The Plating Industry in World War II

Part 1: The Winds of War

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Introduction

Although the story is far from complete, the indicators suggest that the Great Recession - arguably the worst economic crisis since the Great Depression - may be on the wane. Whether it leads to renewed prosperity or is another "lull before the storm" remains to be seen. We can only hope that the latter does not materialize.

Nonetheless, the entire affair has posed unprecedented challenges to the metal finishing industry. The near loss of the North American automotive industry threatened one of the dominant segments of our industry. Coupled with decline in virtually all other segments - electronics, engineering coatings, aerospace, medical - you name it, the entire surface finishing industry came close to the tipping point.

As we reflect on what has happened to us, it is worthwhile to consider a time of even greater challenge to our industry - indeed the entire world as we knew it was a stake. I am referring to the time of World War II, which in perspective remains the seminal event of the 20th century. Had it turned out differently, our way of life would be considerably - dare I say radically - different than it is today. To those living at the time, those gathering clouds were ominous. After the war, for those of us who were old enough to understand, our parents told us of realistic fears that all could go the other way.

As we now know, victory for the free world was ours - although the path ever since has been filled with many challenges, not least the Cold War period which followed for many decades. But in getting there, North American industry was transformed forever. It all began with the transformation from a civilian-oriented industry gradually recovering from the Great Depression to all-out mobilization to become the "Arsenal of Democracy."

Clearly, the surface finishing industry was transformed along with everything else. One would think that these would be boom times for the plating industry. Yet at the time, it really didn't look that way. From our perspective, there are nearly forgotten aspects of all this, including the transfer of resources from the civilian sector to the military, mandated by law. In the early years, it was felt that the lack of platable metals for the civilian sector would seriously shrink the plating industry to levels that could not be filled by military opportunities. The plating business faced disaster - or so it seemed in the beginning.

Fortunately, we have the records of those times, including the records of the Annual Conventions of the American Electroplaters' Society. In the next few issues, you will have the opportunity to read what it was on the minds of the players in the industry and government in those days. A reading of those times shows that, although today's situation is far from the best of times, it is by no means the worst of times.

Accompanying this article are photos of plating installations of that era, gleaned from the pages of the AES Proceedings of the day. Although originally part of other papers in the proceedings, they are used here to capture the flavor of the plating industry of the day.

The Situation before Pearl Harbor

For the United States, World War II began in earnest on December 7, 1941 with the attack on Pearl Harbor. For Europe, the clouds had been gathering for the last decade, and the war had been a reality for well over two years, when Nazi Germany attacked Poland on September 1, 1939. For the Allies, things had gone miserably, and Britain stood alone.

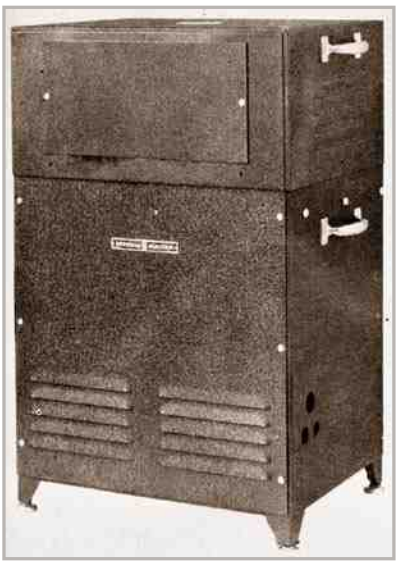
Though in America, isolationist tendencies were strong, the country was preparing for war, through Lend-Lease and other programs. American industry was on a war footing, gearing up at that point to supply what was left of the Allied cause. In contrast to the shocking surprise of Pearl Harbor, it seemed that much of American industry was already affected by the mindset of impending conflict.

This situation was quite apparent to the attendees of the Twenty-Ninth Annual Convention of the American Electroplaters' Society, held at the Statler Hotel, in Boston, Massachusetts, June 9-12, 1941. Virtually six months before the Pearl Harbor attacks, it was clear that the surface finishing industry was in a war situation. The primary issue was not one of growth, but rather curtailment of available metals to plate, in favor of the defense sector. Much of plating was given over to decorative uses, from jewelry to automotive trim, seen as civilian luxuries, which would have to be sacrificed to defense needs. And at "SUR/FIN 1941" (although the culture of the day would look down upon using the term coined four decades later), the outlook was for shutting down much of the plating industry, as any market for plating in the defense sector seemed miniscule by comparison.

