Some Production Plating Problems & How They Were Solved—Part 20

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When perusing this first item, the subject of which has been explored by Dr. Heiman and his peers previously, the reader should keep in mind that the writers were (and are) the same people who laud the AESF as a professional technical-educational society, but they have a sense of humor, too.—JHL.

1. More on Finagle's Laws

Not enough effort has been spent in analyzing the laws of frustration. While this is understandable—we're all under pressures and the laws are elusive—it is a fault nonetheless. Take, for example, Finagle's laws. Have you ever wondered about their origin? I have. Now, after months of researching Finagle, I am ready to share my findings.

To start at the beginning, I want to take you back to your school days. As every boy and girl knows, you need help when you get the wrong answer in an exam. Fortunately there is the Finagle factor. It is that number which, when added to, subtracted from, multiplied by or divided into the wrong answer, will yield the right answer. Who knows how long this factor has been with us? I learned it from my elders when I was in school and I am sure it was not new to them.

Certainly this "variable constant" of Finagle's has all the markings of a wonderful tool. Is it therefore surprising that a scientific law was attributed to him? The law (now known as his First Law) was, "If anything can go wrong with an experiment, it will."[1]

No doubt, John W. Campbell was reminiscing about these matters one snowy evening in 1957 when he sat down to write an article for the November issue of *Astounding Science Fiction* magazine. As editor, he regularly chatted with his readers in his column *Brass Tacks*. He mentioned the Finagle factor and law and asked his readers for other worthwhile laws that could serve Science.

Let us pause for a moment to look at the word "finagle" itself. It was at one time informal English but now is working its way into the regular language. It was listed in the 1960 *Dictionary of American Slang* but the new *American Heritage® Dictionary of the English Language: 4th Edition* (2000) lists it without restriction like any other word. It means (1) to obtain or achieve by indirect, usually deceitful methods (finagle a day off from work) or (2) to cheat; swindle (shady people who finagle people out of fortunes). I don't believe that story about how it originated from the devious German Dr. von Nagle who moved to Ireland where his name was mispronounced (though the late, great Johnny Carson's legendary law firm, Dicker, Haggle, *Finagle* and Connive, could have been involved somewhere). More likely, "finagle" is a variation of the dialect word *fainaigue* (of unknown origin) which means to renege at cards, hence to shirk or cheat.

But to return to John Campbell's readers. The next year (1958), more than a dozen readers wrote in a large number of amusing and interesting letters concerning the make-believe Dr. Finagle and his laws (Note that Finagle has now acquired a degree the better to show his wisdom.). Nearly four score laws were proposed. They were contributed by some highly competent and widely experienced scientists and engineers, as evidenced by the depth of feeling expressed by them. Dr. Finagle then was built up by a group of John Campbell's readers.

The common laws of frustration, those of Finagle[1] and Chisholm,[2] are too well established to warrant repetition here. It is instructive, however, to examine some of the lesser known corollaries. Each is a fine tribute to Dr. Finagle:

Bernstein's Law: *A falling body always rolls to the most inaccessible spot*.[3]
Bums' Law: *The best laid schemes of mice and men gang aft a-gley*.[4]
Gumperson's law: *The outcome of a given desired probability will be inverse to the degree of desirability*.[5]
McGurk's Law: *Any improbable event which would create maximum confusion if it did occur, will occur*.[6]

Note how each man dwells on the specific phenomenon of concern to him. Thus, Bernstein wanted to explain "if you drop a cuff link, it is useless to look at the open floor area near your feet. The only thing to do is to get down on all fours, preferably with a flashlight, and peer under the bed." Gumperson wanted to "account for the fact that you can throw a burnt match out the window of your car and start a forest fire while you can use two boxes of matches and a whole edition of the Sunday paper without being able to start a fire under the dry logs in your fireplace."

Incidentally, that some of these corollaries antedate Finagle need not surprise us. Other instances are known where the general theory postdates restrictive statements.

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References

1. "Finagle's Laws," *Prod. Eng.*, **29**, 32 (April 21, 1958).
2. F.P. Chisholm, in *A Stress Analysis of a Strapless Evening Gown*, R.A. Baker, Ed., Prentice-Hall, New York, 1963; p. 1.
3. T.M. Bernstein, *The Careful Writer*," Atheneum, New York, 1965; p. 70.
4. Robert Burns, *"To a Mouse" Poems*, John Wilson, Kilmarnock, 1786; p. 138.
5. "Gumperson's Law," *Changing Times*, **11**, 45 (November 1957).
6. H.S. Kindler, *Organizing the Technical Conference*, Reinhold, New York, 1960; p. 105.

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The next is given with apologies to the conscientious organic finishers of today—JHL.

