This is a digital reprint of "Practical Electrotyping Guide - How to Make Your Own Matrices" by Mike Anderson. It appeared originally in the *Newsletter* of the American Typecasting Fellowship, No. 27 (March 2002). This reprint was done from the version distributed by Mike Anderson in his presentation on matrix electroforming at the American Typecasting Fellowship conference in 2010 in Piqua, Ohio.

Anderson notes that his current procedures are essentially the same as those described here. He now uses a small pump to circulate the electrolyte. He also hangs a piece of lead on the positive side (anode, copper souce) of the electroforming circuit.

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Practical Electrotyping Guide—
How to Make Your Own Matrices

By Mike Anderson

How many times have you looked into a case of type and wished you had a few more sorts of a character so you could do something with the face? Or how often have you looked at a set of matrices and wanted to cast the font, but it was missing the "e" matrix or some other character? Well, you can fill up that box or replace the mat in the set if you set up a mini-electrotype station and "grow" your own matrices.

The Fever Strikes

In 1999 I had the opportunity to attend Monotype University 3, held at Rich Hopkins' Hill & Dale Private Press and Typefoundry in Terra Alta, West Virginia. Two of the instructors, Roy Rice and Paul Duensing, were well qualified in the art of electrotype matrix making. Both gave presentations in matrix production, and Roy provided a copy of his excellent paper *Matrix Making at the Oxford University Press: With notes on the same process as used at The Recalcitrant Press* (Atlanta, Georgia, The Recalcitrant Press, 1982). Paul, who has mastered the art of punch cutting and engraving, provided his definitive work, *Matlas: An Atlas of Matrices* (The Private Press & Typefoundry of Paul Hayden Duensing, 1988). It was from these presentations and papers that the urge to produce my own matrices consumed me.

Later, I read Theo Rehak's *Practical Typecasting* (Oak Knoll Books, 1993). Theo's chapter 12 covers the process of electros in great, but very understandable, detail and bred new life into the process. Then Jim Walczak, printer and typefounder (who is responsible for getting me into casting my own type), gave me two pounds of copper sulfate. The fever was burning!

However, everything I read seemed to be talking about seven to 50 gallons of chemicals and an extensive (and probably expensive) power supply. And above all else, where to buy the copper sulfate and sulfuric acid needed to make the solution? I decided to find a way to produce my own matrices on a *small scale* at a reasonable startup cost. To do this, I had to determine what was needed. (Table 1)

Background

Copying other foundry typefaces was a common practice almost from the beginning. There was no such thing as patents in the 14- and 1500s, so once a face was designed, cut and produced, it became fair game for the other printers to copy. Aldus Manutius understood this all too well. Aldus petitioned the Venetian Senate for a ten-year privilege for the exclusive use of italic to prevent its usurpation in Venetian territory for the famous italic face cut by Francesco Griffo in 1500-1501. However, Griffo had cut a second set of punches and sold them to Girolamo Soncino of Fano, who used them in 1503.

The early copyists had to re-cut the punches, a time-consuming and often inexact art that resulted in altered characters. This was to change in the 18th century when, in 1789, Luigi Galvani chemically produced electricity and in 1799 Aslessandro Volta built the first electric battery. In 1834, two other players invented improved versions of galvanic cells, using zinc and copper plates suspended in copper sulphate and sulfuric acid. Thomas Spender found that copper was deposited on the cathode "negative metal," and that the zinc pole (positive or anode) was etched. Spencer

Table 1
Costs for Small Electrodepositing System

ITEM	AMOUNT	COST
Copper Sulfate	7 pounds	$10.00
Sulfuric Acid	1 Ltr.	6.00
Distilled Water	2 gal.	2.00
Power Supply	1-12 volts 300 ma	13.00
Variable Resistor	3 Watts/wire wound	4.00
Hydrometer	Battery Tester (scale)	6.00
Multi meter	2 v/dc min.	20.00
Container	3 gal. min.	5.00
Copper Tubing	3 ft. @ $1.60 ft.	4.80
Aquarium Air Pump	30 gal capacity	5.00
Wire 12 Gauge	10 ft. @ .60 ft.	6.00
Total		$81.80

Does not include additional items such as bolts, nuts, connectors, small gauge wire and shipping and John Wilson were granted a patent in 1840 for "engraving metals by voltaic electricity." Spencer continued research and was able to reverse the procedure (*i.e.*, not etch the positive, but deposit on the negative) and reproduce seals and plate small objects by the process that became known as "electrotype."

