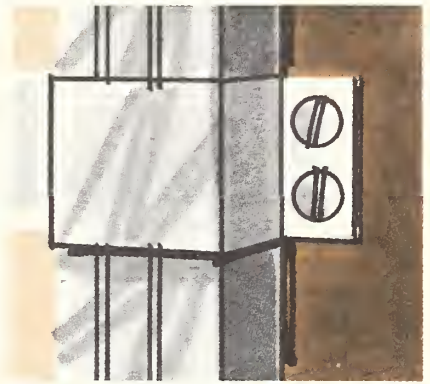
Crevice corrosion takes place
when a portion of a metal object
is covered by dirt, a gasket,
bolt and rivet heads, or the like,
and is exposed to corrosive
environments.

PITTING

Pitting corrosion occurs when a
very small bare metal area is
exposed to a corrosive environ-
ment, for example, at a chip in
the paint of your automobile.
This type of intense corrosive
attack results in holes or "pits"
and can also occur on un-
painted surfaces.

STRESS

Stress corrosion occurs when a
metal that has been pulled or
bent in the manufacturing pro-
cess to produce a desired shape
is exposed to corrosive environ-
ments. A crack in the metal
piece often results.



HOW TO MINIMIZE CORROSION

THE more you know about corrosion, what causes it, and how it attacks metals, the better able you will be to combat it. Some metals are more susceptible to corrosion than others. In the diagram below, metals are rated from 1 to 12. The higher the number, the more susceptible the metal is to corrosion. To minimize GALVANIC corrosion, only metals rated closely in the scale should be used in contact with each other. When two metals are used together, the metal rated higher on the scale is more likely to corrode.

For example, if you combine copper pipe (rated 5) with ordinary steel pipe (rated 9) in a plumbing system, the steel pipe will frequently corrode. If an unfavorable metal combination cannot be avoided, coat the lower numbered metal with a good paint.

Some common galvanic corrosion-promoting combinations include:

- copper wire or iron objects left in the bilge and bottom of an aluminum boat;
- steel bolts and washers used to fasten brass sheets exposed to a marine atmosphere; and
- steel nails used to install aluminum gutters, or copper gutters installed with aluminum or galvanized downspouts.

CREVICE corrosion can occur if wet leaves are left in gutters or drains. To avoid or minimize crevice corrosion, keep metal surfaces clean. When gaskets are used with metal, choose plastic gaskets that will not absorb moisture. Remove wet packing material from metal objects in packing cases as soon as possible. If crevice corrosion occurs, caulk or solder the crevices as soon as possible.

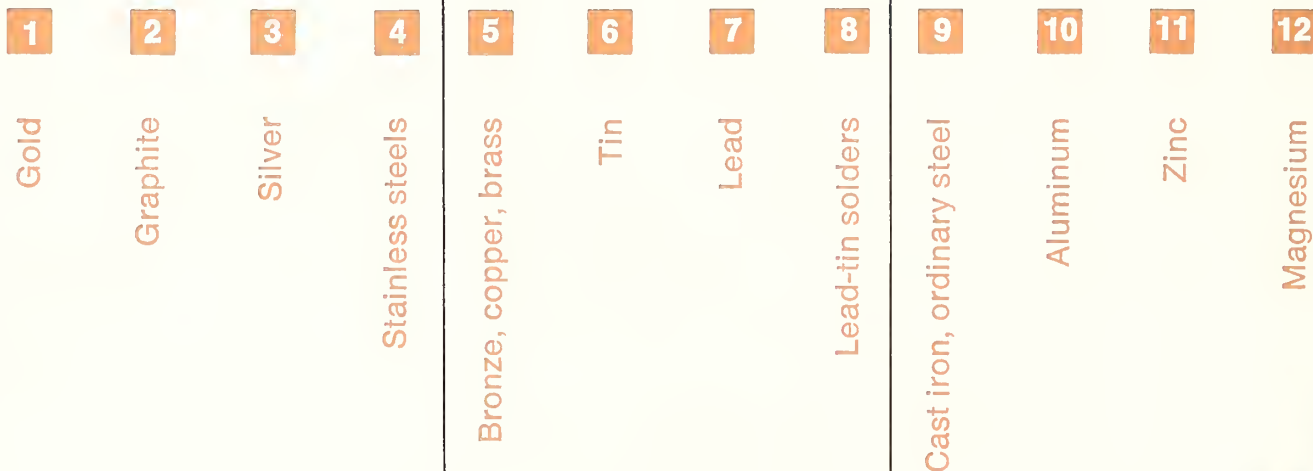
To stop PITTING corrosion before it becomes a problem, cover holes in the coating with a new paint or lacquer where

the rust spots or pitting first appears. This is especially important for automobiles. Be sure to remove all corrosion before applying a new coat of paint or lacquer. If possible, avoid exposure of the metal to salt or salt water. Wash automobiles or other metals often when exposed to salt or sea-air.

