STEEL FACING OF ENGRAVINGS
(ACIÉRAGE DES GRAVURES)

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Abstract:

Copper and zinc plates used in engravings have a limited lifespan due to wear caused by the friction of inks and tarlatan during the cleaning process. Some inks are more abrasive than others, exacerbating this issue. Dry points and mezzotints are particularly susceptible to damage. Contrary to common belief, the press itself does not cause damage to the plate.

In 1857, Garnier invented the steel-facing technique for copper plates using an electrolytic bath.

The aim of this paper is to discuss various procedures for steel plating and recommend an effective yet straightforward method suitable for individual users or small shops. Before discussing the iron plating methods, I will present two alternative metal plating options.

Nickel plating

Nickel can be used for plating copper. Conventional bright nickel baths are not suitable as they contain levelling agents which can result in the loss of fine detail. I have used a commercial bath with a brightener but without levellers. It gave very satisfactory results. However, this bath was custom made for me by a supplier of chemical components and is no longer available.

Similar to iron plating, a high pH increases the hardness of the deposit. However, the anodes are not dissolved, so there is no need to use nickel in them. Below is an alkaline bath recipe that produces a very hard nickel deposit, bright but without levelling. It is harder than the commercial nickel baths, I have printed a hundred copies of a dry point with no sign of wear.

Nickel sulphate $NiSO_4.7H_20$	210 g/l
Nickel chloride $NiCl_2.6H_2O$	60 g/l
Ammonium sulphate $(NH4)_2SO_2$	50 g/l

Ammonia to get pH = 8,5
Temperature: 25º - 30 ºC
Intensity: 2 A/dm^2
Recommended time: 15 minutes.

The disadvantage of this bath, compared with the standard ones, is that the nickel content decreases with use.

The main problem with nickel is that the removal of the nickel layer is quite difficult. It can be done in an electrolytic bath containing sulphuric acid, or with special chemical baths.

Chromium plating

Chromium is very hard.

Chromium plating requires precise control of temperature and current to achieve a bright deposition. The current should be set very high, for example 17 A/dm2 at 50°C. Adequate ventilation is essential due to the production of gas carrying chromic acid, which can be very irritating. As the chromium content decreases with use, the bath must be analysed regularly and chromic acid added if necessary. Because of these requirements, chrome plating may not be suitable for domestic or small scale use. An advantage of chromium is that it can be removed using muriatic (hydrochloric) acid.

Steel plating

If the correct electrolytic process is used, iron deposition can produce a very hard surface, hence the term "steel" plating. The advantages of steel plating include its cost effectiveness, simplicity, low current density requirements and ease of removal of the iron layer.

There are many iron plating bath compositions, some of which work very well but use components that are difficult to obtain, others are not suitable to engravings. Examples include Watt's iron citrate bath and Loubat and Weil's iron ammoniacal with citrate bath, Klein's bath, Maximovitsh's bath, fluoroborate baths, etc. Of course, I have not been able to try all these baths. Here I present a simple but very effective bath.

A traditional steel plating bath

Derived from the Garnier invention, this bath provides a simple and cost effective solution to steel plating, giving a bright[1] and durable deposit at low current levels. I recommend the addition of a brightener to improve the performance of this traditional bath. Stirring of the bath is highly recommended.

In water, preferably distilled:

- Ammonium chloride (NH_4Cl) 100 g/l
- Iron sulphate ($FeSO_4.7H_20$) 40 g/l

Brightener option:

- Methanol (methyl alcohol) 6 cm^3/l

or

- Sodium saccharin 3 g/l

The brightener is not essential, especially if the bath is stirred. A bath containing only ammonium chloride, without iron sulphate, will also work. Then, using any copper plate, run the current for 4 to 5 hours to load the bath with iron ions.

Using a Hull cell, I have found that the ideal current density at 23°C is 0.5 A/dm². It is highly recommended to stir the bath during the electrolytic process. Stirring the bath makes the deposit more uniform, allows the current to be increased to 1 A/dm² halving the processing time. This can be done slowly by hand with a piece of plastic or wood. This can also be done automatically using small pumps or even by injecting air bubbles using aquarium equipment. If the current exceeds 0.7 A/dm² without stirring the bath, the deposit becomes grey and softer. I do not recommend less than 0.2 A/dm².

Recommended time: 30 minutes at 0.5 A/dm².