Once electrotyping was understood, the next step was to buy a font from another foundry and electrotype new matrices—and this was done throughout the printing world for decades. Today most fonts are, shall we say, in the public domain. However, there are many that are the property of private presses and their ownership *must* be respected. *In other words, do not copy someone else's work!*

The keywords in the above are: anode, cathode, copper sulfate and sulfuric acid. These, plus distilled water, are the key players in making matrices.

Preparation

During a phone conversation with Roy concerning the building of his power supply, he mentioned that his electrical unit was providing only 0.58 volts and 85 milliamps (mA—or 1000ths of an amphere), very low voltage and current. Also, Theo's book had addressed low voltage and current and it was then that the thought of a simple power supply came to mind.

After further study and consideration I decided to try to control the voltage of the common AC/DC power adapter used to re-charge or run various direct current (DC) devices, such as cell phones. To do this, a very low voltage, low current adapter would be needed along with a variable resistor to control the voltage output.

A trip to Radio Shack provided a 1.5–12 volt, 300 mA AC/DC power adapter and a 25-Ohm rheostat (3 watt, wire wound variable resistor), and a Vtvm (Multitest unit). All this was mounted on a wooden block, wires fixed on one end with connector and soldered to the rheostat (also known as a "pot") on the other. Checks with the Vtvm showed the voltage could be varied with the pot from almost zero to the full three volts and drop the current from 300 mA to almost zero.

A stop at the local auto parts supply house provided me with a cube (1 liter) of sulfuric acid. Sulfuric acid is used in all automobile batteries, but today, most car batteries come "charged" and ready to put in the car. However, motorcycle batteries are not charged because the demand for them is less and they sit on the shelves much longer. Therefore, some auto parts supply houses will have sulfuric acid.

Copper sulfate ($CuSO_4$) can be purchased from ceramic shops, pet supply companies (and probably veterinarians), and some nurseries. Copper sulfate must have greater than 25% copper. Distilled water is on the supermarket shelves. Mixing the three ingredients together in the proper proportions provides the electrolyte (or "soup," as it is sometimes called).

Step 1: Preparing the Solution

As mentioned, copper sulfate, sulfuric acid and distilled water are needed to make the electrolyte solution for electrotyping. The following formula follows Roy Rice's article advice on specific gravity of the mix. The volumes have been determined through experiments in preparation for this paper.

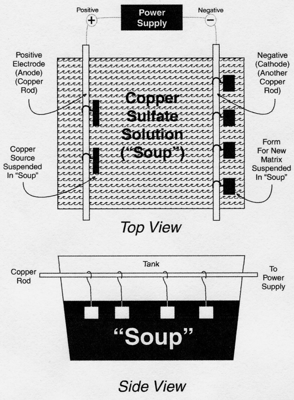
The finished electrolyte needs a final specific gravity (SG) of approximately 1.125. A simple hydrometer purchased at the auto supply store will perform well for the following procedure (however, be sure to buy one that has a floating indicator with markings and not the floating balls).

The following formula and procedure works for all volumes, with one for a 2-gallon batch being presented here.

2 gallons distilled water.
2½ pounds of copper sulfate
Approximately 18 fl. oz. sulfuric acid

Pour one gallon of the distilled water into a large plastic container. Slowly add the copper sulfate and stir with a wooden stick until most of it is dissolved. This may take some time and it is best to return periodically and stir. At saturation, no more copper sulfate will be dissolved; if all does dissolve, add a few more ounces of copper sulfate until saturation is reached. The SG of saturated copper sulfate is approximately 1.150 to 1.160 (according to my hydrometer). Pour the heavy solution into a one-gallon plastic container; keeping the remaining sludge in the larger container to dispose of.