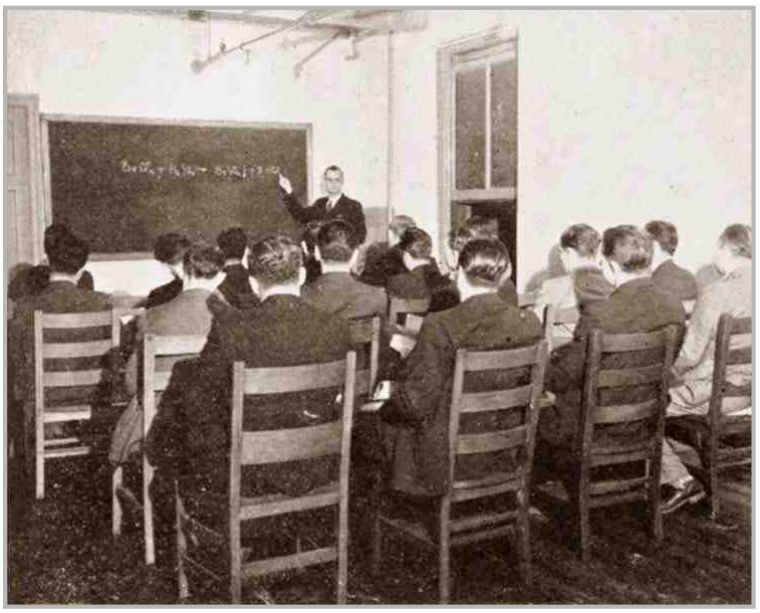
Thus it was with some trepidation that the attendees gathered in the Georgian Room of Boston's Hotel Statler for the Opening Session to hear what the future held. The future as seen at that moment was laid out in full by Dr. Samuel Stratton, of the U.S. Office of Production Management, who spoke on "The Effects of Priorities on the Metal Industry." Before beginning, Dr. Stratton noted, "When I was asked to come to this meeting, I said, 'I'll do anything, but please don't send me into a meeting of electroplaters, because it is such dismal news I can take there,' and I really like to go somewhere where I can hand out something pleasant and optimistic, but …"

"*By definition, priority means giving preference in delivery to those customers whose needs for materials or equipment can be identified with defense contracts or subcontracts. By implication it can be seen that if the supply of a material is inadequate to take care of all defense orders and of civilian orders, then the defense needs must be supplied at the expense of the non-defense customers. It must appear reasonable to you that in depriving non-defense customers of a scarce material, it is the government's duty to see that luxury and non-essential industries give up such materials before public utilities and essential industries are placed under rationing.*

"*For example, in April the supply of aluminum was adequate for all defense needs and for all the requirements for essential industry and public health. It was not adequate to fill the entire demands for luxury and non-essential uses. Hence, for April, the Priorities Division restricted the sale of aluminum for such non-essential uses to a certain percentage of the consumption for the same uses in 1940. For June, the supply of aluminum, because of the increase in defense requirements, will not be sufficient to make possible any allocation of any of the primary metals to the non-essential uses. That is a simple fact to state. … there will be no primary aluminum sold for luxury or non-essential uses in June.*



Early copper oxide rectifier.



A lecture being conducted in electroplating at the Institute of Electrochemistry and Metallurgy in New York City.

"*Despite the simplicity of this statement, you are keenly aware, and so are we in the Priorities Division, of the impact of this simple fact on whole segments of our economy. You know that sincere and competent American businessmen have labored and sacrificed to build up successful businesses that serve luxury and non-essential needs. Indeed, in this country we have always boasted of our richness and of the high standard of living which we enjoy. We are proud of our aluminum coffee-pots. Yet, by our priority orders we may be forced to check the growth of, or even destroy, these non-essential businesses until such time as substitute raw materials can be used by them.*"

"*In short, priority orders are intended to interfere with business as usual, and hence such orders impose hardships. They may force the use of substitutes in instances where companies and industries have spent great sums of money in developing markets for their products. That is particularly true in the case of nickel. International Nickel over a space of years, spent great sums of money building up markets for nickel, which markets are now being curtailed. They may also force suppliers to cut off or curtail shipments to some of their best customers if these customers are not engaged in defense work. … Priority orders may force certain industrial consumers to curtail operations with consequent loss of profits and loss of skilled workers whom they have trained at considerable expense. Priorities may for interim periods cause unemployment for workers in non-defense industries.*

So if you were able to land defense contracts, you might stay in business, and if not, going out of business was a distinct possibility, as Dr. Stratton clearly indicated:

