CASWELL

electroplating in miniature

Aluminum Anodizing Instructions

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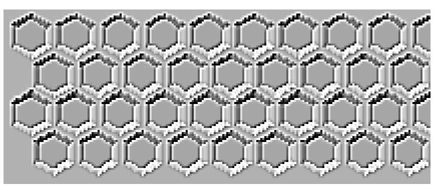
ANODISING ALUMINUM

The process of anodizing is, chemically speaking, rather complicated, but in practice is extremely simple.

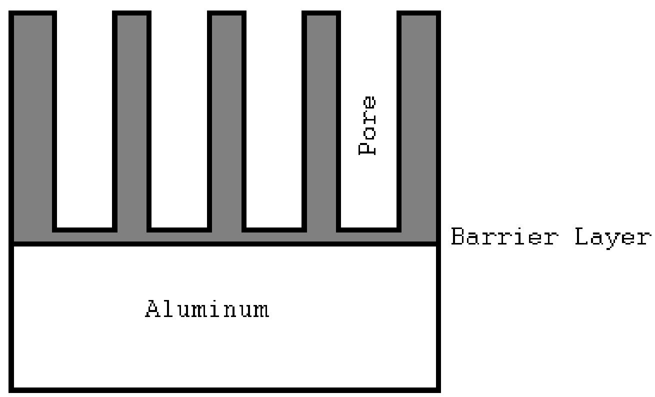
The process involves placing aluminum in an electrolyte, weak sulfuric acid, and passing a low voltage current through it. The aluminum part is connected to the positive (anode) side and the negative side is connected to a cathode made of lead. This causes the aluminum to oxidize, similar to steel rusting, with the net result of a very hard, tough abrasion resistant protective coating being formed. An interesting 'quirk' of this process is that the film formed looks like honeycomb, and has 'tubes' growing up from the aluminum. These tubes conveniently allow color dyes to flow into them

For the technically inclined, the surface of the aluminum actually grows a layer of aluminum oxide on itself, which is then transformed into aluminum hydroxide (anodize) and finally hydroxide monohydrate. The whole anodize layer is non conductive. The hydroxide is microscopically porous which allows it to absorb dyes. This layer looks somewhat like a honeycomb, as can be seen from this photo, magnified some 40,000 times.

The 'barrier layer' at the base of the pores is thin enough to pass some current, even though the complete layer is non-conductive, so the honeycomb structure continues to grow, as long as current is flowing through the system.



Looking from above



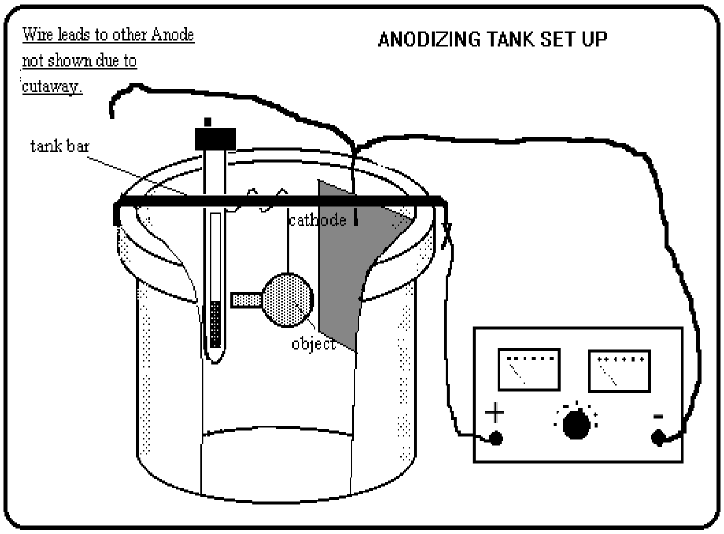
Cross section

Aluminum can be processed in a number of ways to achieve different effects. It may be highly polished to look like 'chrome', brushed with a wire wheel or Britex Wheel to provide a 'scratch brushed' finish, or even bead blasted to provide a 'satin' look. All of these processes would be done prior to anodizing, and the surface may, be sealed without dying.

Most types of aluminum can be anodized using this process. The purer grades of the metal will produce a better finish. Silicon & manganese alloy components tend to retard the process somewhat, however experimentation with different types of alloys will give the operator an idea if the process is suitable for a particular application. The anodized surface can always be removed!

The most exciting part of aluminum anodizing, is without doubt, experimenting with the amazing array of colors and effects one can produce, with a little practice and skill. The metal can be pretreated in a variety of ways, polished, scratch brushed etc., the anodize film grown, and then the colors applied prior to sealing the anodize surface, permanently locking the colors into the metal.