FIGURE 1



Wash out the larger container with fresh water, and then return the heavy solution. The SG will be approximately 1.150. Add approximately three quarts of distilled water (from the second gallon), checking the SG, until it reads between 1.103 and 1.105.

Now, caution and protection is required for the next procedure. Wear rubber gloves, apron and eye protectors, and in a throw-away measuring cup (can be purchased at camera supply houses) or a Pyrex measuring cup marked with fluid ounces, slowly pour 18 fluid ounces of sulfuric acid from the cube into the cup. Add sulfuric acid to the solution 5 fl. oz. at a time, and with the wooden stick slowly stiring the contents. Check the SG, and repeat the process until the SG reads approximately 1.125. Your solution is finished.

NOTE: add the acid to the copper sulfate solution *slowly*—never, never add the solution to the acid!!!! Remember, add acid to water, never water to acid!

You can make the electrolyte without a hydrometer by mixing all the solution as listed (7 quarts distilled water, 2 pounds copper sulfate and 18 fl. oz. sulfuric acid) and the process will function fine. However, if the SG is too low, the growth will be faster and perhaps a little rough. When the SG is too high, the growth will be slower and complete filling of the hole will not always occur.

The soup you have mixed is low on sulfuric acid by volume, but please remember that it does have acid in it and can irritate the skin, burn the eyes and rent holes in fabric. This is similar to the solution found in car batteries, so use caution and common sense. *Read the label on the cube.*

Step 2: Building the Growing Tank

Growing tanks can be made from any glass or plastic/rubber material. It was found that a deep, square, two-quart glass container was ideal for growing up to four mats at a time. For doing more mats, a plastic container worked well. The plastic container was drilled with ¼-inch holes two inches above the two-gallon mark on opposing sides of the container to hold the copper rods from which the anode and cathode are hung (Figure 1). These were made from ¼-inch tubing. One end of each rod was flattened and a 5/16-inch hole drilled through and a bolt and nut were inserted to attach the power source on both rods.

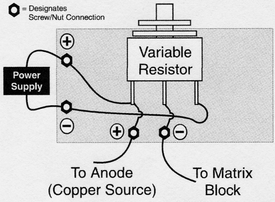
Step 3: Building the Power Supply

To build the power supply you will need the following:

1 piece of ¾"x4"x5" wood
4 1½" No. 42 bolts with 8 hex nuts to fit
1 3-watt rheostat
1 ½"x1/16"x4" piece of metal strapping (a tin can cut in 1" strip and folded in half will work).
1 1.5-12 volt 300 mA AC/DC power adapter
1 wood burning tool and a piece of solder (you can do without this if necessary)
1 16" piece of small gauge wire cut into 4 equal pieces. Remove insulation from both ends approximately ½ inch
2 ½" wood screws
1 package solderless connector rings.

Following the layout (Figure 2, next page), drill four holes, insert the bolts and tighten down with one nut each. Drill two holes into the metal strap, one ½" from end and the other

FIGURE 2



1" from same end. Drill a ⅝" hole in the strap ½" from the opposite end. Bend the strap at a 90 degree angle ½" inch from the second small hole drilled. Attach the strap as shown in Figure 3. Remove the hex nut and washer from the rheostat and insert and attach with washer and nut to metal strap (as shown).

With the soldering iron or wood burning tool, tin the ends of the four pieces of wire, bending one end of all in half (for attachment to solderless connector rings). Attach the connector rings to the ends of all wires using the wire cutter portion of a pair of needle nose pliers (do this gently as you can cut through the connector). Attach two of the ring connectors to the poles on the input side, and two to the poles on the output side. Place second nut onto pole and tighten down to hold the connector rings.