"*There is, of course, the old saying, 'You can lead a horse to water, but you can't make him drink." And so in many instances we find manufacturers who have never desired to take on defense orders, and have found it too expensive and too much of a nuisance to attempt to use substitute materials. Such manufacturers, if they are in luxury lines using scarce materials, may find it necessary to go out of business. But we have groups of manufacturers coming to Washington, within a given trade or industry - some, who all summer have been planning to use substitutes for things now designed out of these scarce products, making use of substitutes; others who started hurrying around getting defense business weeks ago - and both of these groups are relatively well off. You will find within the same industry, making the same product, whatever it may be, certain manufacturers who have neither tried to find substitutes nor to get defense business and they are the ones who now, unfortunately, are in a very bad way.*"

It was clear that more and more metals would be given over to defense purposes, by mandate:

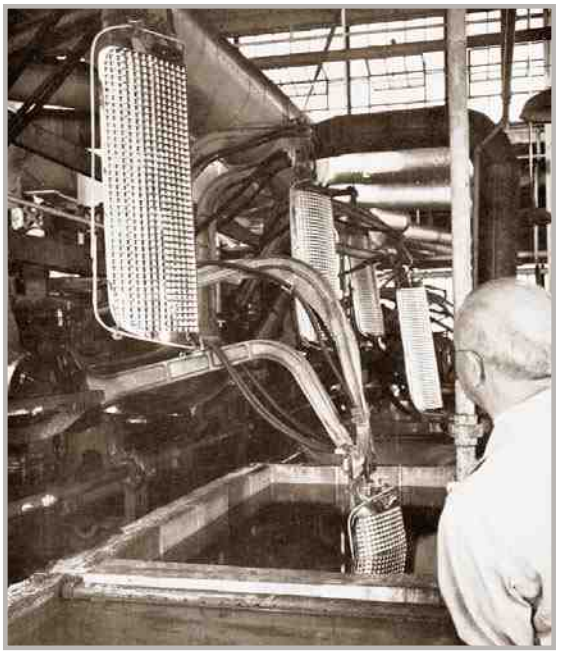
"*To us, it seems certain that defense requirements will increase and will increase faster than supplies of scarce materials can be augmented. In short, I should venture to say, to any user of aluminum, nickel or magnesium; of alloy steels, tungsten or ferro-chrome; of copper, zinc or brass, that whatever quantity of these materials he is now obtaining for use in luxury and non-essential industries, such quantities will be substantially reduced in the months ahead.*"

Dr. Stratton then focused on metals germane to the plating industry. First nickel:

"*Of chief interest to electroplaters is the situation with regard to nickel and copper. Nickel was first brought under mandatory priority control early in March. On May 19, the earlier regulations for priority control of nickel were superseded by General Preference Order No. M-6, and nickel is now being controlled by the Priorities Division of OPM under this order. Very briefly, the Order makes it mandatory for producers of nickel to give preference in deliveries to defense orders. For the administration of this General Preference Order, all customers for primary nickel must file certain information with the Director of Priorities. It is the intent of this questionnaire to ascertain the quantities of nickel which the customer requires, and the product or products which are to be made from such nickel, and the uses to which such products will be put. Once this information is assembled, it is possible to ascertain the quantity of nickel demanded for defense purposes for essential industries and for non-essential or luxury uses.*

"*The Priorities Division then gives instructions to the nickel producers to make shipments in such manner that all defense requirements will be fulfilled. To the extent that there is nickel available after defense orders have been filled, the Director of Priorities gives instructions for the disposition of such excess of nickel, giving preference, of course, to essential uses. The following figures may be of interest: In March, 1941, the demand for nickel in this country was approximately 20,500,000 lb. …. after defense needs were taken care of, only 3,000,000 lb. of nickel were available to meet demands for non-defense needs of approximately 8,000,000 lb. On this basis, it will be seen that non-defense needs could be supplied only to the extent of 40% of the demand in the month of May.*

"*Here are some figures on the electroplating industry. In April, 965,695 lb. of nickel were requested - that is, placed on order for the automotive industry. Eighty percent of that amount, or 781,000 lb., was requested for nickel plating, 19% was requested by the steel mills for nickel steels for the automotive industry. The total automotive plating requirements of 781,000 lb. in April were 53% of the total nickel requirements of electroplaters in the United States in that month. The requirements of 781,000 lb. which were asked for by the plating industry for automotive plating*



Decorative Automotive Plating

requirements equaled 126% of the amount actually allocated in April in the entire plating industry for all requirements. You may be familiar with those figures - I have lots more of them. … It is obvious that the quantity of nickel allocated to electroplaters in the United States in June will be less than the quantity allocated in the past."