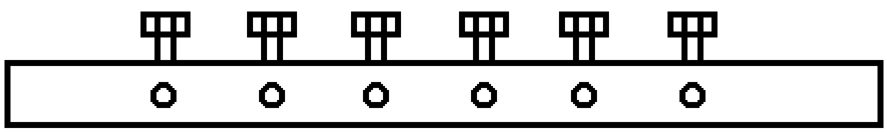
Setting up the Anodizing Tank



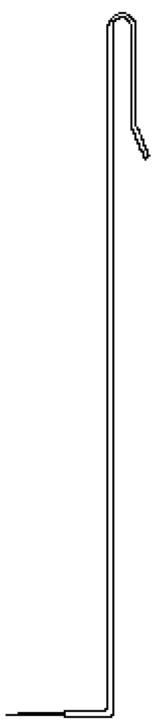
Wiring up the parts.

Anodizing requires special attention to wiring up the pats, because only aluminum parts can be placed into the solution, so the actual wire, or rack, must be made of this. Consequently, this also is anodized. If a connection is poor, then the anodize film grows on the wire, where it is touching the part, and an insulating barrier is formed, preventing further film growth.

Thin aluminum wire may be obtained from almost any garden center/hardware shop. This is ideal for wiring small parts, as long as you make sure you twist the wire on very tightly. You may also like to ensure a good connection by placing a 'Bull Dog' type clip over the wire.



An aluminum tank bar, using hex head bolts to secure the wire rack



Ideally, the tank bar should also be made of aluminum. This will avoid any corrosion problem, which may arise from the acid attacking a copper tank bar. A solid bar of aluminum could be used, and for the engineering inclined, this could be drilled with holes to accommodate the needle, which could be secured with hex head bolts, tapped into the block.

An alternative technique to wire is to use knitting needles. By removing the top of the needle and bending it into the shape needed, it can be forced into a slightly smaller hole, using the needle's tapered point as a wedge.

Aluminum knitting needles are usually anodized, and as this is an insulator, the anodize must be removed, either by sandblasting, abrading with emery paper, or stripping in the anodize stripper. If stripping, leave the needle in the stripper until all the color has gone, usually about 3 minutes. Some needles are coated with lacquer, so you may have to abrade this off.

Knitting needles (see left) are usually made of harder material and so, when the taper is forced into the hole, it slightly enlarges the softer aluminum, ensuring a tight fit. Soft wire will actually decrease in size if pushed into a work-piece, which is harder than itself, thereby shrinking it, and causing a loose connection.

There is a host of different types of Titanium grips and racking clips available. Titanium is actually better than using aluminum, as it is not anodized in the process, saving you the job of stripping your racks after each operation.

Servi-Sure Inc are suppliers of these racks.

www.servisure.com

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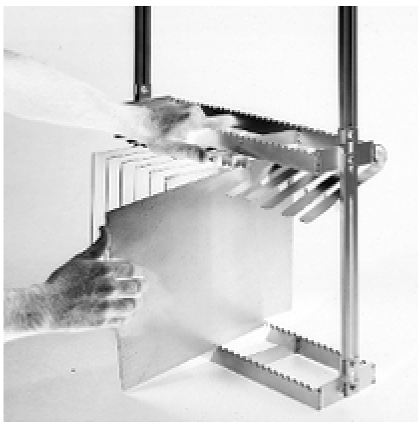
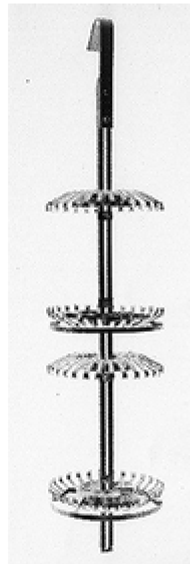
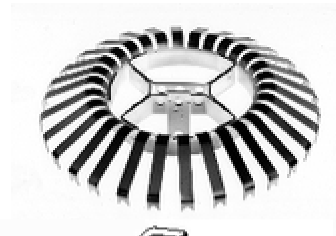
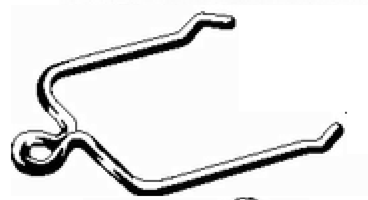
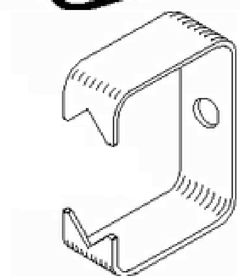








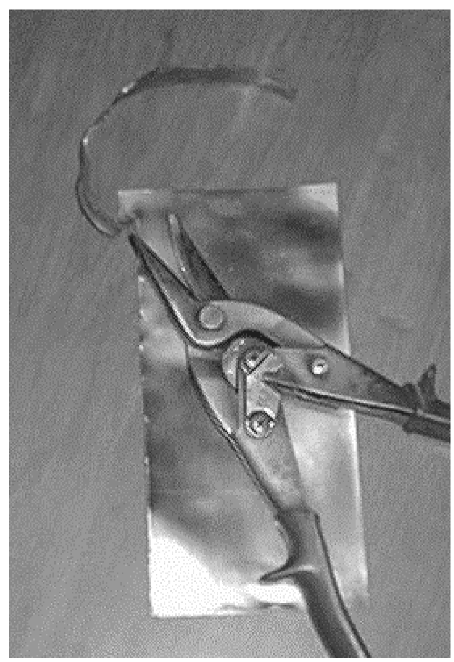


Installing the GP Plates (Cathodes)

The anodizing system uses 2 GP plates 8" x 12" as cathodes. (The actual part being anodized becomes the anode). To install these into the tank, see page 11 & 12 for anode/cathode installation procedures.