It is difficult to protect metals against STRESS corrosion because most of the metals you purchase have stresses built in by the manufacturing process.

Certain metal-environment combinations are particularly vulnerable to stress corrosion. To prevent stress corrosion avoid the following combinations:

- aluminum alloys with salt water;
- copper, brass, and bronze with ammonia vapor and solutions;
- ordinary steel and ammonium nitrate fertilizer solutions; and
- stainless steel with salt water.



HOW TO PREVENT CORROSION

THE following are some simple steps you can take to prevent or inhibit corrosion:

PAINT

Paint has long been the major means of preventing rust by providing a barrier between the metal and the corrosive environment. There is a wide variety of paints on the market, many of which contain corrosion inhibitors. Epoxies, epoxy-coal tar, vinyl-alkyds, asphaltics and coal tars, silicone-alkyds, polyurethanes and phenolics, chlorinated rubbers, and zinc-rich paints provide good corrosion resistance.

The most important part of any paint job is surface preparation and the application of a good primer or prime coat. Thoroughly clean and dry the metal surface before applying primer or paint. Follow the manufacturer's recommendation for each type of paint, paying particular attention to proper surface preparation.

LACQUERS AND VARNISHES

Lacquers and varnishes are transparent coatings that protect the metal without hiding its original finish. Lacquers and varnishes can be used to protect many household items including bare metal table tops, rough-textured aluminum card tables, copper art objects, window screens, and metal doors. For best results use products containing acrylics, methacrylates, or butyrates. Before applying any lacquer or varnish, be sure to clean and dry the metal surface thoroughly.

INHIBITORS

Inhibitors are chemicals that are added to an environment to make it less corrosive or applied to a metal to protect it from the environment. Water displacing sprays or tarnish preventive sprays are available in most hardware, jewelry, and department stores for use on jewelry, silver, and metal art objects. However, the most familiar use of inhibitors is in the cooling system of your car. For more information about car corrosion, write: "Automotive Rust—Its Causes and Prevention," Consumer Information Center, Pueblo, Colorado 81009.

Most antifreeze and coolant preparations contain inhibitors to protect your engine cooling system from corrosion. Because the effectiveness of inhibitors is progressively reduced over time, it is necessary to add or reapply the inhibitor periodically.

Vapor phase inhibitors, available at hardware and department stores, can be placed in drawers and enclosed spaces to protect tools and silverware from corrosion.