Iron alkaline baths (high pH)

Similar to nickel plating, a high pH produces a harder layer than neutral or slightly acid baths. However, when the pH is raised above 7, the iron precipitates in the form of iron hydroxide and it is not possible to raise the pH further. A viable method to overcome this challenge is the use of organic iron compounds, commonly referred to as chelates. Chelates interact with iron ions to form stable complexes that prevent them from precipitating as iron hydroxide. This makes it easier to adjust the pH above the critical threshold of 7. As in alkaline baths the anode is not attacked by the bath, a stainless steel plate can be used at the anode (positive).

The first alkaline bath was the ferrocyanide bath invented by Rudolf Christian Böttger (1806-1881) which produces a very hard and bright coating, not surpassed by modern baths. Although the modern gluconate bath described below is much simpler, I describe this bath in detail in the appendix to prevent this great invention from being lost.

[1] When I say "bright", I mean bright on a bright surface, but keeping of the details if the surface is not glossy.

Gluconate baths

Modern baths use chelating agents such as sodium gluconate (a food additive, E576) and can operate at high pH levels. However, they suffer from the problem of iron depletion over time. This is the composition of such a bath[2]. In water (preferably distilled):

- Iron sulphate ($FeSO_4.7H_20$) 20 g/l
- Sodium gluconate ($NaC_6H_{11}O_7$) 50 g/l
- Caustic soda (sodium hydroxide, NaOH): about 0,4 g/l to get pH = 10 to 12.

23 to 25ºC, 0,17 A/dm^2.

Recommended time: 45 minutes to obtain a layer of iron approximately 1 µm thick.

Due to the low current density it is not necessary to stir the bath, although this would allow a higher current density and a shorter time.

It is possible to estimate the amount of iron lost in the process. Each time you steel a plate, note the current and the elapsed time. Multiply both magnitudes and accumulate the result with the previous ones. If A·min is the total amperes per minute, the total iron sulphate loss can be estimated as

A·min x 0.05 grams.

It is advisable to replace the bath or add iron sulphate when about 30% of the initial amount has been used. Then check the pH and add caustic soda if necessary.

To give you an idea, you could plate 50 20x15 cm engravings in a 10 litre bath until the iron content drops by 30% (A·min = 0.17 A/dm^2·3 dm^2·45 min·50 = 1147 A·min; 1147·0.05 g = 57 g of iron sulphate, about 30% of the 200 g of the original bath).

I cannot confirm that the bath regeneration process works well and can be repeated several times. After adding the sulphate, I recommend a test on a worthless copper plate and checking the hardness with fine sandpaper (grade 400): if copper appears at the first friction, the bath is impoverished. If in doubt, replacing the entire liquid is a safe and inexpensive procedure.

Recommended iron bath

I recommend using the gluconate bath as it produces a very hard and bright iron layer without the need for stirring.

If you prefer not to worry about the iron content of the bath, or find it difficult to obtain sodium gluconate, the "traditional" bath will work well, as long as you stir it.

Equipment

Container

Use a plastic or glass container; a fish tank can be a suitable option. A width of 10 to 20 cm will be adequate.

Temperature adjustment

It is very important to work at the right temperature. To increase the temperature, you can use an aquarium heater, which is available at a low price up to 100W. In summer, you may need to decrease the temperature: use plastic bags filled with ice or cold water. Stir the bath before measuring the temperature.


Water heater

Power supply

[2] "Electroplating of iron from alkaline gluconate baths". E. A. Abd El Megjuid et al.. Science Direct.

There is no need for a high voltage power supply, 5 V is sufficient although most available units reach 15 V or more. A variable current limit is required. The maximum current depends on the largest copper plate you will use. For example, if the maximum size is 20 x 30 cm, and the current density is 0.5 A/dm², the maximum current required is 2 x 3 dm² x 0.5 A/dm² = 3 A.



Power supplies are available from any electronics shop. See the example in the figure.

Plating process

Bath stirring.

It is easy to understand why bath stirring is favourable. The iron ions pass to the copper and therefore the area close to the copper is impoverished in iron. It can only be renewed by diffusion. The agitation of the bath allows the zone close to the copper to always have the same amount of iron.

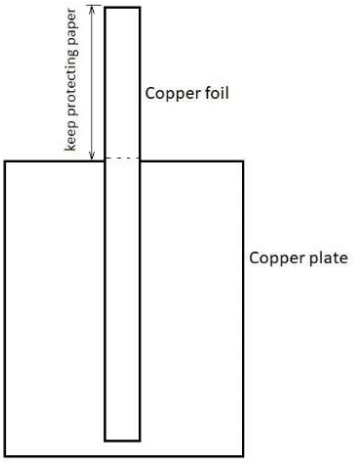
Anode

Use a plate as large as possible.