The GP Plates should be occasionally cleaned using wire wool or Scotchbrite type material.

Remove the plates from the solution when not in use.



TANK TYPE	De-Plating
SOLUTION TEMP RANGE deg F	65-80 opt =72
AIR AGITATION	yes
ANODIZING TIME (MINS)	7-10
CATHODE	GP Plates
ANODE BANDAGE	no
VOLTS SHOWING ON VOLTMETER	12
AMPS REQUIRED PER SQ. INCH	0.1 - 0.15
FUME HOOD	yes
USE AS A STRIKE COAT	no

The Power Supply and Power Requirements.

Unlike other plating procedures, where the amperage has to be controlled with a resistor or a bulb, anodizing draws only whatever current it needs from the power supply. This makes the power supply problem somewhat easier, and inexpensive battery chargers, or car batteries may be employed. The main consideration is, will the power supply output enough power for the time it takes to successfully anodize something?
Therefore, a small battery charger, having a limitless source of power (the mains) can successfully anodize anything up to its amperage rating at the rate of 0.15 amps per sq. inch of surface area of the part. A 12 volt battery, however, will anodize much larger parts.

a. Battery chargers

Battery chargers do a really good job of anodizing., whereas they are not quite as good for electroplating.

Set the charger to the 12 volt position. If you have 'fast charge' positions, such as 30 or 50 amps, do not use these, as the charger is not designed to operate at these outputs for long periods, and it will cut out.
If you have a 2 amp. charger, it will only be able to output enough current to anodize a part up to 20 sq. inches (2 amps divided by 0.1 amp per sq.inch)
If you have a 10 amp. charger, this will anodize up to 100 sq. inches (10 amps divided by 0.10 amp per sq.")
Therefore, the Caswell 25 amp rectifier will, in theory, deal with up to 250 sq. inches.

b. Batteries.

A 12 volt car battery is capable of giving out relatively large amperages, for a reasonable length of time. There is certainly enough power in a fully charged car battery to anodize a large part for at least an hour.

It is advisable to purchase an ammeter to measure the current flow when using a battery. This should be placed between the positive terminal of the battery and the GP Plates (Cathode)
Normally, the current draw will be less than the capability of the battery, so no problems will occur, but on smaller parts, you may have to insert a bulb or two to restrict and control the current.

c. **Rectifiers.**

Rectifiers are the ultimate in anodizing. Variable controls, voltage and amperes dials, allow you to fine tune your anodizing efforts. This can be especially useful when dying, as the minor variations can effect pore size of the anodize, which may interfere with the acceptance of the dye.

Setting up the Anodizing Solution

TO MAKE UP THE ANODISING SOLUTION

The battery acid bath (electrolyte) should be made up as follows:-

Using a plastic container mix up the following solution:-

Add battery acid to water - stirring constantly. Do not add water to acid!
Battery Acid is a mix of Sulfuric Acid and water 33% acid 66% water. It is available already made up from any NAPA Auto Store. Specific Gravity = 1.26

For general purpose anodizing:-

Add 3 quarts of distilled water
Add 2 quarts of battery acid

For Hard surface anodizing:- This is specialized and not normally used.
Add 4 quarts of distilled water
Add 2 quarts of battery acid

For dyeing anodize-

Add 2 quarts of distilled water
Add 2 quarts of battery acid

Multiply these amounts if you wish to make a larger tank.

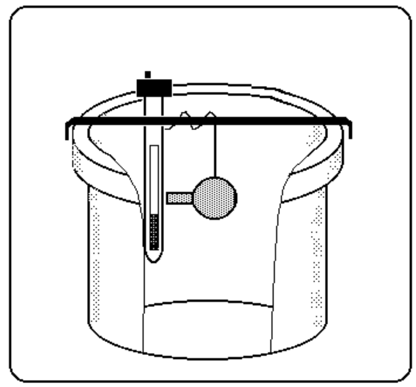
All these solutions operate at 70-75 deg F (20-25 deg C)

Add the Fume Control Balls. These help reduce fumes and hold in the heat.

Add one teaspoon of Anodize Fume Control per 2 gals made up anodizing solution.
You will need to add more of this occasionally, if you begin to notice an odor during operation.

Aluminum De-oxidizer

Aluminum De-oxidizer is a concentrated, easy to use liquid material designed to deoxidize and de-smut aluminum prior to anodizing, bright dipping and chromating. Aluminum De-oxidizer is non-chromated, yet offers performance comparable to or better than most chromate bearing products. The product is especially useful on certain types of aluminum alloys found on Japanese motorcycles, which have a certain amount of zinc in them. The prescence of zinc makes the casting smut as soon as it enters the anodizing tank. Pre-dipping with Aluminum De-oxidizer reduces this problem.



