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Second Edition

HANDBOOK FOR SOLVING PLATING PROBLEMS

Trouble in your tank?

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FOREWORD

Since *Trouble* was originally written, a one-day course in how to apply the system was developed and presented several times throughout the country.

In developing this course, I realized that two additional discussions would be helpful: a treatment of the logic system that utilizes the rules; and further discussion on how to build the data base that is so essential to the troubleshooting process.

These discussions have been added to this new edition.

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Introduction

The Logic Of Troubleshooting

To better understand the use of the rules that follow, it helps to be familiar with the logical principles underlying the system. The system assumes that one of two main conditions exists:

1. The system worked previously; i.e., it produced quality work at an acceptable rejection level, or
2. The system is a new system; i.e., it is a system for a new or different part, a new machine, or a new type of plated coating.

An intermediate condition may also exist: the system worked, but only marginally; i.e., the rejection rate fluctuated to undesirably high levels; the system required unrealistically close control of some critical parameter; or the system needed modification to increase production rates.

The troubleshooting process applied to the system being investigated is a decision-making process based on the logic of change vs. no change, representing two mutually exclusive conditions: i.e., change either has or has not taken place.

We can also safely assume that a working system cannot become a non-working system without some change occurring. If everything were the same, the system would still work.

An acceptable extension of this proposition is that a system cannot work only sometimes unless there is some unrecognized change taking place. The range of the soil condition may be beyond the tolerance of the system. Or the tolerance of the system may only accommodate the soil range when the solutions are new—the aging of the solutions constitutes change. Soil loads build up, wetters are used up, and rinses become contaminated.

Since in the systems we are investigating, change is essential to the condition of trouble, the objective of the troubleshooting process is to define the nature and extent of the change, and then, if possible, correct it. For the three conditions previously listed, however, the emphasis of the investigation differs.

For Case 1—the system worked previously—the emphasis is on where the system has changed, or how the parts have changed, or how the equipment has changed. Once the nature and extent of the change has been defined, the emphasis is on how to restore the system to its original condition. Since this case generally occurs with a production system, the element of urgency can at times be severe.

In some instances, it may not be possible to accomplish this restoration. For example, the soil load on the parts may have increased dramatically and it is impossible to reduce it to its original level. Or some characteristic of the metal has necessitated a change to a different type of lubricant in a previous operation, and the change cannot be reversed. The problem then changes from a Case 1 problem to a Case 2 problem—a new system. However, because of the production urgency, it is often necessary to devise some temporary, even if inefficient, corrective procedure.

For Case 2—a new system—the emphasis shifts to how to change the system to accommodate the new set of conditions. This may mean a complete redesign of the entire system. Or it may be as simple as changing a single solution in the system, e.g., a cleaner. In many instances, the urgency factor of a Case 1 correction does not exist. Where a Case 1 system has been changed to a Case 2 as indicated above, the urgency will depend on the effectiveness, efficiency, and cost of the temporary correction devised.

For Case 3—a marginal system—the emphasis is on establishing the cause of the marginality; i.e., what is the variable that causes the system to change to a non-working system. It becomes necessary to review previous records of rejections to show, if possible, the pattern of the change, and from this re-

TABLE I

Station	Variables	Total
1. Soak clean	Conc., temp., soil load, balance	4 × 2 = 8
2. Electroclean	Conc., temp., soil load, balance, voltage, bus bars, cathodes	7 × 2 = 14
3. Rinse	Dragin, temp., flow rate	3 × 2 = 6
4. Acid	Conc., dissolved metal, balance	3 × 2 = 6
5. Rinse	As above	3 × 2 = 6
6. pH adjust	Conc., contamination	2 × 2 = 4
7. Plate	Conc. (at least 3 variables), temp., anodes, bus bars, contam. (3), filtrat., agitation	11 × 2 = 22
8. Rinse	As above	3 × 2 = 6
9. Dry		

Total Possibilities:

8 × 14 × 6 × 6 × 6 × 4 × 22 × 6 = 12,773,376

view of data to establish a range of past conditions that will show the possible limits of the system. Once these values have been identified and quantified, the problem reverts to a Case 2 problem—that of a new system.

It would, of course, be helpful if this initial classification of the system by case type was always clear-cut. However, it seldom is. The three specified conditions often shade into each other, making it extremely difficult to decide on the proper classification. Often the major part of the troubleshooter's work is gathering enough information just to make this decision. This shouldn't be surprising, considering the complexity of finishing systems. Consider a very simple plating cycle—soak clean, electroclean, rinse, acid dip, rinse, nickel plate, rinse and dry.

Table 1 shows a calculation of the number of possibilities that can exist when we assign even a limited number of possible variables to each solution. (Note: each variable is multiplied by two since it can be right or wrong.) Even for such a simple system, the number is staggering—almost 13 million! How can anyone

TABLE II

Station	Variables	Total
1. Soak clean	Soil load, balance	2 × 2 = 4
2. Electroclean	Soil load, balance, voltage, bus bars, cathodes	5 × 2 = 10
3. Rinse	None	
4. Acid	Dissolved metal, balance	2 × 2 = 4
5. Rinse	As above	
6. pH adjust	Contamination	1 × 2 = 2
7. Plate	Anodes, bus bars, contam. (3), filtrat., agitation	7 × 2 = 14
8. Rinse	As above	
9. Dry		

Total Possibilities:

4 × 10 × 4 × 2 × 14 = 4,480

investigate such a complexity? To steal a line from *The King and I*—"Is a puzzlement!"

Fortunately, a number of these variables can be easily checked, such as temperatures, concentrations, voltages, and flow rates in rinses. Table 2 shows what happens when we make such adjustments to our simple system. The number of possibilities drops to about 4,500. Still a large enough number, but much better than 13 milion. (Incidentally, just this simple step may solve the problem—see Rule 3.)

Notice now that three variables have been assigned to the nickel solution for contamination. If a Hull Cell panel is run, it should be possible to determine whether this contamination exists. If it does, we are now down to three possibilities. If it does not, we are not quite so well off, but the number of possibilities has been reduced to about 1,500.

And so the troubleshooters proceed, step by logical step, until they have completely defined the problem. They can then propose a solution.

To do this, however, one must be familiar with the rules of logic and how they can be applied. From mathematics, for example, we recognize the principle, "Things equal to the same thing are equal to each other." We can, for example, write a simple syllogism (logical group operation—you'll recognize it)—

$$A = C + D$$
$$B = C + D$$
$$A = B$$

and no one will argue as long as we abide by certain rules of mathematics and use valid numbers.

But how about this one:

- Men are human (some women will argue the truth of this.)
- Women are human (some men will etc.)
- Men are women.

Whoops! Something went wrong. But what? Human is a class that encompasses two subclasses *that are not equivalent.* Therefore, while the two propositions are valid, the conclusion isn't.

Metal finishing is loaded with just such cases, and troubleshooters must be prepared to make some very fine distinctions or their conclusions will not be valid. For example: "All acids will attack metals." Valid? Yes, in a general way, but remember—concentrated nitric acid can be shipped in aluminum drums or tanks. It really only attacks aluminum if it is dilute enough. In order to accept this proposition as valid, you will have to specify concentration, temperature, or some other variable.

There is a need, therefore, for extensive background knowledge; e.g., in a nickel plating solution, at one level cadmium acts as a brightener; above that level it acts as an impurity. Where does the changeover take place? The troubleshooter has to know—or be able to find out. How you can establish this background knowledge will be discussed later. For now, go on to the rules, and get familiar with them.

Building the Data Base

Throughout all the rules just discussed, there has been a constant reference (implied in some cases, stated directly in others) to the need for an extensive data base—bits of knowledge and/or understanding that enable you to derive solutions for the problems pinpointed by your logical, analytical procedure. Indeed, in discussing Rule 2, brief reference was made to the need for this information, and how some of it can be obtained. Let us now take a more detailed look at what information is needed, how it can be organized, and where it can be obtained.

Four kinds of information are of value:

1. General information.
2. Process information.
3. Product or part information.
4. Tangential information.

General information is basic—it is the foundation of the data structure we need. This should include at least a working knowledge of chemistry—including the reactions of the metals and the major acids and bases; the interactions and the solubilities of the major salts used in finishing solutions; electrochemistry in fair detail; some organic chemistry, colloid chemistry, and surfactant chemistry. It is helpful to know some metallurgy, electricity, and electronics, and as much as possible about various machining and forming methods and how they affect the structure of metals subjected to them.

This information is needed and used in many ways, but to keep it simple, consider only the various metal forming operations—blanking, forming, drawing, deep drawing, ironing, and coining. Each one of these uses different lubricants, produces different stresses and different amounts of heat in the formed metal. All of these factors can affect the way a metal reacts in a preplating cycle, and knowing the differences can be important in solving a problem.

Process information includes all the pertinent information about all the materials used in the cycle: cleaners, acids, plating solutions, brighteners, etc.

Product or part information encompasses the history of the part, including all manufacturing processes used, heat treating processes (if any), the intended use of the part, the corrosive conditions it will encounter, and similar information about mating parts if it is an assembly.

Tangential information is the hardest to define. It is anything and everything that you have ever read or heard that might have any possible connection with anything involved in the cycle. It is especially hard to recognize, because it does not become information until you have dredged it out of memory and made the connection. The connection may be very indirect and may rely on your recognizing some hidden attribute that forms the connection. For example, an article on EP (extreme pressure) lubricants can yield information on the nature and reactions of burnishing compounds, additives for high-speed machining oils, or lubricants for deep drawing operations once you recognize the fact that the lubrication problem is the same in all the cases mentioned. Understanding this chemistry could be essential to solving a subsequent cleaning problem. An article on oil-well-drilling muds once yielded the information necessary to solve a settling problem in a waste disposal system. Tangential information is where you find it, and that can be anywhere.

Where do you get this information?

General information, for the most part, will come from formal courses in the subjects mentioned. However, the disciplined student can gather a great deal of it from a well-planned and sustained reading program. Often, in the absence of formal courses, informal instruction from someone trained in the field—e.g., a chemist or a metallurgist—can be an effective procedure, although the information is usually obtained item by item as needed, and will, therefore, be somewhat unorganized. One effective method is to combine a careful reading program with help from someone in the field for those sections that are somewhat difficult to grasp.

Information on manufacturing processes generally cannot be obtained from formal courses, but can be gathered by discussing the processes with the foreman/supervisor of the department, or the engineer who lays out the manufacturing process. Metallurgists can explain heat-treating furnaces and atmospheres. Trade magazines often have informative articles on machining, grinding, forming, and heat treating. Remember that truly valuable information in this area often comes from combining general information and process information. For example, information on a heat-treating process will probably give data on resulting metallurgical structure, furnace atmosphere (if any), temperatures, holding times, and quenching procedures, but no information on the oxides or scales formed. Yet it is the oxide and scale information that is needed to develop a proper preplating cycle. If the knowledge of metallic reactions is adequate, however, the oxides can be predicted from the two sets of information, and the cycle corrected or developed on the basis of this prediction. It is also possible, of course, that someone who has already derived this information will be willing to share it with you.

The reverse process is also possible. If there is a sudden change in a heat-treated part from a readily removed oxide to an oxide difficult to remove, sufficient knowledge of furnace atmospheres and the way they are generated may allow you to pinpoint the problem in heat treating and correct it, or allow you to provide information to the metallurgist or heat treater so he or she can correct it.

Product information is available from process sheets, blueprints, and/or manufacturing sheets. Probably no one, however, will volunteer to show these to you, mainly because they do not realize how helpful they can be to you. You have to ask for them.

When reviewing this product information, take a very critical approach. Study it carefully, looking for possible problem areas. Remember also that the time between various processing steps can often be a source of trouble unless certain preventative measures are taken.

A simple case will illustrate this point. Zinc die castings were blistering intermittently. Investigation showed that, as part of the die casting process, the parts were quenched in a dilute soluble oil, and then stored without washing and/or drying on the assumption that the dilute soluble oil would provide a protective film. Examination of the parts before finishing showed that the emulsifiers in the unremoved oil were reacting with the die casting to form zinc salts and soaps embedded in corrosion pits. The extent of this reaction and, consequently, the difficulty of removal, depended on storage time and the ambient atmosphere (season). The problem was completely eliminated by adding a thorough water rinse and a drying step after the quenching operation.

Tangential information is available from numerous sources, but mostly it is obtained by being curious. Numerous publications, such as *Scientific American*, specialize in broad-view articles on a wide variety of subjects. If you are curious enough to read these articles, you will often be struck by the overlap between some small part of the theory presented in the article and some phase of metal finishing. When that occurs, dig deeper and see how much more information can be found. The added insight will often help you to solve a problem.

This also works in reverse—you may read an interesting article or a brief item about some subject widely different from metal finishing—and, apparently, promptly forget about it. Days, weeks, months, or even years later, when faced with a problem, that little bit of information will pop unbidden into your mind, you will make the necessary connection, and solve the problem. So read everything you can get your hands on about almost everything.

How do you organize all this information? In whatever way suits you best. Make summaries on index cards. Put items into a computer file listing them by code words. Make up troubleshooting charts. Trust your memory. Whatever works for you.

But one way or another, file it away. Someday you'll need it.

Part I

Rule One

Don't Panic

It may come as a surprise that the first and foremost rule should apparently have no bearing on the troubleshooting procedure. But unless this rule is observed, no effective troubleshooting effort can begin.

What is panic? Depending on the dictionary used, you will find "a sudden overpowering terror," or "sudden onset of unreasoning fear," or some similar statement. Notice the key words—"sudden," "fear," and "overpowering" or "unreasoning." Of particular importance is the implication or suggestion that the mind is blanked out. Expressed another way, "when panic comes in the door, reason goes out the window."

This is why a person in such a state is often said to be in a "blind panic." Indeed a really severe attack may affect the senses—causing the eyes to defocus, hearing to be impeded, and muscles to be almost paralyzed. Milder attacks do not produce such obvious symptoms but even the earliest stages severely limit logical mental activity. In the grip of panic, logical thought becomes an impossibility.

No one who has spent any appreciable time in production plating can honestly deny that he has not had the urge to panic. When a production plating line develops a "glitch," more often than not it occurs with amazing speed. Things go from good to bad with stunning swiftness. Shortly thereafter additional ulcer-generating pressures develop: one has to find some place to store (or hide) the rejects; provisions for strip and replate or other salvage operations have to be made; expeditors or customers begin screaming for their parts; the operators want down time credit so they won't lose their production bonus; and the big boss probably calls you in, and while pounding the desk bellows, "If you can't straighten it out, we'll get someone who can!!!"

Anyone who can keep his head in the midst of this uproar obviously doesn't understand the gravity of the situation. And so panic sets in. There is an almost irresistible urge to do something, not necessarily the right thing, but anything to show that you are "on top of the situation" and "are taking steps." If you give in to this urge, things will probably get fouled up even more. But how do you avoid it? And just as importantly, how do you avoid precipitous action and still keep management convinced that you are doing what needs to be done? By proper training and preparation.

If you were an airline pilot, or an astronaut, or a nuclear reactor operator, you would be required to spend hours in a "simulator." This is a computer-controlled training device which reproduces with startling fidelity the conditions, mood, atmosphere and appearance of the real device. The proper sound effects may even be provided. To get some faint idea of how realistic a simulator can be, visit the Aerospace Museum of the Smithsonian Institute in Washington, D.C. It offers several simple but impressive examples. Stand on the very solid and stationary mockup of an aircraft carrier bridge looking at the projected view of the ocean, moving slowly up and down as if the ship were rolling gently. Try to keep from swaying in time to the moving waves! Watch others as they, too, sway!

Simulators are much more complicated and realistic. Outside the simulator, a training specialist can feed in all kinds of "glitches" and emergencies. The students learn to cope under safe but very realistic conditions until the reaction to almost any emergency is immediate application of a well known corrective or protective procedure. Panic is therefore avoided.

If this type of training is analyzed carefully, two characteristics become evident:

1. Although the onset of the problem may be sudden and unexpected, the problem itself is not completely unfamiliar. It or a variation of it has probably been experienced in the simulator.

2. The corrective action or procedure has been laid out ahead of time. During the period of most intensive stress, the onset and recognition of the problem, decision making is held to a minimum. The automatic responses programmed in have a calming effect to push back panic, and allow the mind to gain control of the situation.

Obviously, since problems in a finishing installation are seldom if ever of a life-and-death nature, the cost of constructing a simulator, even if it could be built, would scarcely be justified. In fact with all the variables that exist it is doubtful if one could be designed. How then can a training program be set up?

The answer lies in the two points we have already extracted as being the essence of simulator training: familiarity with possible problems; and a corrective procedure or routine laid out ahead of time.

Part II of this volume contains a series of troubleshooting charts for various solutions, followed by questions and answers from "Finishing Clinic." Study of these and the "what if" procedure explained in Rule Two will acquaint you with what can happen. (Remember Murphy's Law—If anything can possibly happen, it will.) So any problem that crops up will not be completely unfamiliar.

The routine that will enable us to avoid panic and find the solution is known as the scientific method; it consists of four steps:

1. Analysis—the study of the problem to determine its exact nature.

2. Data collection—the gathering of the necessary information to complete the analysis.

3. Synthesis—the building up of a theory or hypothesis to explain the reasons for the problem and the corrective action needed.

4. Testing—the proof of whether the theory developed is right, or whether it is necessary to discard it and start over.

The rules which follow and are discussed in detail spell out the necessary actions and procedures to complete the required four steps of the method.

Notice in particular that each rule spells out specific steps that are to be taken. By following such a routine methodically, several things are accomplished:

1. *Panic is avoided* by taking planned, positive action.
2. *Impulsive, non-rational* and possibly complicating actions are avoided.
3. *Management quickly becomes aware* that you are "taking steps" and are indeed "on top of the situation."

Remember, there are many people who look but do not see; who think but do not reason. Don't be one of them.

Rule Two

Define the Problem

Now that emotions are under control and reason is once more in charge of the brain, work can begin on the problem. The first step is to determine exactly what is the problem.

This sounds like a simple procedure—the work is peeling, or blistering, or there is a haze under the plate. Not so. These are all symptoms, not problems. The existence of the symptom may very well cause problems in production; or with the boss; or with quality control. And these are very real problems that must be dealt with while continuing the troubleshooting procedure. In fact, the pressures from these problems may increase almost exponentially with time. It will probably be necessary periodically, or even constantly, to remind yourself of Rule One. Nonetheless, these are not problems but symptoms pointing to a problem area in the cycle.

If these are not the problem, what is? To determine this, it may be necessary to use some of the rules we have not yet explained. The application of a little careful thinking will usually narrow down the area of investigation, and probably indicate which of the subsequent rules must be used to pinpoint the problem. A high percentage of the time, once the problem has been defined, it is also solved. After all, the cures for most difficulties are fairly well known; if the cleaner is not removing the oil from the parts, it can be strengthened or replaced; if the copper bath is low in cyanide, more can be added; if an acid is weak, it can be strengthened or replaced. The trick is to determine what has to be corrected; in other words, what is the problem.

It is especially important at this stage to use your powers of observation. What does it look like? What to look for is treated in Rule Eight. Remember, there is no substitute for accurate observation. And you must not only look and observe carefully, but make notes. Notice how this is emphasized not only here, but in Rules Six, Seven and Ten.

We will repeat over and over: *memory is a fragile thing.* Facts are easily lost, distorted, or even conveniently ignored. Keeping notes insures that the available facts will remain constant. Furthermore, the sequence of events is frequently important—the fact that incident A occurred before incident B may be an essential clue.

Notes have another helpful function. The process of taking them and arranging them in a suitable form helps to clarify your thinking (and incidentally has a calming effect as well).

One helpful technique is to set up three columns on a sheet of paper. In column A, put the known facts. In column B, opposite each fact put its known meaning or meanings. In column C place the proper corrective action or actions. Now, can you draw a single meaning out of what is available, or do you need more information?

Because Rule Two can involve the use of almost all the other rules, and because the choice of the rule to use, and the sequence in which to use it, are determined by the answers that develop in a very fluid situation, its application is best taught by example. It can then be developed by practice.

Example No. 1

My nickel is peeling.

Apply Rule Eight—*Look at the Parts.* Is the nickel peeling from the basis metal? Or nickel from nickel?

If from the basis metal, the problem may be in the preplating cycle. Apply Rule Three—*Obey the Letter of the Law.* Are all the conditions "bible" right?

Apply Rule Four—*Walk the Line.* See anything wrong?

Apply Rule Seven—*Look for the Pattern.*

You should now have enough information to define the problem accurately—and probably arrive at a solution. Review your notes. Arrange them in the three columns mentioned above. Can you find an answer? In better than 95 pct of the cases, you will. If not, go deeper into Rule Eight and check the history of the part. Go over Rules Three, Four and Seven again; perhaps you missed something the first time around.

If nickel is peeling from nickel, the problem is probably in the nickel tank; it is likely to be either a current problem or a brightener problem. A somewhat different use of the rules is therefore required.

Apply Rule Four—*Walk the Line.* Condition of the bus bar? Rectifier O.K.? Make and break possibility anywhere?

Apply Rule Five—*Look at the Record.* Condition of the nickel solution? Brightener additions normal? Hull Cell appearance? Bend test indicate anything?

Apply Rule Seven—*Get the Pattern.* Is it a consistent problem or an intermittent one? Is it associated with one barrel, one rack, one carrier arm?

You are now ready to pinpoint the problem. Analyze your notes as mentioned above. You should find the answer.

Example No. 2

My copper plated zinc die castings are blistering.

Apply Rule Eight—*Look at the Parts.* Peel off one of the blisters and look at the back of the copper layer. Is there zinc on the back of the copper? Does the exposed zinc substrate have a "pebbly" appearance? Are the blisters apparent as soon as the part is plated, or do they appear later? Is the condition made worse by applying heat? (These last two questions also bring Rule Seven into action.) If the answer generally is yes, you have a diffusion problem. If the answers to the first two questions are no, you may have a cleaning problem or a problem with the copper solution. Take a closer look at the exposed zinc layer. Is it relatively bright and light in color? If the answer is yes, the problem is probably in the cleaning line. If the zinc is dark, or has a faint coppery tinge, suspect the plating solution.

If it is a diffusion problem, the most likely cause is contamination of the cleaners, or the acid with copper.

Apply Rule Four—*Walk the Line.* Any evidence of copper in the solutions? Immerse a die casting for more than the normal period—does it turn unusually dark? Or is there evidence of an immersion copper deposit? Watch the parts as they transfer. Does the die casting turn dark in the drainage areas, near holes? Do the blisters usually appear where the darkening occurs? (Notice the application of Rule Seven—*Get the Pattern,* as part of Rule Four.) When you find the tank that appears to be causing the problem, apply Rule Ten—*Test It.* Either add a copper inhibitor or make a new solution and check again for the problem.

If you suspect the copper solution, apply Rule Three. Is everything "bible" right? Temperature? Free cyanide? Copper metal? Voltage? Anode condition?

If you suspect cleaning, apply Rules Three and Four. Do you need Rules Six and Seven? Unless you are very sure of your answer, you will need both of these to be certain that the problem is solved.

Example No. 3

There is a haze under the plate.

This can be a troublesome problem because it can result from so many different possibilities. Additionally, it is very hard to determine visually whether the haze is really under the plate, rather than in it. The first step then requires use of Rules Three and Five. What is the condition of the plating solution? How does the Hull Cell deposit look? Is the haze really under the plate?

Assuming that it is, there are a number of different causes:

1. Failure to remove smut. Apply Rule Four. Is there anything that indicates smut is not being removed? Wipe parts with a clean cloth or a piece of filter paper after each step. Can you see smut on the cloth or paper? You'll probably always see some, but the question you have to decide is whether or not it is too much. Do the wiped areas plate without haze? Apply Rule Five. When were the cleaners last changed? Have they been properly maintained?

2. An immersion copper deposit forming in the acid dip. Is copper or brass run in the line? How about exposed copper on racks or rack tips? Apply Rules Three, Four and Five. Can you eliminate this as a cause?

3. Dry down of cleaners during transfer. Apply Rule Four. Can you spot the problem?

4. Oil or grease under a metallic smut. This will appear as a water-break after the acid. Apply Rule Four. Can you spot anything?

5. Too much soap in the cleaners. Are you removing buffing compound? Apply Rule Five. How long since the cleaners were changed?

Have you solved the problem? Assemble your notes and analyze. Do you need more information? What other rules should you apply? How about Rule Seven—what is the history of the part? Is there a light rust on the part that would leave a haze when removed?

Chances are that by now you have solved it.

These three problems not only illustrate the way the rules can be applied to satisfy Rule Two, but also emphasize the point made in the Foreword that the troubleshooting "pro" has a mental file of numerous guiding pieces of information. Notice the ones that have appeared in just these three examples: nickel peeling from nickel can be caused by too much brightener or by a make and break contact; blisters on die castings can be caused by diffusion of copper into the zinc; where this diffusion occurs, the zinc under the blister will have a characteristic "pebbly" appearance; this copper/zinc diffusion can be caused by an immersion copper deposit; it will be accentuated by heating; etc.

How do you get this information? Talk—read—listen.

Talk—to the people who have lots of experience; to suppliers who know the characteristics of their solutions; to anyone who can teach you about metallurgy, or chemistry, or electrochemistry, etc., etc., etc. Ask questions about anything that you don't understand.

Read—books about plating, journals, operating bulletins on solutions (many of which contain troubleshooting charts), books on related subjects—chemistry, physics, electricity, in fact, almost any science.

Listen—to lectures at technical meetings; platers talking over their problems; troubleshooters describing their experiences. Think about what you hear—build mental models to explain what is happening.

Our three examples clearly illustrate the way the various rules can be applied to define the problem. Notice too, that as mentioned in the beginning, once the problem is properly defined, the answer is usually obvious. Since it is also apparent that there is a wide variability in what rules have to be applied, and the sequence in which they must be used, no precise step-by-step procedure can be set up. The ability to select the proper rule and sequence has to be learned by practice. How can you obtain the practice necessary? The average plating room does not have problems every hour, or even every day. (At least one would hope not.)

There are four ways to increase your know how.

First: On those problems that you do encounter, make a sincere effort to apply the rules and find the answer before calling for a "pro" troubleshooter's help. Keep notes on how you proceed. If you are successful, review your notes with a critical eye. Could you have applied the rules in a different sequence? Would it have helped or sped the analysis? Was there information you should have remembered or looked up?

If you are not successful and have to call for help, get the "pro" to go over your notes and make suggestions as to how you can improve your technique.

Second: Anyone who has been in the plating field for any length of time has solved some problems and is aware of "mysteries" that other people have solved. Review these to find out how it was done. Did you actually use some of the rules before you knew they existed? Could you have solved it more quickly if you had known the rules? What rules would you use now, and in what sequence would you use them?

Third: Talk to other people at meetings and technical sessions. Try to use their problems as practice for yourself.

Finally: Play the game of "What if. . . ." Pose yourself a problem. Then apply the rules and work toward a solution. Vary the conditions to make it more complex.

The "pro" does this all the time. On his way to the problem, he will set up a "battle plan" (probably unconsciously). He would probably think about it a while and then outline it like this:

This symptom is caused by A, or B, or C.

If A, I will probably find conditions D, E or F. I will then need information d, e or f. The cure will then be . . .

If B, I will etc., etc.

If C, etc., etc.

He then walks in, looks at some parts, checks a few other things, and quickly (sometimes) provides a solution. It looks like "black magic," but it is really just proper application of the troubleshooting rules plus plenty of practice.

You can teach yourself to do it too!

Rule Three

Obey the Letter of the Law

Over three thousand years ago, almost at the dawn of recorded history, before the Greeks and the Romans thought of becoming civilized, much of the land around the Arabian Gulf was the subject of dispute by two tribes, the Medes and the Persians. (The dispute still goes on but the names have been changed.) A great and powerful king finally laid down a series of immutable laws, and the punishments appropriate for violations. These laws governed the relations between the two tribes, and peace reigned for a considerable period, until someone decided that these "Laws of the Medes and the Persians" were too complicated and difficult to administer; so they fell into disuse. Shortly thereafter war again broke out, and as far as anyone can tell, has continued ever since.

Ninety pct of the trouble in a plating room occurs the same way. Someone decides that the proper conditions are too difficult to maintain, or remember; or they are not properly recorded, so they are allowed to drift to new values over a period of time. Days or weeks may go by with no problem rearing its ugly head. But one day, the sum of all the neglect reaches critical mass—and the roof falls in.

A case in point: A large automatic nickel chrome machine depended for complete insulation between arms on some circular insulators that kept the arms insulated from the main frame. It had been routine to check these insulators once a month and replace any that were cracked or broken. One day, the machine began producing an unacceptable number of rejects. The pattern seemed to be connected with the particular arms involved. Checking showed that enough bushings had cracked and fallen out that shorts were occurring between the reverse-current cleaner and one of the stations in the nickel tank. When were the bushings checked last? Nobody knew. When did they stop checking them? Nobody knew. The had forgotten The Law.

To compound the problem, many people feel deeply that the old bromide "when all else fails, read the instructions," should be taken literally. They never read them—or if they did, they didn't believe them. Some sample conversations between a caller (C) and a troubleshooter (T):

- C: My cleaner isn't rinsing right.
  T: What's the concentration?
  C: 16 oz/gal.
  T: It's supposed to be 8 oz/gal.
  C: But I always run my cleaners at 16 oz/gal.

- C: Your cleaner isn't working.
  T: What's the concentration?
  C: It's gotta be O.K. I put in a whole drum.
  T: How big is the tank?
  C: I don't know, but I always put in a whole drum and then I don't have to add anything for six weeks.

- C: Your bright nickel is lousy; it won't plate bright and it's brittle as ______!!!
  T: What's the pH?
  C: I haven't sent a sample out for test yet.
  T: Don't you test it yourself—with pH papers or something?
  C: That's what you guys are for.

If you think these examples are exaggerated, ask any troubleshooter. He'll be glad to play "I can top that."

Home assembly kits for TVs, stereos, furniture, clocks, etc. are popular and successful, at least for the people who pay attention to the warning *do not attempt to assemble this* (whatever it is) *until you have read the instructions completely* printed in several conspicuous places on the boxes containing the components.

Why won't platers do the same? Possibly it is because they have plated nickel, or copper, or chromium before and fail to realize that this new and better solution is just a little bit more sensitive, or requires slightly different conditions than those they have used before.

But as we improve technology, we have to realize that tighter controls are necessary if we are to benefit from the improvements. The old Watts nickel was a very forgiving bath; but it did not plate bright, and its current densities were limited.

The high cyanide zinc baths were cleaners in themselves, and could tolerate huge amounts of contamination. One bath that contained 22 pct by volume of emulsified oil was still giving acceptable results. But the low cyanide baths required for waste control do not tolerate that kind of abuse. A sliding conversion to a low cyanide formula was carried out on the contaminated bath just described. When the cyanide dropped to a critical level, rejects suddenly soared. And nobody could understand why!

Generally speaking, operating instructions are prepared by technical people who are thoroughly familiar with the product. Since they are interested in enhancing the reputation of the product (and incidently reducing the demands on their time for service and problem solving) they try to be as complete and clear as they can. As new information is obtained from additional research, or from field experience, the instructions are revised and updated.

Platers, like kit builders, should never start to use a product without completely familiarizing themselves with the instructions. Perhaps plating supply houses should stencil that notice previously quoted on every drum sent out.

But being familiar with the instructions is not enough. The special conditions of use that satisfy your needs must be known, and recorded. Does the material work best for you when used at the "normal" concentration, or is it necessary for you to increase concentration? One job shop I know of uses the same cleaner in seven different automatic machines. But the conditions are different in each machine!

The importance of having conditions recorded properly is emphasized by the experience of a large plant. The plating room covered the top floor of seven buildings—roughly 35,000 sq ft—and was extremely diversified. There were about 150 workers involved. Without notice the foreman left. An experienced supervisor, who had no plating experience or knowledge of chemistry was made foreman. Within a day or two he put in a request for a "bible." When questioned, he explained that he knew nothing about plating, and really didn't want to learn. He needed a complete listing, tank by tank, line by line, of the proper operating conditions. It took a week of concentrated effort, but the list was finally compiled. Thereafter, when trouble was reported on a line, he would take "bible" in hand and methodically check every tank on the line, method of operation, and procedures. If anything was found off standard, it would be corrected. In 90 pct of the cases, that ended the trouble and operations went back to normal.