If an alkaline bath is used, a stainless steel plate is a good choice as it will not rust. Otherwise, use as pure iron as possible, making sure it is not galvanised. The anode must be very clean.

Attaching the electrode

The plate needs an electrode to which the current will connect. The classic way to do this is to sold a copper or brass strip to the back of the plate. However, if the plate is not too heavy, a simpler method is to use copper tape with conductive adhesive, available from electronic shops, such as Farnell, Mouser, etc. under the name “copper foil shielding tape” or “cooper foil with conductive adhesive”. The recommended width is 25 mm. In case of big plates two bands can be used. The foil has a protective paper in the adhesive side that has to be removed, but only from the part that is attached to the back of the copper plate.



Before adhering the copper foil to the back of the plate, make sure it is very clean. Then press the adhesive tape firmly against the plate.

How to clean the plate

First remove any ink residue with a strong solvent such as trichloroethylene.

If there are stubborn ink stains, apply a stripper gel and leave it on the plate for a while before removing and reapplying the solvent.

Once the plate appears clean, a final cleaning is required.

Wear rubber or plastic gloves and ensure access to a water source.

Take a clean cloth or kitchen paper and rub a mixture of ammonia and fine calcium carbonate powder (whiting or "Spanish white") onto the etched surface of the copper plate.

Rinse the plate thoroughly with a jet of water. The water should cover the plate evenly. If it forms droplets or leaves dry spots, repeat the cleaning process.

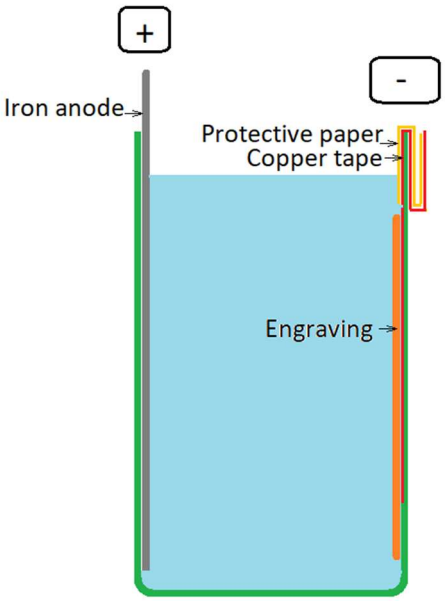
Immerse the plate in a solution of muriatic acid for a few seconds to remove any remaining calcium carbonate and copper oxidation.

Rinse the plate again with a jet of water.

The plate should now have a clear and uniform copper colour with an even film of water on the surface. If not, repeat the cleaning procedure.

Plating

The anode iron plate must reach or exceed the height of the tank. Make sure it is very clean, using emery paper if necessary. Hang the copper plate vertically in the bath from the copper tape(s). Fold the tape over the edge of the tank (double folding) as shown, to ensure electrical contact with the uninsulated surface. Secure it with an alligator clip (or crocodile clip) connected to the negative terminal of the power supply. Connect the iron anode to the positive terminal of the power supply using an alligator clip. Set the output voltage of the power supply to 5V or more and the current to 0. Gradually increase the output current of the power supply until it reaches the rated current.



Gently stir the bath if using the traditional bath. But stirring the bath is always good for any type of bath. When the time is up, switch off the power supply, disconnect the plate, rinse it thoroughly with water and dry it well with cloths. Remove the copper tape and apply oil or varnish to prevent rusting. Ensure that the plate is very dry before applying the varnish. You can use a hairdryer.

Removing the iron from the copper plate

If the copper begins to show during the printing process, remove the iron and repeat the plating process.

If a plate is to be stored for an extended period of time, it is advisable to remove the iron to prevent rusting, which could lead to corrosion of the copper.

Clean the plate thoroughly as if it were being plated, then immerse it in muriatic acid (hydrochloric acid). Use a brush to remove any sediment from the plate while it is in the bath.

Appendix

Böttger, ferrocyanide bath

For 1 litre:

In 800 cm^3 of water:
- 80 g of Rochelle (Seignette) salt
- 40 g of potassium ferrocyanide

In 200 cm^3 of water:
- 12 g of iron sulphate

Mix both solutions.

Then solve the blue sediment adding caustic soda while stirring the solution. If it is concentrated at 50% you will need about 28 cm^3.

23 to 27ºC, 1 A/dm^2
Recommended time: 20 minutes

Unfortunately, because the bath is alkaline, it does not attack the anode, so the iron content decreases with use, and the bath has to be changed frequently because it is not easy to add iron to the bath.