PRODUCT FEATURES
No chromate disposal problems. No heat required.

EQUIPMENT
Tank: HDPE Plastic tanks
Agitation: Continuous air agitation is recommended to increase effectiveness.

OPERATING PARAMETERS
Concentration: Mix 1 qt (1 liter) of Aluminum De-oxidiser with 2 gallons water
Temperature: 70-110°F Optimum 100 deg f
Immersion time: 1-3 minutes
Water: De-ionized or distilled

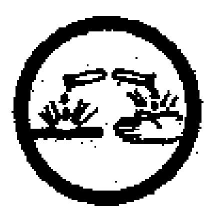
SOLUTION MAKEUP
Before making up or replenishing the working solution, refer to the Material Safety Data Sheet for protective safe handling measures.
1. Fill tank 2/3 full of water.
2. Add required amount of Aluminum De-oxidizer to the water with mild agitation.
3. Add water to operating level and mix again.
4. Adjust heater to 100 deg F

To prevent excessive heat generation and spattering, never add water to Aluminum De-oxidizer. Always add Aluminum De-oxidizer to water. Add in small amounts over the entire surface of the solution with mild agitation.
Dip the parts into the solution for 1-3 minutes, rinse in fresh water, then immediately proceed to anodize the part.

Operating the Anodizing System.

1. **Check the part for cleanliness**. After thoroughly preparing the part, by bead blasting, polishing etc. ensure it is completely degreased by using the 'water break test'. Simply run water over the part, if the water sheets evenly, then the part is clean. If it 'balls up' or spots, then it needs further cleaning. At this point, the part should already be wired up to the tank bar. This will prevent you from handling it.

2. **Caustic Etch**. Dip, for a few seconds only, into a room temperature solution of Caustic Soda (Sodium Hydroxide or Lye) This is usually sold under the brand name "Red Devil". Add 6 oz per gal of water. This operation may be ignored, especially if you have a highly polished part, as the etching action will dull the finish slightly. However, the part MUST pass the 'water break test'. Rinse the part.



3. **Anodizing De-Oxidizer** Dip the part for 1-3 minutes into the pre-mixed solution at 100 deg F. See the section on Aluminum De-oxidizer.

4. **Rinse**, thoroughly in fresh water. Agitate the part, and if necessary, spray with water to rinse chemical from hard to reach areas. A shower hose attached to a faucet is a great idea.

5. **Anodizing the Part**. Place the pat into the tank, and connect the tank bar to the positive side of your power supply. Make sure the negative wire is connected to the GP Plates (cathodes). Switch on the power. You should see small bubbles moving around between the part and the GP Plates.

   Genral Duration of Anodizing.

   - Jewelry 15 minutes
   - Small hand tools, implements etc 30 minutes
   - Motorcycle parts subject to road abrasion 60 minutes

   Anodize film forms at the rate of 2-3 minutes per 0.10 mil oxide coating thickness. 24 microns = 1 mil

   Remember: Parts requiring deep colors will require longer anodizing times – experiment.

   Remove the part from the tank and rinse off in distilled water - thoroughly.

6. **Acid Neutralizer.** Make up a tank of 1 gal distilled water and 1/2 lb baking soda, as your neutralizer tank. Before proceeding to dying, the part must be completely ridden of acid; otherwise, this will cause you problems. Acid dragged from the anodizing tank into the dye tank will cause streaking and blemishes. It will also eventually alter the dye's color. After neutralizing, rinse in fresh or distilled water.

7. **Dying**. (If a clear anodize is required, skip this part). It is important to try to dye the part as quickly as possible after growing the anodize film, otherwise the pores will begin to close up, and the dye will not be able to penetrate quite so effectively. Dying techniques are covered in a separate section. Rinse in fresh water.

8. **Fixing (or sealing)** Using the porcelain steel container supplied with the kit, place 1 or 2 gals of water, depending on what will cover the part, and add 1 oz per gallon of ANODIZING SEALANT POWDER, and bring to the boil on any heat source, such as a gas or electric burner. Then place the anodized part into the tank, using the tank bar as the suspension support. Boil for 2-3 minutes per 0.10 mil oxide coating thickness. 24 microns = 1 mil Wipe the parts dry and immediately apply a mineral oil (WD40 etc) with a soft cloth.

9. **Polishing.** You may polish the part using a loose cotton buffing wheel and either a white or blue buffing compound. Be sure to take care, the anodize film is not very thick. You could damage it.

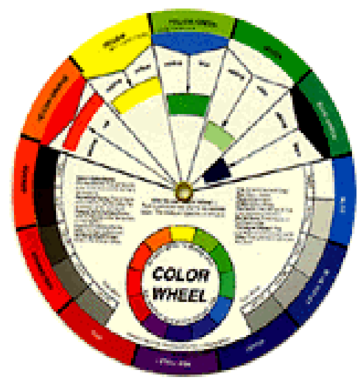
Dying the Anodize

The dying of anodized aluminum is probably one area where artistic creativity can really come to the fore. Limited only by your imagination, parts can be dyed in many ways and colors, to create amazing results. The application of the dye can be done in several ways: simple immersion for a single color, multi immersions for two or three tone effects, air brush painting, silk screen, splash dying etc. etc.