Then there was the matter of copper:

"*Two months ago, it was being confidently forecast that there would be adequate supplies of copper for all defense and civilian requirements. Today, we know that the demand for copper is greatly in excess of the supply available for both defense and civilian uses. In May, the Metals Reserve Corporation, which, as you know, has been importing South American copper, received applications for approximately 160,000 tons of copper, against its supply of approximately 40,000 tons, which it had brought up from South America. Requests for allocations of copper from the Metals Reserve Company come from users who cannot get adequate quantities of copper from their normal sources of supply. On that basis alone, you would say that in May we were short over 100,000 tons of copper for civilian and defense uses.*"

"*From experience, we have found in the Priorities Division that it is dangerous to forecast that one metal may be more plentiful than another. But, at present, despite the facts I have stated, there will presumably be more copper available for industrial uses than can be the case in nickel. Nevertheless, I should most certainly not wish to go on record as advising that in the months to come there will be copper available for completely non-essential and luxury uses.*"

Dr. Stratton then went to the heart of the matter, and in doing so, gives us a feel for the mood in Washington at that critical time:

"*I doubt if it is necessary to convince anyone at this gathering that this country must mobilize for an all out effort. Nevertheless, there are a great many sincere American citizens who do need to be convinced of the serious threat which daily grows more ominous. A month ago we received a great many sincere letters every day showing the poor attitude of many people in this country; but I will say that now we very infrequently see this type of letter. Those were sincere letters. We used to get dozens of them; we don't any longer because it is becoming more and more obvious than ever when these things do disturb our daily bread and butter, etc., we are in an all out program in defense of democracy; or, we cannot have our cake and eat it, too.*

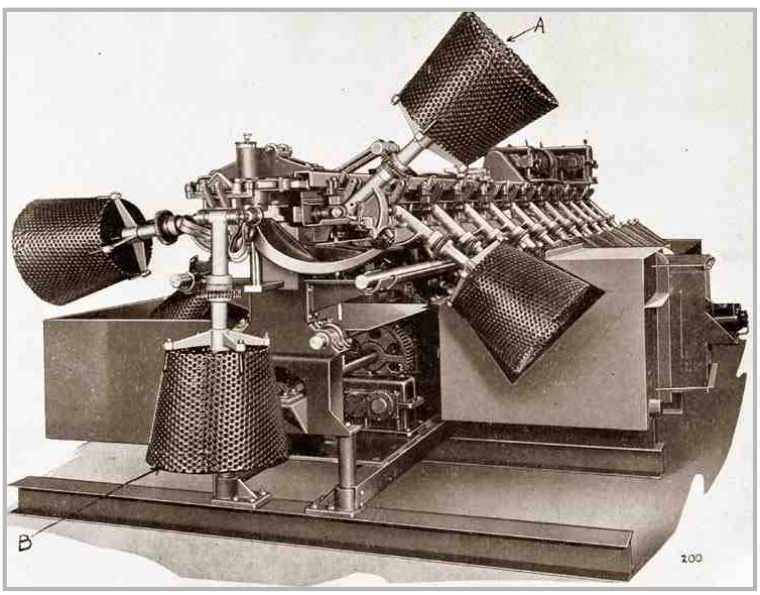
"*We are not engaged on a glorified WPA program. We must keep the fortress of Great Britain intact, or the so-called wave of the future will sweep the Atlantic to our very shores. We must produce and we must deliver the goods that will hold and eventually conquer the sworn and avowed enemies of our democracy. We want no "new order" of the Hitler variety over here. We like the new order which our forefathers created in 1776 - a new order that stood and still stands for freedom, for freedom from fear, from subservience - a new order that stood and still stands for individual liberty and opportunity - a new order that stood and still stands for ever-increasing standards of living for all the people. A new order that has been under constant improvement during the less than 200 years of its existence.*

"*We started the wave of the future in 1776, and we propose that it shall continue to go on. Totalitarianism is not a wave of the future - it is a cesspool of the past. But words will not defend us. We have appropriated 40 billion dollars for defense. But dollars will not save us. Guns and planes, bombers and tanks delivered to the places where they can be used; these alone will stop the greatest military machine the world has ever known.*

"*It is now commonplace that the present war is a war of materials. We, of course, are not at war, but we have committed ourselves to become the arsenal of those democracies who have pledged themselves to defeat Nazi-ism. If the United States of America is to keep its solemn promises, we must divert our steel, our copper, our nickel, our tungsten and ferrous alloys into defense uses. The Director of Priorities, and all those associated with him have a single, determined purpose - to strive always to provide the defense industries of this country with adequate supplies of metals and minerals.*