GREASES

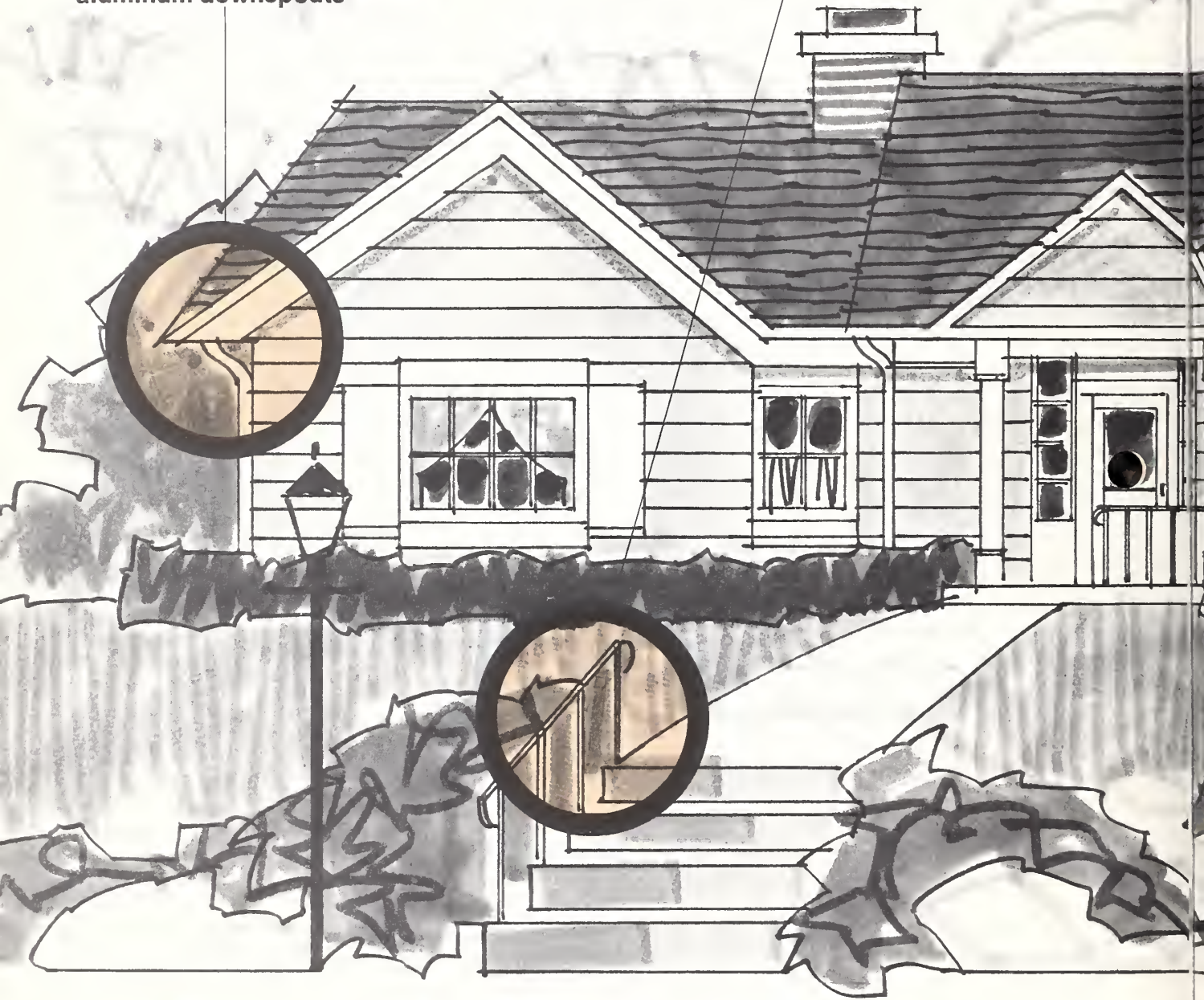
Greases, like petroleum jelly, are very useful for protecting tools or other metal items that are to be stored or shipped long distances. By coating the terminals of your car battery with grease, you can prevent unnecessary drains on your battery caused by the corrosion produced by battery acid.

OILS AND WAXES

Oils and waxes, such as the penetrating motor oils and liquid waxes, are effective when applied periodically to lawn mowers, tools, skis, ice skates, guns, fishing tackle, and water sprinklers. Thoroughly clean and dry the surface to be protected. Wipe oil or wax on surface with a cloth, making sure to cover the metal completely.