Code	*Color name*
DYERB9	Red Bordeaux 2R
DYEY9	Yellow 4A
DYEB9	Blue 4A
DYEV9	Violet 3D
DYEBLK27	Black HBL
DYEGR9	Green SCG
DYEGO9	Gold S (Simulates Gold Plate)
DYET9	Turquoise PLWN
DYEGRY9	Grey BL
DYEOD9	Olive Drab
DYEBR9	Brown GL
DYEO9	Golden Orange

Here, we hope to address all of these techniques, but your best way of getting the most from this process is to EXPERIMENT!

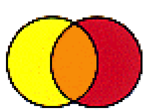
Caswell Inc now carries a range of professional dyes. For a color sample, please visit our web site @ http://www.caswellplating.com/anoidizedye.htm



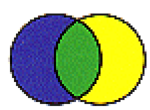
These dyes can be mixed together to create a host of different colors. The dyes are in concentrated liquid form, a 4oz bottle makes up 2 gals of ready to use dye. To make up different colors, we suggest that you make up the colors to the correct dilution first, then take a quantity of each dye and blend them together. A color wheel is supplied with all anodizing kits. The use of a color wheel will give you a good concept of what to expect when dying.

What Does the Color Wheel Do?

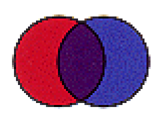
The Color Wheel shows how the three primary or parent colors (the only colors that cannot be made by mixing two others) relate to each other. The wheel clearly illustrates the results of color mixing. For example, equal amounts of two primary colors (red, yellow, or blue) create secondary colors (orange, green, or purple).



Yellow + Red = Orange



Blue + Yellow = Green



Red + Blue = Violet

Anodizing dyes are transparent, so this means you can 'overlap' colors, just as in the diagram above. The dye colors also mix well, which allows plenty of variety in 'mix 'n match' dying. When over-dying, consideration must be given to the color wheel, red and yellow = orange, blue and yellow = green etc. These colors are adjacent to each other on the wheel. However, if you try to dye across the wheel, eg: yellow & violet, or blue and orange etc, you will get only shades of brown. Dying green over red gives you black or brown.

Anodize the aluminum at 72 deg F for 30 minutes @ 12 - 18 volts @ 14 amps per sq foot or 0.1 amp per sq inch. This will yield a film thickness of approx 12 microns. When using a battery charger, simply make sure that the rating is higher than this, and the anodizing process will draw what it needs.

After thorough rinsing, immerse the part in the dye at a temperature of 140 deg F for 15 minutes. Finally, seal by hanging the part in a steam bath for 30+ minutes

COLOR MIXING

You have some choices when it comes to creating new colors.

- **A. You can premix the dyes.** This involves some experimentation to get exactly the right color.
- **B. You can over-dye.** Starting with the lightest color, simply dip the part in, rinse off, then dip into the next color, and so on. Using this technique, you can easily see exactly what is happening, and you don't waste you original colors by premixing.
- **C. Toning a dye color.** Various shades can be created by dipping the colored anodize into a black dye.
- **D. Shades of color.** The duration of dipping time will lighten or darken the overall color of the dye.

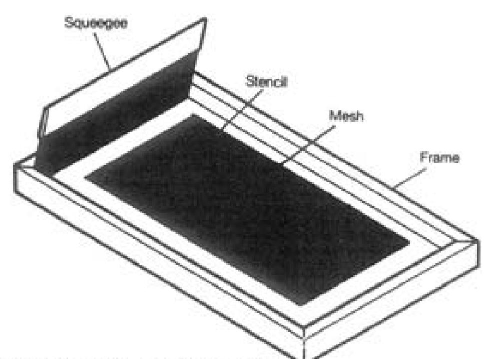
COLOR APPLICATION

There are an almost infinite number of ways you can apply dye to anodized surfaces.

- Immersion.
  - Full immersion to produce one solid color
  - Partial Immersion to produce two or more colors
  - Over dying by immersion.

- Direct Application
  - Air Brush (see right)
  - Paint Brush
  - Syringe
  - Eye Dropper
  - Sponge
  - Splash or spill over
  - Silk Screen
  - The dye may need to be thickened. This is accomplished using the following materials:

Water 1000 parts
Corn Starch 75 parts
Tapioca Starch 25 parts
Gum Tragacanth 225 parts



HAND PRINTING UNIT SHOWING 4 BASIC COMPONENTS OF SCREEN PRINTING.