Admitting the value of this procedure, how do you prepare your own "bible?" There are two basic techniques:

1. By line. This is recommended for high-volume production lines where a variety of parts have to be run under the same conditions. List every tank in the line, including rinses. Next to each tank, list all the conditions, including solution used; concentration; temperature; voltage and amperage if current is used; dwell time; allowable deviations for any condition, e.g., temp. 140-150F, optimum 145F; expected bath life; allowable contaminants, and their limits. For rinses, record temperature, flow rate, and normal appearance of the rinse.

2. By part. This is recommended for low-volume, specialized parts requiring different treatment sequences. List every step required to finish the part, including rinses. Opposite each step, list the particular tank to be used and all the conditions that had to be listed above.

Remember that a "bible" like this is good only if it is kept completely updated. Any time a process or condition is changed, the record must be changed also.

How do you use it? When trouble is reported, take the "bible," and tank-by-tank check to insure that all the proper conditions exist. If any deviations outside the allowable range are found, correct them.

What happens if you do all this and the problem continues? After all, this works in about 90 pct of the cases, but in the other 10 pct, the problem persists. Obviously, you will either call for help, or start one of the other procedures listed and explained under the other rules that follow. But you will not have wasted your time. If you call for help, the troubleshooter you call is going to have you do exactly what you have just done. If you go it alone, the rules that follow presume that you have already carried out this step. By starting this procedure immediately, you may very well solve the problem quickly.

In metal products finishing, there is very little black and white, but a great deal of gray. The trick is to know the landmarks that will guide you through the fog.

Rule Four

Walk the Line

Walking the processing line is an important troubleshooting technique. It serves three functions: first, it acquaints you with the line so that when trouble strikes you can look for possible differences; second, it enables you to correct problems before they occur; third, it helps to pinpoint the troublesome area when a problem does occur. Its effectiveness, however, will be dependent on how well you have prepared yourself to use it. Furthermore, it is an area where, if you have prepared yourself properly, you will have a distinct advantage over any troubleshooter you call in to help. As a matter of fact, as we will emphasize later, an observant operator will have a still greater advantage. The edge lies in really knowing the line.

So Corollary No. 1 for this rule is *don't just walk the line when it is in trouble; walk it when it is running properly.* If you don't know what it looks like when everything is right, how can you tell when something is wrong? And talk to the operator. Because the operator works the line every day, all day, if he is observant, he will know the line far better than you can ever know it. He may not know what is wrong or how to correct it, but he may be able to point out what is different than it was when the line was operating properly.

At one time, we were struggling with a problem of pitted nickel. Everything on the line looked normal. Analysis of the nickel showed values well within tolerance. There was no abnormal change over several analyses. Surface tension measurements indicated the proper level of anti-pitting agent. A sample of solution in a beaker was crystal clear, so the filter was working properly.

It was head-scratching time. Fortunately, it was also coffee break time—so we took the operator to the canteen and bought him coffee and danish. As we munched away, we asked if he noticed anything different. He hemmed and hawed, didn't really know, but "when I take a rack out, there's no bubble."

More questioning revealed what he meant. When he lifted the rack out of the plating tank, it was usually completely enveloped by a bubble of solution, which broke before he got the rack to the rinse tank. Now there was no bubble.

A detailed check showed that because of an ordering problem, it had been necessary to use a non-pitter from a different nickel solution for a few days. But nobody had made a record of the change. An addition of the right non-pitter cured the problem. But it was the operator's observation that supplied the clue.

Now that you've decided to walk the line, how do you do it? Slowly and carefully. Don't rush. Remember, the object is to memorize how it looks, how the parts look, possible areas of trouble, signs of maintenance problems where neglect can lead to trouble. In short, everything. *Don't miss anything.*

For example, consider a recent unbelievable but verified case. A young engineer who had taken this rule to heart walked the line daily before production started. When he was especially rushed, he accepted the offer of a group leader to do the walk for him. An hour later he received a panic call: 100 pct rejects. Obviously it was a cleaning problem. He rushed out to the line and found everything was fine except that there was no solution in the cleaner tank.

Keep in mind that lighting can be a problem in many plating rooms, particularly with automatics that are placed close to a wall, or have the light obscured by overhead exhaust ducts. So take a good flashlight, or a floodlight on an extension. Tanks on automatics can be high, and often semi-hidden by exhaust plenums. Simple ladders permanently fixed in strategic places will enable you to climb up safely for a better view.

Now start tank by tank. What you look for depends on the solution. Let's do a couple of tanks as examples to show what's needed.

Consider soak cleaning tanks. What's the color of the solution? Is oil floating on top? How much? What color? Where? Is there foam? What color? How much? What's the solution temperature? How does the cleaner drain off the parts? Is there any drying during transfer? What do the parts look like? Is there any water break? Any oil still on the parts? Is there a rinse following? What's the flow rate? Is the dam overflow working properly? Is there air agitation? How much? How distributed? When a rack goes in does the foam and/or oil release into the water quickly? Does it clear off the top of the tank before the rack comes out? Is there any precipitate in the rinse? Is it cloudy or clear?

Or look at electrocleaner tanks. All of the above must be considered. Then look at what voltage is being used. Amperage? How quickly does the foam build up once the current is applied? Are there signs of oil in the foam? Smut? Any sign of smut on the parts? Are the high-current-density areas O.K.? Any discoloration of the parts? Are the anodes and anode bars clean? Are the insulators O.K.?

Got the idea? Now go over the rest of the line the same way. Don't forget the auxiliary equipment. Filters, ductwork, rectifiers, timers.

Two horrible memories occasionally plague me—both failures of observation. I once failed to notice that the valves on a filter had been improperly set, and 500 gallons of cadmium solution were pumped down the drain before being noticed.

In the second case, a missing drain plug on a chromium exhaust duct went unnoticed. The drain happened to be over a nickel tank. When the maintenance men washed out the duct, all the chromium washings went into the nickel tank. The chromium contamination was unbelievable. It took a whole week to get the tank back into production.

Don't limit yourself to the immediate area. Go afield into the surrounding areas. Consider these examples:

A plater had periodic hazing problems with nickel plating. They would appear without apparent reason, and disappear just as mysteriously. After much study, it appeared that the problem was related to changing weather. Finally, the problem was found. The intake for the air agitation blower was on the roof, not too distant from the exhaust for the bright dipping operation. When the weather was just right, the nitric oxide fumes would drift along the roof and be sucked into the blower, thus introducing nitrites into the nickel bath. When the weather cleared up, so did the problem.

A similar case occurred to cause roughness in a bright acid copper. The blower was near a door to an unpaved parking lot. When the door was open during the summer and an operator left the filter off the air intake, dust was pumped into the tank.

One company used a silicone aerosol mold lubricant while molding polystyrene. Due to exhaust fans in the plating room, air was pulled 150 feet from the molding machine to the plating machine. Result: pitting and skip plating.

When conditions like these are encountered during your walk around, they should be corrected before trouble strikes. At the very least, if they can't be corrected, they should be mentally filed for consideration as possible causes when trouble does occur.

While you're walking, take time to make friends with the operator. This will not only save on your clothing bill (unfriendly operators have a tendency to splash solution on people they don't like) but will make him (or her) an excellent source of information. A friendly operator will often give you advance warning that something seems to be going wrong. If you really make friends with him, he can be a tremendous help by providing this information and the clues mentioned before. If he's hostile, he can hide information just as effectively.

Now you've done all this. You've memorized the line; checked the surrounding areas; made friends with the operator. How do you use Rule Four?

Very simply. When trouble hits, take another walk. But this time look for differences between existing conditions and your memory of the line. Is there more oil in the soak tank? Are the rinses dirty instead of clean? Is there smut on the foam of the electrocleaner? Are parts drying during transfer? The differences you find may be the cause of the problem. At the very least they are clues.

One final example is worth noting. While touring the plating room at an electronics facility, I noted that the aluminum plating line had a peculiar arrangement. The rinse tank after silver plating was on the opposite side of the aisle, in back of the operator. When he took a rack out of the silver tank he was supposed to turn to his left to get to the rinse tank. If he turned to his right he had to carry the rack over the zincate tank to get to the rinse.

Some time later a call was received from the foreman—he was having trouble with blistering on his aluminum line. The conversation went like this:

F: I'm having blistering on my aluminum line.

T: Are you plating now?

F: Yes.

T: Can you see the line from your office window?

F: Yes.

T: When the operator takes a rack out of the silver tank is he turning left or right to get to the rinse?

F: (after a pause) Right.

T: Your zincate is contaminated with silver and that's what's causing the blistering. Make a new zincate, and either move the rinse tank or make sure the operator always turns to his left.

See—it's easy. You can do it too!

Rule Five

Look at the Record

Records and record keeping have been the subject of extended discussion. In part this is because it is hard to get agreement on what is adequate record keeping; and in part because records, once set up, unlike generals, do not fade away. A simple listing of rejects set up for a specific short term purpose, may surface years later as a file cabinet full of unread reports, because no one issued a stop order.

Because records and record keeping cost money and are nonproductive functions, good managers take a hard line approach when it comes to setting up record keeping systems. But for the proper operation of a plating room, and finding the cause of trouble when it occurs, some records are essential. We have already discussed the development and proper maintenance of a "bible." What other records should be kept? Let's break them down into categories, and discuss their purpose, extent, and what can be learned from examining them carefully.

1. Analytical. The results of a single analysis rarely give enough information about a solution to permit valid conclusions to be drawn. Variations in solution level, work throughput, and analytical technique can easily produce deviations of

5 to 10 pct from standard values. While normal deviations will be much less than this, one to two pct perhaps, the larger swings can occur. To draw any valid conclusions, the current analysis has to be compared with several previous results. Or perhaps it should be repeated under more carefully controlled conditions to determine that the deviation from the normal pattern is indeed a valid deviation, and not an error in sampling or analytical technique. Figure 1 shows a form that is easily maintained and yet contains all the necessary information. Changes in pattern can be recognized very easily since the previous results are available.

2. Material consumption. Additions to the tank can provide important information, but only when compared with normal additions. In order to determine what constitutes normal, some record of additions is required. There should also be some form of record, or a system of checks, to insure that the recommended additions have been made; or if they have not been made, why not. Otherwise the next analysis may not make sense. Or even worse, may indicate a problem where none exists.

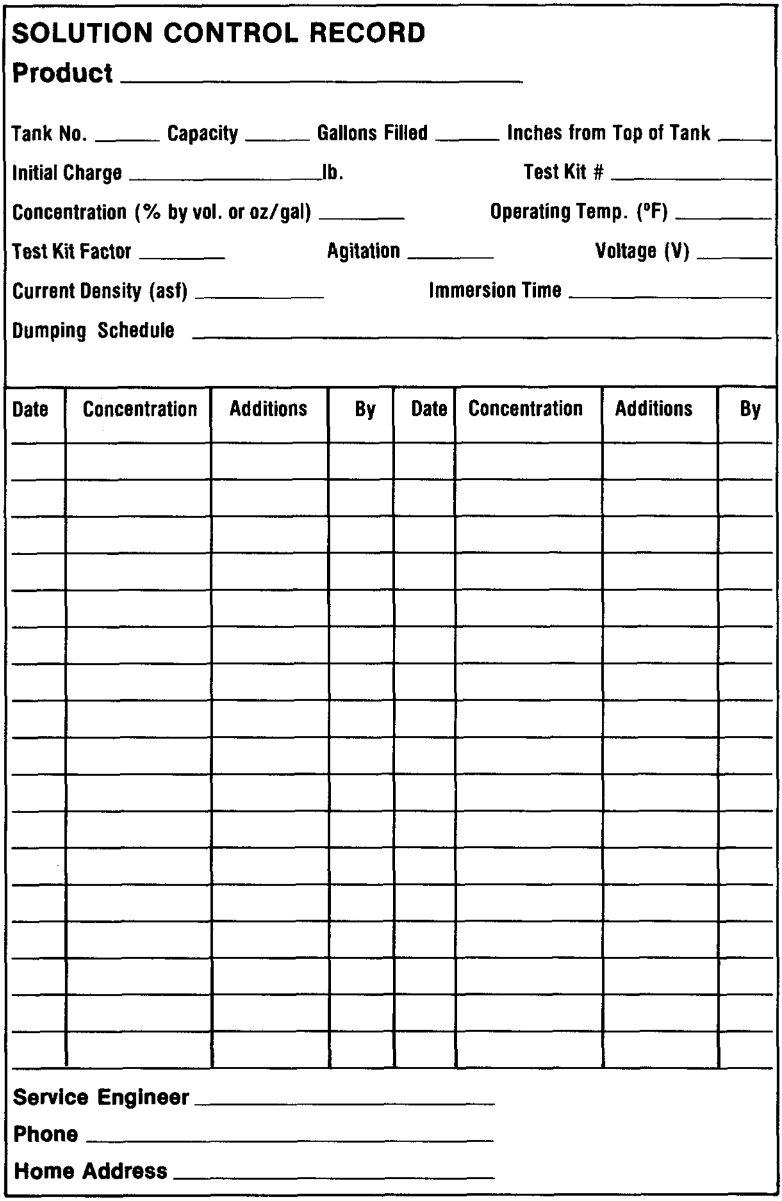
3. Rejection rates. These provide base line information to be compared with that during a trouble period. Since trends in rejection rates can often be used to predict and thereby prevent trouble, some minimum record of reject rates should be kept. Consider also that small, gradual increases in reject rates often go unnoticed. Yet these same gradual increases signal trouble. If they are noticed and investigated while still small, the problem, waiting to explode like a time bomb, can often be located and defused before it goes off.

What can be read from these records? Consider a few hypothetical cases.

Case No. 1: alkaline descaler. A study of analytical records and replenishment records showed a gradual increase in the additions required to maintain the concentration as the bath aged. The conclusion was drawn that dissolved iron was increasing the viscosity of the bath and thereby increasing dragout. The dump schedule of the solution was changed to optimize consumption based on these records. The yearly material saving was $13,000.

Case No. 2: nickel tank. The analytical record showed that nickel metal was being depleted more rapidly than normally. At the same time, brightener consumption was increased, and less than normal amounts of acid were being used to maintain the proper pH. It was decided that some of the anodes were

Fig. 1—Typical Form to Record Solution Control



SOLUTION CONTROL RECORD

Product ____________________

Tank No. ______ Capacity ______ Gallons Filled ______ Inches from Top of Tank ______

Initial Charge ______________ lb. Test Kit # ______________

Concentration (% by vol. or oz/gal) ________ Operating Temp. (°F) ________

Test Kit Factor ________ Agitation ________ Voltage (V) ______

Current Density (asf) ____________ Immersion Time ______________

Dumping Schedule ______________________________

Date	Concentration	Additions	By	Date	Concentration	Additions	By

Service Engineer ____________________

Phone ____________________

Home Address ____________________

badly polarized. Thorough examination of the tank showed that the connection to one section of the bus bar had become insulated with corrosion products so that the anodes were not drawing current. This threw an excessive load on the other anodes, resulting in their becoming polarized. The chlorine and oxygen generated had oxidized brightener; the polarization prevented proper solution of the anodes and caused the drop in nickel content. Continued operation in this condition would have resulted in expensive additions of nickel salts, brightener imbalance, and organic contamination from oxidized brightener, requiring carbon treatment. The problem was remedied before it became serious.

We could continue piling example on top of example, but these should suffice to establish that good records *properly interpreted* can be of tremendous help.

How do you avoid overkill? By proper application of reasonable limits. For example, how often should a bath be analyzed? There are two principles to be considered. The first of these was mentioned earlier: normal variations in analytical technique will produce variations of one to two pct with occasional runouts of five to 10 pct if someone gets careless. Therefore if under normal conditions, the additions called for are normally less than five pct of bath makeup, the analysis is being performed too frequently. At the other end of the scale, additions that are too large can upset the equilibrium of the bath. Hence the rule of thumb "never shock the bath." Therefore, if the additions called for are regularly over 10 pct of the bath makeup, the analysis should be performed more often.

Is there any way to reduce the number of analyses and still stay within these limits? Sometimes. If consumption is fairly regular; that is if production is fairly uniform and parts are relatively similar in drag out characteristics, the required additions should be fairly uniform. If this is the case, daily or more frequent additions can be made without benefit of analysis, and the analysis made at less frequent intervals to determine how well the regular addition is maintaining the bath. If the analysis shows that the bath is slightly overconcentrated, the regular addition can be reduced. If a supplemental addition is needed, the regular addition can be increased. In this way very large, high production, automatic plating machines are very successfully operated with only one analysis a week. It cannot be done in every case, but where it is successful, it materially cuts down on the analytical load.

Some constituents in plating baths are not consumed but are lost only by dragout. Such is the case with boric acid in a nickel bath. Where there is another ingredient which also satisfies this condition, such as chloride in a nickel bath, the two can be linked together, and only one analysis performed. In this case, the chloride would be analyzed, and when chloride had to be replenished, boric acid would also be replenished in the same ratio as the original makeup of the tank. In this way, the analysis for boric acid need only be made at much longer intervals, reducing the analytical load.

For brighteners in particular, uniform additions are important for maintaining consistent results. The use of ampere hour meters to regulate brightener additions often yields savings in brightener consumption as well as more consistent results. One large job shop calculated that brightener savings repaid the cost of automatic brightener feeding equipment in a three-month period.

There is one other set of records that should be prepared. That is the plating test cell library.

One of the greatest control and troubleshooting tools is the plating test cell: the Hull Cell, or whatever alternative is preferred for the bath in question. But a period of trouble is no time to start learning how to read the test cell results. Therefore as soon as a new type of solution or brightener system is installed, a test cell library should be made up and filed for reference purposes.

This should include panels showing the bath with no addition agents, with proper brightener levels, and with all the various contaminants you think probable or possible. Plates run with variations in brightener balance, metal content, or concentration of other ingredients, at various pH values, and so on, can also be very helpful. These should be filed in envelopes showing the date prepared and the conditions the plate illustrates carefully marked on the outside of the envelope.

It is also helpful to number the back of the panel and put the same number on the envelope. It is all too easy to mismatch the panels and the envelopes after examining a series of panels while trying to solve a problem. And you can imagine the confusion that would cause at a later date!

Panels for solutions such as copper, brass, and non-chromated zinc and cadmium should be lacquered to preserve their appearance. This makes it a little harder to evaluate and compare panels, but the longer life is worth it.

If you're a photography bug, or if you know someone who is, you can make your record photographic. Special techniques have to be used, however, since any bright metal will usually photograph black and without detail. Use somewhat diffuse lighting and mount a piece of screen at a 45-degree angle over the panel. Photograph the reflection of the screen in the panel and you will be able to see the condition of the plate. All the information you would normally put on the storage envelopes mentioned above should be written on the back of the print.

It is also good practice to run a plating test panel each time an analysis is run and record the observations along with the analysis. Similarly, after deciding on the required additions and adjustments, the solution sample should be corrected and another test panel run to determine if the correction has been successful.

A typical report and recommendation might then read as follows:

	Analysis (oz/gal)	**Standard**
Nickel metal	11.4	—
Nickel chloride	12.2	12.0
Nickel sulfate	37.6	40.0
Boric acid	6.3	6.0
pH	4.4	4.2
Brightener	O.K.	—

Test cell panel shows metallic contamination in LCD area; slight trace of pitting, and slight organic contamination.

1. Dummy at two to five asf for 500 amp-hr with carbon filtration.
2. Adjust pH to 4.2 and maintain.
3. Add two fl oz of non-pitter.

Test cell panel O.K. after adjustment.

When trouble strikes, how do you use this information? Review the last several analytical reports. Have the adjustments been carried out properly? Do the analyses show a trend that would indicate a particular problem? How does the current analysis and test panel compare with the record? If there is a defect visible in the panel, does it match what's happening on the parts?

When you have answered all these questions, you will probably be able to give the plating solution a clean bill of health or make adjustments and evaluate the effect on the problem. In either case, you will be closer to finding the proper answer.

All records and record keeping systems should be reexamined at intervals of six months to a year. Ask these questions in each case:

1. Is this record worth keeping? How often have I used it in the past six months or one year? If I got in trouble, would I need it?

2. How extensive a file of the record do I need? Should I retain results back three months, six months or one year?

3. Does it really tell me what I what to know? Can I get the information quickly? Can it be presented in a more readily or quickly understood form? Can the information be graphed easily? (Trends especially can be more quickly spotted in graphic form.)

4. Is there other information I need? Can it be incorporated in the present report? Or does it need a special report?

Be firm and even hard hearted. Excess records not only cost money, they make information hard to find.

When you go to look at the record, make sure that you can see it!

Rule Six

Get the Facts

In the popular television series "Dragnet," Sargeant Friday had a well known line, "All I want is the facts, Ma'am." Frequently the troubleshooter's lament sounds remarkably similar. "Could I get the facts, P-L-E-A-S-E." Eavesdrop with me on a conversation:

Plater: Look at all the rejects I'm getting!

Troubleshooter: How many do you usually get?

Plater: I don't know—but not this many!

Proper record keeping would help a lot (see Rule Five). You have to know where you were in order to know where you're going.

Let's eavesdrop again!

T.S. What have you done so far?

Plater: Well, we changed the cleaners, raised the pH in the nickel, added inhibitor to the acid, and a few other things.

T.S. What happened?

Plater: We still got rejects—look!

T.S.: Yeah, but which ones are which? Which parts were run after each change?

Plater: Aw, sorry about that; they're kinda mixed up.

Back to square one. The troubleshooter now has to examine everything, see if he can sort the rejects into groups, and figure out if the changes have had any effect. How much time could have been saved if all the samples were properly grouped and marked (see Rule Eight)?

Back to eavesdropping:

T.S.: How many rejects do you have?

Plater: 10 to 15 pct.

T.S.: All a result of blistering (or hazing or whatever the problem is)?

Plater: Naw, some are from polishing, or bad holes or other reasons.

T.S.: But how many are from blistering?

Plater: I don't know—I haven't separated them.

Back to square one again. The troubleshooter has to sort the rejects and determine how many are actually due to the problem.

Once more with the big ear:

T.S.: This part looks pretty good. How come it's rejected?

Inspector: See that little spot?

T.S.: Boy, that's a tough standard. Do you always call them that close?

Inspector: Nope, but all the wheels are breathing down our necks today so we're being extra careful.

Can we draw some guidelines to overcome some of these problems? Certainly.

First: Get an accurate record of the number of rejects from each cause. It is also important to record the way rejects occur. For example, a 10 pct reject rate could mean that 10 pct of the parts on each rack are rejected; or it could mean that one rack out of every 10 is rejected completely. These two different rates of reject occurrence still represent a 10 pct rejection rate, but are indicative of two entirely different problems. This type of information is also needed when the time comes to decide how many parts must be run to determine if any change actually produces an improvement. It will also be helpful when you apply Rule Seven—"*Look for the Pattern.*"

But, back to the number of rejects for each cause. How do these numbers compare with normal rejects (Rule Five—*Look at the Record)? Is the difference significant? Has it been a gradual increase or a sudden development? If sudden, can you pin down exactly when it started?*

Do the numbers for more than one type of reject meet these criteria? In other words, are you dealing with more than one problem? Or more than one manifestation of the same problem?

Second: When test samples are run after any change, make sure that they are kept separate and properly tagged so that the effect of the change can be evaluated accurately. Equally important, make sure that the parts used for the test are from the same lot or in the same condition as the parts causing the problem. I once missed badly on a problem because the parts used to test the effect of a change were made from a different coil of steel than the ones causing the problem.

The test showed the complete elimination of the trouble. So did a rerun. I happily got in the car and started home, congratulating myself all the way. Four hours later as I walked in the door, I was greeted with the news that the trouble was back again, as bad as ever.

The ride back to the plant wasn't half as cheerful. I kept consoling myself with the fact that I had at least found out that the problem was somehow associated with differences in the coils of steel.

Third: Make sure that the standards haven't changed. It is a natural psychological reaction for inspectors to tighten the standards when attention is focused on a problem. They know that management is watching. People are waiting for their decision. They can feel the tension.

They unconsciously slow down and look more carefully at every piece. They are subconsciously afraid that they may be accused of not doing their job properly. Anything requiring a decision or anything even slightly marginal is going to have the decision go against it. The standards tighten up, and the reject rate is skewed out of line.

This is a tough situation to overcome and there are no firm rules for combatting it. If there are retained acceptable quality standards to be used for comparison, it helps. It sometimes helps to have a salvage inspector or a supervisory inspector (if the plant is large enough to have such a set-up) reinspect the rejects.

Sometimes having a final assembly inspector or even someone from the sales force to do the reinspection will bring the standards back to normal. (On second thought, not the sales force—they always want jewelry.) But one way or another, it has to be done.

Finally: How many pieces do you need for a test? That depends on how the rejects are distributed. As a rough rule of thumb, you need twice as many units as describe the rejection rate. For example, if five pieces on each rack are bad, you will need at least two racks with less than five rejects per rack to show improvement. If every other rack is bad, you will need at least four good racks. If 10 pct of the parts are bad but not distributed uniformly on the racks, you will need 20 racks to make a judgement. And so on. It may take a lot of parts to prove a point.

Also it is important to remember that when the sample parts are run, the loading of the machine or tank or barrels has to conform to the normal work load or the problem may not manifest itself.

For example, two racks plated in a tank that normally holds six racks may come out O.K.; but six racks might not. The opposite could also be true. This type of occurrence can be an important clue as to the source of the problem, but it will not tell you if you have solved it.

This emphasizes the need previously spelled out of having a good record of the rejection rate. Only if this is true can you select the number of units to test a result.

One other danger: opinions or misinterpreted information are sometimes presented as fact. If you accept these as presented, you will be led astray. If you question them, or check them for yourself, you may commit a tactical error and alienate a boss or a customer. But you have to do it. You have to have facts that you can rely on. So damn the torpedoes and full speed ahead!

Get the facts!

Rule Seven

Look for the Pattern

What constitutes a pattern? A pattern is any continually repeating occurrence. It may be a matter of position, time, or spacing. It may be readily apparent or difficult to find.

Patterns almost always point the way to the solution because they call attention to the nature or location of the problem. Sometimes it requires a great deal of background information to be able to recognize the pattern. As is so often the case with plating, patterns are so complex and varied that they can best be explained by examples. It helps even further to group them by types.

Patterns of Position

1. The leading edge of every rack shows a haze or a burn.
2. The bottom row of every rack shows burning.
3. Any flat horizontal surface on a part (shelf) shows roughness.
4. The inside center parts on a rack show lack of coverage.
5. Barrel plated parts show areas of poor coverage that can be matched to show sticking or overlapping.

Patterns of Time

6. An electroless nickel bath decomposes every day at 10:10 A.M. and 3:10 P.M.

7. Every Monday, for the first hour, the two bottom rows on the racks show burning.

8. At the start of every shift and after every shut down (coffee breaks, lunch), several racks show poor coverage in the chromium.

9. Delayed blistering (three to five days after plating) is encountered on cadmium plated high alloy steel. Investigation shows that all blistered parts are plated on the night shift.

Patterns of Spacing

10. Periodically, a rack comes off the machine showing laminated nickel.

11. Periodically, a barrel load shows unusually low plate thickness.

Answers

To show how these patterns point the way to the solution, look at the answers to these problems.

1. The machine was checked for points where only the leading edge of the rack would be affected. As the rack entered the nickel tank, it started to plate. But when it began to move to the next position, there was a period of about 10 seconds when contact was broken. During this time, the rack went bipolar, causing the leading edge to become anodic. Eliminating the break in contact cleared up the problem.

2. Checking the racks showed that they were shorter than normal. As a result, the anodes extended below the bottom of the racks—a situation that can lead to burning of the bottom row of parts. Altering the rack configuration stopped the burning.

3. A ripped anode bag was found. It was replaced, and as the filter removed the particles that had been released, the shelf roughness gradually disappeared.

4. A check with an ohmmeter showed that the cross pieces of the rack had inadequate current carrying capacity.

5. The size of the load was reduced to allow more movement. Problem ended.

6. The operator normally agitated the work in the tank

periodically. At 10:00 and 3:00 he took his coffee break—and did not agitate the load. Localized depletion and overheating caused decomposition. Leaving the tank empty when he took his coffee break stopped the problem.

7. Temperature measurements showed that the tank was not uniformly heated. Increased agitation while heating the solution got rid of the problem.

8. Analysis of the incoming water showed that there was a higher than normal chlorine content. Until enough organics in the form of dragged in brightener were introduced, the excess chlorine caused passivation of the nickel and poor coverage. A few ounces of a dilute brightener solution were added to the rinse just before starting up and the problem was solved.

9. The cycle included a direct electrocleaner and a direct caustic-cyanide smut remover. Investigation showed that the night foreman was turning up the rectifier voltage on these two tanks to get "better cleaning." He also got increased hydrogen absorption, which led to the delayed blistering action. Keeping the voltage at the right value eliminated the problem.

10. Careful checking of the machine showed that there was a low spot on the current pick-up bar. Some arms on the machine had worn pick-up shoes. When these arms reached the low spot, they lost contact and plating stopped. When they moved on, plating started again, but the damage had been done.

11. Checking showed that it was always the same barrel that gave the poor results. When this was checked, a broken dangler cable hidden by the plastic insulating cover was located. Replacing this cable eliminated the problem.

These examples are fairly straightforward. Sometimes the pattern exists and can be identified but additional information is needed in order to recognize the meaning of the pattern and what the solution will be. Consider the following problems, oddly enough all involving silver plating.

Silver plating. After a weekend shut down, silver plated parts suddenly began showing oddly shaped bare spots. Careful investigation of the cleaning line led nowhere. A closer examination of every tank in the line revealed algae growing on the liner of the rinse tank following the acid and immediately ahead of the silver strike.

A biology book provided the information that algae are high in protein, that the algal cell wall breaks down rapidly in alkali, and that protein can form a slimy gel in alkaline solution.

Scrubbing and cleaning the tank eliminated the problem. Algae broken loose during the rinsing step were clinging to the parts, being broken down and converted to a gel in the strike and preventing plating.

Sticky bearing races. Stainless steel bearing races were being given a Woods nickel strike, heavy silver plate, and high-temperature heat treatment. After about a week of operation, the parts would begin to stick together during heat treatment. Making a new Woods strike would eliminate the problem for another period.

It is a known fact that a Woods strike, unless carefully watched, will build up nickel metal with use. A metallurgical handbook listed a low-nickel silver alloy that melted at a temperature lower than the melting point of pure silver. From these two facts was drawn a theory: as the strike aged and nickel concentration increased, the amount of nickel deposited also increased. During the heat treatment, nickel diffused into the silver to form an alloy, and when the amount of silver deposited was enough to form the low-melting alloy, sticking would occur. When the problem next occurred, the strike was analyzed and found to contain 10 oz/gal of nickel. A limit of eight oz/gal was set for the strike, and the problem has not occurred since.

In a similar case, carbon steel bearing races were given a nickel strike, heavy silver plate, and an unusually high-temperature heat treatment in a controlled-atmosphere furnace. Periodically, blistering would occur during heat treatment. When the blister was opened, the underlying nickel was noticeably darker. The metallurgical handbook yielded the information that at very high temperature silver is highly susceptible to oxygen penetration. Theory: the atmosphere in the furnace is not being controlled closely enough to insure that a reducing atmosphere is always present. Closer control of the atmosphere-generating equipment eliminated the problem.

As these examples show, even the best patterns can sometimes be poorly defined. It is important to remember that in troubleshooting there are very few pat answers, very little that is black and white. There is just a great deal of gray.

Like a ship's pilot navigating in fog, the troubleshooter must learn to pick out the markers that keep him in the right channel, on course to the solution.