Following the diagram, insert the negative input wire into the bottom finger (#3) of the rheostat and the positive input wire to the top finger (#1). Twist the wires making a solid connection. Next, insert the negative wire from the output side to the center finger (#2) on the rheostat and the positive finger into the top finger (#1). Twist to make good connections. Now, with the soldering iron or wood burning tool, heat each finger and flow the solder onto it, making sure the solder runs smoothly and makes a good solid connection.

Step 4: Testing the Power Supply

With the multimeter (Vtvm), test all connections for continuity (place in the ohm test position and then touch the positive to the positive input pole and the negative to the other poles in turn on the rheostat)—you should get a reading. Now zero adjust the ohm meter, fix the positive to the positive pole output and the negative to the negative pole output and vary the rheostat. You should see the ohms move lower as you increase the resistance and rise as you reverse directions.

Clip off the end of wire coming from the power adapter (your power supply) and strip the ends bare as done above, tin and bend. Then attach connector rings. Check with Vtvm to determine which output wire is the negative (usually the side with writing on it is the negative output line). Loosen the second nuts and attach according to the diagram. Tighten the second nuts down tight again.

Step 5: Designing the Form

A "Form" consists of a variety of quads, rules, leads and the pattern type element all precisely built together to replicate dimensions of a Monotype matrix, and having guides (called "bearing walls") on the top and right edge to assist in the accurate positioning of the blank matrix for the depositing process.

The form (or type holder) consists of four main bodies (Figure 3): the upper quad (A), the type piece (B) the lower quad (C) and a standoff (D). Dimensions of quads A and B vary according to the point size of the type you're duplicating. Check Table II for proper sizes. These dimensions are very important if the matrix is to be used on Monotype Sorts Caster, for the operator of this machine is not

FIGURE 3

Components of a "Form"

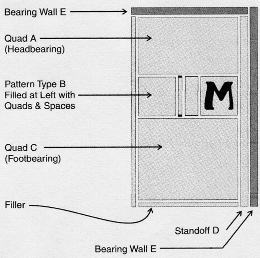


Table II
Image Positioning on Matrix

Point	Body	Quad A (Headbearing)	Quad B (Footbearing)
12	.166"	.441"	.518"
14	.193"	.414"	.518"
18	.249"	.358"	.518"
24	.332"	.428"	.365"
30	.415	.345"	.365"
36	.498"	.262"	.365"

able to move the character on the body very much in either direction (as *is* possible with the Thompson); thus, the matrix must be accurate in the first place. As you will note, there are two important foot bearings, one for 12 through 18 point (0.607"), and the other for 24 through 36 point (0.760"). To insure that the typeface is consistently located the proper distance from the edge of the matrix, a "standoff" (.0117" wide) must be positioned to the right of the sample letter.

To guarantee correct alignment of the matrix blank to the face with the body (horizontally and vertically), two pieces of type-high 6 point rule are placed on the right side and the top. These pieces (called "bearing walls") form a right angle in which the prepared matrix is held. A 3 point lead is used as a low bearing wall on the offsides of the form. The spacing material used to hold the pattern type firmly against the standoff pieces are shoulder-high quads and spacing to fill the remaining width precisely.

Step 6: Building the Form

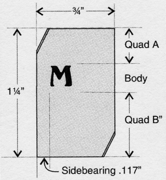
The form has two important functions: 1) holding the piece of type square and firm, and 2) holding the prepared matrix square and firm. To do this, the form must be prepared square and firm.

The two body parts are first positioned with the correct point size 2 em quad between. The pattern type, which has had a layer of Scotch tape affixed to the feet (this gives added height so that the face can be worked down to type high (.9185), is placed against the quad. The pattern type is fitted into place with the notch facing Quad B and more quads and/or spaces added until it is held tightly in place like filling out a line of type in a stick. The standoff pieces are then placed against the sides of the body pieces and the pattern type. The right bearing wall is longer (7.5 picas) and overlaps the top of the top body piece by 6 points. The top bearing wall (4.5 picas) butts up against the overhang. Next position a 3-point lead (7 picas) as an offside bearing wall to help hold the form together. Do the same for the bottom of the form. Then the whole form is tightly Scotch taped around the body, to hold the form together. The form will be secured further later when the prepared matrix has been added.