Add this mix @ 20% to 80% of the dye depending on the consistency required.
There is a huge potential for silk screen work in the decoration of aluminum for road vehicles. In particular, the motorcycle and Hot Rod enthusiasts would love to see the large areas of aluminum, such as side covers, with more permanent decoration. By using a silk screen process, and starting with the lighter colors, several colors could be screened over the aluminum, to create full color logos etc. Pastel dyes could be used as a background color. A good example would be a side cover from a Harley motorcycle. Dip it in the gold dye first, then screen on the orange of the Harley logo, and finally screen on the black element of the logo. The part would need to be set in a jig of some sort, to ensure the logo colors are printed in the correct places. A little 'Imagineering' and a small production run could easily be set up.

MASKING OFF

There may be areas where you want the original color of the metal to show through, yet total immersion would spoil the effect, or you may want to create patterns in the over dye or subsequent colors. To prevent dye from affecting these areas, a number of 'masks' can be used, such as: masking tape, Avery Labels, clear contact paper, rubber cement, grease pencils, etc. Liquid masks can also be applied using a simple silk-screen process. Grease pencils will be removed in warm water. Check the melting point of the pencil.

REMOVING DYE

You may find that a mistake has been made on your work-piece, perhaps the color is wrong, whatever the reason, you have to remove some, or all, of the dye. As long as the part has NOT been sealed, most dyes will easily be removed by immersing in household bleach. We've found that our black dye (the most dense color) whites out in about 1 minute with a splash of bleach. Rinse the part thoroughly afterwards in room temperature water (not hot, or you will start to seal the anodized surface). You may apply the bleach with a brush, or a cotton swab, or you may even fully immerse the part.
MAKE SURE YOU DO NOT ACCIDENTALLY DROP BLEACH INTO ACID, (e.g. the anodize tank), AS THIS CREATES DANGEROUS FUMES!

If the part has been sealed, then you can immerse it in ANODIZE STRIPPER to remove all the dye along with the anodize film. Of course, after doing so, you'll have to re-anodize the part.

SEALING THE ANODIZE WITH ANODIZING SEALANT
High Temperature Sealant

Any lined vessel may be employed for sealing.
Ceramic lined or stainless steel cooking pots are ideal.
Do NOT use aluminum, as it causes problems.
Always use distilled water, as ordinary water may leave mineral deposits on/in the film.

Anodizing Sealant is a nickel acetate compound for sealing anodic coatings on aluminum. Anodizing Sealant is a fine flowing greenish powder, readily soluble in water. It is specifically formulated with a pH regulator and an agent to help minimize smut. Anodizing Sealant is suitable for clear anodize and offers increased weather and light-fastness on coatings dyed with aluminum dyes.

OPERATING PARAMETERS

Make up a solution of 1 oz per Anodizing Sealant to 1 gal of distilled water - or 7.5 grams per liter
Time: 5 to 30 minutes depending on anodize thickness (2-3 minutes per 0.10 mil oxide coating thickness) 24 microns = 1 mil. (The anodize film will grow at the rate of 0.10 mil every 3 minutes of anodizing.)
Temperature: 202-210°F
pH: 5.5 to 6.0
Water: Deionized or Distilled water

CONDITIONS FOR USING ANODIZING SEALANT

Tank: Sealant solution should be contained in a non-metallic or ceramic lined steel tank.

pH: pH adjustments will not be necessary unless acetic or alkaline compounds are carried over into this sealing bath. Then acetic acid (to lower pH) or ammonia (to increase pH). Acetic acid is difficult to come by, and it is preferable to discard the bath, especially as it has a limited shelf life anyway.

Rinse: Before sealing, a thorough rinse is necessary to remove any foreign substances. After sealing, the work should be thoroughly rinsed at once, as is normal in nickel acetate sealing, before it is dried.

Filtr Filtration clears the bath of precipitates with interfering action. Filter through coffee filters after each use.

Maintenance: Bath life is 14-60 days dependent upon operating conditions and bath upkeep.

BATH TURBIDITY

Freshly prepared nickel acetate sealant baths are clear green solutions. In use they become contaminated by precipitates and grow cloudy. If not removed, these contaminants can form deposits on the sealed surface. The effect can be due to the following: High pH (at pH values above 6.0, nickel acetate may be converted into soluble nickel hydroxide), hard water and entrained impurities.

The following measure can be taken to minimize this affect: Maintain pH value of 5.7 ± 0.3, through rinsing of anodized, dye or un-dyed work prior to sealing to prevent possible introduction of contaminants and filtration to clarify the bath and to prevent surface deposit formation

BATH REPLENISHMENT

As mentioned the bath life will range from 14-60 days. This is due to contamination of the sealing bath and decrease in the active substance. A decrease on preventing smudging and an increase in smut may be noticed. Thus even when the bath concentration is strengthened regularly, the Anodizing Sealant must be replaced from time to time.

BATH CONSUMPTION

The consumption of Anodizing Sealant is calculated from the amount absorbed by the anodic film, the amount carried out of the bath and the amount of active ingredients inactivated by the introduction of foreign substances. Below is the average consumption of Anodizing Sealant per unit area of sealed surface:

Absorption by the film	0.4 g/m2
Amount carried off .	3 g/m2
Consumption for strengthening additions	7.0 g/m2

STRIPPING THE ANODIZE FILM

Mix up a solution of 4-6oz of Anodize & Chrome Stripper with 1 gal of water. Add the powder slowly to the water.