Rule Eight

Look at the Parts

In order to explain this rule, it is necessary to break the discussion into two parts: one dealing with looking at the plated part, in essence analyzing the symptoms present to determine the nature of the problem; and the other dealing with looking at the part before plating to determine if the cause of the problem is ahead of the plating operation.

In explaining Rule Two—*Define the Problem,* we have already used three examples which illustrate how the plated part should be examined to help pinpoint the problem. Now let's try to lay down a general procedure that will guide our examination of the plated part. It is important to note that the information gathered in this way may actually be considered under one of the other rules as well, and where this is so, the connection will be pointed out.

First, gather a suitable number of rejected parts for examination. It is very hard to specify what a suitable number might be; it can range from four or five up to 100, or perhaps even more depending on the problem, the size of the part, the nature of the defect, and the frequency of occurrence.

If an error is to be made however, it is far better to err on the high side. You can always cut short the examination when you have decided that you have enough evidence. But it may not be so easy to gather suitably identifiable rejects if you do not have enough beforehand. This is especially true if corrective measures and changes have already started.

One problem I worked on was made unnecessarily complicated because only two of the rejects were still available to show the original condition. All the others had been run after there were changes made in the cycle. The problem was complicated even further by the fact that no one had tagged the rejects to show which ones had occurred after which changes. Which automatically leads us to the next point.

Second (Rule Six—Get the Facts), *identify the rejects clearly!* This identification should include when they were run, on which machine or line, any pertinent differences in operating conditions, equipment, and so on. If the information is available, lot numbers or sources of supply should also be shown.

In another case, the problem solution was delayed because no one could identify which rejects were original parts and which were from lots that had been stripped and replated.

Third, examine the parts carefully by visual, microscopic, or any other method required by the nature of the defect. At this stage you are seeking to determine the following points:

- Are all the rejects due to a common cause, or is there more than one problem involved?
- What is the actual rejection rate, and how is it distributed?
- If more than one cause is apparent, what are the respective rejection rates and how are they distributed?
- Are the rejection rates being affected by a change in the inspection standards due to the fact that the problem exists?

Marginally acceptable parts will often become rejects once a problem develops. (Remember the conversation with the inspector in Rule Six?) This often occurs even when the problem is a completely different one. Adjust your reject collection and reject percentages based on your evaluation of the situation.

All of this information should be collected and filed under either Rule Six—*Get the Facts*, or Rule Seven—*Look for the Pattern.*

Finally, make a list of all the possible causes for the various rejects you have found. (Remember Rule Two—*Define the Problem?)* Fit this information into what you have already found by following the other rules. Now begin checking all the possibilities.

On to part two: looking at the parts before plating.

First, when do you examine the unplated parts? Certainly if you have exhausted other possibilities. Definitely if the parts show a defect that could possibly be caused by a defect in the part.

For example, consider spotting out of brass plated zinc die castings. This suggests the possibility of porous castings. Therefore, if spotting out is the problem, the unplated castings should be checked. I personally prefer to do it automatically whenever parts are available. In addition to sometimes providing a quick shortcut to the solution, comparison of parts before and after gives added insight into the performance of the plating and/or pretreatment solutions.

Second, what do you look for? First of all, the obvious. Look for porosity, improper buffing or polishing, inclusions, cracks or unusual grain structure.

Secondly, look for the unusual or the out of place: embedded polishing or grinding compounds; unusual oxides or discolorations; corrosion products; and condition of the oil or other surface contamination. In short, anything that deviates from the normal condition.

Thirdly, check the history of the part—what machining operations were peformed? Were they changed in any way? How was it heat treated? Was heat treating changed in any way? Was the raw material purchased from the same source? Is the rust proofing compound the same? How old is the raw stock? (In one case the problem stemmed from stock stored excessively long because inventory was increased in anticipation of a steel strike. During the long storage, the rust proofing compound oxidized to a varnish like material.)

Third, don't necessarily be satisfied with "nothing has changed" as an answer. Dig deep. People are not always aware that changes have been made.

In one case the problem was finally traced to the fact that the supplier has changed the wetting agent content of a soluble oil and didn't tell the customer.

In another case, the night press operator had found that he could speed up the press and still get good work if he added hydraulic fluid to the forming oil. The parts were much harder to clean but he was beating the piece-work rate and making more money. Did he tell anyone?

In another case, parts barrel plated with copper had to be burnished. At times the copper was too hard to burnish properly. The solution was analyzed and reanalyzed. Brightener levels were checked and rechecked. The answer—the plating operator would sometimes be backlogged and would turn off the current, but not take the plating barrel out of the tank for an hour or more. This hour of rolling would work harden the copper and interfere with the subsequent burnishing.

Finally, are there pit falls to watch out for? Of course. There is the psychological pressure to put the blame on the parts rather than the process; to see what you want to see; to take the easy way out. But you must maintain your objectivity. Make sure that what you think you see is really there; make sure that it's being there can really cause the problem.

Let's look at some examples. First an easy one: cadmium plated screws were discoloring in the thread area two to four days after plating. The condition was very similar to spotting out of copper and brass.

Plating and rinsing procedures seemed good. Microscopic examination of the plated parts showed what appeared to be exfoliation and peeling of the plate. Microscopic examination of the parts before plating showed a similar condition in the original steel. Further digging revealed that the parts were roll threaded. Due to improper heat treatment, the roll threading operation caused delamination. A short sand rolling operation removed the delaminations and the rolled parts, when plated, no longer discolored. The heat treating procedure was corrected and the sand rolling operation could then be discontinued.

Now, a little tougher one: precision ground parts were being cadmium plated. Suddenly a very high rejection rate for blistering developed. After much investigation of the pretreatment cycles, microscopic examination showed green particles, later identified as abrasive, embedded in the steel. Repolishing the surface before plating eliminated the blistering problem. Eventually, the embedding of the particles was traced to an operator on the night shift who had found that he could make the rough and finish grinds without changing grinding wheels if he turned off the flow of coolant. Of course, without coolant he glazed the surface and left particles embedded in it—but he didn't have to change wheels.

Notice in reviewing these examples that there is always an interaction with one or more of the other rules. Let's rephrase what we said at the end of Rule Four:

It is not enough to look; you must also observe!

Rule Nine

Keep It Simple

Despite the fact that all too often we do not understand what's going on, the operation of natural phenomena is basically simple. A cause exists, a result follows. Furthermore, you cannot break the laws of nature—at least not and get away with it. What goes up must come down, and so on. As it says in the TV commerical, "It's not nice to fool Mother Nature." You can get zapped, and quickly too.

But you can sometimes manipulate the laws to your advantage. What goes up must come down—yet if you throw something high enough, fast enough, and in the right direction, it will go into orbit, and perhaps never come down. You've broken the law? Not so; it's coming down—but coming down in such a way that it is falling around the earth instead of back to the surface. You haven't broken the law—you have manipulated it to produce the result that you want.

When we set up a finishing line, there are literally hundreds of these cause and effect laws which are brought into operation—all at the same time—all interacting with each other. If something goes wrong, it is very easy, knowing the complexity of the total system, to start looking for a cause that is equally complex.

I recently had a problem with the electrical system of a foreign car. I traced the electrical diagram, checked fuses, checked relays, and so on. It finally dawned on me when I put my head under the dash that I was looking *up* at the fuse block, not *down* on it as in the diagram. The fuse I wanted was on the other end of the block—and was blown.

In a complex system, such as that in a car or a TV set, or a finishing line, there is often a domino effect. Sort of like Rube Goldberg's famous alarm clock, which started with a rooster crowing to greet the sun and wound up 20 or 30 hilarious steps later dumping the sleeper on the floor by turning the bed upside down.

How easy it is under these circumstances to look at a problem, ignore the domino effect, and begin searching for some strange and complex chemical phenomenon to explain the difficulty. How easy it is to forget that any finishing cycle consists of a series of steps, each of which is affected by what went before, and in turn affects that which follows. It seems so much simpler to concentrate on a single tank or operation as being the single *total* cause of the problem. If Rules Three through Eight have been carefully followed and anlayzed according to Rule Two, you are probably looking in the right place. But if the theory needed to explain the difficulty seems rather unusual or obscure or involved—beware! You have probably missed something along the line.

Remember, we started off this rule by reminding you that nature is basically simple. We can sum it up best perhaps by proposing an axiom—the axiom of inverse probability—"the more complicated the explanation, the less probable is its validity." Or to reverse it, "the simpler the explanation, the more likely it is that it is right."

In the Foreword, we mentioned the "elegant" solution. This was a term often used by our family pediatrician. And with a large family, one's pediatrician becomes a friend as well. Highly intelligent, cultured, with broad interest and knowledge, she was a brilliant diagnostician. But no solution to a problem of any kind satisfied her unless it was "elegant." By this she meant that all the facts were explained; any domino effect was considered; it was practical, effective, and most important, *simple*. The "elegant solution always leaves you feeling "gee, why didn't I think of that," not "if I had access to the Library of Congress, five research labs, and a computer, I might have been able to come up with that answer, too!"

One good example immediately comes to mind. A reader sent in a question about white spots he was encountering on dyed anodized parts. He detailed the cycle adequately, and explained all the various tests he had conducted. A possible (rather complicated) answer was sent. And just to be sure that he got the proper help, the question was also referred to two aluminum companies, who also sent (rather complicated) answers.

Several weeks later, the reader sent a generous letter of thanks, along with the right answer. He used plastic balls as a cover on his dye and sealer tanks to retard evaporation. With time and use, these had become roughened enough to abrade the soft, unsealed, anodized coating in spots as the racks were immersed in the dye tanks. When he replaced the old, roughened balls with new smooth ones, his problem was solved.

The experts blew it because we forgot the basic rule—*keep it simple.*

On another occasion, I was called into a plant which made, buffed and direct-chromium-plated aluminum extrusions. About 80 pct of the shapes that were plated ran with almost no rejects. The other 20 pct had very high reject rates.

All plated extrusions, both good and bad, were of the same alloy. The defective area was almost always a prominent curved surface. A great deal of effort had already gone into attempts to solve the problem. (This is as good a place as any to point out that the last troubleshooter to be called in usually has an advantage. Because of what those ahead of him have done, he knows a lot of things that won't work, or are not the problem! Of course, because the problem has been in existence for some time, it is probably now a crisis situation, so the pressure is much greater.)

Because of the location of the problem area, the buffing operation was investigated. Parts were buffed automatically on a machine with a single buffing head.

Buff pressures on the problem area were especially high. At the expense of a small blister on the index finger of the right hand, the temperature on the aluminum was checked as it left the buffing wheel. Preliminary conclusion: excessive buffing pressure causing high temperature leading to the formation of a metallic soap from the fatty acid in the buffing compound.

Back to the plating line—walk the line—check the materials used in each tank. Conclusion: there is no good solvent for metallic soaps in the cycle.

Suggestion: for the problem extrusions, add a short soak in a paraffinic solvent before entering the cleaning cycle; result—end of problem.

This is one of my favorite examples because it illustrates a number of rules:

- Rule Eight—*Look at the Parts.* The shape of the part and the location of the defect gave an important clue.
- Rule Seven—*Look for the Pattern.* The constant occurrence of the problem in the same area was a pattern and an important clue.
- Rule Four—*Walk the Line.* In this case, extended to include the buffing area.
- Rule Nine—*Keep It Simple.* The solvent dip was easy, practical and effective. Because of the shape of the part, the temperature during buffing got too high; this caused formation of the metallic soap, which was not removed in the regular cycle, and in turn led to a poor zincate film; and the inferior zincate led to the plating defect.

Only by recognizing the domino effect could the solution be kept simple. Trying to correct the problem at any other point would complicate matters, involving either a design change in the buffing machine or a major alteration in the plating cycle. By breaking the domino effect with a simple dip, the problem was eliminated at minimum cost and with little disruption of the processing cycle.

Be "elegant," and keep it simple.

Rule Ten

Test It

Before going any further, go back and review Rule Six—*Get the Facts.* We'll wait 'til you've done it. . . Now, have you satisfied yourself that you appreciate the need for record keeping?

You have carried out the evaluation of the situation and think that you have an answer. Before you can consider your job completed and walk away, you have to test your proposed solution to see if the problem is really solved. At this point, record keeping is especially important.

Why should this be so critical?

There are two possible results from your test.

One, the test will prove that you have the right answer. To convince other people that this is true requires a good record.

Two, the test will prove that you do not have the answer, or perhaps only part of it. The test will then become part of the data that you use to re-evaluate the situation and come up with a new and improved answer. Unless you have a good record of the results of your test, you may wind up working with inaccurate and misleading data. Remember the basic axiom of the computer programmer, "garbage in, garbage out." It also applies to troubleshooting.

Above all, don't rely on your memory! Memory can be lost; it can change; even worse, it has a tendency to soften or drop out unpleasant experiences like rejects or tests that didn't work. Add to this the fact that troubleshooting is invariably carried out in an atmosphere of tension and urgency. People will be talking into both your ears at once; it is easy to misinterpret or only hear part of the information being given to you. So write it down carefully, precisely. List the exact change that was made, the size of the sample, and the results. And don't do this on scraps of paper. They, too, have a tendency to get lost or have coffee spilled on them. Keep a notebook.

Now, back to the test. Let's emphasize an important point. Make only one change at a time! In Rule Nine we pointed out that nature is usually simple. The inverse probability law is also valid; therefore, the odds are in favor of one cause being the source of the problem. If you make more than one change at a time, you will not be able to tell which change corrected the problem. Even worse, if one change is right, and the other change is wrong, they may cancel out each other and produce no change in the problem. If that happens, you have learned nothing. In fact, you have been misled, because now you think that the changes you made were ineffective.

But, you say, suppose the problem is due to additive effects from more than one cause or perhaps a domino effect. If you make only one change at a time, you may not correct the problem.

That certainly is a possibility. But let's analyze it further, one case at a time.

First, the domino effect: what are the possibilities?

1. If the change is made in the right place, the domino effect will be ended, and the problem will be solved.

2. If the change is made in the wrong place, three possibilities exist: a) the change will break the domino chain and the problem will go away, but since the basic cause has not been corrected, it will probably come back again; b) the change will alter the domino effect, so there will be either a change in the problem, or some partial improvement, so that you have established the fact that the proper change has not been made; and c) no change occurs, so that you know the right change has not been made.

Nothing has been lost by making only one change at a time.

Now consider the additive effect. To begin with, if you carefully followed Rule Three—*Obey the Letter of the Law*, you have probably reduced the odds of it being an additive effect by about 95 pct. However, for the remaining five pct, consider that if you make a change three possibilities exist: a) no change in the problem will result, so that you know you made the wrong change; b) some improvement will occur, but it will not be 100 pct, and therefore you know that you have corrected part of the problem but you have to look further; and c) the problem will be solved, in which case you have actually solved the problem or you have made enough of a correction to eliminate the problem temporarily, until the additive effect can build up again. In any case, for all practical purposes, the problem has been solved.

Again, nothing has been lost by making only one change at a time.

For a moment now, go back again to Rule Six—*Get the Facts*, especially to the section on rejection rates. At this point in your testing procedure, these rates are critically important. They determine for you the size of the sample you have to run in order to assess the effect of any change. Review the examples in Rule Six again. Make up some cases of your own and decide what size sample you should use.

Now, what constitutes a significant change or improvement? Statisticians could calculate it for you precisely if they had enough data, but the pressures of troubleshooting dictate the use of rules of thumb instead. Provided you have selected the right sample size, the following rules have proven acceptable:

1. A 25 pct reduction in rejects represents an indicative change. You're moving in the right direction probably, but no cigar.
2. A 50 pct reduction in rejects represents a significant change. You've hit on part of the problem, but have to look further.
3. No rejects at all. Light the cigar and have a drink! You did it again.

Under very special circumstances, the testing procedure can become part of the preliminary process. There are three of these special cases.

Case No. 1. Two duplicate lines are available, only one of which has a problem. When this is the situation, test racks can be run in a criss-cross pattern—step one on line one; step two on line two; step three on line one; step four on line two, and so on. The second rack would start with step one on line two and proceed similarly. If the problem is in the processing cycle, it can usually be pinpointed rather quickly. Generally the problem area will be defined by running a number of test racks equal to the number of steps in the process.

Case No. 2. A pilot or small scale line is available, and *you can duplicate the problem on this line.* Because of the much smaller size tanks, it is easier to make changes and modifications in the process, and therefore experimentation is more rapid. Additionally, fewer parts are required to run the test, and the parts that are run can be observed much more closely during processing. This is the procedure that is usually followed by a supplier when you send parts to his laboratory for experimentation.

Unfortunately, the process is useless unless the problem can be duplicated in the pilot laboratory. Due to numerous slight differences that exist because of water supplies, tank size, and other factors, duplication is not always possible, and unless you can reproduce the problem, it cannot be solved. When that situation exists, it's back to the big tanks for testing.

There is also the possibility that the problem can be solved in the pilot line, but the results cannot be duplicated on the production line. Both discrepancies are often caused by failure to properly reproduce the production conditions on the pilot line. Common sources of error include failure to duplicate transfer times, use of current densities (in cleaners and descalers) which are not attainable on the production line, and failure to duplicate rinsing conditions. Attention to detail is a *must.*

Case No. 3. You can isolate the problem to the plating solution, and the problem can be reproduced in a plating test cell. The plating test cell has two advantages: 1) time for plating is relatively short, generally five to 10 minutes; and 2) solution volumes are small, so that changes and purification treatments can be carried out quickly.

Plating test cells will usually reproduce the problems either exactly or in recognizable form, if the problem is in the composition or the operating conditions of the solution.

In this case, the library of panels recommended in Rule Five can be especially helpful. If the panel from the problem bath duplicates or nearly duplicates one of the panels in your library, you have instant information on the source of the problem and the corrective measures needed.

Plating test cells will not reproduce the condition if the problem is caused by some other factor such as improper current distribution in the tank, make and break contact, excess ripple in rectifiers, and so on.

Plating test cells thus offer a double advantage: if the problem is in the solution, it will be evident and quickly corrected; if the plating test cell yields good results, the search for the source of the problem can usually be directed elsewhere.

Remember what the youngster said about the opera: "It ain't over 'til the fat lady sings."

For the troubleshooter: "It ain't over 'til you prove it works."

of Dale Carnegie. Yet the successful troubleshooter seems to do it almost effortlessly.

He will be firm without being autocratic. Operators never seem to splash solution on his clothes, or step on the toes of his nicely polished shoes. He explains without appearing to feel superior. He listens to others opinions, even of the lowliest tank man. He praises and compliments without resorting to flattery.

Listen to the way he gives orders—they sound more like requests. Notice how often he uses phrases like "maybe it would help if. . .;" "suppose we try . . .;" "have you been able to. . .;" "don't you think that. . . ." Notice how often in reporting to management he will credit the people working on the line. "Tony suggested that. . .;" "Joe came up with the idea that. . .;" "Pete noticed that. . . ."

Remember, you lose nothing by being considerate of people's feelings, status and reputation. If the problem is solved, you do not have to grab the credit at the expense of the other people involved. Your reputation comes not from knowing everything, but from being able to coordinate everyone's effort so that the problem does get solved. And to do that you need their cooperation.

Equally obviously, it is somewhat easier to obtain this cooperation if you have the respect of the people involved. And this respect is in part based on the fact that they know your reputation—that you know your business; that you have had a lot of success in the past; that you have pulled the chestnuts out of the fire for other people in the past. But even the most knowledgeable and experienced person will run into trouble if he fails to be considerate of his co-workers.

The fact that in your position of authority you will be giving orders puts two additional burdens on your shoulders: attention to detail and careful communication.

Two examples will show how both of these have an effect.

A zinc cyanide solution suddenly showed heavy metallic contamination. It was quickly determined that a box of cadmium ball anodes had been loaded into the anode baskets. The foreman was given instructions on pumping out the tank, treating it with zinc dust, and filtering it back. He was also shown how to identify the cadmium anodes.

Three days later the tank was back in trouble again, apparently due to the same cause. The ensuing conversation went something like this:

Troubleshooter: What did you do with the cadmium anodes?

Foreman: They're in the tank.

T.S.: I thought I told you to separate them.

F.: I did. They're in these three baskets here.

T.S.: They weren't supposed to go back in!

F.: You just told me to separate 'em. You didn't say they shouldn't go back in!

Who's right? Well, the foreman wasn't too bright. But he's right. The troubleshooter, failing to pay attention to detail, did not make sure his orders were exact and understood. It would also have helped if he had taken time to explain the reason for his order and the importance not only of removing the cadmium anodes this time, but of making sure that the same mistake was not made again in the future.

Communications can be a real problem. On a zinc and chromate line with two 400-gal zinc tanks, the operator in charge of additions and minor troubleshooting contacted the finishing engineer:

Operator: The two zinc tanks have just quit plating.

Finishing engineer: Check the rectifier.

O.: It's O.K. There's lots of gassing but no plate.

F.E.: Any additions made to the line today?

O.: Twenty pounds of bichromate in the chromate tank.

F.E.: Did you do it yourself?

O.: I weighed it out and gave it to the tank man to put in.

F.E.: What did you tell him?

O.: I told him to put it in the zinc. . . . O-O-H-H . . .

The operator assumed that the tank man would know that he meant the chromating tank of the zinc line. But he said "zinc." The operator thought that because the tank man had seen bichromate being put in the chromate tank before; after all, bichromate is red and so is the chromate solution, etc., etc. But because of the way he phrased his order, the tank man took it literally, carefully divided the addition into two parts, and added it to the zinc plating tanks. Lack of attention to detail? Failure to communicate properly?

Remember especially that words sometimes have different meanings to people of different ethnic backgrounds, or even to people from different parts of the country. Sometimes changes have been made that make the standard designations wrong.

On one machine, it was necessary to add some caustic to the first tank on the machine, a soak cleaner. The operator was told to "put 10 pounds of caustic in Tank No. 1." It was suggested that we go to lunch while he made the addition, but we decided to stay and watch. When he came back with the caustic he started to put it in the second tank, the electrocleaner. When corrected, he said, "Oh, you mean the presoak." The machine had been modified after some years of use by adding the soak tank. To the operator, Tank No. 1 was the electrocleaner, as it was when the machine was first set up.

If we had gone to lunch instead of waiting, the caustic would have gone into the wrong tank, and instead of solving the problem we would have been pushed off track with inaccurate data.

What does all this have to do with troubleshooting? Nothing and everything. Nothing because it doesn't give you any answers for the problems. Everything because you can't win if you don't do it.

Remember: don't be a tyrant; be a leader.

Rule Twelve

The Unsolvable Problem

Up to this point, all the discussions have been on an upbeat note. It may seem strange then to make the final discussion one that at least on the surface appears to be defeatist and even discouraging.

Actually, the opposite is true. To avoid this discussion is to leave the embryo troubleshooter open to discouragement and a feeling of defeat.

It is vitally important to remember that despite the best efforts of even the most experienced troubleshooter, there are times when the problem cannot be solved. Recognition and acceptance of this fact is important to your confidence, interest and satisfaction as a troubleshooter.

This does not mean that because the problem is unsolvable, that there are no steps that you can and should take. Nor does it mean that at the first setback in the troubleshooting process you should class the problem as unsolvable. If you do this too quickly, you may find that someone else will find a solution and your batting average will go down.

What then do we classify as an unsolvable problem? And equally important, what should you do when you run into one?

There are four categories of unsolvable problems. Each of these occurs for a number of different reasons, and they each must be handled in particular ways.

The problem that goes away. This can be particularly frustrating because it corrects itself before the cause can be found and corrected. It appears again without warning, and again, equally mysteriously disappears. Or it may never come back again. Of course, if it never comes back again, you're lucky. But it's not good policy to bank on luck, so it's best to prepare as if it were going to come back.

How do you cope with this type of problem?

You make two assumptions. First, you assume that the next time this problem appears, you will not have to recheck those steps of the troubleshooting procedure that you had managed to get through before it disappeared. In other words, you treat repeated cycles as a single occurrence and carry out your system of troubleshooting as if it were one continuing problem. Good record keeping is highly important. It is also important to recognize the onset of the problem early so you have as much time as possible to spend on furthering your troubleshooting program.

Secondly, you assume that there may be some cyclic outside influence causing the problem. Therefore you record every condition you can think of that might have any bearing on the operating conditions: temperature, humidity, wind direction, time of day, strange odors (if any), elapsed time between occurrences, and so on. Review the nickel problem under Rule Four. The weather was a factor. Also check Case No. 3 in Rule Seven. Other cases also come to mind. Consider one more.

Problem. A continuous conveyor was used to clean, phosphatize, spray paint and bake chair components. Periodically, the parts would show a serious problem with "fish eyes." The problem would persist for an hour, perhaps two, and then disappear. When the problem existed, a faint but noticeably different odor could be detected in the paint area.

Solution. After several cycles, the answer was found. A plastic molding plant across the street occasionally molded a plastic containing an appreciable percentage of a silicone. If they were molding this plastic and the wind was from the right direction, the exhaust fumes from the plastic plant would be drawn into the paint area, resulting in "fish eyes." Better filters on the air intakes for the replacement air in the paint area solved the problem.

Notice the interaction of the causes. It took a long time to find the pattern and the answer.

In another case, it took six years to find the cause! The problem occurred only once a year, and then only for a few days in the early spring. It was finally traced to the sediments and iron stirred up when local authorities flushed the water mains. Filtering tank makeup water (but not rinse waters) during the critical period has eliminated the problem.

The problem for which there is no answer. In some cases, the problem can be pinpointed, but there is either no known remedy, or those that are known are unattractive or untenable for economic or other reasons.

To cope with this type of problem, you select the least expensive or laborious of the various alternatives, put into practice as many control steps for the problem as are feasible, and then wait for some improved technology. Let's look at some examples.

Chromium baths contaminated with iron, copper and other metals show hazing in the mid- to high-current-density ranges. There is no really good way to remove these metals: they cannot be plated out; ion exchange resins require dilution before use, followed by evaporative concentration after purification.

Discarding part of the bath and making up the difference with chromic acid and catalyst is the best workable answer. So you make every possible effort to reduce the introduction of the contaminants, and when necessary, dilute the bath.

Meanwhile you wait for newer technology to develop, such as better ion exchange resins, a method of precipitating the contaminants, or some other better solution.

Printed circuit board production offers another good example. In through-hole printed circuit work, adhesion between the electroless copper and the laminate on the board used to be poor. So it was common practice to sand the boards between the electroless copper step and the plating step. This left the electroless copper in the holes and removed it from the laminate—a costly expedient, but it corrected the problem. Over the years, improved catalysts and better control of solutions improved the adhesion and therefore the sanding was finally eliminated.

The problem is caused by the parts. In this case some operation carried out on the parts is the cause of the problem. Once the offending operation is identified, every possible effort must be made to correct or change the operation. This may take some time, however, or even be too costly. Meanwhile you are faced with the problem of what to do with the defective parts.

Your choices are limited and inolve some careful cost/benefit analyses. Depending on the cost and delivery factors, it may be possible to scrap the parts and make new ones. But this is not always possible. Your next choice is to find the most economical way of repairing or overcoming the defect. Review the example of the screws in Rule Eight.

Sometimes the problem can be in the metal rather than in the operation. Consider the manufacture of lipstick cases. They were made of steel, drawn from sheet stock, burnished, brass plated, burnished again and lacquered. Rejects from spotting out suddenly soared.

When parts were examined after forming, the surface showed a characteristic "orange peel." A metallurgical check of the sheet steel revealed that the grain size of the steel sheets in these was considerably larger than specification. When the proper grain size was used, the problem went away.

But there were too many of the defective pieces to discard. A barrel cut-down with an abrasive compound before the burnishing operation removed the "orange peel" and salvaged the defective parts.

The problem is caused by the process. Not every process is completely suitable for all the parts that must be put through it. There may not be enough tanks in the line; there may be some limitation as to the variety of alloys that can be processed; processing more than one alloy may cause problems; and so on. It may not be possible to correct the process, or the correction may be too expensive.

Your choice then is to set up an extra operation off the line, make an intermittent correction to some step in the line, or reconsider the line to see if some relatively inexpensive re-engineering can correct the problem.

A fully automatic zinc line offers an example. It produced excellent results on all work except for one part. This part constituted about 10 pct of the production. Changing cleaners to properly handle this part represented a 17 pct increase in cleaner cost. This was deemed overly expensive.

A simple off line presoak in a high-flash solvent proved to be the answer. This presoak thinned the oil sufficiently to permit good performance in the standard cycle. The cost of the solvent was materially less than the increase in the cost of improved cleaners.

Another example. A fully automatic nickel line ran some parts that were fairly massive. When the cleaners were operated at the optimum temperature, these parts dried during transfer and showed a haze under the plate. If the temperature was lowered to prevent dry down, cleaning became erratic.

Installation of simple, inexpensive fog nozzles at the exit end of the cleaning tank cooled the parts, improved drainage and rinsing, and eliminated the problem.

Or consider a fully automatic nickel line that had to process brass and steel through the same cycle. The acid would pick up copper from the brass and this would come out on the steel as an invisible immersion deposit. Result: a haze under the nickel. For several years, the acid tank was dumped every week, sometimes oftener, to eliminate the problem. A material was finally found that when added to the acid tank in small amounts prevented the immersion deposits. The life of the acid was promptly extended to six to eight weeks.

You may have to live with a problem, but you don't have to accept it! Keep plugging. Maybe you can pull an end run!

Trouble Tables

On the following pages are tables of possible troubles that can be encountered in commonly used plating solutions. It should be emphasized again that each of these visible "problems" is really a symptom. In most cases there will be more than one possible cause. These causes are listed opposite the symptom, and when the symptom appears, the investigation should include examination to see if the causes listed are the sources of trouble.

These tables are general in nature, and may be materially changed and altered by the specific characteristics of the brightener systems used. Therefore you should prepare your own tables covering the specific solutions you use. With the tables on the following pages as a guide, sit down with the supplier of your brightener system and modify each so that it fits your particular solution.

Then keep these modified tables handy so that when trouble strikes you can refer to them quickly.

ANODIZING

Symptom	Possible Causes
Small pits or craters at contact points	Improper or loose electrical contact, causing arcing
No film in recesses	Trapped air or gas pockets in recesses
Variation of thickness of film on some parts	Poor electrical contact made by parts involved
Patchy or streaky appearance	Improper or insufficient cleaning; variation in alloy; variations in polishing or buffing; variation in heat treatment of alloy
Pitting or etching	Corrosion of surface before anodizing; reanodizing without stripping previous film; excess chlorides in bath; insufficient agitation, causing localized overheating; too-high bath temperature
Excess current density	Bath temperature too high
White powdery "bloom"	Temperature too high; current density too high; local overheating due to insufficient agitation; excessive sealing time; high calcium salt content in sealer
Failure to absorb dye	No film; film is sealed; dye too cold; dye too dilute; dye time too short; film too hard (bath temperature too low and voltage too high)
Variation in color between pieces	Alloys vary from the norm; variation in heat treating or mechanical processing of the same alloy; variations in contact; variations in dyeing time; change of dyeing conditions (concentration, pH, temperature); failure to maintain dye balance (this will produce a gradual change over time)
Dark specks on surface	Particles of undissolved or precipitated dye in the dye bath; inclusions in the surface of the alloy
Film dull or colored slightly	Nature of the alloy; impure alloy; excess aluminum in solution
For Chromic Acid Anodizing Only	
Anodic film a dirty yellow	Too much trivalent chromium
Too high current density	Copper-containing alloy with more than 5 pct copper; temperature too high

BRASS PLATING

Symptom	Possible Causes
Poor adhesion, blistering, flaking	Excess free cyanide; low free cyanide; inadequate cleaning and/or oxide removal; surface not neutralized after acid dipping.
High copper content (red color)	Careful—some high-zinc alloys are also bronzy red—temperature too high; lack of ammonia; copper/zinc ratio off (low zinc); free cyanide out of range; current density too low
High zinc content (pale color or sometimes bronzy red)	Temperature too low; copper/zinc ratio off (low copper); free cyanide too low; current density too high
Anodes polarized	Low ammonia; low cyanide; lack of tartrates if used.
Anodes black	May be lead contamination or polarization, as above.
Anodes bright and crystalline	Free cyanide too high.
Rough deposit	Suspended particles in solution
Poor efficiency	Low metal; high free cyanide
Failure to plate	High free cyanide; chromium contamination; insufficient cleaning
Solution crystallizes when cold	Carbonates too high.