2. A practical approach in solving some finishing problems

Many—in fact the majority—of the finishing problems we are called upon to investigate and help resolve occur because someone has deviated from the process specifications, operating instructions or Military Specifications.

The Federal Government, most of the larger corporations and many smaller companies maintain standard or process departments, staffed by specialists in various fields including finishes. The standards, processes and specifications written by these people have been developed and tested in the laboratory and proved on the production floor. These documents reflect a broad background of knowledge, experience and effort. This does not mean, however, that they are perfect and cannot be improved upon in a specific instance. It does mean that they do work and will provide definite guidelines to attain the required result.

Most finishers, platers and painters, particularly in short order departments or job shops, are under intense pressure to get the job done. Finishing is usually the last operation in the total manufacturing process. Thus slippages in schedule can accumulate and give the finisher insufficient time to complete the job properly. At this point, *haste makes waste* becomes a truism. To meet a deadline, the finisher is often tempted, and sometimes encouraged, to deviate in some manner.

In all fairness to platers, it must be acknowledged that the greater amount of deviations, and hence problems, seem to occur with organic finishers. Painters, as a group, seem more prone to substitute, shortcut or vary processes than do platers whose problems very often arise from overlooking the obvious or departing from the basic fundamentals of plating. (*!!—JHL*)

A few instances in support of these observations:

A. Paint system—pinholes

A paint system consisting of wash primer, zinc chromate primer and a modified alkyd air dry enamel was giving a particular paint vendor troubles with pinholes. The first cry was, "This paint system/specification is no good." The paint system, however, was in accordance with MIL-Specifications and the process was described in detail in terms of materials, thinners, mixing, application and drying cycles. Investigation of the problem disclosed that the painter, instead of thinning the zinc chromate primer and the enamel with toluol as specified in the process, was using a proprietary thinner someone had told him "did the same thing as toluol." Maybe so, but not with this particular modified alkyd enamel.

B. Paint system—poor adhesion

Another vendor performing paint operations and working to a similar paint specification noted that alcohol was to be used for thinning the wash primer. The specification stated, "ethyl alcohol per MIL-A-6091," and also mentioned the conditions under which butyl alcohol could be used. Temporarily out of these materials and pushed for delivery, the vendor purchased rubbing alcohol from the drug store. Rubbing alcohol is usually about 45 to 50% isopropyl alcohol and often contains oil of wintergreen, eucalyptus oil or other additives not quite in accordance with MIL-A-6091! Needless to say, the wash primer did not achieve good adhesion and consequently the whole paint system peeled.

C. Chromate conversion coating on aluminum—improper cleaning

Aluminum electronic chassis having spot welded lap joints were specified to be treated per MIL-C-5541A, *Chemical Films for Aluminum*. The manufacturer's process, developed and written around this specification, provided for two methods of cleaning the aluminum. One method used alkaline etches and cleaners. The other, noted in the process as being mandatory for fabrications having lap joints, Dutch bends, etc., used acid-type cleaners. One plater used the alkaline method for cleaning and after processing, the chassis looked good. However, after a week or so, the entrapped alkali reacting with the aluminum caused salts to exude from the joints. Government agencies will not buy such a condition and I doubt if civilian customers would either. The whole situation became very costly for all concerned.

D. Electroless gold—improper preparation of substrate

A plater had difficulties in depositing electroless gold on a nickel alloy. The deposit was erratic in color, thickness and coverage. The plater blamed the metal and thought that the nature of the alloy caused areas of different potential to develop over the surface and this interfered with the reaction. However, in tracing the processing of the metal before the plater got it, it was learned that the metal had been bright annealed. Under magnification a faintly iridescent scale was observed. The plater then developed a pickling cycle to remove this film. He now had a clean active surface and the gold deposited with good color, coverage and uniformity.

It is hoped that no one interprets these comments as disparaging anyone in the finishing industry because I do not intend them to do so. It is our experience that most finishers, platers and painters have a high level of job interest, imagination, ingenuity and initiative. When a problem such as those cited arises, it is most often just plain detective work that finds the answer. The detective work during these investigations must be methodical and omit no detail, however seemingly obvious or apparently unimportant. Some of the points to be covered are:

- Is the specification or process in the proper hands?
- Is the specification or process understood?
- Is the specification or process being followed? By what assurance?
- Are the facilities and equipment adequate for the job?
- Are the plating and chemical treatment solutions being operated and controlled properly?
- Are the specified and proper paint materials being used? According to spec? Mixing? Application?
- Is the complete processing of at least one part or a good representative sample observed?

When these lines of investigation are followed, it is surprising how often the problem seems to solve itself.