Dip the anodized part into the solution for between 20 seconds and 10 minutes, depending on the thickness of the existing anodize film.

Rinse off the part thoroughly in fresh water.

Test for anodize film (see below) and if present re-immerse.

Ideally, the solution should be at approx 70 deg f plus. The hotter the solution, the more rapidly the anodize film will be stripped.
Solution temperature range is 70-150 deg f.

Use only plastic vessels, not aluminum as this material is extremely corrosive to this metal.

TESTING FOR ANODIZE FILM CONTINUITY

Anodize film in non-conductive, whereas the actual aluminum is not.
It is therefore relatively easy, using a multimeter, to determine if we indeed have grown an anodize film.
Set any multimeter to the 1000 ohm setting.

Place the black and red probes on the aluminum in different places. The needle on the multimeter dial will swing over if there is NO anodize film. If you have grown an adequate film, then the multimeter will not register at all.

Some Interesting Points about Anodized Aluminum.

Anodized aluminum has a very durable surface that is unaffected by weather and many chemicals
The surface will resist high temperatures, even a blowtorch, for short periods.
Many other types of dye may be used with varying effects, fabric dye, leather dye, water-based ink, felt tip pens etc.

Anodized films are usually measured by their intended operation:

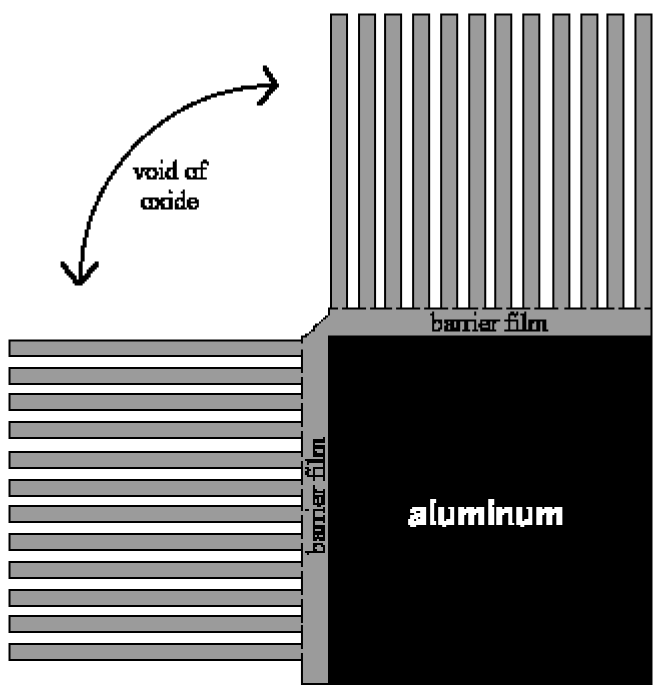
Interior or unexposed articles	0.1 - 0.2 mil	(mil = 1/1000")
Auto Trim	0.2 - 0.4 mil	
Architectural or construction	0.8 -1.0 mil	

Once a part has been anodized, it cannot be reshaped, and any great degree of flexing will cause the anodize film to crack.

Sharp edges can create problems, because the anodize pores grow out at right angles to the metal. On the example here, the corner area is almost completely void of pores. This will show up when dying.

Consideration needs to be given to this phenomenon, and sharp edges should be rounded over.

Pore diameter and barrier film thickness will vary depending on the voltage and the electrolyte temperature. Different alloys will also have different effects. Pore size is related to voltage, higher volts means larger pores. This can sometimes have adverse effects on dying, because the pores are too large and the dye runs out.



TROUBLESHOOTING ANODIZING

FAULT	PROBABLE CAUSE	REMEDY
Decrease in depth of color	Bath contamination Dye used up	Improve rinsing Extend dying time Replace bath
Color depth changes in a production run	Anodizing film is inconsistent	Improve conditions to ensure constant procedure
Color differences	Irregular current in anodizing procedure Different alloys	Clean contacts Dye only similar alloys
Darker edges	Irregular current density and heat building up film	Reduce current/heat Lower dye temp and dye for longer period
Large cloudy areas	Anodizing temp not uniform	Increase air agitation
Pale spots	Oily Uneven wetting of the parts when dying impurities Local overheating by polishing Gas bubbles on anodize pores	Add 2 drops liquid detergent Immerse in the wet state only. Agitate the parts in the dye bath. Re-anodize -briefly Agitate parts. Increase air agitation.
Dark Spots	Over heavy dyeing, superficially attached particles	Reduce dying temp & extend dying time. Clarify dye bath by filtering.
Dull &/or chalky dye (probably won't wipe from surface.	Inadequate anodize, too soft. Current free suspension in anodize. Coating attacked by low anodize bath pH.	Reduce anodize temp/time &/or acid concentration. After switching off current, remove parts & rinse off. Increase PH to 4.
Opaque & dull coating, removed by wiping.	Excess of hydrolysed aluminum.	Replace dye bath. Acid dip part prior to dying to dissolve & clear aluminum.
Surface pitting & soft coating	Part to close to the cathode	Increase tank size &/or move part further away