"*Finally, I want to state, emphatically, that we do not believe that Government can do this job alone. We do not want to do it alone. We need and we want the willing and eager cooperation of the American business man. We believe that with this cooperation, and only with it, this country can insure itself against the fate of becoming the appeasing and subservient nation that its enemies would like to make of it. We believe that with this cooperation we Americans can preserve our democratic institutions and that we and our children will continue to live free from fear, free from subservience, free from gangster rule. We in Washington are supremely confident that we shall get that cooperation from this group.*"

After Dr. Stratton's sobering assessment, one of the pioneers in modern electroplating, Dr. William Blum, of the then-National Bureau of Standards (now National Institute of Standards and Technology (NIST), focused on the plating industry itself in his



Barrel Plating Machine

talk, entitled "Effects of Metal Shortages on the Plating Industry." He got into the specifics of how to deal with the lack of nickel and other metals via substitutes, including cadmium and lead, both of which were looked upon more benignly than they are today. In his introductory remarks, he tried to bring a ray of light to the audience. Because his talk portrayed the situation facing the plating industry so well, it is present here in its entirety:

"*From certain reports, I thought that the Electroplaters' Society, or at least the plating industry, was nearly dead and that it was about time to conduct a funeral service. Your presence here, the large attendance and the deep interest are evidences that the plating industry is very much alive. I have full confidence that it is going to stay alive in spite of the rather gloomy statements that were made this morning by Dr. Stratton.*

"I am very glad that he was able to be here to speak to you officially and to give you the point of view which must determine the policy of the O.P.M. He apologized to me in advance because he felt badly about coming with any such message as he had to give to you this morning. He also stated frankly that he did not know anything about electroplating and had never been in an electroplating plant in his life. I am therefore put in the position of trying to suggest what the plating industry can do about the situation. Dr. Stratton really gave the clue this morning when he said that to stay in this or any other business, a firm must either obtain defense contracts or must find substitutes for the materials that are not available.

"In discussing this subject, I will speak particularly from the standpoint of the government, because, as interested as I am in the Electroplaters' Society, I am working for the government, and trying to advise and assist on its numerous problems. We have not only the branch of the government that you heard from this morning, but also all those other branches of the government that are seeking to meet defense needs.

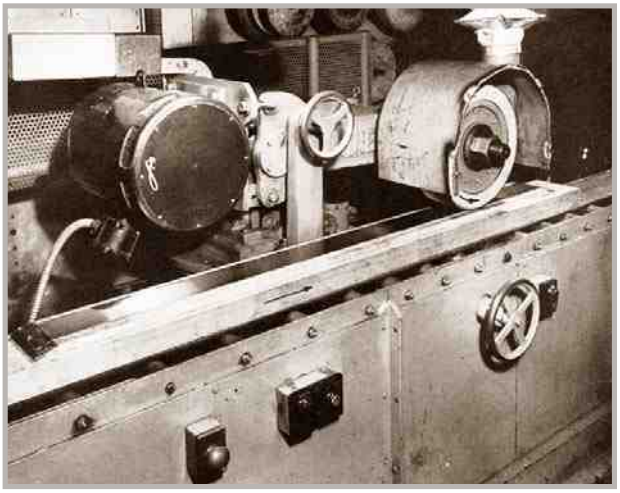
"The term 'defense needs' is rather vague and covers a great deal more than simply guns and planes and battleships, as essential as they are. It is not possible to have one million or more men in arms without having all the equipment with which to live. They must have pots and pans for cooking, knives and forks and spoons, they must have garbage cans! Those things are just as much a part of the defense project as are the obviously military devices. In addition, there are a great many activities, like defense housing, that make it possible for people to work in the factories, which will require materials, such as hardware and plumbing fixtures, to make those dwellings habitable. The picture is not as dark as it might at first seem to the electroplating industry.

"There will be innumerable applications of electroplating that will be absolutely essential to the conduct of this program by the government. It is not possible for anyone, either in the position of Dr. Stratton, or familiar with the plating industry as I am, to attempt to predict in advance just what these applications will be. I believe you should go back to your plants and your firms with the idea of finding something that is needed by the government that involves and requires the use of plating. To the extent that those conditions are met, you need not worry about the continuation of plating.

"In the present emergency, the very shortage of materials such as aluminum and brass and stainless steel will require that, at least for defense purposes, substitutes must be found for those metals; and many of the substitutes that will be found will require plating. One of the questions that was asked this morning was about the availability of steel. Of course, if there is no steel or copper or brass or zinc base die castings to be plated, then you need not worry about anything with which to plate them. We can feel confident that certainly first, for defense purposes and secondarily for civilian needs, other metals, particularly steel, will be used. This steel will have to be plated, and consequently in many cases more plating will be done or required. Just to cite a single instance, I know that careful consideration is being given to the substitution of steel cooking utensils plated with nickel and chromium for the aluminum pots and pans that have been used by the Army and Navy. I am not prepared to say how well they will meet the requirements under the severe conditions of camp life, but I want you to recognize that this is the sort of thing that the plating industry should be alive and on its toes to meet. While I am not prepared to give you a purely optimistic picture, I do not quite share the pessimistic picture that you might have gathered from the remarks of Dr. Stratton this morning.