CADMIUM PLATING

Symptom	Possible Causes
Poor adhesion	Inadequate cleaning; low cyanide (anodes will also be polarized); failure to neutralize after acid dipping; hydrogen absorption (blisters will develop some time after plating)
Dark, granular deposit	Current density too high; cyanide content too low; lack of brightener, or imbalance
Dark deposit	*Metallic contamination*
Shelf roughness	Suspended material in solution
Poor efficiency	Low metal; high cyanide; chromium contamination
Poor throwing power	Excess cyanide; low metal
Anodes too bright	Excess cyanide
Anodes polarized	Low cyanide; lack of sufficient anode area
Metal content climbs	Excess anode area
Poor conductivity	Lack of caustic; low temperature
Solution crystallizes when cold	Excess carbonates
Staining after plate	Poor rinsing; failure to use neutralizing dip or chromate conversion coating
Failure to plate	Excess cyanide; chromium contamination; inadequate cleaning; parts may be magnetized

CHROMIUM PLATING, DECORATIVE

Symptom	Possible Causes
Blistering or peeling	Nickel too brittle or non-adherent
Brown or iridescent deposits	Insufficient current; bath out of balance
Deposit smooth but gray and dull	Intermittent contact; bi-polar effect at exit end of nickel tank; chloride contamination
Deposit gray but rough	Current density too high; temperature too low
Smears and dull patches	Improper cleaning; nickel not activated uniformly
Poor coverage	Temperature too high; poor contact or improper racking; solution out of balance; gas pockets; improper activation of nickel
Anodes corroding	Bath contaminated with chlorides
Narrow bright range	Trivalent chromium too high; metallic contamination
Haze in mid-current-density range	High iron concentration

CHROMIUM PLATING, HARD

Symptom	Possible Causes
Peeling and blistering	Improper part preparation; interrupted current; incomplete stripping of previous chromium
Roughness	Suspended solids in solution; excess current; low temperature; basis metal not properly polished; bath out of balance
Pitted deposit	Trapped gas
Soft deposit	Current too low; temperature too high
"Milky" deposit	Temperature too high; current too low; bath out of balance
Bare patches	Improper part preparation; part magnetized; solution out of balance; temperature too high; trapped gas; trivalent chromium too high
No plate	Poor electrical connections; solution out of balance; contamination with chloride

COPPER PLATING, BRIGHT ACID

Symptom	Possible Causes
Burning at high current density	Low copper content; low chloride levels
Dullness in low current areas	Excess chloride; brightener imbalance
Loss of brightness	Lack of brightener; organic contamination
Ridging or gas streaking	Brightener imbalance; insufficient agitaiton
Brown deposits at low current	Excess brightener
Rough deposit	Suspended matter in solution
Coarse, granular deposit	Low acid content; temperature too low; current density too high
Deposit soft	Low acid content; bath too warm; current too low
Deposit hard and/or brittle	Too much free acid; solution too cold; organic contamination; excess brightener; high iron contamination
Poor throwing power	Low acid
Low conductivity	Temperature too low; low acid; low copper
Anodes bright and crystalline	Free acid too high
Anodes polarized	Low acid content; insufficient anode area
Anodes polarized with green deposit	High chloride contamination (Note: plate will also be seriously affected)

Note: These problems are typical of one widely used bright acid copper. Other proprietary solutions may respond somewhat differently. Consult your supplier for exact information on the bath you are using.

COPPER PLATING, CYANIDE

Symptom	Possible Causes
Insufficient adhesion	Inadequate cleaning and/or oxide removal; free cyanide too high; free cyanide too low
Copper "hard"	Current density too low; metal content too low
Rough, granular deposit	Current density too high
Shelf roughness	Suspended solids in solution
Solution not clear	Free cyanide too low; suspended material in solution
Solution blue (where tartrates are also used)	Free cyanide too low
Solution crystallizes when cold	Carbonates too high
Poor efficiency	Free cyanide too high; metal too low; chromium contamination (chromium may also result in scattered blistering, or failure to obtain coverage, resulting in patchy deposits especially in the low-current-density areas)
Anodes too bright	Excess free cyanide
Anodes polarized	Lack of free cyanide
Anodes black (film does not always dissolve when current is off)	Metallic contamination, especially lead
Staining or spotting out	Insufficient rinsing; porosity of basis metal; porosity of plate; see special section on spotting out
No plate	Chromium contamination; free cyanide too high; inadequate cleaning and/or oxide removal.

Note: Some proprietary bright cyanide copper solutions also require the use of sodium or potassium hydroxide. Failure to maintain the hydroxide content at the proper level can strongly affect the performance of the brighteners. Bright copper solutions are also affected by the presence of organic contamination. This usually produces a haze in the mid- to low-current-density ranges. Consult your supplier for the exact effect to be expected.

COPPER PLATING, PYROPHOSPHATE

Symptom	Possible Causes
Lack of brightness	Ammonia content too low; solution contaminated with cyanide; brightener levels out of balance.
Dullness in low current areas	Temperature too high; ammonia content too high; pyrophosphate content too low.
Burning in high current density areas	Lack of agitation; temperature too low; current density too high; low metal content; low pyrophosphate content
Steps or ridges in low-current areas	Excess brightener
Patchy dullness or lack of plate	Chromium contamination
Dull, brittle or stressed deposit	Organic contamination

LEAD PLATING

Symptom	Possible Causes
Lack of adhesion	Improper part preparation
Rough deposit	Current too high; agitation too low; temperature too low
Shelf roughness	Suspended material in solution
Deposit crystalline or feathery, treed	Lack of colloid in solution
Deposit bright but thin	Current too low; metal concentration too low
Deposit dark and non-adherent	Organic contamination

NICKEL PLATING

Symptom	Possible Causes
Poor adhesion	Inadequate cleaning; parts not acidified before entering nickel bath; pH out of range (too high or too low); nickel too stressed (may be due to metallic contamination or excess brightener); chromium contamination; nitrate contamination
Poor adhesion or laminated deposit	Current interrupted; nickel over nickel without proper activation; replating without complete stripping of chromium; deposit highly stressed; excess iron in solution
Poor adhesion involving peeling from copper	Failure to remove brightener film from copper plate; copper tarnished in rinsing process
Deposit too highly stressed	Contamination with zinc or cadmium; iron content too high; brighteners out of balance or too concentrated; organic contamination; pH out of range; chloride content too high
Pitting of deposit	Solution contaminated with grease or oil; solid particles in solution; pH too low; metal too low; organic contamination; inadequate agitation; temperature too low
Deposit dark	Metallic contamination, especially copper (zinc and cadmium first produce a bright stressed deposit, then at higher levels, black streaky deposits)
Deposit streaky	See above; chromium contamination; nitrate contamination; brightener imbalance; pH out of range; inadequate agitation; low wetting agent concentration; wrong wetting agent (wetting agents for mechanical agitation are usually different than those for air agitation)
Deposit rough	Solid material in solution (check anode bags); smut not removed in cleaning; excessive current density; boric acid content too high (usually also associated with low temperature)
Deposit hazy	Organic contamination; immersion deposit on basis metal (usually from processing multiple alloys through the same acid dip); iron content too high; pH out of range; inadequate cleaning
Failure to plate	Faulty electrical system; contamination with chromium or nitric acid

SILVER PLATING

Symptom	Possible Causes
Poor adhesion	Inadequate cleaning; failure to use proper strike (immersion deposit); passive nickel layer; wrong cleaning cycle for alloy being processed
Porous deposits	Excess current density; lack of filtration
Rough deposits	Suspended solids in solution; conductive smut not removed in cleaning cycle
Hard dull deposits	Current density too low; temperature too low
Thin deposits (usually bluish-white)	Low temperature; low metal content; polarized anodes
Polarized anodes	Free cyanide too low; insufficient anode area
Anodes bright and/or crystalline	Cyanide too high—usually also gives high current at normal voltage
Poor conductivity (low current at normal voltage)	Low temperature; low metal; low cyanide; poor electrical connections; high carbonates
Brown stains or spots	Poor rinsing; spotting out—see special section on spotting out of copper alloys
Patchy brightness	Organic contamination; brightener imbalance
Yellowish or pink deposits	High copper contamination combined with low silver content
Failure to cover nickel	Improper activation of nickel
Overall dullness	Low brightener content

TIN PLATING

Symptom	Possible Causes
Stannate Solutions	
Poor conductivity, anodes grey	Low caustic content and/or low metal content
Rough, dark or spongy deposits	Stannous tin in solution (anodes must be kept properly polarized); use hydrogen peroxide regularly as a preventive
Anodes black	Anode current density too high; anodes improperly polarized
Solution crystallizes when cold	Carbonates too high
Staining after plate	Improper rinsing
Anodes lose polarization or will not polarize properly	If anode area is right, caustic level is too high
Acid Sulfate Solution	
Coarse-grained deposit	Addition agent concentration too low (voltage required for normal current densities will also be low; use this as a signal of approaching problems)
Shelf roughness	Suspended solids in solution
Burned deposits	Current density too high
Slow deposition rate	Low temperature; low metal content; low acid concentration
Polarized anodes	Anode current density too high
Acid Chloride Solution	
Dull low-current areas	Chloride content too high; lack of brightener; temperature too high
Dull high-current areas	Lack of brightener; temperature too high; suspended solids in solution
Poor coverage	Current density too low; metal too high; acid content too low
Pitting	Low wetter content; current density too high; agitation too low; solution needs dummying
Rapid tarnishing of deposit	On brass and zinc alloys, zinc will migrate through the tin, therefore use copper or nickel flash; insufficient rinsing; low brightener levels
Dark streaks	Excess brightener
Turbid solution	Excess of stannic tin, which may also produce shelf roughness

ZINC PLATING, ACID

Symptom	Possible Causes
Dull deposits	Lack of brightener
Brittle deposits	Solution imbalance; excess brightener
Pitting	Solution imbalance; lack of wetting agent
Deposit generally dull with burning in high current area	Low metal concentration
Deposit brownish	Excess chloride; temperature too low; brightener imbalance
Poor throw	The pH is too low; zinc too high
Deposit darkens in chromating or nitric dipping	Metallic contamination; high iron contamination
Shelf roughness	Suspended matter in solution; pH too high
Barrel work shows print of barrel holes	Current density too high; barrel speed too low (parts sticking to side of barrel); high iron contamination
Spongy, dark deposit	Acid concentration too low
Low efficiency	Temperature too low; metal content too low; solution out of balance (deficiency of conducting salts)

ZINC PLATING, CYANIDE

Symptom	Possible Causes
Poor adhesion	Inadequate cleaning and/or oxide removal; hydrogen absorption (blistering usually is delayed); contamination with chromium or nitrates; solution out of balance
Burned deposit	Excessive current; low cyanide content; low caustic content
Deposit dark	Metallic contamination; brighteners out of balance; solution out of balance
Deposits hazy or stained	Solution out of balance; organic contamination; metallic contamination; insufficient rinsing; lack of brightener
Shelf roughness	Solids suspended in solution
Low conductivity	Lack of caustic; lack of cyanide; low metal; low temperature
Poor throw	Cyanide too high; caustic too high; metal too high
Anodes polarized	Low cyanide; low caustic; insufficient anode area
Metal content increasing	Anode area (zinc) too high; increase proportion of steel to zinc
Solution crystallizes when cold	Carbonates too high (note: conductivity also may be low and anodes tend to polarize)
Steel embrittled	Hydrogen absorption
Staining in storage	Failure to use proper post treatment (chromates and so on); poor rinsing; spotting out (see special section)

A Checklist for Chromium Platers

Trouble-shooting in chromium plating can be particularly vexing. Too often chromium plating baths begin to produce rejects not because of a single defect in the processing procedure, but because of a combination of minor problems. Thus you may find and correct one problem without completely correcting the conditions causing rejects.

Most suppliers of proprietary chromium plating baths have charts listing causes and remedies. You should use them, since they will help to solve many problems. But every troubleshooter with field experience can tell you of the day that it was impossible to find the problem, let alone the cause.

What do you do then?

The checklist which follows is not in order of importance, but in order of the ease of performance. The idea is to begin with the easy and obvious and work toward the more difficult tests until the difficulty is eliminated.

Routine Control

Check chromium and nickel for:

____ Concentration.
____ Hull Cell performance.
____ Temperature.
____ Current consumption.
____ Voltage.
____ Anode conditions and ratios.

Electrical-Mechanical

Check equipment as follows:
____ Rectifiers, for output and for ripple, using oscilloscope or modified voltmeter.
____ Busbar junctions, for possible poor connections, indicated by heat.
____ Plating machine and other components, for shorts. Include heating coils, water inlets, push bars and carrier arms.
____ Tanks, for fallen parts and for racks on the bottom, either of which could lead to bi-polar effects.
____ Hot entry and exit, for proper operation.
____ Contact bar, for over-greasing, hollows and other undesirable conditions that lead to "make-and-break" contact.
____ Racks, for broken contacts, oxidized hooks and other insulating conditions.

Chemical Control

Look at the solutions and rinses, with the following in mind:
____ Preplate solutions, for concentration, temperature and freedom from floating oils and soils.
____ All solutions, for possible contamination.
____ All rinses, for purity.
____ Activators, to be sure they are activating nickel before chromium.

Typical Problems

Here are some of the typical things you may find, as have other trouble-shooters:

Plastic insulating bushings on some arms of a plating machine have broken and caused intermittent shorts. The nickel plating is affected and defects show in the chromium. Replacing the bushings solved the problem.

Vibration in a rectifier has caused lead wires to shift, shorting out diodes. This increased ripple, which in turn caused chromium-plating problems. Rearrangement of wires to eliminate the short solved the problem.

Insulation on push bars has worn through, causing intermittent shorts that interfered with chromium deposition. Reinsulating the push bars solved the problem.

Excess brightener in the nickel plating solution has produced a viscous film on the plated part; it's hard to rinse off and has caused haze in the chromium plate. Temporarily reducing or eliminating brightener additions solved the problem.

Suppose your local water utility increases chlorine, perhaps while mains are being cleaned. There have been cases where the first racks in the morning and after each break show passive nickel, until enough brighener has been dragged into the rinse water to knock out excess chlorine. Six or seven racks may go through before the problem corrects itself. That's a tough condition to run down, but it goes away when chlorine levels return to normal.

Check everything! Those are but a few of the problems chromium platers can encounter. So be methodical, correct everything, and don't get discouraged if you don't immediately find an obvious cause for the problem. It may be that several problems exist and that the combination of these is bad news. So keep looking. You may have to correct three or four problems before you get completely satisfactory results.

One more tip: keep accurate records. List *everything* you do and when. Keep track of the effect. And change only one thing at a time. Happy hunting!

"Spotting-Out" in Copper and Brass Plating

"**Measles.**" That's the appearance of otherwise good copper or copper-alloy plated parts that have succumbed to the disease platers long ago named "spotting-out."

The disease may not appear immediately after plating. The spots may show only after parts have been lacquered, or, even worse, the spots may not be visible until the customer receives his plated parts or until the plated object is in use.

Summer always seems to bring about more spotting-out than does winter.

If someone had developed a sure "cure" no one would talk about the disease anymore. But the truth is that even expert platers occasionally encounter spotting-out. Furthermore, a cure that works sometimes on some parts may not work at other times with other parts.

We do know that spotting-out usually occurs when using cyanide solutions or solutions containing or capable of generating ammonia. Porosity is always involved. Moisture is a contributing factor, too, which helps to explain why spotting-out occurs more often in hot, humid weather.

We also know that spotting-out occurs when plating solution is trapped in pores. Under certain conditions a series of chemical reactions occurs in which the plating solution breaks down to form copper oxide (the spot) around the pore.

The spot will grow until all of the ammonia or all of the moisture has been consumed or eliminated.

Note that there are three essential conditions that promote spotting-out:

1. Trapped plating solution (some copper ions must be present to start the reaction).
2. Presence of ammonia. It can be produced as a result of cyanide breakdown or it may be present as a plating bath constituent—ammoniacal pyrophosphate, for example. Or it could come from a post treatment used in copper or brass plating.
3. Presence of moisture. The moisture could be retained by salts in the pores or it could be absorbed later from the atmosphere by these salts. This explains why spotting-out may occur weeks later: it takes that long for the moisture to penetrate the lacquer or other coating and begin the reaction.

Knowing some of the causes, how can we lessen the incidence of spotting-out?

First of all, try to eliminate porosity. If you're plating castings, try to avoid cutting through the "skin" in polishing and buffing operations and don't "hog" the steel to leave slivers and overlaps that promote porosity.

Use a good grade of steel. A serious spotting out problem involving plated drawn steel was cured by switching to steel with finer grain size, thus eliminating pores that had been opening up in a deep draw.

In the plating operation itself, use procedures that help to minimize porosity. Make sure you are cleaning the surface properly. Filter the plating solution.

The first rinse after plating should be at the same temperature or warmer than the plating solutions. This avoids having plating solution sucked into pores in a sudden contraction caused by rapid cooling. Alternate hot and cold rinses will sometimes cause enough "pumping" action to clean out the pores.

A cyanide destruct solution—dilute chromic acid or a chlorinated water rinse—may help, but only if a complexer is present to remove the copper ions released by the cyanide being destroyed. And a good hot water soak still is a good idea to facilitate removal of ammonia.

Remember that solutions having low surface tension do not penetrate pores as well as solutions having high surface tension, assuming that the interior of the pore is already wetted by the solution. So avoid the use of wetting agents in post treatments.

The use of a tarnish preventive—chromated or nonchromated—will inhibit spotting, but this is no substitute for removal of the contaminants that are the root of the problem.

Thoroughly drying the part to be sure all moisture is removed from any trapped salts is helpful only if the lacquer completely seals out moisture. Often that's a big order. If the lacquer is permeable to moisture, the spotting-out may simply be delayed until it causes a field failure rather than a shop reject.

Sometimes a combination of several of the above techniques may be required to deal with spotting-out, and even so, you still probably won't win them all.

When you encounter spotting-out in spite of all your efforts to conquer, set aside the affected parts until all the spots have developed. You can accelerate the reactions by exposing the parts in a steam cabinet, to provide both heat and humidity.

After all the spots have appeared, buff, scratch brush or barrel tumble to remove the spots, then dry and lacquer. Since the trapped chemicals have been used up, it is unlikely that the spotting-out will recur.

The Case for Ultrasonics

Question a number of finishers about the use of ultrasonics and you will get opinions ranging from "the greatest thing since sex" to "not worth the powder to. . .", depending upon their experience with it. Many of the problems stem from a lack of understanding of ultrasonics and how best to use it, and the tendency of some manufacturers to *under* power their units to keep the purchase cost down. Many applications fail or are only marginally successful because of these factors.

Two statements are often heard which are true, but incomplete: "Ultrasound is just a fancy form of mechanical agitation." True, but it works on a dimensional level not attainable any other way. And it has chemical and electrical effects as well. "Anything you can do with ultrasonics you can do chemically, but ultrasonics may be faster." True, but ultrasound may be more controllable as well as faster, and this can make a difference.

Now let's get some definitions and corollaries out of the way.

What is ultrasound? Just that—sound that is beyond the range of normal hearing. In other words, 18,000 hertz or higher—most generally 20 or 40 kHz. This sound is transmitted through the cleaning fluid with appreciable energy—generally 5 to 10 watts per square inch (32-64 watts/cm^2) of cleaning area—and thereby creates a great deal of mechanical action from the alternate compression and relaxation of the fluid.

Of particular importance is the fact that as a result of the high frequency, the wavelength is close to the size of many of the solid soil particles we are trying to remove. Therefore it is particularly effective in dislodging them from the surface.

If you are a high-fidelity buff you already know that at higher frequencies sound is quite directional, so "tweeters" must be aimed to get the best effect in a room. Even more so with ultrasound, so the work must be more or less directly in front of the transducer (speaker). Incidentally, the sound you hear from an ultrasonic unit is a result of the sub-harmonics caused by reflections within the tank acting on each other. Even though directional, there will be very little shadowing effect, since as long as the material being cleaned is not too elastic, the sound will be transmitted right through it and out the opposite side; however, each time the sound passes from one medium to another, there is about a five pct loss of intensity, so transmitting into a piece of steel and back into the solution results in about a 10 pct loss. Remember always that you are dealing with sound and the energy available depends on where you are on the sound wave.

It is quite possible to set up "standing waves" in a tank. When this occurs, there exists a series of nodes (low energy) and antinodes (very high energy). For best results then, keep the work moving at least a little. While the work, being relatively inelastic, will not "shadow" or attenuate the sound, small, moveable particles or gas bubbles will attenuate the sound badly.

If the particles are abrasive, as when buffing compound is removed, they may also mark the work by being rubbed against the surface by the ultrasound. Therefore, keep the solution clean, either by filtering, frequent dumping, or allowing adequate settling area *below* the level of the transducers. Obviously, air agitation should not be used.

When the energy input is high enough, cavitation results. Cavitation is literally the ripping apart of the fluid by the forces of the ultrasound (hence cavity or bubble formation) and the effects are awesome. Pressure of 10,000 to 30,000 psi (68,900-206,700 kPa) can result when the bubbles collapse.

Voltages of up to 700 v across opposite walls of the bubble can exist momentarily. The pressure can literally tear holes in metal; indeed, one test for cavitation is to immerse a sheet of thin aluminum foil in the bath for a few seconds and check the number of holes formed. The voltages can produce ozone if there is air in the solution, and other oxidative effects when air is absent. The pressures generally effectively "degas" a solution in a few minutes by driving off the dissolved gas.

Some engineers feel that the cavitation pressure cannot be controlled, but it can. The pressure developed during cavitation is a function of the vapor pressure of the fluid and its cohesive force. Raising the temperature lowers the cavitation pressure. At or close to the boiling point, cavitation pressure will be almost zero; incorporating in the fluid a compound with relatively low vapor pressure, such as ammonia, also reduces cavitation pressure.

Ultrasound can sometimes interfere with wetting and penetration by shortening contact times, reducing osmotic pressure, interfering with capillary action, etc. Ultrasound is better in the rinse rather than in cleaning.

How can we pull all this together and make it usable? Some examples should help.

An ultrasonic degreaser was built with the transducers in the hot tank. It didn't work (cavitation pressure essentially zero). In the cool tank the transducers worked well.

Attempts were made to ultrasonically clean zinc phosphated steel parts. Cleaning was good, but the ultrasound chipped out crystals of the zinc phosphate, causing spotty salt spray failures. Incorporating a low vapor pressure compound in the cleaner reduced the cavitation pressure and gave good results.

Ultrasound was used with an alkaline paint stripper and stripping times went up. (It interfered with penetration.) Moving the transducer to the rinse gave some excellent results.

Trouble was encountered removing buffing compound from a blind hole. Using ultrasound, the hole came clean quickly. Adding ultrasound to the rinse gave even better results.

A finisher was getting marginal results using ultrasound and a buffing compound remover at 180F (82C). Dropping temperature to 160F (71C) gave consistently good results. (Increase in cavitation pressure resulted from lower temperature.)

We could go on and on—but these should give you the general idea. Study the basic principles outlined above, analyze your ultrasound problem, then solve it.

For The Card File

Nickel peeling off nickel indicates problems with electrical system. More rarely it may mean an excess of brightener or any imbalance in the brightener system. If parts are replates it may mean failure to strip all the chromium, or improper activation of the nickel.

Blisters on copper plated zinc base die castings can show hidden porosity (if so, pore should be visible under a microscope after the blistered copper is removed) or diffusion of the copper layer into the basis metal (if so, back of copper will show zinc, and zinc under blister will be pebbly in appearance).

Diffusion of copper into zinc will be accelerated by heat, and/or by contamination of preplate solutions with copper.

Metallic or conductive smuts very often will not be removed in electrocleaners. Use very strong acids, or alkaline descalers.

If a smut is metallic, it will usually show a "flash" of gas when it is immersed in a strong acid (50-75 pct by volume hydrochloric acid).

High silicate-low caustic cleaners if allowed to dry during transfer may be difficult to rinse off and will show a pattern in the plate. Use fog nozzles and/or a fluoride salt in the acid.

Oil can sometimes be trapped under a smut and suddenly produce a waterbreak after acid dipping. A double cleaning cycle will eliminate this.

Many strike solutions rapidly increase in metal content if not watched carefully. Particularly Woods Nickel. High metal content can cause problems.

Iron can be plated out of alkaline descalers, particularly at high current density. Blistering and hazing can result. Make sure reverse cycle is longer than direct cycle.

Other causes of haze: brightener imbalance; organic contamination; immersion plate in the acid; dry down of cleaners during transfer; oil under a metallic smut; too much soap in a cleaner (from removed and reacted buffing compounds).

Grain size of steel in sheet metal that is formed drasticly or deep drawn is an important factor. Improper grain size can cause parts to have an "orange peel" surface and also cause spotting out.

Fog nozzles solve many rinsing problems. They cool the parts to prevent dry down; dilute the solution on the part for better drain off and reduced drag out; and aid in removal of loosely attached particles.

When brass and steel must be run through the same cycle, watch for copper contamination in the acids. Copper can cause a haze under the plate even before an immersion deposit becomes visible.

Chloride content of a sulfuric acid anodizing bath should not exceed 200 ppm. When it does, pitting can result.

Part II

Questions and Answers

In this section we present a selection of questions and answers from "Finishing Clinic," the popular monthly column appearing in PRODUCTS FINISHING magazine.

To make this selection, over 600 Q & A's received and answered since the column started were reviewed. Most of these have been used at one time or another in the column; many, however, appear here for the first time.

The Q & A's have been roughly grouped as follows:

1. According to the Rules presented in the first section. Not every rule has been exemplified. No Q & A, for example, would illustrate *Rule One—Don't Panic.* By the time a written question is received, panic time is long past.

In other cases, the primary rule is used as the classification, even though other rules may constitute an important part of the answer. Such is the case with many of the Q & A's classified under *Rule Two—Define The Problem.* Some of these have been annotated to show what rules were applied. The rest have been left without comment to serve as examples on which you can practice what you have learned from the first section.

2. A grouping which provides helpful information that you

can use to expand your background knowledge. This group has been subdivided into several classes:

a. ***Should I***—questions which ask for help in deciding on a process or equipment change or choice. Generally, the need is for information, but may also involve one or more of the rules from Section I.

b. ***How do I***—questions of two types: the problem has been defined, but the next step cannot be taken because the questioner does not have enough information; or straightforward requests for information on how to carry out some desired process, or to obtain a desired result.

c. ***What if***—questions that ask for help in interpreting available data. These probably could also be titled ***What does . . . mean***? In short, the questioner is looking for help in defining the problem.

d. ***Why does***—questions asking for explanations of things that have happened. The questioner is seeking to obtain a better understanding of what is going on—something that will contribute greatly to his success in the future as a troubleshooter.

In all categories, a frequent occurrence is the recommendation to consult with one or more suppliers for materials or help in solving a particular problem, or in finding a needed process. Most suppliers have laboratories, service personnel skilled in various aspects of finishing, and detailed information on processes. They are an excellent source of information. In the interest of saving space, however, such recommendations have been eliminated from the answers.

It is also important to remember that sometimes the question is condensed. Sometimes the information provided, plus the question that arrives in the mail, is longer than the answer! Where we have condensed, however, there will usually be an indication of it either in the question, or in the answer. So, let's have at it!

Rule Two—Define the Problem

Two conditions repeat themselves consistently in this group: the questioner needs help in defining the problem, and/or he has defined the problem but doesn't realize it because of a lack of background information.

Gold Plate Peeling

Q. *We are applying 24-karat gold over a bright nickel base. Periodically, we have a problem with the gold plate peeling. It occurs intermittently, and only a few pieces or the entire rack of parts may peel. There does not seem to be any pattern to its occurrence.*

A. The problem may be caused by passivation of the nickel during rinsing. You indicate that the racks may be held in the rinse after nickel for four to eight minutes. Nickel can passivate quite noticeably under these conditions. Oddly enough, passivation may often be worse during the winter when rinse water is cold, since it can hold much more dissolved oxygen at lower temperatures.

Similar conditions frequently lead to covering problems in subsequent chromium plating. If you cannot avoid this prolonged storage time, add an activation step and a rinse ahead of the gold plate. Suitable activators would be 15 to 30 pct hydrochloric acid, or 10 pct sulfuric acid with an addition of a proprietary activating salt.

Comment: Notice that he has already tried Rule Seven but could not find the pattern. I feel sure that if he had looked closer he would have found a pattern to this occurrence. Of course he was also short of background information. If he had been familiar with nickel passivation, its causes and results, he would have found the pattern, recognized it and made the suggested corrections. This is not a criticism, but just another reminder to convince you that you should gather as much information as you can about everything.

* * * * *

Copper-Nickel-Chromium

Q. *In our plant, we have tried to plate a part made of brass and* *steel sections. We electropolish, cyanide copper flash, bright nickel plate 0.0002 inch, and chromium plate 0.00001 inch. The plating peels off the steel sections even though the cleaning is very good.*

A. The part you are trying to plate is a composite of steel and brass and the cause of the peeling is the buildup of copper in your electropolishing solution. Since this acid is probably not inhibited, the dissolved copper will deposit as an immersion deposit on the steel during the rinsing cycle. If this deposit is not eliminated by a subsequent step in the cycle such as a reverse current treatment in sodium cyanide solution, peeling from the steel can result.

Comment: If the possibility of an immersion deposit from the copper in the electroplishing solution had been recognized, the problem would have been solved. It is especially important to recognize that this could happen either during transfer or in the rinse tank.

* * * * *

Iridescent Chromium Plate

Q. *What causes iridescence after decorative chromium plating on bright nickel? What can be done to prevent this? We are using proprietary nickel and chromium solutions.*

A. Iridescence of bright chromium over nickel can be caused by improper solution balance (especially low catalyst content), improper temperature, or passivity of the nickel layer. Occasionally it may be caused by insufficient voltage, or low voltage related to poor rack design (i.e., insufficient current-carrying capacity in rack members or contacts).

Nickel passivity may be avoided by rinsing as quickly as possible after nickel plating, and chromium plating immediately. Alternatively parts should be passed through a suitable activiting dip (many proprietary solutions are available, or strong hydrochloric acid may be suitable) and chromium plating immediately. Remedies for the other causes are obvious.

Comment: What other rules should be applied here as part of Rule Two?

* * * * *

Etching Brass and Copper

Q. *We have an automatic plating machine with the following cycle: soak clean, reverse electroclean, 20 pct by volume hydrochloric acid, dilute sulfuric acid and nickel plate. Periodically we have a problem with etching of brass and copper parts. Over ninety pct of our work involves plating on steel. Why do we have problms with etching the copper?*

A. The most probable cause involves your hydrochloric acid solution. A standard etching solution for printed circuit boards is ferric chloride. With your heavy production of steel, the hydrochloric acid solution will build up iron salts fairly rapidly. Most of this will remain in the ferrous state due to the constant production of hydrogen from new parts in the solution. However, gradually, due to air oxidation, ferric salts will build up. The solution will then be a powerful etchant for copper and copper alloys.

This will most likely happen when the acid is old and nearly ready to be replaced. Analyze the acid for total iron, or ferric iron, as well as concentration. If you do not have facilities for the required iron analysis, run a practical test. Before processing copper or brass, immerse a piece of cleaned, buffed brass in the acid for twice the expected processing time. If no etching occurs, it is safe to process the parts. If etching does occur, replace part or all of the acid before running the copper parts.

Comment: Notice the lack of information, specifically the fact that ferric chloride can cause etching. What other rules should have been used and apparently were not? Rule Four? Rule Seven? Rule Eight?

* * * * *

Pitting in Anodizing

Q. *We extrude and anodize aluminum. Intermittently we encounter pitting of the surface. It comes and goes without any apparent reason, but is always evident after the pretreatment cycle.*

A. Intermittent problems are always the worst kind to solve. You should try to answer the following questions:

1. Are all the pieces in the load affected or only some?
2. Is the condition always found on the same surface, or is it randomly distributed?