ANALYSING DYING PROBLEMS

Questions to ask	Main Reasons parts fade:
1. What dye was used? 2. What was dye-bath concentration, ph and temperature? 3. What was the oxide coating thickness? 4. How long was the part dyed? 5. What sealant was used? At what concentration, temperature, pH and time? 6. Were the parts cleaned, etched and deoxidized prior to anodizing? 7. Does the faded part have exposure to light from a window? 8. Does the part get hot?	1. Wrong type of dye used. 2. Parts not dyed long enough. 3. Oxide coating to thin. 4. Poor sealing. 5. Parts exposed to high temperatures. 6. Interior parts were dyed with wrong type of dye and placed by a window. 99% of the time, the cause is dye time (too short), poor sealing and too thin oxide coating. Please remember, just because a dye may have a good rating for lightfastness, it does not mean that it will have an unlimited life expectancy.

SULFURIC ACID ANODIZING

Sulfuric acid anodizing produces oxide coatings with excellent corrosion and wear resistance. It is also the basis for most decorative coloring finishes on aluminum in use today. The information on anodizing listed below relates to standard anodizing (type II) parameters.

Sulfuric acid (free)	165-225 g/l	Aluminum content	5-15 g/l
Current density	12-15 amps./ft. sq.	Voltage	15-25 volts
Current	D.C.	Temperature	70°-72°F
Time	10-75 minutes	Oxide thickness	0.10-1.0 mil.

The direct current sulfuric acid process is preferred because it produces a coating with optimum properties for dyeing with organic dyes and inorganic colorants.

In the adsorptive dyeing of anodic coatings, the final shade is not determined by the dyeing process alone, but to a great extent by the properties of the anodic coating structure, which are determined by the anodizing parameters.

Deviation from standard anodizing conditions

Standard Parameter	Deviation from standard	Difference in intensity of dyeing
Sulfuric acid concentration	higher	deeper
	Lower	paler
Aluminum concentration	higher	alter coating structure
	Lower	slightly paler
Current density	higher	paler
	Lower	deeper
Temperature	higher	deeper
	Lower	paler
Time	longer	deeper
	Shorter	paler
Oxide thickness	thicker	deeper
	Thinner	paler

Sulfuric Acid Concentration

Most conventional sulfuric acid anodizing is carried out using electrolyte concentrations ranging from 165-225 g/l free sulfuric acid. An increase in the sulfuric acid concentration intensifies re-dissolution of the coating, producing a pore structure of greater average diameter allowing dyeings of greater intensity. It is most important to maintain the free sulfuric acid concentration within narrow limits to ensure successive dyeings of equal intensity.

Aluminum Content

Experience has shown that the presence of small amounts of aluminum in the electrolyte is advantageous. The dye adsorption capacity decreases when the aluminum content is below 5 g/l, but remains constant at higher concentrations. Aluminum content above 15 g/l lead to irregularities in the anodic coating. It is good practice to keep the aluminum between 5-15 g/l.

Current density

The standard current density is carried out 12-15 A/Ft 2. An increase in the current density decreases the porosity of the anodic coating and thus the dye adsorptive capacity is lower since the metal is exposed for a shorter time to the dissolution action of the sulfuric acid. At very high current density, burning of the parts can be caused by high current flow at local areas and overheat the parts.

Voltage

The voltage is given by the anodizing parameters and the type of alloy being anodized. It usually will range between 12-25 volts.

Temperature

Standard anodizing temperature for sulfuric acid anodizing (type II) is 70°-72°F. A higher temperature increases the dissolution of oxide and limits the amount of anodic thickness attainable, but results in a more porous or softer films with a higher capacity of dye adsorption. However, as the pore size is increased, sealing becomes more difficult and more dye will bleed during the sealing process.

Anodizing Time and Coating Thickness

Anodizing time can range from 10-75 minutes with an anodic coating thickness in the range of 0.10-1.0 mil. The anodic thickness is dependent on the current density and the time left in the anodizing solution. The current density needed can only be calculated in plant production. The anodic thickness increases with increases in time.

Rinsing After Anodizing

Thorough rinsing after anodizing is important to remove all acid residues clinging to the work. Insufficient rinsing can result in the drag-in of the electrolyte into the dyebath causing uneven dyeing, streaks discoloration, and/or dyebath contamination. Double rinsing is recommended with at least one of the rinse tanks with overflow.

TITANIUM ANODISING

For reference only

Any electrolyte will do: phosphoric, coca-cola, sulfuric
Colors are achieved by varying oxide thickness.

Colors are achieved thru refraction of light on titanium surface.
The color changes with the voltage rather than amperage.
Clean parts in 25%-30% nitric with 2-4 oz/gal HF

1-8 volts	yellow
9-12 volts	brown
13-20 volts	maroon
21-25 volts	blue
26-35 volts	green
36-45 volts	gold
46-50 volts	rose
70 volts	purple/fuscia