"Those of you who are old enough - George Hogaboom and I are among those who remember the conditions twenty-four years ago - know that there was lots of plating done for the government during the last war, [*i.e.*, World War I] *and that plating will take all kinds of turns and applications which you will never think of or anticipate in advance. Just at the end of Dr. Stratton's remarks, I was called out for a long distance call from the War Department in Washington asking me to go to a particular plant where there was trouble with some plating being done for them. George again smiles because that is what we had him doing; he was a trouble-shooter twenty-three years ago. Plating is essential, and it is merely necessary to find out where and how you can get into that kind of work.*

"The situation on nickel plating is particularly acute and therefore the industry has naturally given a great deal of thought and study to what it can do in the way of substitutions for nickel in plating. In normal production the automobile industry used over 60% of the nickel anodes and in turn the nickel anodes constituted normally 7% of the total production of metal. During the last couple of months the quota for nickel anodes has been cut to about 50% of its normal amount, and consequently it was necessary for the automobile industry, as well as all the other users of nickel anodes, to reduce their consumption of nickel.



Polishing machine.

"In getting along with that curtailed supply of nickel, I urge very strongly that the plating industry should not simply spread the same amount of nickel over a larger area without attempting to compensate for it. The plating industry must give very careful consideration at this time to maintaining standards of quality of plating, even in these difficult conditions. If you put out poor, inferior plating, you are playing into the hands of those other industries, such as the plastic, paint and enamel industries, which are having a great opportunity today to compete with plating, because of the difficulty of getting metals. Far better that you do half as much plating and do it well, than simply to do a large amount and do it so poorly that people will thank their lucky stars that they can buy plastics or something else instead of plating.

"If we are to keep up the quality, we must find substitutes. In the automotive industry and in general plating on steel, the obvious course is to increase the proportion of copper, that is, to substitute copper for a part of the nickel. The exposure tests that were conducted with your organization in recent years have shown that in thin coatings, copper does not have a protective value equivalent to that of nickel. Therefore if in thin coatings, you cut down the proportion of nickel and increase that of copper, it is necessary to use more copper than you save nickel. That relation is not necessarily true in thicker coatings, those of the order of 0.001", particularly if the copper is buffed. We do not have exact data, but the indications are that for coatings of 0.001" or more, that is, the higher grades that have been adopted in the specifications, the copper can be substituted for nickel nearly pound for pound or inch for inch without any serious decrease in quality.

"On the other hand, there is a lower limit to the thickness of nickel that can be put on over the copper and still get a satisfactory coating. Even though you may have protected the steel against corrosion, it is necessary to have a moderate thickness of nickel in order to protect against the copper tarnish which will come out through any pores in the nickel. Without attempting to fix an exact value, I would say that certainly not less than 0.0001" and preferably 0.0002" of nickel should be used, no matter how much you substitute copper for nickel. There is no use putting on such a thin coating of nickel that it does not serve any useful purpose.

"It does not sound encouraging when you hear that copper is being put on the Priorities List, but in this whole picture we must maintain a sense of proportion. These metals may all be scarce, but not equally scarce. If, for example, there is potentially much more copper than nickel, and if the plating is justified, you can get copper more readily than you can nickel, at least to substitute for part of the nickel.

"The question is often raised of the substitution of cadmium for zinc. Zinc is scarce and Dr. Stratton said this morning that zinc is just now being put on Priorities. Some people say, "Well, if we cannot get zinc plating, we will use cadmium." I was told by one of the O.P.M. officials that the defense needs for cadmium are double the present production of cadmium. At present about 50% of all the cadmium that is produced is going into plating and there is no obvious way of increasing the production. So do not fool yourself and feel that you can substitute cadmium for zinc in plating. Of course, if you have the cadmium, thank your lucky stars and use it, but, except in those cases where somebody may have unusual stocks, the cadmium will be a good deal scarcer than the zinc.