3. Is there any correlation between the surface affected and the position of the piece on the rack; i.e., is it always the upper surface?
4. Are the billets cleaned before extrusion and if so how?
5. What type of lubrication is used during extrusion?
6. What alloy is used, and what is its heat treating history? Is this carefully controlled?

Examination of the pits on the sample sent to us shows that they have a tendency to follow the extrusion marks on the surface. One is led to suspect, therefore, that they are related to the presence of an impurity or segregated alloying element in the surface of the billet. Or the problem may be the result of some uncontrolled condition during extrusion. This could then lead to preferential attack during pretreatment.

It is also possible that solids suspended in the etching tank may be settling on the surface. However, since the problem comes and goes in a random fashion, I would discount this.

Comment: What rules is he being told to follow? Why? Would you add any? Select any others? Why?

* * * * *

Tarnished Copper Plate

Q. *We copper coat steel wire with an acid copper sulfate solution. The deposit tarnishes before reaching the customer, even when lacquered. Chromate passivation does not seem to help. What's wrong?*

A. Without knowing your whole cycle it is difficult to pinpoint the problem. It would appear, however, that the main cause of the problem is a porous deposit, and possibly insufficient rinsing and/or drying. A porous deposit can result from:

1. Insufficient or improper cleaning of the wire before coating.
2. Excess pickling of the wire, producing smut before coating.
3. Too much dissolved iron in the copper immersion solution, or too-high pH.

Insufficient rinsing can result in residues of the immersion solution on the surface. These residues absorb moisture from the air and cause rusting and/or tarnishing. Similarly, if the plated wire is not dried properly, residual moisture will cause corrosion, even when a lacquer has been applied.

It is also possible that the acid content of your immersion bath is too high. If this is so, a neutralization step after coating may be necessary to insure complete removal of the acid during rinsing.

Comment: Walk the line; look at the parts; letter of the law. What else? Can you suggest any short-cuts?

* * * * *

Black Chromate on Zinc

Q. *We are applying a black chromate on freshly plated zinc. We periodically have a problem with streaking of the chromate—the streaks are lighter in color than the rest of the coating. Would the use of a wetting agent in the chromate help?*

A. It is possible that a wetter in the chromate would help, but from the description of the problem (we made a phone call to get additional needed details) it would seem that the problem is basicaly one of rinsing.

Alkaline films in particular are not always removed by brief rinses. If any such film remains on the parts when they enter the chromate, it will interfere with the action of the chromate by locally raising the pH and depleting the acidity. Try neutralizing with a dilute acid before applying the chromate.

* * * * *

Blue Bright Chromate on Zinc

Q. *We operate an automatic barrel machine, plating zinc with a bright blue chromate. We have trouble maintaining the blue color and the work tends to have a yellow cast. Our transfer time is 35 sec. We use raw well water (analysis attached). Could this be part of the problem? What can we do to help maintain the color?*

A. I see nothing in the water analysis that I would expect to cause a yellowish cast in your chromate. This problem is almost always associated with the chromate film being too thick. In part this is probably due to your transfer time, although this should not present an insurmountable problem. I presume that your chromate is a proprietary product, and your supplier should be able to assist you in obtaining the finish you want. It might be necessary for him to change the product you are using to a less active material. You may be able to make the correction yourself based on the following principles.

The color of a clear chromate film is determined by the thickness of the film, its uniformity, and the proportion of hexavalent and trivalent chromium retained in the film. The color of a uniformly thin film will go from colorless to blue to green to yellow as the film thickness increases. An increase in chromate concentration, time of immersion, agitation, temperature or transfer time will usually increase the thickness of the film. An increase in nitric acid concentration can decrease the thickness, but too great an increase may remove too much zinc plate.

A new dip usually produces too thick a film to give the deepest blue, especially if the transfer time is long, since the solution remaining on the part continues to act until rinsed off. A new bath therefore should be operated at a slightly lower chromate concentration or with a slightly higher nitric acid concentration (be careful though, don't over do it, or you may get no film at all). After the bath has aged, the concentrations can be adjusted. An older bath also has a higher trivalent chromium concentration. This makes the operation of the solution less cricital. Many people therefore do not discard the whole bath at one time, but retain about one-fourth of it and make up the remainder new.

The full depth of the blue color does not appear until the film is dry. It frequently increases with drying temperature. Some manipulation is possible by varying the temperature in the final rinse and drying stages. Increasing the temperature and the flow rate of the hot rinse will increase the amount of hexavalent chromium compounds leached out of the film. This tends to make the film bluer. Excessive temperatures should be avoided, however, since heat can destroy the corrosion resistance.

Comment: Would it have helped in both these cases to have read the instructions? What about Rule Four, or Rule Three? If Rule Seven had been applied, would it have suggested the possibility that drip feed rather than intermittent replenishment might have helped? Can you think of other Rules?

From here on you are on your own; no more comments. How well can you do?

* * * * *

Paint Flakes from Magnesium

Q. *We etch magnesium sheet, apply a two-minute chrome pickle, spray a white epoxy paint and shear to final shape. On about 50 pct of the parts paint will flake at the sheared edge. How can we stop this?*

A. Since only a percentage of the sheets fail, it would appear to be a problem of technique rather than a problem with materials.

You do not mention any precleaning step prior to the chromium pickle. If you do not have a precleaner in your line, one should be added. The chromium pickle is not an outstanding cleaner, so you may be having a problem with incomplete oil removal from the sheets. If oil is removed in the pickle, it could float to the surface of the solution and redeposit on the sheet as it is withdrawn.

If you find that this is not the problem, look for oil contamination after chemical treatment and before painting. If compressed air is used to dry the sheets, check air lines and filters to insure complete oil removal. Check areas where the sheets are stored between operations for airborne oil from a nearby machine, air chuck or hydraulic press. Check on handling methods to make sure that oily hands and gloves are kept off the surface. If tack rags are used to wipe the surface before painting, make sure that they are oil free.

It is also possible that the adhesion of paint to the magnesium is marginal. If this is the case, the use of a suitable prime should eliminate the problem.

It is also possible that the sheet is not being held firmly enough when sheared, or that there is too much clearance in the shear, so that the sheet is deformed close to the sheared edge. If this occurs, it can break the bond and cause flaking.

* * * * *

Smudge on Zinc Plate

Q. *I am getting a milky smudge on large flat zinc-plated pieces even after a nitric bright dip. Why?*

A. I suspect that you either have insufficient current density in the milky dull area, or you have insufficient low-current-density brightener in your solution.

A complete chemical analysis and a Hull cell panel should enable you to determine which cause is the culprit. You might try increasing cyanide concentration to improve the throwing power and see if this helps with the problem.

It is also possible that the smudging might be caused by inadequate rinsing. Large flat pieces are very difficult to rinse. Try multiple rinses or even better, a good spray rinse.

* * * * *

Problems in Nickel and Cadmium

Q. *Enclosed is a sketch of our plating room. Some tanks are very close to each other because the plating room has recently been squeezed down to make room for other expansion. Since rearranging the tanks, problems have quickly shown up in bright nickel and in cyanide cadmium. The nickel shows a fine speckled pattern, which nothing seems to remove. The cadmium bath produces a dark, rough plate which started in the high current density area and spread over the whole range. The solution is a dark red brown color and does not feel slippery even with the caustic at 3 oz/gal. Carbon filtration does not help. Could this be the result of the proximity of the tanks?*

A. Frankly, I think you have several problems.

In the cadmium, your description of the color, the feel, and the appearance of the Hull cell panel you sent make me suspect a low cyanide content. Have you checked this? Are the anodes polarized? There is also some indication of nickel contamination. Have you dummied the tank?

You do not show on your diagram the locations of rinse tanks. From the positioning of the plating tanks and the obvious lack of space, I suspect rinse tanks are in short supply, and generally used for more than one purpose. Under these conditions, a great deal of cross contamination can occur. Thus you could very easily get nickel into the cad and vice versa. Additionally you might inadvertently introduce some cleaner into the nickel and the precipitated silicate could easily account for the very fine pitting you have found in the nickel. A torn or broken anode bag could also cause it. Have you checked this? Do you filter continuously? Check these items.

* * * * *

Copper-Tin-Nickel

Q. *We nickel plate an assembly of magnets and 1008 steel laminations. Components are copper flashed, tin plated, and then soldered together to form the assembly. A 60/40 solder with a rosin core is used. Parts are then machined and nickel plated. We are getting skip plating at the seam areas. What is causing it?*

A. There are three possibilities: 1) failure to get complete, pore-free soldering so that the machining operation exposes pores that cannot be covered over in the nickel plating cycle; 2) a less severe case of item 1, which retains flux in the partial pore and thereby prevents complete coverage; 3) a preplating cycle which improperly prepares the solder for plating. You do not mention whether you use a copper strike before nickel plating. It would probably be helpful to do so.

I suspect that all three causes are involved to some extent. Careful examination of your rejects over a period of time should enable you to establish the predominant cause, after which suitable corrective steps can be taken.

* * * * *

Chromium-Plated Aluminum

Q. *I build and race model aircraft engines as a hobby. The engines use a cylinder liner of A380 aluminum, chromium plated. I use a double zincate and chromium plate in a 500-ml tank at 135F and at four amperes per square inch, using a ¼-inch internal anode. The liner is 0.570 inch internal diameter and one inch long. The plating sometimes flakes and blisters. What can I do?*

A. Check the following points:

Working in a volume of 500 ml, you may be having problems with temperature control. This is particularly true since you are putting seven amperes through this solution, which would have a definite heating effect. I would suggest using a minimum of one gal of solution to avoid this problem as well as the possibility of rapid changes in solution composition.

While you mention that you are using a double zincate, you do not spell out the details. Temperature control as well as timing; the acid dip used prior to the first zincate and the acid used to remove the zincate before applying the second zincate can have major effects on the performance of the zincate film. I am sending you an operating bulletin on a zincate which gives some of these details.

I would also suggest that your parts enter the plating solution "live," to avoid any possibility of extensive reaction of the zincate with the chromium bath before current is applied.

Additionally, I think that four amperes per square inch is too high a current density. Also attached is some information on a process for direct chromium plating over a zincate. It calls for a two-step procedure in which the temperature of the first solution is kept in the range of 18-20C, and the second at 40-42C. Note that the recommended current densities are in the range of 1-2 amperes per square inch.

* * * * *

Zinc Plate on Grit Blasted Steel

Q. *We have a problem with coverage of zinc plating on grit-blasted cold-rolled steel parts. An alkaline zinc plating solution is used. The cleaning cycle includes soak clean, HCl pickle, reverse electroclean, pickle, reverse electroclean, reverse caustic cyanide, and plate. If parts are stripped and replated there is no problem. No problem with non-grit blasted parts, either. What's the problem?*

A. Since the problem is only associated with grit-blasted parts, the problem is in the grit blasting process. There are two possiblities.

Steel grit is sometimes made from grey iron, rather than regular steel. Even if made from steel, if it is also used to blast grey iron, it can be contaminated with particles of grey iron. If this is the case, you may be embedding some of the grey iron in the surface of the blasted parts. The high carbon and silicon content of grey iron makes them very difficult to cover in alkaline zinc. Therefore, you would have a great deal of trouble covering those areas where the grey iron was embedded.

If you are using air for blasting, it is possible that your filters are not removing all the oil from the air. This oil could contaminate the grit and would then be very deeply embedded into the surface where the parts are blasted. If this is the problem, putting a new charge of grit in the machine, and cleaning all the air filters in the line to insure complete removal of oil would correct the condition.

Since you indicate that stripping and replating eliminates the problem, try using a double cleaning cycle, or spending more time in the reverse cleaner.

* * * * *

Highlighted Russian Gold

Q. *We finish jewelry with a highlighted Russian Gold and dip lacquer. After a few months there is a loss of lustre in the highlighted areas. Why?*

A. Consider the following possible causes:
1. Inadequate rinsing after application of the Russian Gold.
2. Inadequate cleaning after highlighting.
3. Inadequate rinsing after step 2.
4. Contaminated hot rinse after step 2.
5. Contamination of the lacquer dip tank with water.
6. Incompatibility of lacquer with Russian Gold finish.
7. Contamination of wrappings or boxes with sulfur.

* * * * *

Tin-Lead on PC Board

Q. *On a tin-lead-plated printed circuit board, we screen solder mask and cure for five minutes at 400F. The solder mask comes off the tin-lead surface in subsequent wave soldering. We use the same method on bare copper circuits and have no problem. How can we correct this?*

A. The problem could stem from insufficient or improper rinsing after tin-lead plating, resulting in a film of precipitated metals and oxides on the tin-lead surface. If this is the case the use of an acid rinse, either two to five pct fluoboric acid or ½ to two oz/gal of chromic acid after plating and before drying, could be helpful.

Another cause might be melting and reflowing of the tin-lead plate during the wave soldering operation. If this is the case it is necessary to prevent this remelting in order to maintain adhesion. Altering the composition of the plated alloy to raise the melting point, increasing the thickness of the solder resist layer to reduce heat transfer to the underlying plate, and/or lowering the temperature in the wave soldering bath are all ways to reduce the tendency of the plate to melt.

* * * * *

Black Oxide

Q. *We black oxidize brass, copper, and beryllium bronze. We fail to get a black on the beryllium bronze. Composition is two pct beryllium, 0.2-0.4 pct nickel, balance copper. The beryllium bronze is heat treated before finishing, but we are careful to thoroughly descale before trying to oxidize. We have tried numerous blackening baths without success. What can we do?*

A. One of the most common solutions for producing a black oxide on copper consists of caustic soda (90 g/liter) and sodium chlorite (30 g/liter) at 160 to 200F. Generally there is no problem in producing a good black on beryllium alloys if the surface film of beryllium oxide is removed after descaling and before processing. This is best accomplished by immersion in strong (30-50 pct) hydrochloric acid. There are also proprietary powdered acids especially designed for this purpose. The blackening bath is also available in the form of premixed proprietary salts.

* * * * *

Chromium on Nickel Wire

Q. *We are chromium plating nickel wire, drawing it directly from the spool through the chromium bath. Occasionally several feet of wire will show poor adhesion. How can we avoid this?*

A. This lack of adhesion could be caused by soil on the wire, or passivation of the nickel wire. A good direct current cleaner ahead of the chromium bath would both clean and activate. Strong muriatic acid (30-50 pct by volume) would activate but would not clean. Sulfuric acid at 10-15 pct by vol with direct current at two to four volts could also be used to activate, but also would not clean. Proprietary acid salt mixtures usually may be substituted for either of the acid mixtures. Whatever is used, you must be careful to rinse thoroughly and avoid contamination of the chromium bath by dragged in materials.

Rule Three—Letter of the Law

It was not easy to locate examples of this rule. Most people have already checked out these aspects before they write. In other cases, this rule is suggested as part of the answer to a question classified under Rule Two. However, consider these two examples.

Hazy Nickel-Chromium

Q. *We have a nickel-chromium installation in which the parts enter and leave the tank "live." Excess current problems are avoided by using a separate rectifier for these two stations. Lately we have been getting white, hazy streaks and star dusting on the parts. Stripping the chromium shows the nickel to be okay. Only the outside pieces on the rack are affected. What can be the cause?*

A. Check the live entry rectifier and wiring. One of the flexible cables, probably at the entry station, may have a break, producing intermittent current. One or more of the stacks or diodes in the rectifier may be defective, giving excessive ripple. A quick check can be made by running a series of racks with the "live" rectifier off. If the problem disappears, you can be sure the problem is in this area.

Comment: Notice that the area of the problem has been defined. What next? Letter of the Law; Walk the Line.

* * * * *

Nickel Coverage

Q. *I am having trouble with complete coverage in my nickel, as shown on the enclosed Hull Cell panel. Also enclosed are details on the bath composition, homebrew brighteners used, and so on. Can you help?*

A. The characteristic you discuss in your letter is referred to as "throwing power." This is the ability of the solution to "throw" into, or cover a recess or low-current-density area.

In the case of nickel baths, throwing power is somewhat affected by low pH and iron contamination. You do not indicate the pH at which you operate your bath. It should be close to 4.0-4.5. You might also treat for iron contamination.

It is also possible that you have allowed your brightener combination to get out of balance. Try adjusting the balance by additions of the different brightener components in a Hull Cell. If you cannot bring it back into balance, carbon treat to remove the brighteners completely and start over with a fresh charge of properly balanced brightener. You can find considerable helpful information in the chapter on nickel in *Modern Electroplating* by Lowenheim, published by John Wiley and Sons, Inc., 605 Third Ave., New York, N.Y. 10016.

Rule Four—Walk the Line

Most of these examples share some other rule, and many of the examples for the other rules share this one even though they are listed elsewhere. Can you find them all?

Painted Welds

Q. *We manufacture an item from welded steel tubing. The welds appear clean and free of scale and flux as they are hung on the finishing conveyor. They pass through a three-stage zinc phosphate unit, a dry-off oven and then are primed electrostatically with a low-bake epoxy primer cured twenty minutes at 275F. Still on the line, but with the phosphate unit off, they are coated with a high-quality acrylic finish with the welded areas reinforced by additional hand spray. Cure is twenty minutes at 350F. In the field we get some failures at the weld areas. A zinc-rich primer does not seem to correct these problems.*

A. It is necessary to examine units at all stages of finishing, and carefully examine failed parts to determine the cause of failure. Check the following points:

1. Is it possible that although the welds appear good there are some small pin holes or voids that can trap solutions containing salts that contribute to later failure?
2. Despite the good appearance, is there some passivity which interferes with the proper formation of the zinc phosphate coating?
3. Are changes in the structure of the metal as a result of the welding setting up electrochemical couples which either prevent the formation of the zinc phsophate coating or cause it to locally accelerate its formation so that locally excessive thicknesses are produced?
4. On the second trip through the line, even though the spray unit is off, is there a possibility that some condensation is taking place on the parts going through the unit?
5. Since the hand reinforcement of the weld area will result in an appreciable difference in thickness of the acrylic in this area, is the baking schedule adequate to guarantee the cure of this thicker coating?

Comment: What other rules are involved here?

* * * * *

Powdered Acid Pickle

Q. *We have been using a powdered acid in our automatic plating cycle for some time, with good results. Recently after only three days of operation of this solution, steel parts began coming out of the solution with a heavy brown film that interfered with plating. A new solution cleared up the problem, but it reappeared after about three days. Solutions made from the same drum of powdered acid are performing well in other lines. What's happening, and how can it be stopped?*

A. If there were anything wrong with the powdered acid, the problem would be seen on the other lines as well as on the automatic line. The most probable cause is excessive drag-in of cleaner. This will raise the pH of the powdered acid to a point where the depletion of the available acid at the surface of the work allows the precipitation of iron hydroxide. Hence the brownish film. To test this try agitating a rack while it is in the tank. If the film does not form, you can be sure that this is the cause. To get some idea of the magnitude of the problem, add sulfuric acid to the tank to eliminate the problem and keep track of how long it takes for the problem to reappear.

Check the flow of rinse waters between the cleaner tank and the acid tank, and if possible check for cleaner concentration in these rinses. Someone may be trying too hard to conserve water. Check on the parts being processed. It may be necessary to redesign the racks to get better drainage and reduce drag-over. Installation of fog nozzles at the exit end of the cleaner tank may be helpful.

More frequent replenishment of the powdered acid may enable you to avoid the problem. But unless the basic problem is corrected, there will be excessive acid consumption.

* * * * *

Barrel Nickel

Q. *I am having trouble getting enough current into my nickel barrel to maintain a bright deposit. How do I correct this?*

A. Assuming that your nickel plating solution is at the right concentration, in proper balance and at the proper temperature, you have enough anode area, and are using the proper voltage, the problem must be in the equipment.

Check the plating barrel and if the holes are plugged, drill them out. Plugged holes reduce solution transfer so that the solution in the barrel depletes and will not carry current. Such plugging can also reduce the available area through which current can pass to the work and act as an added resistance in the circuit. However, in this case, the current would remain at a constant low level, not start off at the proper level and fall off as plating progresses.

Check the horns and saddles. Make sure they are clean and making contact. An improper contact increases resistance and causes current flow to fall off. Check the barrel danglers or contacts to make sure that a similar condition does not exist there. Check the bus bar all the way back to the rectifier for poor contact. Heat is a sure sign of trouble.

Check all the insulators on the plating tank to make sure that the current is not shorting through the tank instead of going to the barrel.

When you have all these factors checked you should be able to get the current you need. If you have a continuing problem, have the rectifier checked to insure that it is operating properly.

In addition to all of the above, or even as a first step, it might be well to check that you are not overloading the barrel. Try plating a smaller load and note whether you draw the same amount of current on this smaller load. If so, is the plate bright? If the answer to both these questions is yes, you may have to rework your equipment to provide additional current-carrying capacity, or reduce the load size.

* * * * *

Silver Peels from Beryllium Copper

Q. *We are having problems with peeling of silver from beryllium copper. What can be done?*

A. There are two immediate areas of concern that occur to me. First: are you using a suitable copper strike? Second: beryllium copper requires special acid treatments in order to avoid the formation of a smut on the surface. These are generally oxidizing type acid dips, available through most suppliers as proprietary acid compounds. Additionally, you should make use of the information and help available from the supplier of your cleaning compounds and/or silver brighteners. Both of these companies should be most willing to help solve the problem.

* * * * *

Spotty Black Anodize

Q. *We black anodize 2024-T4 aluminum, using a titanium rack. The anodizing solution is held at 68-75F; the dye bath at 150F; we seal in hot water. Our anodizing voltage is 20V. The appearance of the product is spotty. What can we do?*

A. I would suggest investigating the following points:

1. Alloy 2024 is high in copper, and the acid etch that you are using is a straight fluoride type. It is possible that this is leaving a non-uniform film of copper on the surface. This results in a spotty anodize film. The addition of 10-20 pct nitric acid to the etch would help eliminate this.
2. Since you indicate that your anodizing tank is 50 ft long, you may be experiencing non-uniform temperature in the solution, which is producing the non-uniform appearance. This is particularly true since you give a temperature range of 68-75F. Your upper limit is close to the point at which a "chalky" condition could be expected in a fairly long cycle, and if insufficient agitation is used in the tank you might be exceeding the temperature locally.
3. It is also possible that the condition could be caused by too-high lime content in your dye bath. Because of the size of your tanks, you probably run the dye bath for long periods between dumps. In a situation like this, I would strongly recommend the use of deionized water for makeup and replenishment of the bath, to hold down lime buildup. Lime salts can react with the dye to form an insoluble precipitate which can adhere to the surface of the parts, causing a spotty condition.
4. A somewhat similar situation applies to your sealing tank. I strongly recommend that you refer to the section on Sealing in Wernick and Pinner—*The Surface Treatment and Finishing of Aluminum and its Alloys.* If you have a non-uniform temperature in the sealing bath, it could be that you are over-sealing in certain areas, thereby producing a condition known as "sealing bloom." This would also result in non-uniform appearance.

* * * * *

Residue on Black Anodize

Q. *We black anodize aluminum parts and seal in nickel acetate at 190-200F. The parts always have a residue that we have to wipe off. How can we eliminate this?*

A. First, use deionized or distilled water in the dye tank and the sealing tank. If tap water is used, impurities can build up and cause precipitation of the dye as well as drying on of salts. These could be the films you have to wipe off. Second, perhaps the anodizing tank is being run too warm and/or the parts are being anodized for too long a time. If the acid concentration is on the high side, this could also make the condition somewhat worse. To get a good black coating, a rather thick, porous anodic film is needed. In trying to get this, the temperature, time, and acid concentration are usually pushed toward the upper limits. But if any of these limits are exceeded, the anodic film can become chalky and powdery.

Third, it is also possible that the coating is being over sealed, producing "sealing bloom." The heavy coatings discussed under the second point are particularly susceptible to this. Reducing the sealing time and temperature should help.

* * * * *

Pinholed Hard Chromium

Q. *We hard chromium plate SAE 43 bronze castings. After plating, the chromium has pin or gas holes. What are we doing wrong?*

A. First, check to be sure that there is no porosity in the casting. Chromium will not bridge over pin holes. All these should be filled before the plating starts.

Second, be sure your cleaning process prior to chromium plating is not too severe. Certain bronzes are susceptible to attack by high-alkalinity cleaners and strong acids. Such attack may open up hidden pin holes or gas holes within the casting and then the chromium will not cover them. Try using milder cleaners and acids to see if this has any effect.

As a last resort, try avoiding any cleaning at all. To do this, remove heavy oils and greases and preclean with a mild detergent, such as dishwashing liquid. After being thoroughly rinsed, the part is hung in the chromium plating tank, where it is allowed to rest for five minutes, with no current applied. In this case the chromium bath is used for cleaning.

After the five minutes has elapsed, the current is applied in the usual way. I once had a great deal of success with the cutter blades of an aluminum-magnesium bronze, used in the first garbage disposal units, using this technique.

Finally, check to see if your chromium bath is badly contaminated as a result of precleaning steel, brass, bronze, and other metals in the tank. When the total dissolved metal (iron, copper, nickel, zinc, and so on) totals approximately 20 g/liter, a chromium solution becomes very unstable. It will become very difficult to maintain proper conditions, and gas pitting is a common problem. Discarding the bath and building a new one usually eliminates the problem. One correspondent, who hard chromium plates zinc base die-castings has just reported such an occurrence to me.

* * * * *

Non-Adherent Dye on Zinc

Q. *I'm having problems with adhesion of a dye to zinc plated parts. The brass dye wipes off, even after lacquering. Also I have excess drips on some dip-painted parts—mostly dark enamels. The detearing unit doesn't seem to help. Baking these parts results in blisters at the drips. Can you suggest ways of eliminating these problems?*

A. I presume that you are applying a clear chromate, which is then dyed to produce the brass color. When a chromate is dried at too high a temperature, it becomes powdery, non-adherent, and loses it's corrosion resistance. If you are drying at too high a temperature, it would explain your problem. Keep your drying temperature below 150F and see if this corrects the problem. Other possible causes are failure to maintain pH of the chromating solution, and failure to properly neutralize between zinc plating and chromating. Both of these conditions can contribute to the formation of a powdery coating. Lacquer applied over such a powdery, non-adherent coating will not adhere.

To avoid the drips, you will have to either adjust the viscosity of the paint or alter the rate of withdrawal of the parts from the dip tank. The more viscous the paint, the slower the rate of withdrawal required. When these two factors are mismatched, the drip will not have time to form properly before the parts pass over the detearing unit, which will then not be effective.

* * * * *

Chromated Cadmium

Q. *We plate cadmium and then apply a clear chromate. Small fasteners (e.g., 6-32 ×* $\frac{5}{16}$*) are being plated. We need a bright, shiny appearance, but every job shop we have tried has great difficulty producing it consistently. We also have problems with gray spots developing on the threads. How can this be corrected?*

A. Assuming your fasteners are made from a suitable steel using proper metalworking techniques, you should have no problem. Since you also report gray spotting in the threads, I suspect you are having problems with your threading machines and/or your base stock.

Gray spotting in cadmium is similar to the spotting out that occurs on brass. It very often occurs on threaded parts when there are problems with the tooling, the threading machines, or the stock, so that there is some delamination of the metal in the threaded area. This delamination results in the formation of capillaries, which are extremely difficult to clean and rinse. They therefore retain solution, which reacts with the cadmium plate to cause the gray spotting.

Since they retain solution so tenaciously, they also carry over materials from tank to tank and make it difficult to get a consistently bright finish. Some of the delaminated material may even break off and contaminate the plating solution with metallic particles, which will then adhere to the work, producing a very rough finish.

Check your tooling and the maintenance program for your tooling. Examine the consistency and the quality of the wire used as raw material. Look particularly at the possibility of scale being drawn into the surface; and at grain size, temper, and the consistency of composition.

Once all of this is corrected, your problem will probably be eliminated. The existence of this delaminated condition can easily be confirmed by microscopic examination of some of the parts both before and after plating.

Rule Five—Look at the Record

Bath Analysis

Q. *What is good practice in scheduling the analysis of plating baths?*

A. There is no need to repeat here the answer given to this questioner. It was included almost verbatim in the discussion of Rule Five. It won't hurt to go back and read it again, though.

* * * * *

Nickel Bath Temperature

Q. *In analyzing nickel solutions should I reduce the temperature of the solution from 140F to room temperature and then begin to titrate, or titrate at the solution temperature of 140F? I notice that when I reduce the temperature of the sample, there is crystallization in the bottom of the sample bottle.*

A. Pipettes for use in measuring out a sample for analysis are usually calibrated for use at room temperature. If rigorous accuracy is required, the tank sample should be cooled to room temperature before the pipette is used to measure out the titration sample.

In practice however, the tank sample will vary with differences in solution level at the time the sample was taken. For example, in a tank 36 inches deep, a difference of one inch in solution level will introduce an error of 2¾ pct in the analytical results.

Since errors of this type will often cancel each other out, it is usually permissible to take the titration sample without regard to the temperature.

The crystallization problem you mention may be the result of excess boric acid in the solution. This generally is not harmful to the bath but if the solution temperature is allowed to drop for long periods, as for example, over the weekend, rough plate can be encountered when starting up on the following Monday. It will occur because the precipitate will take some time to redissolve. Unless there is some reason for operating at this high boric acid concentration it might be wise to allow the concentration to drop somewhat.

* * * * *

Peeling Watts Nickel

Q. *We are having peeling problems in plating from our Watts nickel bath. We have just added boric acid. Could this cause the problem? The pH is 5.7; the current density, 7-10 asf.*

A. Assuming that you are operating your bath at or near room temperature, the addition of boric acid should not cause the problems you are encountering. The pH of 5.7, however, might be a problem. The pH should be close to 4.5 or at least between 4.5 and 5.0. Also it should be noted that 7-10 asf is not a very high current density for this type of solution; 20-25 asf is usually quite acceptable (generally obtained at 4.0-4.5 volts) and this will quite probably prevent peeling at the contact point.

You should also check to make certain that the parts are properly wired and that the wire is of adequate size, i.e., it should not get hot during plating.

If agitation is used during plating, either of these conditions can result in arcing and/or passivation at the contact point. This results in intermittent current supply and the peeling condition you describe.

* * * * *

Lead in Gold Bath

Q. *How do I remove lead from my gold tank sample before I begin gold analysis? It appears that the lead is precipitating out as lead sulfate and altering my results.*

A. A bath so heavily contaminated with lead that the lead interferes with the gold analysis would be essentially useless, unless it was being used to produce a "smut" for decorative relief purposes. A friend at a large gold plating supply house confirmed this, but gave me a procedure for avoiding the problem. The precipitation of the gold and lead should be carried out as usual. After precipitation, the precipitate should be washed extensively and thoroughly with a mixture of ammonium acetate and acetic acid. This will solubilize and remove the lead, so that the residual precipitate can be dried and weighed as pure gold sulfate.

* * * * *

Need Blue Chromate for Zinc

Q. *We operate chloride and cyanide barrel zinc lines plating a variety of fasteners in large quantities. We are looking for a bright bluish clear chromate. We have tried every major clear chromate but consistently have problems maintaining the blue color. The finish is often clear rather than blue. We check bath concentrations and rinses daily. What else should be done?*

A. You are probably depleting the chromate between analyses. Since most of the "blue brights" are relatively dilute, consistent results are best obtained by replenishing continuously. Consider the use of a brightener-feed pump to automatically maintain your chromate concentrations. The pump could be coupled to the drive unit on your automatic machine, so that the pump operates only when the machine is running. I know of several installations using chromates in this manner and they have no problems with consistent results. In a number of cases, the operators have found that the automatic pumps actually save materials, since the chromate is used more efficiently and consumption is thereby reduced.

Rule Six—Get the Facts

Notice that this rule sometimes refers to getting information. Not just checking what you are told.

Scallops in Chromium Plate

Q. *Enclosed is a chromium plated part which has a scalloped appearance at the back edge of the I.D. Can you give us any advice to prevent this scalloping?*

A. To give a firm answer, much more information would be needed about your racking and masking procedure, type and positioning of internal anodes, and the preplating cycle. Your plating bath appears to be in balance, but some information about the trivalent chromium level and the levels of contaminants such as iron, and possibly nickel and copper, would be helpful.