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3. Stripping and reclaiming silver

During the manufacture of certain high temperature nuts and bolts, the nut and bolt blanks are silver plated to provide lubrication during extrusion to their final shape. Without the silver plate, the die life would be extremely short and the surface metal of the nuts and bolts would be smeared. Silver has given the best results of many lubricating materials tested. After the extrusion, the silver is removed before any further manufacturing operations.

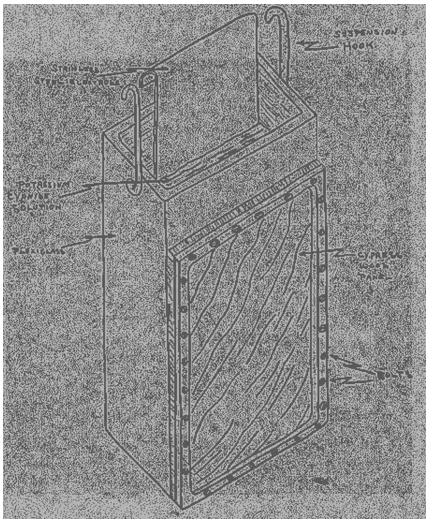

Figure 1—Diaphragm concentration cell.

At first, the silver was stripped using a proprietary stripping material. When the stripping solution was spent, it was discarded. There was no effort to reclaim the silver. An economy move soon prompted an investigation to find a method to reclaim it.

It was decided to strip the plated parts by making them anodic in a silver plating bath and plating the silver on stainless steel sheets. These sheets would later be used as anodes in the shop plating bath and in this way, it was expected that the same silver would be used over and over.

The idea was sound, but it didn't quite work out in practice as expected. The set-up was simple. A load of nut and bolt blanks (about 30 SF) was placed in a standard 14 × 30 in. hexagonal plating barrel and this was made anodic in a silver plating solution. The current was adjusted to the normal 120A and the parts stripped nicely in about 30 min. At first, the silver deposit on the stainless steel sheets was sound, but after further stripping the deposit became nodular and brittle and fell off the cathode with even the least bit of handling. It was obvious that this type of silver could not be used again as anodes in the production silver plating tank. To lower the current to a point where a good sound silver would plate from this solution would have extended the deplating time to a point where a production bottleneck would have resulted.

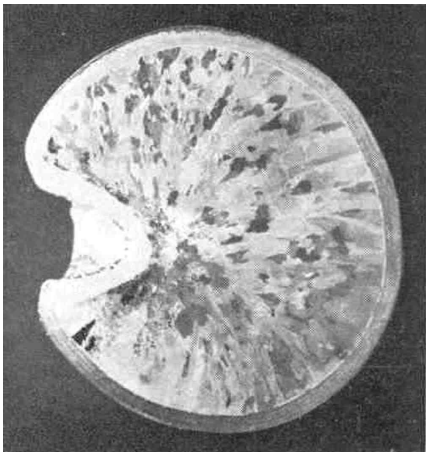

Figure 3—Section of silver ball anode with reclaimed silver deposit.

It was found that the silver content of the bath decreased during the stripping operations, and after a few weeks it had decreased from 26.0 to 4.0 g/L (3.5 to 0.5 oz/gal).

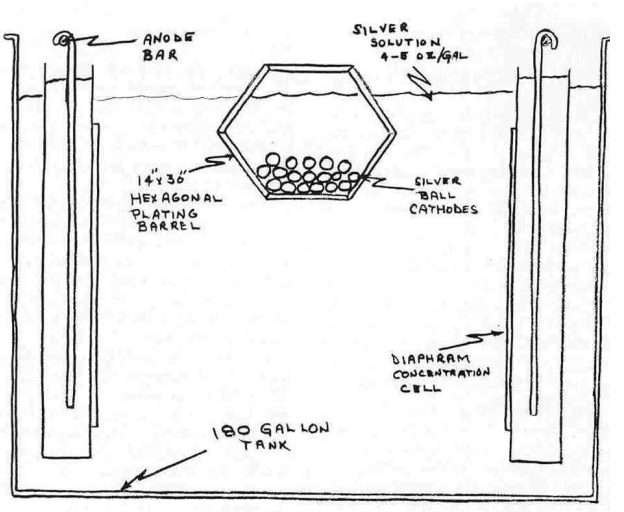

Figure 2—Tank arrangement for silver reclaim.

In essence, the following had happened. Whereas the *cathode* efficiency remained at or near 100%, the *anode* efficiency started at 100%, but during the course of the stripping operation decreased steadily until it reached zero when the parts were completely stripped.

At this point, it was decided to adopt a new system for stripping and reclaiming the silver which incorporated the following feature: Use a stainless steel sheet electrode in a diaphragm cell containing potassium cyanide solution. Details of this cell are described in the references below and are given in Fig. 1.