Step 7: Preparing the Matrix

The matrix (Figure 3), is described in Paul Duensing's paper as .747"x1.125"x.096" brass stock with 30° chamfered corners on the upper left and lower right. *Reuse of matrices that are mismatched or unusable is possible (and recommended).* If new stock is used, it is very important that all sides be true, insuring proper alignment of the form and the matrix for proper casting.

FIGURE 3



Matrix Dimensions

A hole in this stock must be drilled and counter-sunk in the precise area where you wish to grow your matrix face. Precisely determine the positioning of the letter and drill a hole slightly larger than the type body being deposited. Remember, you are working from the backside of the matrix: The face will be "looking up" through the hole when placed over the form.

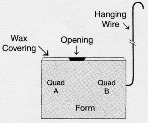
After your hole is drilled, use a larger size drill to counter-sink the hole. Bring the larger drill down into the previous hole just enough to add slope to the sides of the first hole. The counter-sink provides a more secure back to the matrix face. Clean burrs off the matrix by rubbing it across 220 grit sandpaper and check the fit of the hole over the pattern type, insuring that there is clearance all the way around the body of the pattern type for the new copper to be deposited. If the hole needs to be opened, use a chain saw sharpening file.

Once drilled, the matrix is securely taped to the form, insuring that the matrix is firmly and squarely held against the bearing walls. The form is then completely covered with Scotch tape in preparation for drilling of the form and immersion in melted wax.

Step 8: The Hanger

To suspend the finished matrix, cut a piece of #22 gauge insulated copper wire to a length that will allow the form to be hung from the copper tubing, which the negative pole is attached, plus 1-inch. Strip the insulation 3/8" for one end and 1" from the other. The short end will be inserted into the form and the long end will be bent into a hook for hanging.

FIGURE 4



Adding Hanging Wire

Using a 5/64" bit, drill into the center of filler and quad B 3/8". Insert the bared end of the wire hanger, then bend the wire at the entrance hole to a 90 degree up angle (Figure 4). The form is ready for waxing.

Step 9: Waxing the Form

Using a wide-mouth jelly jar and a pan of water, melt canning sealing wax (available at the local supermarket). Reduce the heat to where the wax is held in the liquid state, but the water is not boiling. Holding the form by the hanging wire, dip into the wax, completely covering the form. Pull the form out of the wax, allow the wax coating time to solidify, then dip again. Do this three times, then move the dipped form to the opposite hand, pick up another form and continue. Repeat the process until all forms have been dipped, dried and re-dipped three times. This will provide about 1/16" coating over the form and onto the hanging wire.

Step 10: Finishing the Form

Once the form has been dipped in wax and the coating is solidified, use an X-Acto knife to carefully cut the wax and Scotch tape from over the typeface, following the outline of the drilled hole. With swabs, clean the exposed area with rubbing alcohol to remove any oils or wax that may have contaminated the area.

Step 11: Turning on Power

Once the power adapter is attached to the input poles, set the variable switch on the adapter to 3 volts (second marking). Plug into wall outlet. With the multimeter set to volts (at least more than 3), touch the probes to the proper input poles and read the voltage, which should be 3 volts. Now turn the meter to DC mA (insuring that it is set higher than 300 mA) and check that reading, which should be approximately 300 mA.

Now put probes to output poles and check the readings—again making sure that the meter is set high enough to handle the load. By varying the rheostat you should be able to adjust the voltage from near zero to 3, and the amps from 0 to 300. If this doesn't happen, use your probes to check the input into the rheostat and the outputs. If the connections are not "cold," you should read the same input as you do at the poles and be able to vary the output by moving the dial.

Step 12: Power to the Soup

To get the power to the soup, cut the 24" piece of #8 wire in half, strip the ends, tin, fold in half the tinned ends and attach connector rings. Attach one to each of the output poles, tightening down the second nut. Attach the end of the positive output to the anode copper rod at the tank and the negative output to the cathode (or form) rod.