Your current density is a little higher than I personally prefer for this type of part (I like 1.5-1.75 a.s.i.) and this could account for some of the nodular growth.

The front edge gives indications that there was considerable nodular growth on this edge and that this was removed by breaking the nodules off. This would imply that your masking and shielding procedures could be improved.

The scalloped effect at the back of the recessed area could be due to improper masking and shielding, inadequate cleaning, improper positioning of the internal anode, gas tracking, or improper cleaning of the internal anode.

It might help if you consulted the chapter on chromium plating in *Modern Electroplating*, edited by Lowenheim, published by John Wiley & Sons, Inc.

Comment: This could have been placed under Rule Eight—*Look at the Parts.* We did look at the part, and what we saw led us back here.

* * * * *

Iron in Cleaner for Aluminum

Q. *We clean 7075 aluminum in a cycle using a proprietary cleaner. Occasionally we get random severe pitting on about 20 pct of our production. Chemical tests show large amounts of* *iron in the cleaner when the problem occurs. Dumping the cleaner and making a new one eliminates the problem for several weeks, then it recurs. Could the problem be iron contamination? Why does the cleaner attack the tank? How can we correct it?*

A. From your description, I would assume that the cleaner you are using is a buffered, relatively low pH, non-silicated, non-etch cleaner for aluminum. This type of cleaner, if run hot for long periods with only minimal replenishment, can undergo a pH change; this will result in attack of the aluminum and occasionally of the tank. Attack is more likely if the racks make contact with the tank in such a way that the circuit is closed and a galvanic cell can be set up. It might be helpful therefore for you to monitor the pH of the solution over the next operating period and see if the onset of the problem coincides with any shift in pH.

The symptoms you describe could also fit another situation encountered previously. The problem was an alternating current short in a hoist motor that was used to transport parts down the line. When the motor was repaired, the problem disappeared. From your description of the problem, the amount of iron found in the solution seems to be more than could be expected from simple attack on the tank. This also points to the possibility of an alternating current short, since even relatively strong, silicated alkaline cleaners will attack steel when a short of the proper magnitude is encountered.

* * * * *

Silver Plate on Glass

Q. *We apply heavy silver plate to a conductive silver pattern fired into the surface of a glass. From time to time, we get a nodular growth on the edges of the pattern. The bath is filtered constantly. The problem sometimes disappears without our doing anything. Can you help? (Solution analysis given.)*

A. Since your problem is intermittent, it is going to be hard to find. However, you might check the following:

1. The pattern itself. . . is there any possibility that the conductive coating fired into the glass is non-uniform and the nodules are the result of build up of silver on areas of heavy concentration of the condutive coating?

2. Free cyanide . . . does the free cyanide of the solution occasionally drop too low?

3. Current density . . . even though you are using a relatively small amount of current, the printed area on the glass might be small enough to allow excessive current density, producing heavy build up. Can you calculate the actual area to be plated?

4. Carbonate content . . . your level of carbonate is approaching the point where it could cause rough plate; however, this is not likely to be the cause, since the result would be a continuous problem, not an intermittent one.

5. Check your filter for entrapped air. Occasionally introduction of air can cause a problem similar to what you describe. However, I think the probability of this is low.

Comment: This could also fit under Rule Twelve. What other rules should be applied? There has to be a pattern; how would you go about finding it?

* * * * *

Deburr Before Nickel Plate

Q. *We deburr and shine steel hooks prior to plating with nickel, but five pct of them are turned down due to rust. How can we stop this?*

A. You do not specify whether the rusting is occurring between the shine roll operation and plating, or after plating. If the rusting is occurring prior to plating, it is possible that there is insufficient temporary rust preventative in your shine roll compound. If it is occurring after plating, it is possible that the plating is too thin, or somewhat porous.

Porosity could be caused by impurities or solid particles in the plating solution. A thorough filtration might be helpful in eliminating it.

If you are using an abrasive compound for your deburring operation and not completely removing it in the shine roll operation, this could also contribute to porosity. It is sometimes desirable to incorporate acid cleaning between deburring and shine rolling.

Rule Seven—Look for the Pattern

Once again, it was difficult to find examples specific enough to illustrate this rule, since usually other rules are more outstanding. However, look at these two examples and then see how many others you can find in other sections.

Rusting Phosphatized Parts

Q. *We have a barrel line used to etch and deoxidize aluminum. The same line also has a tank for phosphatizing steel. The same rinse is used for the phosphate and the non-chromated deoxidizing solution. Lately phosphatized steel parts have been rusting occasionally before they are dried. What could be the cause?*

A. Check your production schedules. If aluminum is being run at the same time, or immediately prior to the steel, it is possible that the common rinse tank is at fault. The aluminum deoxidizer would be quite acid, and dragged-in deoxidizer could drop the pH of the rinse to the point where it could cause rusting of the phosphate. If the schedule cannot be changed, use one of the other rinses for the phosphate.

* * * * *

Bright Nickel Plus Silver

Q. *We apply bright nickel and silver to highly buffed reflectors. Occasionally we encounter streaking. It is most prevalent on the deeply recessed reflectors. Stripping of the silver has established that the streaking is in the nickel. We use an air agitated nickel and the problem never occurs on Monday morning. Batch treating the nickel eliminates the problem for a day or two. What can we do to stop it completely?*

A. You are obviously dragging something into the nickel: most probably small blobs of buffing compound. Try to improve your cleaning by raising the temperature and concentration of the cleaning compound. Use spray rinsing to help dislodge the blobs of compound, before reaching the nickel. Filter the nickel to remove the dragged-in compound before the air agitation causes it to impinge on the parts. Consult with the buffing room supervisor, asking him to keep the buffing fixtures cleaner; if this is done, less compound will adhere to the parts and this will simplify cleaning. Let the filters run all night and run the problem parts in the morning, when there is less chance of contamination. If the filters run all night make sure you check hoses and hose fastenings carefully so that there is no chance that a hose will slip and pump your nickel solution down the drain.

Rule Eight—Look at the Part

Tin Plate on Brass

Q. *We tin plate small brass pins. Some of these come out of the barrel stuck together. (Sample enclosed.) How can we prevent this?*

A. Two of the three samples sent had broken apart by the time they were received, but examination of these and the remaining sample under the microscope indicated that fusion of the tin plate was the cause. This could be caused by locally excessive current or an arc occurring during plating. This, incidentally, is not an uncommon occurrence in plating small, light-weight parts. The relatively low melting point of tin results in fusion and sticking rather than the burning or arc pitting that would occur with metals having a higher melting point.

Increasing the rate of rotation of the barrel might help. Better still would be to mix another part or some scrap with the pins, to break up the load. This would also help carry the current and prevent arcing. The parts or scrap should be chosen to permit easy separation after the plating is complete. A third alternative would be to use a barrel with button or bar contacts rather than danglers, to get better distribution of current to the load.

* * * * *

Notice that in the next three examples, the finishing procedure can be determined by looking carefully at the parts.

Spotting Out on Antique Brass

Q. *We manufacture a small item that requires an antique finish. This is produced by oxidizing brass, and after relieving it, coating it with lacquer. We have trouble with consistent color and with spotting out. One of our competitors doesn't seem to have these problems. Can you tell us what finish he is using (sample enclosed)?*

A. Stripping the samples you sent in with a neutral paint stripper removes the colored finish and leaves a burnished, bronze-colored surface. The procedure would appear to be as follows: 1) plate with bronze (or copper-rich brass to give a bronze color); 2) burnish; 3) coat with dyed lacquer. The uniformity of the color raises the possibility that the sequence might be as follows: 3) coat with clear lacquer; 4) dye the lacquer coating. The second procedure avoids any variation in color due to differences in the thickness of the lacquer film.

* * * * *

Better Brass Plate

Q. *We manufacture a brass item which does not look as good as that produced by some of our competitors. How can we improve our finish?*

A. Examination of the sample brass tubes you sent leads me to believe that the competitor's sample has been chemically brightened. Typical formulas and information can be found on pages 183-185 of *Electroplating Engineering Handbook*, edited by Graham, published by Van Nostrand Reinhold Company. If a formula using chromic acid is used, there will be some residual protection against tarnishing after treatment.

* * * * *

Silver Plated Brass

Q. *We enclose a brass watch dial, which has a blue color. Apparently it is silver-plated brass. Could you tell us how to duplicate this finish?*

A. The finish is a silver sulfide film. The sequence used to apply it probably resembles the following: 1) scratch brush the brass to produce the desired finish; 2) clean and flash with silver; 3) oxidize the silver in a dilute polysulfide solution (1 oz/gal sodium or calcium polysulfide—heated if necessary to 100-200F); 4) buff with a loose buff to lighten the sulfide film and produce the blue color; 5) buff with a hard leather buff to remove silver and brighten brass at indices; 6) clean and apply lacquer.

This item also could be produced by oxidizing the brass directly, without the silver flash. The resulting finish, however, would not be quite as blue as can be obtained by using the silver strike; and it would be more difficult to maintain at a uniform color level in production.

* * * * *

Here are two on zinc base die-castings. What other rules would apply?

Blistered Plate on Zinc Die Cast

Q. *The enclosed samples of die-castings are typical of a blistering problem we occasionally encounter. Can you help us solve it?*

A. Microscopic examination of the die-castings shows that when the blisters are broken and examined carefully, there is zinc on the back of the peeling plate, and the underlying surface has a characteristic "pebbly" appearance. This is always indicative of an over active surface on the die-casting at the time it is given a copper strike. The result is that the copper diffuses into the zinc fairly rapidly in those areas. This forms a zinc/copper intermetallic compound, which is extremely brittle and which breaks loose from the surface.

Old time platers used to refer to this as "overcleaning." It is now more generally recognized that this is caused by the use of either improper cleaning procedures, or by contamination of the cleaners and/or acids in the cleaning line. Copper in particular is extremely active as a contaminant capable of producing this effect.

* * * * *

Speckles on Plated Zinc Die Cast

Q. *I am sending you a plated and an unplated die-casting. Can you tell me what is causing the "speckles" on the plated one?*

A. Your problem is a combination of several conditions. Plated part: the "speckles" are a combination of pits and very small blisters. Unfortunately, the blisters were so small that I could not under cut them to see what the underlying metal looked like. Their size, however, would suggest the presence of very small pores in the casting. The areas in which they occur also coincide with defects in the raw casting. However, the number and distribution is greater than would be expected from the conditions of the raw casting. Hence, the conclusion that there are other causes as well.

Raw casting: both side faces of the raw casting show numerous cold shots and pitted areas. The front face and rounded edges show a denser cold chill area, suggesting a firmer casting structure. During buffing, the areas with cold shots and pitting would probably open up to show numerous small pores, and the blisters observed on the plated casting are more numerous in these areas. Therefore, I would conclude that part of your problem is in the castings.

The plating cycle: (eliminated from the question, but you can reconstruct it from the answer.) An electrocleaner is generally a poor choice for a soak cleaner, since the alkalinity is fairly high in order to give good conductivity. Therefore when electrocleaners are used as soak cleaners, they tend to attack the castings and open up pores. Install a properly buffered buffing compound remover in your line. This will improve buffing compound removal and reduce attack of the castings.

It is also important to keep both cleaners as free as possible of copper contamination, since copper will deposit by immersion on the castings, and even when noticeable only as a darkening effect, will promote blistering. Special cleaners and inhibitors for this purpose are available from plating supply houses.

Similarly, although one half of one pct sulfuric acid is a classical acid dip for die-castings, better materials are now available. Fluoboric acid at five pct will provide about the same activity, with the advantage that there is a greater reservoir of acid and therefore the dip will change its activity more slowly. The free fluoride will remove traces of adsorbed silicate from the cleaner. There are proprietary materials available that are even more effective.

The pitting: when viewed under the microscope the pits appear to be of two kinds—those caused by particulate matter, and those typical of grease or gas pitting. Better filtration of the plating solutions coupled with the use of a suitable nonpitter should help to eliminate this problem.

* * * * *

Sometimes the answer is not perfectly clear. Analyze the next three examples—where would you look? What rules apply?

Oxidized Bronze Plate

Q. *We oxidize bronze using a proprietary selenious acid compound to produce a decorative brown finish. The parts are then* *protected with a silicone oil and paste wax mixture. We are having trouble with parts turning blue or purple. This occur both before and after oiling. Sometimes only a portion of the part is affected. There also appear to be purple water marks. We are sending samples. Can you tell from looking at them what is wrong?*

A. Three parts is a small sample, but let's look in these three areas: 1) make sure that all parts are properly cleaned and activated in suitable pre-dips so that they enter the oxidizing solution with a uniform activity. 2) I suspect that your oxidizing dip is not being maintained with sufficient uniformity, therefore try holding concentrations and pH within narrower limits; 3) there is definite evidence that rinsing after the oxidizing step is not adequate.

It may also be helpful to use a neutralizer. However, this should not be used until the oxidizing solution has been at least partially rinsed off. Otherwise you are liable to precipitate some of the components and make the problem worse.

* * * * *

Smokey Copper-Nickel-Gold

Q. *What is the cause of the smokey appearance on the back of the parts and around the hole at the top? Parts are rack plated copper, nickel, and gold. The problem does not occur on every rack, nor on all parts on a given rack.*

A. Your problem stems from one of two causes: 1) your racks are not being properly stripped, therefore there is a buildup of metal on the rack; or 2) the parts are being pushed too far back on the rack tips so that they are too close to the rack insulation, or perhaps even touching it. In either event, the result is the same, the area is being shielded so that the copper and nickel cannot build up proper thickness and brightness.

* * * * *

Black Zinc Chromate

Q. *For over a year, we have tried to develop a black zinc chromate to replace spray painting of small parts. The results are disappointing as evidenced by the enclosed parts. Can you help?*

A. You have rinsing and drainage problems. With only a few finished parts to look at, I cannot tell which stage of the operation is causing the problem but complete examination of every step should make it clear which step is the culprit.

A stain like this also might result from drying the chromate with an excess of water on the surface. In the oven excess water can run down and collect at the points where you find the dull appearance. If this is the case, blowing the parts off with air prior to drying would be helpful.

* * * * *

Remember the last question under Rule Four? That time it was from a non-plater. This time it's from a plater, and there were parts to look at. The answers are somewhat different, even though the cause is the same.

Cadmium Plate Turns Black

Q. *We cadmium plate some small-diameter screws. A day or two after we plate them, the insides of the threads turn black. This seems to happen only when the weather is humid. A few samples are enclosed. Any suggestions?*

A. Microscopic examination of the screws indicates that the problem is in the threading of the screws. The face of the thread shows numerous instances of shredded, slivered, and delaminated steel.

While you have been successful in plating over these defects, the space between the defect and the underlying sound metal acts as a capillary pore, retaining certain amounts of various processing solutions. The occurrence of the problem only during humid weather indicates that you have been reasonably successful in eliminating retained plating solution, leaving only a residue of chromating solution, which has been dried more or less completely.

These retained salts can absorb water during periods of high humidity. They then set up a galvanic cell, attacking the surrounding cadmium and producing the darkening.

The best solution, although possibly not practical, would be to call the defects to the attention of the screw producer, and have him correct the condition. It could be caused by the threading dies, or by improper control of the metallurgical character of the steel used.

Alternative procedures would be to use the same techniques that are used to prevent spotting out in brass plated materials. More thorough rinsing might help, but from the nature of the defect, adequate rinsing would be difficult to maintain. Alternate hot and cold rinsing would be helpful in pumping out some of the retained solution. Even more thorough drying during humid periods might be helpful, too. However, care must be exercized not to exceed 160F, since this is normally the temperature at which the chromate gel is dehydrated, causing it to lose its protective characteristics. The use of a water shedding solvent rinse containing some rust preventive material is sometimes helpful in cases such as this.

* * * * *

This one we know we answered properly. The questioner later wrote in to tell us that our suggestions cured the problem.

Spotty Anodize

Q. *I am sending you a few pieces of anodized aluminum alloy 6063-T42. (Complete manufacturing and finishing cycle given.)*

We are seeing spots which look like the holes you may find in a sand casting. The spots are not evident until after the spray rinse following the dye bath. Not all pieces are affected, but the percentage is too high to tolerate. We feel it might be galvanic action, but do not have it on other items processed in the same manner.

A. Under the microscope, the spots appear to be caused by galvanic attack. However, this could be a result of selected removal of segregated materials in the extrusion. Check carefully to determine that the imperfections are not visible after anodizing.

It is possible that since you do not use an etch cleaner, but only a deoxidizer, there may be some residual abrasive from satin finishing. This could initiate galvanic action in the dye tank. If you can determine definitely that the imperfections are forming in the dye tank, make sure that the racks are suspended in such a way that they cannot complete the circuit with the tank walls, i.e., insulate the support bar from the tank, and/or the rack from the support bar. It is also possible that the condition can be alleviated by running the dye tank for shorter periods between makeups, or by using deionized water for makeup and replenishment. Occasionally, the build up of salts, including chlorides from the tap water, can lead to the development of a condition of this type.

* * * * *

Sometimes you have to look at the equipment rather than the parts.

Generator Overheats in Hard Chromium Plating

Q. *We use a six-volt, 1000-ampere generator for hard chromium plating. After several hours running, the generator heats up, and the voltage and amperage drop. Lubricating the commutator and brushes helps for about one half hour, but then heating begins again. What's wrong?*

A. There are three possibilities: 1) the pigtails on the brushes on your generator have oxidized as a result of overheating at various times in the past and are now unable to carry the current without heating; if this is so, replace the brushes with careful attention to the sizing of the pigtails; 2) your brushes are improperly or unevenly worn as a result of the pressure springs being off center; when this occurs, the brushes tend to bind up in the holders, make poor contact and therefore heat up; the net result is that the pigtails also heat up and produce the condition above; replacement of the brushes and adjustment of the pressure springs will usually correct this condition; 3) your armature has not been cleaned in a long time, and as a result there is leakage across the armature slots, resulting in a buildup of heat and a loss of power; again the net result is to ruin the brushes as they overheat.

It may be enough to clean the armature slots, or if the armature is worn unevenly, it may have to be turned down to a smooth surface before the slots are cleaned. The brushes should then be replaced.

Rule Nine—Keep it Simple

We were going to repeat here the full question and answer used as a condensed illustration in the discussion of Rule Nine. But why bother? Added detail will not re-emphasize the point. Go back to Rule Nine and read the condensation again.

Spots in Brass and Silver

Q. *Our company has recently experienced some spotting problems. How do you explain: 1) yellow brown spots while brass plating over steel, cast iron, and die-castings; 2) white spots after silver plating brass, copper, and brittania; and 3) blisters when silver plating over brittania?*

A. Without knowing your exact cycle, my best guess is that all three problems are related, and probably originate in pores in the basis metal.

Problem No. 1 is probably typical spotting out, and information on how to cure it can be found in the special section on spotting out.

Problem No. 2 probably has the same cause. The first stage in spotting out with silver is the formation of a white spot. This often turns black after exposure to light over a period of time.

Finally, the trapped solution in a pore can be plated over and result in blisters such as you are experiencing with the brittania.

If the three problems are not related, there are a multitude of possibilities which could only be sorted out by going over the detailed cycles.

Rule Ten—Test It

Stained Rhodium Plate

Q. *After rhodium plating, we have two still rinses and a spray rinse, followed by a hot air dryer. How can we avoid the stain left by the last drop of water?*

A. If rinsing after rhodium plating is not adequate, there will be enough salts left on the surface to cause such a spot. Perhaps you are running your still rinses too long between changes. Drying with a hot air dryer, especially if your spray rinse is heated, has a tendency to produce spots for two reasons: 1) the water evaporates before it can drain off the parts, thereby leaving a heavier residue of salts in the last spot; 2) the action of the chemicals present in the water on the plated surface is more rapid at high temperature and can sometimes produce a spot. Reducing the temperature of the final rinse and using cool air to dry frequently eliminates the problem. Try it.

* * * * *

Cleaning Brass

Q. *I am sending you some small threaded brass parts which give us a severe problem in cleaning prior to plating. Any suggestions?*

A. Your problem is twofold: 1) it is difficult to obtain good cleaning in very fine threads; 2) there appears to be an oxide on the threaded areas and it incorporates oil as part of the oxide coating.

I am returning some of your parts which have been successfully cleaned in the following cycle: 1) soak clean in an effective soak cleaner at about 8 oz/gal and 140F for three minutes, then water rinse; 2) deoxidize in a proprietary powdered acid mixture at one lb/gal and room temperature for one to two minutes, then water rinse; 3) repeat steps 1 and 2; 4) blow dry.

* * * * *

Chemically Cleaning Brass

Q. *I am sending you some brass parts which have a build up of solder fluxes, rolling oil, and finger prints. At present, the only way we can successfully clean these prior to oxidation is by mechanical abrasion. Can you tell us how to do it chemically?*

A. We are returning two of the parts that you sent. They have been finished according to the following cycle: 1) clean in an alkaline soak cleaner for one to two min at 140-150F; 2) water rinse; 3) deoxidize in powdered acid mixture at room temperature for 30 sec to one min; 4) water rinse; 5) oxidize in a sulfide solution; 6) rinse and blow dry.

* * * * *

Tarnished Brass

Q. *We lacquer highly finished brass pieces, wrap them carefully in tissue, then box and ship. We sometimes have trouble with staining and tarnishing of pieces received by the customer. Unboxed pieces wrapped and stored in tote pans never are rejects. Help?*

A. The most probable cause is the cardboard in your box. This type of paperboard often contains appreciable amounts of sulfur and this can be a problem when shipping brass, copper, or silver. Cardboard for this use should be sulfur free. To test your cardboard, lay a strip on a clean polished brass panel, moisten and apply a weight to insure good contact, and inspect the brass after 24 to 48 hours. There should be little or no tarnish if the cardboard is sulfur free.

* * * * *

Cleaning Electroforms

Q. *We electroform copper over wax molds and melt the wax out in hot water. The wax sticks and is difficult to remove before nickel and gold are electrodeposited. What can we do?*

A. The problem wax can be removed quite easily in mild, hot alkaline soak cleaner. The secret of success is to agitate, making sure that the temperature of the cleaner is above the melting point of the wax.

Some of the wax you sent was melted onto a clean, copper panel and allowed to harden. This was then cleaned in approximately two minutes in an alkaline cleaner at eight oz/gal and 200F, with agitation. The copper plated with no problem.

* * * * *

Flash Rusted Steel

Q. *We often encounter flash rusting on steel parts after leaving the electrocleaner following a muriatic acid pickle and rinse.*

A. This is usually associated with one of two problems: 1) rinsing is inadequate and residual acid is left on the parts so that when the parts enter the electrocleaner, materials precipitate on the surface of the part and these then attack the surface during electrocleaning; 2) excess iron contamination in the pickle, precipitating as ferrous hydroxide in the rinse.

This ferrous hydroxide is converted to ferric hydroxide in the electrocleaner and appears as flash rust. If occurrence is periodic, it is almost certainly caused by No. 2. If it disappears when a new pickle is made, you can be sure of it.

* * * * *

Manganese Phosphatizing

Q. *We operate a manganese phosphatizing system which includes a vapor degreaser, a rust and scale remover, rinse, soap rinse, and hot rinse prior to immersion in the phosphate. The majority of the material being phosphatized is 4140 steel.*

We are having smutting problems. This does not occur when we grit blast materials and by-pass the rust and scale remover, an inhibited phosphoric/HCl solution containing a surfactant.

We suspect that the inhibited acid is passivating the steel and thereby producing the smut in the phosphate. Can you tell us of any additive we can use in our rinse prior to phosphatizing, to sensitize the cleaned metal surfaces?

A. I assume the manganese phosphate you are using is a proprietary material and not one you make yourself. You should therefore be able to get considerable help from the supplier of the phosphate.

Since the phosphoric/HCl solution would be a powerful activator for the steel, it may be that the steel is being made too active. If so, the rate of attack in the phosphatizing solution will be too high to permit proper precipitation of the manganese phosphate and you will get solution of the steel rather than coating of it.

The use of a slightly higher pH for the phosphate solution will usually remedy this problem. Alternatively, it is possible to restore some degree of passivity by going through a plain phosphoric acid solution before going into the phosphatizing solution.

You may also use approximately 10 pct oxalic acid as a pretreatment before phosphatizing, after the rust and scale has been removed. Some suppliers have titanium-based grain refiners that can be used as a predip before phosphatizing. These mainly function as nucleating agents to produce a fine-grained phosphate coating.

You would not have this problem with the grit blasted parts, since they would not have been activated by the rust and scale remover and could therefore tolerate lower pH in the phosphatizing solution.

An alternate possibility is that the inhibitor in the rust and scale remover is so powerful that it is not removed in the subsequent rinses. Therefore it is still on the surface when the parts enter the phosphatizing solution. If this is the case, processing the parts through a good soak cleaner before phosphatizing should remove the inhibitor and eliminate the problem. As you can see, there are a number of possibilities; some experimentation will be necessary to arrive at a solution.

Rule Eleven—One Boss

We couldn't find any examples for this one.

Rule Twelve—The Unsolvable Problem

We found only one example of this. It made up two parts of a three part question.

Blackening Anodize

Q. *Problem 1: black dye on sulfuric anodized parts. Residual black dye covering sulfuric anodized parts is costly to remove mechanically. Problem 2: so-called smut, also on anodized parts after nickel acetate sealing, is difficult to remove without incurring costs. Problem 3: in one of your previous answers you mentioned blackening nickel plate chemically. What is the process?*

A. To answer Problem 1, there is simply no economical way to remove it. The best thing to do is prevent its development in the first place. To do this make up dye and sealing baths with deionized water and replenish only with deionized water. Discard the solutions as soon as there is any evidence that hard water salts dragged in from the rinses have built up to a point where they are precipitating the dye.

In answer to Problem 2: again there is no way you can remove it cheaply once it has occurred. This smut is what is known as "sealing bloom." The best thing is to prevent its formation in the first place. In addition to the suggestions above, make sure that you do not overseal, and that the pH of the dye bath and the sealing bath are maintained properly. Consult Wernick and Pinner's *The Surface Treatment and Finishing of Aluminum Alloys*, starting on page 704. This work covers in considerable detail the problem of sealing bloom and its prevention.

In answer to Problem 3: the method for blackening nickel plate chemically actually involves the use of a metal stripper. A proprietary metal stripper with sulfuric acid and activator, as used for stripping nickel plate from brass can be used, but at one half the recommended concentration of nickel stripper (sulfuric acid, usually three or four percent). Keep the temperature below the recommended stripping temperature. A temperature of 90 to 110F is usually satisfactory. Conditions should be adjusted so that the parts turn black in not less than 30 seconds and not more than one minute.

Should I?

Copper-Nickel-Brass

Q. *What are the advantages and disadvantages of having nickel, copper and brass in one line, using the same cleaning cycle, as compared with three separate lines?*

A. The relative merits of the two systems are so involved with production requirements, product blend, available space and other engineering values that they can hardly be said to have relative advantages and disadvantages. Rather we must say that there will be an optimum choice in each case based on engineering considerations.

For example, under the heading of production requirements it is necessary to consider the problem of flexibility of capacity. If production requirements are high, the installation of a separate line will provide a more spacious arrangement, which will be better able to handle temporary surges of production. At a lower level of production it would not be possible to justify the added floor space.

Under the heading of product blend, it is necessary to consider the variety of finishes required. Thus if nickel is to be applied to all parts, and a proportion flashed with copper or brass for decorative purposes, the single line (or a variation thereof which would separate after the nickel into separate lines for the copper and brass) would probably be preferred. But if copper and/or brass were to be applied directly to the basis metal in some cases, separate lines would be more desirable. This choice would be based on the desired cycle containing a final pH-adjusting step immediately before plating. It would be alkaline for copper and brass and acid before nickel.

The variety of basis metals to be plated also must be considered. If only a limited variety of basis metals and a relatively narrow range of soils are involved, the cleaning cycle can be optimized for these conditions and a single line would be effective. Where multiple basis metals and multiple soils are involved, separate lines with varied cleaning cycles would be advantageous.

There is always of course the possibility of cross contamination when a number of plating baths are placed in the same line. Careful arrangement of the various travel paths is necessary to prevent drippage of contaminants during transfer. Rinses must be similarly arranged to prevent cross usage and resultant contamination.

If waste treatment is involved, the problem of collecting and segregating the various wastes is generally simplified by the use of separate lines.

Only after careful consideration of these and other factors can a proper decision be made.

* * * * *

Programmed Hoist Versus Open and Closed Barrel Automatics

Q. *What are the advantages and disadvantages of a programmed-hoist zinc plating system when compared with open-barrel and closed-barrel types?*

A. The programmed-hoist automatic system offers maximum versatility in regard to variation of cleaning cycle, time of plate, and choice of post treatment. This flexibility is combined with the advantage that once the necessary program has been set up, the process becomes essentially automatic. Changes in various programs often can be made quickly by adjusting timers, current controls, and other controls on the master panel.

Both closed and open barrel automatics have essentially fixed cycles, and the difference lies mainly in the fact that the open-barrel type can be arranged easily for automatic loading and unloading.

Based on these very brief considerations, it can be said that the programmed hoist system would be preferred where this flexibility would be of special advantage. The closed-barrel system would be preferred in fixed cycles with relatively small lots of many types of parts which must be kept separate by lot or type. The open type would be preferred for cases where relatively long runs of a single type part are made.

Programmed hoist and closed-barrel types generally require a higher ceiling clearance than the open type. Depending on the complexity of the flexibility built into the units, costs can vary widely, but generally, the more flexible the unit, the more costly it will be.

Both the programmed hoist and the closed barrel type will usually require more floor space than the open-barrel type.

Be prepared to provide information on the following points when calling manufacturers: 1) production requirements, both present and anticipated; 2) areas available, with complete details as to free space (locations of columns, etc.), ceiling height, location of services (water, steam, electricity, etc.) and service capacity; 3) pertinent information as to waste disposal requirements, present and proposed treatment equipment and so on; 4) the variety of basis metals expected, together with the expected cycles for handling the various types; 5) the variety of finish requirements and the relative proportion of the various finishes in the production requirement.

With this information at hand, engineers can make recommendations as to the best use of their equipment, and how to exploit its various advantages to provide the best possible set up.

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Electroless Nickel Versus Nickel Electroplate

Q. *What are the advantages and disadvantages of electroplated nickel compared with electroless nickel? Which has the better corrosion protection, hardness, fatigue strength, ability to withstand higher operating temperature and lower cost? Could they both be used prior to brazing?*

A. In discussing the relative merits of these two finishes, it is important to remember that they are not just two different methods of applying nickel to a surface but are actually two different materials.

Electrodeposited nickel, despite the rather wide range of modifications possible by solution changes and the use of selected additives, remains essentially pure nickel. Electroless nickel, on the other hand, is an alloy of nickel and phosphorus, the composition of which can vary only over fairly restricted limits. While the major portion of this alloy is deposited by chemical reduction, it is possible to produce the alloy electrolytically and with a somewhat wider range of composition than can be obtained by chemical reduction alone.

Therefore two different sets of differences must be considered: those attributable to the different application methods, and those caused by differences in composition.

While the characteristics of a deposit produced by chemical reduction will vary depending on solution composition and operating conditions, any given set of conditions will yield uniform results over the entire piece if sufficient agitation is provided to prevent localized changes in the solution.

Electrolytic deposition is subject to variations caused by solution composition and operating conditions, but it is also affected by current density. Uniform results over the entire piece can therefore only be obtained if the current density is also made uniform over the entire piece. In many cases this presents an almost insoluble problem in rack and anode design.