The stripping operation was carried out in the same manner as described above. However, no silver plated out on the stainless steel in the diaphragm cell and the concentration of the silver in the solution, therefore, increased.

In the reclaiming operation (See Fig. 2), the polarity was reversed. The stainless steel sheets became anodes (efficiency = zero) and the silver was plated out on small "used" silver ball anodes in the rotating barrel. These were then returned as anodes to the production tank. Figure 3 is a photomicrograph of a sectioned anode ball with approximately 2.54 mm (0.1 in.) of reclaimed silver. The technique has worked out so successfully that it has been used for the stripping and reclaiming of cadmium.

References

W.R. Binai, *Plating*, **39**,1120 (1952).
E.R. Jorczyk, *Metal Finishing*, **56**, 46, (October 1958).

4. Oversize rectifier makes trouble

Recently my chromium plater came running, "There's something wrong with the plating solution." (the usual cry), "The ammeter is jumping all over the place and the work is peeling!" The first impulse is not to get off your chair, but to assign your chemist to analyze the chromium plating solution.

The results of the analysis, to be sure, checked out nicely and even the temperature of the solution was on the mark; but the work still left much to be desired. A first-hand investigation of the system showed that a new and much larger 4000-A rectifier was tied into that particular tank, but the total amperage that the chromium tank drew was only about 150A. Obviously, the rectifier was much too large for that job. Switching back to a smaller power source, the work came out the way it was supposed to come out - good.

In a subsequent discussion about this problem with some other platers, it was brought out, using that analogy, that if too small a current is passed through a king-sized ampere-hour meter, the meter will register slower and lower readings than are actually the case, resulting in parts that are overplated and out of range on the high end of a specification. Plating by clock and an accurate ammeter proved this to be the case.

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5. Pipe dopes and assorted complications

Years ago when plants were smaller and job functions not as departmentalized as they are today. The man at the tank was usually a plumber and an electrician, as well as the plater. With maintenance now mostly in the hands of the specialists, plating problems are often compounded by the complete lack of understanding of what can happen to ordinary plating processes on the part of plumbers, electricians and millwrights. Plumbers, who have a predilection for the excessive use of pipe dopes in making a steam connection on a plating tank, would be much better off using Teflon® tape for their connections. Quite often pipe dopes are a source of bath contamination.

Along the same line recently, our quality control supervisor reported excessive pitting on some electroformed parts. Analysis of the sulfamate plating solution showed nothing wrong and the wetting agent was within recommended bounds. On the spot tank site investigation showed that the maintenance man had moved the pump circulating the nickel solution above the tank level, and the seal was sucking in air. The air bubbles were the cause of the pits.
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6. Plating on leaded copper

Copper is one of the easiest metals to plate on, and one would think that leaded copper should be plated with not too much more difficulty. Yet, work hardened leaded copper often shows a laminated structure when bent. One of the common tests for adhesion of a plated deposit, is to bend a part around its own diameter. Recently, a leaded copper connector was nickel and gold plated and subsequent adhesion tests showed a brittle non-adherent deposit. The underside of the peeling deposit looked as if it had a copper underplate. Investigation proved that the parts were never copper plated. Further investigation on the raw parts showed the same brittle, laminated pattern. The leaded copper parts were then annealed before plating with subsequent excellent results.

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Technical Editor's Note: The edited preceding article is based on material first compiled and contributed by Dr. Samuel Heiman, as part of the "Plating Topics" series that ran in this journal. It dealt with everyday production plating problems in the late 1960s, many of which are still encountered in the opening years of the 21st century. Much has changed ... but not that much. The reader may benefit both from the information here and the historical perspective as well. For many, it is fascinating to see the analysis required to troubleshoot problems that might be second nature today. In some cases here, words were altered for context.

Reader Says "Shop Talk" Series Could Use Technology Update

I have taken a serious interest in reading the presentations in Shop Talk and I question why you didn't perhaps add an additional paragraph to perhaps suggest what our answers might be today, based on currently available technology or equipment.

For example, in the attached ("Shop Talk" feature on page 8 of the January, 2005 issue) you refer to oil and contaminants in the phosphate solution. While it's true silicone could have been a problem, today's cleaning and phosphating solutions will run much longer if a combination of filtration, coalescing and carbon for adsorption are employed.

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As pointed out in most of the "Shop Talk" features that have appeared in *P&SF,* the articles about plating problems from the late 1960s are presented so that readers may benefit "both from the information … and the historical perspective as well." The analysis required to troubleshoot problems then may be second nature today. However, we will always welcome input from surface finishing professionals, such as Jack Berg, who can provide readers with information on technology and equipment used today to provide metal finishers with methods of solving plating problems that were not available back then.—*Editor*