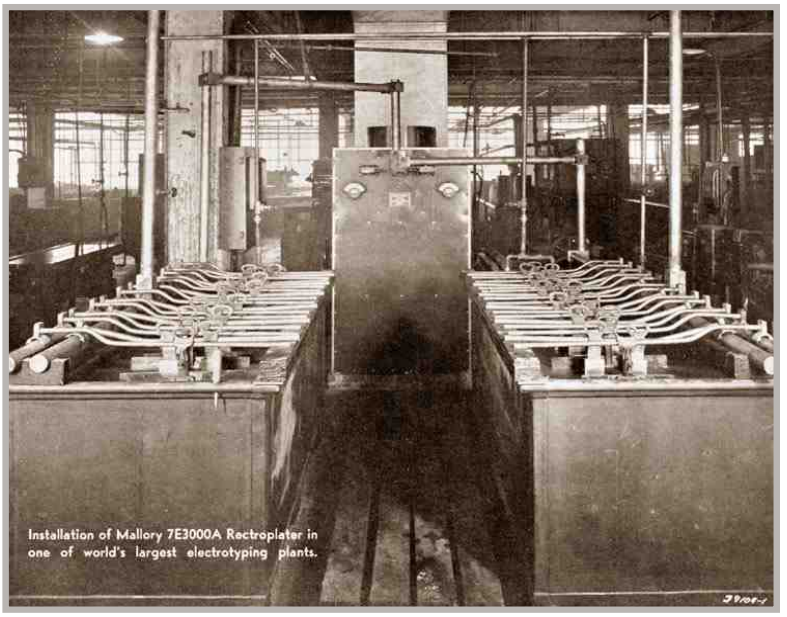
"The problem is exactly the same as if there was an attempt to substitute cobalt for nickel. It was shown over twenty-five years ago by Kalmus, Harper and Savell that cobalt plating can be done satisfactorily, but cobalt is much scarcer than nickel and the demand for cobalt is relatively just as great as that for nickel.*

"I suggest that you keep in mind the possibility of substituting lead plating for certain applications and not simply for those purely military applications where it may be particularly valuable. In general, when lead coatings meet the requirements, lead plating is the logical procedure, because in hot-dipping with lead, you must use some tin, in the so-called terne plate. If tin becomes scarcer it will be on the priorities list.

"In nickel plating, substitution of insoluble anodes is being tried. The use of insoluble anodes, for example, of lead, is likely to oxidize most of the brighteners used in bright nickel, so that, while it may be possible to operate a semi-bright nickel solution with insoluble anodes, it is at least doubtful whether the present bright nickel solutions can be operated with insoluble anodes.

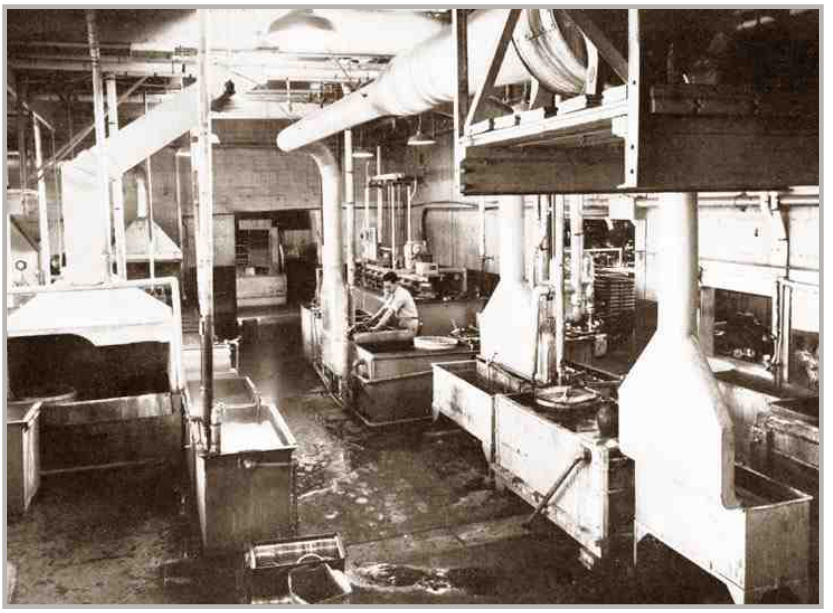
"When using insoluble anodes, where will the nickel come from? Of course, you say, from nickel salts. Today these are produced almost entirely as by-products from copper refining. The total supply of nickel salts, as far as we have been able to learn is equivalent to from one to two per cent of the total available production of nickel. This is equal to about one-fourth of the normal amount of nickel anodes used, or perhaps as much as a half of the nickel anodes that are now permitted to be used.

** H.T. Kalmus, C.H. Harper and W.L. Savell, Electroplating With Cobalt (Metals And Alloys Engineering Series), Wexford College Press, 2008 (Second reprint)(available Amazon.com).*



Rectifier-controlled electrotyping installation.