**Stress—bent iron railing
exposed to fertilizers**

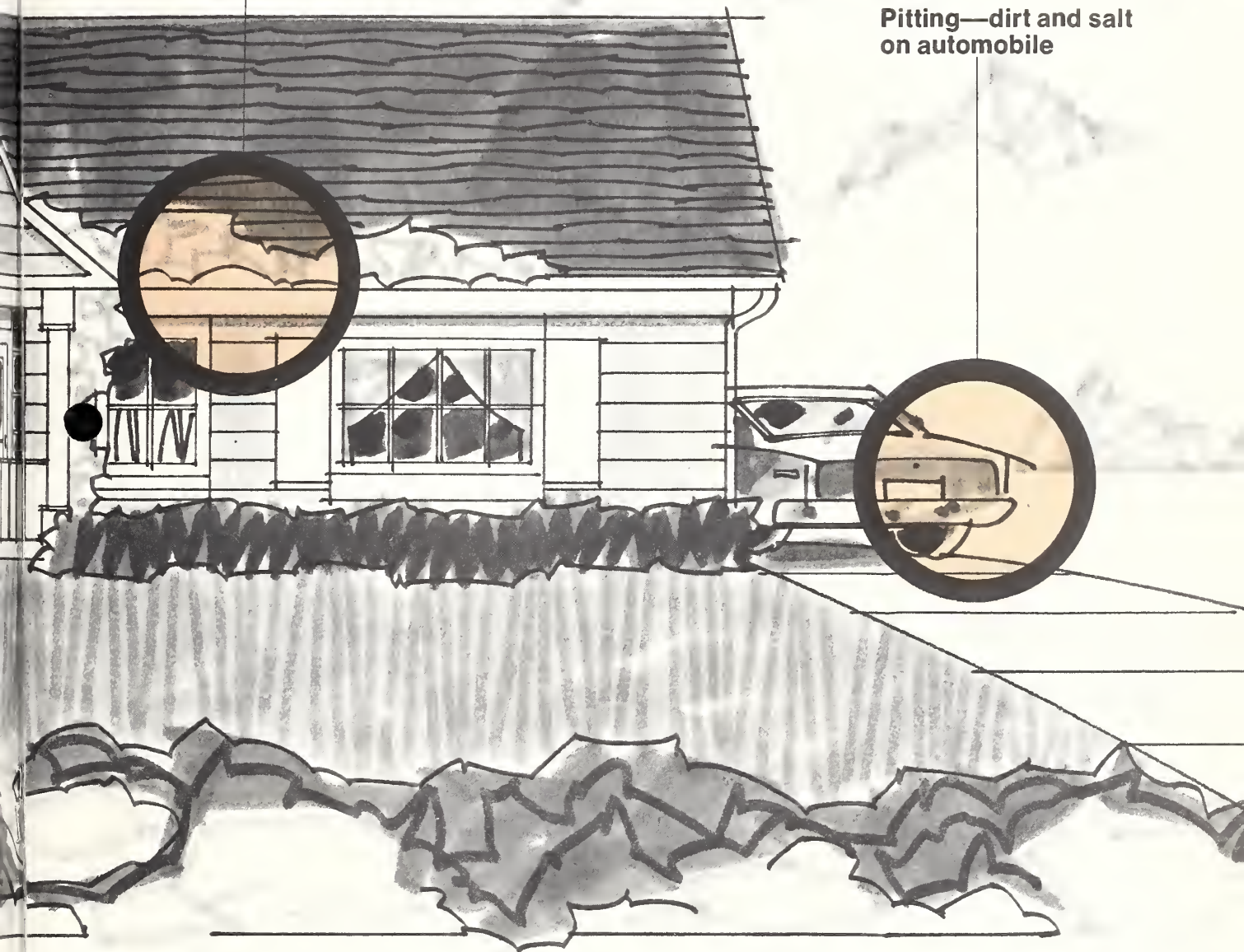
**Galvanic—copper gutters with
aluminum downspouts**



CORROSION AROUND THE HOME.

● Crevice—leaves left
in gutters

Pitting—dirt and salt
on automobile



HOW TO REMOVE CORROSION

UNSIGHTLY rust, tarnish, and other corrosion can be removed from metals with a thorough cleaning. There are many metal cleaners available on the market that will do a good job if used properly. Or, you may prefer to try one of the home preparations described in this booklet. In either case, for best results, try the following procedure.

- Test the cleaner on a hidden area to make sure it will work and not do any damage.
- Follow directions carefully—this includes using the right amount of cleaner at the right temperature for the right amount of time.
- Do not mix cleaners.
- Remove the cleaner thoroughly, especially from cracks, corners, and holes.
- When working with any toxic or poisonous substance, wear plastic or rubber gloves as a precautionary measure.

Corrosion on all metals used in the home can be cleaned by using commercially available cleaners, but some home preparations are less expensive and are just as effective. All of the preparations given below are for removing CORROSION only. They are not intended for other stains or deposits such as burnt-on foods, grease, or dirt. In a few cases, the cleaning methods described here are useful for stubborn stains on which commercial cleaners are not effective or are less easy to use. Acid solutions should always be used with **caution**.

STEEL, CAST IRON AND WROUGHT IRON

For heavily rusted objects:

1. Dissolve 4 teaspoons of citric acid (or sour salt) in 1 quart of water.
2. CAREFULLY add small amounts of household ammonia to this solution, mixing thoroughly, and VERY CAREFULLY sniffing the mixture after each addition. After the first few additions of the ammonia you will not smell an ammonia-like odor from the mixture. Keep adding small amounts of ammonia and mixing until the mixture just starts to smell of ammonia again.
3. Now bring the volume of the mixture up to a total of 2 quarts by adding more water.
4. Place this solution in a large glass or enameled container.

5. Place the container on a surface burner of your kitchen range and bring the temperature of the liquid up to about 150 to 160 degrees Fahrenheit and maintain that temperature. Soak the rusty object in the hot solution.