Step 13: Charging the Soup

The soup is now ready for use. Slowly pour the solution into your growing tank and mark the level on the side. The soup evaporates and the level will go down. However, only the distilled water is lost and by bringing the level back to the mark with more water, your solution will remain usable. However before use, attach the power source (see Figure 1) hang a copper anode on the positive rod and another one on the negative (cathode) side. Apply the power and leave for 24 hours. This will "charge" the solution and provide better initial growth.

Step 14: Loading the Tank

Turn the power on before loading the forms and have the anode(s) in place from the positive rod. Hang the forms onto the negative rod. With the Vtvm reading the output poles, set the output voltage at .50 volts (half a volt). Check the output amps, which will be between 90 and 140 mA. If the amps are higher than 140 mA, adjust the pot to read 120 mA, then check the voltage. The voltage should never be less than .45. If it is, move the forms around on the rod—there might be a bad connection between hanger and rod, causing more amps to be drawn.

Step 15: Checking the Progress

Check your voltage at least once a day—at the source and again at both rod connections at the tank. This voltage will change as the matrices begin collecting copper deposits. Readjust the voltage to the original setting to ensure smooth deposits.

Continual circulation of the soup is very useful in assuring a more even deposit. To do this, a small aquarium tank air pump is used. The plastic hose is inserted in a ¼" hole in the lid of the tank. The hole is located against the side of the tank behind the positive rod and the bubbles move the soup continually.

Step 16: Growing Time and Rewaxing

Growing time varies because of changes in temperature and voltage. Growing time ranges from 7 to 14 days. The matrix is considered finished when the deposit has completely filled the hole. Sometimes the "flower" (or copper deposit around the hole) grows too fast and it is necessary to re-wax the form to force the deposit to fill the hole rather than add to the flower. To do this, heat the wax as initially recommended. Then pull the form and fill the hole with a small, rolled piece of paper towel. This keeps the face area moist (otherwise oxidation will occur). With a small oil/watercolor paintbrush, carefully cover the flower. Keeping the twisted piece of paper towel in the opening also ensures that wax will not get into the area where you want more growth. After re-waxing, remove the paper towel and return the form to the soup.

Step 17: Finishing the Matrix

Once the copper deposit is of sufficient depth to insure complete growth inside the matrix, remove form and wash under running water. Remove the hanging wire, strip the wax and tape from the form and disassemble. The pattern type will be affixed to the matrix. This can be removed by dangling the matrix by holding the pattern type shank and gently tapping with a small metal rod. The type will break loose and then be removed from the matrix. If part of the face remains in the matrix, continue with the finishing and remove it by submerging the matrix quickly in molten metal at your caster's pot and tap gently.

Once the matrix is free from all attachments, place in a vice and with a hacksaw remove the flower. You will note that the wrapping and wax will form a slot large enough for the hacksaw blade and to act as a guide. The matrix is now ready to be "dressed." If you have a mill, this step can be accomplished with an end mill and a flycutter.

Step 18: Dressing

Remove all excess copper from the back of the matrix with a draw file until it is smooth and flush with the rest of the matrix surface. Run the face side of the mat gently over the draw file (always draw the mat toward you while holding down with the thumb and index finger). Set up your caster for the approximate size of the face, insuring that the type is aligned in the matrix as you would with any matrix. Cast a piece of type. (If using a Thompson, retrieve it before it goes under the type shoe. Break off the jet and file away the raised area of the jet.) Check height to paper with a micrometer. If too tall, rub the face of the matrix with wet emory cloth. Repeat this process until you get the type height desired. Aim for .9185" unless you're matching an existing matrix font. If that's the case, compare with type cast from other mats in the font. (I stop at .919 and then allow the Thompson to actually plow the jet on several samples and then check height to paper again. Final finishing of the depth also can be checked with a needle depth gauge (most U. S. Lanston display mats from 12 to 36 point are .050").

Step 19: Enjoy

The cost is small and the rewards are wonderful, so get started *and enjoy!* You can cast from this matrix now and for years and years to come.