"To the question of what becomes of the nickel salts, the answer is very simple; you throw it all down the sewer in the dragout. Every pound of nickel sulfate that you buy and use in normal nickel plating goes down the sewer. The only way you can increase the supply is to save the dragout, for example, to reduce it by appropriate standing rinse tanks. You cannot replace the deposited nickel directly with nickel sulfate. You must replace it with a basic material like nickel carbonate in order to neutralize the acid that is set free when insoluble anodes are used. Fortunately, nickel carbonate can be produced more cheaply per pound of nickel than nickel sulfate, because from the purified nickel solution, the nickel carbonate can be precipitated and sold in the wet form more cheaply than crystals of nickel sulfate can be produced. It is possible for a certain proportion of nickel plating to be done from nickel salts, provided you will reduce the waste of nickel salts in the dragout, and will add nickel carbonate to replenish the nickel that is deposited by the use of insoluble anodes.



Plating Room

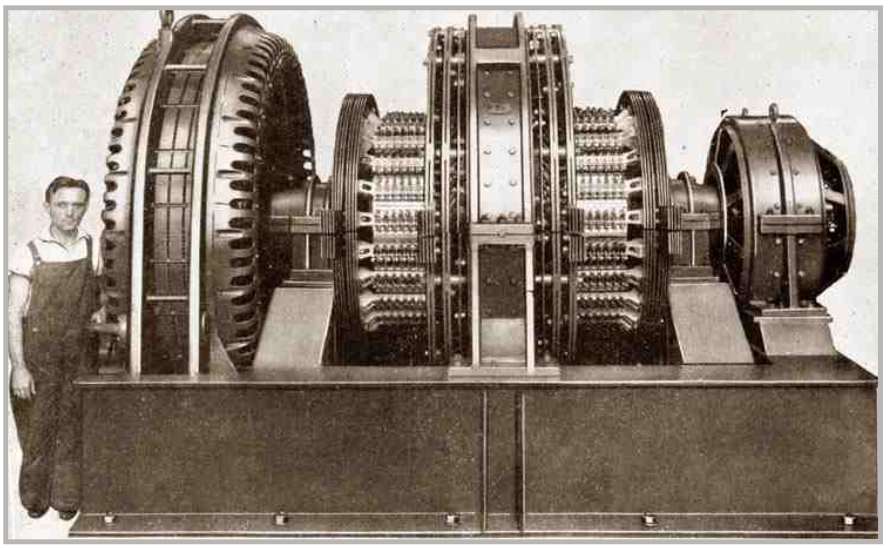
"If there is more extensive deposition of copper from cyanide solutions, the first question is the availability of cyanides. Approximately 10% of the total production of cyanide goes into the plating industry. One of the companies that has not heretofore produced the white cyanide suitable for plating has just started its production. The chances are there will be no actual shortage of cyanide, although there may be at particular times difficulty in getting deliveries on it.

"Another material that many of you use in the copper baths is Rochelle salt that has heretofore come from France, where it is produced from the "tartar" in the residues from the wine barrels. Because we do not have much trade with France these days, Rochelle salt has become very scarce. I have not been able to find out whether any serious efforts are being made to recover the cream of tartar from the wine industry in California. Some effort is being made to substitute citrate for the tartrate in copper cyanide baths. I do not know how well the citrate will work. If the Rochelle salt had never been used and someone would ask whether it would be better to use tartrate or citrate, you might as well toss up a penny, as to predict whether tartrate or citrate would be preferable in a cyanide bath.

"The chromium ores are mostly imported, but on the other hand the grade of chromium ore that is used for manufacturing chromic acid and chromates is a lower grade and at present is not competing with the grade of chromium ore used for making ferro alloys. As long as we can continue to import the chromium ores, there is not likely to be a shortage of chromic acid.

It is interesting to note that just one year earlier, at the 1940 AES Annual Convention in Dayton, Ohio, the title of the opening address was "Metallurgical Aspects of Hydrogen in Electroplating." The tenor of the technical sessions involved engineering and science, and the winds of war amounted to nothing more than a light zephyr. What a difference a year made.

Such was the situation before America's entry into World War II. In essence, the viability of the plating industry was at grave risk, owing to metal shortages in the civilian sector. In the next installment, in one year's time, at the 1942 AES Annual Convention ("SUR/FIN 1942") in Grand Rapids, Michigan, America had been attacked at Pearl Harbor and the American involvement in the war was proceeding all-out. As will be seen, the priority in the defense sector was paramount, which had even stronger consequences for the long-term survival of the electroplating industry.



Motor-Generator Set