6. From time to time, remove the object, rinse with clear water, and wipe it with a cloth to see how much rust has been removed. This procedure may take several hours. When you have removed all the rust on a heavily rusted object, you may find holes caused by the corrosion that were not conspicuous before cleaning. NOTE: This cleaning procedure is for iron and steel *only*. Ammonia will cause stress corrosion of brass.

For small rust spots:

1. Prepare a powder by combining 2 ounces of cream of tartar and 1 ounce of oxalic acid (**caution—poisonous**).
2. Moisten the rust spot, apply the powder, and leave it on for 10 minutes.
3. Rinse the object thoroughly with water and dry quickly to prevent new rust from forming.

ALUMINUM

The tarnish most often found on aluminum occurs in pots used to cook eggs or to heat certain types of tap water. This tarnish, usually a black or dark brown color, can be removed easily by cooking sour foods such as tart apples, sauerkraut, or tomatoes in the pot.

The white powdery corrosion sometimes found on aluminum can be removed by rubbing the object with a stiff brush, not stiff enough to scratch, while washing it with water and a mild detergent.

STAINLESS STEEL

The only kind of corrosion you will need to remove from stainless steel is the discoloration or "heat tint" that occurs after stainless steel has been heated extensively in use. A stainless steel wool or scouring pad combined with a scouring powder is usually sufficient to remove "heat tint." If the discoloration remains some of the stainless steel cleaning preparations on the market can be used to remove it. You can also immerse or swab the object with a 5 percent oxalic acid solution (**caution—poisonous**).

COPPER BRASS AND BRONZE

Before attempting to clean any copper, brass, or bronze objects, remove any lacquer with a lacquer thinner and wash with warm water and detergent. After thoroughly rinsing and drying the metal, try one of these methods for removing tarnish:

A. Mix equal parts of salt, flour, and vinegar and apply the mixture to the metal with a dry cloth.

OR

B. Moisten the tarnished area with water and cover with salt and rub vigorously with a lemon half or slice.

OR

C. For tough stains, mix a few ounces of oxalic acid (**caution—poisonous**) with 1 quart of water. Wet a cleaning cloth in the solution, and dip the cloth into powdered pumice, and rub it briskly over the metal. Wipe with a clean dry cloth.

After removing the tarnish, wash the metal with warm water and detergent, rinse and dry thoroughly. To preserve the gleaming finish, apply a good lacquer to the surface. **DO NOT** lacquer copper-clad cooking pots and pans.

SILVER

As with the other metals discussed, the many cleaning preparations available at your supermarket, department store, or hardware store will do an excellent job of removing tarnish on silver. However, if you have a silver item that has an intricately inscribed design that is difficult or time-consuming to clean, the following procedure may be worth a try:

1. Wrap the entire object in aluminum foil, making a few cuts in the foil to allow liquid to leak into the space between the silver and the foil.
2. Place the foil-wrapped object in a large glass, enameled, or stainless steel pot that can be placed on the stove.
3. Fill the container with a solution of water and bicarbonate of soda (4 to 5 tablespoons per quart of water) and simmer gently for 30 minutes. Use enough water to cover the object. The tarnish in the cracks should be removed by this procedure. If not, repeat.
4. Remove the aluminum foil, rinse, and dry the silver thoroughly.

WHAT CORROSION PROTECTION TO LOOK FOR WHEN BUYING METAL OBJECTS

MANUFACTURERS use a number of methods to protect their products from corrosion. The most common method is the application of metallic, polymeric, or ceramic coatings to the metal.

METALLIC COATING

The metallic coating most widely used is a zinc coating applied to steel. The resulting coated steel is called galvanized steel. Galvanized steel is used in the production of trash cans, gutters, water pipes, chain-link fencing, and siding. The quality of a galvanized steel is determined by the thickness of the zinc coating. The thickness is usually defined as the number of ounces per square foot of steel and ranges from $\frac{1}{4}$ ounce to 3 ounces per square foot. The more ounces of coating per square foot, the longer the galvanized product will usually last.

ELECTRO-PLATING

Electroplating is another widely used method of metallic coating. Electroplated items around the house include chrome-plated auto bumpers and trim, silver-plated flatware, household appliances, and tin cans (tin-coated steel). The coated objects take on the appearance of the material used for the coating such as copper, silver, or chrome. An important property of electroplated coatings is their thickness. The thicker the coating, the fewer pores, and the less likely pitting corrosion will occur. Some articles are plated with more than one kind of metal, for example an auto bumper that is plated with copper, nickel, and chrome. It then becomes difficult to compare on the basis of thickness alone.