Electrolytic solutions during use change composition relatively slowly, and generally in relatively minor ways. Electroless solutions, on the other hand, change relatively rapidly, and in a comparatively drastic manner, because of the consumption of metal and reducing agents, and because of the build up of by-products which alter the characteristics of the bath and the deposit. Control of electroless solutions is therefore more important and more difficult than control of electrolytic solutions. Electroless nickel solutions tend to produce deposits which have lower porosity than electrolytically deposited material. Electrolytic deposits show a more or less linear increase in corrosion resistance with thickness as a general rule. Electroless deposits will exhibit the same linear increase until a critical thickness, which varies with the condition of the substrate and with the pretreatment procedures used. At this point, porosity essentially disappears, and there is a sudden and very marked increased in corrosion resistance. Thereafter, corrosion resistance continues to increase as a function of thickness.

Electroless solutions tend to deteriorate with age because of the by-product buildup. Periodically, they must be subjected to extensive purification procedures, or discarded and made up new. In addition, they may, if not carefully maintained, spontaneously decompose and plate out on tank walls, pumps, filters and so on. This together with the greater cost of chemical reducing agents as opposed to consumption of current, results in an appreciably higher cost for electroless nickel.

The nickel-phosphorus alloy is somewhat more resistant to corrosion than pure nickel. This in combination with the lower porosity results in generally higher corrosion resistance for electroless nickel. If a top layer of chromium is applied, however, this situation may be reversed and electrolytic nickel may provide better corrosion resistance.

Electrolytic nickel, depending on the solution and conditions used, may vary in hardness from 140 to 500 Vickers. Electroless nickel lies in the range of 350 to 700 Vickers, and may be raised as high as 1100 or lowered to 3 by varying conditions and post treatments such as heat treating.

Stainless steel plated with electroless nickel shows favorable fatigue characteristics. The case for plain steel is not as clear cut.

The higher lubricity of electroless nickel alloy is sometimes of value in anti-galling applications. It is also claimed that electroless nickel deposits inhibit stress corrosion of stainless steel.

Electroless nickel, in general, brazes and solders well, but is difficult to weld. Problems with hydrogen embrittlement appear to be less pronounced than those associated with electrolytic nickel. The preplating cycle, however, has a strong effect on this characteristic.

Electroless nickel is less magnetic than electrolytic nickel. In addition, on non-catalytic metals, deposition may be controlled by careful manipulation of the activation process, eliminating or simplifying the need for masking.

Electroless nickel is extremely difficult to strip, except with nitric acid, and the processing of rejects becomes a problem unless the basis metal is resistant to nitric acid.

In each particular application, it is important to weigh the advantages of the electroless process carefully to determine if the higher cost of application is justifiable.

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Nickel-Brass Versus Brass Alone

Q. ***What are the advantages and disadvantages of a nickel brass finish compared with a brass burnished finish on low carbon steel?***

A. The greatest advantage of the burnished brass is its combination of a greater thickness of brass plate, and the fact that it is burnished. The heavier thickness insures that if and when the overlay of protective lacquer is worn off the brass surface may be repeatedly cleaned and polished without wearing off. The burnishing operation ensures a low degree of porosity, and as a result gives a lower incidence of spotting out. If the thickness is adequate, somewhat greater resistance to rusting of the basis metal may be expected. Depending on the methods used to produce the burnished finish, a very high degree of smoothness can be produced, and because of the softness of the brass plate, this can be done with less time and effort than are required to produce the same finish on the harder steel substrate.

The disadvantages arise from the same combination. The greater thickness of plate requires considerably longer plating times (the efficiency and current density range of brass solutions are generally considerably lower than those for nickel solutions).

The problem of maintaining color also becomes more pronounced as the thickness is increased. The burnishing operation represents an additional step in the procedure, and since it is not always adaptable to automation, the labor costs of the process tend to be higher.

The nickel brass system has the advantage that it may be conveniently automated. It also produces excellent brightness from the plating solution, without further operations. Color maintenance is simplified.

The disadvantages arise from the same sources. The brass film is thin and will not withstand cleaning and polishing if the lacquer film is worn off. Because the bright nickel tends to magnify surface defects, the basis metal must be more carefully finished. This can in part be overcome by using a high-leveling nickel, or a duplex nickel, but the process then becomes more complicated.

If an adequate thickness of nickel is applied from a carefully purified and filtered nickel solution, corrosion resistance will be excellent and spotting out will be minimal. If however, the nickel film is thin, or the solution not properly cared for to reduce porosity and inclusions, corrosion resistance will be low, and spotting out a problem.

Both systems can be used to produce quality finishes. The final determination as to which system to use must be based on the end use of the product (the degree of wear resistance required, etc.), the facilities available, and the sizes and shapes of the parts (some parts by nature are not easily burnished or because of construction are too easily damaged).

* * * * *

Clean Bronze Anodically or Cathodically?

Q. *Should bronze basis metals be cleaned anodically or cathodically?*

A. All metals should be cleaned anodically, at least for the last portion of the cleaning cycle. Time should be sufficient to insure that any impurities plated out on the surface during cathodic cleaning are completely removed. This implies as a corollary that cleaners suitable for the various basis metals will be used, and that concentrations, temperatures and current densities will be kept within acceptable limits.

* * * * *

Phosphatize Aluminum Before Painting?

Q. *What is your opinion of painting aluminum parts without a phosphate coating pretreatment?*

A. While it is entirely possible to obtain excellent adhesion of paint on aluminum which has simply been adequately cleaned, the need for rigorous and exact cleaning makes it difficult to maintain consistent results in production. For consistently good adhesion, it is desirable to coat the surface with either a chromate, a phosphate or an oxide.

Where it is necessary to process both aluminum and steel in the same cycle, chromates are eliminated, since no suitable chromate coating has been produced on steel. Similarly the procedures for producing oxides are widely different for steel and aluminum and therefore a single solution for oxide coating both metals is not available.

Phosphate coatings present a different situation. While many of the iron phosphates do not produce suitable coatings on aluminum, there are specialty products which will produce an iron phosphate on steel and a mixed phosphate/oxide on aluminum. The resulting coatings provide excellent adhesion of paint to both steel and aluminum.

If the aluminum is being painted by electrodepositing the paint (electrocoating) no conversion coating may be necessary. Research indicates that there may be some "in situ" anodizing in the electrocoating process. The resulting oxide film would of course provide excellent adhesion.

* * * * *

Finishing SS Surgical Instruments

Q. *Our company makes surgical instruments used in probing joints in various parts of the body. We use 300 series stainless* *steels. What finish should be employed to insure that all surface impurities including steel particles are removed?*

A. In view of the end use of the probe, a high degree of smoothness would most likely be desired. Electropolishing would impart this smoothness and at the same time partially passivate the surface and remove any embedded particles. Alternatively, passivation in hot 50 pct nitric acid would insure removal of particles but would not smooth the surface. Ultrasonic cleaning or standard cleaning procedures would not insure the removal of all metallic particles.

* * * * *

Skin Irritation from Black Oxide

Q. *We have just set up a proprietary high temperature bath for applying a black oxide coating on steel. The bath works well but we are having a great deal of trouble with irritation of operators' skin. Is there any way to overcome this?*

A. Black oxide baths of the type you mention are all highly caustic and operate above the boiling point of water. Unless properly operated there is a great deal of splattering and spray release. This carries salts into the air and if they should settle out on the operators' skin, they will cause irritation.

The following precautions should be observed. While the solution must be kept at the boiling point, it need not boil violently. The process of boiling causes steam bubbles to form and rise to the surface, where they break, throwing salts into the air. An excessive boiling rate leads to unnecessary fuming and splatter. The boiling rate should therefore be kept as low as is consistent with maintenance of uniform temperature.

Secondly, as much as possible of the excess water should be removed from the parts being processed before they are immersed in the solution. The parts should be immersed very slowly so that most of the water is evaporated before the parts actually enter the bath. Under no conditions should a basket full of wet parts be immersed quickly in the solution, since the water carried in in this way will generate a great deal of localized boiling and cause a severe fume problem.

Additionally, since the evaporation of water requires approximately 1000 Btus per pound, appreciable energy savings will result from the elimination of this excess.

When water is added to the bath it should be added as slowly as possible, and preferably under the solution surface. Otherwise excessive splatter and fuming will take place. Most suppliers of proprietary salts have available descriptions or diagrams of devices suitable for the safe addition of water. They may also have available an addition agent to provide a light foam blanket on the solution, to hold down fuming.

Operators should wear long-sleeved shirts, long-sleeved gloves, and goggles or a face mask. Clothing should be washed daily. Workers should wash exposed skin thoroughly and often, and after washing use a dilute boric acid solution to insure complete neutralization of any alkali splatter.

The baths should of course be ventilated.

Rinsing parts after treatment should be very thorough to ensure that no residual salts remain. Failure to rinse thoroughly can lead to skin irritation on the part of operators who subsequently handle the parts.

Where these techniques are properly applied, I have never seen any problem with skin irritation on the part of the operators.

* * * * *

Fumes from Cyanide Solutions

Q. *We barrel plate using cyanide solutions and are having fume problems. Are there any fume suppressants that we can use, or must we install an exhaust?*

A. There are two sources of fumes from a cyanide tank. The first is the spray of solution carried into the air by the gas generated during plating. This is both irritating and poisonous, but may be controlled by developing a foam blanket on the solution. Most proprietary brighteners contain surface active agents which will produce such a foam blanket.

In the absence of a brightener system, small amounts of a compatible wetting agent such as sodium lauryl sulfate may be used. It is wise to check the compatibility of any wetting agent selected by running Hull Cell tests before it is added to the production bath.

The second source of fumes is the cyanide compounds released as a result of the carbon dioxide in the air reacting with the solution at the air/solution interface; the breakdown of cyanide in the bath as a result of electrolysis and pH changes, particularly at the anode; and in the case of brass solutions, the release of ammonia fumes when ammonia is used to control color. These fumes will not be prevented by a foam blanket, although their generation will be somewhat reduced and their release distributed more uniformly over a longer period.

Safety dictates that some form of mechanical exhaust or fume extraction be used to remove these gases from the area. They can be particularly dangerous, since at low levels, olefactory fatigue desensitizes the sense of smell and operators may be exposed to dangerous concentrations without realizing the danger.

* * * * *

Paint on Cadmium Plate

Q. *We use a steel can, cadmium plated, with corners soldered and spray painted outside. We would like to eliminate either the plating or the painting. Would you comment on: 1) cadmium or tin plating without painting; 2) immersion phosphatizing followed by painting the outside? Exposure is indoors in unheated industrial buildings.*

A. Either system should give you adequate protection. However there are certain considerations and drawbacks in each case.

Tin plating will give protection from corrosion and retain its appearance over a considerable period, provided that it is completely pore free. If the plate is not bright enough, it can be reflowed to give a hot-dipped appearance.

Cadmium is sacrificial in nature and will therefore protect steel even if there are small pores in the coating. Cadmium, however, since it is somewhat reactive, tends to lose its bright appearance as a result of being handled and exposed to the air. The resulting matte white finish is not unpleasant and this natural degradation can be considerably retarded by the application of a clear chromate after plating.

There are also available chromate coatings which produce an iridescent yellow coating, or even an olive drab coating that will even further increase the corrosion resistance of cadmium plate.

Cadmium has come under severe restriction because of waste disposal problems. However, this discussion of cadmium applies equally well to zinc, which could be substituted.

A good phosphate coating properly covered with a suitable paint would certainly protect for very long periods against the atmosphere that you indicate. However on the inside of the can you would be banking on the phosphate coating alone as a rust preventive.

Since you indicate that the can is not hermetically sealed, temperature and/or atmospheric pressure changes are going to cause the can to "breathe" with the result that a certain amount of atmospheric moisture is going to find its way inside the can. This will ultimately cause the interior surface of the can to rust, since phosphate alone has only limited rust preventive characteristics.

The use of a good chromate seal after phosphatizing would provide an improvement in corrosion resistance. In any event, it is not likely that the amount of rust generated in this way would be extensive, nor that it would occur rapidly.

To sum up, it is quite probable that either system you propose could be made acceptable and the decision can be made on a cost basis.

* * * * *

Acid Tin for Food Handling?

Q. *Can an acid tin bath be substituted for an alkaline stannate bath for plating cast and malleable iron products to be used in food handling?*

A. The throwing power of an acid tin bath is not always as good as that of an alkaline stannate bath. Assuming that the shape of the parts is such that the throwing power is not a problem, or that a suitable proprietary tin bath with good throwing power is selected, there is no reason why an acid tin solution cannot be substituted for the alkaline tin. However, it is extremely important, particularly when plating food handling equipment, that the parts be completely and thoroughly covered with an adequate deposit of tin.

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Ball Blankets for Dip Lacquering

Q. *We are considering using "poly" balls to retard evaporation from a dip-lacquering tank. Are they effective? What problems could we anticipate?*

A. Personally, I have used "poly" balls only to retard the evaporation of aqueous solutions, and they can be very effective. They have the drawback that they tend to get caught in the parts and the racks entering and leaving the solutions, and may be dragged into the rinses or other tanks. So there is the constant problem of scooping the balls up and returning them to the original tanks. Furthermore, constant contact with the parts entering and leaving the tank can roughen the balls' surfaces, so that parts entering and leaving the tank can be abraded by the roughened balls, causing rejects.

The application that you are considering would require that the plastic used to produce the balls be resistant to attack by the solvents contained in the lacquer and its associated thinner. Furthermore, the lacquer/thinner combination should not "wet" the plastic balls. If this occurred, the surfaces of the balls would in essence be converted to a thin film evaporator, greatly increasing the available area for evaporation, and consequently the loss of material from the tank.

* * * * *

Magnesium Anodes in Zinc Bath

Q. *My company has been using magnesium alloy (0.10-1.23 pct) zinc ball anodes for years to prevent high zinc build up during weekends and holidays. Our equipment has many obstructed areas that make it almost impossible to keep pulling out anode baskets. These anodes however cost considerably more than regular zinc anodes. Do we have to keep using them?*

A. While the use of magnesium anodes is acceptable, pure anodes are to be preferred not only because of the lower cost, but because of the effect on the plating bath.

This problem is a common one and can sometimes be offset by balancing the ratio of zinc to steel. Additionally, the presence of sodium carbonate in the bath is sometimes helpful in retarding dissolution. However, in many cases, despite all efforts in this regard, the amount of zinc will continue to build up. The problem was treated at some length in a note to *Plating and Surface Finishing* in April, 1971, by Graham and Zurbach. They make several suggestions as to how the problem can be corrected.

It is of particular interest to note in their discussion that the contact of the zinc anodes with the steel basket greatly increases the rate of dissolution. You might wish to consider their procedure, which involved plating the anodes and the anode baskets with a relatively thin layer of zinc, by reversing the polarity of the rectifier and using plain steel anodes on the cathode bar. This layer materially reduces the dissolution over a weekend and yet is thin enough to dissolve readily when operations are started again, permitting the steel to act as a depolarizing agent so that the zinc balls do not become polarized.

* * * * *

Silver on Copper Bus Bars

Q. *I have a three part question regarding plating silver on copper busbars: 1) your recommendations please as to the best acid pickle and bright dip combination prior to silver strike and silver plate; 2) what anodes if any can be substituted for fine silver anodes (we thought possibly 316 stainless [bagged], or titanium could be used); 3) is there a product on the market to prevent oxidizing of silver after plating?*

A. It is very difficult to specify a "best" acid pickle and bright dip for silver plating busbar. The exact choice will depend on the condition of the busbar as it is received, and the degree of brightness desired. Generally since the sulfuric acid salts of copper are more soluble than salts of other common acids, I prefer the use of sulfuric acid. If the oxide layer is light, and does not contain too much cuprous oxide, a simple powdered acid, or 10-15 pct sulfuric acid would probably be adequate. If there is an appreciable amount of cuprous oxide present, it may be necessary to use a mixed acid containing some chloride.

Similarly, if a good general luster rather than a definite brightness is acceptable, the use of a powdered acid containing one of the peroxyacids would probably produce acceptable results. These are generally available from suppliers of proprietary chemicals. The use of a material such as this will avoid the use of nitric acid with its associated fume problem.

Fine silver is the only material that is considered to be desirable in the plating bath. Generally the anode and cathode efficiencies of a silver plating bath are sufficiently close that the bath maintains its metal content at a very stable level.

The replacement of any appreciable percentage of the silver anodes with an inert anode such as stainless steel could result in a gradual loss of silver content in the bath. To replace this silver, cyanide would have to be used, and to obtain the silver content from this source is generally more expensive than maintaining it from the anodes.

If for any reason you do wish to replace a percentage of the silver anodes, the information available would indicate that stainless steel would be preferred. In some cases steel can be used, but there is a tendency for iron to build up in the bath. This acts as an impurity and must be removed by freezing. Similarly, use of anything less than fine silver as anode material can lead to the introduction of metallic impurities into the bath which could affect its performance.

Numerous materials have been developed to prevent oxidation of silver after plating. The most effective of these are the chromates, although in their heaviest form they may introduce some surface resistance.

There are also available non-chromated proprietary materials which can be quite effective when applied properly.

One fact which is not given sufficient consideration is the importance of the packaging material used for the finished silver plated items. (See previous answer on tarnishing of brass in which a test for sulfur content of paper was given. This same test can be used for silver by substituting a silver plated panel for the brass test strip.)

* * * * *

Zinc Plate Versus Hot Dip Galvanize

Q. *We are about to manufacture parts from cold-rolled steel for use outdoors. Which will give better corrosion resistance, zinc plating or hot dip galvanizing?*

A. At equivalent thicknesses, zinc plating and hot dip galvanizing generally provide about the same protection. For economic reasons, when very heavy thicknesses are required, they are usually applied by hot dip galvanizing. The newer bright zinc plating baths, especially when combined with a bright chromate finish, sometimes present a more appealing appearance than hot dip coating. For help in selecting the proper thickness, obtain a copy of *Quality Metal Finishing Guide—Zinc and Cadmium Coatings* from the Metal Finishing Suppliers Association, 1025 E. Maple Road, Birmingham, Mich. 48011.

How Do I . . .?

Primary Current Distribution

Q. *How can I determine the primary current distribution on a part to be plated?*

A. There is an extensive body of literature on procedures for the calculation and determination of the primary current distribution on objects of various shapes. Fairly complete bibliographies may be found following Chapter 16 of the *Electroplating Engineering Handbook* by Graham (3rd Edition), and Chapter 1 of *Modern Electroplating* by Lowenheim. Particular attention should be given to the publications of Wagner, Kinney and Festa, Rousselot, Lukens, and Kronsbein.

The procedures in general are cumbersome and time consuming. A model may be prepared on special semi-conductive paper, and a suitable voltage impressed across the paper model. Then a high impedance voltmeter and probe are used to determine the voltage on many points on the model surface. When the points at the same voltage are connected they will form a series of equipotential lines. Lines drawn perpendicular to these lines will show the current density.

An alternative procedure is based on the fact that the primary current distribution on a piece is essentially the same as the distribution of a static charge on a non-conductor of the same shape. The part is modeled of a suitable non-conductive material, and charged by friction, or from a static generator. A special voltage probe is then used to measure the charge distribution on the surface.

Unfortunately, the primary current distribution (PCD) is valid only under rigid conditions of anode/cathode location, and in solutions not subject to polarization. This means that PCD determined for a single piece will no longer be valid when that piece is placed on a multi-unit rack. Agitation of the work rod in a still plating tank, or movement past the anodes on an automatic machine, will similarly alter the situation.

To complicate the problem still further, polarization, which modifies the PCD to develop the secondary current distribution (SCD), or working current condition, is not a constant factor. It varies with solution composition, current density, temperature, and degree of agitation. It tends, therefore, to be predictable only in rather general terms.

Some work has been done on methods of determining the equipotential lines in the actual plating solution to be used, with the part itself, and at the expected current densities. This permits the determination of the actual SCD. However, the equipment needed is cumbersome, the procedure time consuming, and any change in the conditions alters the result. A computer is most helpful, if not a necessary accessory. It is likely, therefore, that this will remain a research tool rather than an on-line procedure.

The apparent current distribution (ACD) can be determined from thickness measurements on a piece plated at a controlled current and time. If enough is known of the bath's efficiency in relation to current density, the SCD can be calculated from the ACD. Rarely, however, is sufficient information available on the polarization characteristics of a bath to permit back calculating to the PCD.

The PCD for some relatively simple configurations (including the Hull Cell panel) have been rather fully established. It is quite feasible to use these established forms to study the characteristics of a solution under varying conditions. The results may then be applied empirically to more complex figures.

* * * * *

Stripping Versus Scrapping

Q. *Metal and paint stripping operations are relatively expensive, both in labor and materials. How should we decide when to strip and when to scrap a part?*

A. Economic considerations of stripping must be broken into two parts: stripping to reclaim parts and stripping to maintain equipment.

Parts should be stripped if: 1) the value of the parts exceeds the cost of stripping and refinishing; 2) parts are from a limited run and the cost of setting up for a new run exceeds the cost of the reclaiming operation; 3) production commitments cannot be met on schedule unless the reclaiming operation is carried out. Unless one or more of these criteria can be met, the parts should be scrapped.

In determining the cost of stripping, three factors must be considered: 1) the labor involved; 2) the unit cost of the stripper (the original cost of the stripper divided by the expected life in terms of units stripped); 3) the prorated costs for floor space, heating and overhead.

Maintenance stripping must be carried out in order to avoid rejects and prevent an unnecessary load on equipment. Racks build up with metal or paint; paint trays become heavily loaded and by absorbing heat, slow the cure of parts being painted; paint masks become loaded and no longer fit properly. Here it becomes a question of determining the optimum frequency of stripping to give the desired balance of economical operation and high operating efficiency.

Certain rules of thumb are of help in reaching decisions on frequency. Generally, it is more economical to strip single coats of paint or metal than multiple coats, provided the process can be made automatic, or semi-automatic to eliminate much of the labor cost.

Fast stripping costs money: concentrations must be increased and therefore dragout losses increase; more expensive, higher-speed materials must be used; temperatures may have to be raised, increasing heat losses. Allowing more time for the stripping operation will usually reduce costs.

In paint stripping, heated strippers will usually be less expensive than their room-temperature equivalents. (Because of the large increases in energy costs since this was originally written, this may no longer be. Careful analysis is necessary.)

Intermittent batch-type operations sometimes may be carried out more efficiently with higher-priced room-temperature materials, avoiding the cost of a permanent heated installation. Avoid setups where room temperature strippers remain inactive for long periods. The evaporative loss may exceed the actual use loss.

For room-temperature strippers use tanks with the lowest possible ratio of surface area/volume, to hold down evaporative losses.

In stripping metal, electrolytic strippers will generally be more economical than chemical strippers. They must be maintained carefully, however, to avoid attack of the racks and the expense of replacing damaged contacts.

As nearly as possible, try to strip during normal working hours to avoid overtime premiums. It may well be more economical to provide a 20 pct excess of racks or trays and strip 20 pct of the equipment each day, than to do the whole job on a weekend.

* * * * *

Measuring Surface Area

Q. *What is the easiest, most economical method for measuring the surface area of parts?*

A. One of the easiest ways of determining surface area is to use tables relating surface areas to weight and/or length. For example, in *Electroplating Engineering Handbook*, 3rd Edition, by Graham, starting on page 46, there are a number of tables which can be useful for this purpose.

The data for flat metal products are given in terms of surface area in square feet for 100 pounds of metal (neglecting the edges). If the parts are stamped from a known gauge of metal, the area may be determined simply by weighing a suitable number of pieces and back calculating.

For round metal products, the data are given in terms of surface area per 100 inches of length in square inches as a function of the diameter of the pieces. If the diameter is known, it is easy to calculate the area for any given length.

As a rule of thumb, a threaded portion has approximately twice the area of an unmachined portion.

If the parts are castings, there are no short cuts, and it is necessary to calculate the area based on the usual mensuration formulas.

* * * * *

Calculating Heat Losses from a Tank

Q. *How can I calculate the heat losses from a tank? How can I reduce these losses? How can I figure the savings made by reducing these losses?*

A. The heat loss from a tank is the sum of three separate losses: 1) radiation from the tank walls; 2) radiation from the solution surface; 3) heat required for the work processed.

To calculate these values, determine the total area of the tank walls, neglecting the bottom, in square feet. From column A in the accompanying table, determine the loss per square foot at the temperature used. Multiply this figure by the total area. Then determine the total area of tank surface. From column B in the table determine the loss per square foot at the temperature used. Multiply this figure by the total area.

Determine the pounds of work processed per hour. Subtract room temperature from the temperature being used, and multiply the result by the pounds per hour being processed. Divide the result by 5 for aluminum and copper alloys and 8 for steel.

The sum of these three figures is the loss per hour in Btus.

These losses can be reduced by lowering the temperature, or insulating the tank walls. Two inches of insulation will reduce losses from tank walls approximately 90 pct. A foam blanket on the surface of the tank will reduce surface losses, but the amount is difficult to calculate.

To estimate cost savings, determine the reduction of heat loss and convert to kilowatt hours or pounds of steam. One kilowatt hour equals 3,413 Btu. At 15 psi gauge, one pound of steam condensed yields approximately 1,000 Btu. The cost of either of these units can be obtained from your electrical bill, maintenance department, fuel dealer, or similar source.

Energy Losses
(Btu/hr/sq ft)

Temperature, °F	**A** **Tank Wall**	**B** **Tank Surface**
100	50	200
125	110	500
150	175	950
175	240	1,550
200	310	2,750

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Adhesion of Nickel to Nickel

Q. *We nickel and chromium plate steel. Occasionally we have parts that we would like to replate without completely stripping the nickel. Adhesion of the second layer of nickel plate is a sometime thing—sometimes excellent, sometimes not. How can we get consistent adhesion?*

A. Adhesion of the second layer of nickel will be dependent on having thorough activation of the first nickel layer. Nickel is readily passivated in reverse current alkalies, making the activation step more difficult. If possible therefore, strip the chromium layer in an acid solution rather than in a reverse-current cleaner. Parts stripped in strong (33-50 pct by volume) hydrochloric acid are frequently sufficiently active to go directly to the nickel tank after rinsing. If the chromium must be stripped in a reverse-current cleaner, use a highly chelated cleaner if possible. This will give faster stripping and hold down passivation.

Follow this, if you can, with a direct-current cleaner and a good acid activation. If current is available in the acid tank, use 10-15 pct by volume sulfuric acid, or a suitable proprietary acid, with 50-100 asf direct current.

When no current is available, the best procedure usually is to use a proprietary powdered acid with fluoride and other activators included. Proprietary activators for use with dilute sulfuric acid (5-10 pct) are also available.

Remember that once activated, nickel can be readily repassivated, even by the dissolved oxygen in rinse water. Therefore after activation, do not delay—use the fastest possible rinsing and transfer times.

If all else fails, you might consider the use of a Woods nickel strike. This is made up of approximately 6 oz/gal of nickel as nickel chloride in 10 pct by volume hydrochloric acid, used at room temperature. After a 30-second to one minute strike, the parts are rinsed as rapidly as possible and transferred to the nickel tank. Provided that not too high a volume of work is being processed this way, so that the dragged in strike solution would upset the balance of the main plating tank, the rinse can be eliminated and the work transferred directly from the strike to the plating tank, thus avoiding any possibility of repassivation during the rinsing cycle.

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Refinishing Die Castings

Q. *How can blistering and bleed out be eliminated when refinishing old die-castings?*

A. If the old die-castings you are refinishing are badly corroded and pitted, it may be almost impossible to prevent blistering and bleedout problems.

After the parts have been thoroughly stripped and buffed to restore a smooth surface, they can be given a copper strike, and then a heavy acid copper plate. Buffing can then remove surface imperfections and close off the pores that have resulted from previous corrosion.

It is sometimes helpful to use a greaseless composition for fine polishing rather than a buffing operation as the first step, because there is less tendency to plug holes with thin layers of flowed metal which will fail during the plating process. After this, the heavy acid copper can be applied and the results will generally be satisfactory. However, the main consideration is the amount of corrosion that has taken place; since this is highly variable, there is no guarantee that a good result will be obtained 100 pct of the time.

* * * * *

Gold Peels from Nickel

Q. *We nickel and gold plate, but cannot always plate gold immediately after nickel. Some of the parts are nickel plated elsewhere and shipped in for us to do the gold plating. We have a problem of gold peeling from the nickel. How can be prevent it?*

A. Unless nickel is gold plated immediately after nickel plating the nickel will go passive and there will be a pronounced tendency for the gold to peel, or to plate with an improper color.

Even when the gold is applied immediately after nickel plating, it is desirable to use an activating step prior to the gold plate, since even holding the nickel plated parts in a rinse tank for slightly too long can result in sufficient passivation to cause peeling of the gold.

For parts shipped in for gold plating, it is absolutely essential to have a preclean and an activation step prior to gold plating. Any good, mildly alkaline soak cleaner would serve as a precleaner, and the activation step can be chosen from the many available materials. One of the simplest is to use a proprietary activator in dilute sulfuric acid. Cathodic activation in dilute sulfuric acid or a proprietary powdered acid salt is also a possibility. A brief treatment in a Woods nickel strike is another excellent possibility.

* * * * *

Bright Nickel Too Concentrated

Q. *Our semi-bright nickel drags into our bright nickel. The reclaim rinse after bright nickel is pumped into the bright nickel as evaporation permits. As a result, our bright nickel gets over concentrated and loses brightness until we dilute it. We are running out of space to store the solution we remove to* *permit dilution. Can we clean up this solution so we can use it in our semi-bright tank?*

A. In order to return your excess bright nickel solution to your semi-bright nickel, you will have to treat the solution to remove the brighteners it contains. Your brightener supplier should be able to give you a procedure for doing this. In all probability this would include a treatment with hydrogen peroxide, or potassium permanganate, followed by a thorough carbon treatment. If metallic brighteners are included, an eletrolytic treatment may also be necessary.

If this procedure is properly carried out, the resulting solution should be brightener free and then can be added back to the semi-bright tank. You will undoubtedly have to adjust pH, ratio of chloride to sulfate, and possibly boric acid content, in order to maintain the proper values in the semi-bright tank.

* * * * *

Racking Efficiency

Q. *I am an engineer in a company that plates small die-castings and metal stampings. I am presently redesigning the racking stations to provide greater operator comfort and higher speed. Where can I get help? I am considering a bench that would raise and lower the rack mechanically so the empty part of the rack is always at the most comfortable level.*

A. Details on racking bench design will be dictated by the parts being handled, the design of the rack, whether the set-up is automatic, and whether the racks are loaded and unloaded separately from the machine, on the machine, on a connecting conveyor, or at a separate off station. The type of contact, i.e. whether it is a two- or three-point positive contact or a simple hanging contact, will also have an influence on the design. The following design points must always be kept in mind:

1. An adequate supply of parts must be within easy reach of the operator. Design of the bench must permit replenishment of the supply without disturbing the racker.
2. Unless rackers work from both sides of the rack, the design must permit easy and rapid reversal of the rack.
3. Unless racks are on a conveyor or on a machine, storage for loaded and empty racks must be within easy reach of the racker.

4. The rack must be adequately supported at the bottom to prevent swaying during racking.

Unless a rack is unusually long, it is generally not practical to move the rack vertically during racking and still conform to requirement No. 4. If the racks are on a conveyor, it may be possible to arrange a series of racking stations at different levels to accomplish this type of spread.

* * * * *

Spot Tests for Metals

Q. *We are trying to find a handbook showing chemical reagent spot tests for metal identification, such as using dilute hydrochloric acid to identify zinc and cadmium plating. Can you help us?*

A. The standard manual on spot testing is *Qualitative Analysis by Spot Tests* by F. Feigel, published by Elsevier. The third edition (1946) gives a complete scheme for metals and alloys (p. 291 and ff.). Also available are excellent schemes in *Rapid Identification of Some Metals and Alloys* published by International Nickel Company, Inc., 67 Wall St., New York, N.Y. 10005, and *Method of Identifying Stainless Steels*, from Carpenter Technology Corp., 101 West Bern St., Reading, Pa. 19603. Working with these sources, a simple analytical scheme can be developed for almost any combination of alloys.

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Analyzing Aluminum Deoxidizer

Q. *We use a nitric/sulfuric/fluoride deoxidizer for aluminum. We have trouble controlling the fluoride content. Is there an acceptable analytical procedure?*

A. While most analytical procedures are not adequate for determining free fluoride in the presence of aluminum, a specific ion electrode used in conjunction with a pH meter will usually give acceptable results.