Small pin holes, that can result in rust spots, may develop in electroplated surfaces. This can be controlled by cleaning off the rust, being careful not to damage the remaining electroplated surface, and sealing with a lacquer or wax.

CERAMIC COATING

Ceramic coated items you may encounter include enameled cooking utensils, glass-lined hot water tanks, and porcelain enamel-lined appliances. These coatings are usually applied to steel surfaces. Porcelain enamel on steel can be recognized by the following characteristics: will attract a magnet,

cannot be scratched by a coin, and has an "orange peel-like" surface. Ceramic coatings of excellent corrosion resistance and are usually pore-free. Some glass-lined hot water tanks are equipped with magnesium rods known as anodes for additional protection against corrosion should a defect in the coating exist. Though it will cost slightly more, a hot water tank with an anode is a worthwhile investment. Most glass-lined hot water heaters now come with anodes.

QUALITY OF WORKMANSHIP

Smooth rims, coatings, linings, and finishes without pits, chips or gaps are marks of good workmanship. They not only improve the appearance of the product, they also increase its durability. For example, rough edges or finishes could expose bare metal to a corrosive environment, or a defect in a porcelain coating could allow the underlying metal to rust and the coating to chip further.

With the information in this booklet you should be able to avoid much of the damage corrosion can cause. REMEMBER, nearly all environments are corrosive, but with proper care, corrosion can be prevented, slowed, or stopped.

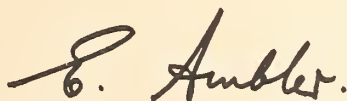
A Word from the Director

MEASUREMENT and standards are needed and used by all areas of society. A consumer wants to compare energy consumption rates for a certain appliance. A transportation manager needs to measure the fire safety of bus seats. A chemical manufacturer must be able to monitor the environmental levels of toxic materials.

The National Bureau of Standards is a Federal laboratory that supports science and technology in the United States through the provision of uniform measurements, test methods, codes, and standards. Dedication to basic research leading to humane application of technology is a distinguishing feature of our work.

One important part of our work is the sharing of information—making sure that the results of our various projects are readily available to all who need to know. This publication, CORROSION FACTS FOR THE CONSUMER, is part of our Consumer Information Series, which is designed to share our knowledge and experience with you—the consumer. Our research in the field of metallurgy has produced a great deal of information on the corrosion process, information that has been distilled in this booklet.

Corrosion exacts a very heavy toll. The battle against corrosion, through plating, painting, humidity control, and other techniques, is very costly. So is the replacement of products whose usefulness, or attractiveness, has been destroyed by corrosion. Corrosion has a complex impact on the environment. The mining and production of metals to replace products destroyed by corrosion can contribute to water and air pollution; and corroded, discarded metals are a visual blight. Corrosion can, through catastrophic failure, pose a real safety hazard. For these reasons corrosion is a topic of interest and concern for many consumers, and I hope the information in this booklet has been of practical value to you.



Ernest Ambler
Director

U.S. DEPARTMENT OF COMMERCE
National Bureau of Standards
Washington, D.C. 20234

OFFICIAL BUSINESS

POSTAGE AND FEES PAID
U.S. DEPARTMENT OF COMMERCE
COM-215

Fourth Class



by

JEROME KRUGER

Center for Materials Science
National Measurement Laboratory
National Bureau of Standards
Washington, D.C. 20234

NBS CONSUMER INFORMATION SERIES 9

Editor: Suellen Halpin
Center for Consumer Product Technology
National Engineering Laboratory
National Bureau of Standards

Issued: March 1978

U. S. DEPARTMENT OF COMMERCE
Juanita Kreps, Secretary
Sidney Harman, Under Secretary
Jordan J. Baruch,
Assistant Secretary for Science
and Technology

NATIONAL BUREAU OF STANDARDS
Ernest Ambler, Director

For sale by the Superintendent
of Documents,
U. S. Government Printing Office,
Washington, D. C. 20402

Price:
For sale by the Superintendent
of Documents,
U.S. Government Printing Office,
Washington, D.C. 20402

Price: 80 cents

Stock No. 003-003-01947-0



FROM THE NATIONAL
BUREAU OF STANDARDS
U.S. DEPARTMENT
OF COMMERCE