It is also possible to control the fluoride content by etching and desmutting a sample of the aluminum alloy under controlled conditions, adjusting the flouride based on the action of the deoxidizer on the standard sample.

Most proprietary materials use a complex fluoride which has a limited ionization constant. They can, therefore, include an excess of fluoride in the solution without having an excessive free fluoride content. Under these conditions, control of total acidity, and an occasional analysis for oxidizer content, usually provide adequate control.

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Cyanide Vs. Pyrophosphate Copper

Q. *We have been successful in eliminating cyanide solutions from our plant except for the cyanide copper used for stop-off for selective carburizing. We would like to use a pyrophosphate copper for this but understand that a cyanide copper strike is needed. It there any way around this?*

A. For complete information on the pyrophosphate copper bath, I would suggest that you consult Chapter 7, pages 204-223, of *Modern Electroplating.*

Copper pyrophosphate strikes are available for use on ferrous metals in place of the cyanide copper strike, The secret appears to be the immediate application of current when work enters the strike, and good agitation.

The chapter mentioned has a very extensive bibliography and among the references you might wish to consult are the articles by F. Passal published in *Plating*, Vol. 46, page 628, 1959. Also the articles published in *Metal Progress* by Sternberger and Fahy, Vol. 47, page 278, 1945, and Vol. 48, p. 1311, 1945, and then in the same journal by Miller, Vol. 49, p. 783, 1946.

Since most of the pyrophosphite solutions call for the use of additives to control deposit characteristics, they generally fall in the class of proprietaries and the suppliers of the additives would have considerable information on the proper methods for using the strike to obtain the required characteristics for good selective carburizing.

* * * * *

Recovering Silver

Q. *We have a silver stripper containing at various times 0.6 to 6.0 oz/gal of silver. We would like to recover this for use in our silver strike. When we raise the pH of the stripping solution, we get a black precipitate. Can we use this in our strike? How should we treat it?*

A. When silver is precipitated from an acid solution by neutralizing to a high pH, it precipitates first as silver hydroxide, which is white. This then rapidly changes to a light-sensitive form of silver oxide, which turns black by partial conversion to silver. This mixture of silver and silver oxide should be washed thoroughly and then redissolved in sodium or potassium cyanide before use in the strike.

You must also consider the purity of the stripping solution. If other metals such as copper, lead, and zinc are also present in the stripper, there is an excellent chance that these will co-precipitate with the silver. These will also dissolve in the cyanide, and the result will be a badly contaminated strike bath.

If there is a possibility that your stripper might be contaminated in this way, it might be better to filter off the precipitate, wash it thoroughly, and send it out to a refiner for purification and conversion to the cyanide form.

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Plating Silver from Spent Stripper

Q. *How can silver chloride, recovered from our stripping bath, be converted so that the silver can be plated out? I understand that the chloride will cause non-adherent deposits.*

A. Long ago, silver plating baths were made by dissolving silver chloride in potassium or sodium cyanide. It is reported that the chloride that was left in the solutions did not seem to interfere with proper plating. I am referring to *Electroplating and Electroforming* by Blum and Hogaboom, published in 1930. To utilize this method, filter out your silver chloride, and wash it very thoroughly to remove all traces of acidity. It can then be dissolved in a suitable amount of sodium or potassium cyanide according to the following reaction:

$$AgCl + 2NaCN \rightarrow NaAg(CN)_2 + NaCl$$

This solution could then be used with insoluble anodes, preferably carbon, to plate the silver out onto stainless steel cathodes. The bath could be replenished with additional silver chloride until the total chloride concentration becomes too high, at which point the bath should be plated to complete depletion and discarded, or the cyanide destroyed. Any residual silver would precipitate as silver chloride, which could be put back into the cycle.

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Reclaiming Silver from Blast Beads

Q. *We vacuum deposit silver onto the inside surfaces of reflector lamps, using glass beads to mask off the face of the lamp. How can we reclaim silver from the glass beads?*

A. There are numerous ways to dissolve the silver from the beads. Some of these, such as the use of 50 pct nitric acid would be quite effective, but would present you with a recovery problem.

The use of a sodium cyanide solution appears to have the most promise for you. The exact procedure to use will depend on the thickness of silver that is built up on the beads before it is necessary to strip them. The basic reaction is:

$$4Ag + 8CN^- + O_2 + 2H_2O \rightarrow 4Ag(CN)_2^- + 4OH^-$$

If the silver on the beads is fairly thick, I would first deplate most of the silver, using reverse current in a solution of four to eight ounces of sodium cyanide per gallon of solution.

This could be done in a standard plating barrel, and the dissolved silver would build up in the solution until it begins to plate out on the cathodes. If stainless steel cathodes were used, the plated silver sheet could be stripped off and either reused or remelted.

When the silver is removed to the point where adequate contact is no longer being made with the beads, you will notice a fall off in the current being used. At this point the beads could be transferred to an oblique tumbling barrel with some of the cyanide solution and tumbled to remove the rest of the silver according to the reaction shown above. The resulting solution could then be added back to the tank in which electrolytic stripping is being carried out. The process may be repeated as often as necessary. Obviously some experimentation will be necessary in order to determine the optimum conditions.

* * * * *

Metallic Stripping and Recovery

Q. *How can I strip and recover in the metallic form: 1) copper from titanium; 2) tin from plastic?*

A. Copper may be removed from titanium by reverse current in a cyanide bath. The copper removed may be recovered at the cathode as metallic copper.

To remove tin from coated plastic, treat the plastic with a solution of sodium hydroxide and a proprietary metal stripper. When the resulting solution is sufficiently high in tin content, the tin may be recovered by plating it out on inert cathodes, using carbon or stainless steel anodes.

* * * * *

Demagnetizing Parts

Q. *Enclosed are samples of fan guards, plated and raw. Our problem is that the parts become magnetic in the welding operation and it seems impossible to remove the metal fines from the ends.*

We use two soak cleaners, one reverse electrocleaner, electro acid with reverse current, and a final electroclean with reverse current, and still have this problem. Can you help?

A. You could purchase or build a demagnetizing unit. This is essentially a large coil activated with alternating current, through which the parts are passed. Two or three passes through the field of the coil are usually enough to completely demagnetize parts. Any of the firms supplying magnetic inspection methods can supply such units. Parts can be run through the unit in bulk to speed the process.

Since any current passed through a metallic part tends to produce a certain amount of magnetism, it is possible that by switching the current in one of your tanks you might be able to accomplish this demagnetization in the cleaning process. Your present cycle uses all reverse current. One possibility is to use cathodic current in your electro acid instead of reverse current. A second possibility is to substitute a periodic reverse alkaline descaler for one of your present electrocleaners. This may be sufficient to reduce the magnetization and eliminate the particles.

* * * * *

Plating on Silicone Mold

Q. *I have recently heard of a process in which a flexible mold of some type can be stripped from a model (even with undercuts), and then electroplated to a desired thickness. Can you supply any information on this process?*

A. We think the process you refer to may be based upon use of Silastic RTV, a self-curing silicone rubber made by the Dow Corning Corp., Midland Mich. General Electric supplies a similar material.

This self-curing silicone faithfully reproduces the surface with which it is in contact. After curing, the resin retains enough resiliency so that it may be stripped out of extremely complicated molds (except, of course where the exit area is smaller than the part; you probably couldn't get the resin out of a bottle, for example, without breaking the bottle).

After removing the molded silicone, it is sensitized, activated, and plated with electroless copper or nickel. It may then be plated to desired thickness. The silicone may then be stripped from the electroform and reused. It may be possible to get three or four electroforms from one silicone casting before the severe working in the removal process causes it to crack.

* * * * *

Cleaning/Brightening Stainless

Q. *We are manufacturers of vending machines and are interested in a simple but effective method of cleaning and brightening stainless steel parts. We currently send parts out for passivating, but this is too costly and time consuming. What alternatives do we have?*

A. The appropriate cycle for chemically finishing stainless steels depends on the condition of the part as received for finishing. Stainless steel stampings with a good surface will yield a quite acceptable finish by a simple cycle of 1) clean, 2) rinse, 3) passivate, 4) rinse and 5) dry.

Cleaning can be carried out in any good proprietary soak cleaner operated at 6-12 oz/gal and 140 to 180F. The amount of soil to be removed determines the time of treatment and conditions of operation. The tank may be of plain steel and vented to remove steam.

Passivation may be accomplished in a solution of 20 pct by volume of 42-deg Be' nitric acid operated at 120F for 20 min, or in a solution of 50 pct by volume of 42-deg Be' nitric acid operated at room temperature for two hours. The addition of 2-4 oz/gal of sodium dichromate is also helpful, particularly on high-carbon straight-chromium steels.

The effectiveness of passivation may be checked by a copper sulfate drop test. Five grams of copper sulfate pentahydrate is dissolved in 100 ml of water and acidified with a few drops of sulfuric acid. A drop or two of this solution is placed on the surface to be tested and allowed to remain for 15 sec. It is then rinsed off. Improperly passivated surfaces will show an immersion copper deposit. Completely passivated surfaces will be unaffected. Questionable surfaces will darken somewhat.

Military specifications sometimes call for more stringent treatment and testing, but the above procedure should be adequate for most work.

Additional luster and smoothing may be obtained through the use of a chemical polishing step prior to passivation. The cycle would then be: 1) clean, 2) rinse, 3) activate, 4) rinse, 5) chemical polish, 6) rinse, 7) passivate, 8) rinse, 9) dry.

Activation may be accomplished by immersion for two to five minutes in a five pct by volume sulfuric acid solution operated at 120-140F. The tank should be lined with a suitable plastic, and vented. The pickling solutions described later for scale removal are also excellent activators.

A suitable bright dip can be made as follows: nitric acid (42Be'), four gallons; muriatic acid, one gal; 85 pct phosphoric acid, one gal; and acetic acid, glacial, five gal. The solution is operated at 160-180F and ventilation is a must. The solution may be maintained either by analysis, or empirically by adjusting a small sample and using test strips to determine the effect of additions. Water content is most critical, with insufficient water materially slowing the action and an excess producing a matte or an etched finish.

Parts which have been welded must go through a pickling step for scale removal. If the scale is particularly heavy, a prepickling conditioning step also may be necessary.

Where the parts are to be chemically polished, the pickling step replaces the activation step (step 3 in cycle above). If the parts are to be passivated only, pickling follows cleaning and precedes passivation.

Pickling may be accomplished in a solution of 20-40 pct by volume nitric acid to which is added eight oz/gal to one lb/gal of a proprietary fluoride salt. Temperature may range from room temperature to 150F depending on the scale. Hydrochloric acid is sometimes added to increase the activity. Reducing the nitric acid content will also increase the activity, but both of these changes increase the possibility of etching.

If a conditioning step is necessary, hot 10-15 pct by volume sulfuric acid, sometimes with the addition of a fluoride salt, is effective. All these solutions should be ventilated.

* * * * *

Dyeing Anodized Aluminum

Q. *We are anodizing aluminum in chromic acid and would like to dye it but have been unsuccessful. Can you help?*

A. One of the best books on finishing aluminum is *Surface Treatment and Finishing of Aluminum and Its Alloys*, by Wernick and Pinner, mentioned so often in these answers. If you can gain access to a copy, I would suggest that you read chapters seven and nine to gain additional information on the subject of dyeing chromic acid anodized aluminum.

According to these authors, success in this process requires the use of nine pct chromic acid solution (10 oz/gal or 75 g/liter) at a voltage of 40 volts and a temperature of 85-90F (29-32C). Time should be approximately 30 minutes. The dye bath should be heated and should contain approximately 10-15 g/liter of dye. After the anodic coating has been dyed, it should be sealed in a nickel acetate solution. Only certain dyes are suitable, since the retained chromic acid in the film can destroy certain dyes that are sensitive to oxidation.

* * * * *

Polysulfide for Finishing Bronze

Q. *We use a polysulfide solution to obtain a US 10B finish on 90-10 commercial bronze. The finish is brushed and a light film of oil applied. The finish does not hold up well in storage. Do you have any information on preserving this finish?*

A. The beauty of the US 10B finish (or oxidized and oiled) lies in the fact that with proper care, it develops a beautiful patina. Proper care is relatively simple, consisting of periodic rubbing with a soft cloth and oil. The preferred oil is a good grade of castor oil, which will gradually oxidize to an adherent protective film. If the finished parts are stored or not rubbed frequently enough, darkening or staining of the finish may occur, but the appearance can be readily restored by proper rubbing; somewhat strenuous and demanding, but the rich finish obtained is worth the effort.

A good clear synthetic coating can be substituted for the castor oil, and the finish will remain stable during storage and use. However, it is important to make certain that the coating used has good light resistance so that darkening will not occur on exposure to sunlight. However, the rich patina of the oiled finish will never develop if a synthetic is used.

Before making the substitution be sure that it is permitted under the specification; sometimes the use of a synthetic in place of the oil is not allowed.

* * * * *

Heat Treated Brass

Q. *We heat treat brass at 1,000F (538C) and have a problem removing the scale. We use hydrochloric acid. Is there a better way?*

A. Hydrochloric acid is an excellent pickling agent for the type of scale you have to remove. Its life probably could be extended and its action improved by the periodic addition of some hydrogen peroxide to oxidize the copper to the cupric state.

It is also possible that this solution could be operated as a maintained bath by periodically adding hydrochloric acid and hydrogen peroxide. The dissolved metals could then be recovered from the portion of the solution withdrawn to make room for the additions. This procedure is frequently followed in the printed circuit industry, where mixtures of cupric chloride and hydrochloric acid are used to etch the circuit boards. In at least one such installation, chlorine is used as the oxidizer for the copper, thus regenerating the hydrochloric acid at the same time the copper is oxidized.

* * * * *

Faster Antique Brass

Q. *We do antique brass plating and have to plate each rack for one hour. How can we reduce the time to one-half hour?*

A. In order to cut the required plating time in half, double the current density. To do this, it probably will be necessary for you to make some changes in your plating solution. If you are running your brass bath at room temperature, you can increase the current density if you heat the bath somewhat. I would not go beyond 110-120F. You must also bear in mind that if you do raise the temperature in this way, it will be necessary to rebalance the solution in order to maintain proper color.

There are some proprietary solutions which allow a somewhat higher plating rate than the standard brass plating formulas and it may be of advantage to you to investigate the use of one of these materials.

* * * * *

Avoiding Hydrogen Embrittlement in Zinc Plating

Q. *We have to plate zinc 0.0002 to 0.0006 inch thick on carbon steel SAE1050 or higher, hardened to 45-55 Rockwell C. How can we do this without hydrogen embrittlement?*

A. Without knowing the condition of the parts, it is impossible to spell out a complete cycle. Every effort must be made, however, to avoid the introduction of hydrogen at any point in the cycle. Relieving before plating would certainly be indicated at this hardness level. Use only reverse-current cleaning. All acids should be avoided, or very thoroughly inhibited. The use of an acid zinc plating bath if possible, because of its very high efficiency, would also be beneficial.

Finally, before applying any chromate coatings, or other finishes, the plated parts should be baked at 400F for two to three hours in order to remove the absorbed hydrogen. The zinc can then be cleaned, and any subsequent coatings such as chromates or phosphates applied. Assuming that the parts are of a suitable shape, you might also want to consider the possibility of mechanical or peen plating. This process is almost completely free of any possibility of hydrogen embrittlement.

Why Does...also, What If?

Solidified Cleaner

Q. *Prior to dumping my cleaning solution, I neutralized it in the tank with sulfuric acid. It turned solid and had to be shoveled out. What happened?*

A. You undoubtedly had a fairly concentrated silicated cleaner. By neutralizing it in this concentrated form, using concentrated acid, you formed silica gel. Next time, dilute the cleaner at least three or four times with water, and then neutralize with dilute acid. The best procedure is to drain the tank slowly and mix dilute acid and water with the cleaner as it drains out.

* * * * *

Removing Polishing Compound

Q. *Can a polishing compound form a substance that would not be removed by trichloroethylene?*

A. Possibly. Depending on the pressures applied, the wheel speeds, the temperature developed, the nature of the buffing compound, and the basis metal, a wide variety of end products could be formed on the surface.

Most buffing compounds contain fatty acids. Under the right conditions these can form metallic soaps,which would not be particularly soluble in trichloroethylene, but which would dissolve fairly readily in paraffinic hydrocarbons, such as naphtha or kerosene. The effectiveness of this type of solvent for these particular soils is the basis for the use of emulsifiable solvents as precleaners for buffed work.

* * * * *

Too Much Foam on Aluminum Etchant

Q. *My aluminum etching solution when freshly made has a thin foam blanket, which controls spray nicely. As the bath gets older, the foam increases until it becomes uncontrollable. Why?*

A. There are two possible reasons. First, the soil being removed from the work contains a foaming agent. Second, the aluminum being removed during etching is precipitating as a flocculant gel and stabilizing the foam so that it does not break down quickly enough.

Typical of dragged in soils that would react this way are buffing compounds which react to form soaps; emulsifiers from soluble cutting oils; and additives from lubricants used for stamping and drawing.

If the soil is the problem, there are two approaches: 1) add a defoamer such as kerosene, octyl alcohol, or a special defoaming agent from the supplier of your etching compound; 2) flow off or skim off the foam at frequent intervals. Since the stabilizing agent will be concentrated in the foam, it may be possible to remove enough of it in this way so that the foam can be kept manageable.

If the precipitated aluminum is the problem, there are also two approaches: 1) remove foam frequently as mentioned above; 2) keep the solution hot during idle periods; most modified etching solutions when treated this way will drop the precipitated aluminum to the bottom as a granular sludge and this will not float into the foam to stabilize it.

If none of the above are effective, try dumping a portion of the tank each day instead of waiting until the situation is uncontrollable to dump the entire tank. This may keep the contamination at an acceptable level and at the same time will reduce the surge load on the waste disposal system.

* * * * *

Silver Plating Hollow Ware

Q. *I replate hollow ware. When replating deeply recessed pieces of Brittania metal, the silver strike sometimes disappears from the inside during silver plating. I have no trouble with copper or nickel-silver pieces. Why?*

A. Brittania has a much lower conductivity than either copper or nickel-silver. Depending on how the pieces are racked, this may make it more difficult for the current to get to the inside of deeply recessed pieces made from this alloy. In fact it may be possible that there is no current at all flowing to the bottom of a deep recess.

Under these conditions, the free cyanide in the plating bath can dissolve the thin strike layer.

A change in racking will sometimes overcome this problem. Increasing the plating voltage may also overcome it, but could result in burning of the high current density areas.

A better solution would be to use an auxiliary anode when plating these pieces. A thin silver or stainless steel rod should be placed equidistant from the sides and the bottom of the inside of the recess and connected to the anode bar with flexible cable.

* * * * *

Stripping Chromium

Q. *I use a reverse-current alkaline cleaner for stripping chromium. Occasionally, when stripping heavy chromium we find that the steel pits slightly. This never happens when stripping thin deposits. Why?*

A. When using a cleaner for this purpose, it is important to maintain the proper alkalinity, particularly if long-term stripping is involved. This becomes more important as the amount of dissolved chromium builds up in the cleaner. From your description, this appears to be your problem.

It is also possible to deplete the alkalinity in the immediate vicinity of the part, even when the concentration in the bulk of the solution is properly maintained, if the stripping times are very long and there is not sufficient movement of the solution.

It is helpful on long stripping operations to periodically agitate the solution rather strongly to make sure that fresh solution is brought to the surface being stripped. Die cavities with deep recesses are particularly susceptible to this problem since the solution tends to stagnate within the cavity and become depleted.

* * * * *

Too-High Copper in Rochelle Strike

Q. *The metal content of our Rochelle copper strike keeps increasing. It is now five oz/gal. Why? How can we correct it?*

A. A copper metal content of five oz/gal is too high for a strike bath. It should be reduced to no more than two oz/gal. To do this, remove all the copper anodes and replace them with steel or stainless steel. If you are using ball anodes in baskets, empty the baskets and replace them in the tank. When the metal content reaches the desired level, replace approximately one-half of the copper anodes. If the metal content again starts to climb, remove copper anodes, replacing them with steel, until the metal content holds steady.

The reason for the climb in metal content is the difference in efficiency between the anode and the cathode in the strike bath; the cathode has a very low efficiency; the anode a very high efficiency. Therefore, more metal is dissolved from the anode than is plated on the work. Unless a good portion of the anode area is inert, the metal content will climb, hence the use of steel anodes to replace a good portion of the copper anodes.

* * * * *

Anode Baskets Attacked by Cyanide Copper

Q. *We use a proprietary cyanide copper bath. In the last six months it has dissolved one complete set of anode baskets and started on another. Our vendor has no explanation. Help!*

A. I had exactly the same experience 40 years ago when I was a neophyte in the business and mistakenly used calcium chloride to precipitate the carbonates in my cyanide copper bath. In that case it didn't even take six weeks! Based on this past experience, I suspect that your bath has a high chloride content. I can offer no suggestions as to possible sources, but you might check it.

Another possibility is that you have somehow superimposed an appreciable ac voltage on the system. Iron resists solution in cyanide solutions because it polarizes when made the anode. If an ac voltage higher than the dc voltage were superimposed on the system, the anode baskets would go cathodic 60 times a second. This might depolarize them and result in attack by the solution. Check for a stray ac voltage greater than your plating voltage.

* * * * *

Stainless Steel Anodes in Silver Strike

Q. *I use a standard silver strike bath with stainless steel anodes. The anode-to-cathode ratio is two to one. At this ratio, there is no gassing at the anode, but a yellowish tint forms near the anode. If I reduce the anode area, the anodes begin to gas,* *but only on the upper portion, and the yellow tint is still visible. After five days the anodes do not appear to be etched. The bath seems to be turning slightly green. Will this do any harm? How do you explain it? How can I stop it?*

A. The condition you report is definitely an unusual one. I would theorize that either iron or chromium is dissolving from the stainless steel. The amount being dissolved is small and therefore etching would not be evident until a period considerably longer than five days had gone by. The mechanism is probably something like this:

The strike solution with its relatively high free cyanide has sufficient reducing characteristics that when the current is off, the stainless steel is activated. Because of the high anode to cathode ratio, the anode current density is sufficiently low that a considerable period will pass before the surface is again passivated.

During this induction period, iron and/or chromium is dissolving from the surface. Frankly, I suspect that it is most probably iron, since at this low current density it is not likely that the potential at the interface would be high enough to dissolve the chromium in the hexavalent state. Since the film you see is yellow, chromium would have to be in this hexavalent state.

The dissolved iron is converted to a ferro-cyanide complex, which can then react with additional dissolved iron to form one of the iron ferro-cyanide pigments, which in a very dilute concentration would appear green. Alternatively, if it were chromium dissolving, this would gradually react with the cyanide and be changed from the hexavalent state (yellow) to the trivalent state (green). The chromium would precipitate as green chromic hydroxide, which in very dilute concentration would probably be colloidal and therefore not settle out. This would give a slight greenish tint to the solution.

In any event it is a situation to be avoided. Reduce your anode area until gassing starts immediately, and you no longer see this yellow film.

* * * * *

Iridescent Vacuum Metallize

Q. *For the past few months, we have had problems with iridescence on our vacuum metallized parts. What can be the cause?*

A. Iridescence is a phenomenon which in part explains its own existence. It is due to the presence of a film whose thickness is approximately one-quarter to one-half the average wave-length of the incident light. This results in internal reflections and interferences that produce the pattern of iridescence.

It is not clear from your letter, but you apparently have a vacuum-deposited layer sufficiently thick that you have a good mirror effect. Therefore, the vacuum deposited aluminum layer is not at fault. This leaves only the lacquer topcoat. Check to determine that too much thinner is not being used to dilute this lacquer. Also check to ensure that an adequate coating thickness is being applied. It is quite probable that your problem is that this topcoat is too thin.

There are two other rather remote possibilities: 1) if the baking oven is direct gas fired, and the gas mixture is not properly adjusted for complete combustion, acid compounds may be attacking the surface of the lacquer coating to produce a partially reflective film, or partially burned materials may be depositing on the surface as an "oil" to produce the same result; 2) if another lacquer is being baked at the same time, some cross contamination may be taking place to produce a partially reflective film.

* * * * *

Variations in Phosphatizing Steel

Q. *I recently read an article in which it was stated that different pieces of steel from the same coil may clean and phosphate differently. Can you tell me why?*

A. There are several reasons for the differences in cleaning requirements on the same coil, as spelled out in the article. These reasons include the following: the rustproofing oils applied when the sheet is rolled into a coil are generally cut back with solvents in order to provide greater fluidity and reduce the thickness of coating; depending on how tightly the coils are rolled, the evaporation of the solvents can proceed at different rates, so that the rust proofing oil will have different viscosities in various areas of the coil.

Many of the rust proofing oils contain materials which can oxidize on exposure to air, forming a sort of varnish; depending on the degree of evaporation of the solvent mentioned above, the degree of penetration of air into the coil, and the length of time that the coil has been stored, this oxidation can proceed at different rates in various areas; the further the oxidation proceeds, the more difficult will be the removal problem; thus you will find differences in cleaning requirements in different areas.

Some of the materials added to these mixtures to provide rust protection can under certain circumstances react with the steel substrate. When this occurs, metallic soaps are formed, which can be very difficult to remove; oddly enough, this may sometimes be promoted by the absence of air, and the reaction may proceed more rapidly in those areas of the coil which are most tightly wound; the longer the coil is stored before use, the more difficult the problem is likely to be.

Adding all these factors together, with all the possible variations, the reasons for differences in cleaning requirements from point to point on the coil become readily apparent.

* * * * *

Peeling Nickel

Q. *I use cadmium chloride as a brightener in a barrel nickel solution and have a problem with peeling due to laminated plate. Why?*

A. When cadmium chloride is used as a brightener in this way, it produces a very brittle plated deposit. This can result in a laminated plate which can separate on forming.

The use of yellow dextrin along with the cadmium produces a more ductile coating. However, due to the difficulty in controlling the relative concentrations of the two brightener ingredients, it is more general practice these days to use a proprietary brightener mixture which contains stress relievers as well as brighteners.

Incidentally, if the parts are heavy enough, the impact of part on part in the plating barrel may be enough to trigger the delamination mechanism, and the peeling will occur right in the barrel. This can even happen in a bright zinc bath overloaded with brightener, when heavy objects such as plumb bobs are being plated. The first appearance of the problem is usually on an edge or corner.

* * * * *

Solution Balance in Chromium Plating

Q. *In my chromium plating solution, there are wide fluctuations in the sulfate concentration. The chromic acid concentration varies only slightly. No chemicals are added. Can you explain?*

A. The variation is probably related to your analytical procedure. If you are using a centrifuge to determine sulfate, it is extremely important that the speed of the centrifuge, as well as the time of centrifuging be maintained within rather narrow and consistent limits. It is also important that the balancing tube of the centrifuge be filled with a "blank" of the solution being analyzed, so that any suspended material will be centrifuged out in the blank and can be subtracted from the sulfate centrifuged out in the other tube.

* * * * *

Hypo-Allergenic Gold Plate for Jewelry

Q. *What constitutes a hypo-allergenic finish, as specified for jewelry? How thick must gold be to avoid porosity? Is there a preferred gold finish, e.g. gold over silver; gold over nickel?*

A. A hypo-allergenic finish is one which will not be likely to produce an allergenic reaction when in contact with human skin. Since sensitivity varies tremendously between individuals, it is rather difficult to specify just what such a finish is. However, since most allergenic reactions are produced by either nickel or copper salts produced from the jewelry by the action of perspiration, a suitable finish will be one which avoids the production of these salts.

I believe that a gold/silver combination would be preferred over a gold/nickel combination. There have also been developed some hypo-allergenic alloy plates which can be licensed or obtained as proprietaries.

The minimum thickness required is extremely difficult to specify since the degree of porosity is dependent on the finish of the substrate, and the condition in which the solutions are maintained. Very heavy deposits would obviously avoid this problem, but may be economically undesirable.

* * * * *

Room-Temperature Electroless Plating

Q. *What formulations of electroless plating baths may be operated at room temperature, and for what metals?*

A. Silver, copper, and some electroless nickel baths may be operated at room temperature. The spray electroless baths such as silver, and "LockSpray" gold also work at room temperature. Except for the silver and copper baths, the formulations are usually proprietary. Some formulations are given in the *Metal Finishing Guidebook* and also in *Modern Electroplating* by Lowenheim. Note that many of the formulations given are patented.

* * * * *

Promoter Chemicals for Mechanical Plating

Q. *What are the chemicals used as promoters in mechanical plating?*

A. The promoter chemicals used depend on the base metal, and the metal to be deposited. They are generally proprietary mixtures and are formulated so they will keep both the base metal and the metal powder being deposited free of oxides, so that cold welding can take place. They are frequently acidic in nature, well buffered, and contain a mixture of complexing agents.

* * * * *

Electroless Plating Catalysts

Q. *What catalysts are used for electroless plating? What determines the need to use a catalyst?*

A. The essential requirement for an electroless plating catalyst is that it be an effective dehydrogenation catalyst in the solution being used. Palladium is the most widely used, but may be replaced by platinum, gold, or silver in most cases.

Tin is not a catalyst, but tin salts are used rather generally as sensitizers to activate the catalyst solutions, by precipitating some of the catalyst on the surface to be plated. Since silver will be reduced by tin salts, there is no need to use a separate catalyst when going into an electroless silver solution. Since silver will deposit by immersion on copper and brass, a catalyst is not needed when these metals are introduced into an electroless silver. Similarly, they need no catalyst when immersed in an electroless copper.

Electroless nickel will also start plating in most cases. Sometimes however, it may be necessary to initiate plating by touching the surface with an aluminum wire. Nickel will of course, if properly activated, function as a catalyst for electroless nickel, and steel will generally start plating without any problems. Aluminum, particularly if zincated, will usually plate in an electroless nickel without special treatment.

Plastics usually require the use of both a tin salt sensitizer and a catalyst for plating in either copper or nickel. The sensitizer alone is adequate if the plastic is to be coated with electroless silver.

* * * * *

Rochelle Salt

Q. *What is rochelle salt?*

A. Rochelle salt is sodium potassium tartrate, $NaKC_4H_4O_6$. It is an excellent complexing agent for copper and is frequently added to cyanide copper baths. It is also used extensively in electroless copper plating solutions.

* * * * *

Ion Exchange for Calcium and Magnesium

Q. *What are "green sands"? We have iron in our water and want to remove it.*

A. Green sands are natural zeolites that have the ability to act as ion exchange resins for calcium and magnesium. They are frequently used in water-softening devices. To the best of my knowledge they will not remove iron except by virtue of their filtering action.

* * * * *

Current Pulsation in Chromium Plating

Q. *We noticed "pulsating" in one of our conventional chromium plating baths. The electrical contacts and rectifier were all O.K. The sulfate level in the bath was very low, and it* *would not increase even after adding the required quantities of sulfuric acid. The color of the chromium plate was dull, and there was no throwing power. When we discarded the bath and made a new one, the pulsating (amperage) disappeared. What caused the current pulsation in the first place?*

A. Slight pulsating of the amperage such as you noticed is not at all uncommon when the current density level is such that it is just producing polarization. The solution will plate, yield gas, plate, and so on, thereby producing a slight pulsation of the meter. The fact that your sulfate content was very low made it difficult to polarize the solution, so pulsation occurred at the normal plating voltage rather than at a much lower voltage.

Generally, in order to obtain the normal plating current, it is necessary to increase the voltage so that this pulsating effect is overridden and there is a combination of plating with gas evolution maintaining a constant amperage. The fact that the color was dull and you had no throwing power was also an effect of the low sulfate ratio.

Why you could not bring up the sulfate by adding the proper amount of sulfuric acid is not at all clear. Perhaps someone had added an excess of barium to the solution.

To avoid having the pulsating effect in the future, simply maintain the proper sulfate/chromate ratio and apply a sufficiently high voltage to attain a current density of 1.5-2 a.s.i.

Process Index